



FIFTH EDITION



EXOTIC ANIMAL FORMULARY

JAMES W. CARPENTER



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Rapid Reference to the *Exotic Animal Formulary*, Fifth Edition

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FIFTH EDITION

EXOTIC ANIMAL FORMULARY

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DEDICATION

This book is dedicated to the 40 (yes, 40!) interns and residents whom I've had the honor to train from 1991 to 2018, and who have brought great joy to my life and pride to our profession: Dr. Rob Browning (2017-2018), Dr. Louden Wright (2016-2017), Dr. Melissa R. Nau (2015-2016), Dr. Dana M. Lindemann (2014-2015), Dr. Christine Higbie (2013-2014), Dr. Katie Delk (2012-2013), Dr. Daniel V. Fredholm (2011-2012), Dr. Rodney Schnellbacher (2010-2011), Dr. Kristin Phair (2009-2010), Dr. Judilee Marrow (2008-2009), Dr. Kim Wojick (2007-2008), Dr. Julie Swenson (2006-2007), Dr. Gretchen Cole (2005-2006), Dr. Karen Wolf (2004-2005), Dr. Jessica Siegal-Willott (2003-2004), Dr. Jennifer D'Agostino (2002-2003), Dr. Adrian Mutlow (2001-2003), Dr. Nancy Boedeker (2001-2002), Dr. Robert Coke (2000-2001), Dr. Greg Fleming (1999-2000), Dr. Peter Helmer (1999-2000), Dr. Tama Cathers (1998-1999), Dr. Cornelia Ketz (1998-1999), Dr. Geoff Pye (1997-1998), Dr. Nancy Morales (1996-1998), Dr. R. Scott Larsen (1996-1997), Dr. Pilar Hayes (1995-1996), Dr. Cynthia Stadler (1995-1996), Dr. Ray Ball (1994-1996), Dr. Christine Kolmstetter (1994-1995), Dr. James K. Morrissey (1994-1995), Dr. Edward Gentz (1993-1994), Dr. Lisa Harrenstien (1993-1994), Dr. Janette Ackermann (1992-1993), Dr. Ted Y. Mashima (1992-1993), Dr. Sandra C. Wilson (1991-1992; 1992-1995), Dr. Craig A. Harms (1991-1992), Dr. Mel Shaw (1990-1992), and Dr. Mitch Finnegan (1990-1991).

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James W. Carpenter

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Foreword

The practice of exotic animal medicine is founded on a strong understanding of medical science. With confidence in one's knowledge of medicine, treating many different species is possible. It is absurd to believe that one should know all about every companion exotic animal one treats—so much so that if that were the case, veterinarians would never have even treated the first bird, snake, or rabbit patient when this area of veterinary medicine was in its infancy. As veterinary practitioners who treat exotic animals, we owe much to those who paved the way and revealed the challenging yet rewarding work that has become an accepted veterinary discipline. It was their confidence in their medical knowledge and abilities that allowed early exotic animal practitioners to push veterinary medicine into this new realm. With the information we have available today and the challenges faced by our patients, the question persists: "How did they do it?" There were no books to speak of, no Internet, and no veterinary associations. It was through dedication, collegial interaction, and meeting notes that the dissemination of companion exotic animal medical knowledge first occurred. The need to share and gain information through firsthand knowledge of exotic animal clinical medicine was the genesis of what has quickly grown into the widely recognized area of companion exotic animal medicine. Many influences have contributed to the growth of exotic animal medicine, including the continued consumer demand for veterinary services and an increasing interest over the years among young veterinary students who see both the challenges and rewards of treating these exceptional animals. Also, over the last 35 years, there has been an increase in the availability of published veterinary medical literature, the advent of Internet resources, the formation of veterinary associations, and specialty designations related to companion exotic animals. All of the contributions to the medical knowledge of exotic animal species during the last 3 to 4 decades have allowed many individuals to develop their interest in this area of medicine, who previously may have been reluctant.

Practicing medicine requires treatment of patients who are ill. This is a fact, and so is the fact that proper dosage and duration of medications should be used. As with any medication, there are adverse side effects. Often there are more potential adverse side effects with a medication than therapeutic benefits. Therein lies the basis of many doctors' decision to prescribe medications when the good outweighs the bad. Moreover, that is why there should be knowledge of an appropriate length of treatment. Again, when companion exotic animal medicine began, practitioners used personal communication and published case reports to determine appropriate dose ranges and durations of treatments. Often this information was extrapolated from other species, and possibly the exotic animal patient did not die from the treatment and may have even improved. Of course, all veterinarians knew this had to improve, and there was much to be done to make pharmacologic information more detailed and as verifiable as possible through structured scientific studies. As exotic animal practitioners, we have come a long way but still have a long way to go in this regard. We can extrapolate dosages between species from scientifically determined information, but it is known that this is done at the risk of providing an incorrect treatment dose. It is simply not possible to scientifically determine all of the correct dosages for the approximately 10,000 species of both birds and reptiles, as well as the numerous companion exotic mammals and other species that may

be treated by exotic animal veterinarians. Consequently there have been formularies published in exotic animal medical books over the last 35 years that help provide a basis for prescribing medication to a patient. If a veterinarian treats all different groups of companion exotic animals, it is difficult and time consuming to get the most up-to-date information regarding drug dosages for these patients. Dr. James W. Carpenter saw this problem and in the 1990s decided to do something about one of the most important tools used by veterinarians treating exotic animals: the formulary. As editor, he published the first edition of the *Exotic Animal Formulary* (1996) and has subsequently edited three other editions (2001, 2005, 2013), as well as this fifth edition (2018). Since the first edition, the *Exotic Animal Formulary* has arguably become the most important source of information that a veterinarian treating these patients can own. It is quite possible that no other area of veterinary medicine has changed as quickly over time than pharmacology. Drugs are often used by practitioners treating exotic animals long before there is validation of a proper dosage or the effectiveness has been determined. Through the publication of new editions of the *Exotic Animal Formulary*, veterinarians' ability to have within grasp the latest information relating to the treatment of exotic animals has been maintained.

It is an honor for me to be asked to write the foreword for this seminal exotic veterinary text. The *Exotic Animal Formulary* is used on a daily basis in our veterinary hospital and is the "go to" book for students and veterinarians alike when determining a treatment plan for any animal species. The *Exotic Animal Formulary* also allows one to use their veterinary medical knowledge. The extensive drug tables may not provide an exact, scientifically determined dose for the species of animal being treated. One may need to extrapolate from the information provided for another species. There are often wide dosage ranges provided for the drugs listed, and the references may be associated with a single case report. Therefore it is incumbent on the user of this text to assess his or her patient and use the information in the *Exotic Animal Formulary* to determine whether the drug he or she would like to use is advisable and if so, based on the patient's condition, select a proper dose.

Never before has so much valuable information been published in a condensed text covering as many animal groups and species as the fifth edition of the *Exotic Animal Formulary*. In addition to the 295 drug tables that have the most current information and references (over 2400), there are many informative tables and charts at the end of each chapter. The information contained in the tables and charts includes biological information, therapeutic details to treat specific disease conditions, dietary recommendations, common venipuncture sites, and useful websites related to exotic pet practice. All in all the information provided in the fifth edition of the *Exotic Animal Formulary* will elevate the ability of veterinarians to practice exotic animal medicine.

The veterinary medical community, as a whole, owes a debt of gratitude to the 29 authors who contributed to this text and to Dr. James W. Carpenter for his vision and supreme effort to bring this work to fruition. The benefits of their work will be found in veterinary hospitals the world over as patients recover through the use of information provided by the fifth edition of the *Exotic Animal Formulary*.

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Preface

Welcome to the fifth edition of the *Exotic Animal Medicine Formulary*! As we know, the medical care of exotic pets has become an integral part of most companion animal practices. The *Exotic Animal Formulary*, fifth edition, therefore, was compiled to accommodate this rapid growth of exotic animal medicine. For this revision, 29 of the most recognized specialists in our field were invited to contribute; their role was to evaluate published drug dosages and related biologic and medical information and references, and to select those that would be most clinically useful and relevant to the practitioner.

Not only is this edition updated and expanded (now containing 295 tables), but we've added a section on "Backyard Poultry and Waterfowl," in addition to sections on invertebrates, fish, amphibians, reptiles, birds, sugar gliders, hedgehogs, rodents, rabbits, ferrets, miniature pigs, primates, and wildlife. The "Selected Topics for the Exotic Animal Veterinarian" has also been expanded and now includes information on compounding resources.

This book is not intended to replace existing medical resources or the use of sound medical judgment, but rather to serve as a guide in providing medical care to exotic animals. This formulary assumes that the reader has a reasonable understanding of veterinary medicine. For example, drug indications are generally listed only in unique situations. Supporting tables have been carefully selected to include those topics of major importance in clinical practice.

As in previous editions of this book, the selection of species, drugs, and other information used in this reference was based on an extensive review of the literature (over 2400 references are cited) and on our collective teaching and clinical experience. The book, therefore, is not intended to be all-inclusive, but rather to serve as a quick reference for the common questions and medical situations we encounter in clinical practice.

Unfortunately, relatively few pharmacokinetic/pharmacodynamic studies in exotic companion pets have been published. Until more pharmacokinetic, efficacy, and safety studies of the drugs that we use are conducted, most dosages used in these species are based on empirical data, observations, and experience.

This book is intended to be a practical, user-friendly, quick reference for veterinary clinicians, students, and technicians working with exotic animals. We hope that you find this formulary and accompanying tables handy to use and that it adds to the quality of the medical care you provide to your exotic animal patients. Because exotic animal practitioners face daily challenges to meet the pharmaceutical and clinical needs of their patients, our hope is that this book will be a valuable tool in helping meet these challenges.

James W. Carpenter MS, DVM, Diplomate ACZM

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This book would not have been possible without the invaluable assistance of many dedicated and hard-working people. Certainly, first and foremost, my appreciation goes to Dr. Christopher J. Marion, who, as the Assistant Editor for this edition of the *Exotic Animal Formulary*, provided editorial assistance, technical expertise, and personal encouragement. I am also greatly appreciative of the numerous contributors who unselfishly shared their expertise and gave of their time, and are largely responsible for the success of this book! I am indebted to Megan Cabot, Danielle Windle, Sarah Wilson, and Nichole Arbona for assistance in the preparation of this formulary; to Lea Pearlman and Amanda Wonn for assistance in preparing the Primate chapter; and to Dr. Butch KuKanich for reviewing the appendix on antimicrobial agents.

I also wish to thank all those colleagues, interns and residents, and veterinary students, both national and international, who encouraged me to prepare the *Exotic Animal Formulary*, fifth edition. It let me know that our efforts into preparing this book are appreciated by the veterinary community and provided a powerful incentive for me to continue working on this reference.

In addition, a special thanks to Dr. Bonnie Rush for her many years of strong support and encouragement for me and for our Zoological Medicine Service! And thanks to Dr. Roger Fingland for his role in strengthening KSU's zoo animal medicine program.

I also thank Penny Rudolph (a very special person and strong supporter of this "project"), Jennifer Flynn-Briggs, Umarani Natarajan, Courtney Sprehe, Dee Simpson, and Lucia Gunzel, our publishing team at Elsevier, for their patience and support, and to their commitment to this fifth edition.

James W. Carpenter

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The Editor, Assistant Editor, and the Contributors attempted to verify and double-check all references, dosages, and other data contained in this book. However, despite these efforts, errors in the original sources or in the preparation of this book may have occurred. All users of this reference, therefore, should empirically evaluate all dosages to determine that they are reasonable prior to use. The publisher assumes no responsibility for and makes no warranty with respect to results obtained from the uses, procedures, or dosages listed, or for any misstatement or error, negligent or otherwise, contained in this book. In addition, the authors do not necessarily endorse specific products, procedures, or dosages reported in this book. Also, the listing of a drug or commercial product in this book does not indicate approval by the FDA or the manufacturer for use in exotic animals.

About the Editors

ABOUT THE EDITOR

James W. Carpenter, MS, DVM, Diplomate ACZM, is a professor of zoological medicine at the College of Veterinary Medicine, Kansas State University. He has been a clinical and research veterinarian for 42 years in the field of exotic animal, wildlife, and zoo animal medicine, and he has trained 40 interns and residents. He is the author of numerous scientific papers and book chapters; is editor/co-author of the *Exotic Animal Formulary* (1996, 2001, 2005, 2013, 2018) and its Japanese (2002), Spanish (2006), and Portuguese (2010) translations; and was co-editor of *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery* (2004, 2012). Dr. Carpenter is also the former editor of the *Journal of Zoo and Wildlife Medicine* (1987-1992), served on the Wildlife Scientific Advisory Board of the Morris Animal Foundation (1998-2001; Chair, 2000-2001), and is the past president of the American Association of Zoo Veterinarians (1998-1999), the Association of Avian Veterinarians (2006-2007), and the American College of Zoological Medicine (2008-2009). He was awarded the Edwin J. Frick Professorship in Veterinary Medicine from the KSU College of Veterinary Medicine in 2002 and the Emil Dolensek Award by the American Association of Zoo Veterinarians in 2004. Dr. Carpenter was named the Exotic DVM of the Year for 2000 and the T.J. Lafeber Avian Practitioner of the Year for 2012. He was also named an Alumni of the Year by the Oklahoma State University College of Veterinary Medicine in 2009. In 2013, the Veterinary Health Center (KSU College of Veterinary Medicine) named the new veterinary facility at Manhattan's Sunset Zoo the "James W. Carpenter Clinic at Sunset Zoo." In 2016, Dr. Carpenter was awarded both the E.R. Frank Award by the KSU College of Veterinary Medicine Alumni Association for "outstanding achievements, humanitarian service, and contributions to the veterinary profession" and the KSU Distinguished Service Award for "outstanding leadership and clinical/diagnostic service to Kansas Veterinary Medical Association members." Dr. Carpenter is currently the editor-in-chief of the *Journal of Avian Medicine and Surgery*.

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Christopher J. Marion, DVM, MPH, received his doctor of veterinary medicine and master of public health degrees from Kansas State University. He has managed and monitored clinical trials in the clinical research industry for the past 11 years. During this time, he has also consulted with the Association of Avian Veterinarians as an associate to the editor on the quarterly publication of the *Journal of Avian Medicine and Surgery*.

Chapter 1 **Invertebrates**

Gregory A. Lewbart



TABLE 1-1 Antimicrobial and Antifungal Agents Used in Invertebrates.^{a-e}

Agent	Dosage	Comments
Ampicillin	100 mg/L q12h × 7 days ⁶⁹	Control of white band disease (WBD) in <i>Acropora</i> sp.
Benzalkonium chloride	0.5 mg/L long-term ⁷¹ 10 mg/L for 10 min ⁶⁰	Quaternary amine with broad disinfection properties, not for use on live animals
Ceftazidime (Fortaz, Pfizer)	20 mg/kg intracardiac q72h × 3 wk ⁶⁰	Spiders/cephalosporin with good activity against Gram-negative bacteria (e.g., <i>Pseudomonas</i>); although this regimen appears safe, efficacy has not been determined
Chloramphenicol	75 mg/kg PO, IM q12h × 6 days ⁶³ 10-50 mg/L as an immersion treatment for several days ^{10,66,68} (prepare fresh solution with 100% water change q24h)	Cephalopods Corals/reduce lighting for treated animals if possible (slows metabolic rate and may reduce stress and improve drug tolerance); rinse animals well with fresh seawater before return to primary habitat; properly treat any effluent before discharge; florfenicol may be a better alternative (risk to humans from chloramphenicol)
Enrofloxacin	5 mg/kg IM, IV ^{33,63} 5 mg/kg IV ⁶⁰ 5 mg/kg ICe ⁶² 10 mg/kg PO ^{33,63} 10 mg/kg ICe ⁵⁹ 10-20 mg/kg IM ⁷⁰ 10-20 mg/kg PO q24h ⁶⁰ 2.5 mg/L × 5 hr immersion q12-24 h ^{33,63} 5 mg/L × 24 hr immersion ¹⁴ 5 mg/L immersion for 6 hr ⁶² 10 mg/L immersion for 6 hr ⁵⁹	Cuttlefish (PD) and possibly other cephalopods Spiders Purple sea stars (<i>Pisaster ochraceus</i>)/PD Cuttlefish (PD) and possibly other cephalopods Green sea urchins (<i>Strongylocentrotus droebachiensis</i>)/PD Chinese mitten crabs/PD Spiders Cuttlefish (PD) and possibly other cephalopods Manila clams (<i>Ruditapes philippinarum</i>)/PD; decreasing temperature and/or salinity slowed elimination Purple sea stars (<i>Pisaster ochraceus</i>)/PD Green sea urchins (<i>Strongylocentrotus droebachiensis</i>)/PD
Fluconazole	3 mg/kg intracardiac q4d × 6 treatments ⁶⁴	Horseshoe crabs

TABLE 1-1 Antimicrobial and Antifungal Agents Used in Invertebrates. (cont'd)

Agent	Dosage	Comments
Formalin	1-1.5 ppm immersion for 4 hr ⁴²	Horseshoe crabs/ectocommensals; can also be administered indefinitely (i.e., until diluted out)
Furazolidone	50 mg/L q12h for 10 min immersion ⁶³	Cephalopods
Iodine, Lugol's 5% solution	5-10 drops/L of seawater; use as an immersion for 10-20 min ⁶⁸ Topically at full strength (5%) for 20-30 sec ⁶⁸	Corals/antiseptic; cauterize wounds; strong oxidizing agent; some corals are sensitive, including pulse corals (<i>Xenia</i> sp.), <i>Anthelia</i> spp., and star polyps (<i>Pachyclavularia</i> spp.); remove corals at first signs of stress (polyp expulsion)
Itraconazole (Sporanox, Janssen)	10 mg/kg IV q24h ²	Horseshoe crabs/PD
Nitrofurazone	1.5 mg/L for 72 hr ⁶⁷ immersion 25 mg/L q12h for 1 hr ⁶⁷ immersion	Cephalopods/nitrofurazone; carcinogenic; drug inactivated in bright light; water soluble formulations preferred
Oxolinic acid	10 mg/kg intrasinus ⁷² 50 mg/kg PO ⁷²	Kuruma shrimp/PD; quinolone; Gram-negative bacteria; decreased uptake in hard water; better uptake pH <6.9 Kuruma shrimp/PD
Oxytetracycline	10 mg/kg intrasinus ^{72,73} 25 mg/kg intrasinus ⁷² 25-50 mg/kg IV ⁵⁶ 50 mg/kg PO ^{72,73} 100 mg/kg PO ⁶¹ 200 mg/colony PO q4-5d × 3 treatments ^{75,76} 10-15 mg/L q48-72 h × 3-5 treatments ³⁸ 1 g/lb of feed ⁵⁵	Tiger shrimp/PD; cooking reduced muscle levels by 30%-60% and shell levels by 20% Kuruma shrimp/PD Horseshoe crabs/PD Kuruma shrimp/PD; tiger shrimp/PD; cooking reduced muscle levels by 30%-60% and shell levels by 20% White shrimp/PD Honeybees/for treating American and European foulbrood; withdrawal time of 6 wk; should not be used on hives where honey will be consumed by humans Chocolate chip sea stars/cutaneous ulcerations; may be applicable to other echinoderms with bacterial lesions American lobsters/gaffkemia; approved for use in food animals by the FDA
Paromomycin	100 mg/L q12h immersion with a 25% water change × 6 days ⁶⁹	Control of white band disease (WBD) in <i>Acropora</i> sp.

Continued

TABLE 1-1 Antimicrobial and Antifungal Agents Used in Invertebrates. (cont'd)

Agent	Dosage	Comments
Silver sulfadiazine cream (Silvadene, Marion Merrill Dow)	Apply topically to lesions	Proceed with caution (biotest if possible) as treatments are empirical
Sulfadimethoxine	50-100 mg/kg in feed \times 14 days ⁵⁵	Penaeid shrimp
Sulfadimethoxine/ormetoprim (Romet-30, Alpha)	42 mg/kg intrapericardial ⁷	American lobster/PD; although no frequency is given, it appears that q3-5d may be reasonable based on the long half-life
Sulfamethoxazole/trimethoprim	Bioencapsulated in brine shrimp PO q12h ^{13,45,53,54}	White shrimp/PD; combine 20%-40% trimethoprim sulfamethoxazole with a lipid emulsion (Selco, INVE Aquaculture) at a concentration of 1:5
Tetracycline	10 mg/kg PO q24h ⁶³ 10 mg/L bath ^{41,68}	Cephalopods Corals/efficacy questionable in saltwater; anecdotal evidence of successful treatment for bacterial infections
Trifluralin	0.01-0.1 ppm as an immersion ⁵⁵	Penaeid shrimp/larval oomycetosis
Tris EDTA and neomycin (Tricide-Neo, Molecular Therapeutics)	100 mL/L for 45 min q24h \times 7 days as an immersion ³⁸	Cushion sea stars/cutaneous ulcers; may be applicable to other echinoderms
Tylosin (Tylan, Elanco)	200 mg/colony q7d \times 3 treatments ^{75,76}	Honeybees/antibiotic applied topically to the brood chamber for control of American foulbrood (<i>Paenibacillus larvae</i>); approved by the FDA; should not be used in hives where the honey will be consumed by humans
Winter savory extract (<i>Satureja montana</i>)	0.01% in microcrystalline sugar ¹⁶	Honeybees/chalkbrood fungal disease (<i>Ascosphaera apis</i>); a number of plant aromatic oils have been tested, some with more promise than others, on various diseases of honeybees ^{22,75,76}

^aNot to be used with invertebrates intended for human consumption unless government approved.

^bPreferable to treat a single animal of a species (biotest) to determine toxicity.

^cTank treatment: when treating the invertebrates' resident aquarium, disconnect activated carbon filtration to prevent drug removal. Many drugs adversely affect the nitrifying bacteria, so water quality should be monitored closely (especially ammonia and nitrite concentrations). Keep water well aerated when appropriate and monitor patient(s) closely. Perform water changes and reconnect filtration to remove residual drug following treatment. Discard carbon following drug removal.

^dBath (immersion) treatment: remove invertebrates from resident aquarium and place in container with known volume of water and concentration of therapeutic agent. Watch closely for signs of toxicity.

^eInvertebrate species, temperature, and water quality parameters can influence the pharmacodynamics of many drugs, especially antimicrobials.

TABLE 1-2 Antiparasitic Agents Used in Invertebrates.^{a-e}

Agent	Dosage	Comments
Acetic acid, glacial	3%-5% solution for 1 hr ¹²	Horseshoe crabs
Amitraz (Apivar, Véto-pharma)	Use as directed ^{75,76}	Honeybees/acariasis; commercial packaging should be consulted prior to use
Diflubenzuron	0.03 mg/L for 7 days ²¹	Control of amphipods in <i>Chrysaora</i> jellyfish
Formalin	50-100 µL/L for 4 hr or 25 µL/L indefinitely ⁵⁵	Shrimp/protozoal ectoparasites; approved for use by the FDA in food animals
Formic acid	Use as directed ^{75,76}	Honeybees/acariasis; commercial packaging should be consulted prior to use; an empty super must be used on hive during treatment
Freshwater	1-3 min dip ⁶⁸	Stony corals, some soft corals/flatworms, and other ectoparasites; buffer to pH 8.2 and use clean, dechlorinated water; do not use on small polyp corals or xenids; biotest first, if possible, especially when attempting with a new species
Fumagillin	Use as directed ^{75,76}	Honeybees/nosemosis (caused by microsporidian parasites); commercial packaging should be consulted prior to use
Ivermectin	Stock solution of 1:1 (1% ivermectin and propylene glycol); dilute 1:50 with distilled water prior to topical use ⁶⁰	Spiders/for the treatment of individual parasitic mites; apply carefully to mites with fine paintbrush or similar implement
Levamisole (Levasole, Schering Plough)	8 mg/L immersion for 24 hr ⁶⁸	Corals/metazoan parasites; well tolerated by <i>Acropora</i> spp., <i>Montipora digitata</i> , <i>M. capricornis</i> , <i>Seriatopora histrix</i> , <i>Stylophora pistillata</i>
Menthol	Use as directed ⁷⁵	Honeybees/acariasis; commercial packaging should be consulted prior to use
Metronidazole	50 mg/kg intracardiac × 1 treatment ⁶⁰ 100 mg/L immersion for 16 hr ⁶³	Spiders/appears safe, but efficacy is unknown Cephalopods/antiprotozoal
Milbemycin oxime (Interceptor, Novartis)	0.625 mg/L as an immersion ^{26,37,43} 0.16 mg/L as an immersion q6-7d × 2 treatments ⁹	Stony corals (<i>Acropora</i> / "red bug" (<i>Tegastes acroporanus</i>) For amphipod parasites of jellyfish; use with caution on hydrozoans
Potassium permanganate	25-30 ppm for 30-60 min ⁵⁵	Penaeid shrimp/external parasiticide
Povidone iodine	0.75% solution for topical treatment ⁶⁰	Spiders/fungal infections; use water-based solution

Continued

TABLE 1-2 Antiparasitic Agents Used in Invertebrates. (cont'd)

Agent	Dosage	Comments
Thymol	Use as directed ^{75,76}	Honeybees/acariasis; commercial packaging should be consulted prior to use

^aNot to be used with invertebrates intended for human consumption unless government approved.

^bPreferable to treat a single animal of a species (biotest) to determine toxicity.

^cTank treatment: when treating the invertebrates' resident aquarium, disconnect activated carbon filtration to prevent drug removal. Many drugs adversely affect the nitrifying bacteria, so water quality should be monitored closely (especially ammonia and nitrite concentrations). Keep water well aerated when appropriate and monitor patient(s) closely. Perform water changes and reconnect filtration to remove residual drug following treatment. Discard carbon following drug removal.

^dBath (immersion) treatment: remove invertebrates from resident aquarium and place in container with known volume of water and concentration of therapeutic agent. Watch closely for signs of toxicity.

^eInvertebrate species, temperature, and water quality parameters can influence the pharmacodynamics of many drugs.

TABLE 1-3 Chemical Restraint/Anesthetic/Analgesic Agents Used in Invertebrates.

Agent	Dosage	Comments
Alfaxalone	200 mg/kg intracardiac ³¹	Used as a general anesthetic for tarantulas (<i>Grammostola roseae</i>)
Benzocaine	100 mg/L ^{4,35} bath	Abalone/anesthesia; not sold as anesthetic in United States; available from chemical supply companies; do not use topical anesthetic products marketed for mammals; prepare stock solution in ethanol (benzocaine is poorly soluble in water); store in dark bottle at room temperature
	400 mg/L ²⁰	Leeches/this could be applied, with caution, to other aquatic annelids
	1 g/L ²⁹	Prepare as 1:4 w/v added to 95°C water to dissolve the benzocaine; for use in apple snails (<i>Pomacea paludosa</i>)
	2.5-3 g/L ⁶³ bath	Cephalopods/euthanasia
Butorphanol	Fish, amphibian, and reptile dosages can be employed with care	Analgesia; use with caution as dosing regimens are empirical; biotest when possible
Carbon dioxide	3%-5% ³⁶	Terrestrial arthropods/euthanasia; isoflurane and sevoflurane may be preferable with regard to recovery; an anesthetic chamber has been developed/described for use in the fruit fly ⁷¹
Clove oil (eugenol)	0.125 mL/L (approx. 125 mg/L) as an immersion ²⁸	Crustaceans/stock solution: 100 mg/mL of eugenol by diluting 1 part clove oil with 9 parts 95% ethanol (eugenol is poorly soluble in water); over-the-counter preparation (pure) available at most pharmacies contains approximately 1 g eugenol per mL clove oil
	0.35 g/L ²⁹	Apple snails (<i>Pomacea paludosa</i>)

TABLE 1-3 Chemical Restraint/Anesthetic/Analgesic Agents Used in Invertebrates. (cont'd)

Agent	Dosage	Comments
Ethanol	1.5%-3% solution ³⁹ 3% solution ³⁵ 5% solution ^{27,36} 5% solution ^{18,46} 5% solution ³² 10% solution ⁶³	Cuttlefish/anesthesia may not be effective for cold water cephalopods ³⁵ Abalone/anesthesia Aquatic gastropods/anesthesia Oligochaetes/adequate anesthesia for terrestrial earthworms such as <i>Lumbricus terrestris</i> Octopuses for general anesthesia Cephalopods/euthanasia
Ethanol/menthol (Listerine, McNeil-PPC)	10% in saline ⁷⁹	Aquatic gastropods/anesthesia
Isoflurane	Can be used with an anesthetic chamber 5% with 1 L/min oxygen ²⁵ 2 mL on a cotton ball ⁵	Terrestrial gastropods, ³⁰ arachnids ^{18,24,47,50,60,80} /anesthesia; fast induction with a possible excitatory period; anesthetic depth may not be appropriate for invasive surgery; ²⁷ usually applied at a 5% concentration for arachnids Tarantulas (<i>Grammostola roseae</i>)/sedation and anesthesia (depending on the amount of time in the anesthetic chamber Place cotton ball in a 500 mL beaker with the tarantula; cotton ball should be placed/protected to avoid direct contact
Ketamine	40-90 mcg/g IM ¹¹ 0.025-1 mg/kg ²⁸ 20 mg/kg intracardiac with 200 mg/kg alfaxalone ³¹	Crayfish/induction time of less than 1 min and anesthetic duration of 10 min at low dose and 2 hr at high dose Australian giant crabs/fast induction (less than 30 sec) with an excitatory phase; dose dependent anesthetic duration of 8-40 min Tarantulas/results in deep plane of anesthesia
Lidocaine	0.4-1 mg/g IM ¹¹	Crayfish/induction time of less than 2 min and duration of anesthesia of 5-30 min when injected into the tail
Magnesium chloride	Intracoelemic, 25-50% bodyweight with a 1000 milliosmolar solution ^{15,49a} 6.8 g/L ^{33,35} 30-50 g/L ⁴⁰ 1:1 mixture of 7.5% with seawater ^{38,49}	Sea hares/short induction time (2-5 min) and good muscle relaxation Cephalopods/induction time of 6-12 min in cuttlefish Scallops/fast induction and recovery Echinoderms/concentration adjustments may be required for prolonged anesthesia

Continued

TABLE 1-3 Chemical Restraint/Anesthetic/Analgesic Agents Used in Invertebrates. (cont'd)

Agent	Dosage	Comments
Magnesium chloride (cont'd)	7.5% immersion ^{45,52} 10% solution pm ⁶³ 30 g/L for 20 min ¹ 32.5 g/L for 20 min ³²	Polychaetes Cephalopods/euthanasia Queen conch (<i>Strombus gigas</i>) Octopuses
Magnesium sulfate	4-22 g/100 mL ⁷⁸	Abalone/fast induction and good recovery
Morphine	5 mg/kg intracardiac with 200 mg/kg alfaxalone ³¹	Tarantulas
MS-222 (Finquel, Argent)	—	See tricaine methanesulfonate
2-phenoxyethanol	0.5-3 mL/L ⁷⁸	Abalone/quick induction and short recovery
	1-2 mL/L ³⁵	Quick induction and short recovery
Potassium chloride	1 g/kg (330 mg/mL solution) IV ⁸	Lobsters/euthanasia; inject at base of second walking leg
Procaine	25 mg/kg IV ⁵⁸	Crabs/very short induction time (less than 30 sec) and prolonged anesthesia (2-3 hr)
Propylene phenoxetol	1-3 mL/L of a 1% solution ^{35,51,57}	Oysters/anesthesia; this concentration should produce anesthesia in less than 15 min; recovery time is short (under 30 min); higher doses can be used but induce a deeper level of anesthesia; can also be used for giant clams ⁵¹
	2 mL/L ^{35,74}	Echinoderms
Sevoflurane	Can be used with an anesthetic chamber at a 5% concentration ^{35,81}	Terrestrial arthropods/see isoflurane for details of administration; use with a 1 L/min oxygen flow in tarantulas ⁸¹
Sodium bicarbonate tablets (Alka-Seltzer, Bayer)	2-4 tablets/L bath ³⁴	Euthanasia; generates CO ₂ ; use when other agents unavailable; keep aquatic invertebrate in solution >10 min after respiration stops; dosage based on piscine literature
Sodium pentobarbital	400 mg/L ⁴⁸	Aquatic gastropods/anesthesia; very slow onset but apparently safe; controlled drug
	1 mL/L ⁴	Abalone

TABLE 1-3 Chemical Restraint/Anesthetic/Analgesic Agents Used in Invertebrates. (cont'd)

Agent	Dosage	Comments
Tricaine methanesulfonate (MS-222; Finquel, Argent)	Dosages and efficacy vary widely depending on species and application; consult taxon-specific literature ^{35,36} 0.4-0.8 g/L immersion ³	Anesthesia; stock solution: 10 g/L, buffer the acidity by adding sodium bicarbonate at 10 g/L or to saturation; store stock in dark container; shelf-life of stock extended by refrigeration or freezing; stock that develops an oily film should be discarded; aerate water to prevent hypoxemia; euthanasia: keep animal in solution >20 min after respiration stops Purple sea urchin (<i>Arbacia punctulata</i>)/safe and effective
Xylazine	16-22 mg/kg IV ²⁸ 20 mg/kg intracardiac with 200 mg/kg alfaxalone ³¹	Giant crabs/fast induction (3-5 min) and approximately 30 min of anesthesia (dose dependent) Tarantulas/results in a deep plane of anesthesia

TABLE 1-4 Miscellaneous Agents Used in Invertebrates.

Agent	Dosage	Comments
Barium sulfate	4 mL/15 g food ²³	Tarantulas, scorpions, millipedes, hissing cockroaches/contrast radiography; inject into a strawberry and feed to millipedes; inject into crickets and/or other prey for carnivorous invertebrates
Benzocaine topical (Orabase, Colgate-Palmolive)	Topically ⁶⁸	Corals and, potentially, other aquatic invertebrates/used as a water-resistant paste; chemotherapeutics can be combined for topical therapy
Carbon, activated	75 g/40 L tank water ⁵⁵	Removal of medications and other organics from water; usually added to filter system; discard after 2 wk; 75 g ≈ 250 cc dry volume
Chlorine/chloramine neutralizer	Use as directed	See sodium thiosulfate
Diatrizoate meglumine and diatrizoate sodium (Hypaque-76, Amersham Health)	4 mL/15 g food ²³	Tarantulas, scorpions, millipedes, hissing cockroaches/contrast radiography; combine with/inject into the food item and feed 1-3 hr prior to radiography
Hydrogen peroxide (3%)	0.25 mL/L water ⁵⁴	Acute environmental hypoxia; dose from the piscine literature
Iohexol	12 mL/kg IV ⁶⁵ 15 mL PO ⁶⁵	Horseshoe crabs/contrast radiography

Continued

TABLE 1-4 Miscellaneous Agents Used in Invertebrates. (cont'd)

Agent	Dosage	Comments
Methylmethacrylate	Apply topically as needed ^{19,60}	Arthropods (spiders, scorpions, insects)/repair fractured exoskeleton; there are numerous references for the application of surgical adhesives, so consult the appropriate taxon-based literature
Mineral oil	1 mL/kg PO	Insects/laxative ¹⁹
Nitrifying bacteria	Use as directed for commercial products Add material (e.g., floss, gravel) from a tank with an active biological filter and healthy fish to new tank ⁵⁴	Seed or improve development of biological filtration to detoxify ammonia, nitrite, and nitrate; numerous commercial preparations; do not expose products to extreme temperatures; use before expiration date Must evaluate risk of disease transmission with this technique
Oxygen (100%)	Fill plastic bag with O ₂ containing 1/3 vol of water ³⁴	Acute environmental hypoxia common with transportation; close bag tightly with rubber band; keep animals in bag until normal swimming and respiratory behavior
Sodium thiosulfate	Use as directed for chlorine/chloramine neutralizers 10 mg/L tank water ⁴⁴ 10 g neutralizes chlorine (up to 2 mg/L) in 1000 L water ⁴⁴ 100 mg/L tank water ⁶⁷	Active ingredient in numerous chlorine/chloramine neutralizers; chlorine and chloramine are common additions to municipal water supplies and are toxic to many aquatic invertebrates; ammonia released by detoxification of chloramine is removed by functioning biological filter (see nitrifying bacteria) or chemical means (see zeolite) Chlorine exposure
Zeolite (i.e., clinoptilite) (Ammonex, Argent)	Use as directed 20 g/L tank water ⁵⁴	Ion-exchange resin that exchanges ammonia for sodium ions; clinoptilite is an active form of zeolite; used to reduce or prevent ammonia toxicity

TABLE 1-5 Common Captive Invertebrate Taxa.^a

Arthropods

Chelecerates: This group includes the spiders, scorpions, and horseshoe crabs. Some common species are listed here.^{60,64}

Chilean rosehair tarantula (*Grammostola spatulata*)

Mexican fireleg tarantula (*Brachypelma boehmei*)

Mexican redknee tarantula (*Brachypelma smithi*)

Emperor scorpion (*Pandinus imperator*)

American horseshoe crab (*Limulus polyphemus*)

Myriapods (centipedes, millipedes):²⁴

African banded millipedes (*Isulus* spp.)

Desert millipede (*Orthoporus* sp.)

Giant desert centipede (*Scolopendra heros*)

Giant train millipedes (*Spirostreptida* spp.)

Madagascar fire millipedes (*Aphistogoniulus* spp.)

Crustaceans: Decapods are a diverse group of readily recognized species including the crabs, lobsters, and shrimp. Some common examples include the banded shrimps, crayfish (numerous species), marine hermit crabs, and terrestrial hermit crabs (*Coenobita* sp.).⁵⁵

Sea monkeys (*Artemia* sp.).⁵⁵

Insects: Insects, sometimes referred to as the phylum Hexapoda, are an immense group of over a million described species. Some common captive insects include the beetles (Order Coleoptera), butterflies and moths (Order Lepidoptera), crickets (grey crickets [*Acheta domestica*]; black prairie cricket [*Gryllus* sp.]), honeybee (*Apis mellifera*), Madagascar hissing cockroach (*Gromphadorhina portentosa*), and the silkworm (*Bombyx mori*).^{19,24,60,75,76}

Coelenterates

Scyphozoans (jellyfishes): Although not common as pets, some individuals, and many public institutions and establishments, maintain jellyfish aquaria. Some popular species include fried egg jellies (*Phacellophora camtschatica*), moon jellies (*Aurelia aurita*), and the sea nettles (*Chrysaora* sp.).⁶⁸

Anthozoans (anemones and corals): Numerous species of sea anemones and corals (hard and soft) are commonly maintained in reef aquaria. Frequently maintained soft coral groups include members of the families Alcyoniidae, Nephtheidae, and Xeniidae.⁴³ Commonly maintained scleractinian (hard coral) genera include *Acropora*, *Montipora*, and *Porites*.⁴³

Echinoderms

This entirely marine phylum includes five major classes:³⁸

Asteroidea: sea stars

Crinoidea: feather stars, sea lilies

Echinoidea: sand dollars, sea biscuits, sea urchins

Holothuroidea: sea cucumbers

Ophiuroidea: basket stars, brittle stars

Mollusks

Gastropods (nudibranchs, sea hares, slugs, and snails): This group includes a diverse array of terrestrial, freshwater, and marine species.^{15,30,43}

Cephalopods (cuttlefish, nautilus, octopuses, squid): This group includes a diverse group of marine species. Some species of octopus, and the chambered nautilus (*Nautilus pompilius*), are occasionally found in home aquaria.⁶³

Bivalves (clams, mussels, oysters): This group includes a diverse group of freshwater and marine species. One of the most common reef genera is the giant clam (*Tridacna* sp.).^{43,51,57}

^aThis is not a comprehensive list of taxa. The reader should be aware that taxonomy is a dynamic science and taxonomists frequently assign different taxonomic levels to the same groups depending on the anatomical, genetic, and other criteria being considered.

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Chapter 2 Fish

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TABLE 2-1 Antimicrobial and Antifungal Agents Used in Fish.^{a-f}

Agent	Dosage	Comments
Acriflavine	4 mg/L × 4h ¹¹⁸ 10 mg/L × 4h ¹¹¹	Rainbow trout/organic dye and antifungal agent Channel catfish/PK
Amikacin	5 mg/kg IM q12h ¹⁵² 5 mg/kg IM q72h × 3 treatments ¹⁵² 5 mg/kg ICe q24h × 3 days, then q48h × 2 treatments ⁷⁷	Koi/PK
Amoxicillin	— 12.5 mg/kg IM ¹⁶ 25 mg/kg PO q12h ¹⁴² 40 mg/kg IV q24h ³² 80 mg/kg PO q24h × 10 days ³² 40-80 mg/kg/day in feed × 10 days ¹⁰⁰ 110 mg/kg/day in feed ⁸	Infrequently indicated in ornamental fish because few pathogens are Gram-positive Atlantic salmon/PK Seabream/PK Seabream/PK Channel catfish/PK
Ampicillin	— 10 mg/kg q24h IM ^{16,149} 10 mg/kg q24h IV ¹¹⁰ 50-80 mg/kg/day in feed × 10 days ¹⁰⁰	Infrequently indicated in ornamental fish because few pathogens are Gram-positive Striped bass
Azithromycin (Zithromax, Zoetis)	30 mg/kg q24h × 14 days ³⁹ 40 mg/kg ICe ⁴⁰	Chinook salmon/PK Chinook salmon/PK
Aztreonam (Azactam, Bristol-Myers Squibb)	100 mg/kg IM, ICe q48h × 7 treatments ¹²⁰	Koi/ <i>Aeromonas salmonicida</i> ; used by hobbyists
Benzalkonium chloride	0.5 mg/L long-term ¹⁴⁹ 10 mg/L for 10 min ¹⁴⁹	Quaternary amine with broad disinfection properties
Bronopol (Pyceze, Novartis)	15-50 mg/L × 30-60 min bath ^{114,152}	For mycotic infections (eggs and fish); eggs may require the higher dose
Cefovecin (Convenia, Zoetis)	— 16 mg/kg SC ¹³³	Some intraspecies variability; rapidly eliminated in white bamboo sharks (not recommended) ¹³⁸ Adult copper rockfish/plasma levels of >1 µg/mL persisted for 7 days
Ceftazidime (Fortaz, Zoetis)	22 mg/kg IM, ICe q72-96h × 3-5 treatments ¹²⁰	Cephalosporin with good activity against Gram-negative bacteria (e.g., <i>Pseudomonas</i>)

Continued

TABLE 2-1 Antimicrobial and Antifungal Agents Used in Fish. (cont'd)

Agent	Dosage	Comments
Chloramine-T	2.5-20 mg/L as immersion treatment ^{29,149} for 60 min/day up to 3 days ³ 20 mg/L as immersion \times 4 hr ⁹⁵	Disinfectant; used to control bacterial gill disease and some ectoparasites; dosage and duration varies widely with species and water quality Rainbow trout, striped bass, yellow perch/PK
Chloramphenicol	— 40-182 mg/kg q24h ICe ⁸⁴ 50 mg/kg PO, IM once, then 25 mg/kg q24h ¹⁴³ 50 mg/kg PO q24h ²⁷	Florfenicol may be a better alternative than chloramphenicol (risk to humans) Carp/PK Rainbow trout/PK
Ciprofloxacin	15 mg/kg IM, IV ¹⁰²	Carp, African catfish, rainbow trout/PK
Difloxacin	10 mg/kg PO q24h ³⁷ 10 mg/kg PO q24h ¹⁴⁴ 20 mg/kg PO q24h \times 3 days ³⁴	Atlantic salmon/PK; plasma levels were higher in marine fish compared with freshwater fish Olive flounder/PK Goldfish/PK
Diquat dibromide (Reward, Syngenta)	2-18 mg/L for 1-4 hr \times 1-4 treatments q24-48h; 19-28 mg/L for 30-60 min \times 1-3 treatments q48h ¹	For control of columnaris disease in freshwater fish
Doxycycline	20 mg/kg PO q24h ¹⁵⁸ 20 mg/kg PO, IV ¹⁵⁸	Tilapia/PK; possible intrahepatic cycling; dosing intervals not established
Enrofloxacin (Baytril, Bayer)	— 2.5 mg/kg IV q24h ³¹ 5 mg/kg PO, IM, ICe q24h ¹⁴² 5-10 mg/kg PO q24h ¹⁴⁹ 5-10 mg/kg IM, ICe q48h ⁹² \times 7 treatments 10 mg/kg PO q24h \times 10 days ¹⁰⁸ 10 mg/kg PO q24h ^{31,126} 10 mg/kg PO, IV ⁸¹ 10 mg/kg ICe q96h \times 4 treatments ⁹⁰	For a review of quinolones used in fishes, see Samuelsen, 2006 ¹²⁶ Seabream/PK; no ciprofloxacin detected Red pacu/PK ⁸⁹ Pacu (<i>Piaractus mesopotamicus</i>)/ withdrawal period (non-USA) 23 days at 27°C; ciprofloxacin detected Atlantic salmon, seabream/PK; no ciprofloxacin detected Korean catfish/PK; ciprofloxacin detected Koi/PK (21°C, 70°F)

TABLE 2-1 Antimicrobial and Antifungal Agents Used in Fish. (cont'd)

Agent	Dosage	Comments
Enrofloxacin (Baytril, Bayer) (cont'd)	30 mg/kg PO q24h ¹⁵⁶ 10 mg/kg of feed q24h ^{88,100,139} 0.1% feed × 10-14 days ⁸⁸ 2.5-5 mg/L × 5 hr bath q24h × 5-7 days ³²	Grass carp (<i>Ctenopharyngodon idella</i>)/prevention of resistance mutation for <i>Aeromonas hydrophila</i> strain AH10 Atlantic salmon/PK Oral or injectable form can be used; equivalent to 10 mg/kg of feed Red pacu/PK; change 50%-75% of water between treatments
Erythromycin	— 10-25 mg/kg IM, ICe; ³⁸ 10-25 mg/kg IM, ICe 1-3 × q3wk ³⁸ 75 mg/kg PO q24h × 7 days ²⁸ 75 mg/kg PO q24h × 10 days ³⁵ 100 mg/kg PO, IM q24h × 7-21 days ^{142,149} 100-200 mg/kg PO q24h × 21 days ⁹⁷	Commonly sold as tank treatment for aquarium fish; not generally recommended because of toxicity to nitrifying bacteria ¹⁰⁰ For treatment of bacterial kidney disease; second dose is for control of vertical transmission of bacterial kidney disease Barramundi/successful treatment of <i>Streptococcus iniae</i> For control of <i>Streptococcus iniae</i> in seabream/PD Salmonids/to control <i>Renibacterium salmoninarum</i>
Florfenicol (Nuflog, Merck Animal Health; Aquaflor [Veterinary Feed Directive-medicated feed], Merck Animal Health)	5-20 mg/kg PO q24h ⁷² 10 mg/kg IM q24h ^{160,161} 10-15 mg/kg PO q24h ¹⁰ 10-20 mg/kg PO q24h ^{127,130} × 10 days 10, 25, or 50 mg/kg PO q24h ^{160,161} 10, 25, or 50 mg/kg PO q12h ^{160,161} 10 or 100 mg/kg IM q12h ^{160,161} 40 mg/kg IM ¹⁶² 40-50 mg/kg PO, IM, ICe q12-24h ^{91,142}	Atlantic salmon/PK Koi/PK (for MICs [minimum inhibitory concentration] of 1-6 µg/mL) Catfish/PK Cod/PK Koi/PK, for MIC of 1, 3, and 6 µg/mL, respectively Gourami/PK; for MICs of 1, 3, and 6 µg/mL, respectively Gourami/PK; for MICs of 1 µg/mL or 6 µg/mL White-spotted bamboo shark/PK Red pacu/PK ⁹¹
Flumequine (Apoquin aqualtes, Sigma-Aldrich)	— 10 mg/kg PO q48h ⁵⁴ 12-25 mg/kg PO, ICe, IV q24h ¹²⁸ 25 mg/kg ICe q24h ¹²⁹	Quinolone; Gram-negative bacteria; freshwater fish at pH 6.8-7.2; decreased uptake in hard water; increase dose for marine fish Cod, goldsinny wrasse/PK Atlantic halibut/PK Corkwing wrasse/PK

Continued

TABLE 2-1 Antimicrobial and Antifungal Agents Used in Fish. (cont'd)

Agent	Dosage	Comments
Flumequine (Apoquin aqualtes, Sigma-Aldrich) (cont'd)	25-50 mg/kg PO q24h ¹²² 30 mg/kg IM, ICe ¹⁰⁰ 50-100 mg/L × 3 hr bath ¹⁰⁰ 10 mg/kg q24h in feed × 10 days ¹⁰⁰	Atlantic salmon High antibiotic levels for several days when given IM
Formalin	All doses based on volumes of 100% formalin (=37% formaldehyde solution) 0.23 mL/L bath up to 60 min ¹⁰⁰ 1 mL/38 L as 12-24 hr bath followed by 30%-70% water change, may be repeated ⁴⁸ 1-2 mL/L bath, up to 15 min ¹⁰⁰ 25 mg/L (9.3 mg formaldehyde/L) bath for 144 hr ¹⁵⁵	Mycotic infections on eggs; do not treat within 24 hr of hatching; caution: carcinogenic; do not use if highly toxic white precipitates of paraformaldehyde are present; some fish are very sensitive; test on small number first, monitor fish for respiratory distress and pale color; increased toxicity in soft, acidic water and at high temperature; treat with vigorous aeration because of oxygen depletion; toxic to plants Degradation in saltwater recirculating aquaculture systems occurred rapidly by day 3 presumptively due to microbial digestion (biotic) or abiotic factors; for intended multiple day treatments, testing and variable additions may be required to achieve target dose above 15 mg/L ⁶³ For eggs only Striped bass
Furazolidone	— 1 mg/kg PO, IV q24h ¹¹² 30 mg/kg PO ¹⁵⁷ 67.5 mg/kg PO q12h × 10 days ⁸⁵ 25-35 mg/kg q24h in feed for 20 days ⁶³ 50-100 mg/kg q24h in feed × 10-15 days ¹⁰⁰ 1-10 mg/L tank water for ≥ 24 hr ¹⁰⁰	Nitrofurans; caution: carcinogenic; toxic to scaleless fish; absorbed from water; drug inactivated in bright light Channel catfish Nile tilapia Rainbow trout/PK; at 14°C (57°F), half-life ≈ 30 days and residue present at 40 days post 10-day treatment Some salmonids/not approved for fish intended for human consumption in the United States

TABLE 2-1 Antimicrobial and Antifungal Agents Used in Fish. (cont'd)

Agent	Dosage	Comments
Gentamicin	1 mg/kg IM, ICe q24h ¹³⁴ 2 mg/kg IM, then 1 mg/kg IM at 8 and 72 hr ¹⁴³ 2.5 mg/kg IM q72h ⁹⁸ 3.5 mg/kg IM q24h ⁷⁸	Channel catfish/PK Brown shark/PK Nephrotoxic; substantial risk in species for which dosages have not been determined ¹¹⁷ Goldfish, toadfish/PK
Hydrogen peroxide (HP) (3%)	0.1 mL/L × 1 hr ¹²³	For treatment of external bacteria in swordtails
Hydrogen peroxide (HP) (35% PEROX-AID, Eka Chemicals)	— 50 mg/L × 1 hr ¹⁰⁹ 50-75 mg/L × 1 hr ¹⁰⁹	Each mL of 35% PEROX-AID contains 350 mg HP For control of columnaris disease in channel catfish fry For control of columnaris disease in channel catfish fingerlings and adults
Iodine, potentiated (Betadine, Purdue Frederick)	Topical to wound, rinse immediately ¹⁰⁰ 20-100 mg/L for 10 min ¹⁴⁹	Do not use solutions combined with detergent (e.g., Betadine scrub) For disinfecting eggs (available iodine)
Itraconazole	1-5 mg/kg q24h in feed q1-7d ¹⁴²	Systemic mycoses
Kanamycin sulfate (Kantrex, Apothecan)	20 mg/kg ICe q3d × 5 treatments ¹⁰⁰ 50 mg/kg q24h in feed ¹⁰⁰ 40-640 mg/L × 2 hr bath ⁴⁶ 50-100 mg/L q72h × 3 treatments ¹⁰⁰	Toxic to some fish Channel catfish Change 50%-75% of water between treatments; absorbed from water
Ketoconazole	2.5-10 mg/kg PO, IM, ICe ¹⁴²	Systemic mycoses
Malachite green (zinc-free)	— 0.1 mg/L tank water q3d × 3 treatments ¹⁰⁰ 0.25 mg/L × 15 min q24h ¹⁵³ 0.5 mg/L × 1 hr bath ¹⁰⁰ 1 mg/L × 30-60 min bath ¹⁰⁰ 1 mg/L × 1 hr ¹⁴⁹ 2 mg/L × 15 min q24h ¹⁴⁹ 10 mg/L × 10-30 min bath ¹⁰⁰ 50-60 mg/L × 10-30 sec bath ¹⁰⁰ 100 mg/L topical to skin lesions ¹⁰⁰	Freshwater fish/mycotic infections; caution: mutagenic, teratogenic; toxic to some fish species and to fry; increased toxicity at higher temperatures and lower pH; stains objects, especially plastic; toxic to plants; not approved for use on fish intended for human consumption Remove residual chemical with activated carbon after final treatment Fungal control on fish eggs Freshwater fish eggs Use 2 mg/L if pH is high Fungal control on fish eggs Fungal control on fish eggs Freshwater fish eggs

Continued

TABLE 2-1 Antimicrobial and Antifungal Agents Used in Fish. (cont'd)

Agent	Dosage	Comments
Methylene blue	2 mg/L tank water q48h, up to 3 treatments ¹⁰⁰	Preventing infections of freshwater eggs; toxic to nitrifying bacteria and to plants; stains many objects
Miconazole (Monistat, McNeil-PPC)	10-20 mg/kg PO, IM, ICe ¹⁴²	Systemic mycoses
Nalidixic acid (NegGram, Sanofi-Aventis)	5 mg/kg PO, IM q24h ¹⁴² 5 mg/kg PO, IV q24h ⁷⁶ 20 mg/kg PO q24h ¹⁴⁹ 13 mg/L × 1-4 hr bath, repeat prn ¹⁰⁰	Quinolone; Gram-negative bacteria Rainbow trout/PK
Neomycin	66 mg/L tank water q3d, up to 3 treatments ¹⁰⁰	Commonly sold as tank treatment for aquarium fish; toxic to nitrifying bacteria; keep fish densities low
Nifurpirinol	— 0.45-0.9 mg/kg PO q24h × 5 days ¹⁰⁰ 4-10 mg/kg in feed q12h × 5 days ¹⁰⁰ 0.1 mg/L tank water q24h × 3-5 days ¹⁰⁰ 1-2 mg/L × 5 min-6 hr bath ¹⁰⁰	Nitrofurans; caution: carcinogenic; toxic to scaleless fish; absorbed from water; drug inactivated in bright light
Nitrofurazone	— 2-5 mg/L tank water q24h × 5-10 days ¹⁵² 50 mg/L × 3 hr ²³ 100 mg/L × 30 min bath ¹⁰⁰ 100 mg/L × 6 hr ²³	Nitrofurans; caution: carcinogenic; toxic to scaleless fish; absorbed from water; drug inactivated in bright light; water soluble formulations preferred; change 50%-75% of water between treatments Seabream/no residues were found in muscle following treatment Tilapia/no residues were found in muscle following treatment
Oxolinic acid	— 5-25 mg/kg PO q24h ¹⁴² 10 mg/kg q24h PO ¹⁴⁹ 25 mg/kg ICe q24h ¹²⁹ 25-50 mg/kg q24h PO ¹⁴⁹ 50 mg/kg q24h × 5 days PO ^{24,25}	Quinolone; Gram-negative bacteria Freshwater species/PK in many species Corkwing wrasse/PK Marine species Rainbow trout/PK

TABLE 2-1 Antimicrobial and Antifungal Agents Used in Fish. (cont'd)

Agent	Dosage	Comments
Oxolinic acid (cont'd)	10 mg/kg q24h in feed × 10 days ¹⁰⁰ 3-10 mg/L tank water × 24 hr ¹⁰⁰ 25 mg/L × 15 min bath q12h × 3 days ¹⁰⁰	Decreased uptake in hard water; better uptake in pH <6.9
Oxytetracycline	3 mg/kg IV q24h ³⁶ 7 mg/kg IM q24h ³⁶ 10 mg/kg IM q24h ¹⁴² 20 mg/kg ICe ¹⁴⁹ 20 mg/kg PO q8h ¹⁴² 25-50 mg/kg IM, ICe ¹⁰⁰ 60 mg/kg IM q7d ⁵⁰ 70 mg/kg PO q24h × 10-14 days ¹⁵¹ 82.8 mg/kg PO × 10 days ²¹ 100 mg/kg IM q24h ¹¹⁹ 10-100 mg/L tank water ¹⁰⁰ 7 mg/g feed q24h × 10 days ¹⁵¹ 55-83 mg/kg q24h in feed × 10 days ¹⁰⁰ 75 mg/kg PO q24h in feed × 10 days ¹⁴⁹ 10-50 mg/L × 1 hr bath ¹⁰⁰	Red pacu/PK Red pacu/PK Produces high levels for several days when given IM Some salmonids Carp/PK Walleye pike, tilapia, hybrid striped bass, summer flounder/PK Tench/PK Higher doses in hard water; if fish still sick, retreat on day 3 after 50% water change; light sensitive, so keep tank covered to prevent photo-inactivation; drug turns dark brown when decomposing; change 50% of water immediately; change 50%-75% of water between treatments Surface bacterial infections; yellow-brown foam may develop in treatment water
Potassium permanganate	2 mg/L as an indefinite bath ¹⁵²	Heavily organic systems may require a higher dose; test efficacy by adding the appropriate amount of KMnO ₄ to a small amount of system water (without fish); red color should remain for at least 4 hr (if not, then KMnO ₄ should be added until the 4-hr test is completed); however, in systems with lower organic loading (e.g., moderate to lower intensity recirculating aquaculture systems), and for sensitive species, treatment durations may need to be shortened to 1-2 hr

Continued

TABLE 2-1 Antimicrobial and Antifungal Agents Used in Fish. (cont'd)

Agent	Dosage	Comments
Potassium permanganate (cont'd)	5 mg/L × 30-60 min bath ¹⁰⁰ 1000 mg/L × 10-40 sec bath ¹⁰⁰	Freshwater fish/skin and gill bacterial infections; toxic in water with high pH; do not mix with formalin; can be toxic in goldfish ¹⁴⁰
Sarafloxacin (Sarafloxacin hydrochloride, Enzo Life Sciences)	10-14 mg/kg PO q24h × 10 days ¹⁴² 10 mg/kg PO q24h ¹⁴⁹ 10 mg/kg PO q24h × 5 days ⁴⁷	Fluoroquinolone Marine Atlantic salmon Channel catfish
Silver sulfadiazine cream (Silvadene, Pfizer)	Topical q12h ⁸⁸	External bacterial infection; keep lesion out of water 30-60 sec after application; keep gills submerged
Sulfadimethoxine/ormetoprim (Romet, Zoetis)	50 mg/kg/day in feed × 5 days ¹⁰⁰ Medicated brine shrimp ¹⁰⁰	Available as a powder to add to feed and as medicated feed Place brine shrimp nauplii (larvae) in 3 mg/L seawater for 4 hr, rinse in seawater with brine shrimp net, then feed immediately to fish; may also work with adult brine shrimp and other live feeds
Thiamphenicol	15 and 30 mg/kg PO ⁷³	Sea bass/PK; drug was not detected in plasma or tissues at either dose on day 7; recommended withdrawal times of 5 and 6 days, respectively
Tobramycin	2.5 mg/kg IM, then 1 mg/kg IM q4d ¹⁴³	Brown shark/PK
Trimethoprim/sulfamethoxazole	30 mg/kg PO q24h × 10-14 days ¹⁰⁰ 20 mg/L × 5-12 hr bath q24h × 5-7 days ¹⁰⁰ 0.2% feed × 10-14 days ¹⁰⁰	Change 50%-75% of water between treatments
Triple antibiotic ointment (polymyxin B sulfate/bacitracin/neomycin sulfate)	Topical q12h ⁸⁸	External bacterial infection; keep lesion out of water 30-60 sec following application; keep gills submerged

^aNot to be used in fish for human consumption.

^bPreferable to treat a single fish of a species (biotest) to determine toxicity.

^cTank treatment: When treating the fishes' resident aquarium, disconnect activated carbon filtration to prevent drug removal. Many drugs adversely affect the nitrifying bacteria, so water quality should be monitored closely (especially ammonia and nitrite concentrations). Always keep water well aerated and monitor fish closely. Perform water changes and reconnect filtration to remove residual drug following treatment. Discard carbon following drug removal.⁸⁹

^dBath (immersion) treatment: Remove fish from resident aquarium and place in container with known volume of water and concentration of therapeutic agent. Watch closely for signs of toxicity (e.g., listing and dyspnea). Always keep water well aerated.

^eSpecies of fish, temperature, and water quality parameters can influence the pharmacodynamics of many drugs, especially antimicrobials.

^fFor more information, refer to the Web site by Reimschuessel et al.¹¹⁸ This is a comprehensive and informative resource for many drugs and other compounds used with aquatic animals.

TABLE 2-2 Antiparasitic Agents Used in Fish.^{a-d}

Agent	Dosage	Comments
Acetic acid, glacial	1-2 mL/L × 30-45 sec bath ^{100,152}	Monogeneans, crustacean ectoparasites; safe for goldfish; may be toxic to smaller tropical fish
Albendazole	5 mg/kg PO once ⁹⁹ 10 mg/kg PO once ¹³⁵ 10-50 mg/L × 2-6 hr ¹³²	Atlantic salmon/PK Atlantic salmon, rainbow trout, tilapia/PK Sticklebacks/treating <i>Glugea anomala</i> infection
Chloramine-T	—	See Table 2-1
Chloroquine diphosphate	50 mg/kg PO once ⁹³ 10 mg/L tank water, once ¹⁰⁰	Red drum <i>Amyloodinium ocellatum</i> ; monitor for 21 days, repeat prn; use activated carbon to remove drug if no relapse
Closantel (50 mg/mL)/ mebendazole (75 mg/mL) (Supaverm, Janssen-Cilag)	1 mL/400 L once; may repeat in 3-7 days following a water change if necessary ¹⁵²	Koi/very safe and effective for external monogeneans; reported to be highly toxic to goldfish and medaka; used in the United Kingdom to kill digenean trematodes of sheep
Copper sulfate	— Total alkalinity (TA) (mg/L)/ 100 = mg/L (CuSO ₄ · 5H ₂ O) 0.012 and 0.094 mg/L bath for 28 days ⁵¹ 0.02 mg/L bath × 65 or 72 hr ^{52,53} 0.1-0.2 mg/L ¹⁴⁹ Maintain free ion levels at 0.15-0.2 mg/L tank water, until therapeutic effect ¹⁰⁰ Maintain copper levels at 0.2 mg/L tank water × 14-21 days ¹⁵¹	Marine fish/protozoan, monogenean ectoparasites; copper levels must be assessed with a commercial kit, and adjusted as needed; blue copper sulfate is copper sulfate (II) pentahydrate (= CuSO ₄ · 5H ₂ O); when calculating free copper 2 ⁺ ion levels, copper sulfate pentahydrate is approximately 25% free copper; in marine systems, concentration should be increased gradually to target concentration over the course of 3-4 days; toxic to gill tissue; immunosuppressive; extremely toxic to invertebrates and many plants; copper removed by activated carbon General dose recommendation for use in freshwater systems (FS), for 50 < total alkalinity (TA) < 250 mg/L; not recommended for use in freshwater systems with TA < 50 mg/L; chelation may be required for TA > 250 mg/L ¹⁰⁰ European eel Rainbow trout Use higher dose in hard water Citrate copper sulfate; prepare stock solution of 1 mg/mL (3 g CuSO ₄ · 5H ₂ O and 2 g citric acid monohydrate in 750 mL distilled water)

Continued

TABLE 2-2 Antiparasitic Agents Used in Fish. (cont'd)

Agent	Dosage	Comments
Copper sulfate (cont'd)	Maintain free ion levels at 0.25-1 mg/L \times 24-48 hr bath ⁵⁷ 100 mg/L \times 1-5 min bath ²⁰	Prepare stock solution of 1 mg/mL (1 g CuSO ₄ · 5H ₂ O in 250 mL distilled water)
Diflubenzuron (Dimilin 25W, Chemtura)	0.01 mg/L tank water \times 48 hr q6d \times 3 treatments ¹⁴⁰	Crustacean ectoparasites; inhibits chitin synthesis; drug persists in water long-term; marketed for control of terrestrial insects; may need EPA restricted use pesticide license for use in the United States
Dimethyl phosphonate	—	See trichlorfon
Dimetridazole	28 mg/kg in feed q24h \times 10 days ¹¹⁶ 80 mg/L \times 3 days (minimum)	Rainbow trout/ <i>Ichthyophthirius multifiliis</i> ; available through compounding veterinary pharmacies Experimental evidence suggests some control of <i>Cryptobia iubilans</i> and/or associated mortalities ¹³⁹
Doramectin	200 μ g/kg PO once 750 μ g/kg PO ⁶⁴ 1 mg/kg PO q24h \times 10 days ⁶⁵	Carp (<i>Labeo fimbriatus</i> and <i>Catla catla</i>)/ <i>Lernaea</i> Carp (rohu, <i>Labeo rohita</i>)/ <i>Argulus</i> Carp (fringed-lipped peninsula carp, [<i>Labeo fimbriatus</i>] and major/Indian carp [<i>Catla catla</i>])/ <i>Lernaea</i>
Emamectin (SLICE, Merck Animal Health)	5 μ g/kg PO q24h \times 7 days ⁵⁶ 50 μ g/kg PO q24h \times 7 days ¹³¹ 50 μ g/kg PO q24h \times 7 days ⁵⁶	Koi/ <i>Argulus</i> Atlantic salmon/PK; an avermectin compound used to control sea lice (<i>Lepeophtheirus salmonis</i> , <i>Caligus elongatus</i> , <i>C. teres</i> , and <i>C. rogercressy</i>) Goldfish/ <i>Argulus</i>
Fenbendazole	1 mg/kg IV ³⁰ 5 mg/kg PO \times 1 dose ⁸² 6 mg/kg q24h PO ⁷⁵ 50 mg/kg PO q24h \times 2 days, repeat in 14 days ¹⁵¹ 0.2% in feed \times 3 days, repeat in 14-21 days ⁸⁸ 40 mg/kg in feed q4d \times 2 treatments ¹⁴⁹ 1.5 mg/L \times 12-hr bath ⁷⁵ 2 mg/L tank water q7d \times 3 treatments ¹⁰⁰ 2.5 mg/g feed \times 2-3 days, repeat in 14 days ¹⁵¹ Bioencapsulation of brine shrimp ⁷	Channel catfish Channel catfish Rainbow trout Carp/ <i>Bothriocephalus acheilognathi</i> Rainbow trout Nonencysted gastrointestinal nematodes Place 1 tablespoon of strained adult brine shrimp and 4 g fenbendazole per 500 mL volume for 30 min to achieve 15.3 μ g fenbendazole per shrimp

TABLE 2-2 Antiparasitic Agents Used in Fish. (cont'd)

Agent	Dosage	Comments
Formalin	— All doses based on volumes of 100% formalin (=37% formaldehyde) 0.015-0.025 mL/L tank water ¹⁰⁰ 0.125-0.25 mL/L, up to 60 min bath, repeat q24h × 2-3 days pm ¹⁰⁰ 0.4 mL/L up to 1 hr bath q3d, up to 3 treatments ¹⁴⁰ 0.5 mL/L up to 1 hr bath q3d, up to 3 treatments ¹⁴⁰	Formalin combination follows Protozoan, monogenean, crustacean ectoparasites; caution: carcinogenic; do not use if highly toxic white precipitates are present; some fish are very sensitive: test on small number first, monitor for piping and pale color; increased toxicity in soft, acidic water and at high temperature; treat with vigorous aeration because of oxygen depletion; toxic to plants For <i>Ichthyophthirius</i> , use 0.025 mL/L tank water q48h × 3 treatments; change up to 50% of water on alternate days When using maximum dose, treat q3d Soft water Hard water
Formalin (F)/malachite green (M)	(F) 0.025 mL/L + (M) 0.1 mg/L tank water q48h × 3 treatments ¹⁰⁰	Combination synergistic for <i>Ichthyophthirius</i> ; change up to 50% water on alternate days; several premixed commercial products available; malachite green should never be used on fish intended for human consumption
Freshwater	3-15 min bath, repeat q7d pm ¹⁰⁰ 4-5 min bath ⁸⁷	Marine fish/ectoparasites; aerate well; match pH with seawater pH; monitor closely; some small fish are sensitive
Hydrogen peroxide (HP) (3%; 30 mg/mL)	— 0.22 mL/L × 1 bath ¹²³ 1-1.5 mL/L × 20 min bath ¹⁴⁷ 5 mg/L × 24 hr or 10 mg/L × 1 hr ¹²³ 5.4 mg/L × 24 hr or 20.2 mg/L × 1 hr ¹²³ 5.6 mg/L × 24 hr or 7 mg/L × 1 hr ¹²³ 17.5 mL/L × 4-10 min bath, once ⁵⁷	Not recommended for use in blue gourami or suckermouth catfish (<i>Pterygoplichthys</i> spp.) ¹²⁴ Swordtails/ <i>Ichthyobodo</i> Atlantic salmon/sea lice Tiger barb Swordtail Serpae tetra Ectoparasites; monitor closely; may be harmful to smaller fish
Hydrogen peroxide (HP) (PEROX-AID 35%, Eka Chemicals)	— 170-560 mg/L (static bath) × 30 min ¹¹⁵ 75 mg/L × 30 min ⁹⁸ 300 mg/L × 10 min ⁹⁴	These are unlabeled experimental treatments Rainbow trout/ <i>Ambiphrya</i> and <i>Gyrodactylus</i> ¹¹⁵ Pacific threadfin (<i>Polydactylus sexfilis</i>) juveniles/ <i>Amyloodinium</i> Kingfish/monogenean <i>Zeuxapta seriola</i>

Continued

TABLE 2-2 Antiparasitic Agents Used in Fish. (cont'd)

Agent	Dosage	Comments
Ivermectin	—	Do not use; neurologic signs and death at therapeutic doses; ^{57,149} toxic to many environmental invertebrates ¹⁴⁹
Levamisole	0.5 mg/kg ICe ⁷⁹ 10 mg/kg PO q7d × 3 treatments ⁵⁷ 11 mg/kg IM q7d × 2 treatments ⁵⁷ 1 mg/L × 24 hr bath ¹⁴⁵ 1-2 mg/L × 24 hr bath ⁵⁷ 50 mg/L × 2 hr bath ⁵⁷ 4 g/kg feed q7d × 3 treatments ⁵⁷	Rainbow trout/immunostimulant Eels/swimbladder nematodes Internal nematodes, especially larval External monogeneans
Lufenuron (Program, Novartis)	0.13 mg/L prn ^{120,152}	Control of crustacean ectoparasites
Malachite green	— 0.1 mg/L tank water q3d × 3 treatments ¹⁰⁰ 1 mg/L × 30-60 min bath ¹⁰⁰ 50-60 mg/L × 10-30 sec bath ¹⁰⁰ 100 mg/L topical to skin lesions ¹⁰⁰	See formalin for combination Use 2 mg/L if pH high Freshwater fish/protozoan ectoparasites; prepare stock solution of 3.7 mg/mL (1.4 g malachite green in 380 mL water); caution: mutagenic, teratogenic; toxic to some fish species (e.g., tetras) and fry; increased toxicity at higher temperatures and lower pH; toxic to plants; stains objects, especially plastic; remove residual chemical with activated carbon after last tank treatment; not to be used on fish intended for human consumption
Mebendazole	20 mg/kg PO q7d × 3 treatments ¹⁴² 1 mg/L × 24 hr bath ^{57,74} 1 mg/L × 72 hr bath ¹⁷ 10-50 mg/L for 2-6 hr immersion ¹³² 100 mg/L × 10 min-2 hr bath ⁵⁷	Gastrointestinal nematodes; do not administer to brood fish: embryotoxic and teratogenic Monogeneans European eels/branchial monogeneans (<i>Pseudodactylogyrus bini</i> and <i>P. anguillae</i>) Sticklebacks/ <i>Glugea anomala</i> Monogeneans
Methylene blue	1-3 mg/L tank water ¹⁰⁰	Freshwater fish/ectoparasites; not recommended because of poor efficacy; toxic to nitrifying bacteria; stains objects; toxic to plants

TABLE 2-2 Antiparasitic Agents Used in Fish. (cont'd)

Agent	Dosage	Comments
Metronidazole	25 mg/kg q24h in feed × 5-10 days ¹⁰⁰	Equivalent to 0.25% in feed (250 mg/100 g food) at 1% BW/day
	50 mg/kg PO q24h × 5 days ⁵⁷	
	100 mg/kg q24h in feed × 3 days ¹⁰⁰	Equivalent to 1% in feed (1 g/100 g food) at 1% BW/day
	6.6 mg/L tank water q24h × 3 days ¹⁰⁰	<i>Spironucleus (Hexamita)</i> and other internal flagellates; some external flagellates; poorly soluble in water; dissolve before adding to water or feed; change water between tank treatments
	25 mg/L tank water q48h × 3 treatments ¹⁰⁰	
	6.25-18 mg/g feed × 5 days ¹⁵¹	
	Brine shrimp encapsulation of metronidazole ⁵	One Tbs of live strained adult brine shrimp is approximately 16 g wet weight (≈262 shrimp/g); 5 g metronidazole plus 1 Tbs brine shrimp in 500 mL water for 0.25 hr will yield 9.32 µg metronidazole per shrimp (2500 µg per g of shrimp)
Niclosamide	0.055 mg/L × 24 hr bath ⁷¹	Rainbow trout/lampricide
Piperazine	10 mg/kg q24h in feed × 3 days ¹⁰⁰	Nonencysted gastrointestinal nematodes; equivalent to 0.1% in feed at 1% BW/day
Potassium permanganate	5 mg/L × 30-60 min bath ¹⁰⁰	Freshwater fish/protozoan, crustacean ectoparasites; toxic in water with high pH; do not mix with formalin; can be toxic in goldfish ¹⁴⁰
	100 mg/L × 5-10 min bath ¹⁰⁰	
	1 g/L × 10-40 sec bath ¹⁰⁰	
Praziquantel	5 mg/kg PO q24h × 3 treatments ¹⁴⁹	Cestodes, some internal digenean trematodes; could be administered in feed Adult cestodes; gavage or give 0.5% in feed at 1% BW/day Metacercaria Monitor closely for lethargy, incoordination, loss of equilibrium Monogenean ectoparasites, cestodes; aerate water well; some marine fish sensitive; may be toxic to <i>Corydoras</i> catfish Place 1 Tbs of strained adult brine shrimp and 2.5 g praziquantel per 500 mL volume for 30 min to achieve 8.6 µg praziquantel per shrimp
	5 mg/kg PO in feed q7d, up to 3 treatments ¹⁴²	
	5 mg/kg PO, ICe, repeat in 14-21 days ⁶⁷	
	50 mg/kg PO once ¹⁰⁰	
	2 mg/L × 2-4 hr ¹¹³	
	2-10 mg/L up to 4 hr bath ¹⁵¹	
	5-10 mg/L × 3-6 hr bath, repeat in 7 days ⁶⁷	
5-12 mg/kg feed × 3 days ¹⁵¹		
	Bioencapsulation of praziquantel in brine shrimp ⁵	

Continued

TABLE 2-2 Antiparasitic Agents Used in Fish. (cont'd)

Agent	Dosage	Comments
Pyrantel pamoate	10 mg/kg in feed, once ¹⁴²	Gastric nematodes
Salt (as sodium chloride, seawater, or artificial sea salts)	— 1-5 g/L tank water, indefinitely ¹⁰⁰ 3 g/L ¹⁴⁹ 10-30 g/L up to 30 min bath ¹⁰⁰ 30 g/L for 10 min ¹⁴⁹ 30-35 g/L × 4-5 min bath ⁸⁷	Freshwater fish/protozoan, monogenean ectoparasites; seawater or artificial sea salts preferred; seawater is normally 30-35 g/L; use non-iodized table/rock salts; some anticaking agents in solar salts are highly toxic; species sensitivity is highly variable (some catfish sensitive); may be toxic to plants Prophylaxis or treatment of ectoparasites Supportive care With salt-sensitive or weak fish, use lower dosage and repeat in 24 hr Fish >100 g only Safe for goldfish and koi in most cases
Thiabendazole	10-25 mg/kg in feed, repeat in 10 days ¹⁴² 66 mg/kg PO, once ¹⁴²	Gastric nematodes; anorexia may be seen (more severe at higher doses), generally resolves within 2-4 days
Trichlorfon (dimethyl phosphonate)	— 0.25 mg/L tank water; ¹⁰⁰ 96 hr bath at this concentration in channel catfish ¹¹⁸ 0.5 mg/L tank water q10d × 3 treatments ⁸⁷ 0.5-1 mg/L tank water ¹⁰⁰	Caution: organophosphate, neurotoxic, avoid inhalation and skin contact; aerate water well; especially toxic to larval fish, some characins (i.e., pacu, piranha, and silver dollars); other species sensitivities; liquid form marketed for cattle is convenient to dispense Freshwater fish/use 0.5 mg/L tank water if >27°C (80°F); treat q3d × 2 treatments for <i>Dactylogyrus</i> and other oviparous monogeneans; treat q7d × 4 treatments for anchor worms (<i>Lernaea</i>) and fish louse (<i>Argulus</i>); single treatment will usually suffice for other copepods, other monogeneans, leeches Crustacean ectoparasites; change 20%-30% of water 24-48 hr following each treatment Marine fish/treat q3d × 2 treatments for oviparous monogeneans; use 1 mg/L q48h × 3 treatments for turbellarians; single treatment will usually suffice for copepods (except sea lice), other monogeneans, leeches

^aNot to be used in fish for human consumption.

^bPreferable to treat single fish of a species to determine toxicity.

^cTank treatment: when treating the fishes' resident aquarium, disconnect activated carbon filtration to prevent drug removal; many drugs adversely affect the nitrifying bacteria, so water quality should be monitored closely (especially ammonia and nitrite concentrations); always keep water well aerated and monitor fish closely; perform water changes and reconnect filtration to remove residual drug following treatment; discard carbon following drug removal.⁸⁹

^dBath (immersion) treatment: remove fish from resident aquarium and place in container with known volume of water and concentration of therapeutic agent; watch closely for signs of toxicity, e.g., listing and dyspnea; always keep water well aerated.

TABLE 2-3 Chemical Restraint/Anesthetic/Analgesic Agents Used in Fish.^{a-d}

Agent	Dosage	Comments
Alfaxalone (Alfaxan, Jurox)	5 mg/L induction ¹⁸ 10 mg/L induction; 1-2.5 mg/L maintenance ⁹⁶	Oscar (cichlid)/sedation and anesthesia Koi/sedation and anesthesia; not recommended as an injectable agent for koi carp; ¹³ may have opercular cessation at 2.5 mg/L
Atipamezole (Antisedan, Zoetis)	0.2 mg/kg IM ⁴³	Reversal agent (α_2 antagonist) for medetomidine
Benzocaine	— 15-40 mg/L bath ¹⁰⁰ 50-500 mg/L bath ¹⁰⁰ 70 mg/L for 5 min then 35 mg/L for 30 min ¹¹⁸ 1 g/L spray ¹⁰⁰	Not sold as fish anesthetic in United States; available from chemical supply companies; do not use topical anesthetic products marketed for mammals; prepare stock solution in ethanol (benzocaine is poorly soluble in water); store in dark bottle at room temperature Transport sedation Anesthesia Channel catfish Large fish/anesthesia; spray onto gills with an aerosol pump sprayer
Butorphanol	0.05-0.1 mg/kg IM ¹⁴² 0.4 mg/kg IM ^{59,60} 10 mg/kg IM ¹⁴	Postoperative analgesia Koi/postoperative analgesia Koi/postoperative analgesia; respiratory depression at this dose; lower dosage might be warranted
Carbon dioxide	—	Euthanasia; bubble gas through water until respiration stops >10 min; other agents preferred ¹⁰⁰
Clove oil (also see Eugenol)	— 40-120 mg/L bath ⁸⁷	Clove oil consists of a mixture of eugenol, methyleugenol, isoeugenol, and other compounds and in this generic form is not approved by the FDA for use in fish intended for human consumption Stock solution: 100 mg/mL of clove oil by diluting 1 part clove oil with 9 parts 95% ethanol (eugenol is poorly soluble in water); over-the-counter preparation (pure) available at most pharmacies contains approximately 1 g eugenol per mL of clove oil; recovery may be prolonged; use lower end of this range to start; many bony fishes readily anesthetized with 25-50 mg/L
Dexmedetomidine ^d	—	See medetomidine for comments
Ethanol	1%-1.5% bath ⁵⁸ >3% bath ⁵⁸	Anesthetic levels difficult to control, resulting in overdose; not recommended Euthanasia; other agents preferred
Etomidate	1-4 mg/L ¹⁴⁹	Lower doses should be used with striped bass and related species ¹⁴⁹

Continued

TABLE 2-3 Chemical Restraint/Anesthetic/Analgesic Agents Used in Fish. (cont'd)

Agent	Dosage	Comments
Eugenol (a purified derivative of clove oil; also see clove oil)	10-100 mg/L bath for sedation to handleable ² 17-25 mg/L bath ¹⁴⁹	Aqui-SE contains 50% eugenol and Aqui-S20E, 10% eugenol, a compound mixture of eugenol and polysorbate 80 (for solubility); lower doses (6 mg/L) will produce sedation without general anesthesia ^{2,149}
Isoflurane	0.5-2 mL/L bath or vaporize then bubble in water ⁵⁸	Anesthetic levels difficult to control, resulting in overdose; not recommended
Ketamine	— 66-88 mg/kg IM ¹⁴²	Ketamine combination follows Immobilization for short procedures; complete recovery can take >1 hr
Ketamine (K)/medetomidine (M) ^d	(K) 1-2 mg/kg + (M) 0.05-0.1 mg/kg IM ⁵⁸	Immobilization; reverse (M) with atipamezole (0.2 mg/kg IM); see medetomidine
Ketoprofen (Ketofen, Zoetis)	2 mg/kg IM ⁶⁰	As a postoperative analgesic in koi
Lidocaine	—	Local anesthetic; use cautiously in small fish; do not exceed 1-2 mg/kg total dose ⁵⁹
Medetomidine ^d	0.03-0.07 mg/kg IV ⁴	See ketamine for combination; medetomidine is off-market, but is available through selected compounding services
Metomidate (Aquacalm, Syndel USA)	— 0.06-0.2 mg/L water ¹⁴¹ 0.1-1 mg/L ⁹ 1 mg/L ⁸⁰ 0.5-1 mg/L water ⁵⁸ 1-10 mg/L bath induction; 0.1-1 mg/L maintenance ¹⁴¹ 2.5-5 mg/L water ⁵⁸ 2.5-5 mg/L bath induction; 0.2-0.3 mg/L maintenance ¹⁴¹ 3 mg/kg IV ⁵⁵ 5-10 mg/L bath ⁵⁸ 7 mg/kg PO ⁵⁵ 9 mg/L bath for 5 min ⁵⁵	Gouramis may be sensitive; contraindicated in cichlids in water of pH <5 Transport sedation Convict cichlids/for 24 hr transport sedation Light sedation Freshwater fish/anesthesia Heavy sedation Marine fish/anesthesia Atlantic halibut, turbot/PK Anesthesia; some species require 10-30 mg/L bath Turbot/PK Atlantic halibut, turbot/PK
Morphine	5 mg/kg IM ¹⁴	Koi/analgesia
MS-222 (Tricaine-S, Syndel USA)	—	See tricaine methanesulfonate
Pentobarbital	60 mg/kg ICe ¹⁰⁰	Euthanasia
2-Phenoxyethanol	0.1-0.5 mL/L bath ¹⁴⁹ 0.6 mL/L bath ¹⁴⁹	Carp/surgery

TABLE 2-3 Chemical Restraint/Anesthetic/Analgesic Agents Used in Fish. (cont'd)

Agent	Dosage	Comments
Propofol	3.5-7.5 mg/kg IV ⁴³ 7 mg/L bath ⁴⁵	Gulf of Mexico sturgeon Goldfish/anesthesia; induction time, 7.4 min; recovery, 8.5 min
Quinaldine sulfate	25 mg/L bath ¹⁴⁹ 50-100 mg/L bath induction; 15-60 mg/L maintenance ⁵⁸	Channel catfish, salmonids/do not use with largemouth bass; not recommended for long surgical procedures Anesthesia; not sold as fish anesthetic in United States; stock solution: 10 g/L, buffer the acidity by adding sodium bicarbonate to saturation; store stock in dark container; shelf-life of stock extended by refrigeration or freezing; aerate water to prevent hypoxemia; drug not metabolized, excreted unchanged; euthanasia: keep in solution >10 min after respiration stops
Sodium bicarbonate	30 g/L bath ¹⁰⁰	Euthanasia; generates CO ₂ ; use when other agents unavailable; keep fish in solution >10 min after respiration stops; generally not recommended; not an AVMA-approved method of euthanasia
Sodium bicarbonate tablets (Alka-Seltzer, Bayer)	2-4 tablets/L bath ⁴⁸	Euthanasia; generates CO ₂ ; use when other agents unavailable; keep fish in solution >10 min after respiration stops; generally not recommended; not an AVMA-approved method of euthanasia
Tricaine methanesulfonate (MS-222; Tricaine-S, Syndel USA)	15-50 mg/L water ⁵⁸ 50-100 mg/L bath induction; 50-60 mg/L maintenance ¹⁴¹ 100-200 mg/L bath induction; 50-100 mg/L maintenance ⁵⁸ 1 g/L spray ¹⁰⁰	Sedation Anesthesia; stock solution: 10 g/L, buffer the acidity by adding sodium bicarbonate at 10 g/L or to saturation (unbuffered solution may cause some ectoparasites to leave fish) ²⁰ store stock in dark container; shelf-life of stock extended by refrigeration or freezing; stock that develops an oily film should be discarded; aerate water to prevent hypoxemia; narrower margin of safety in young fish, and soft, warm water; euthanasia: keep fish in solution >20 min after respiration stops Large fish/anesthesia; spray onto gills with an aerosol pump sprayer

^aNot to be used in fish for human consumption.

^bPreferable to treat single fish of a species to determine toxicity.

^cAerate water during anesthetic procedures; dissolved oxygen concentrations should be maintained between 6 and 10 mg/L (ppm).

^dMedetomidine is no longer commercially available although it can be obtained from select compounding services; a dosage is listed here as a guide for possible use with dexmedetomidine, an α_2 agonist that is the active optical enantiomer of racemic compound medetomidine; in other species, dexmedetomidine is used at {1/2} the dose of medetomidine but the same volume due to a higher concentration. However, the effects of the w/v use of the two drugs may not be equivalent, so the dose of dexmedetomidine may need to be adjusted based on clinical response.

TABLE 2-4 Miscellaneous Agents Used in Fish.^{a-c}

Agent	Dosage	Comments
Atropine	0.1 mg/kg IM, IV, ICe ¹⁴⁰	Organophosphate, chlorinated hydrocarbon toxicity
Becaplermin (Regranex, Smith & Nephew)	Topically as a thin layer for 3 min ⁴²	Ocean surgeonfish/light debridement of the head and lateral line erosion (HLE) lesions is recommended prior to treatment; multiple treatments are not warranted, but fish should be returned to a habitat without predisposing factors to HLE
Carbon, activated	75 g/40 L tank water ¹⁰⁰	Removal of medications and other organics from water; usually added to filter system; discard after 2 wk; 75 g ≈ 250 cc dry volume
Carp pituitary extract	0.75 mg/kg IM ¹⁴⁹ 1-1.5 mg/kg IM ¹⁴⁹ 1.5 mg/kg IM ¹⁴⁹ 2.5-3 mg/kg IM ¹⁴⁹ 5 mg/kg IM, repeat in 6 hr ¹⁴²	Female fish (<2 kg) Male fish Female fish (2-5 kg) Female fish (>5 kg) Dose when combined with human chorionic gonadotropin (20 U/kg); hormone to stimulate release of eggs (may be given in 2 doses, 24 hr apart; the first "preparatory" dose ≤10% of the total dose); does not cause eggs to mature; do not administer unless eggs are mature
Chlorine/chloramine neutralizer	Use as directed	See sodium thiosulfate
Dexamethasone	1-2 mg/kg IM, ICe ¹⁴² 2 mg/kg IV, ICe q12h ⁸⁷	Adjunct to treatment of shock, trauma, chronic stress syndromes Chlorine toxicity; may improve prognosis
Doxapram	5 mg/kg IV, ICe ¹⁴⁰	Respiratory depression
Epinephrine (1:1000)	0.2-0.5 mL IM, IV, ICe, intracardiac ¹⁴⁰	Cardiac arrest
Furosemide	2-5 mg/kg IM q12-72 h ¹⁴²	Diuretic; ascites, generalized edema; of questionable value since fish lack a loop of Henle
Glucans (MacroGard, Orffa)	2-10 mg/kg ICe ^{121,149} 1 g/kg in feed × 24 days fed at 3% BW ¹²⁴ 2 g/kg in feed × 7 days ¹³⁶	Polysaccharides; immunostimulant Red-tailed black sharks/significant decrease in mortalities from <i>Streptococcus iniae</i> Rainbow trout/tested with positive results
sGnRHa (salmon gonadotropin-releasing hormone analogue) + domperidone (Ovaprim, Syndel USA)	0.5 mL/kg (0.5 μL/g) IM, ICe ^{66,106}	For use as a spawning aid in fish; enhances/triggers ovulation and spermiation; for ovulation of eggs
Haloperidol	0.5 mg/kg IM ¹⁴²	Dopamine blocking agent; use with luteinizing releasing hormone analog (LRH-A) to stimulate release of eggs

TABLE 2-4 Miscellaneous Agents Used in Fish. (cont'd)

Agent	Dosage	Comments
Human chorionic gonadotropin (hCG) (Chorulon, Merck Animal Health)	20 U/kg IM, repeat in 6 hr ¹⁴² 30 U/kg (22.7-232 U/kg for males; 30.5-828 U/kg for females) IM, repeat in 6 hr ¹⁴² × 1-3 injections ²² 800-1000 U/kg IM q8h ¹⁵⁴	Dose when combined with carp pituitary extract (5 mg/kg) Indicated for use as an aid in improving spawning function in male and female broodfish; hormone to stimulate release of eggs (ovulation) and sperm (spermiation); does not cause eggs to mature: do not administer unless eggs are mature Carp
Hydrocortisone	1-4 mg/kg IM, ICE ¹⁴²	Adjunct to treatment of shock, trauma, chronic stress syndromes
Hydrogen peroxide (3%)	0.25 mL/L water ¹⁰⁰	Acute environmental hypoxia; see oxygen
Luteinizing releasing hormone analog (LRH-A)	2 µg/kg IM, then 8 µg/kg 6 hr later ¹⁴²	Synthetic luteinizing releasing hormone analog; stimulates release of eggs; does not cause eggs to mature: do not administer unless eggs are mature; in species that do not respond to LRH-A alone, administer with haloperidol or reserpine with the first injection of LRH-A
Methyltestosterone	30 mg/kg PO q24h × 2 or 4 days ¹¹⁸	Rainbow trout/PD; functional masculinization of genetic females
Nitrifying bacteria	Use as directed for commercial products Add material (e.g., floss, gravel) from a tank with an active biological filter and healthy fish to new tank ¹⁰⁰	Seed or improve development of biological filtration to detoxify ammonia and nitrite; numerous commercial preparations; do not expose products to extreme temperatures; use before expiration date Must evaluate risk of disease transmission with this technique
Nucleotide (Aquagen, Novartis)	2 g/kg feed at 3% BW × 24 days ¹²⁴	Red-tailed black sharks/reduced mortalities from <i>Streptococcus iniae</i> ; product may be difficult to find as commercial production has been discontinued.
Oxygen (100%)	Fill plastic bag with O ₂ containing 1/3 vol of water ⁸⁷	Acute environmental hypoxia common with transportation; close bag tightly with rubber band; keep fish in bag until normal swimming and respiratory behavior
Reserpine	50 mg/kg IM ¹⁴²	Dopamine blocking agent; use with LRH-A to stimulate release of eggs
Salt (sodium chloride)	1-3 g/L tank water ⁸⁶ 3-5 g/L tank water ¹⁰⁰ Add chloride to produce at least a 6:1 ratio (w/w) of Cl: NO ₂ ions ¹⁰⁰	Freshwater fish/prevention of stress-induced mortality; seawater or artificial sea salts preferred; use non-iodized table/rock salts; some anticaking agents in solar salts are highly toxic; highly variable species sensitivity to salt (some catfish sensitive); may be toxic to plants Treatment of nitrite toxicity; table/rock salt = 60% Cl, artificial sea salts = 55% Cl

Continued

TABLE 2-4 Miscellaneous Agents Used in Fish. (cont'd)

Agent	Dosage	Comments
Sodium thiosulfate	Use as directed for chlorine/ chloramine neutralizers 10 mg/L tank water ⁸⁷ 100 mg/L tank water ¹⁴⁰ 10 g neutralizes chlorine (up to 2 mg/L) from 1000 L water ⁸⁷	Active ingredient in numerous chlorine/ chloramine neutralizers; chlorine and chloramine are common additions to municipal water supplies and are toxic to fish; ammonia released by detoxification of chloramine is removed by functioning biological filter (see nitrifying bacteria) or chemical means (see zeolite) Chlorine exposure
Zeolite (i.e., clinoptilolite)	Use as directed 20 g/L tank water ¹⁰⁰	Ion-exchange resin that exchanges ammonia for sodium ions; clinoptilolite is an active form of zeolite; used to reduce or prevent ammonia toxicity; more effective for removal of some compounds (e.g., sulfonamides, enrofloxacin) than activated carbon ^{15,67,104}

^aNot to be used in fish for human consumption.

^bPreferable to treat single fish of a species to determine toxicity.

^cBath treatment: remove fish from resident aquarium and place in container with known volume of water and concentration of therapeutic agent; watch closely for signs of toxicity, e.g., listing and dyspnea; always keep water well aerated.

TABLE 2-5 Euthanasia Agents Used in Fish.^a

Agent	Dosage	Comments
Benzocaine	≥250 mg/L immersion for at least 10 min ¹²	Solution should be buffered; once the fish loses consciousness, a secondary method (double pithing, decapitation, injectable pentobarbital) should be used
Carbon dioxide	Immersion to effect ¹²	Fish may become hyperactive before losing consciousness; use in a well ventilated area
Ethanol	10-30 mL 95%/L as an immersion to effect ¹²	
Eugenol (a purified derivative of clove oil; also see clove oil)	≥17 mg/L as an immersion to effect ¹²	Concentrations up to 5 times this amount can be used; once the fish loses consciousness, a secondary method (double pithing, decapitation, injectable pentobarbital) should be used
Isoflurane/sevoflurane	5-20 mL/L as an immersion to effect ¹²	Due to the volatility of these compounds and risk to humans, ventilation precautions should be taken
Ketamine	66-88 mg/kg IM ¹²	Follow with a lethal pentobarbital injection
Ketamine (K)/ dexmedetomidine (D)	(K) 1-2 mg/kg + (D) 0.05-0.1 mg/kg IM ¹²	Follow with a lethal pentobarbital injection

TABLE 2-5 Euthanasia Agents Used in Fish. (cont'd)

Agent	Dosage	Comments
2-phenoxyethanol	≥ 0.5 -0.6 mL/L or 0.3-0.4 mg/L as an immersion to effect ¹²	
Propofol	1.5-2.5 mg/L IM ¹² 5-10 mg/L as an immersion to effect ¹⁰³	Follow with a lethal pentobarbital injection Once the fish loses consciousness, a secondary method (double pithing, decapitation, injectable intracardiac pentobarbital) should be used
Quinaldine sulfate	≥ 100 mg/L as an immersion to effect ¹²	Buffering may be required in some cases
Tricaine methanesulfonate (MS-222) (Tricaine-S, Syndel USA)	250-500 mg/L as an immersion for at least 10 min after cessation of respiration ¹²	Buffering is required and a secondary method (double pithing, decapitation, injectable intracardiac pentobarbital) should be used

^aNot to be used in fish for human consumption; CO₂ euthanasia is the exception.

TABLE 2-6 Hematologic and Serum Biochemical Values of Fish.^a

Measurement	Goldfish (<i>Carassius auratus</i>) ⁴⁹	Koi (<i>Cyprinus carpio</i>) ^{49,107,150}
Hematology		
PCV (%)	31 ± 7.3	35 (24-43)
RBC (10 ⁶ /μL)	1.5 ± 0.1	1.61-1.91
Hgb (g/dL)	9.1 ± 0.4	6.32-7.55
MCV (fL)	—	166.3-190
MCH (pg)	—	37.7-42.7
MCHC (g/dL)	—	20.4-22.9
WBC (10 ³ /μL)	—	19.8-28.1
Heterophils (%)	29 ± 3	7.96-13.89
Lymphocytes (%)	70 ± 5	74.5-83.7
Monocytes (%)	1 ± 0.1	2.3-3.4
Basophils (%)	—	3.5-5.6
Chemistries		
ALP (U/L)	—	12 (4-56)
ALT (U/L)	106 (97-115)	31 (9-98)
Anion gap	—	17 (14-23)
AST (U/L)	220 (111-433)	121 (40-381)
Bicarbonate (mmol/L)	—	6 (3-8)
Bile acids (μmol/L)	—	1 (0-6)
BUN (mg/dL)	28	2 (0.2-5)
Calcium (mg/dL)	9.1 (4.3-13.5)	8.7 (7.8-11.4)
Chloride (mEq/L)	—	114 (108-119)
Cholesterol (mg/dL)	—	149 (94-282)

Continued

TABLE 2-6 Hematologic and Serum Biochemical Values of Fish. (cont'd)

Measurement	Goldfish (<i>Carassius auratus</i>)	Koi (<i>Cyprinus carpio</i>)			
Chemistries (cont'd)					
Creatine kinase (U/L)	4515 (0-10,000)	4123 (80-9014)			
Creatinine (mg/dL)	—	—			
Glucose (mg/dL)	35.7 (15-93)	37 (22-65)			
GGT (U/L)	—	1 (0-6)			
LDH (U/L)	—	359 (41-1675)			
Phosphorus (mg/dL)	8.83 (3.1-16.3)	6.1 (3.5-7.7)			
Potassium (mEq/L)	2.16 (0.1-5.6)	1.4 (0-2.9)			
Protein, total (g/dL)	2.03 (0.1-4.02)	3.4 (2.7-4.3)			
Albumin (g/dL)	1.9 (0.3-3.2)	2 (1.4-2.7)			
Globulin (g/dL)	0.69 (0.3-1.2)	0.9 (0.6-1.1)			
A:G (ratio)	2.75	1.1 (0.8-1.6)			
Sodium (mEq/L)	139 (126-176)	133 (110-143)			
Total bilirubin (mg/dL)	—	0.5 (0.2-2)			
Uric acid (mg/dL)	0.08 (0-0.2)	0.1 (0-0.5)			
<table border="0" style="width: 100%; text-align: center;"> <tr> <td></td> <td>Striped bass (<i>Morone saxatilis</i>)^{62,101}</td> <td>Palmetto bass (<i>Morone saxatilis</i> × <i>M. chrysops</i>)^{69,70,101}</td> </tr> </table>				Striped bass (<i>Morone saxatilis</i>)^{62,101}	Palmetto bass (<i>Morone saxatilis</i> × <i>M. chrysops</i>)^{69,70,101}
	Striped bass (<i>Morone saxatilis</i>)^{62,101}	Palmetto bass (<i>Morone saxatilis</i> × <i>M. chrysops</i>)^{69,70,101}			
Hematology					
PCV (%)	42 (34-28)	20-34			
RBC (10 ⁶ /μL)	—	2.42-4.96			
Hgb (g/dL)	—	4.2-8.4			
MCV (fL)	—	65-117			
MCH (pg)	—	16.2-24.8			
MCHC (g/dL)	—	19-26			
WBC (10 ³ /μL)	—	32.6-118.2			
Neutrophils (10 ³ /μL)	—	0-6.8			
Lymphocytes (small and large) (10 ³ /μL)	—	23.7-125.1			
Monocytes (10 ³ /μL)	—	0-3.2			
Eosinophils (%)	—	0-2.7			
Chemistries					
ALP (U/L)	—	72			
Anion gap	29 ± 5	24 ± 1			
AST (U/L)	23 ± 6	45 ± 21			
Calcium (mg/dL)	10.6 ± 0.1	11.1 ± 0.2			
Chloride (mEq/L)	143 ± 2	144 ± 2			
Cholesterol (mg/dL)	—	164			
Creatinine (mg/dL)	0.5 ± 0	0.3 ± 0			
Glucose (mg/dL)	100 ± 28	118 ± 10			
LDH (U/L)	221 ± 92	164 ± 54			

TABLE 2-6 Hematologic and Serum Biochemical Values of Fish. (cont'd)

Measurement	Striped bass (<i>Morone saxatilis</i>)	Palmetto bass (<i>Morone saxatilis</i> × <i>M. chrysops</i>)
Chemistries (cont'd)		
Osmolality (mOsm/kg)	348 ± 2	356 ± 2
Phosphorus (mg/dL)	10 ± 0.3	9.8 ± 0.2
Potassium (mEq/L)	3.9 ± 0.1	3.3 ± 0.2
Protein, total (g/dL)	3.8 ± 0.1	3.0
Albumin (g/dL)	1.1 ± 0	1.3
Globulin (g/dL)	—	1.7
A:G (ratio)	0.4 ± 0	0.76
Sodium (mEq/L)	181 ± 4	151
Chloride (mEq/L)	150	
Total CO ₂ (mmol/L)	9.5 ± 1	10.7 ± 0.9
Hematology		
PCV (%)	26 (22-32)	34.8-56.9
RBC (10 ⁶ /μL)	1.7 (1.2-2.9)	1.4-1.8
Hgb (g/dL)	—	6.4-9.5
MCH (pg)	—	35.3-62.4
MCHC (g/dL)	—	14.2-18.9
WBC (10 ³ /μL)	33.5 (13.6-52.3)	9.9 ± 1.3
Heterophils (%)	5.2 (0.3-36.7)	—
Lymphocytes (%)	84 (53-96)	—
Monocytes (%)	4 (0.8-11.2)	—
Eosinophils (%)	0.3 (0.3-0.7)	—
Chemistries		
Anion gap	6.9 (1.2-12.5)	—
AST (U/L)	49 (0-125)	102
BUN (mg/dL)	—	—
Calcium (mg/dL)	10.8 (9.5-12.5)	2.3
Chloride (mEq/L)	139 (146-159)	137
Creatine kinase (U/L)	—	—
Creatinine (mg/dL)	0.3 (0.2-0.4)	0.4
Glucose (mg/dL)	—	103
Lactate (mmol/L)	—	—
LDH (U/L)	238 (65-692)	—
Osmolality (mOsm/kg)	—	—
Phosphorus (mg/dL)	7.3 (4.1-8.9)	
Potassium (mEq/L)	3.9 (2.7-5)	

Continued

TABLE 2-6 Hematologic and Serum Biochemical Values of Fish. (cont'd)

Measurement	Red pacu (<i>Piaractus brachypomum</i>)	Rainbow trout (<i>Oncorhynchus mykiss</i>)
Chemistries (cont'd)		
Protein, total (g/dL)	—	—
Albumin (g/dL)	0.9 (0.5-1)	—
Sodium (mEq/L)	150 (146-159)	—
Total CO ₂ (mmol/L)	7.5 (6-10)	—
Uric acid (mg/dL)	—	—
	^a Mbuna cichlid (<i>Metriaclima greshakei</i>) ^{137a}	^a <i>Cichlasoma dimerus</i> (a South American cichlid) ^{150a}
Hematology		
>PCV (%)	25.3 (21-29.5)	31.3 (22.5-39.1)
RBC (10 ⁶ /μL)	2.3 (1.7-2.7)	3.1 (1.7-4.3)
Hgb (g/L)	75 (63-91.3)	68.2 (52.3-83.3)
MCV (fL)	113.8 (95.3-132.4)	110.3 (70.1-198)
MCH (pg)	33.6 (26.9-40.3)	24.5 (14.5-40.6)
MCHC (g/dL)	3.0 (2.7-3.2)	22.3 (17.4-30.3)
WBC (10 ³ /μL)	33.2 (22.9-55.2)	12.2 (6.6-18.6)
Granulocytes (10 ³ /μL)	1.48 (0.3-2.4)	3.4 (1.9-5.2) (heterophils)
Lymphocytes (10 ³ /μL)	30.9 (21.2-52.4)	4.7 (2.5-7.1)
Monocytes (10 ³ /μL)	—	2.2 (1.2-3.3)
Eosinophils (%)	—	1.9 (1-2.8)
Chemistries		
ALP (U/L)	44.5 (30.1-61.9)	—
ALT (U/L)	59.8 (34.7-236.1)	—
AST (U/L)	12.5 (3.5-46.3)	—
Calcium (mmol/L)	2.6 (2.5-2.7)	—
Chloride (mEq/L)	147 (143-150)	—
Cholesterol (mmol/L)	10.6 (6.8-13.9)	—
Creatinine (μmol/dL)	512 (265-941)	—
Glucose (mmol/L)	2.4 (2.1-2.7)	—
Phosphorus (mmol/L)	1.5 (1.3-1.6)	—
Potassium (mmol/L)	3.1 (2.4-3.6)	—
Protein, total (g/L)	39 (34.6-46.2)	—
Albumin (g/L)	9.5 (8.1-10.5)	—
Globulin (g/L)	29 (25.8-37)	—
A:G (ratio)	0.33	—
Sodium (mmol/L)	161 (156.3-163.4)	—
Chloride (mmol/L)	147 (143-150)	—

TABLE 2-6 Hematologic and Serum Biochemical Values of Fish. (cont'd)

Measurement	^a Tilapia (<i>Oreochromis hybrid</i>) ⁶⁸	^a Channel catfish (<i>Ictalurus punctatus</i>) ¹⁴⁶
Hematology		
PCV (%)	33 (27-37)	31 (27-54)
RBC ($10^6/\mu\text{L}$)	6.1 (4.8-7.8)	3 (15-41)
Hgb (g/dL)	8.2 (7.0-9.8)	7 (4.4-10.9)
MCV (fL)	135.7 (115-183)	108 (88.6-186.7)
MCH (pg)	34.9 (28.3-42.3)	—
MCHC (g/dL)	25.7 (22-29)	22 (15.7-28.7)
WBC ($10^3/\mu\text{L}$)	7.6	—
Heterophils (%)	1.8 (0.56-9.9) (neutrophils)	—
Lymphocytes (small) (%)	61 (6.8-136)	—
Lymphocytes (large) %	10.7 (2.9-31)	—
Monocytes (%)	1.5 (0.4-4.3)	—
Eosinophils (%)	0.3 (0.03-1.6)	—
Thrombocytes ($10^3/\mu\text{L}$)	52.8 (25-85)	—
Thrombocyte-like cells ($10^3/\mu\text{L}$)	1 (0.03-4.3)	—
Chemistries		
ALP (U/L)	26 (16-38)	—
ALT (U/L)	—	—
AST (U/L)	18 (5-124)	—
Calcium (mmol/L)	2.9 (2.6-4.7)	2.7 (2.3-3.3)
Chloride (mEq/L)	141 (136-147)	108 (80-147)
Cholesterol (mg/dL)	156 (64-299)	—
Creatinine (mg/dL)	0.2-1.1	—
Glucose (mg/dL)	52 (39-96)	35.1 (17-86.5)
Magnesium (mEq/L)	2.5 (2.3-2.8)	1.2 (1.0-2.0)
Phosphorus (mg/dL)	4.6 (3.5-7.2)	—
Potassium (mEq/L)	3.9 (3.2-4.3)	3 (2.1-4.8)
Protein, total (g/dL)	2.9 (2.3-3.6)	4.2 (2.6-6.6)
Albumin (g/dL)	1.2 (1.0-1.6)	—
Globulin (g/dL)	1.6 (1.3-2.1)	—
A:G (ratio)	0.75	—
Sodium (mEq/L)	150 (140-156)	141 (132-155)
Total bilirubin (mg/dL)	0 (0-0.1)	—
Measurement		
Rainbow trout (<i>Oncorhynchus mykiss</i>)^{33,68a,137}		
Hematology		
PCV (%)	34.8-56.9	
RBC ($10^6/\mu\text{L}$)	1.4-1.8	
Hgb (g/dL)	6.4-9.5	
MCV (fL)	192-393	
MCH (pg)	35.3-62.4	

Continued

TABLE 2-6 Hematologic and Serum Biochemical Values of Fish. (cont'd)

Measurement	Rainbow trout (<i>Oncorhynchus mykiss</i>)																																																													
Hematology (cont'd)																																																														
MCHC (g/dL)	14.2-18.9																																																													
WBC ($10^3/\mu\text{L}$)	9.9 ± 1.3																																																													
Chemistries																																																														
ALP (U/L)	31																																																													
AST (U/L)	102																																																													
Calcium (mmol/L)	2.3																																																													
Chloride (mEq/L)	137																																																													
Cholesterol (mg/dL)	144																																																													
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Protein, total (g/dL)	2.7																																																													
Albumin (g/dL)	1.2																																																													
Globulin (g/dL)	1.5																																																													
A:G (ratio)	0.8																																																													
Sodium (mEq/L)	152																																																													
Total bilirubin (mg/dL)	0.1																																																													
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Measurement</th> <th>^aBonnethead shark (<i>Sphyrna tiburo</i>)⁶¹</th> <th>^aSandbar shark (<i>Carcharhinus plumbeus</i>)¹¹</th> </tr> </thead> <tbody> <tr> <td colspan="3">Hematology</td> </tr> <tr> <td>PCV (%)</td> <td>24 (17-28)</td> <td>17.5-23</td> </tr> <tr> <td>Hgb (g/dL)</td> <td>—</td> <td>7.6-10.1</td> </tr> <tr> <td>WBC ($10^3/\mu\text{L}$)</td> <td>—</td> <td>—</td> </tr> <tr> <td> Heterophils (%)</td> <td>—</td> <td>40-58 (total granulocytes)</td> </tr> <tr> <td> Lymphocytes (%)</td> <td>—</td> <td>40-55</td> </tr> <tr> <td> Monocytes (%)</td> <td>—</td> <td>2-6</td> </tr> <tr> <td colspan="3">Chemistries</td> </tr> <tr> <td>Anion gap</td> <td>-5.8 (-15.7-7.5)</td> <td>—</td> </tr> <tr> <td>AST (U/L)</td> <td>42 (15-132)</td> <td>—</td> </tr> <tr> <td>Bicarbonate (mmol/L)</td> <td>3 (0-5)</td> <td>—</td> </tr> <tr> <td>BUN (mg/dL)</td> <td>2812 (2644-2992)</td> <td>—</td> </tr> <tr> <td>Calcium (mg/dL)</td> <td>16.8 (15.8-18.2)</td> <td>—</td> </tr> <tr> <td>Chloride (mEq/L)</td> <td>290 (277-304)</td> <td>—</td> </tr> <tr> <td>Cholesterol (mg/dL)</td> <td>—</td> <td>—</td> </tr> <tr> <td>Creatine kinase (U/L)</td> <td>82 (18-725)</td> <td>—</td> </tr> <tr> <td>Creatinine (mg/dL)</td> <td>—</td> <td>—</td> </tr> <tr> <td>Glucose (mg/dL)</td> <td>184 (155-218)</td> <td>—</td> </tr> <tr> <td>Lactate (mmol/L)</td> <td>—</td> <td>—</td> </tr> </tbody> </table>			Measurement	^a Bonnethead shark (<i>Sphyrna tiburo</i>) ⁶¹	^a Sandbar shark (<i>Carcharhinus plumbeus</i>) ¹¹	Hematology			PCV (%)	24 (17-28)	17.5-23	Hgb (g/dL)	—	7.6-10.1	WBC ($10^3/\mu\text{L}$)	—	—	Heterophils (%)	—	40-58 (total granulocytes)	Lymphocytes (%)	—	40-55	Monocytes (%)	—	2-6	Chemistries			Anion gap	-5.8 (-15.7-7.5)	—	AST (U/L)	42 (15-132)	—	Bicarbonate (mmol/L)	3 (0-5)	—	BUN (mg/dL)	2812 (2644-2992)	—	Calcium (mg/dL)	16.8 (15.8-18.2)	—	Chloride (mEq/L)	290 (277-304)	—	Cholesterol (mg/dL)	—	—	Creatine kinase (U/L)	82 (18-725)	—	Creatinine (mg/dL)	—	—	Glucose (mg/dL)	184 (155-218)	—	Lactate (mmol/L)	—	—
Measurement	^a Bonnethead shark (<i>Sphyrna tiburo</i>) ⁶¹	^a Sandbar shark (<i>Carcharhinus plumbeus</i>) ¹¹																																																												
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TABLE 2-6 Hematologic and Serum Biochemical Values of Fish. (cont'd)

Measurement	Bonnethead shark (<i>Sphyrna tiburo</i>)	Sandbar shark (<i>Carcharhinus plumbeus</i>)
Chemistries (cont'd)		
LDH (U/L)	<5 (<5-11)	—
Osmolality (mOsm/kg)	1094 (1056-1139)	—
Phosphorus (mg/dL)	8.8 (5.9-12.7)	—
Potassium (mEq/L)	7.3 (5.7-9.2)	—
Protein, total (g/dL)	2.9 (2.2-4.3)	—
Albumin (g/dL)	0.4 (0.3-0.5)	—
Globulin (g/dL)	2.6 (1.9-3.8)	—
A:G (ratio)	0.1 (0.1-0.2)	—
Sodium (mEq/L)	282 (273-292)	—
Measurement	Sand tiger shark (<i>Carcharias taurus</i>) ¹⁰⁵	Cownose ray (<i>Rhinoptera bonasus</i>) ⁴¹
Hematology		
PCV (%)	31 (24-38)	—
RBC (10 ⁶ /μL)	—	5.11 (2.6-7.15)
WBC (10 ³ /μL)	—	0.55 (0.16-1.98)
Fine segmented eosinophilic granulocytes (%)	—	4 (0-13)
Fine nonsegmented eosinophilic granulocytes (%)	—	2 (0-10)
Lymphocytes (%)	—	86 (72-95)
Monocytes (%)	—	1 (0-3)
Coarse segmented eosinophilic granulocytes (%)	—	4 (0-14)
Coarse nonsegmented granulocytes (%)	—	3 (0-15)
Chemistries		
ALP (U/L)	8-31	33 (22-46)
ALT (U/L)	3	—
AST (U/L)	13-45	39 (15-78)
Bilirubin, total (μmol/L)	1.5	—
BUN (mg/dL)	—	1,154 (1010-1270)
Calcium (mmol/L)	3.3-4.4	4.2 (3.75-4.85)
Chloride (mEq/L)	227-257	255 (192-290)
Cholesterol (mg/dL)	0.9-2.1	166 (118-321)
Creatine kinase (U/L)	5-79	—
Creatinine (μmol/L)	32	8.84
Glucose (mmol/L)	2.2-3.2	2.78 (1.94-4.0)
Magnesium (mmol/L)	1.6-2.2	—
Phosphorus (mmol/L)	1.7-2	5.8 (4.4-7.1)

Continued

TABLE 2-6 Hematologic and Serum Biochemical Values of Fish. (cont'd)

Measurement	Sand tiger shark (<i>Carcharias taurus</i>)	Cownose ray (<i>Rhinoptera bonasus</i>)
Chemistries (cont'd)		
Potassium (mmol/L)	4.3-5.7	1.5 (1-2.4)
Protein, total (g/L)	24-36	2.9 (1.9-4.2)
Albumin (g/dL)	—	0.6 (0.5-0.8)
Globulin (g/dL)	—	2.2 (1.4-3.6)
A:G (ratio)	—	0.29 (0.17-0.38)
Sodium (mEq/L)	249-267	276 (208-312)
Total bilirubin (mg/dL)	—	0.17 (0.1-0.3)
Triglyceride (mmol/L)	0.5-0.6	9.16 (3.16-22.8)

Measurement	Southern stingray (<i>Dasyatis americana</i>) ¹⁹
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Hematology	
PCV (%)	22 (15-25)
RBC ($10^6/\mu\text{L}$)	—
WBC ($10^3/\mu\text{L}$)	22.1-42.2
Heterophils (%)	—
Lymphocytes (%)	—
Monocytes (%)	—
Eosinophils (%)	—

Chemistries	
Anion gap	—
AST (U/L)	14.5 (3.6-61.2)
BUN (mg/dL)	1243 (1185-1293)
Calcium (mg/dL)	16.5 (12.06-19.3)
Chloride (mEq/L)	342 (301-362)
Creatine kinase (U/L)	80.5 (11.7-296.5)
Creatinine (mg/dL)	0.3 (0.2-0.4)
Glucose (mg/dL)	30.5 (16.9-42.4)
Lactate (mmol/L)	3.1 (<2-6.2)
LDH (U/L)	—
Osmolality (mOsm/kg)	1065 (1007-1144)
Phosphorus (mg/dL)	4.7 (3-6.4)
Potassium (mEq/L)	5 (3.2-6.4)
Protein, total (g/dL)	—
Albumin (g/dL)	—
Sodium (mEq/L)	315 (301-362)
Total CO ₂ (mmol/L)	—
Uric acid (mg/dL)	—

^aValues listed are means except where indicated with an ^a, which are medians. In some cases the data are not based on a large sample size. These values are only meant to be guidelines. Age of fish, time of year, and water temperature may all affect "normal" clinical pathological data.

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Chapter 3 Amphibians

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TABLE 3-1 Antimicrobial Agents Used in Amphibians.^{a,b}

Agent	Dosage	Species/Comments
Amikacin	5 mg/kg IM q36h ⁵⁹ 5-10 mg/kg SC, IM, ICe q24-48 h ⁵⁸	Bullfrogs/PK Most species; may be used in combination with piperacillin
Carbenicillin	100 mg/kg SC, IM q72h ⁵⁹ 200 mg/kg SC, IM, ICe q24h ⁵⁹	
Ceftazidime	20 mg/kg SC, IM q48-72h ⁵⁹	
Chloramphenicol	50 mg/kg SC, IM, ICe q12-24h ⁵⁹ 20 mg/L bath ^a changed daily ⁵⁹	Caution: even minuscule exposure carries risk of aplastic anemia in susceptible individuals; wear disposable gloves when handling; aplastic anemia-like findings in <i>Bufo regularis</i> exposed to 125 mg/kg PO q24h × 12 wk ¹⁴
Ciprofloxacin	10 mg/kg PO, ⁵⁹ ICe ⁵⁸ q24h 500-750 mg/75 L as 6-8 hr bath ^a q24h ⁵⁹	May be used for large numbers of animals
Doxycycline (Psittivet, Vetafarm)	50 mg/kg IM q7d ⁵⁹	Broad-spectrum antibiotic, part of 4-quadrant therapy; may have antiinflammatory effect; chlamydiosis
Doxycycline (Vibramycin, Zoetis)	5-10 mg/kg PO q24h ⁵⁹ 10-50 mg/kg PO q24h ⁵⁹	Chlamydiosis African clawed frogs/chlamydiosis
Doxycycline 1% topical gel, compounded	Apply topically q8-12h not to exceed 10 mg/kg per day ⁵⁹	Useful for localized lesions; may have antiinflammatory effect
Enrofloxacin	5-10 mg/kg PO, SC, IM q24h ⁵⁹ 10 mg/kg SC, IM ¹⁵ 10 mg/kg topically ⁵² 500 mg/L × 6-8 hr bath ^a q24h ⁵⁹	Most species/PK (bullfrogs); ⁵⁹ ICe and topical routes also used but with limited PK data ⁵⁹ African clawed frogs/PK; high kidney concentrations of enrofloxacin and ciprofloxacin; ¹⁵ no significant difference between routes ²³ Coqui frogs/detectable tissue concentration for >24 hr, no correlation to plasma concentration
Enrofloxacin and silver sulfadiazine solution (Baytril Otic, Bayer)	Apply topically to lesions q12h ⁵⁹	May have some antifungal effect, but does not appear effective against chytrid
Gentamicin	2-4 mg/kg IM q72h × 4 treatments ⁵⁹ 2.5 mg/kg IM q72h ⁵⁰ 3 mg/kg IM q24h at 22.2°C (72°F) ⁵⁹	Coldwater salamanders (i.e., <i>Necturus</i>)/PD; more frequent dosing may be needed if temperature >4°C (39.2°F) Leopard frogs/PD; at higher temperatures, serum concentrations will be lower

TABLE 3-1 Antimicrobial Agents Used in Amphibians. (cont'd)

Agent	Dosage	Species/Comments
Gentamicin (cont'd)	Topical to eyes ⁵⁹ Intracameral injection once; not to exceed 4 mg/kg ⁵⁹	All species/ocular infections; dilute to 2 mg/mL Panophthalmitis
Metronidazole	10 mg/kg PO q24h × 5-10 days ⁴² 10 mg/kg IV q24h × 2 days ⁵⁹ 12 mg/kg topically q24h × 5-10 days ⁵⁹ 20 mg/kg PO q48h × 20 days ⁵⁹ 50 mg/kg PO q24h × 3 days ⁵⁹ 60 mg/kg topically q24h × 3 days ⁵⁹ 50 mg/L × 24 hr bath ^{a,59}	For chronic diarrhea Anaerobic infections For chronic diarrhea Anaerobic infections Anaerobic infections Anaerobic infections Anaerobic infections
Ofloxacin 0.3% ophthalmic solution	1 drop q2-4h × 10 days ⁵⁸	Keratitis; may also be applied topically to wounds
Oxytetracycline	25 mg/kg SC, IM q24h ⁵⁹ 50 mg/kg PO q12-24h ⁵⁹ 50-100 mg/kg IM q48h ⁵⁹ 100 mg/L × 1 hr bath ^{a,59} 1 g/kg feed × 7 days ⁵⁹	Most species Most species Bullfrogs/PK; especially useful in cases of chlamydiosis (use up to 30 days) ⁵⁹ Most species Most useful with axolots and <i>Xenopus</i> fed compounded pelleted diet ⁵⁹
Piperacillin	100 mg/kg SC, IM q24h ⁵⁹	Anaerobes; may be used in combination with amikacin
Silver sulfadiazine (Silvadine Cream 1%, Marion)	Topical q24h ⁵⁹	Antibiotic cream
Sulfadiazine	132 mg/kg PO q24h ⁵⁹	
Sulfamethazine	1 g/L bath ^a to effect ⁵⁹	Change daily
Tetracycline	50 mg/kg PO q12h ⁵⁹ 150 mg/kg PO q24h × 5-7 days ⁵⁹ 167 mg/kg (5 mg/30 g) PO q12h × 7 days ⁵⁹	
Trimethoprim/sulfa	3 mg/kg PO, SC, IM q24h ⁵⁹	Unspecified sulfa
Trimethoprim/sulfadiazine	15-20 mg/kg IM q48h ⁵⁹	Chronic diarrhea ⁵⁹
Trimethoprim/sulfamethoxazole	15 mg/kg PO q24h ⁵⁹	Chronic diarrhea

^aWater baths containing antibiotics or topical applications may not provide as consistent distribution as parenteral administration.^bSC can be administered in the dorsal lymph sac of anurans.⁵⁹

TABLE 3-2 Antifungal Agents Used in Amphibians.

Agent	Dosage	Species/Comments
Amphotericin B	1 mg/kg ICe q24h ⁵⁹	Internal mycoses; acutely toxic to <i>Alytes muletensis</i> tadpoles at 8 µg/mL bath ³³
Benzalkonium chloride	0.25 mg/L × 72 hr bath ⁵⁹ 2 mg/L × 1 hr bath q24h ⁵⁹	Saprolegniasis
Chloramphenicol	20 mg/kg topically (applied as Chlorsig 1% ointment [Sigma] which also contains paraffin and wool fat) ⁵ 10-30 mg/L (10-30 ppm) as continuous bath replaced fresh daily for up to 30 days ⁵⁹ 20 mg/L by continuous shallow immersion × 14 days, changed daily ⁶¹	Chytridiomycosis; safe for larvae, recent metamorphs, and adults; confirm negative result by real-time PCR; ^{5,59} caution: even miniscule exposure carries risk of aplastic anemia in susceptible individuals; wear disposable gloves when handling; aplastic anemia-like findings in <i>Bufo regularis</i> exposed to 125 mg/kg PO q24h × 12 wk ¹⁴ Australian green frog (<i>Litoria caerulea</i>); severely ill frogs treated with combination of chloramphenicol, SC fluids q8-12h × 6 days, and temperature increased to 28°C × 14 days ⁶¹
Florfenicol	10 µg/mL topical spray q24h × 14 days ³⁹ 30 ppm as continuous bath replaced fresh daily for up to 30 days ⁵⁹	Experimentally infected <i>Alytes muletensis</i> adults/reduced zoosporangia numbers but did not eliminate infection; GI and renal toxicity to tadpoles at 100 µg/mL ³⁹ Chytridiomycosis; safe for larvae, recent metamorphs, and adults; confirm negative result by real-time PCR ⁵⁹
Fluconazole	60 mg/kg PO q24h ⁵⁹	
Itraconazole	10 mg/kg PO q24h ⁵⁹ 0.01% in 0.6% salt solution × 5 min bath q24h × 11 days ⁵⁹ 0.01% in buffered solution × 5 min bath q24h × 11-14 days ¹⁸ 0.5-1.5 mg/L × 5 min bath q24h × 7 days ¹⁷ 50 mg/L × 5 min bath q24h × 10 days ²⁵	Topical route best choice to treat chytridiomycosis; caution with tadpoles ^{17,59} Multiple species/cleared chytridiomycosis by PCR 14 days post-treatment; 6-15 mo post-treatment follow-up yielded positive PCR in some individuals <i>Alytes muletensis</i> tadpoles/safe at varying concentrations and duration of 7-28 days; confirmed negative PCR post-treatment; varying levels of depigmentation observed in all individuals ¹⁷ Multiple species/cleared chytridiomycosis in subclinical animals; confirmed with PCR

TABLE 3-2 Antifungal Agents Used in Amphibians. (cont'd)

Agent	Dosage	Species/Comments
Itraconazole (cont'd)	0.0025% × 5 min bath q24h × 6 days ⁸	Australian green tree frog (<i>Litoria caerulea</i>), coastal plains toad (<i>Incillus nebulifer</i>)/cleared PCR positive juveniles with no clinically apparent side effects
Ketoconazole	10-20 mg/kg PO q24h ⁵⁹ Topical cream ⁵⁹	
Methylene blue	2-4 mg/L bath to effect ⁵⁹ 4 mg/L × 1 hr bath q24h ⁵⁹	Tadpoles/may reduce mortality in newly hatched tadpoles Saprolegniasis
Miconazole	5 mg/kg ICe q24h × 14-28 days ⁵⁹ Topical cream or solution ⁵⁹	Systemic mycoses Topical route best choice for chytridiomycosis; solutions containing alcohol may cause irritation; do not use with larvae ⁵⁹
Neomycin, polymixin B, bacitracin (Neosporin, Pfizer)	Apply topically to wound q24h ²⁰	Microsporidian infections; not recommended for bacterial infections, appears to inhibit re-epithelialization ⁵⁹
Nystatin 1% cream	Topical ⁵⁹	Cutaneous mycoses
Potassium permanganate	1:5000 water × 5 min bath q24h ⁵⁹	Cutaneous mycoses
Sodium chlorite (NaOCl ₂)	20 mg/L × 6-8 hr bath ⁵⁹	Cutaneous mycoses
Temperature elevation	30°C (86°F) × 10 days ¹¹ 37°C (98.6°F) for 16 hr ⁵⁶	<i>Rana catesbeiana</i> , <i>Acris crepitans</i> /confirm negative result by real-time PCR ¹¹ Chytridiomycosis, caution with temperature elevation in sensitive species
Terbinafine hydrochloride (Lamisil AT, Novartis)	0.005%-0.01% in distilled water × 5 min bath q24h × 5 days, or q48h × 6 treatments ⁷	Various species/no adverse clinical effects noted with treatment; pH 7.0; confirm negative result by real-time PCR ⁷
Voriconazole	1.25 µg/mL q24h topically via spray × 7 days ³³	Poison dart frogs, Iberian midwife toad (<i>Alytes cisternasii</i>)/cleared chytridiomycosis in naturally infected individuals in vivo; performed poorly with in vitro assays ³³
Voriconazole (V) + polymixin E (P) + elevated temperature (T)	(V) 12.5 µg/mL q24h topically via spray + (P) 2000 IU/mL × 10 min bath q12h + (T) 20°C (68°F) continuous × 10 days ⁶	Fire salamanders/treatment of <i>Batrachochytrium salamandrivorans</i> ; no effect of medications at 15°C (59°F) ⁶

TABLE 3-3 Antiparasitic Agents Used in Amphibians.^a

Agent	Dosage	Species/Comments
Acriflavin	0.025% bath × 5 days ⁵⁹ 500 mg/L × 30 min bath ⁵⁹	Protozoa Protozoa
Benzalkonium chloride	2 mg/L × 1 hr bath q24h to effect ⁵⁹	Protozoa
Distilled water	3 hr bath ⁵⁹	Protozoa
Febantel (in combination with pyrantel pamoate and praziquantel; Drontal Plus, Bayer)	0.01 mL/1 g (10 mL/kg) PO q2-3wk ⁴⁰	Nematodes, cestodes, possibly trematodes
Febendazole	— 30-50 mg/kg PO ⁵⁹ 50 mg/kg PO q24h × 3-5 days, repeat in 14-21 days ⁵⁹ 50-100 mg/kg PO ⁴² repeat in 2-3 wk prn 100 mg/kg PO, ⁵⁹ repeat in 14 days	Febendazole combinations follow Gastrointestinal nematodes Gastrointestinal nematodes Most species/gastrointestinal nematodes Gastrointestinal nematodes
Febendazole (F)/ivermectin (I)	(F) 100 mg/kg PO on day 1, then (I) 0.2 mg/kg PO on days 2,11 ⁵⁹	Gastrointestinal nematodes
Febendazole (F)/metronidazole (M)	(F) 100 mg/kg PO, repeat in 10-14 days + (M) 10 mg/kg PO q24h for 5 days ⁵⁹	Concurrent gastrointestinal nematodes and protozoa
Formalin (10%)	— 1.5 mL/L × 10 min bath q48h to effect ⁵⁹ 0.5% × 10 min bath once ⁵⁹	Do not use if skin is ulcerated; may be toxic to some species Protozoans; may be toxic in some species Monogenic trematodes; may be toxic to some species
Ivermectin	— 0.2-0.4 mg/kg PO, SC, repeat q14d as needed ⁵⁹ 2 mg/kg topically, repeat in 2-3 wk ³⁰ 10 mg/L × 60 min bath, repeat q14d prn ⁵⁹	See febendazole for combination; caution: may cause flaccid paralysis with overdosage; caffeine or physostigmine may ameliorate effects ⁵⁹ Nematodes, including lungworms; mites Especially useful for small specimens ⁵⁹ and <i>Rana</i> spp. ³⁰ Mites
Levamisole	— 6.5-13.5 mg/kg topically to pelvic patch, repeat in 10 days ⁴ 10 mg/kg IM, ICe, topically, ⁵⁹ repeat in 2 wk 12 mg/L bath × 4 days ²⁴	May cause paralysis in some species at suggested dosages; ⁵⁹ caffeine or physostigmine may ameliorate effects ⁵⁹ <i>Anaxyrus houstonensis</i> /reduced nematode egg counts Nematodes, including lungworms African clawed frogs/cutaneous nematodes; use ≥4.2 L of tank water/frog

TABLE 3-3 Antiparasitic Agents Used in Amphibians. (cont'd)

Agent	Dosage	Species/Comments
Levamisole (cont'd)	100 mg/L \times \geq 72 hr bath ⁵⁹ 100-300 mg/L \times 24 hr bath, repeat in 1-2 wk ⁵⁹	Resistant nematodes Nematodes, including subcutaneous nematodes in aquatic amphibians; water soluble form is available through aquaculture supply companies
Metronidazole	— 10 mg/kg PO q24h \times 5-10 days ⁵⁹ 50 mg/kg PO q24h \times 3-5 days ⁵⁹ 100 mg/kg PO q3d ⁵⁹ 100-150 mg/kg PO, repeat in 2-3 wk or prn ⁵⁹ 50 mg/L \times 24 hr bath ⁵⁹ 500 mg/100 g feed \times 3-4 treatments ⁵⁹	See fenbendazole for combination; toxicity possible at high doses Protozoa; for unfamiliar or sensitive species Confirmed cases of amoebiasis and flagellate overload Protozoa Protozoa (i.e., <i>Entamoeba</i> , <i>Hexamita</i> , <i>Opalina</i>) Aquatic amphibians/protozoa Ciliates
Moxidectin	200 μ g/kg SC q4mo ⁴⁴	Nematodes
Oxfendazole	5 mg/kg PO ⁵⁹	Gastrointestinal nematodes
Oxytetracycline	25 mg/kg SC, IM q24h ⁵⁹ 50 mg/kg PO q12h ⁵⁹ 1 g/kg feed \times 7 days ⁵⁹	Protozoa Protozoa Protozoa
Paromomycin	50-75 mg/kg PO q24h ⁵⁹	Gastrointestinal protozoa
Piperazine	50 mg/kg PO, repeat in 2 wk ⁵⁹	Gastrointestinal nematodes
Ponazuril	30 mg/kg PO q12h \times 3 days, repeat in 3 wk; often more effective at 30 mg/kg PO q24h \times 30 days; may work with less frequent treatments ⁵⁹	Coccidia but not <i>Cryptosporidium</i> ; may have some effect on unidentified protozoan cysts
Potassium permanganate	7 mg/L \times 5 min bath q24h to effect ⁵⁹	Ectoparasitic protozoa
Praziquantel	8-24 mg/kg PO, SC, ICe, topically, ⁵⁹ repeat q14d 10 mg/L \times 3 hr bath, ⁵⁹ repeat q7-21d	Trematodes, cestodes Trematodes, cestodes
Pyrantel pamoate	5 mg/kg PO q14d ⁴⁰	Nematodes
Ronidazole	10 mg/kg PO q24h \times 10 days ⁵⁹	Flagellated protozoa, amoebas
Salt (sodium chloride)	4-6 g/L continuous bath ⁵⁹ 5 g/L bath up to 12h, 10 g/L bath up to 1h ³² 6 g/L \times 5-10 min bath q24h \times 3-5 days ⁵⁹ 25 g/L \times \leq 10 min bath ⁵⁹	Ectoparasitic protozoa Axolotls, immediate negative clinical effects in baths $>$ 20 g/L ³² Ectoparasitic protozoa Ectoparasitic protozoa
Selamectin (Revolution, Zoetis)	6 mg/kg topically ¹²	Bullfrogs/PK

Continued

TABLE 3-3 Antiparasitic Agents Used in Amphibians. (cont'd)

Agent	Dosage	Species/Comments
Sulfadiazine	132 mg/kg PO q24h ⁵⁹	Coccidiosis
Sulfamethazine	1 g/L bath ⁵⁹	Coccidiosis; change daily to effect
Tetracycline	50 mg/kg PO q12h ⁵⁹	Protozoa
Thiabendazole	50-100 mg/kg PO, ⁵⁹ repeat in 2 wk prn 100 mg/L bath, repeat in 2 wk ⁵⁹	Gastrointestinal nematodes Verminous dermatitis
Trimethoprim/sulfa	3 mg/kg PO, SC, IM q24h ⁵⁹	Coccidiosis; unspecified sulfa

^aSC can be administered in the dorsal lymph sac of anurans.⁵⁹

TABLE 3-4 Chemical Restraint/Anesthetic/Analgesic Agents Used in Amphibians.^a

Agent	Dosage	Species/Comments
Alfaxalone	5-25 mg/kg IM ²⁸	Most species/recommend starting at lower dose (5-10 mg/kg) and titrating up
	10-17.5 mg/kg IM ⁴¹	Bullfrogs/immobilization, respiratory depression, still responsive to noxious stimuli; dose dependent time to recumbency and time to recovery; no effect by immersion at 2 g/L for 30 min ⁴¹
	18 mg/kg IM, IV, ICe ²²	African clawed frogs/deep sedation for 1-3 hr (IM, IV), 10-60 min ICe; no effect via immersion at 18 mg/L ²²
	20-30 mg/kg IM ⁴⁶	Australian tree frogs/initial effect within 10 min, respiratory depression; insufficient anesthesia as sole agent for painful procedures
	5 mg/L in fresh water bath ³⁵	Axolotls/single individual; induction of anesthesia, maintained continuous irrigation of gills and skin with additional 0.03 mL drops of alfaxalone for maintenance of anesthesia during surgery ³⁵
	200 mg/L in fresh water bath ²	Fire-bellied toads/buffer with sodium bicarbonate to pH 7.2; anesthetic induction in 14 ± 4 min, variable duration of anesthesia up to 30 min; not sufficient for painful procedures
Alfaxalone (A)/morphine (M)	(A) 3 mg/100 mL + (M) 5 mg/100 mL as bath ¹	Fire-bellied toads/provided anesthetic induction and antinociception
Atipamezole (Antisedan, Zoetis)	Titrate to effect IM, IV	Antagonist for dexmedetomidine ³¹

TABLE 3-4 Chemical Restraint/Anesthetic/Analgesic Agents Used in Amphibians. (cont'd)

Agent	Dosage	Species/Comments
Benzocaine (Sigma Chemical)	— 50 mg/L bath to effect ⁵⁹ 200-300 mg/L bath to effect ⁵⁹ 200-500 mg/L bath ⁵⁹	Anesthesia; not sold as fish anesthetic in United States; available from chemical supply companies; do not use topical anesthetic products marketed for mammals; prepare stock solution in ethanol (poorly soluble in water); store in dark bottle at room temperature Larvae/dissolve in ethanol first Frogs, salamanders/dissolve in ethanol first Dissolve in acetone first
Buprenorphine	38 mg/kg SC ³¹ 50 mg/kg ICe q24h ²⁶	Analgesia >4 hr; ED ₅₀ ^b in leopard frogs ³¹ Eastern red spotted newts/return to normal behavior following limb amputation; may take >1 hr for onset of clinical effects; postsurgical bath in 0.1% sulfamerazine (w/v; Sigma Chemical Company) ²⁶
Butorphanol	0.2-0.4 mg/kg IM ⁵⁹ 0.5 mg/L continuous immersion for 3 days ²⁶	Analgesia; efficacy uncertain ⁵⁹ Eastern red spotted newts/return to normal behavior following limb amputation; may take >4 hr for onset of clinical effects; postsurgical bath in 0.1% sulfamerazine (w/v; Sigma Chemical Company) ²⁶
Clove oil (eugenol)	0.3 mL/L (~310-318 mg/L) ⁵⁹ 0.35 mL in 1 L purified water ¹⁹ 0.45 mL/L (~473 mg/L) ³⁸	Anesthesia; deep anesthesia after 15 min bath; caused reversible gastric prolapse in 50% of leopard frogs African clawed frogs/anesthetic plane for frogs <10 g after 5 min immersion, for frogs ~30 g after 10 min immersion Anesthesia; deep anesthesia induced in 80% of tiger salamanders
Codeine	53 mg/kg SC ³¹	Analgesia >4 hr; ED ₅₀ ^b in leopard frogs
Dexmedetomidine	40-120 mg/kg SC ³¹	Analgesia >4 hr; ED ₅₀ ^b in leopard frogs
Diazepam	—	See ketamine for combination
Fentanyl	0.5 mg/kg SC ³¹	Analgesia >4 hr; ED ₅₀ ^b in leopard frogs
Flunixin meglumine	25 mg/kg intralymphatic ¹⁰	African clawed frogs
Isoeugenol (Aqui-S; 0.54 µg/mL isoeugenol)	20-50 µL/L ⁴⁷	<i>Litoria ewingii</i> tadpoles/higher doses resulted in faster induction and longer recovery

Continued

TABLE 3-4 Chemical Restraint/Anesthetic/Analgesic Agents Used in Amphibians. (cont'd)

Agent	Dosage	Species/Comments
Isoflurane	—	Anesthesia; induction chamber
	3%-5% induction, 1%-2% maintenance ⁵⁹ 5% ⁵⁹	Terrestrial species Terrestrial species/euthanasia; induction chamber
	Topical application of liquid isoflurane ⁵⁹	<i>Bufo</i> spp. (0.015 mL/g BW), African clawed frogs (0.007 mL/g BW)/ induce in closed container; once induced, remove excess from animal
	Topical mixture of isoflurane (3 mL), KY jelly (3.5 mL), and water (1.5 mL) ⁵⁹	<i>Bufo</i> spp. (0.035 mL/g BW), African clawed frogs (0.025 mL/g BW)/ induce in closed container; once induced, remove excess from animal
	Topical mixture of 1.5 parts distilled water, 3.5 parts nonspericidal jelly, and 1.8 parts isoflurane ⁶³	American tree frogs/induced in closed container; once induced remove excess from animal; erythematous lesions and signs of systemic illness noted following application ⁶³
0.28 mL/100 mL bath ⁵⁹ Bubbled into water to effect ⁵⁹	Induce in closed container Aquatic species	
Ketamine	—	May have long induction and recovery times; does not provide good analgesia so may not be suited for major surgical procedures; other agents preferred; ketamine combination follows; see lidocaine
	50-150 mg/kg SC, IM ⁵⁹	Most species
Ketamine (K)/ diazepam (D)	(K) 20-40 mg/kg + (D) 0.2-0.4 mg/kg IM ⁵⁹	Variable results
Lidocaine 1%-2%	Local infiltration ⁵⁹	All/local anesthesia; with or without epinephrine; 2% lidocaine in combination with ketamine has been used for minor surgeries; ⁵⁹ use with caution
Meloxicam	0.1 mg/kg ³⁷	American bullfrogs/decreased circulating prostaglandin E2 (PGE2) levels measured 24 hr post muscle biopsy ³⁷
	0.4-1 mg/kg PO, SC, ICe q24h ⁵⁹	Analgesia
Metomidate hydrochloride	30 mg/L bath ¹³	<i>Rana pipiens</i> /immersion for 60 min then transferred to amphibian Ringer's solution; clinical sedation in 11/11 frogs; surgical anesthesia in 3/11; prolonged recovery; not recommended as sole anesthetic agent
Morphine	38-42 mg/kg SC ³¹	Analgesia >4 hr
Nalorphine	122 mg/kg SC ³¹	Analgesia >4 hr

TABLE 3-4 Chemical Restraint/Anesthetic/Analgesic Agents Used in Amphibians. (cont'd)

Agent	Dosage	Species/Comments
Naloxone	10 mg/kg SC; ³¹ titrate to effect	Antagonist for buprenorphine, butorphanol, codeine, fentanyl, morphine
Naltrexone	1 mg/kg SC; ³¹ titrate to effect	Antagonist for buprenorphine, butorphanol, codeine, fentanyl, morphine
Pentobarbital sodium	60 mg/kg IV, ICe ⁵⁹	Euthanasia; can also be administered in lymph sacs in anurans
Pentobarbital sodium + sodium phenytoin	1100 mg/kg + 141 mg/kg ICe ⁵¹	African clawed frogs/complete cardiac arrest within 3 hr
Propofol	10-30 mg/kg ICe ⁵⁹ 35 mg/kg ICe ³⁸ 35 mg/kg ICe ⁵⁷ 60-100 mg/kg ICe ⁵⁹ 88 mg/L by immersion ²¹ 100-140 mg/kg topically ⁵⁹	White's tree frogs/pilot study; use the lower dosage for sedation or light anesthesia; induction within 30 min; recovery in 24 hr Deep anesthesia in 83% of tiger salamanders ³⁸ Sonoran desert toads/sedation only; did not achieve surgical plane of anesthesia Euthanasia African clawed frogs/induced for 15 min, then rinsed; respiratory depression, darkened skin color; death at doses over 175 mg/L Maroon-eyed tree frogs (<i>Agalychnis litodryas</i>)/unpublished data; 15-20 min to max effect at 100 mg/kg dose; 10-15 min to max effect at 140 mg/kg; ⁵⁹ sedation to deep anesthesia; remove and rinse when desired level achieved; recommended only for animals <50 g
Sevoflurane	Topical application Topical mixture of 1.5 parts distilled water, 3.5 parts nonspicidal jelly, and 3 parts sevoflurane ^{48,63}	Rapid recovery unless constant reapplication American tree frogs/induced in closed container with 2 mL of sevoflurane jelly per individual; once induced, remove excess from animal; recovery 4.5 times faster than topical isoflurane jelly; ⁶³ in cane toads, reliable loss of righting reflex when 37.5 µg/g sevoflurane in jelly was applied to dorsum ⁴⁸
Tiletamine/zolazepam (Telazol, Fort Dodge)	10-20 mg/kg IM ⁵⁹	Results variable between species; rapid recovery; not suitable as single anesthetic agent for anurans ²⁹

Continued

TABLE 3-4 Chemical Restraint/Anesthetic/Analgesic Agents Used in Amphibians. (cont'd)

Agent	Dosage	Species/Comments
Tricaine methanesulfonate (MS-222) (Finquel, Argent)	—	Anesthesia; buffer the acidity by adding sodium bicarbonate to buffer the solution to a pH of 7.0-7.1; aerate water to prevent hypoxemia; remove from bath on induction or overdosing can readily occur; following bath, place terrestrial amphibians on moist towel or in very shallow water to recovery; some species can be induced at much lower concentrations than listed here; in some cases, anesthesia can be maintained by dripping a dilute solution of this drug (100-200 mg/L) over the skin or by covering animal with a paper towel moistened with the anesthetic ⁵⁹
	50-200 mg/kg SC, IM, ICe ⁵⁹	Most species/may be irritating administered SC, IM (neutral solution is preferred) ⁵⁹
	100-200 mg/kg ICe ⁴⁹	Leopard frogs
	100-400 mg/kg ICe ⁴⁹	Bullfrogs
	100-200 mg/L bath to effect ⁵⁹	Larvae/induction
	200-500 mg/L bath to effect ⁵⁹	Tadpoles, newts/induction in 15-30 min
	0.5-2 g/L bath to effect ⁵⁹	Frogs, salamanders/induction in 15-30 min
	1 g/L bath to effect ⁵⁹	Most gill-less adult species (unless very large)/induction
	1 g/L by immersion, buffered with 1 g/L sodium bicarbonate ⁵⁷	Sonoran desert toads/surgical plane of anesthesia
	1-2 g/L by immersion ²⁷	African clawed frogs/buffered to pH of 7.0 ± 0.4; 20 min induction then rinsed; respiratory depression; longer duration of surgical anesthesia with higher dosing
	2-3 g/L bath to effect ⁵⁹	Toads/induction in 15-30 min
	5 g/L immersion ⁵¹	African clawed frogs/immersion for 1 hr; death within 3 hr
10 g/L bath ⁵⁹	Euthanasia; can be administered ICe or in lymph sacs	

^aSC can be administered in dorsal lymph sac in anurans.⁵⁹

^bED₅₀, effective dose for 50% of the population.

TABLE 3-5 Hormones Used in Amphibians.^a

Agent	Dosage	Species/Comments
Gonadotropin-releasing hormone (GnRH)	10 µg SC to female followed by additional 20 µg after 18 hr; 5 µg SC to male ⁵⁴ 0.1 mg/kg SC, IM, repeat prn ⁵⁹	Tomato frogs (<i>Dyscophus guineti</i>)/ovulation and spermiation Induction of ovulation in those non-responsive to pregnant mare serum gonadotropin (PMSG) or human chorionic gonadotropin (hCG); administer to females 8-12 hr before males
Human chorionic gonadotropin (hCG)	50-300 U ⁵⁹ SC, IM 250-400 U SC, IM ⁵⁹	For mating or release of sperm in males; follow with GnRH in 8-24 hr African clawed frogs, axolotls/induction of ovulation; may be used with PMSG and/or progesterone
Luteinizing hormone-releasing hormone (LHRH)	5 µg ICe per animal ⁵³ 10 µg in 0.05 mL of 40% DMSO applied to ventral drink patch ⁴³	Salamanders (<i>Desmognathus ochrophaeus</i>)/induced oviposition in 94% of animals <i>Bufo americanus</i> , <i>B. valliceps</i> /induced spermiation in 70% of males
Pregnant mare serum gonadotropin (PMSG)	50-200 U SC, IM ⁵⁹	African clawed frogs, axolotls/induction of ovulation; administer 600 U hCG SC, IM 72 hr later ⁵⁹
Progesterone	1-5 mg SC, IM ⁵⁹	African clawed frogs, axolotls/use in addition to PMSG or hCG for induction of ovulation

^aSC can be administered into the dorsal lymph sac of anurans.⁵⁹

TABLE 3-6 Miscellaneous Agents Used in Amphibians.^a

Agent	Dosage	Species/Comments
Amphibian Ringer's solution (ARS)	6.6 g NaCl, 0.15 g KCl, 0.15 g CaCl ₂ , and 0.2 g NaHCO ₃ in 1 L water ⁵⁹	For treating hydrocoelom and subcutaneous edema; place animal in shallow ARS bath until stabilized (~24 hr or more); replace with fresh solution daily; may need to wean animal off ARS by placing it in gradually more dilute solutions; hypertonic solution created by using 800-950 mL water instead of 1 L and may be more effective for some cases of hydrocoelom; up to 10 g of glucose may be added per L, but then solution must be made fresh daily ⁵⁹
Atropine	0.1 mg/animal SC, IM prn ⁵⁹	Organophosphate toxicosis
Caffeine	Use caffeinated tea bag; steep (soak) until solution is "weak tea"; place amphibian in shallow bath, replace q6h ⁵⁹	Stimulant; may help reverse ivermectin or levamisole toxicosis, or excessively deep anesthesia ⁵⁹
Calcium gluconate (Calcionate, 1.8 g/5 mL, Rugby Laboratories)	1 mL/kg PO q24h ⁵⁹	Nutritional secondary hyperparathyroidism

Continued

TABLE 3-6 Miscellaneous Agents Used in Amphibians. (cont'd)

Agent	Dosage	Species/Comments
Calcium gluconate	100-200 mg/kg SC ⁵⁹ 2.3% continuous bath (with 2-3 U/mL vitamin D ₃) ⁵⁹	Hypocalcemic tetany Nutritional secondary hyperparathyroidism
Critical care diets <ul style="list-style-type: none"> • Carnivore Critical Care (Oxbow) • Emeraid for Carnivores (Lafeber) • Feline Clinical Care Liquid (Pet-Ag) • Hill's Feline a/d (Hill's Pet Nutrition) 	— 3% bodyweight PO q24-72h ⁵⁹ 3% body weight PO q24-48h ⁵⁹ 1-2 mL/50 g PO q24h ⁵⁹ 3-6 mL/50 g PO q72h ⁵⁹ PO ⁵⁹	Dosages are approximate; may be more appropriate to offer larger volume less frequently for easily stressed animals Nutritional support; mix 1:1 with water; generally gavaged
Cyanoacrylate surgical adhesive (Vet Bond, 3M)	Topical on wounds ⁵⁹	Produces a seal for aquatic and semiaquatic species
Dexamethasone	1.5 mg/kg SC, IM ⁵⁹ 1.5 mg/kg IM, IV ⁵⁹	Vascularizing keratitis Shock
Dextrose 5% solution	Bath ⁵⁹ Topically to affected tissues ³⁴	For treating hydrocoelom and subcutaneous edema; ⁵⁹ place animal in shallow bath until stabilized (\approx 24 hr or more); replace with fresh solution daily; may need to wean animal off dextrose by placing it in gradually more dilute solutions; 7.5%-10% solutions may be more effective for some cases of hydrocoelom Small amount can be applied to edematous/inflamed tissue in cases of cloacal prolapse to aid in prolapse reduction
Doxycycline	1.25-2.5 mg/kg PO, SC, ICe q24h ⁵⁹ 1% gel topically q12h ⁵⁹	Antiinflammatory Antiinflammatory
Hetastarch (6% in 0.9% saline)	Bath not to exceed 1 hr without reassessment ⁵⁹	May help with initial treatment of hydrocoelom
Hypertonic saline, 5% ophthalmic solution	Topically to affected tissues ³⁴	Small amount can be applied to edematous/inflamed tissue in cases of cloacal prolapse to aid in prolapse reduction
Laxative (Laxatone, Evsco)	PO ⁵⁹	Laxative, especially for intestinal foreign bodies
Meloxicam	0.4-1 mg/kg PO, SC, ICe q24h ⁵⁸ 0.5% gel topically q24h; do not exceed 0.4 mg/kg ⁵⁹	Antiinflammatory; presumptive analgesia; adjunct therapy for septicemia Antiinflammatory for localized wounds
Methylene blue	2 mg/mL bath to effect ⁵⁹	Nitrite and nitrate toxicoses

TABLE 3-6 Miscellaneous Agents Used in Amphibians. (cont'd)

Agent	Dosage	Species/Comments
Oxygen	100% for up to 24 hr ⁵⁹	Adjunct treatment for septicemia, toxicoses
Physostigmine (ophthalmic drops)	1 drop/50 g topically q1-2h to effect ⁵⁹	May ameliorate flaccid paralysis from ivermectin or levamisole toxicosis
Prednisolone sodium succinate	5-10 mg/kg IM, IV ⁵⁹	Shock
Sodium thiosulfate	1% solution as continuous bath to effect ⁵⁹	Halogen toxicoses
Vitamin A (Aqualos A, 50,000 U/mL, Mayne Pharma)	Dilute 1:9 with sterile water; make fresh weekly; apply 1 drop from a tuberculin syringe with 27 g needle to amphibians under 5 g; 1 drop from tuberculin syringe w/out needle is about 200 U and useful for 15-30 g BW; >30 g, try 1 drop per 10 g BW; topically q24h × 14 days, then q4-7d ⁵⁹ Dilute 1:10 in sterile water; applied as one drop from 18g needle; estimated as 50 U/frog q48h to q7d ⁴⁵ 1 U/g PO daily × 14 days ⁵⁹	Hypovitaminosis A; given the plethora of organ systems that hypovitaminosis A may affect, it is reasonable to institute vitamin A supplementation of any clinically ill amphibian, particularly ones with signs similar to "short tongue syndrome," swollen eyelids, evidence of infectious dermatitis, hydrocoelom, or simply "failing to thrive"; ⁵⁹ the use of mixed dietary carotenoids may also be effective in some species ⁹ African foam-nesting frogs/weight range, 2-7 g; dosing q48h and once weekly significantly increased whole body vitamin A levels over control group and group treated with vitamin A fortified supplement dusted over crickets ⁴⁵
Vitamin A gel caps (10,000 U/cap)	Dilute 1:9 with corn oil to yield 1000 U/mL; give 1 U/g PO q24h × 14 days, then q7d ⁵⁹	Hypovitaminosis A; given the plethora of organ systems that hypovitaminosis A may affect, it is reasonable to institute vitamin A supplementation of any clinically ill amphibian, particularly ones with signs similar to "short tongue syndrome," swollen eyelids, evidence of infectious dermatitis, hydrocoelom, or simply "failing to thrive"; ⁵⁹ the use of mixed dietary carotenoids may also be effective in some species ⁹
Vitamin B ₁	25 mg/kg PO ⁵⁹ 25-100 mg/kg IM, ICe ⁶⁰	Deficiency resulting from thiaminase-containing fish
Vitamin D ₃	2-3 U/mL continuous bath (with 2.3% calcium gluconate) ⁵⁹ 100-400 U/kg PO q24h ⁵⁹	Nutritional secondary hyperparathyroidism
Vitamin E (alpha-tocopherol)	1 mg/kg PO, IM q7d ⁵⁹ 200 U/kg feed ⁵⁹	Steatitis

^aSC can be administered into the dorsal lymph sac of anurans.⁵⁹

TABLE 3-7 Physiologic and Hematologic Values of Select Amphibians.⁵⁹

Measurement	African clawed frog (<i>Xenopus laevis</i>) ^{55,59}	American bullfrog (<i>Rana catesbeiana</i>) ⁵⁹	Australian common green tree frog (<i>Litoria caerulea</i>) ⁶²	Australian white-lipped tree frog (<i>Litoria infrafrenata</i>) ⁶²	Cuban tree frog (<i>Hyla septentrionalis</i>) ⁵⁹	Leopard frog (<i>Rana pipiens</i>) ⁵⁹ ♂ ♀		Tiger salamander (<i>Ambystoma tigrinum</i>) ⁵⁹
BW (g)	—	—	—	—	28-35	25-42	25-46	35
Blood volume (mL/100 g BW)	—	3.1-3.6	—	—	7.2-7.8	—	—	—
Hematology^a								
PCV (%)	23.3-47.0	39-42	34-40.8	26.0-34.0	20-24	19-52	16-51	40
RBC (10 ⁶ /μL)	0.80-1.48	0.45	0.62-0.82	0.63-0.82	—	0.23-0.77	0.17-0.70	1.66
Hgb (g/dL)	6.06-15.19	9.3-9.7	8.0-10.6	6.1-8.2	5.6-6.8	3.8-14.6	2.7-14	9.4
MCV (fL)	31.6-62.8	—	461-602	374-486	—	722-916	730-916	—
MCH (pg)	6.9-22.1	—	111-148	84-115	—	182-221	182-238	—
MCHC (g/dL)	19.3-32.3	21.1-25.9	236-268	210-250	25-31	22.7-26.8	19.9-27.7	—
WBC ^b (10 ³ /μL)	0.64-9.56	—	12.4-22.1	14.2-29.1	—	3.1-22.2	2.8-25.9	4.6
Early stages ^b (%)	—	—	—	—	—	—	—	—
Neutrophils ^b (%)	8 ± 1.1	—	14-27	15.0-32.0	—	—	—	—
Lymphocytes ^b (%)	65.3 ± 2.7	—	—	57.0-78.3	—	—	—	—
Monocytes ^b (%)	0.5	—	5.0-10.0	4.0-8.0	—	—	—	—
Eosinophils ^b (%)	—	—	1.0-5.0	0-1.3	—	—	—	—
Basophils ^b (%)	8.5 ± 1.4	—	0	0-1.0	—	—	—	—
Plasmocytes ^b (%)	0.2	—	—	—	—	—	—	—
Thrombocytes (10 ³ /μL)	17.1	—	23.2-33.5	25.8-38.8	—	—	—	—

Chemistry

ALP (U/L)	59-282	—	—	—	—	—	—	—
ALT (U/L)	10-39	—	—	—	—	—	—	—
AST (U/L)	27-1774	—	66-122	41-119	—	—	—	—
Bilirubin, total (mg/dL)	0.01-0.26	—	—	—	—	—	—	—
BUN (mg/dL)	2-10	—	—	—	—	—	—	—
Calcium (mg/dL)	5.2-12.3	—	10.6-13.1	8.6-11.3	—	—	—	—
Chloride (mEq/L)	72.7-92.7	—	—	—	—	—	—	—
Cholesterol (mg/dL)	56-563	—	—	—	—	—	—	—
Creatine kinase (U/L)	10-5400	—	347-705	233-722	—	—	—	—
Creatinine (mg/dL)	0.1-1.1	—	—	—	—	—	—	—
GGT (U/L)	1-19	—	—	—	—	—	—	—
Glucose (mg/dL)	18-111	—	55-78	45-81	—	—	—	—
LDH (U/L)	21-240	—	—	—	—	—	—	—
Phosphorus (mg/dL)	3.5-11.6	—	3.3-5.0	3.2-4.9	—	—	—	—
Potassium (mEq/L)	2.3-7.3	—	4.9-7.7	3.2-4.7	—	—	—	—
Protein, total (g/dL)	2.0-4.6	—	5.5-6.8	3.0-4.1	—	—	—	—
Albumin (g/dL)	0.1-2.3	—	—	—	—	—	—	—
Globulin (g/dL)	1.1-4.1	—	—	—	—	—	—	—

Continued

TABLE 3-7 Physiologic and Hematologic Values of Select Amphibians. (cont'd)

Measurement	African clawed frog (<i>Xenopus laevis</i>)	American bullfrog (<i>Rana catesbeiana</i>)	Australian common green tree frog (<i>Litoria caerulea</i>)	Australian white-lipped tree frog (<i>Litoria infrafrenata</i>)	Cuban tree frog (<i>Hyla septentrionalis</i>)	Leopard frog (<i>Rana pipiens</i>) ♂ ♀		Tiger salamander (<i>Ambystoma tigrinum</i>)
Sodium (mEq/L)	111-134	—	107-114	104-108	—	—	—	—
Triglyceride (mg/dL)	57-555	—	—	—	—	—	—	—
Uric acid (mg/dL)	0.1-0.4	—	0.2-0.7	0.1-0.2	—	—	—	—

^aHematology is presently of limited diagnostic value because of the lack of normal data and the wide variation in hematologic and biochemical values according to sex, season, and state of hydration.

^bFor leukocyte totals and percentages for various species, refer to The Wildlife Leukocytes Web site at wildlifehematology.uga.edu.

TABLE 3-8 Blood Collection Sites in Amphibians^{3,a}

Collection Site	Species Reported	Notes
Ventral abdominal vein	Anurans	Vessel present on midline along the ventral coelom, between sternum and pelvis; risk of hitting coelomic organs; visualization may be confirmed via transillumination of coelom in some species
Lingual plexus	Anurans	With mouth open, depress tongue to expose buccal surface of the oral cavity; lingual plexus can be visualized as superficial vessels; sedation may be needed in some species; safely used in frogs as small as 25 g, possible salivary contamination
Femoral vein	Anurans	Superficial vessel present along the medial aspect of the femur; runs parallel with femoral nerve; sedation may be needed
Heart	Multiple	Sedation recommended; aim needle at ventricle, allow heart to passively fill syringe to avoid collapsing ventricle; visualization may be assisted with ultrasound
Ventral tail vein	Urodelans	Similar to reptiles; caudal vein runs along the ventral caudal vertebrate and can be accessed via ventral or lateral approach; tail autotomy possible in some species
Facial vein/musculo-cutaneous vein ¹⁶	Anurans (Ranidae)	Facial vein forms at the middle of the orbit and courses caudally to the angle of the jaw, turning into the musculo-cutaneous vein as it passes the caudal half of the tympanum; blood may be collected just rostral or just caudal to the tympanum; insert needle in rostrocaudal direction at 30° angle to the skin ¹⁶

^aBlood volume has been reported to vary by species or genus. In general, it is safe to collect 10% of the blood volume from healthy animals (approx. 1% of body weight). Clinical judgment should be used in collecting blood from sick or debilitated animals.

TABLE 3-9 Differential Diagnoses by Predominant Signs in Amphibians.^a

Sign	Common Causes	Suggested Diagnostics ^b
Changes in skin color	Infectious agents: virus, bacteria, mycobacteria nodules, saprolegniasis, chromoblastomycosis, other mycoses, protozoa, myxosporeans, microsporidia, helminths (<i>Capillaroides xenopi</i>), leeches, fly larvae, other arthropods, fish lice, mollusks Noninfectious causes: toxicosis, hypothermia, hyperthermia, dehydration, desiccation, burn, frostbite, trauma, neoplasia, nutritional secondary hyperparathyroidism, xanthomatosis/hyperlipidosis, drug reaction	Biology review of species in question; husbandry review (diet, water quality tests, soil pH, temperature); skin scrapes (wet mount and stained); PCR tests for ranavirus and chytrid; skin and blood cultures; fecal parasite exams; plasma cholesterol and triglycerides; radiograph for skeletal density; plasma calcium and phosphorus; CBC and other plasma biochemistries
Changes in skin texture	Infectious agents: virus, bacteria, mycobacteria, mycoses, protozoa, myxosporeans, microsporidia, helminths, fly larvae, leeches, mites, ticks, fish lice, other arthropods, mollusks Noninfectious causes: toxicosis, hypothermia, hyperthermia, dehydration, desiccation, stress, trauma (especially rostral abrasion), neoplasia, normal (e.g., dorsal crests in European newts, egg brood patch of Surinam toad, nuptial pads in male anurans)	Biology review of species in question; husbandry review (diet, water quality tests, soil pH, temperature); skin scrapes (wet mount and stained); PCR tests for ranavirus and chytrid; skin and blood cultures; fecal parasite exams; CBC and plasma biochemistries

Continued

TABLE 3-9 **Differential Diagnoses by Predominant Signs in Amphibians. (cont'd)**

Sign	Common Causes	Suggested Diagnostics
Excess mucus production	<p>Infectious agents: virus, bacteria, mycoses, protozoa, helminths, arthropods, mollusks</p> <p>Noninfectious causes: toxicosis (ammonia, nitrite, chlorine, chloramine, salt, nicotine), poor water quality (pH, hardness, supersaturation), stress (cagemate, escape behavior, inappropriate soil pH or composition), hyperthermia, trauma</p>	Husbandry review (diet, water quality tests, soil pH, temperature); skin scrapes (wet mount and stained); PCR tests for ranavirus and chytrid; skin and blood culture; fecal parasite exams; CBC and plasma biochemistries
Fluctuant mass	<p>Infectious agents: bacterial abscess, mycobacteria (rare), mycoses (rare), protozoal cyst, myxosporeans, helminths (e.g., immature trematodes and cestodes), subcutaneous leeches, fly larvae, mites, pentastomes</p> <p>Noninfectious causes: lymphatic blockage (e.g., gout), xanthomatosis, toxicosis, trauma, fluid overload, thermal injury, hypocalcemia, neoplasia, normal (e.g., active marsupium of <i>Gastrotheca</i> spp. females, water sacs of <i>Cycloderma rana</i>, distended lymphatic sacs of <i>Ceratophrys</i> spp.)</p>	Biology review of species in question; husbandry review (diet, water quality tests, soil pH, temperature); aspirate (wet mount, stained, culture); fecal parasite exams; plasma uric acid, cholesterol, and triglycerides; radiograph for skeletal density; plasma calcium and phosphorus; skin and blood cultures; CBC and other plasma chemistries
Corneal opacity	<p>Infectious agents: bacteria, mycoses, nematodes</p> <p>Noninfectious causes: scar, corneal lipidosis/xanthomatosis, trauma, chemical irritation, toxicosis, neoplasia</p>	Husbandry review; slit lamp ophthalmic exam; culture and sensitivity; plasma cholesterol and triglycerides
Sudden death	<p>Infectious agents: iridovirus, bacteria, chlamydiosis, chytridiomycosis</p> <p>Noninfectious causes: toxicosis (ammonia, household pesticides, chlorine), electrocution, hypothermia, hyperthermia, trauma, gastric overload/impaction, stress, drowning, neoplasia</p>	Biology review of species in question; husbandry review (diet, water quality tests, soil pH, temperature); PCR tests for ranavirus and chytrid; necropsy; physical exam of cagemates (include CBC, plasma biochemistries, blood culture, fecal parasite exams); consider euthanasia and necropsy of one or more cagemates
Weight loss	<p>Infectious agents: bacteria, virus, chromomycosis, other mycoses, mycobacteria, coccidiosis, flagellate or ciliate overgrowth, helminths</p> <p>Noninfectious causes: heavy metal toxicosis (e.g., copper), chemical irritation (e.g., ammonia, chlorine, salt, pH), stress from inappropriate husbandry (e.g., environmental temperature too high, cagemate aggression), ocular disease with vision impairment, xanthomatosis</p>	Biology review of species in question; husbandry review (diet, water quality tests, soil pH, temperature); skin scrapes (wet mount and stained); fecal parasite exams; PCR tests for ranavirus and chytrid; CBC; skin and blood cultures; plasma calcium, phosphorus, cholesterol, and triglycerides; radiograph for skeletal density; other plasma biochemistries

TABLE 3-9 Differential Diagnoses by Predominant Signs in Amphibians. (cont'd)

Sign	Common Causes	Suggested Diagnostics
Anorexia, inappetence	<p>Infectious agents: iridovirus, Lucke's herpesvirus, other virus, bacteria, mycobacteria, chytridiomycosis, chromoblastomycosis, mucormycosis, protozoa, myxosporean, microsporidial, helminth, fly larvae, pentastomes, mites, ticks</p> <p>Noninfectious causes: inappropriate environment (e.g., substrate, temperature, illumination, photoperiod, humidity, lack of furnishings and hiding spots, inappropriate cagemates, too many cagemates or visible specimens in adjacent cages, activity in room), inappropriate feeding practices (e.g., wrong kind of food/prey, wrong size of food/prey, feeding at wrong times, too many prey items offered at one time), frequent handling or cage servicing, nutritional secondary hyperparathyroidism, hypocalcemia, toxicosis (e.g., copper, ammonia, chlorine), xanthomatosis, ocular disease with vision impairment, neoplasia, geriatric/senescence, normal (i.e., estivation or hibernation cues)</p>	<p>Biology review of species in question; husbandry review (diet, water quality tests, soil pH, temperature); skin scrapes (wet mount and stained); PCR tests for ranavirus and chytrid; skin and blood cultures; fecal parasite exams; plasma cholesterol and triglycerides; radiograph for skeletal density; plasma calcium and phosphorus; CBC and other plasma biochemistries</p>
Bloating	<p>Infectious agents: virus, bacteria, mycoses, mycobacteria, gastrointestinal nematodes</p> <p>Noninfectious causes: hypocalcemia (especially in hylid frogs), toxicosis, hypothermia, decomposition of ingesta (e.g., gastric overload, low or high temperatures), pneumocoelom (i.e., ruptured lung or trachea), gas supersaturation</p>	<p>Biology review of species in question; husbandry review (diet, water quality tests, soil pH, temperature); fecal parasite exams; PCR tests for ranavirus and chytrid; plasma calcium and phosphorus; radiograph; aspirate (wet mount, stained, culture); plasma biochemical analysis; ultrasonography; radiograph; skin and blood cultures; CBC</p>
Hydrocoelom	<p>Infectious agents: virus, bacteria, mycoses, mycobacteria, verminous granulomata, filarids, other helminths</p> <p>Noninfectious causes: toxicosis (e.g., heavy metal, chlorine, ammonia, insecticide, distilled or reverse osmosis water), hepatic failure, renal failure, hypocalcemia, xanthomatosis, gout, neoplasia (especially ovarian, hepatic, or renal), failure to oviposit, normal (e.g., ovulation)</p>	<p>Biology review of species in question; husbandry review (diet, water quality tests, soil pH, temperature); aspirate (wet mount, stained, culture); fecal parasite exams; PCR tests for ranavirus and chytrid; plasma biochemical analysis; ultrasonography; radiograph; skin and blood cultures; CBC</p>
Cloacal prolapse	<p>Infectious agents: helminths, protozoa, colitis/cloacitis (bacterial, fungal)</p> <p>Non-infectious causes: mechanical ileus, dehydration, gastric overload, intussusception, hypocalcemia, nutritional secondary hyperparathyroidism, constipation, physiologic behavior, iatrogenic (handling, sedation), straining with oviposition (females), neoplasia</p>	<p>Biology review of species in question; husbandry review (diet, water quality tests, soil pH, temperature); fecal parasite exams/ impression smear of prolapsed tissue; radiograph; ultrasonography; plasma biochemical analysis; CBC</p>

Continued

TABLE 3-9 Differential Diagnoses by Predominant Signs in Amphibians. (cont'd)

Sign	Common Causes	Suggested Diagnostics
Lameness	<p>Infectious agents: virus, bacteria, mycobacteria, mycoses, protozoa, myxosporeans, microsporidia, helminths, fly larvae, pentastomes, mites</p> <p>Noninfectious causes: nutritional secondary hyperparathyroidism, trauma, malnutrition (e.g., hypovitaminosis B), thiaminosis, hypervitaminosis D, gout, xanthomatosis/hyperlipidosis, toxicosis (especially insecticides), neoplasia, drug reaction</p>	<p>Husbandry review (diet, water quality tests, soil pH, temperature); radiograph; plasma calcium and phosphorus; plasma cholesterol and triglycerides; fecal parasite exams; CBC and other plasma chemistries</p>
Spindly leg	<p>Infectious agents: iridovirus, larval cestodes or trematodes, subcutaneous nematodes</p> <p>Noninfectious causes: nutritional secondary hyperparathyroidism, malnutrition (e.g., hypovitaminosis B, protein deficiency, iodine deficiency, trace mineral deficiency, diet of parents, outdated food or vitamin supplements), toxicosis (ammonia, chlorine, nitrites), water quality (pH, hardness, temperature), crowding, poor illumination, trauma, genetic, hybridization</p>	<p>Biology review of species in question; husbandry review (water quality tests, temperature); diet (inspect actual food items and supplements in original containers); PCR tests for ranavirus and chytrid; necropsy; physical exam of cagemates and parents; consider euthanasia and complete necropsy of one or more cagemates</p>

^aThis is based on the previous author's (Dr. Kevin M. Wright) clinical impressions of the most common underlying etiologies for gross symptomology; a patient's differential list should be a comprehensive review of all potential etiologies regardless of likelihood. Edited by current authors.

^bSuggested diagnostics are presented in prioritized order.

TABLE 3-10 Selected Disinfectants for Equipment and Cage Furniture. ^{40,a}

Batrachochytrium dendrobatidis

- Sodium hypochlorite (household bleach) 1% for 1 min contact time
- Ethanol 70% for 1 min exposure time
- Benzalkonium chloride 1 mg/mL for 1 min contact time
- Desiccation and exposure to 50-60°C (122-140°F) heat for 30 min
- Exposure to 1:1000 quaternary ammonium compound Quat-128 (Waxie Sanitary Supply, San Diego, CA; 800-995-4466; www.waxie.com) for 30 sec; this contains 6.8% didecyl dimethyl ammonium chloride (DDAC) as the active ingredient

Ranavirus

- Nolvasan (chlorhexidine) 0.75% for 1 min contact time
- Sodium hypochlorite (household bleach) 3% for 1 min contact time
- Virkon S 1.0% for 1 min contact time
- Desiccation and exposure to 60°C (140°F) heat for 15-30 min

^aIn order to increase efficacy of disinfectants, rinse all organic material and debris from the surface before applying disinfectants.

TABLE 3-11 Guidelines for Managing Pet Amphibians with Nematode Parasites.⁵⁹

- Determine purpose of captive amphibian
 - Pet amphibians are often kept for different purposes than captive assurance colonies
 - Plan must be with owner's informed consent
- Assess current health and body condition score (BCS)
 - If unthrifty
 - Consider any nematode ova, larvae, or adults significant. Treat for nematodes appropriately in light of other clinical findings
 - If well-fleshed, score the fecal parasite exam
 - If diarrhea, blood, mucus, or visible nematodes are present at any stage of the fecal parasite examination, treat
 - If stool appears grossly normal
 - and there are ≤ 5 RBC/HPF or < 1 WBC/HPF, parasites may not be significant
 - and there are > 5 -10 RBC/HPF or > 1 -5 WBC/HPF, parasites are likely significant, treatment may be indicated
 - or there are > 5 strongyle larvae/HPF on direct or float, treat
- Treatment of amphibians that are apparently healthy, eating well, and maintaining or gaining weight, should be done with caution despite the presence of a few nematode ova or larvae per high-power field on direct or flotation fecal parasite exams
- If any amphibians in the collection appear unthrifty, there are mortalities with nematodes implicated, or there are otherwise unexplained mortalities, treat for nematodes
- Monitor with regular direct fecal parasite exams to evaluate a shift in cytology and fluctuations in nematode ova and larvae; while there is often no correlation between reduction in nematode ova or larvae in feces and actual reduction in nematode numbers, improvements in BCS and weight often happen when the ova or larvae counts go down and the feces has ≤ 5 RBC/HPF and < 1 WBC/HPF
- Success is measured by an amphibian having a normal weight and BCS, producing normal-appearing feces, and exhibiting normal behaviors
- With problematic pets, routine randomly collected feces should be assessed for parasites

TABLE 3-12 Amphibian Quarantine Protocols.⁵⁹

Because of worldwide amphibian population declines and local extinctions, assurance colonies are being brought into captivity in hopes of preserving species for the future. The importance of these assurance colonies, and the possibility of future reintroduction efforts, makes proper quarantine and infectious disease testing paramount. In most cases, amphibians destined for use in reintroduction programs should remain in permanent quarantine to prevent introduction of novel pathogens. A 30-day quarantine is the minimum suggested time for quarantine of low risk amphibians, and moderate to high-risk animals should be quarantined for 60-90 days. Release from quarantine is predicated on interpretation of morbidity and mortality, appropriate testing to detect important diseases, and a healthy body condition score and normal physical examination prior to release. Any quarantine plan must have the owner's informed consent before implementation.

Husbandry

- Facilities and equipment
 - Ideally, each quarantine area is spatially separated from areas containing other animals. In addition, separate air-handling systems should exist for individual areas. Tools should be designated for use only in quarantine areas. Some facilities may employ shower-in/shower-out protocols, but at the very least boots, smocks/coveralls should be worn when servicing quarantine animal areas.
 - Enclosures

Continued

TABLE 3-12 Amphibian Quarantine Protocols. (cont'd)

- Enclosures should be escape-proof and made of non-abrasive, non-toxic material that is easy to clean and disinfect. Enclosures with spartan furnishings are easiest to monitor and maintain in quarantine situations; however, many animals will not thrive in such conditions. Critical husbandry requirements should always take precedence over other needs.
- Food
- Transmission of infectious disease through food animals is possible. In cases where this is of significant concern, it may be prudent to establish on-site breeding colonies of prey items and occasionally screen for various pathogens.

Quarantine Examination

- Physical examination can be facilitated via manual restraint, restraint in a clear container, or via anesthesia.
- To control the spread of *Batrachochytrium dendrobatidis*, new gloves should be changed after handling each patient. Nitrile gloves are preferred for their ability to kill zoospores on contact. Bare hands are preferred over rinsing the same pair of gloves between patients.³⁶
- It is important to individually identify animals maintained in groups. Microchips and subcutaneous polymers can be placed; however, retention can be a problem. Charting of characteristic colors/patterns can be useful in some species (maintaining a database of digital photographs can be helpful in this regard). Toe-clipping has been used as a last resort, but is not recommended in zoological or private collections for humane and health reasons.
- Body weight and body condition scores should be assessed on arrival, periodically throughout quarantine, and immediately prior to release.

Diagnostic Testing

- Fecal flotation and direct examination
 - Quality samples can be obtained by placing the animal in a small container lined with damp, plain paper toweling overnight following a meal. It is best to assume wild amphibians are parasitized even though fecal exams can often be negative for the presence of parasites or ova.
- Complete blood count and chemistry panel
- A large percentage of amphibians are too small to safely take routine blood samples. Even larger specimens can present venipuncture challenges. See Table 3.8 for venipuncture sites in amphibians. Normal ranges for bloodwork parameters are not available for the vast majority of species which creates interpretive challenges.
- Specific infectious disease testing
 - It is paramount that all amphibians entering quarantine (whether wild caught or captive bred) be screened for chytridiomycosis and ranavirus infection. Polymerase chain reaction tests are available for both pathogens, although chytrid fungus may also be detected via cytology of skin scrapings. Other specific pathogen testing will depend on individual circumstances.

Prophylactic Treatment

- Fluid therapy
 - Newly captured or shipped amphibians can be stressed and dehydrated. Amphibian Ringer's solution (see Table 3.6) can be used as a bath to help hydrate the animal and replenish solutes.
 - Deworming
 - It is impractical to impossible to completely clear most amphibians of parasites. Treatment is aimed at reducing overall parasite burden. Treatment should address the results of diagnostic testing, otherwise empirical therapy with broad-spectrum anthelmintics is recommended.
 - Treatment for chytridiomycosis
 - Animals brought into captivity from areas suffering local declines due to chytridiomycosis should always be prophylactically treated. In other situations, it is recommended to avoid treatment unless an infection is diagnosed to avoid development of resistance to available drugs.
-

TABLE 3-12 Amphibian Quarantine Protocols. (cont'd)

Maintenance and Hygiene

- A variety of disinfectants are available for use in amphibian applications. Care should be taken to choose a product that meets the disinfection needs but is not unsafe for the amphibians.
- Heat, desiccation, and ultraviolet light can be used, in some cases, to disinfect equipment and materials without the hazards associated with chemical use.
- Proper disposal of solid waste/water is paramount to avoid exposure of native amphibians in the area to novel pathogens. At the least, wastewater should only be discarded into a sanitary sewer and solid waste be deeply buried or transferred to a landfill. Best practices involve treating all waste that comes in contact with quarantined amphibians as potential biohazardous waste and disposing of accordingly. Wastewater and other materials should never be discarded into the environment in a manner where exposure to native amphibians is likely.

Infectious Disease Screening

There are a number of laboratories that will perform various tests to document exposure to or presence of chytrid fungus or ranavirus particles via PCR. It is up to the clinician to evaluate the tests run by the various laboratories and interpret the results accordingly. The following are contact information for laboratories that perform ranavirus and/or chytrid testing. This list is by no means conclusive, and contact information was verified as of September 16, 2016.

Amphibian Disease Laboratory

San Diego Zoo Institute for Conservation Research

15600 San Pasqual Valley Rd.

Escondido, CA 92027, USA

760-291-5472 or 760-291-5470

<http://institute.sandiegozoo.org/resources/amphibian-disease-laboratory>

Chytridiomycosis and ranavirus

Pisces Molecular

1600 Range St., Suite 201

Boulder, CO 80301, USA

303-546-9300

www.pisces-molecular.com

Chytridiomycosis

Research Associates Laboratory

14556 Midway Rd.

Dallas, TX 75244, USA

972-960-2221

www.vetdna.com

Chytridiomycosis

Zoologix

9811 Owensmouth Ave., Suite 4

Chatsworth, CA 91311, USA

818-717-8880

www.zoologix.com

Chytridiomycosis, ranavirus, and various *Mycobacterium* species

A more complete list of laboratories for *Batrachochytrium dendrobatidis* testing can be found at:

<http://www.amphibianark.org/the-crisis/chytrid-fungus/>

A more complete list of laboratories in various countries for ranavirus testing can be found through the

Global Ranavirus Consortium at: <http://www.ranavirus.org/resources/testing-labs/>

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^aNote: Pessier AP, Mendelson JR⁴⁰ remains an important and convenient source of information on amphibian medicine and is available free online.

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Chapter 4 Reptiles

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TABLE 4-1 Antimicrobial Agents Used in Reptiles.^{a,b}

Agent	Dosage	Species/Comments
Amikacin	— 26 µg/kg/hr via osmotic infusion pump implant ^{55,374} 3.48 mg/kg IM once ¹⁸² 5 mg/kg IM, then 2.5 mg/kg q72h ²³³ 5 mg/kg IM, then 2.5 mg/kg q72h ^{16,363} 5 mg/kg IM q48h ⁴⁴ 2.25 mg/kg IM q72h ¹⁷² 50 mg/10 mL saline × 30 min nebulization q12h ¹¹⁷	Potentially nephrotoxic; maintain hydration; frequently used with a penicillin or cephalosporin Snakes/PD; consider loading dose at time of implant Pythons/PK (ball pythons) Gopher snakes/PD; house at high end of optimum temperature range during treatment Lizards Gopher tortoises/PK; 30°C (86°F) Alligators/PD Most species/pneumonia; aminophylline at 25 mg/9 mL of sterile saline in nebulizer before antibiotics for bronchodilation ³¹⁶
Amoxicillin	22 mg/kg PO q12-24h ^{79,103}	Most species/use with an aminoglycoside
Ampicillin	— 10-20 mg/kg SC, IM q12h ¹⁷⁴ 50 mg/kg SC, IM q12h ³⁴³ 20 mg/kg IM q24h ¹¹⁷ 50 mg/kg IM q12h ³⁵⁷	May use with an aminoglycoside Most species, including chameleons Chelonians Tortoises Tortoises/PD
Azithromycin	10 mg/kg PO q2-7d ⁵⁹	Ball pythons/PK; single dose study; may cause nonregenerative anemia; <i>Mycoplasma</i> , <i>Cryptosporidium</i> , <i>Giardia</i> , and other susceptible organisms; location dictates dosage frequency: skin, q3d; respiratory tract, q5d; liver/kidneys, q7d
Carbenicillin	— 200 mg/kg IM q24h ¹⁵⁸ 400 mg/kg IM q24h ²¹⁵ 400 mg/kg IM q48h ²¹⁴	Discontinued; more stable than ampicillin; extended G-spectrum Carpet pythons/PK Snakes/PD; 30°C (86°F) Chelonians/PD (<i>Testudo</i> spp.)
Cefazolin	22 mg/kg IM q24h ³⁰⁷	Chelonians
Cefoperazone (Cefobid, Pfizer)	100 mg/kg IM q96h ¹⁰⁶ 125 mg/kg IM q24h ¹⁰⁶	Snakes/PD (false water cobras; 24°C [75°F]) Lizards/PD (tegus; 24°C [75°F])
Cefotaxime	20-40 mg/kg IM q24h ¹¹⁷ 100 mg/10 mL saline × 30 min nebulization q24h ²⁷⁸	Most species/may use with an aminoglycoside Most species/pneumonia
Cefovecin	— 10 mg/kg SC q12h ²⁸¹	Short dosing interval is likely for most reptile species ^{281,378} Green iguanas/PD (25°C [77°F])

TABLE 4-1 Antimicrobial Agents Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Ceftazidime	20-40 mg/kg SC, IM, q48-72h ^{106,363,391}	Most species/chameleons use q24h
	20 mg/kg SC, IM, IV q72h ^{16,213}	Snakes/PD; 30°C (86°F); often effective against Gram-negative aerobes (i.e., <i>Pseudomonas</i>)
	22 mg/kg IM, IV q72h ^{165,366}	Sea turtles
Ceftiofur	2.2 mg/kg IM q48h ⁷⁹	Snakes/ceftiofur sodium
	15 mg/kg IM q24-120h ¹	Snakes/PK; ceftiofur crystalline-free acid; ball pythons; 26.1°C (79°F); dosing interval based on MIC
	5 mg/kg SC, IM q24h ²⁶	Lizards/PK; ceftiofur sodium; (green iguanas)
	30 mg/kg IM, SC ⁵⁴	Lizards/PK; ceftiofur crystalline-free acid; bearded dragons 30°C (86°F); interval may be q10-12d
	2.2 mg/kg IM q24h ⁷⁹ 4 mg/kg IM q24h ⁷⁹	Turtles/ceftiofur sodium Tortoises/ceftiofur sodium; upper respiratory infection
Cefuroxime	100 mg/kg IM q24h ⁷⁹	Most species/30°C (86°F)
Cephalexin	20-40 mg/kg PO q12h ¹⁰⁶	Most species/unknown absorption
Cephalothin	20-40 mg/kg IM q12h ¹⁰⁶	Most species
Chloramphenicol	—	Most species/public health concern; reserve for meningitis or encephalitis caused by susceptible organisms
	40 mg/kg PO, SC, IM q24h, or 20 mg/kg PO, SC, IM q12h ¹⁰⁶	Most species/20 mg/kg may be given q24h in larger crocodylians
	40 mg/kg SC q24h ⁴²	Snakes/PD (gopher snakes, 29°C [84°F])
	50 mg/kg SC q12-72h ⁵⁶	Snakes/PD; q12h in indigo, rat, king snakes; q24h in boas, moccasin snakes; q48h in rattlesnakes; q72h in red-bellied water snakes
Chlorhexidine (Nolvasan 2%, Fort Dodge)	Topical 0.05% aqueous solution q24h ²⁶⁴	All species/topical disinfection; dermatitis; infectious stomatitis; periodontal disease in lizards q24h
	Topical 0.07% (1:30 [solution:water]) ^{35,277}	Most species/topical disinfection; infectious stomatitis; abscess lavage; middle ear infection flush in box turtles
Chlortetracycline	200 mg/kg PO q24h ¹⁰⁶	Most species
Ciprofloxacin	10 mg/kg PO q48h ⁷⁹	Most species
	11 mg/kg PO q48-72h ¹⁹⁸	Pythons/PD (reticulated pythons)
Ciprofloxacin ophthalmic ointment or drops (Ciloxan, Alcon)	Topical ¹¹⁷	All species/infectious stomatitis; gingivitis
Clarithromycin	15 mg/kg PO q84h ³⁹⁷	Tortoises/PD (desert tortoises); upper respiratory tract disease (mycoplasmosis)

Continued

TABLE 4-1 Antimicrobial Agents Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Clindamycin	10 mg/kg PO, IM, IV q12h ¹³⁵	Loggerhead sea turtles/PK; 29.1-30.3°C (84.4-86.5°F) insufficient to be effective
Danofloxacin	6 mg/kg SC, IM ²⁴⁷ 6 mg/kg SC q48h × 30 days ¹¹⁷	Loggerhead sea turtles Tortoises/upper respiratory tract disease
Dihydrostreptomycin	5 mg/kg IM q12-24h ^{103,117}	Most species/maintain hydration
Doxycycline (Vibramycin, Pfizer)	5-10 mg/kg PO q24h × 10-45 days ¹¹⁷ 50 mg/kg IM, then 25 mg/kg q72h ^{38,357}	Most species/respiratory infection (i.e., mycoplasmosis) Tortoises/Hermann's tortoise; 27°C (81°F)
Enrofloxacin	5-10 mg/kg q24h PO, SC, IM, ICe ¹¹⁷ 6.6 mg/kg IM q24h, or 11 mg/kg IM q48h ¹⁹⁸ 10 mg/kg IM q48h ^{391,392,407} 5 mg/kg PO, IM q24h ²⁵⁵ 10 mg/kg IM q5d ¹⁶⁰ 5 mg/kg IM q24-48h ³¹⁰ 5 mg/kg IM q12-24h ³²⁰ 5 mg/kg IV, IM q48h ²¹⁰ 10 mg/kg ICe q48h ^{123,332} 10 mg/kg IM q24h ³⁵⁷ 5 mg/kg IV q36-72h ^{146,250} Nasal flush 50 mg/250 mL sterile water; 1-3 mL/naris q24-48h ¹¹⁷	Most species/IM administration is painful and may result in tissue necrosis and sterile abscesses; may cause skin discoloration or tissue necrosis if given SC; to administer SC, dilute with sterile NaCl Pythons/PD (reticulated pythons); <i>Pseudomonas</i> Snakes/PK (Burmese pythons, rattlesnakes, pit vipers) Lizards/PD (green iguanas); marked pharmacokinetic variability with PO administration may make IM more suitable in critically ill animals Monitors/PK (savannah monitors); preliminary data Chelonians and most other reptiles/PD (gopher tortoises); hyperexcitation, incoordination, diarrhea reported in a Galapagos tortoise ⁴⁹ Chelonians/PK (Indian star tortoises); q12h for <i>Pseudomonas</i> and <i>Citrobacter</i> ; q24h for other bacteria Sea turtles/PK (loggerhead sea turtles) Chelonians/PD (Hermann's tortoises; yellow-bellied sliders) dilute with saline to 10 mg/mL Chelonians/PD (Hermann's tortoises) Crocodilians/PK; PO pharmacokinetics not fully determined; mycoplasmosis Tortoises/URT syndrome; use until no more discharge (5-10 days); may use concurrently with parenteral antibiotics
Gentamicin	— 2.5 mg/kg IM q72h ^{42,43} 2.5-3 mg/kg IM, then 1.5 mg/kg q96h ¹⁵⁴	Nephrotoxicity has been reported, ²⁷⁵ especially in snakes; maintain hydration; use with a penicillin or cephalosporin Snakes/PD (gopher snakes) Snakes/PK (blood pythons)

TABLE 4-1 Antimicrobial Agents Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Gentamicin (cont'd)	3 mg/kg IM q > 96h ¹⁸ 6 mg/kg IM q72-96h ³¹⁸ 1.75-2.25 mg/kg IM q72-96h ¹⁷²	Turtles/PD (eastern box turtles; 29°C [84°F]); lower dose may be more appropriate Turtles/PD (red-eared sliders; 24°C, [75°F]) Crocodilians/PK (alligators); respiratory infection
Gentamicin ophthalmic ointment or drops	Topical ¹⁰³	Most species/superficial ocular infection; lesions in oral cavity
Gentamicin/betamethasone ophthalmic drops (Gentocin Durafilm, Merck)	1-2 drops to eye q12-24h ¹⁷⁸	Tortoises/upper respiratory infections; may also be given as a reverse nasal flush q48-72h, or intranasal q12-24h
Kanamycin	10-15 mg/kg IM, IV q24h (or divided doses) ^{79,103}	Most species/24°C (75°F); give with fluid therapy; avoid in cases of dehydration or renal or hepatic dysfunction
Lincomycin	5 mg/kg IM q12-24h ⁷⁹ 10 mg/kg PO q24h ⁷⁹	Most species/wound infection; potentially nephrotoxic; maintain hydration Most species
Marbofloxacin	10 mg/kg PO q48h ⁶⁰	Ball pythons/PD
Metronidazole	20 mg/kg PO q48h × ≥ 7 days ¹⁰⁷ 50 mg/kg PO q24h × 7-14 days ¹⁹⁸ 20 mg/kg PO q48h ^{32,206} 20 mg/kg PO q24-48h ²⁰⁷	Most species/anaerobes Most species/may be administered concurrently with amikacin for broader spectrum; because of potential side effects at this dose, a lower dose may be prudent Snakes/PK (corn and rat snakes) Iguanas/PK; use q24h for resistant anaerobes
Oxytetracycline	6-10 mg/kg PO, IM, IV q24h ^{79,103} 10 mg/kg IM, IV q5d ¹⁴⁵	Most species/may produce local inflammation at injection site Crocodilians/PK (alligators; 27°C [81°F]); mycoplasmosis
Penicillin, benzathine	10,000-20,000 U/kg IM q48-96h ¹⁰⁶	Most species/may use with an aminoglycoside
Penicillin G	10,000-20,000 U/kg SC, IM, IV, ICe q8-12h ¹⁰³	Most species/infrequently used
Piperacillin	50-100 mg/kg IM q24h ^{79,103} 50 mg/kg IM, then 25 mg/kg q24h ^{79,117} 100 mg/kg IM q48h ¹⁵⁵ 100-200 mg/kg SC, IM q24-48h ¹⁷⁴ 100 mg/10 mL saline × 30 min nebulization q12h ²⁷⁸	Most species/broad-spectrum bactericidal agent; maintain hydration; may use with an aminoglycoside Snakes Snakes/PK (blood pythons) Chameleons Most species/pneumonia
Polymyxin B sulfate, neomycin sulfate, bacitracin zinc ointment	Topical ¹¹⁷	All species/rostral abrasions, dermal wounds

Continued

TABLE 4-1 Antimicrobial Agents Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Povidone-iodine solution (0.05%) or ointment	Topical/lavage ^{103,300}	All species/fungal dermatitis; dermatophilosis; contaminated wound; can soak in 0.005% aqueous solution \leq 1 hr q12-24h
Silver sulfadiazine cream (Silvadene, Marion)	Topical q24-72h ²³¹	All species/broad-spectrum antibacterial for skin (i.e., wounds, burns) or oral cavity; dressing is generally not necessary
Streptomycin	10 mg/kg IM q12-24h ¹⁰³	Most species/potentially nephrotoxic; maintain hydration; avoid in cases of dehydration or renal or hepatic dysfunction
Sulfadiazine	25 mg/kg PO q24h ¹¹⁷	Most species/maintain hydration
Sulfadimethoxine	90 mg/kg IM, then 45 mg/kg q24h ¹⁰³	Most species/potentially nephrotoxic; maintain hydration
Ticarillin (Ticar, SmithKline-Beecham)	50-100 mg/kg IM q24h ¹⁰³ 50-100 mg/kg IM, IV q24-48h ²³⁷	Most species/maintain hydration Loggerhead sea turtles/PK
Tobramycin	— 2.5 mg/kg IM q24-72h ⁷⁹ 10 mg/kg IM q24-48h ⁷⁹	Potentially nephrotoxic; maintain hydration; potentiated by β -lactams Most species Chelonians/can be given q48h in tortoises; fluid therapy recommended
Trimethoprim/sulfadiazine or sulfamethoxazole	— 10-30 mg/kg PO q24h ¹¹⁷ 30 mg/kg IM q24h \times 2 days, then q48h ³⁵⁷	Maintain hydration; parenteral form must be compounded Most species/maintain hydration Tortoises/PD
Tylosin	5 mg/kg IM q24h \times 10-60 days ⁷⁹	Most species/mycoplasmosis

^aBecause reptiles are ectothermic, pharmacokinetics of drugs are influenced by ambient temperature. Antimicrobial therapy should be conducted at the upper end of the patient's preferred (selected) optimum temperature zone.

^bSee Table 15-4 for antimicrobial combination therapies, some of which are commonly used in reptiles.

TABLE 4-2 Antiviral Agents Used in Reptiles.

Agent	Dosage	Species/Comments
Acyclovir	40-80 mg/kg PO ⁵	Box turtles/PK, low maximum plasma concentrations; uncertain efficacy
	\geq 80 mg/kg PO q24h ¹⁰⁸	Tortoises/PK; herpesvirus; poor oral absorption
	80 mg/kg PO q8h, or 240 mg/kg PO q24h ²⁵⁸	Tortoises/herpesvirus; uncertain efficacy; unlikely to eliminate infection; combine with supportive care
	80 mg/kg PO q24h ²⁹⁹	Mediterranean tortoises/decreased mortality in those infected with TeHV-3
	80 mg/kg PO q24h ⁶³	Australian Kreff's river turtles/herpesvirus; uncertain efficacy
	Topical (5% ointment) q12h ¹⁰³	All species/antiviral (i.e., herpesvirus-associated dermatitis)

TABLE 4-2 Antiviral Agents Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Chlorhexidine solution	0.5% dilution, topical on oral lesions q24h ¹⁹¹	Tortoises/herpesvirus
Famcyclovir	10-30 mg/kg PO q24h using allometric scaling ³⁴⁸	Eastern box turtles/treated during outbreak of concurrent terHV-1 and ranavirus (FV-3); uncertain efficacy
Valacyclovir	40 mg/kg PO q24h ⁵	Box turtles/PK, effective plasma concentrations compared to humans; uncertain efficacy or toxicity

TABLE 4-3 Antifungal Agents Used in Reptiles.

Agent	Dosage	Species/Comments
Amphotericin B	0.5 mg/kg IV q48-72h ¹⁰⁴	Most species/nephrotoxic; can use in combination with ketoconazole; administer slowly
	0.5-1 mg/kg IV, ICe q24-72h × 14-28 days ⁷⁹	Most species/aspergillosis
	1 mg/kg IT q24h × 14-28 days ¹⁷³	Most species/respiratory infection; dilute with water or saline
	0.1 mg/kg intrapulmonary q24h × 28 days ¹⁴⁷	Greek tortoises/pneumonia
	1 mg/kg q24h ICe × 2-4 wk ²¹⁸ 5 mg/150 mL saline × 1 hr nebulization q12h × 7 days ¹⁶⁹	Crocodylians Most species/pneumonia
Chlorhexidine (Nolvasan 2%, Fort Dodge)	20 mL/g water bath ³⁹⁸	Lizards/dermatophytosis
Clotrimazole (Veltrim, Haver-Lockhart; Otomax, with gentamicin and betamethasone, Schering-Plough)	Topical ³²⁸	Most species/dermatitis; may bathe q12h with dilute organic iodine prior to use
F10 super concentrate disinfectant (Health and Hygiene, Roodeport, S Africa)	1:250 nasal flush, 0.1 mL each nare q24h ⁵²	Terrestrial chelonians/benzalkonium chloride/polyhexamethylene biguanide HCl
Fluconazole	5 mg/kg PO q24h ³⁹⁸	Lizards/dermatophytosis
	21 mg/kg SC once, then 10 mg/kg SC 5 days later ^{136,235}	Loggerhead sea turtles/PK
Griseofulvin	15 mg/kg PO q72h ¹⁷⁵⁻¹⁷⁷	Most species
	20-40 mg/kg PO q72h × 5 treatments ³²⁸	Most species/dermatitis; limited success
Itraconazole	5 mg/kg PO q24h ²⁴⁹	Most species/some hepatotoxicity noted when used for <i>Chrysosporium</i> anamorph of <i>Nannizziopsis vriesii</i> ; can cause anorexia in bearded dragons without evidence of hepatotoxicity ¹¹⁴
	10 mg/kg PO q24h ²⁷¹	Snakes

Continued

TABLE 4-3 Antifungal Agents Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Itraconazole (cont'd)	5 mg/kg PO q24h ¹⁴² 10 mg/kg PO q48h × 60 days ²⁹ 23.5 mg/kg PO q24h ¹¹⁰ 5 mg/kg PO q24h, or 15 mg/kg PO q72h ²³⁸	Panther chameleons Chameleons (Parson's)/osteomyelitis Lizards/PD (spiny lizards); following a 3-day treatment, a therapeutic plasma concentration persists for 6 days beyond peak concentration; treatment interval was not determined Kemp's ridley sea turtles
Ketoconazole	— 15 mg/kg q72h PO ¹⁷⁵⁻¹⁷⁷ 25 mg/kg PO q24h × 21 days ¹⁷⁰ 15-30 mg/kg PO q24h × 14-28 days ^{254,304} 50 mg/kg PO q24h × 14-28 days ¹¹⁷	May use antibiotics concomitantly to prevent bacterial overgrowth; may use concurrently with thiabendazole Most species Snakes, turtles Chelonians/PK (gopher tortoises); systemic infection Crocodilians
Malachite green	0.15 mg/L water × 1 hr bath × 14 days ⁷⁹	Dermatitis
Miconazole (Monistat-Derm, Ortho)	Topical ³²⁸	Most species/dermatitis; may bathe q12h with dilute organic iodine before use
Nystatin	100,000 U/kg PO q24h × 10 days ¹⁶⁹	Most species/enteric yeast infections; limited success
Terbinafine	3.4 mg/kg PO q24h × 15 mo ³⁶⁹ Topical ¹⁸⁶	Aldabra tortoises/severe phaeohyphomycosis of carapace; non-responsive to itraconazole Use in conjunction with oral azoles for <i>Chryso sporium</i> anamorph of <i>Nannizziopsis vriesii</i> ; expect long treatment calendar
Tolnaftate 1% cream (Tinactin, Schering-Plough)	Topical q12h pm ⁴	Most species/dermatitis; may bathe q12h with dilute organic iodine before use
Voriconazole	10 mg/kg per cloacal 3 × /wk × 4 wk ²⁶¹ 10 mg/kg PO × 47 days ^{347,383} 5 mg/kg SC ¹⁶²	Rattlesnakes/ <i>Ophidiomyces ophiodiicola</i> ; crushed in suspension (Ora-Plus, Paddock Laboratories) Bearded dragons for <i>Chryso sporium</i> anamorph of <i>Nannizziopsis vriesii</i> ; possible hepatocellular injury Red-eared sliders/exceeded MIC only until 4 hr postinjection; 26°C (78°F)

TABLE 4-3 Antifungal Agents Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Voriconazole (cont'd)	10 mg/kg SC q12h × 7 days ¹⁶⁷	Red-eared sliders/resulted in trough concentrations considered subtherapeutic in humans but may reach MIC for some reptile fungal isolates; possible side effects seen
Voriconazole (V)/F10 super concentrate disinfectant (F10, Health and Hygiene, Roodeport, S Africa)	(V) 10 mg/kg PO q24h × 60 days + (F10) 1:250 dilution for 20 min bath q24h × 60 days ³³⁵	Luthega skinks/systemic <i>Lecanicillium</i> sp. infection; nonresponsive to oral voriconazole and terbinafine ointment

TABLE 4-4 Antiparasitic Agents Used in Reptiles.

Agent	Dosage	Species/Comments
Albendazole	50 mg/kg PO ¹¹⁷	Most species/ascarids; most toxic of the benzimidazoles
Carbaryl powder (5%)	Lightly dust animal and environment; rinse after 1 hr; repeat in 7 days ^{92,106}	Lizards, snakes/mites
Chloroquine	125 mg/kg PO q48h × 3 treatments ¹¹⁷	Tortoises/hemoprotozoa
Dichlorvos (Vapona No-Pest Strip; United Industries)	6 mm strip/10 ft ³ in cage × 3 hr q48h × 2-4 wk ^{103,400}	Most species/mites; toxicity occurs; ¹⁰⁶ prevent contact with animals (e.g., place strip above cage or inside perforated container); avoid in cases of renal or hepatic dysfunction; remove water container; use is discouraged
Dimetridazole (Emtryl, Rhône- Poulenc)	— 100 mg/kg PO once, repeat in 2 wk ¹¹⁷ 40 mg/kg PO q24h × 5-8 days ¹⁶⁹ 40 mg/kg PO, repeat in 14 days ¹¹⁷	Not available in the United States Most species/amoebae Snakes (except milk and indigo)/amoebae, flagellates Milk and indigo snakes/amoebae; flagellates
Emodepside (1.98%) + praziquantel (7.94%) (Profender, Bayer)	1.12 mL/kg ^{265,337}	Many species/PD; nematodes; cestodes; aquatic turtles must be kept dry for 48 hr after application; appears to be safe, but need more safety and efficacy data
Fenbendazole	— 25-100 mg/kg PO q14d for up to 4 treatments ^{38,169,196} 100 mg/kg once ¹¹³	Drug of choice for nematodes; least toxic of the benzimidazoles; may have an antiprotozoan effect; overdose may cause leukopenia, avoid in septicemic patients ²⁸⁵ All species/nematodes Tortoises/nematodes; shedding of ova continues for 30 days
Fipronil (0.29%; Frontline Spray, Merial)	Wipe on then wash off in 5 min q7-10d pri ^{88,92}	Most species/mites, ticks; beware of reactions to alcohol carrier; needs safety evaluation ¹¹⁷

Continued

TABLE 4-4 Antiparasitic Agents Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Imidocloprid and moxidectin (Advantage multi/Advocate, Bayer)	0.2 mg/kg topical q14d × 3 treatments ¹³⁰	Lizards/eliminated hookworms and pinworms; needs safety and pharmacokinetic evaluation
Ivermectin	— 0.2 mg/kg PO, SC, IM, repeat in 14 days ^{93,117} 5-10 mg/L water topical spray q3-5d up to 28 days ¹⁹⁹	Do not use in chelonians, ³⁷⁷ crocodilians, indigo snakes, or skinks ^{38,117,199} Snakes (except indigos), lizards (except skinks) ³⁸ /nematodes (including lungworms), ²²³ mites; can dilute with propylene glycol for oral use; colored animals may have skin discoloration at injection site; rare adverse effects reported in chameleons, possibly associated with breakdown of parasites; ¹⁶ do not use within 10 days of diazepam or tiletamine/zolazepam; rare death and occasional nervous system signs, lethargy, or inappetence have been reported; ¹⁹⁹ used for pentastomids in monitor lizards (with dexamethasone 0.2 mg/kg q2d) ⁹³ Snakes (except indigos), lizards (except skinks)/mites; less effective than fipronil; spray on skin and in newly cleaned cage, then allow to dry before replacing water dish
Levamisole (Levasole 13.65%, Mallinckrodt)	5-10 mg/kg SC, I/Ce, repeat in 14 days ^{16,117,169}	Most species/lungworms; 5 mg/kg in chelonians; 10 mg/kg in lizards, snakes; very narrow range of safety; main advantage is that it can be administered parenterally; avoid concurrent use with chloramphenicol; avoid use in debilitated animals; low dose may stimulate depressed immune system; can be used IM, but less effective
Mebendazole	20-25 mg/kg PO, repeat in 14 days pm ¹⁶⁹	Most species/strongyles, ascarids, effective dosage of 400 mg/kg; ²⁰⁸ may be toxic
Metronidazole	— 40-100 mg/kg PO, repeat in 10-14 days ¹⁰³ 20 mg/kg PO q48h ³² 40 mg/kg PO, repeat in 14 days ^{106,169}	Protozoan (i.e., flagellates, amoebae) overgrowth; may stimulate appetite; may cause severe neurologic signs at doses >200 mg/kg; ²⁷² death occurred in indigo and mountain king snakes at 100 mg/kg; ¹⁶⁹ injectable form can be administered PO; oral suspension is not available in the United States, but can be compounded Most species/flagellate overgrowth Corn snakes/PK; 28°C (82°F); protozoa Uracoan rattler, milk, tricolor king, and indigo snakes/flagellates

TABLE 4-4 Antiparasitic Agents Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Metronidazole (cont'd)	40-60 mg/kg PO q7d × 2-3 doses ³⁶⁴ 40-200 mg/kg PO, repeat in 14 days ²⁶⁸ 20 mg/kg ICe q48h ¹⁶¹ 25 mg/kg PO q24h × 5 days ¹¹⁷	Chameleons/flagellates; amoebae Geckos/ocular lesions (40 mg/kg) and subcutaneous lesions (200 mg/kg) caused by <i>Trichomonas</i> Red-eared sliders/PK; ICe administration not recommended; needs further safety evaluation Chelonians/amoebiasis
Milbemycin	0.25-0.5 mg/kg SC prn ³¹	Chelonians/nematodes; parenteral form is not commercially available in United States; fenbendazole preferred
Nitrofurazone	25.5 mg/kg PO ³⁹³	Most species/coccidia; seldom used
Olive oil	Coat skin q7d ^{16,92}	Most species, especially small, delicate lizards/mites; wash animal with mild soap (and rinse well) the next day; messy to use; environment must be treated with acaricide
Oxfendazole (Benzelmin, Fort Dodge)	66 mg/kg PO once ¹¹³	Most species/nematodes; may be repeated after 28 days prn
Paromomycin (Humatin, Parke Davis)	35-100 mg/kg PO q24h × ≤ 28 days ^{103,169} 100 mg/kg PO q24h × 7 days, then 2×/wk × 3 mo ⁶⁴ 300-360 mg/kg PO q48h × 14 days ³⁰⁵ 300-800 mg/kg PO q24h prn ⁵⁸ 360 mg/kg PO q48h × 10 days ¹²⁹	Most species/amoebae Snakes/cryptosporidia; reduced clinical signs and oocyte shedding; does not eliminate the organism Lizards (gila monsters)/cryptosporidia Geckos/cryptosporidia; reduced clinical signs; does not eliminate the organism Bearded dragons/intestinal cryptosporidia
Permethrin (Provent-a-Mite, Pro Products)	Environmental treatment, 1 sec of spray/ft ² ; wait until dry before returning animal to enclosure ⁹² Topical ⁹²	Lizards, snakes/mites; ticks; FDA approved; safe and effective; wash immediately if accidentally applied to skin Tortoises/ticks
Piperazine	40-60 mg/kg PO, repeat in 14 days ²⁰⁸ 100-200 mg/kg PO ¹⁵⁹	Most species/strongyles, ascarids; poor efficacy at <400 mg/kg ²⁰⁸ Crocodilians
Ponazuril	30 mg/kg PO q48h × 2 treatments ^{33,273}	Bearded dragons/coccidiosis
Praziquantel	— 8 mg/kg PO, SC, IM, repeat in 14 days ^{16,117,174} 25-50 mg/kg PO q3h × 3 treatments ^{2,171}	See also emodepside Most species/cestodes, trematodes; higher dosages have been administered ¹⁰⁶ Sea turtles (green, loggerhead)/PD; spirorchidiasis

Continued

TABLE 4-4 Antiparasitic Agents Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Pyrantel pamoate	5 mg/kg PO, repeat in 14 days ¹⁹⁹	Most species/nematodes
	25 mg/kg PO q24h × 3 days; repeat in 3 wk ¹⁰⁶	Most species/ascarids, hookworms, pinworms
Pyrethrin spray (0.09%)	Topical q7d × 2-3 treatments ⁹²	Most species/use water-based sprays labeled for kittens and puppies; apply with cloth; can also spray cage, wash out after 30 min; use sparingly and with caution; pyrethroids are safer (see permethrin, resmethrin)
Quinacrine (Atabrine, Winthrop)	19-100 mg/kg PO q48h × 14-21 days ³⁹³	Most species/some hematozoa
Quinine sulfate	75 mg/kg PO q48h × 14-28 days ³⁹³	Most species/some hematozoa; toxic at >100 mg/kg q24h; ineffective against exoerythrocytic forms
Spiramycin (Spirasol, May and Baker)	160 mg/kg PO q24h × 10 days, then 2×/wk × 3 mo ⁶⁴	Snakes/cryptosporidia; may reduce clinical signs and oocyte shedding; does not eliminate the organism
Sulfadiazine, sulfamerazine	—	Most species/coccidia; avoid sulfa drugs in cases of dehydration, urinary calculi, or renal dysfunction ²⁷²
	75 mg/kg PO, then 45 mg/kg q24h × 5 days ^{103,393}	Most species/coccidia
	25 mg/kg PO q24h × 21 days ^{16,393}	Snakes, lizards/coccidia
Sulfadimethoxine	50 mg/kg PO q24h × 3-5 days, then q48h prn ¹⁹⁹	Most species/coccidia; ensure adequate hydration and renal function
	90 mg/kg PO, IM, IV, then 45 mg/kg q24h × 5-7 days ^{103,169,393}	Most species/coccidia
	50 mg/kg PO q24h × 21 days ³⁸⁴	Bearded dragons/coccidia
Sulfadimidine (33% solution)	0.3-0.6 mL/kg PO q24h × 10 days ³⁹³	Most species/coccidia; alternatively, 0.3-0.6 mL/kg, then 0.15-0.3 mL/kg q24h × 10 days
	1 oz/gal drinking water × 10 days ³⁹³	Most species/coccidia
Sulfamethazine	25 mg/kg PO, IM q24h × 21 days ³⁹³	Most species/coccidia
	50 mg/kg PO q24h × 3 days, off 3 days, on 3 days ¹¹⁷	Most species/coccidia
	75 mg/kg PO, IM, IV, then 40 mg/kg q24h × 5-7 days ¹⁶⁹	Most species/coccidia; ensure adequate hydration and renal function
Sulfaquinoxaline	75 mg/kg PO, then 40 mg/kg q24h × 5-7 days ¹⁶⁹	Most species/coccidia
Thiabendazole	50-100 mg/kg PO, repeat in 14 days ^{104,169}	Most species/nematodes; fenbendazole preferred
Toltrazuril 5% (Baycox, Bayer)	5-15 mg/kg q24h × 3 days ⁸³	Bearded dragons/coccidiosis
	15 mg/kg q48h × 30 days ¹¹⁸	Tortoises/coccidiosis; needs safety, efficacy, and pharmacokinetic study
Trimethoprim/sulfa	—	Most species/coccidia; avoid potentiated sulfa drugs in cases of dehydration or renal dysfunction ²⁷²

TABLE 4-4 Antiparasitic Agents Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Trimethoprim/sulfa (cont'd)	30 mg/kg PO q24h × 2 days, then q48h × 21 days ^{16,393}	Most species/coccidia
	30 mg/kg IM q24h × 2 days, then 15 mg/kg IM q48h × 10-28 days ³⁹³	Most species/coccidia
	30 mg/kg PO q24h × 14 days, then 1-3 ×/wk × 3-6 mo ⁶⁴	Most species/cryptosporidia; can reduce shedding but does not clear infection
Water	Bath × 30 min ^{92,228}	Snakes, lizards/mites; use lukewarm (29°C [85°F]) water; monitor to avoid drowning; not 100% effective; does not kill mites on head; must treat environment with acaricide

TABLE 4-5 Chemical Restraint/Anesthetic Agents Used in Reptiles.

Agent	Dosage	Species/Comments
Acepromazine	0.05-0.25 mg/kg IM ¹¹⁷	Most species/can be used as a preanesthetic with ketamine
	0.1-0.5 mg/kg IM ^{269,303}	Most species/preanesthetic; reduce by 50% if used with barbiturates
Acepromazine (A)/propofol (P)	(A) 0.5 mg/kg IM + (P) 5 mg/kg IV; (A) 0.5 mg/kg IM + (P) 10 mg/kg IV ⁶	Giant Amazon pond turtles/sedation with both protocols, longer duration with higher propofol dosage
Alphaxalone (Alfaxan, Jurox)	6-9 mg/kg IV, or 9-15 mg/kg IM ²¹⁶	Most species/good muscle relaxation; variable results; drug requires more evaluation; may have violent recovery; ¹⁹ don't use within 10 days of DMSO treatment
	6-15 mg/kg IM, IV ³⁴⁴	Most species
	9 mg/kg IV ³³⁶	Snakes, lizards/induction; not effective for blotched blue-tongued skinks
	15 mg/kg IM ²⁶⁹	Lizards, chelonians/induction, 35-40 min; duration, 15-35 min; good muscle relaxation; variable results
	24 mg/kg ICe ¹³¹	Chelonians (red-eared sliders)/surgical anesthesia with good relaxation
	5 mg/kg IV ²⁰¹ 10-20 mg/kg IM ^{133,193,346}	Turtles, tortoises/induction Horsfield's tortoises (males only)/light to moderate sedation with no to minimal analgesia; red-eared slider turtles/light sedation of short duration; PD turtles administered 10 mg/kg at low temperature more relaxed than warm and turtles administered 20 mg/kg at warm temperature were most relaxed

Continued

TABLE 4-5 Chemical Restraint/Anesthetic Agents Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Alfaxalone (Alfaxan, Jurox) (cont'd)	20 mg/kg IM ¹⁶⁶ 3 mg/kg IV ²⁹⁶	Red-eared slider turtles, Eastern painted turtles, yellow-spotted Amazon river turtles, other undocumented turtle species/ anesthetic induction Crocodilians/induction, but unpredictable results
Alfaxalone (Al)/ medetomidine (Me)	(Al) 10 mg/kg + (Me) 0.10 mg/kg IM; (Al) 20 mg/kg + (Me) 0.05 mg/kg IM ¹³³	Horsfield's tortoises (males only)/ deeper sedation than alfaxalone alone with analgesia
Atipamezole (Antisedan, Zoetis)	Give same volume SC, IV, IP as medetomidine, or dexmedetomidine (5 × medetomidine, or 10 × dexmedetomidine dose in mg) ^{a,95,355} 0.2-0.5 mg/kg IM ⁹⁴ 0.5-0.75 mg/kg IM, ³¹⁹ 0.75 mg/kg SC ²⁴⁴	Most species/medetomidine and dexmedetomidine reversal; causes severe hypotension in gopher tortoises when given IV ⁶⁹ Chelonians/shell repair 5-10 min before finished Chelonians
Atropine	0.01-0.04 mg/kg SC, IM, ³⁴ IV, ¹⁰⁴ ICe ³⁴¹ 0.5 mg/kg IM, IV, IT, IO ²⁷²	Most species/preanesthetic; bradycardia; rarely indicated; generally use only in profound or prolonged bradycardia; ³⁴¹ may help prevent intracardiac shunting; ¹⁷⁵ ineffective at this dose in green iguanas ³⁰² Most species/bradycardia, decrease secretions, CPR
Bupivacaine (0.5%)	1 mg/kg intrathecal ²⁴⁰ 0.1 mL/10 cm carapace ¹⁷	Turtles and tortoises/spinal anesthesia Green sea turtles/spinal anesthesia
Butorphanol	— 0.4-1 mg/kg SC, IM ³⁴¹ 0.5-2 mg/kg IM, or 0.2-0.5 mg/kg IV, IO ²⁴ 1-1.5 mg/kg SC, IM ³⁴¹ 0.2 mg/kg IM ^{139,319}	Butorphanol combinations follow; see ketamine for combinations; inadequate for analgesia Most species/sedation; preanesthetic Most species/preanesthetic Lizards/administer 30 min prior to isoflurane for smoother, shorter induction Chelonians/minimal sedation
Butorphanol (B)/medetomidine (Me) ^a	(B) 0.4 mg/kg + (Me) 0.08 mg/kg IM ¹¹²	Green tree monitors/sedation
Butorphanol (B)/midazolam (Mi)	(B) 0.4 mg/kg + (Mi) 2 mg/kg IM ²³	Most species/preanesthetic; administer 20 min before induction
Dexmedetomidine ^a (Dexdomitor, Zoetis)	—	Dexmedetomidine combinations follow; α_2 agonist that has replaced medetomidine; ^a reverse with atipamezole
Dexmedetomidine (De)/ketamine (K)	(De) 0.03 mg/kg + (K) 6 mg/kg IV ¹³⁷	Hatchling leatherback sea turtles/ anesthesia; reversal with atipamezole (0.3 mg/kg IM, IV)

TABLE 4-5 Chemical Restraint/Anesthetic Agents Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Dexmedetomidine (De)/midazolam (Mi)/ketamine (K)	(De) 0.1 mg/kg + (Mi) 1 mg/kg + (K) 2 mg/kg SC ²⁴⁵	Red-eared slider turtles/deep sedation
Dexmedetomidine (De)/ketamine (K)/morphine (Mo)	(De) 0.075 mg/kg + (K) 8 mg/kg + (Mo) 1 mg/kg IM ²⁶³	Gopher tortoises/anesthesia, reversed with atipamezole
Dextroketa mine (DK)	10 mg/kg IV, ICe ¹⁵⁶	Spectacled caiman/mild sedation ICe; PK
Dextroketa mine (DK)/midazolam (Mi)	(Mi) 0.5 mg/kg + (DK) 10 mg/kg IV, ICe ¹⁵⁶	Spectacled caiman/deep sedation IV; PK; no analgesia
Diazepam	— 0.5 mg/kg IM, IV ²⁷² 2.5 mg/kg IM, IV ³²⁹ 0.2-0.8 mg/kg IM ³⁴¹ 0.2-2 mg/kg IM, IV ³⁴⁴ 2.5 mg/kg PO ³⁴¹ 0.2-1 mg/kg IM ^{341,344}	Diazepam has been replaced by the use of midazolam in many cases; see ketamine for combinations; muscle relaxation; give 20 min prior to anesthesia; potentially reversible with flumazenil; drug interaction with ivermectin All species/seizures Most species/seizures Snakes/use in conjunction with ketamine for anesthesia with muscle relaxation Snakes, lizards Iguanas/reduce anxiety which often leads to aggression Chelonians/use in conjunction with ketamine for anesthesia with muscle relaxation
Disoprofol	5-15 mg/kg IV to effect ³⁷	All species/anesthesia; similar characteristics to propofol; not available in United States
Doxapram	4-12 mg/kg IM, IV ³⁴¹ 5 mg/kg IM, IV ²³ q10min prn 20 mg/kg IM, IV, IO ²⁷² 5-10 mg/kg IV ³⁴⁹	Most species/respiratory stimulant Most species/respiratory stimulant; reduces recovery time; reported to partially "reverse" effects of dissociatives ²¹⁷ Most species/respiratory stimulant American alligators/immediate dose-dependent increase in breathing frequency
Epinephrine (1:1000)	0.5-1 mg/kg IV, IO, IT ²⁷² 0.1 mg/kg IM ¹²⁵	Most species/CPR, cardiac arrest Snapping turtles/reduction in time to spontaneous respiration after isoflurane anesthesia
Etorphine (M-99, Wildlife Pharmaceuticals)	0.3-0.5 mg/kg IM ²⁶⁹ 0.3-2.75 mg/kg IM ²¹⁶	Crocodylians, chelonians/very potent narcotic; crocodylians: induction, 5-30 min; duration, 30-180 min; chelonians: induction, 10-20 min; duration, 40-120 min; not very effective in reptiles other than

Continued

TABLE 4-5 Chemical Restraint/Anesthetic Agents Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Etorphine (M-99, Wildlife Pharmaceuticals) (cont'd)		alligators; ³⁰³ poor relaxation; adequate for immobilization and minor procedures; requires an antagonist; limited use because of expense and legal restrictions
Flumazenil (Romazicon, Hoffman-LaRoche)	— 0.05 mg/kg IM, SC, IV ²⁴¹ 1 mg/20 mg of zolazepam ²²⁰ IM, IV ³¹⁹	All species/reversal of benzodiazepines, including diazepam and midazolam; seldom indicated All species/reversal of midazolam; extrapolated from mammals and birds Crocodilians, chelonians/reversal of zolazepam
Fospropofol	25-50 mg/kg ICe ³⁴⁰	Red-eared slider turtles/muscle relaxation and immobility especially at higher dosage, but prolonged recovery, and profound respiratory depression with resuscitation in 2/8 subjects; use with caution
Gallamine (Flaxedil, American Cyanamid)	0.4-1.25 mg/kg IM ²⁰ 0.6-4 mg/kg IM ²²¹ 0.7 mg/kg IM ²⁷⁶ 1.2-2 mg/kg IM ⁹⁵ 0.5-2 mg/kg IM ²¹¹	Crocodiles/results in flaccid paralysis, but no analgesia; larger animals require lower dosage; reverse with neostigmine; ²²¹ use in alligators questionable; unsafe in alligators at ≥ 1 mg/kg, ³⁰³ deaths reported in American alligators and false gharials ²¹⁸ Crocodilians
Glycopyrrolate	0.01 mg/kg SC, ³⁴ IM, IV ²³	Most species/preanesthetic; for excess oral or respiratory mucus; rarely indicated; generally use only in profound or prolonged bradycardia; may be preferable to atropine; ¹⁰⁴ does not work at this dose in green iguanas ³⁰²
Haloperidol	0.5-10 mg/kg IM q7-14d ³⁶⁷	Boids/aggression management
Hyaluronidase (Wydase, Wyeth)	25 U/dose SC ²²⁰	Crocodilians/combine with premedication, anesthetic, or reversal drugs to accelerate SC absorption
Isoflurane	3%-5% induction, ¹⁷³ 1%-3% maintenance ³⁸ 3% in 100% O ₂ and 21% O ₂ ²⁹²	Most species/inhalation anesthetic of choice in reptiles; induction, 6-20 min; recovery, 30-60 min; not as smooth in reptiles compared to other animals; intubation and intermittent positive pressure ventilation advisable; may preanesthetize with low dose propofol, ketamine, etc. Bearded dragons/trend toward shorter induction and recovery with 21% O ₂ group compared to use of 100% O ₂

TABLE 4-5 Chemical Restraint/Anesthetic Agents Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Isoflurane (cont'd)	5% via chamber in 5 L/min O ₂ ¹⁵³	Green iguanas/15-35 min loss of righting reflex; mean MAC, 1.62%; pH 7.49
Ketamine	—	Ketamine combinations follow; muscle relaxation and analgesia may be marginal; prolonged recovery with higher doses; larger reptiles require lower dose; painful at injection site; safety is questionable in debilitated patients; avoid use in cases with renal dysfunction; snakes may be permanently aggressive after ketamine anesthesia; ¹⁹ generally recommend use only as a preanesthetic prior to isoflurane for surgical anesthesia
	10 mg/kg SC, IM q30min ³⁴	Most species/maintenance of anesthesia; recovery, 3-4 hr
	20-60 mg/kg IM, or 5-15 mg/kg IV ¹¹⁷	Most species/muscle relaxation improved with midazolam or diazepam
	22-44 mg/kg SC, IM ^{19,20}	Most species/sedation
	55-88 mg/kg SC, IM ²⁰	Most species/surgical anesthesia; induction, 10-30 min; recovery, 24-96 hr
	10-20 mg/kg IM ^{271,272}	Snakes, chelonians/sedation
	20-60 mg/kg SC, IM ^{34,180}	Snakes/sedation; induction, 30 min; recovery, 2-48 hr
	60-80 mg/kg IM ³⁸	Snakes/light anesthesia; intermittent positive pressure ventilation may be needed at higher doses
	5-10 mg/kg ^{271,341}	Lizards, snakes/decreases the incidence of breath-holding during chamber induction
	20-30 mg/kg IM ³⁰	Iguanas/sedation (i.e., facilitates endotracheal intubation); preanesthetic; requires lower dose than other reptiles
	30-50 mg/kg SC, IM ^{34,180}	Lizards/sedation; variable results
	20-60 mg/kg IM ^{157,180,303}	Chelonians/sedation; induction, 30 min; recovery, ≥24 hr; potentially dangerous in dehydrated and debilitated tortoises
	25 mg/kg IM, IV ¹¹⁷	Sea turtles/sedation; used at higher doses (50-70 mg/kg); recovery times may be excessively long and unpredictable; combination of ketamine and acepromazine gives a more rapid induction and recovery
38-71 mg/kg ICe ³⁹⁹	Green sea turtles/anesthesia; induction, 2-10 min; duration, 2-10 min; recovery, <30 min	

Continued

TABLE 4-5 Chemical Restraint/Anesthetic Agents Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Ketamine (cont'd)	60-90 mg/kg IM ^{180,269}	Chelonians/light anesthesia; induction, <30 min; recovery, hours to days; requires higher doses than most other reptiles
	20-40 mg/kg SC, IM, ICe (sedation), to 40-80 mg/kg (anesthesia) ²²⁰	Crocodylians/induction, <30-60 min; recovery, hours to days; in larger animals, 12-15 mg/kg may permit tracheal intubation; ³⁴¹ not recommended alone in Nile crocodiles ²¹¹
	20-100 mg/kg IM ²¹⁸	Crocodylians/lower dose for sedation, higher for anesthesia (requires intermittent positive pressure ventilation for hours)
Ketamine (K)/butorphanol (B)	See (K) dosages + (B) ≤ 1.5 mg/kg IM ³⁴¹	Snakes/anesthesia with improved muscle relaxation
	(K) 10-30 mg/kg + (B) 0.5-1.5 mg/kg IM ³⁴¹	Chelonians/minor surgical procedures (i.e., shell repair)
Ketamine (K)/dexmedetomidine (De)	(K) 5-7 mg/kg + (De) 0.025-0.07 mg/kg IV ¹⁶⁶	Red-eared slider turtles, Eastern painted turtles, yellow-spotted Amazon river turtles, other undocumented turtle species/anesthetic induction
	(K) 10 mg/kg + (De) 0.05 mg/kg IM, IV ^{311,312}	Desert tortoises/premedication
Ketamine (K)/diazepam (D)	See (K) dosages + (D) 0.2-0.8 mg/kg IM ³⁴¹	Snakes/anesthesia with improved muscle relaxation
	(K) 60-80 mg/kg ²⁶⁹ + (D) 0.2-1 mg/kg IM ³⁴¹	Chelonians/anesthesia; muscle relaxation
Ketamine (K)/medetomidine (M) ^a	—	Medetomidine is no longer commercially available, but can be compounded; ^a reverse medetomidine with atipamezole
	(K) 10 mg/kg + (M) 0.1-0.3 mg/kg IM ⁸⁰	Most species
	(K) 5-10 mg/kg + (M) 0.1-0.15 mg/kg IM, IV ¹⁴¹	Lizards (iguanas)
	(K) 3-8 mg/kg + (M) 0.025-0.08 mg/kg IV ²²²	Giant tortoises (Aldabra)
	(K) 4 mg/kg + (M) 0.04 mg/kg IM ¹⁴⁴	Green sea turtles
	(K) 4-10 mg/kg + (M) 0.04-0.14 mg/kg IM ⁹⁴	Chelonians/sedation and muscle relaxation for shell repair
	(K) 5 mg/kg + (M) 0.05 mg/kg IV ⁵¹	Loggerhead sea turtles/induction of anesthesia for intubation
	(K) 5 mg/kg + (M) 0.05 mg/kg IM ²⁹¹	Tortoises (gopher)/light anesthesia; tracheal intubation; inconsistent results
	(K) 5-10 mg/kg IM + (M) 0.1-0.15 mg/kg IM, IV ¹⁴¹	Tortoises (small-medium)
(K) 7.5 mg/kg + (M) 0.075 mg/kg IM ²⁹¹	Tortoises (gopher)/anesthesia; tracheal intubation	

TABLE 4-5 Chemical Restraint/Anesthetic Agents Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Ketamine (K)/medetomidine (M) ^a (cont'd)	(K) 10 mg/kg + (M) 0.1 mg/kg IM ²⁰⁰	Hybrid Galapagos tortoises/sedation
	(K) 10-20 mg/kg IM + (M) 0.15-0.3 mg/kg IM, IV ¹⁴¹	Turtles (fresh water)
	(K) 5-10 mg/kg + (M) 0.1-0.15 mg/kg IM ¹⁴³	Alligators/adults
	(K) 10-15 mg/kg + (M) 0.15-0.25 mg/kg IM ¹⁴³	Alligators/juveniles
Ketamine (K)/medetomidine (Me)/midazolam (Mi)	(K) 5 mg/kg + (Me) 0.15 mg/kg + (Mi) 1 mg/kg SC ²⁴³	Leopard tortoises/deep sedation
Ketamine (K)/medetomidine (Me)/morphine (Mo)	(K) 2.5 mg/kg + (Me) 0.15 mg/kg + (Mo) 1 mg/kg SC ²⁴⁴	African spurred tortoises/deep sedation and analgesia
Ketamine (K)/midazolam (Mi)	(K) 20 mg/kg + (Mi) 2 mg/kg IM, (K) 60 mg/kg + (Mi) 2 mg/kg IM ⁷	Giant Amazon river turtles/sedation with both combinations; more rapid and prolonged sedation with higher K dosage
	(K) 20-40 mg/kg + (Mi) ≤ 2 mg/kg IM ³⁰	Chelonians/sedation; muscle relaxation
	(K) 60-80 mg/kg ²⁶⁹ + (Mi) ≤ 2 mg/kg IM ³⁴¹	Chelonians/anesthesia; muscle relaxation
Ketamine (K)/propofol (P)	(K) 25-30 mg/kg IM ²⁶⁹ + (P) 7 mg/kg IV ³¹³	Chelonians/administer propofol \approx 70-80 min post-ketamine; see propofol
Ketamine (K)/xylazine (X)	(K) 30 mg/kg + (X) 1 mg/kg IM ⁴⁷	Broad-snouted caiman juveniles/ provided mild sedation after either forelimb or hind limb administration
Lidocaine (0.5%-2%)	Local or topical ³⁴¹	Most species/local analgesia; infiltrate to effect (e.g., 0.01 mL 2% lidocaine used for local block for IO catheter placement in iguanas); ²¹ often used in conjunction with chemical immobilization
	0.158 mg/cm intrathecal (combined with epinephrine hemitartrate) ³³³	Green iguana/spinal anesthesia
	2 mg/kg intrathecal (IT) ²⁴⁰	Turtles and tortoises/surgical analgesia/anesthesia of caudal body
	0.038 mL/kg (1 mL/20-25 kg) ³²⁴	Hybrid Galapagos tortoises/surgical analgesia/anesthesia for phallectomy
Medetomidine ^a	—	Medetomidine is no longer commercially available, but can be compounded; ^a reverse with atipamezole; produces poor immobilization alone; see ketamine and butorphanol for combinations
	0.1-0.15 mg/kg IM ²³	Most species
	0.06-0.15 mg/kg ³⁴²	Lizards
	0.15 mg/kg IM ^{354,355}	Desert tortoises, crocodilians/sedation; incomplete immobilization; generally produces bradycardia and bradypnea

Continued

TABLE 4-5 Chemical Restraint/Anesthetic Agents Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Medetomidine ^a (cont'd)	0.04-0.15 mg/kg IM ²¹⁸ 0.13-0.17 mg/kg IM ^{294,295} 0.5-0.75 mg/kg IM ^{294,295}	Crocodylians/need to reverse Crocodylians/moderate sedation/ atipamezole (0.1 mg/kg IM) for reversal Crocodylians/sedation only when administered in thoracic limb (versus pelvic limb and tail), with atipamezole (2.5 mg/kg) reversal
Meperidine (Mp)/ Midazolam (Mi)	(Mp) 1 mg/kg + (Mi) 1 mg/kg IM ¹⁷	Green sea turtles/premedication
Methohexital (Brevital, Lilly)	— 5-20 mg/kg SC, ²⁰ IV ¹⁰⁴ 9-10 mg/kg SC, ²⁸⁷ ICe	Recovery time of red-sided garter snakes at 21°C (70°F), 125 min; 26°C (79°F), 86 min; 31°C (88°F), 64 min; thinner snakes had longer recovery times; if within 5 wk of parturition, mean recovery time 2 × as long as nongravid; time postfeeding had no effect at 1, 3, 10 days ³⁰⁹ Most species/induction, 5-30 min; recovery, 1-5 hr; use at 0.125%-0.5% concentration; much species variability; decrease dose 20%-30% for young animals; avoid use in debilitated animals Colubrids/induction, ≥22 min; recovery, 2-5 hr; does not produce soft-tissue irritation seen with other barbiturates; may need to adjust dosage in obese snakes
Metomidate	10 mg/kg IM ^{80,334}	Snakes/profound sedation; not available in the United States
Midazolam	— 0.1-1 mg/kg ¹² 2 mg/kg IM ^{19,20} 0.5-2 mg/kg ³⁴² 1.5 mg/kg IM ²⁹⁸ 2-3 mg/kg IV ¹³⁷	See butorphanol, ketamine for combinations; can be reversed by flumazenil Multiple species/mild to moderate sedation Most species/preanesthetic; increases the efficacy of ketamine; effective in snapping turtles, not in painted turtles ²⁰ Lizards Turtles (red-eared sliders)/sedation; onset, 5.5 min; duration, 82 min; recovery, 40 min; much individual variability Hatchling leatherback sea turtles/ sedation
Naloxone	0.04-2 mg/kg SC ^{350,353} 4 mg/kg IM ¹¹²	Corn snakes, bearded dragons, red- eared sliders/μ-opioid agonist reversal Green tree monitors/reversal of butorphanol

TABLE 4-5 Chemical Restraint/Anesthetic Agents Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Neostigmine	0.03-0.25 mg/kg IM ²²¹ 0.063 mg/kg IV ²²¹ 0.07-0.14 mg/kg IM ²⁷⁶	Crocodiles/gallamine reversal; may cause emesis and lacrimation; fast 24-48 hr before use; effects enhanced if combined with 75 mg hyaluronidase per dose when administered SC, IM ²²¹
Pentobarbital	— 15-30 mg/kg ICe ²⁶⁹ 10-18 mg/kg ICe ²⁶⁹ 7.5-15 mg/kg ICe, or 8 mg/kg IM ^{19,269}	Rarely used as an anesthetic agent in reptiles Snakes/induction, 30-60 min; duration, ≥ 2 hr; prolonged recovery (risk of occasional fatalities); venomous snakes require twice as much as nonvenomous snakes; ¹⁹ avoid use in lizards Chelonians Crocodilians
Propofol	— 0.3-0.5 mg/kg/min IV, IO constant rate infusion, or 0.5-1 mg/kg IV, IO periodic bolus ³⁴⁴ 5-10 mg/kg IV, intracardiac ^{10,334} 10 mg/kg intracardiac ²⁶² 15 mg/kg IV ²⁸ 3-5 mg/kg IV, IO ^{140,141} 5-10 mg/kg IV, IO ²⁵	If administered in supravertebral sinus, be aware of potential submeningeal delivery; ³¹⁴ see ketamine for combination; anesthesia; rapid, smooth induction; may give 15-25 min anesthesia and restraint in most species; rapid, excitement-free recovery; must be administered IV (slowly; no inflammation if goes perivascularly); may be administered IO; dosages may be reduced by as much as 50% in premedicated (e.g., ketamine) animals; may cause apnea and bradycardia; intubation and assisted ventilation generally required; considered by many to be parenteral agent of choice for inducing anesthesia Most species/maintenance anesthesia; must provide respiratory and thermal support Snakes Ball pythons/anesthetic induction for isoflurane maintenance, but prolonged recovery; mild, resolving cardiac lesions South American rattlesnakes/ anesthetic induction Lizards (iguanas)/intubation and minor diagnostic procedures; may need to give an additional dose in 3-5 min; less cardiopulmonary depression than with higher doses Iguanas/higher dose is recommended for induction for short-duration procedures or intubation

Continued

TABLE 4-5

Chemical Restraint/Anesthetic Agents Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Propofol (cont'd)	10 mg/kg IV, IO ^{25,80,282} 2 mg/kg IV ²³ 3-5 mg/kg IV supravertebral sinus ⁹⁴ 5 mg/kg IV ¹²⁵ 10 mg/kg IV (supravertebral sinus) ⁴⁰⁶ 12-15 mg/kg IV ^{77,365} 20 mg/kg IV (supravertebral sinus) ⁴⁰⁶ 10-15 mg/kg IV ²²⁰	Lizards, snakes/0.25 mg/kg/min may be given for maintenance; ¹¹⁷ green iguanas/anesthetic induction ²⁸² Giant tortoises Chelonians/sedation (i.e., shell repair) Snapping turtles/anesthetic induction Red-eared sliders/40-85 min anesthesia Chelonians/lower dosages (5-10 mg/kg IV ³⁴¹) may be used; 1 mg/kg/min may be given for maintenance ³⁴¹ Red-eared sliders/60-120 min anesthesia Crocodilians/duration, 0.5-1.5 hr; maintain on gas anesthetics; experimental IM with hyaluronidase
Rocuronium (Zemuron, Organon)	0.25-0.5 mg/kg IM ¹⁸⁵	Box turtles/neuromuscular blocking agent; no analgesia; for intubation only and small, nonpainful procedures
Sevoflurane	To effect ^{16,326}	Most species/anesthesia; rapid induction and recovery when intubated
Succinylcholine	— 0.25-1 mg/kg IM ¹⁷³ 0.75-1 mg/kg IM ³⁴ 0.25-1.5 mg/kg IM ³⁰³ 0.5-1 mg/kg IM ³⁵ 0.25 mg/kg IM ²¹¹ 0.4-1 mg/kg IM ³⁰³ 0.5-5 mg/kg IM ^{20,218}	No analgesia; narrow margin of safety; generally not recommended, but included for completeness; intermittent positive pressure ventilation generally required; paralysis occurs in 5-30 min; avoid if exposed to organophosphate parasiticides within last 30 days; administer minimal amount required to perform procedure Most species Large lizards Chelonians/induction, 15-30 min; recovery, 45-90 min; facilitates intubation Box turtles/induction, 20-30 min Crocodilians Alligators/rapid onset; 3-5 mg/kg in smaller animals have been used Crocodilians/variable induction and recovery periods
Thiopental	19-31 mg/kg IV ³⁹⁹	Green sea turtles/anesthesia; induction, 5-10 min; recovery, <6 hr; erratic anesthesia
Tiletamine/zolazepam (Telazol, Fort Dodge)	—	Sedation, anesthesia; severe respiratory depression possible (may need to ventilate); ³⁸ variable results; may have prolonged recovery; use lower end of dose range in heavier species; good for muscle relaxation prior to intubation; ^{96,319} other anesthetic agents may be preferable

TABLE 4-5 Chemical Restraint/Anesthetic Agents Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Tiletamine/ zolazepam (Telazol, Fort Dodge) (cont'd)	4-5 mg/kg SC, IM ²⁰	Most species/sedation; induction, 9-15 min; recovery, 1-12 h; adequate for most noninvasive procedures
	5-10 mg/kg IM ²³	Most species
	3 mg/kg IM ¹⁴¹	Snakes/facilitates handling and intubation of large snakes; induction, 30-45 min; prolongs recovery
	3-5 mg/kg IM ²⁷²	Snakes, lizards/sedation
	10-30 mg/kg IM ²⁶⁹ to 20-40 mg/kg IM ^{173,339}	Snakes, lizards/induction, 8-20 min; recovery, 2-10 hr; variable results; longer sedation and recovery times at 22°C (72°F) than at 30°C (86°F); ³⁶⁸ good sedation in boa constrictors at 25 mg/kg IM; ³⁶⁸ generally need to supplement with inhalation agents for surgical anesthesia; some snakes died at 55 mg/kg
	3.5-14 mg/kg IM ²⁶⁹ (generally 4-8 mg/kg)	Chelonians/sedation; induction, 8-20 min; does not produce satisfactory anesthesia even at 88 mg/kg ³⁰³
	5-10 mg/kg IM, IV ³⁴¹	Large tortoises/facilitates intubation; if light, mask with isoflurane rather than redosing
	1-2 mg/kg IM ²¹⁸	Crocodylians/recovery takes several hours
	2-10 mg/kg IM ³⁴¹	Large crocodylians/may permit intubation
Xylazine	5-10 mg/kg SC, IM, ICe (sedation), 10-40 mg/kg (anesthesia) ²²⁰	Crocodylians
	15 mg/kg IM ⁵⁷	Alligators/induction, > 20 min; adequate for minor procedures
	—	Infrequently used; variable effects; potentially reversible with yohimbine; preanesthetic for ketamine; see ketamine for combination
Yohimbine (Yobine, Lloyd)	0.1-1.25 mg/kg IM, IV ¹⁰⁴	Most species
	0.1-1 mg/kg IM ²¹⁸	Crocodylians/atipamezole better reversal than yohimbine
	1-2 mg/kg IM ^{220,303}	Nile crocodiles
Yohimbine (Yobine, Lloyd)	—	Xylazine reversal; rarely indicated; atipamezole commonly used to reverse all α_2 agonists

^aMedetomidine is no longer commercially available although it can be obtained from select compounding services; dosages are listed here as a guide for possible use with dexmedetomidine, an α_2 agonist that is the active optical enantiomer of racemic compound medetomidine; dexmedetomidine is generally used at 1/2 the dose of medetomidine but the same volume due to higher concentration; both compounds tend to have similar effects.

TABLE 4-6 Analgesic Agents Used in Reptiles.

Agent	Dosage	Species/Comments
Bupivacaine	1-2 mg/kg local q4-12h prn ³⁴⁴ 1 mg/kg intrathecal ²⁴⁰	Most species/local anesthesia; 4 mg/kg maximum dose Turtles, tortoises/regional analgesia/anesthesia
Buprenorphine	0.2 mg/kg SC ²⁴⁶	No evidence of analgesic efficacy in red-eared slider turtles or other reptile species
Butorphanol	— 0.4-1 mg/kg SC, IM ³⁴¹ 1 mg/kg IM ⁹⁷ 20 mg/kg SC ¹⁹⁰	Recent studies call into question use of particular doses or of this drug in general in providing analgesia in reptiles, including red-eared sliders, ball pythons, corn snakes, bearded dragons, and green iguanas; respiratory depression is a common side effect ^{338,351,353} Most species; sedation; preanesthetic; 0.2 mg/kg IM used experimentally in tortoises ¹¹⁵ Green iguanas/ineffective for analgesia; presence of observer may affect iguana response Red-eared slider turtles/ineffective for surgical analgesia
Carprofen	1-4 mg/kg PO, SC, IM, IV q24h, ²¹⁷ follow with half the dose q24-72h ²⁵⁹	Most species/nonsteroidal antiinflammatory; no efficacy data in any reptile species
Etodolac	5 mg/kg PO q72h × 30 days ³⁰¹	Komodo dragons
Fentanyl	12.5 µg/hr transdermal patch to cranial epaxial muscles ¹⁸⁸ 12.5 µg/hr transdermal patch to caudodorsal lumbar region ¹⁰⁹	Ball pythons/high plasma concentrations (above analgesic threshold in mammals); analgesic efficacy not proven in any snake species, but anecdotal evidence from certain snake clinical cases demonstrated improved condition after application of patch Prehensile-tailed skinks/no side effects reported after 24 hr when skink blood levels reached human therapeutic levels; environmental temperature can significantly affect absorption
Flunixin meglumine	0.1-0.5 mg/kg IM q12-24h ²¹⁷ 0.5-2 mg/kg IM q12-24h ³⁴⁴ 1-2 mg/kg IM q24h × 2 treatments ^{37,360}	Most species/nonsteroidal antiinflammatory; use for maximum of 3 days; no evidence of efficacy Most species/nonsteroidal antiinflammatory; no evidence of efficacy Lizards/postsurgical nonsteroidal antiinflammatory; no evidence of efficacy
Hydromorphone	0.5-1 mg/kg SC ²⁴⁶	Red-eared sliders/analgesic efficacy
Ketoprofen	— 2 mg/kg PO, SC, IM q24-48h ^{225,381}	Nonsteroidal antiinflammatory Most species/green iguanas/PK study; ³⁸¹ loggerhead sea turtles/frequently used due to historical evidence of safety; ²²⁵ no efficacy data
Lidocaine (0.5%-2%)	2-5 mg/kg local ³⁴⁴ Local or topical ³⁴¹ 4 mg/kg intrathecal ²⁴⁰	Most species/10 mg/kg maximum dosage Most species/local analgesia; infiltrate to effect (e.g., 0.01 mL 2% lidocaine used for local block for IO catheter placement in iguanas); ²¹ often used in conjunction with chemical immobilization Turtles, tortoises/regional analgesia

TABLE 4-6 Analgesic Agents Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Lidocaine (L)/morphine (Mo)	2 mg/kg (L) + 0.1 mg/kg (Mo) intrathecal ³¹²	Desert tortoises/orchiectomy analgesia
Meloxicam	0.1-0.5 mg/kg PO, SC q24-48h ¹⁷⁵⁻¹⁷⁷ 0.3 mg/kg IM ²⁹³ 0.2 mg/kg PO, IV q24h ⁸² 0.1 mg/kg IM, IV ²⁰⁹ 0.1-0.2 mg/kg PO, IM q24h × 4-10 days ⁹⁴ 0.2 mg/kg IM, IV, ³⁸² SC ^{311,312} 0.2-0.4 mg/kg IM ¹⁶⁶ 0.5 mg/kg PO, IM, or 0.22 mg/kg IV ³²⁵	Most species Ball pythons/physiologic changes not consistent with analgesia Green iguanas/PD; no evidence of efficacy Loggerhead sea turtles/PK; plasma concentrations not consistent with analgesia Chelonians; no evidence of efficacy Red-eared slider turtles/PK; plasma concentrations consistent with therapeutic efficacy for 48 hr by IM and IV administration routes; ³⁸² Mojave desert tortoises, postsurgical nonsteroidal antiinflammatory ^{311,312} Red-eared slider turtles, Eastern painted turtles, yellow-spotted Amazon river turtles, other undocumented turtle species/nonsteroidal antiinflammatory; no evidence of efficacy Red-eared sliders/PK; found better absorption IM vs PO, ³²⁵ after IV administration, plasma levels decreased rapidly and the elimination half-life was 7.57 hr
Meperidine	5-10 mg/kg IM q12-24h ¹³⁹ 20 mg/kg IM q12-24h ²¹⁷ 2-4 mg/kg ICe q6-8h ¹⁷⁵ 1-5 mg/kg IM ^{184,351,386} 2-4 mg/kg ICe ⁴	Most species/analgesia; no noticeable effect in snakes even at 200 mg/kg Most species/analgesia Lizards Turtles, crocodiles/analgesic efficacy of short duration Nile crocodiles/analgesia
Methadone	3-5 mg/kg SC, IM ^{63,351}	Aquatic turtles/analgesia
Morphine	— 10 mg/kg IM ^{353,394} 1.5-6.5 mg/kg SC, IM ^{90,350,351,353} 0.1-0.2 mg/kg intrathecal ²⁴⁰ 2 mg/kg SC ¹⁹⁰ 1 mg/kg IM ¹⁶⁶ 0.5-4 mg/kg ICe ³⁵⁵	No effective dose for analgesia documented in corn snakes ³⁵³ Bearded dragons/analgesia; ball pythons/no analgesia Red-eared sliders (long lasting respiratory depression), freshwater crocodiles, <i>Anolis</i> lizards/ may be effective thermal analgesia Turtles, tortoises/thermal analgesia for 48 hr; regional analgesia caudal body Red-eared slider turtles/surgical analgesia Red-eared slider turtles, Eastern painted turtle, yellow-spotted Amazon river turtle, other undocumented turtle species/analgesia Crocodilians/analgesia

Continued

TABLE 4-6 Analgesic Agents Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Naloxone	0.04-2 mg/kg SC ^{350a,350,353}	Red-eared sliders, bearded dragons, corn snakes/ μ-opioid agonist reversal
Oxymorphone	0.025-0.1 mg/kg IV ¹⁰⁴ 0.05-0.2 mg/kg SC, IM q12-48h ³⁹ 0.5-1.5 mg/kg IM ¹⁰⁴	Anecdotal evidence of analgesia in some lizard and turtle species; no efficacy or PK/PD studies; avoid in cases with hepatic or renal dysfunction; no observable effects in snakes even at 1.5 mg/kg
Pethidine	—	See meperidine
Prednisolone	2-5 mg/kg PO, IM ²¹⁷	Most species/antiinflammatory
Proparacaine (0.5%)	Topical to eye ^{126,229,331,345}	Iguanas/desensitizes surface of eye; ineffective in animals with spectacles; bearded dragons/IOP by rebound tonometry; ³⁴⁵ Kemp's ridley sea turtles/ one drop provided 45 min duration of action; ¹²⁶ do not exceed toxic dose 2 mg/kg; ¹¹⁷ Yacare caiman/ IOP by applanation tonometry ³³¹
Tapentadol	10 mg/kg IM ^{121,122}	Red-eared and yellow-bellied slider turtles/ analgesia
Tramadol	11 mg/kg PO ¹²⁸ 5-10 mg/kg PO, SC ¹⁴ 5-10 mg/kg PO ²⁸⁹ 10 mg/kg PO ³⁵⁶ 10 mg/kg IM ¹²⁴	Bearded dragons Red-eared slider turtles, sea turtles/thermal analgesia, higher doses may affect ventilation Loggerhead sea turtles/PK; plasma concentrations consistent with efficacy for 48 hr (5 mg/kg PO) or 72 hr (10 mg/kg PO) Turtles, tortoises/analgesia Yellow-bellied slider turtles/PK/PD comparing forelimb and hind limb administration; analgesia; plasma concentrations consistent with analgesia in both forelimb and hind limb

TABLE 4-7 Hormones and Steroids Used in Reptiles.

Agent	Dosage	Species/Comments
Arginine vasotocin (AVT) (Sigma Chemical)	0.01-1 μg/kg IV (preferred), ICe ²¹⁹ q12-24h × several treatments	Most species/dystocias; administer 30-60 min after Ca lactate/Ca glycerophosphate; more effective in reptiles than oxytocin but not commercially available for use in animals; higher doses have been reported; 0.5 μg/kg commonly recommended
Calcitonin	1.5 U/kg SC q8h × 14-21 days prn ¹⁰⁴ 50 U/kg IM, repeat in 14 days ^{22,117} 50 U/kg q7d × 2-3 doses ^{226,230}	Most species (e.g., iguanas/severe nutritional secondary hyperparathyroidism; administer after Ca supplementation; do not give if hypocalcemic Green iguanas/salmon calcitonin; do not give if hypocalcemic

TABLE 4-7 Hormones and Steroids Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Deslorelin acetate	— 4.75 mg implant SC ³³⁰	No success with use in female reptile reproductive issues Bearded dragons/abnormal aggression in juveniles; decreased serum testosterone, behavior ceased
Dexamethasone	0.2 mg/kg IM, IV ³⁴³ 0.6-1.25 mg/kg IM, IV ¹⁰⁴ 0.3-1.5 mg/kg IM, IV, IO ¹⁷⁷	Most species/laryngeal or pharyngeal edema and inflammation Most species/shock (septic/traumatic) Chelonians/hyperthermia
Dexamethasone sodium phosphate	0.1-0.25 mg/kg SC, IM, IV ¹¹⁷	Most species/shock (septic/traumatic)
Insulin	1-5 U/kg IM, ICe q24-72h ³⁶² 5-10 U/kg IM, ICe q24-72h ³⁶²	Snakes, chelonians/doses are empirical and must be adjusted based on response to therapy and serial blood glucose; doses administered ICe may take 24-48 hr before a response is noted Lizards, crocodylians/see above
Leuprolide acetate (Lupron Depot 1.875 mg/mL, Abbott)	0.4 mg/kg IM ¹⁹²	Iguanas/did not suppress testosterone levels in males
Levothyroxine	0.02 mg/kg PO q48h ¹³² 0.02 mg/kg PO q48h ²⁹⁰ 0.025 mg/kg q24h in AM ¹⁰¹	Geckos/post-thyroidectomy, lifetime management Tortoises/hypothyroidism; stimulates feeding in debilitated tortoises Tortoises/monitor T ₄ levels
Methylprednisolone	1 mg/kg IV q24h ¹⁷⁷	Chelonians/ivermectin toxicity
Nandrolone (Deca-Durabolin, Orgamoon)	0.5-5 mg/kg IM q7-28d ¹⁴⁹ 1 mg/kg IM q7-28d ⁷⁸	Most species/hepatic lipidosis Lizards/anabolic steroid; reduces protein catabolism; may stimulate erythropoiesis
Oxytocin	— 1-10 U/kg IM ^{90,117} 2 U/kg IM q4-6h × 1-3 treatments ¹¹ 1-5 U/kg IM, ⁷⁶ repeat in 1 hr 1-2, ³⁶ 2-20, ²⁵⁴ or 10-20 ³⁵ U/kg IM 1-20 U/kg IM q90min × 3 treatments at increased doses, or 50%-100% first dose 1-12 hr later, or IO drip ³⁷³ 2 U/kg IV q2h ⁷⁴	Dystocias; results are variable; works well in chelonians, less so in snakes and lizards; generally administer 1 hr after Ca administration; use multiple doses with caution Most species/higher end of the range is commonly used; may be repeated up to 3 treatments at 90 min intervals with increasing dosage ¹⁶⁴ Most species Lizards/alternatively, 5 U/kg by slow IV or IO over 4-8 hr ⁷⁶ Chelonians Chelonians Red-eared sliders/faster onset vs IM; fewer animals required second or third doses vs IM route

Continued

TABLE 4-7 Hormones and Steroids Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Prednisolone	2-5 mg/kg PO, IM ²¹⁷ 0.5 mg/kg q24h × 14 days, then q48h until PCV stable ¹⁷⁵	Most species/analgesia (chronic pain) Lizards/autoimmune hemolytic anemia
Prednisolone Na succinate (Solu-Delta Cortef, Pharmacia and Upjohn)	5-10 mg/kg IM, IV, ⁹⁵ 10 ⁷⁸	Most species/shock; brain swelling from hyperthermia; may help reduce nephrocalcinosis
Prednisone	0.5-1 mg/kg PO, SC, IM, IV ²⁵³ 0.8 mg/kg q48h ¹¹²	Most species/lymphoma, leukemia, myeloproliferative disease Most species/chronic T-lymphocytic leukemia; may combine with chlorambucil, but need to monitor uric acid levels
Stanozolol (Winstrol-V, Winthrop)	5 mg/kg IM q7d prn ¹¹⁷	Most species/anabolic steroid; management of catabolic disease states

TABLE 4-8 Nutritional/Mineral/Fluid Support Used in Reptiles.^a

Agent	Dosage	Species/Comments
Calcium	PO prn ⁸⁴	Most species/dietary sources include crushed cuttlebone, oyster shell, egg shell, tablets of Ca salts, or other commercially available products
Calcium carbonate (Rep-Cal, Rep-Cal Labs; Repti Calcium, Zoo Med; Fluker's powdered or liquid forms of calcium)	PO prn ⁸⁴	Omnivores, herbivores, insectivores/dietary Ca supplement
Calcium gluconate (Neo-Calglucon, Sandoz; Calciquid, Breckenridge Pharmaceuticals; Calcionate, Rugby)	10 mg/kg PO q12-24h prn ¹⁰⁷ 25-50 mg/kg PO q24h prn ²⁴² 360 mg/kg (1 mL/kg) PO q12-24h prn ^{22,38}	All species/nutritional secondary hyperparathyroidism All species/nutritional secondary hyperparathyroidism Most species/nutritional secondary hyperparathyroidism; hypocalcemia; dystocia; ensure adequate UVB exposure and proper nutrition
Calcium gluconate	50-100 mg/kg SC, IM, IV ²⁴²	Most species/hypocalcemia (low ionized Ca); hypocalcemic muscle tremors, seizures, dystocia, or flaccid paresis in lizards; when patient is stable, switch to oral Ca; should be diluted in fluids

TABLE 4-8 Nutritional/Mineral/Fluid Support Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Calcium gluconate (cont'd)	100 mg/kg SC, IM, ICe ^{234,259} q6-24h ^{22,38}	Most species/hypocalcemia (low ionized Ca); hypocalcemic muscle tremors, seizures, dystocia, or flaccid paresis in lizards; when patient is stable, switch to oral Ca
Calcium gluconate/borogluconate	10-50 mg/kg SC, IM ¹⁰⁷	Most species/hypocalcemia; hypocalcemic dystocia
Calcium glycerophosphate/calcium lactate (Calphosan, Glenwood)	1-5 mg/kg SC, IM ¹⁰⁷ 10 mg/kg SC, IM, ICe q24h × 1-7 days ^{16,22}	Most species/hypocalcemia; hypocalcemic dystocia Lizards (iguanas)/hypocalcemia
Carnivore Care (Oxbow Animal Health)	10-20 mL/kg PO or via gavage/esophagostomy q24-48h ¹¹⁵ 30 mL/kg (3% of body weight) PO or via gavage/esophagostomy q24h; ⁷¹ range of 2%-10% body weight PO or via gavage/esophagostomy q24h ²⁴²	Carnivores/short-term nutritional support; anorexia; prepare according to directions; begin after rehydration and stable condition; more dilute in first feeding after anorexia, gradually increase concentration over 3-5 days Carnivores
Clinicare—feline and canine (Abbott Animal Health)	Gavage prn ⁴⁰¹	Most species/post-omphalectomy; use canine formula for herbivores and omnivores, and feline formula for carnivores; initially dilute 1:1 with water and gradually increase to full strength over 48 hr; generally precede nutritional supplementation with 48-96 hr of water or electrolyte solution PO
Critical Care for Herbivores (Oxbow Animal Health)	10-20 mL/kg PO or via gavage/esophagostomy q24-48h ¹¹⁵ 30 mL/kg (3% of body weight) PO or via gavage/esophagostomy q24h; ⁷¹ range of 2%-10% body weight PO or via gavage/esophagostomy q24h ²⁴²	Herbivores/long-term nutritional support; prepare according to directions; begin after rehydration and stable condition Herbivores
Dextrose in water (2.5%, 5%)	PO, SC, IV, IO, ICe, EpiCe, prn ¹⁹¹ Calculated water deficit IV, IO ²³²	All species/hyperkalemia; ¹⁹¹ can mix with electrolyte solutions Most species/for intracellular rehydration when mentation is altered and plasma Na >160 mEq/L; for acute Na toxicosis replace deficit in 12-24 hr; for chronic dehydration slowly replace deficit over 48-72 hr

Continued

TABLE 4-8 Nutritional/Mineral/Fluid Support Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Electrolyte solutions (Pedialyte, Abbott; Gatorade, S-VC, Inc.)	Voluntary drinking (whole body soak) ¹¹⁵ 10-20 mL/kg via gavage or esophagostomy tube q24h ¹¹⁵	All species/oral fluid therapy; early treatment of anorexia; dilute 1:1 with water; caution against drowning All species/rehydration; when stable; first stage in supplemental nutrition
Emeraid Exotic Carnivore (Lafeber)	5-30 mL/kg gavage or esophagostomy tube q24-72h ¹¹⁷ 3% body weight PO or via gavage/esophagostomy q24h; ⁷¹ range of 2%-10% body weight PO or via gavage/esophagostomy q24h ²⁴²	Carnivores/nutritional support, severely debilitated, cachectic patients; prepare according to directions; use when hydrated and stable condition; greater dilution in first few feedings Carnivores
Emeraid Herbivore (Lafeber)	5-20 mL/kg gavage or esophagostomy tube q12-48h ¹¹⁷ 3% body weight PO or via gavage/esophagostomy q24h; ⁷¹ range of 2%-10% body weight PO or via gavage/esophagostomy q24h ²⁴²	Herbivores/nutritional support, severely debilitated, cachectic patients; prepare according to directions; use when hydrated and stable condition; greater dilution in first few feedings Herbivores
Emeraid Omnivore (Lafeber)	5-20 mL/kg gavage or esophagostomy tube q12-48h ¹¹⁵ 3% body weight PO or via gavage/esophagostomy q24h; ⁷¹ range of 2%-10% body weight PO or via gavage/esophagostomy q24h ²⁴²	Most species/nutritional support, severely debilitated, cachectic patients; prepare according to directions; use when hydrated and stable condition; greater dilution in first few feedings Omnivores
Hydroxyethyl starch (Hetastarch, HES)	3-5 mL/kg slow IV or IO bolus prn ^{115,232}	All species/hypoalbuminemia; hypovolemic perfusion deficits; increased capillary permeability; use with crystalloids; reduce crystalloid volume 40%-60%; max volume 20 mL/kg ³⁹⁰
Iodine	2-4 mg/kg PO q24h × 14-21 days, then q7d ¹¹⁷	Herbivores/iodine deficiency (i.e., goiter); use in species fed a goitrogenic diet; can use a multivitamin-mineral mixture or iodized salt; suggested daily dietary iodine 0.03 mg/kg BW ³⁴

TABLE 4-8 Nutritional/Mineral/Fluid Support Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Iron dextran	12 mg/kg IM 1-2×/wk × 45 days ³⁷¹	Crocodylians/iron deficiency; in other species for anemia ¹¹⁷
Lactated Ringer's solution (LRS)	15-40 mL/kg SC, IV, IO prn ²³²	Land turtles/fluid replacement; use extracoelomically after warming the patient; avoid lactate if hepatic insufficiency
LRS + 0.9% saline (1:1 solution)	20 mL/kg/day ICe ⁴⁶	Loggerhead sea turtles/highest percentage of acid-base recovery and electrolyte balance compared to LRS, saline, or 5% dextrose in saline (1:1)
Maintenance crystalloid solution: ½-strength LRS and 2.5% dextrose	SC, IV, IO, ICe, EpiCe, prn ²³²	All species/maintenance fluid therapy after losses have been replaced
Metronidazole	12.5-50 mg/kg PO ¹⁰³ 50-100 mg/kg PO ¹⁷⁴	Most species/appetite stimulant (anecdotal; presumably associated with antiprotozoal activity) Chameleons/appetite stimulant (anecdotal; presumably associated with antiprotozoal activity)
Multivitamin Products (ReptiVite, Zoo Med; Herptivite, RepCal; Repta-Vitamin, Fluker's; Exo-Terra; Nekton)	Dust on vegetables, fruits, or insects q84-168h ³⁵⁸	Herbivores, omnivores, insectivores/preformed vitamin A; minerals; multivitamin
Polymerized bovine hemoglobin (Oxyglobin, OPK Biotech)	3-5 mL/kg slow IV or IO bolus prn ^{115,232}	All species/hemoglobin polymer; hypoalbuminemia; hemorrhage; severe anemia; hypovolemic perfusion deficits; increased capillary permeability; use with crystalloids; reduce crystalloid volume 40%-60%; max volume 20 mL/kg; ³⁹⁰ currently under FDA testing by a new manufacturer and unavailable
Replacement crystalloid solutions (Normosol-R, Ceva; Plasma-Lyte, Baxter)	15-25 mL/kg/d PO, SC, IV, IO, ICe, EpiCe prn ³⁷ 10-30 mL/kg q24h, or divided into 2-3 boluses several hours apart ¹⁹¹	All species/replacement fluid therapy; warm to 29°C (84°F) ²³² All species/ongoing regurgitation or severe diarrhea
Ringer's solution for reptiles: 1 part Normosol-R + 2 parts 2.5% dextrose in 0.45% saline ¹⁴¹ or, 1 part Normosol-R + 1 part 5% dextrose + 1 part 0.9% saline	10-20 mL/kg q24h ¹¹⁷ 15 (large reptiles) to 25 (small reptiles) mL/kg q24h, or divided into 2 doses per day ³⁷ 20 mL/kg q12h ³⁸	All species/hypertonic dehydration or to prevent nephrotoxicity due to aminoglycosides All species/hypertonic dehydration; warm fluids to 28°C (82°F) Chelonians/severe dehydration
Selenium	0.028 mg/kg IM ¹⁶	Lizards/deficiency; myopathy
Sodium chloride (0.45%)	PO, SC, IV, IO, ICe, EpiCe, prn ¹⁹¹	All species/hypertonic dehydration; correct deficits over 3 days

Continued

TABLE 4-8 Nutritional/Mineral/Fluid Support Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Sodium chloride (0.9%)	SC, IV, IO, ICe, EpiCe, prn ^{191,232}	All species/hyperkalemia, hypercalcemia, hypochloremic metabolic alkalosis; ²³² can mix with other crystalloid solutions, particularly 5% dextrose; use SC, ICe, EpiCe routes after patient is warm
Vitamin A	— 2000 U/kg PO, SC, IM q7-14d × 2-4 treatments ^{35,38} 2000 U/30 g BW PO once, repeat in 7 days ^{134,358} 200-300 U/kg ⁸⁴ SC, IM	Overdose causes epidermal sloughing; greater risk with aqueous parenteral formulation; for less severe cases, commercial formulated diets or reptile multivitamin supplements may suffice; ^{84,270,358} may help infectious stomatitis Most species/hypovitaminosis A Chameleons/eye swelling, respiratory disease, hemipenile plugs, dysecdysis Turtles/hypovitaminosis A; give in conjunction with PO vitamin A (2-8 U/g feed DM)
Vitamins A, D ₃ , E (Vital E + A + D, Stuart Products)	0.15 mL/kg IM, repeat in 21 days ¹¹⁷ 0.3 mL/kg PO, then 0.06 mL/kg q7d × 3-4 treatments ³⁵	Most species/hypovitaminosis A, D ₃ , or E; product contains alcohol and may sting when administered; a product without alcohol can be compounded commercially Box turtles/hypovitaminosis A; parenteral use may result in hypervitaminosis A and D; given PO may enhance Ca uptake
Vitamin B complex	0.3 mL/kg SC, IM q24h ¹¹⁷ 25 mg thiamine/kg PO q24h × 3-7 days ¹¹	Most species/anorexia; hypovitaminosis B; use with caution as B ₆ toxicity may occur Most species/appetite stimulant; hypovitaminosis B
Vitamin B ₁ (thiamine)	50-100 mg/kg PO, SC, IM q24h ⁴⁵ 30 g/kg feed fish PO ¹¹⁷	Piscivores/thiamine deficiency from thawed fish Crocodilians/treat or prevent deficiency
Vitamin B ₁₂ (cyanocobalamin)	0.05 mg/kg SC, IM ¹¹⁷	Snakes, lizards/appetite stimulant
Vitamin C	10-20 mg/kg SC, IM q24h ^{102,264}	All species/empirical for hypovitaminosis C; stomatitis; skin slough in snakes; supportive therapy for bacterial infections

TABLE 4-8 Nutritional/Mineral/Fluid Support Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Vitamin D ₃	— 1000 U/kg IM, repeat in 1 wk ³⁸ 200 U/kg PO, IM q7d ^{16,22} 400 U/kg IM q7d × 3 treatments ²³⁰	Nutritional secondary hyperparathyroidism; hypocalcemia; deficiency and excess may result in soft-tissue calcification Most species/deficiency; use with oral calcium gluconate and carbonate, general dietary management, and UVB irradiation Lizards/PO may be safer than IM, but absorption is poor in some species ^{27,297} Green iguanas/nutritional secondary hyperparathyroidism; use with calcitonin after normocalcemic; also supplement oral calcium
Vitamin E/selenium (L-Se, Schering)	1 U vitamin E/kg ⁸⁴ IM 50 U vitamin E/kg + 0.025 mg selenium/kg IM ⁸⁹	Piscivores/hypovitaminosis E; myopathy, anorexia, swollen subcutaneous nodule Lizards/hypovitaminosis E (vitamin E/selenium)
Vitamin K ₁	0.25-0.5 mg/kg IM ¹¹⁷	Most species/hypovitaminosis K ₁ ; coagulopathies

^aAlso see Table 4-13.**TABLE 4-9** Miscellaneous Agents Used in Reptiles.

Agent	Dosage	Species/Comments
Activated charcoal-kaolin suspension (ToxiBan, Vet-a-Mix)	5-10 mL/kg PO q24h × 1-3 days ²³⁶	Sea turtles/reduce exposure to brevetoxin
Allopurinol	— 10-20 mg/kg PO q24h ^{78,254,315} 25 mg/kg PO q24h ¹⁵¹ 50 mg/kg PO q24h × 30 days, then q72h ²⁰⁴	Careful when giving with urine acidifiers and uricosuric drugs (probenecid) ⁶⁶ Most species/gout; decreases production of uric acid; ²²⁷ long-term therapy; tortoises may respond best Green iguanas Chelonians/hyperuricemia
Aluminum hydroxide (Amphogel, Wyeth-Ayerst)	100 mg/kg PO q12-24h ²²⁷	Most species/hyperphosphatemia (associated with renal disease); decreases intestinal absorption of P; use cautiously in patients with gastric outlet obstruction

Continued

TABLE 4-9 Miscellaneous Agents Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Amidotrizoate (Gastrografin, Squibb)	5-7.7 mL/kg PO ²³⁹ 7.5 mL/kg PO ²⁶⁷	Gastrointestinal contrast agent; reported faster transit vs barium; no risk if regurgitation Tortoises/gastrointestinal contrast agent; give via gavage; mean transit times: 2.6 hr at 87°F (30.6°C); 6.6 hr at 71°F (21.5°C)
Aminophylline	2-4 mg/kg IM ¹⁰⁴	Most species/bronchodilator
Atropine	0.01-0.04 mg/kg IM, IV q8-24h ²⁶⁶ 0.1-0.2 mg/kg IM prn ¹¹⁷ 0.2 mg/kg SC, IM ³²⁹	Most species/dries up excess mucous secretions with infectious stomatitis Most species/organophosphate toxicity Most species/respiratory distress associated with excessive secretions
Barium sulfate	5-20 mL/kg PO ⁴⁸ 25 mL/kg PO, 35% wt:vol concentration ¹⁵	Most species/gastrointestinal contrast studies Ball pythons/best gastrointestinal image quality
Bleomycin with high voltage electrical pulses	1 U/cm ³ intralesional, repeat in 33 days ³⁹ 3.65 mg/kg (1 mg/mL) intralesional, repeat in 2 wk ²¹²	Green sea turtles/fibropapillomas electrochemotherapy; use concurrent local anesthesia Yellow-bellied slider turtles/squamous cell carcinoma, post-partial surgical excision
Calcium EDTA	10-40 mg/kg IM q12h ²⁸⁸	Most species/heavy metal chelation; ensure hydration
Carboplatin	2.5-5 mg/kg IV, intracardiac ²⁵³	Most species/carcinoma, osteosarcoma, mesothelioma, carcinomatosis
Carboplatin 4.6 mg implantable bead (compounded, Wedgewood Pharmacy)	≤10 mg/kg total q3wk intralesional or surgical excision sites ¹⁷⁹	Chameleons/squamous cell carcinoma, carcinoma; cut bead into smaller pieces to avoid overdose
Chlorambucil (Leukeran, Glaxo SmithKline)	0.1-0.2 mg/kg PO ²⁵³	Most species/lymphoma, leukemia, myeloproliferative tumors
CHOP Therapy (Modified)	See original paper for full protocol details ¹⁰⁰	Green iguanas/successful management of lymphoma post-radiation therapy
Cimetidine	4 mg/kg PO, IM q8-12h ¹¹⁷	Most species/gastric and duodenal ulceration; esophagitis; gastroesophageal reflux; may use in renal failure to increase phosphate secretion
Cisapride (Propulsid, Janssen)	0.5-2 mg/kg PO q24h ¹¹⁷ 1-4 mg/kg PO q24h until defecates ³⁸⁷	Most species/motility modifier; gastrointestinal stasis; not commercially available in the United States; may be compounded; ineffective in desert tortoises at 1 mg/kg ³⁷⁹ Bearded dragons/constipation

TABLE 4-9 Miscellaneous Agents Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Cisplatin	0.5-1 mg/kg IV (prehydrate), intracardiac, intralesional (in oil) ²⁵³	Most species/carcinoma, osteosarcoma, infiltrative sarcoma (intralesional), mesothelioma, carcinomatosis
Cyclophosphamide	10 mg/kg SC, IM, IV, intracardiac ²⁵³	Most species/lymphoma, leukemia, myeloproliferative tumors
Diocetyl Na sulfosuccinate	1-5 mg/kg PO ¹¹⁹	Most species/constipation; use 1:20 dilution
Diphenhydramine	2 mg/kg IM q24h ²³⁶	Sea turtles/brevitoxicosis; rapidly reduced conjunctival edema, prevented corneal ulceration
Doxorubicin	1 mg/kg IV q7d × 2 treatments, then q14d × 2 treatments, then q21d × 2 treatments ³²⁷	Snakes/chemotherapy for sarcoma (also lymphoma, carcinoma, etc.); treatment periods variable
Famotidine	0.5 mg/kg SC q3d ³⁹⁵	Kemp's ridley sea turtles
Furosemide	2-5 mg/kg PO, IM, IV q12-24h ¹⁷⁵⁻¹⁷⁷ 5 mg/kg IM q24h × 1-3 days ²³⁶	Most species/diuretic for edema and pulmonary congestion; while lacking loop of Henle, may effect via other mechanisms Sea turtles/intentional dehydration with brevitoxicosis, no concurrent fluids given
Hydrochlorothiazide	1 mg/kg q24-72h ⁷⁸	Lizards/promotes diuresis; monitor hydration status
Iodine compound (Conray 280, Mallinckrodt)	500 mg/kg IV, IO ⁷⁸	Lizards/IV urography; take radiographs 0, 5, 15, 30, and 60 min postinjection
Iohexol (240 mg I/mL; Omnipaque, Sanofi Winthrop)	5-20 mL/kg PO ¹¹⁷ 75 mg/kg IV ¹⁸⁷	Most species/gastrointestinal contrast studies; nonionic, organic iodine solution; good alternative to barium; ³⁷ faster transit time than barium; can be diluted 1:1 with water Kemp's ridley turtles (juveniles)/GFR assessment
K-Y jelly (Johnson & Johnson)	1-3 mL of 50% K-Y jelly and 50% warm water/100 g ⁹	Most species/enema
Lactulose	0.5 mL/kg PO q24h ^{175,177,361}	Lizards, chelonians/hepatic lipidosis
L-asparaginase (Elspar, Merck)	400 U/kg SC, IM, intracardiac ²⁵³	Most species/lymphoma, leukemia, myeloproliferative tumors
Maropitant citrate (Cerenia, Zoetis)	1 mg/kg PO, SC q24h ¹⁹⁵	Antiemetic; antinausea; no adverse effects seen; Substance P conserved across classes
Melphalan (Alkeran, Cellegene)	0.05-0.1 mg/kg PO ²⁵³	Most species/lymphoma, leukemia, myeloproliferative tumors
Methimazole	2 mg/kg q24h × 30 days ¹³⁴	Snakes/excessive shedding from hyperthyroidism; limited effectiveness

Continued

TABLE 4-9 Miscellaneous Agents Used in Reptiles. (cont'd)

Agent	Dosage	Species/Comments
Methotrexate	0.25 mg/kg PO, SC, IV ²⁵³	Most species/lymphoma, leukemia, myeloproliferative tumors
Metoclopramide	0.06 mg/kg PO q24h × 7 days ^{75,117} 0.05 mg/kg PO q24h × 7 days ²³⁶ 0.5 mg/kg IM q24h ⁸⁷ 1-10 mg/kg PO q24h ⁴⁰²	Most species/stimulates gastric motility Sea turtles/intestinal motility stimulant Sea turtles/supportive care Tortoises/stimulates gastric motility; ineffective in desert tortoises at 1 mg/kg ³⁷⁹
Milk thistle (<i>Silybum marianum</i>)	4-15 mg/kg PO q8-12h ^{175,177}	Lizards, chelonians/hepatoprotectant
Pentobarbital	60-100 mg/kg IV, ICE ^{8,41}	Euthanasia
Pimobendan	0.2 mg/kg PO q24h ¹⁷⁵	Lizards
Potassium chloride	2 mEq/kg IV, ICE ²²	Most species/euthanasia; cardioplegic; administer following a euthanasia solution
Probenecid	250 mg/kg PO q12h ³⁰⁸	Most species/gout; increases uric acid excretion; can be increased prn
S-adenosylmethionine (Denosyl, Nutramax)	30 mg/kg PO q24h ²⁸⁰	Savannah monitors/liver disease
Sodium bicarbonate	0.5-1 mg/kg IV ¹¹⁷	Most species/hypoxic acidosis postanesthesia
Sucralfate	500-1000 mg/kg PO q6-8h ¹⁰⁴ 200 mg/kg PO q24h ³⁹⁶	Most species/oral, esophageal, gastric, and duodenal ulcers Green iguanas/post-duodenoileal anastomosis
Tamoxifen 60-day time-release pellets (Innovative Research of America)	Pellets containing 5 mg tamoxifen implants ICE ⁶⁸	Leopard geckos/inhibition of follicular development for 60 days if implanted before vitellogenesis
Terbutaline	0.01-0.02 mg/kg IM ³⁰⁶ Nebulization, 15-45 min/session q4-12h × 3+ days ³⁰⁶	Reduce bronchospasm Lower respiratory tract particle size should be ≤ 0.5 μm, 2-10 μm for trachea; oxygen flow rates <10 kg 1-2 L/min, 5 L/min for larger reptiles; use bubble humidifier; possible adverse cardiovascular effects
Tricaine methanesulfonate (MS-222)	250-500 mg/kg ICE 1% solution followed by 0.1-1 mL 50% solution ICE or intracardiac ^{13,61}	Fence lizards, desert iguanas, garter snakes, house geckos, anole species/euthanasia
Vincristine	0.025 mg/kg IV ²⁵³	Most species/lymphoma, leukemia, myeloproliferative tumors

TABLE 4-10 Hematologic and Serum Biochemical Values of Reptiles.^a

Measurement	Boa constrictor (<i>Boa constrictor</i>) ^{50,117,224,376}	Emerald tree boia (<i>Corallus caninus</i>) ^{117,376}	Rainbow boa (<i>Epicrates cenchria</i>) ^{117,376}
Hematology			
PCV (%)	29 (12-40)	26 (7-44)	29 (15-44)
RBC (10 ⁶ /μL)	0.71 (0.16-1.4)	2.16 (0.54-5.05)	0.87 (0.23-1.74)
Hgb (g/dL)	8.2 (3.1-13.2)	8.2 (6.1-11.4)	10.6 (8-13.1)
MCV (fL)	395 (122-669)	237 (37-360)	314 (45-619)
MCH (pg)	117 (51-184)	120 (113-128)	160
MCHC (g/dL)	31 (21-40)	34 (30-36)	36 (33-40)
WBC (10 ³ /μL)	7.37 (1.47-19.6)	4.87 (0.48-11.1)	7.64 (1-21.23)
Heterophils (10 ³ /μL)	1.93 (0.20-6.50)	1.25 (0.18-3.64)	1.07 (0.03-3.67)
Lymphocytes (10 ³ /μL)	2.89 (0.34-11.9)	1.92 (0.14-5.68)	4.71 (0.1-14.1)
Monocytes (10 ³ /μL)	0.27 (0.03-2.38)	0.17 (0.02-1.11)	0.9 (0.03-3.06)
Azurophils (10 ³ /μL)	0.84 (0-4.74)	0.23 (0-3.22)	0.60 (0-2.47)
Eosinophils (10 ³ /μL)	0.13 (0-0.60)	0.07 (0.06-0.08)	0.11 (0.04-0.22)
Basophils (10 ³ /μL)	0.21 (0.03-1.01)	0.06 (0.03-0.21)	0.1 (0.02-0.27)
Chemistries			
ALP (U/L)	189 (46-652)	87 (0-236)	27 (14-37)
ALT (U/L)	11 (0-30)	7 (0-27)	4 (1-6)
Amylase (U/L)	14 (0-76)	371 (61-847)	—
AST (U/L)	15 (2-64)	23 (2-61)	18 (3-54)
Bilirubin, total (mg/dL)	0.2 (0-0.6)	0.2 (0.2-0.3)	0.4 (0-0.8)
BUN (mg/dL)	2 (0-8)	2 (1-4)	2 (1-3)
Calcium (mg/dL)	15.3 (10-20)	12.8 (8.1-17.5)	13.8 (10.2-17.5)
Chloride (mEq/L)	125 (108-138)	131 (112-149)	129 (94-158)
Cholesterol (mg/dL)	120 (46-289)	304 (77-614)	206 (140-314)
Creatine kinase (U/L)	489 (57-2099)	454 (41-1445)	95 (0-347)
Creatinine (mg/dL)	0.2 (0-0.5)	0.6 (0.4-0.9)	0.4 (0.1-0.7)
GGT (U/L)	4 (0-23)	2 (1-2)	5
Glucose (mg/dL)	34 (7-74)	27 (5-64)	36 (2-80)
Iron (μg/dL)	113 (103-122)	—	—
LDH (U/L)	149 (0-452)	128 (14-754)	401 (141-661)
Lipase (U/L)	2730	—	—
Magnesium (mEq/L)	2.95 (2.9-3)	—	—
Osmolarity (mOsm/L)	306	—	—
Phosphorus (mg/dL)	4.3 (2.4-8.6)	4.1 (1.8-8)	4.3 (1.6-7.1)
Potassium (mEq/L)	4.7 (3.1-7.3)	5 (3-8.7)	4.8 (2.4-6.7)
Protein, total (g/dL)	7.0 (4.0-10.3)	4.5 (2.6-7.2)	6.8 (4.7-8.9)
Albumin (g/dL) ^b	2.9 (1.6-4.3)	2.6 (2-3.6)	2.4 (1.1-3.6)
Globulin (g/dL) ^b	3.9 (2.0-6.8)	2.8 (1.8-3.6)	4.2 (1.9-6.5)
Sodium (mEq/L)	159 (143-173)	157 (148-167)	162 (142-181)
Triglyceride (mg/dL)	103 (3-457)	24 (10-49)	72 (64-90)
Uric acid (mg/dL)	4.0 (0.3-15.0)	4.7 (1.4-19.2)	3.6 (1.1-9.7)

Continued

TABLE 4-10 Hematologic and Serum Biochemical Values of Reptiles. (cont'd)

Measurement	Rosy boa (<i>Lichanura trivirgata</i>) ³⁷⁶	Ball python (<i>Python regius</i>) ^{181,376}	Blood python (<i>Python curtus</i>) ¹¹⁷
Hematology			
PCV (%)	37 (20-54)	24 (10-33)	25 (15-49)
RBC (10 ⁶ /μL)	—	0.74 (0.31-1.16)	0.65
Hgb (g/dL)	—	7.8 (4.5-11.1)	—
MCV (fL)	—	328 (131-524)	340
MCH (pg)	—	102 (28-175)	—
MCHC (g/dL)	—	32 (24-40)	—
WBC (10 ³ /μL)	4.65 (0.57-8.73)	7.46 (2.22-21.6)	11.7 (1.13-42.5)
Heterophils (10 ³ /μL)	1.67 (0.39-4.13)	1.78 (0.32-6.17)	1.82 (0.31-3.99)
Lymphocytes (10 ³ /μL)	1.74 (0.18-4.92)	3.21 (0.35-13.8)	6.71 (0.34-33.6)
Monocytes (10 ³ /μL)	0.10 (0.03-0.65)	0.73 (0.01-3.26)	0.62 (0.13-2.12)
Azurophils (10 ³ /μL)	0.40 (0-1.68)	0.65 (0.01-4.12)	2.82 (0.27-6.8)
Eosinophils (10 ³ /μL)	—	0.10 (0.02-0.53)	0.08
Basophils (10 ³ /μL)	—	0.22 (0.04-1.08)	0.93 (0.32-1.83)
Chemistries			
ALP (U/L)	—	37 (11-98)	44 (8-56)
ALT (U/L)	—	9 (1-25)	10 (3-17)
Amylase (U/L)	—	1647 (383-2911)	—
AST (U/L)	20 (1-107)	25 (4-97)	56 (6-209)
Bilirubin, total (mg/dL)	—	0.1 (0-0.2)	0.3 (0.2-0.5)
BUN (mg/dL)	—	2 (0-7)	1 (0-2)
Calcium (mg/dL)	13.1 (9.4-17.4)	14.7 (10.4-19.3)	14.7 (13.5-16.2)
Chloride (mEq/L)	—	121 (107-134)	131 (123-138)
Cholesterol (mg/dL)	—	111 (15-232)	214 (76-445)
Creatine kinase (U/L)	—	526 (55-2136)	668 (327-1009)
Creatinine (mg/dL)	—	0.2 (0-0.7)	0.9 (0.5-1.3)
GGT (U/L)	—	—	8 (0-16)
Glucose (mg/dL)	37 (3-73)	25 (8-53)	30 (13-74)
LDH (U/L)	—	122 (4-376)	207 (49-364)
Phosphorus (mg/dL)	2.9 (0.8-6.1)	3.0 (1.4-7.3)	3.7 (3.1-4.5)
Potassium (mEq/L)	5.9 (3.7-10.3)	5.5 (2.4-10.0)	6.3 (3.3-11.2)
Protein, total (g/dL)	5.8 (3.7-8.3)	6.8 (3.6-9.0)	6.2 (3.6-8.1)
Albumin (g/dL) ^b	2.1 (1.2-2.9)	2.1 (1.1-3.6)	2.3 (1.6-2.8)
Globulin (g/dL) ^b	3.7 (2.3-4.8)	4.5 (2.1-6.5)	4.1 (3.1-4.9)
Sodium (mEq/L)	155 (115-174)	153 (137-171)	160 (155-164)
Triglyceride (mg/dL)	—	—	16 (13-22)
Uric acid (mg/dL)	6.4 (1.9-19.0)	3.0 (0.8-8.3)	4.3 (2.1-7.1)

TABLE 4-10 Hematologic and Serum Biochemical Values of Reptiles. (cont'd)

Measurement	Burmese python (<i>Python bivittatus</i>) ^{117,376}	Reticulated python (<i>Python reticulatus</i>) ^{117,376}	Green tree python (<i>Morelia viridis</i>) ^{117,376}
Hematology			
PCV (%)	28 (13-38)	26 (13-39)	25.3 (13-38)
RBC (10 ⁶ /μL)	0.83 (0.13-1.54)	0.72 (0.41-1.25)	0.85 (0.4-1.3)
Hgb (g/dL)	9.0 (4-11)	10.7 (5.2-30)	5.9 (4-7)
MCV (fL)	319 (84-554)	343 (176-429)	229 (208-250)
MCH (pg)	98 (32-143)	138 (60-186)	100
MCHC (g/dL)	32 (18-44)	37 (29-45)	36 (33-40)
WBC (10 ³ /μL)	7.6 (2.19-24.2)	7.48 (1.32-15.8)	7.28 (1.2-18.7)
Heterophils (10 ³ /μL)	2.25 (0.31-5.76)	1.92 (0.08-4.83)	1.59 (0.24-3.49)
Lymphocytes (10 ³ /μL)	3.73 (0.46-17.4)	2.24 (0.12-7.47)	3.46 (0.07-11.8)
Monocytes (10 ³ /μL)	0.17 (0.02-2.13)	1.22 (0.02-5.50)	0.61 (0.02-2.86)
Azurophils (10 ³ /μL)	0.27 (0.01-5.89)	0.10 (0.01-4.30)	0.72 (0.00-3.17)
Eosinophils (10 ³ /μL)	0.45 (0.10-1.4)	0.68 (0.04-1.95)	0.16 (0.1-0.22)
Basophils (10 ³ /μL)	0.12 (0.03-0.33)	0.06 (0.06-0.7)	0.17 (0.04-0.70)
Chemistries			
ALP (U/L)	58 (4-230)	61 (4-211)	177 (43-425)
ALT (U/L)	7 (0-26)	16 (0-51)	18 (0-52)
Amylase (U/L)	3255	1690 (416-2963)	902 (564-1240)
AST (U/L)	14 (3-65)	12 (2-34)	18 (1-63)
Bilirubin, total (mg/dL)	0.6 (0-2)	0.3	0.2
BUN (mg/dL)	2 (1-5)	2 (1-7)	2 (0-2)
Calcium (mg/dL)	16.1 (7.2-25.0)	16.3 (10.9-26.6)	13.8 (9.8-17.9)
Chloride (mEq/L)	118 (104-132)	118 (92-141)	124 (90-153)
Cholesterol (mg/dL)	264 (120-479)	285 (81-531)	251 (72-561)
Creatine kinase (U/L)	381 (39-1577)	351 (24-2338)	606 (21-1843)
Creatinine (mg/dL)	0.3 (0-1.6)	0.2 (0.1-0.4)	0.2 (0.2-0.5)
GGT (U/L)	25 (4-51)	22	—
Glucose (mg/dL)	24 (1-83)	31 (1-77)	37 (1-76)
LDH (U/L)	144 (12-807)	313 (43-1048)	206
Phosphorus (mg/dL)	4.4 (2.3-9.2)	5.6 (2.4-13.0)	5.1 (2.3-10.2)
Potassium (mEq/L)	4.8 (2.6-7.0)	5.0 (3.4-8.1)	5.5 (3.6-7.9)
Protein, total (g/dL)	7.2 (4.4-11.1)	7.8 (4.8-10.7)	7.2 (3.6-10.9)
Albumin (g/dL) ^b	2.3 (1.2-3.4)	2.1 (0.8-3.9)	2.0 (0.4-3.7)
Globulin (g/dL) ^b	4.9 (1.9-7.8)	5.0 (0.8-9.0)	4.9 (3.2-8.1)
Sodium (mEq/L)	158 (145-172)	160 (142-178)	161 (142-179)
Triglyceride (mg/dL)	114 (16-532)	45	—
Uric acid (mg/dL)	4.3 (0.4-10.1)	7.8 (3.5-17.4)	3.6 (0-11.0)

Continued

TABLE 4-10 Hematologic and Serum Biochemical Values of Reptiles. (cont'd)

Measurement	Carpet python (<i>Morelia spilota</i> ssp) ^{10,117,376}	Gopher snake (<i>Pituophis</i> <i>catenifer</i>) ^{117,234,376}	Indigo snake (<i>Drymarchon</i> <i>corais</i>) ^{85,117,376}
Hematology			
PCV (%)	24 (16-32)	35 (13-49)	26 (10-41)
RBC (10 ⁶ /μL)	0.89 (0.32-1.45)	0.67 (0.14-1.4)	0.62 (0.43-0.76)
Hgb (g/dL)	7.9 (4.9-9.7)	9.7 (4.3-12.3)	9.2 (7.3-11.1)
MCV (fL)	327 (260-386)	578 (246-1571)	369 (221-558)
MCH (pg)	111 (86-170)	111 (81-132)	258
MCHC (g/dL)	34 (29-39)	33 (27.5-36)	40 (33-46)
WBC (10 ³ /μL)	13.4 (2.7-24.8)	7.31 (1.66-24.0)	8.4 (1.5-21.6)
Heterophils (10 ³ /μL)	7.13 (1.79-16.8)	1.58 (0.33-5.99)	1.64 (0.14-3.94)
Lymphocytes (10 ³ /μL)	2.59 (0.60-6.91)	4.06 (0.21-13.2)	3.89 (0.24-14.5)
Monocytes (10 ³ /μL)	0.67 (0.03-2.67)	0.14 (0.01-0.86)	0.24 (0.04-2.50)
Azurophils (10 ³ /μL)	1.09 (0.01-5.72)	0.58 (0.01-3.23)	0.47 (0-3.51)
Basophils (10 ³ /μL)	0.16 (0-1.01)	0.14 (0.01-0.44)	0.35 (0.03-1.09)
Chemistries			
ALP (U/L)	36 (10-81)	61 (15-128)	123 (6-547)
ALT (U/L)	17 (6-78)	15 (1-70)	10 (3-16)
Amylase (U/L)	—	711 (107-1315)	—
AST (U/L)	17 (2-45)	20 (5-103)	15 (2-61)
Bilirubin, total (mg/dL)	0.5	0.4 (0.3-0.6)	2.1 (0.6-3.5)
BUN (mg/dL)	3 (2-3)	2.2 (1-5)	7 (0-22)
Calcium (mg/dL)	14.3 (10.9-20.5)	15.5 (11.0-20.0)	39 (12-97) ^c
Chloride (mEq/L)	118 (102-131)	120 (103-138)	121 (104-138)
Cholesterol (mg/dL)	318 (126-630)	368 (118-630)	93 (17-272)
Creatine kinase (U/L)	349 (3-1230)	330 (34-1702)	15
Creatinine (mg/dL)	1.3 (0.3-3.7)	0.3 (0.1-0.6)	644 (68-1923)
GGT (U/L)	32 (9-55)	10 (0-34)	0.3 (0.2-0.3)
Glucose (mg/dL)	30 (3-57)	57 (23-99)	57 (16-103)
LDH (U/L)	201 (11-728)	112 (1-405)	46 (28-89)
Magnesium (mEq/L)	330 (48-547)	76 (20-191)	313 (13-1055)
Phosphorus (mg/dL)	4.1 (0.8-7.9)	3.6 (1.7-7.9)	10.1 (0.1-39.6) ^c
Potassium (mEq/L)	4.9 (3.0-7.1)	4.8 (2.2-7.4)	4.7 (2.1-7.3)
Protein, total (g/dL)	7.2 (5.4-10.3)	6.0 (3.7-8.8)	8.1 (4.2-13.1)
Albumin (g/dL) ^b	2.1 (1.6-2.9)	2.0 (1.1-3.0)	2.4 (1.0-4.3)
Globulin (g/dL) ^b	5.1 (3.7-7.6)	4.0 (1.7-6.3)	5.1 (0.7-9.2)
Sodium (mEq/L)	156 (140-172)	163 (146-180)	162 (149-175)
Triglyceride (mg/dL)	30	27 (16-37)	92 (76-118)
Uric acid (mg/dL)	4.1 (0-9.3)	4.6 (1.9-12.6)	3.8 (0-9.1)

TABLE 4-10 Hematologic and Serum Biochemical Values of Reptiles. (cont'd)

Measurement	Corn snake (<i>Pantherophis guttata</i>) ^{117,376}	Common kingsnake (<i>Lampropeltis getula</i>) ^{117,376}	Rat snake (<i>Elaphe obsoleta</i>) ^{117,317,376}
Hematology			
PCV (%)	30 (13-50)	31 (9-47)	30 (12-46)
RBC (10 ⁶ /μL)	0.88 (0.40-1.60)	0.77 (0.10-1.88)	0.83 (0.23-1.43)
Hgb (g/dL)	11.5 (9.7-13.5)	—	9.8 (2.8-16.2)
MCV (fL)	307 (67-546)	311 (28-618)	354 (73-636)
MCH (pg)	127 (110-143)	—	121 (90-175)
MCHC (g/dL)	35 (32-40)	—	31 (18-45)
WBC (10 ³ /μL)	5.93 (1.12-16.9)	7.45 (1.55-27.7)	7.83 (1.02-25.2)
Heterophils (10 ³ /μL)	1.24 (0.23-5.08)	1.01 (0.16-5.50)	1.20 (0.10-3.89)
Lymphocytes (10 ³ /μL)	2.92 (0.29-11.8)	3.92 (0.35-20.9)	3.89 (0.41-16.1)
Monocytes (10 ³ /μL)	0.31 (0.03-1.78)	1.98 (0.05-5.83)	0.48 (0.02-2.52)
Azurophils (10 ³ /μL)	0.42 (0.01-3.29)	0.24 (0-4.77)	0.41 (0-3.50)
Eosinophils (10 ³ /μL)	0.09 (0.03-0.48)	0.08 (0.02-0.37)	0.11 (0.01-0.55)
Basophils (10 ³ /μL)	0.19 (0.04-1.04)	0.27 (0.04-1.08)	0.18 (0.01-0.72)
Chemistries			
ALP (U/L)	35 (0-85)	41 (13-102)	70 (11-212)
ALT (U/L)	19 (1-57)	11 (0-50)	10 (0-32)
Amylase (U/L)	540 (255-2225)	1268 (371-2671)	1337 (630-2626)
AST (U/L)	25 (4-149)	20 (4-107)	19 (3-75)
Bilirubin, total (mg/dL)	0.3 (0-1.0)	0.4 (0.1-0.7)	0.2 (0-0.8)
BUN (mg/dL)	3 (1-6)	2 (1-10)	2 (1-12)
Calcium (mg/dL)	15.6 (11.9-19.9)	14.9 (9.1-22.2)	15.3 (10.6-21.0)
Chloride (mEq/L)	122 (105-139)	119 (97-141)	121 (96-146)
Cholesterol (mg/dL)	473 (267-678)	294 (75-513)	340 (92-588)
Creatine kinase (U/L)	270 (31-967)	406 (59-1909)	228 (41-1049)
Creatinine (mg/dL)	0.6 (0.2-2)	9	0.3 (0-0.8)
GGT (U/L)	9 (0-25)	0.6 (0-1.6)	9 (1-35)
Glucose (mg/dL)	49 (17-92)	38 (8-92)	62 (11-121)
Iron (μg/dL)	—	190 (30-488)	—
LDH (U/L)	178 (10-585)	126 (15-417)	175 (4-452)
Lipase (U/L)	—	—	4 (3-4)
Magnesium (mg/dL)	—	—	2.5
Phosphorus (mg/dL)	3.7 (1.8-8.0)	3.8 (1.7-11.3)	3.8 (1.5-9.3)
Potassium (mEq/L)	4.9 (1.8-9.1)	4.6 (2.3-9.2)	5.0 (1.2-8.7)
Protein, total (g/dL)	7.0 (3.3-10.7)	6.4 (3.8-10.3)	6.3 (3.8-10.7)
Albumin (g/dL) ^b	2.1 (1.0-3.4)	1.8 (0.8-2.9)	2.3 (1.4-3.6)
Globulin (g/dL) ^b	4.7 (2.6-7.4)	4.4 (2.1-7.2)	4.0 (1.5-6.6)
Sodium (mEq/L)	162 (149-181)	161 (140-180)	164 (148-180)
Triglyceride (mg/dL)	331 (47-1118)	—	195 (21-1017)
Uric acid (mg/dL)	4.4 (1.0-13.6)	4.6 (1.4-16.0)	4.1 (0.9-14.0)

Continued

TABLE 4-10 Hematologic and Serum Biochemical Values of Reptiles. (cont'd)

Measurement	Milk snake (<i>Lampropeltis triangulum</i>) ^{117,376}	Prehensile-tailed skink (<i>Corucia zebrata</i>) ^{376,403}	Blue-tongued skink (<i>Tiliqua scincoides</i>) ^{117,376}
Hematology			
PCV (%)	30 (10-43)	32 (21-43)	28 (16-39)
RBC (10 ⁶ /μL)	0.88 (0.36-1.45)	1.59 (0.91-2.28)	0.89 (0.30-2.00)
Hgb (g/dL)	10.4 (6.9-11.9)	9.3 (5.7-12.0)	10.4 (6-13)
MCV (fL)	354 (135-615)	213 (126-311)	297 (34-441)
MCH (pg)	119 (89-164)	61 (35-91)	98 (44-173)
MCHC (g/dL)	34 (29-45)	28 (19-35)	33 (16-57)
WBC (10 ³ /μL)	7.33 (1.66-23.8)	11.5 (3.4-31.2)	5.93 (2.00-17.7)
Heterophils (10 ³ /μL)	1.29 (0.09-5.32)	3.66 (0.70-10.6)	2.24 (0.43-6.64)
Lymphocytes (10 ³ /μL)	3.55 (0.61-10.33)	3.87 (0.50-16.2)	1.93 (0.31-7.31)
Monocytes (10 ³ /μL)	0.12 (0.03-1.19)	0.68 (0.07-4.55)	0.16 (0.03-1.03)
Azurophils (10 ³ /μL)	0.76 (0.02-6.13)	0.11 (0.02-4.28)	0.16 (0.01-1.93)
Eosinophils (10 ³ /μL)	—	0.45 (0.05-1.48)	0.37 (0.02-1.50)
Basophils (10 ³ /μL)	0.24 (0.02-0.67)	1.26 (0.10-5.30)	0.67 (0.03-2.27)
Chemistries			
ALP (U/L)	115 (27-338)	118 (33-344)	80 (25-159)
ALT (U/L)	8 (3-17)	6 (1-20)	20 (5-34)
Amylase (U/L)	665	792 (255-1971)	—
AST (U/L)	19 (1-74)	14 (3-54)	20 (5-80)
Bilirubin, total (mg/dL)	0.4 (0.1-0.9)	0.2 (0-0.5)	—
BUN (mg/dL)	2 (1-14)	1 (0-4)	2 (1-27)
Calcium (mg/dL)	14.9 (11.0-18.9)	11.8 (8.9-15.2)	12.7 (10.0-15.9)
Chloride (mEq/L)	122 (106-137)	124 (107-138)	116 (100-132)
Cholesterol (mg/dL)	446 (51-631)	97 (39-265)	207 (49-601)
Creatine kinase (U/L)	157 (7-566)	234 (26-1319)	629 (59-5570)
Creatinine (mg/dL)	0.5 (0.3-1.1)	0.3 (0-0.6)	0.3 (0.1-0.6)
GGT (U/L)	8 (3-13)	2 (0-11)	8
Glucose (mg/dL)	52 (12-128)	107 (35-171)	127 (72-202)
LDH (U/L)	816 (18-2807)	183 (28-625)	735 (364-1106)
Lipase (U/L)	—	25 (8-63)	364
Phosphorus (mg/dL)	3.5 (1.0-7.3)	4.3 (2.3-9.8)	4.4 (2.3-10.8)
Potassium (mEq/L)	4.6 (2.2-8.1)	5.0 (2.9-8.1)	5.1 (3.3-7.9)
Protein, total (g/dL)	6.5 (3.9-10.0)	5.8 (4.1-8.3)	6.1 (3.7-8.5)
Albumin (g/dL) ^b	2.0 (0.8-3.2)	2.3 (1.4-3.4)	2.1 (1.1-3.1)
Globulin (g/dL) ^b	4.6 (2.4-6.8)	3.5 (2.3-5.0)	3.9 (2.4-5.8)
Sodium (mEq/L)	164 (148-180)	160 (145-177)	151 (139-175)
Triglyceride (mg/dL)	428 (68-1620)	48 (12-309)	—
Uric acid (mg/dL)	4.9 (1.3-15.0)	1.8 (0.3-5.0)	2.7 (0.6-9.5)

TABLE 4-10 Hematologic and Serum Biochemical Values of Reptiles. (cont'd)

Measurement	Panther chameleon (<i>Furcifer pardalis</i>) ^{117,376}	Veiled chameleon (<i>Chameleo calyptratus</i>) ³⁷⁶	Spiny-tailed lizard (<i>Uromastyx spp.</i>) ^{117,279}
Hematology			
PCV (%)	31 (17-46)	24 (12-37)	29 (4.9-44.5)
RBC (10 ⁶ /μL)	0.83 (0.42-1.6)	—	0.78 (0.33-4.1)
Hgb (g/dL)	—	—	9.9 (3.3-17.4)
MCV (fL)	330 (200-418)	—	415 (119-614)
MCH (pg)	—	—	133 (1.2-203)
MCHC (g/dL)	—	—	33 (22-41)
Thrombocytes (10 ³ /μL)	—	—	958 (290-2290)
WBC (10 ³ /μL)	9.92 (0.47-25.1)	6.30 (1.20-21.0)	3.1 (1-8.1)
Heterophils (10 ³ /μL)	2.68 (0.09-6.64)	2.35 (0.50-8.32)	2 (0.59-5.36)
Lymphocytes (10 ³ /μL)	5.98 (0.21-16.8)	2.18 (0.07-10.8)	0.99 (0.27-4.05)
Monocytes (10 ³ /μL)	—	—	0.04 (0-0.5)
Azurophils (10 ³ /μL)	0.46 (0-2.29)	0.50 (0-2.75)	—
Eosinophils (10 ³ /μL)	—	—	0.04 (0-0.2)
Basophils (10 ³ /μL)	0.13 (0.03-0.92)	—	0.03 (0-0.33)
Chemistries			
ALP (U/L)	32 (1-109)	—	31 (5.9-139)
ALT (U/L)	—	—	11 (2.4-35)
Amylase (U/L)	—	—	134
AST (U/L)	23 (2-70)	397 (93-967)	73 (29-172)
Bilirubin, total (mg/dL)	—	—	0.3 (0.1-0.7)
BUN (mg/dL)	—	—	0.56 (0-3)
Calcium (mg/dL)	10.9 (7.1-14.6)	11.9 (8.7-14.5)	9.9 (7.2-13.2)
Chloride (mEq/L)	—	—	126 (111-135)
Cholesterol (mg/dL)	—	—	161 (64-295)
Creatine kinase (U/L)	367 (47-1474)	1873 (5-8905)	1778 (141-10 k)
Creatinine (mg/dL)	—	—	0.4 (0.1-3)
GGT (U/L)	—	—	0.8 (0-5.0)
Glucose (mg/dL)	319 (174-465)	270 (125-444)	200 (68-356)
LDH (U/L)	—	—	209 (22-899)
Magnesium (mg/dL)	—	—	3.48 (2.1-10.2)
Phosphorus (mg/dL)	9.8 (2.1-17.5)	8.4 (4.4-16.1)	4.5 (1.3-10)
Potassium (mEq/L)	5.5 (1.1-10.0)	6.5 (3.5-12.0)	3.7 (3-4.6)
Protein, total (g/dL)	5.9 (3.3-8.5)	6.4 (4.4-10.9)	4 (2.6-7.4)
Albumin (g/dL) ^b	2.6 (1.2-4.1)	3.1 (1.4-4.2)	2 (1.2-3.1)
Globulin (g/dL) ^b	3.2 (2.0-4.4)	3.3 (2.0-5.9)	2.9 (2.2-4.6)
Sodium (mEq/L)	143 (127-159)	144 (132-169)	173 ± 4
Triglyceride (mg/dL)	—	—	175 (111-238)
Uric acid (mg/dL)	5.1 (0-12.9)	5.6 (0-21.9)	2.94 (0.3-7.3)

Continued

TABLE 4-10 Hematologic and Serum Biochemical Values of Reptiles. (cont'd)

Measurement	Bearded dragon (<i>Pogona vitticeps</i>) ^{85,117}	Gila monster (<i>Heloderma suspectum</i>) ⁶²	Green iguana (<i>Iguana iguana</i>) ^{70,81,150,260,286,376}
Hematology			
PCV (%)	30 (17-45)	37 (22-50)	25-38
RBC (10 ⁶ /μL)	1 (0.40-1.60)	0.50 (0.22-0.67)	1-1.9
Hgb (g/dL)	9.3 (4.7-14)	7.4 (6.0-9.5)	8-12
MCV (fL)	292 (77-506)	812 (415-1773)	165-305
MCH (pg)	90 (16-163)	—	65-105
MCHC (g/dL)	32 (19-46)	21 (14-36)	20-38
WBC (10 ³ /μL)	6.21 (1.45-19.0)	4.72 (3.30-6.40)	3-10
Heterophils (10 ³ /μL)	2.09 (0.24-7.77)	2.17 (1.35-3.31)	0.35-5.2
Lymphocytes (10 ³ /μL)	2.77 (0.29-11.3)	1.54 (0.58-3.39)	0.5-5.5
Monocytes (10 ³ /μL)	0.25 (0.03-1.39)	0.07 (0-0.19)	0-0.1
Azurophils (10 ³ /μL)	0.11 (0.01-1.98)	0.38 (0-1.14)	0-1.7
Eosinophils (10 ³ /μL)	0.12 (0.01-0.37)	—	0-1
Basophils (10 ³ /μL)	0.26 (0.04-1.28)	0.57 (0.23-1.05)	0-0.5
Fibrinogen (mg/dL)	180 (0-300)	—	0-300
Chemistries			
ALP (U/L)	133 (21-569)	—	40 (4-170)
ALT (U/L)	9 (0-33)	—	21 (0-97)
Amylase (U/L)	1670(497-3430)	—	1815 (996-2988)
AST (U/L)	20 (2-90)	42 (20-66)	52 (2-100)
Bile acids (rest; μmol/L)	—	16.2 (2.6-55.1)	7.5 (2.6-30.3)
Bile acids (7.5 h; μmol/L)	—	—	32.5 (15.2-44.1)
Bilirubin, total (mg/dL)	0.4 (0-1.4)	—	0.3 (0-4.9)
BUN (mg/dL)	2 (1-5)	15 (6-30)	2 (0-10)
Calcium (mg/dL)	11.9 (8.6-18)	12.2 (10.2-13.4)	12 (6-18) ^d
Ionized Ca ⁺⁺ (mmol/L)	—	1.26 (1.09-1.50)	1.01-1.62
Chloride (mEq/L)	120 (94-149)	—	117 (102-130)
Cholesterol (mg/dL)	271 (79-606)	—	104-333 ^d
Creatine kinase (U/L)	563 (33-4042)	600 (144-1812)	1876 (174-8768) ^d
Creatinine (mg/dL)	0.2 (0-0.7)	—	0.5 (0.2-1.3)
GGT (U/L)	1 (0-21)	—	3 (0-10)
Glucose (mg/dL)	202 (108-333)	48 (4-109)	169-288
Iron (μg/dL)	—	—	88-133
LDH (U/L)	347 (25-1906)	—	617 (36-7424) ^d
Lipase (U/L)	—	—	21 (17-24)
Magnesium (mEq/L)	—	—	2.4-4
Phosphorus (mg/dL)	4.4 (2.1-10.6)	3.4 (1.1-8.6)	5 (2.5-21) ^d
Potassium (mEq/L)	4.0 (1.5-7.1)	3.9 (2.8-4.6)	1.3-3
Protein, total (g/dL)	5.0 (3.0-8.1)	6.3 (5.4-6.9)	5.4 (4.1-7.4) ^d

TABLE 4-10 Hematologic and Serum Biochemical Values of Reptiles. (cont'd)

Measurement	Bearded dragon (<i>Pogona vitticeps</i>)	Gila monster (<i>Heloderma suspectum</i>)	Green iguana (<i>Iguana iguana</i>)
Albumin (g/dL) ^b	2.5 (1.2-4.0)	—	2.1-2.8
Albumin (PEP; g/dL) ^b	—	2.61 (2.14-3.23)	1.8 (1.4-3.1)
Globulin (g/dL) ^b	2.5 (1.1-4.5)	—	2.5-4.3 ^d
α-1 (PEP; g/dL) ^b	—	2.09 (1.48-2.60)	0.9 (0.4-1.2)
α-2 (PEP; g/dL) ^b	—	0.59 (0.44-0.76)	—
β (PEP; g/dL) ^b	—	0.58 (0.41-0.77)	2.2 (1.6-3.8) ^d
γ (PEP; g/dL) ^b	—	0.33 (0.18-0.68)	0.3 (0.1-0.4)
A/G ratio	—	—	0.5 (0.41-0.78)
Sodium (mEq/L)	157 (140-179)	144 (140-151)	158-183
Triglyceride (mg/dL)	261 (93-437)	—	383 (7-1323) ^d
Uric acid (mg/dL)	3.1 (0.5-9.8)	16.8 (9.8-24.7)	2.6 (0-8.2) ^d
Vitamin D ₃ (25-OH; nmol/L)	—	—	51-393 ^d

Measurement	Green iguana (<i>Iguana iguana</i>) male ^{a,138,183}	Green iguana (<i>Iguana iguana</i>) female ^{a,138,183}	Green iguana (<i>Iguana iguana</i>) juvenile ^{a,138}
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Hematology

PCV (%)	34 (29-39)	38 (33-44)	38 (30-47)
RBC (10 ⁶ /μL)	1.3 (1-1.7)	1.4 (1.2-1.8)	1.4 (1.3-1.6)
Hgb (g/dL)	8.6 (6.7-10.2)	10.6 (9.1-12.2)	9.6 (9.2-10.1)
MCV (fL)	266 (228-303)	270 (235-331)	—
MCHC (g/dL)	25 (23-28)	28 (25-31)	—
WBC (10 ³ /μL)	15 (11-25)	15 (8-25)	16 (8-22)
Heterophils (10 ³ /μL)	3.6 (1-5.4)	3.2 (0.6-6.4)	2.2 (1-3.8)
Lymphocytes (10 ³ /μL)	9.7 (5-16.5)	9.9 (5.2-14.4)	12.9 (6.2-17.2)
Monocytes (10 ³ /μL)	1.3 (0.2-2.7)	1.2 (0.4-2.3)	0.4 (0.3-0.6)
Eosinophils (10 ³ /μL)	0.1 (0-0.3)	0.1 (0-0.2)	0.3 (0-0.4)
Basophils (10 ³ /μL)	0.4 (0.1-1)	0.5 (0.2-1.2)	0.5 (0.1-0.7)
Fibrinogen (mg/dL)	100 (100-200)	100 (100-300)	100 (100-300)

Chemistries

ALP (U/L)	39 (14-65)	59 (22-90)	—
ALT (U/L)	32 (4-76)	45 (5-96)	—
Anion gap (mEq/L)	22 (12-30)	29 (19-41)	—
AST (U/L)	33 (19-65)	40 (7-102)	41 (13-72)
Bilirubin, total (mg/dL)	0.8 (0.1-1.4)	1.5 (0.3-3.1)	—
Calcium (mg/dL)	11.3 (8.6-14.1)	12.5 (10.8-14)	14.3 (12.1-23.2)
Chloride (mEq/L)	119 (115-124)	121 (113-129)	—
Cholesterol (mg/dL)	161 (82-214)	255 (204-347)	—

Continued

TABLE 4-10 Hematologic and Serum Biochemical Values of Reptiles. (cont'd)

Measurement	Green iguana (<i>Iguana iguana</i>) male	Green iguana (<i>Iguana iguana</i>) female	Green iguana (<i>Iguana iguana</i>) juvenile
CO ₂ (mEq/L)	19.9 (15.2-24.7)	19 (16-23)	—
Estradiol (pg/mL)	79 (36-162)	270 (81-512)	—
Glucose (mg/dL)	166 (70-244)	170 (105-258)	273 (131-335)
Phosphorus (mg/dL)	5.3 (3.2-7.6)	6.3 (2.8-9.3)	7.7 (4.3-9)
Potassium (mEq/L)	4 (2.8-6.1)	3.6 (2-5.8)	—
Protein, total (g/dL)	5.4 (4.4-6.5)	6.1 (4.9-7.6)	5 (4.2-6.1)
Albumin (g/dL) ^b	2 (1.3-3)	2.4 (1.5-3)	2.3 (2-2.8)
Globulin (g/dL) ^b	3.5 (2.5-4.4)	3.8 (2.8-5.2)	2.7 (2.2-3)
A:G (ratio)	0.6 (0.4-0.9)	0.7 (0.3-1)	0.8 (0.7-0.9)
Sodium (mEq/L)	157 (152-162)	163 (156-172)	—
Testosterone (ng/mL)	10.2 (2.2-15.7)	0.26 (0.07-0.35)	—
Uric acid (mg/dL)	2.7 (1.5-5.8)	3.6 (0.9-6.7)	3.3 (0.7-5.7)

Measurement	Chinese (Asian) water dragon (<i>Physignathus cocincinus</i>) ²⁵⁶	Crested gecko (<i>Rhacodactylus ciliatus</i>) male ²⁵⁷	Crested gecko (<i>Rhacodactylus ciliatus</i>) female ²⁵⁷
PCV (%)	35 (32-40)	36 (23-45)	31 (24-43)
WBC (10 ³ /μL)	13.5 (11.7-18.2)	15.4 (3.5-38.9)	15.4 (3.5-38.9)
Heterophils (10 ³ /μL)	5.1 (3.9-6.9)	1.5 (0.6-4.2)	1.5 (0.6-4.2)
Lymphocytes (10 ³ /μL)	7.2 (5.6-9.5)	10.7 (2.2-24.9)	10.7 (2.2-24.9)
Monocytes (10 ³ /μL)	1.1 (0.4-1.9)	1.9 (0.8-5.1)	1.9 (0.8-5.1)
Azurophils (10 ³ /μL)	0 (0-0.6)	—	—
Eosinophils (10 ³ /μL)	0.2 (0.1-0.3)	0 (0-0.2)	0 (0-0.2)
Basophils (10 ³ /μL)	0.5 (0.2-0.8)	0.3 (0-0.8)	0.3 (0-0.8)

Hematology

Measurement	Chinese (Asian) water dragon (<i>Physignathus cocincinus</i>) ²⁵⁶	Crested gecko (<i>Rhacodactylus ciliatus</i>) male ²⁵⁷	Crested gecko (<i>Rhacodactylus ciliatus</i>) female ²⁵⁷
AST (U/L)	16.5 (8-52)	30 (12-84)	30 (12-84)
Bile acids (μmol/L)	—	43 (<35-89)	43 (<35-89)
Calcium (mg/dL)	12.4 (11.6-13.3)	12.5 (11.8-13.9)	>20 (15.6-20.0)
Creatine kinase (U/L)	1747 (19-6630)	489 (89-2104)	489 (89-2104)
Glucose (mg/dL)	157 (112-243)	107 (56-180)	107 (56-180)
Phosphorus (mg/dL)	5.7 (3.4-8.2)	4.0 (2.6-6.2)	9.6 (3.8-18.8)
Potassium (mEq/L)	4.2 (3.8-4.5)	2.6 (1.5-4.5)	2.6 (1.5-4.5)
Protein, total (g/dL)	7 (6.6-7.5)	6.0 (4.9-7.7)	6.6 (5.2-8.0)
Albumin (g/dL) ^b	2.2 (2.1-2.3)	2.7 (2.3-3.2)	2.9 (2.4-3.4)
Globulin (g/dL) ^b	4.7 (4.5-5.3)	3.5 (2.6-5.2)	3.5 (2.6-5.2)
Sodium (mEq/L)	150 (147-153)	143 (136-148)	143 (136-148)
Uric acid (mg/dL)	2.3 (1.9-2.7)	2.6 (0.9-6.0)	2.6 (0.9-6.0)

Chemistries

TABLE 4-10 Hematologic and Serum Biochemical Values of Reptiles. (cont'd)

Measurement	Savannah monitor (<i>Varanus exanthematicus</i>) ^{117,376}	Water monitor (<i>Varanus salvator</i>) ^{117,376}	Tegu lizard (<i>Tupinambus spp.</i>) ^{6,117,380}
Hematology			
PCV (%)	34 (16-51)	34 (20-47)	25 ± 2.6
RBC (10 ⁶ /μL)	1.23 (0.63-1.58)	0.98 (0.42-1.42)	0.96 ± 0.14
Hgb (g/dL)	10.5 (6.2-13.2)	10.5 (9.8-11.5)	11.4 ± 1.6
MCV (fL)	284 (229-382)	335 (227-595)	261 ± 23
MCH (pg)	94 (89-99)	140 (104-177)	119 ± 12.5
MCHC (g/dL)	32 (26-38)	33 (30-40)	45.6 ± 3.4
WBC (10 ³ /μL)	4.67 (0.10-10.9)	9.49 (2.9-18.8)	16.8 ± 2.5
Heterophils (10 ³ /μL)	1.58 (0.03-4.55)	4.30 (0.16-8.44)	2.2 ± 0.45
Lymphocytes (10 ³ /μL)	1.87 (0.06-4.88)	2.84 (0.3-7.98)	7.5 ± 0.58
Monocytes (10 ³ /μL)	0.42 (0.01-2.32)	0.81 (0.06-3.38)	1 ± 0.41
Azurophils (10 ³ /μL)	0.02 (0-0.69)	0.75 (0.01-3.72)	1.8 ± 0.56
Eosinophils (10 ³ /μL)	—	—	4.1 ± 0.11
Basophils (10 ³ /μL)	0.15 (0.07-0.28)	0.11 (0.06-0.14)	0.4 ± 0.01
Fibrinogen (mg/dL)	156 (100-300)	500 (200-700)	133 (0-200)
Chemistries			
ALP (U/L)	20 (4-101)	176 (14-405)	160 ± 85
ALT (U/L)	70 (7-374)	19 (1-93)	33 ± 24
Amylase (U/L)	—	1021 (265-1868)	—
AST (U/L)	26 (5-80)	24 (2-58)	18 ± 14
Bilirubin, total (mg/dL)	0.1 (0-0.3)	0.1 (0-0.3)	0.3 ± 0.2
BUN (mg/dL)	1 (0-5)	2 (1-5)	1 ± 1
Calcium (mg/dL)	13.6 (10.8-16.5)	14.0 (9.8-18.2)	12.2 ± 0.8
Chloride (mEq/L)	115 (93-133)	111 (97-124)	121 ± 7
Cholesterol (mg/dL)	116 (49-231)	78 (22-126)	206 ± 67
Creatine kinase (U/L)	1529 (7-6624)	772 (176-1818)	641 ± 568
Creatinine (mg/dL)	8.7 (0-67)	0.5 (0-1)	0.3 ± 0.1
GGT (U/L)	7 (1-11)	24 (7-48)	7
Glucose (mg/dL)	108 (54-163)	98 (29-170)	128 ± 30
Iron (μg/dL)	—	242 (111-429)	—
LDH (U/L)	427 (29-3699)	157 (34-1288)	540 ± 537
Magnesium (mEq/L)	3.1	2.5 (2.2-2.7)	—
Osmolarity (mOsm/L)	332 (319-345)	—	—
Phosphorus (mg/dL)	4.2 (0.8-7.7)	5.2 (2.9-8.9)	5.6 ± 2.1
Potassium (mEq/L)	4.9 (3.0-6.9)	4.6 (3.5-6.1)	2.4 ± 1.4
Protein, total (g/dL)	6.6 (3.4-9.8)	7.0 (5.1-9.8)	6.6 ± 1.3
Albumin (g/dL) ^b	2.0 (0.6-3.3)	2.4 (1.4-3.4)	3.6 ± 0.7
Albumin (PEP; g/dL) ^b	3.2 (3.1-3.3)	3.1 (3-3.2)	—

Continued

TABLE 4-10 Hematologic and Serum Biochemical Values of Reptiles. (cont'd)

Measurement	Savannah monitor (<i>Varanus exanthematicus</i>)	Water monitor (<i>Varanus salvator</i>)	Tegu lizard (<i>Tupinambus spp.</i>)
Globulin (g/dL) ^b	4.6 (1.4-7.9)	4.7 (2.0-7.3)	2.9 ± 1.2
α-1 (PEP; g/dL) ^b	—	0.1	—
α-2 (PEP; g/dL) ^b	—	0.9 (0.8-1)	—
β (PEP; g/dL) ^b	—	0.9	—
γ (PEP; g/dL) ^b	—	4.7 (2.6-6.8)	—
Sodium (mEq/L)	156 (142-169)	156 (143-170)	159 ± 4
Triglyceride (mg/dL)	135 (17-476)	35 (6-78)	31
Uric acid (mg/dL)	6.5 (2.0-14.6)	4.7 (1-12.2)	3.2 ± 2

Measurement	American alligator (<i>Alligator mississippiensis</i>) ^{117,376}	Dwarf caiman (<i>Paleosuchus palpebrosus</i>) ^{117,376}	Aldabra tortoise (<i>Aldabrachelys gigantea</i>) ³⁷⁶
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Hematology

PCV (%)	24 (9-39)	22 (12-35)	22 (11-34)
RBC (10 ⁶ /μL)	0.57 (0.21-1.3)	0.66 (0.43-0.89)	0.45 (0.13-0.77)
Hgb (g/dL)	7.8 (4.0-12.2)	7.7 (6.2-8.8)	7.1 (3.8-10.5)
MCV (fL)	430 (122-786)	362 (180-535)	469 (195-742)
MCH (pg)	135 (37-246)	98	154 (63-244)
MCHC (g/dL)	32 (18-45)	33 (23-38)	32 (21-42)
WBC (10 ³ /μL)	6.39 (2.03-21.3)	6 (2.1-14.7)	5.45 (1.54-17.5)
Heterophils (10 ³ /μL)	2.51 (0.50-8.19)	2.95 (0.51-7.73)	3.17 (0.69-8.79)
Lymphocytes (10 ³ /μL)	2.21 (0.29-12.1)	2.10 (0.28-9.66)	1.52 (0.11-5.53)
Monocytes (10 ³ /μL)	0.31 (0.04-2.04)	0.10 (0.02-0.44)	0.14 (0.02-0.79)
Azurophils (10 ³ /μL)	0.05 (0.01-1.25)	0.04 (0.01-0.73)	0.04 (0-0.68)
Eosinophils (10 ³ /μL)	0.22 (0.03-1.02)	0.12 (0.03-0.43)	0.13 (0.01-0.44)
Basophils (10 ³ /μL)	0.71 (0.04-3.23)	0.15 (0.04-0.46)	0.11 (0.02-0.40)
Fibrinogen (mg/dL)	267 ± 115	100 (0-200)	100 (0-200)

Chemistries

ALP (U/L)	34 (12-105)	13 (2-26)	64 (15-142)
ALT (U/L)	37 (8-92)	37 (5-74)	3 (0-22)
Amylase (U/L)	58 (25-1067)	47 (25-234)	947 (144-3266)
AST (U/L)	246 (111-539)	88 (36-218)	59 (19-155)
Bilirubin, total (mg/dL)	0.2 (0-0.8)	0.2 (0-0.6)	0.4 (0.1-1.2)
BUN (mg/dL)	2 (1-18)	2 (0-4)	18 (4-43)
Calcium (mg/dL)	11.2 (8.1-15.1)	10.4 (8.1-13.8)	11.7 (8.5-42.7)
Chloride (mEq/L)	112 (94-123)	121 (99-144)	93 (86-104)
Cholesterol (mg/dL)	108 (32-291)	115 (29-241)	229 (69-564)
Creatine kinase (U/L)	911 (145-7408)	1926 (89-9228)	59 (11-380)

TABLE 4-10 Hematologic and Serum Biochemical Values of Reptiles. (cont'd)

Measurement	American alligator (<i>Alligator mississippiensis</i>)	Dwarf caiman (<i>Paleosuchus palpebrosus</i>)	Aldabra tortoise (<i>Aldabrachelys gigantea</i>)
Creatinine (mg/dL)	0.3 (0-0.7)	0.3 (0-0.6)	0.2 (0-0.4)
Glucose (mg/dL)	88 (34-177)	64 (13-146)	43 (12-85)
LDH (U/L)	346 (13-1726)	1269 (62-4058)	473 (131-1077)
Osmolarity (mOsm/L)	—	303 (301-304)	—
Phosphorus (mg/dL)	4.3 (1.6-9.9)	4.4 (2.0-9.7)	3.9 (1.9-13)
Potassium (mEq/L)	3.8 (2.4-5.3)	4.3 (3.0-6.3)	5.5 (3.8-8.1)
Protein, total (g/dL)	5.1 (2.6-7.8)	5.4 (2.6-7.8)	5.3 (2.5-7.7)
Albumin (g/dL) ^b	1.5 (0.4-2.6)	1.4 (0.6-2.7)	1.6 (0.7-3.0)
Albumin (PEP; g/dL) ^b	—	2.2 (1.8-2.5)	—
Globulin (g/dL) ^b	3.3 (0.7-5.5)	4.0 (1.8-6.2)	3.7 (1.0-5.5)
Sodium (mEq/L)	147 (134-160)	151 (134-167)	128 (119-141)
Triglyceride (mg/dL)	83 (7-505)	92 (9-174)	425 (17-1010)
Uric acid (mg/dL)	1.3 (0.2-4.0)	2.1 (0.4-5.6)	1.5 (0.2-3.4)

Measurement	Radiated tortoise (<i>Astrochelys radiata</i>) ^{248,376,405}	Red-footed tortoise (<i>Chelonoidis carbonaria</i>) ^{117,376}	Indian star tortoise (<i>Geochelone elegans</i>) ^{117,376}
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Hematology

PCV (%)	10-51	25 (6-38)	23 (14-38)
RBC (10 ⁶ /μL)	0.3-1.1	0.46 (0.14-0.19)	0.37 (0.24-0.55)
Hgb (g/dL)	5.6 (4-8)	7.5 (7-7.9)	7.9 (6.9-8.5)
MCV (fL)	454 (319-571)	482 (22-940)	—
MCH (pg)	108 (82-133)	136 (123-149)	—
MCHC (g/dL)	28 (26-33)	31 (29-32)	27 (26-28)
WBC (10 ³ /μL)	2.5-14	6.51 (1.15-20.0)	6.71 (1.35-27.9)
Heterophils (10 ³ /μL)	0.7-8	1.67 (0.16-7.26)	2.56 (0.24-10.9)
Lymphocytes (10 ³ /μL)	0.4-5.8	1.89 (0.12-9.10)	2.83 (0.20-15.4)
Monocytes (10 ³ /μL)	0.02-0.5	0.16 (0.02-0.58)	0.20 (0.02-0.75)
Azurophils (10 ³ /μL)	0-0.82	0.05 (0-0.87)	0.05 (0.01-0.87)
Eosinophils (10 ³ /μL)	0.03-0.82	0.17 (0.02-0.80)	0.26 (0.03-1.51)
Basophils (10 ³ /μL)	0.1-2.5	0.92 (0.03-3.48)	0.49 (0.09-1.79)
Fibrinogen (mg/dL)	117 (100-200)	—	—

Chemistries

ALP (U/L)	72-392	60 (6-145)	72 (20-164)
ALT (U/L)	0-17	7 (0-18)	4 (0-14)
Amylase (U/L)	—	—	1235
AST (U/L)	25-348	130 (20-406)	54 (14-152)
Bile acids (μmol/L)	0.3-31.3	—	—
Bilirubin, total (mg/dL)	0-0.5	0.5 (0.1-1.1)	0.2 (0-0.5)

Continued

TABLE 4-10 Hematologic and Serum Biochemical Values of Reptiles. (cont'd)

Measurement	Radiated tortoise (<i>Astrochelys radiata</i>)	Red-footed tortoise (<i>Chelonoidis carbonaria</i>)	Indian star tortoise (<i>Geochelone elegans</i>)
BUN (mg/dL)	2-34	14 (1-34)	3 (0-9)
Calcium (mg/dL)	8.6-18	12.2 (7.1-24.1)	11.7 (7.6-21.2)
Chloride (mEq/L)	91-112	99 (81-111)	100 (88-112)
Cholesterol (mg/dL)	56-154	121 (10-257)	115 (15-255)
Creatine kinase (U/L)	33-5666	695 (54-3593)	374 (22-2644)
Creatinine (mg/dL)	0.1-0.5	0.4 (0.2-1.3)	0.3 (0.2-0.5)
GGT (U/L)	5 (0-11)	28 (7-130)	4 (0-5)
Glucose (mg/dL)	21-93	67 (13-154)	76 (37-186)
Iron (μ g/dL)	60	107	—
LDH (U/L)	213-6444	638 (118-1644)	438 (12-863)
Lipase (U/L)	5-50	—	5
Phosphorus (mg/dL)	2.5-7	3.5 (1.0-8.3)	3.6 (1.4-9.4)
Potassium (mEq/L)	3.1-5.8	5.5 (2.8-9.4)	4.8 (2.0-7.7)
Protein, total (g/dL)	3-6.6	4.7 (1.9-7.4)	4.7 (2.2-7.6)
Albumin (g/dL) ^b	0.6-2.4	1.6 (0-3.0)	1.7 (0.4-3.0)
Albumin (PEP; g/dL) ^b	0.9-2.4	—	—
Globulin (g/dL) ^b	1.4-3.2	3.1 (0.2-4.8)	2.9 (1.3-4.6)
α -1 Glob (PEP; g/dL) ^b	0.1-0.5	—	—
α -2 Glob (PEP; g/dL) ^b	0.6-1.9	—	—
β Glob (PEP; g/dL) ^b	0.6-1.5	—	—
γ Glob (PEP; g/dL) ^b	0.4-0.9	—	—
Sodium (mEq/L)	121-146	130 (117-143)	127 (117-137)
Triglyceride (mg/dL)	26-303	246 (28-480)	60 (27-110)
Uric acid (mg/dL)	0.3 (0-0.6)	0.6 (0.1-2.1)	3.3 (0.2-7.9)

Measurement	Desert tortoise (<i>Gopherus agassizii</i>) ^{3,53,72,127}	Gopher tortoise (<i>Gopherus polyphemus</i>) ³⁷⁵	Russian tortoise (<i>Testudo horsfieldii</i>) ^{202,252}
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Hematology

PCV (%)	15-39	23 (15-30)	23 (22-34)
RBC ($10^6/\mu$ L)	0.28-1.34	0.54 (0.24-0.91)	—
Hgb (g/dL)	3.6-10.3	6.4 (4.2-8.6)	—
MCV (fL)	197-688	—	—
MCH (pg)	39-189	—	—
MCHC (g/dL)	19-35	—	—
WBC ($10^3/\mu$ L)	0.97-10.9	15.7 (10-22)	8.5 (5-12.5)
Heterophils ($10^3/\mu$ L)	0.49-7.3	4.7 (1-12.5) ⁹	3.7 (1.3-4.6)
Lymphocytes ($10^3/\mu$ L)	0-3.8	—	4.7 (3.6-7.6)
Monocytes ($10^3/\mu$ L)	0-0.57	8.9 (3.2-17.4) ⁹	0.01 (0-0.02)

TABLE 4-10 Hematologic and Serum Biochemical Values of Reptiles. (cont'd)

Measurement	Desert tortoise (<i>Gopherus agassizii</i>)	Gopher tortoise (<i>Gopherus polyphemus</i>)	Russian tortoise (<i>Testudo horsfieldii</i>)
Azurophils ($10^3/\mu\text{L}$)	0-0.9	1.1 (0.3-2.9) ^g	0.05 (0.03-0.12)
Eosinophils ($10^3/\mu\text{L}$)	0-0.95	—	0.05 (0.02-0.06)
Basophils ($10^3/\mu\text{L}$)	0-4.3	0.94 (0.2-2.4) ^g	0.05 (0.02-0.08)
Chemistries			
ALP (U/L)	43-176	39 (11-71)	498 (181-1188)
ALT (U/L)	21 (0-66)	15 (2-57)	1 (0-2)
AST (U/L)	41-106	136 (57-392)	20 (12-32)
Bile acids ($\mu\text{mol/L}$)	0-5.4	—	—
Bilirubin, total (mg/dL)	0-0.9	0.02 (0-0.1)	0.015 (0-0.09)
BUN (mg/dL)	0-4	30 (1-130)	12 (4-17)
Calcium (total; mg/dL)	9.3-14.7	12 (10-14)	13.2 (9.9-19.5)
Ionized calcium (mmol/L)	—	—	1.28 (1-1.6)
Chloride (mEq/L)	94-112	102 (35-128)	—
Cholesterol (mg/dL)	56-233	76 (19-150)	109 (25-210)
Creatine kinase (U/L)	2262 (944-3880)	160 (32-628)	123 (6-344)
Creatinine (mg/dL)	0.11-0.37	0.3 (0.1-0.4)	—
GLDH (U/L)	—	—	1 (0.6-1.5)
Glucose (mg/dL)	92-165	75 (55-128)	59 (40-86)
LDH (U/L)	25-250	273 (18-909)	—
Magnesium (mEq/L)	2.1 (1.8-2.4)	4.1 (3.3-4.8)	—
Phosphorus (mg/dL)	1-6.3	2.1 (1-3.1)	2.6 (1.3-3.9)
Potassium (mEq/L)	3.5-4.7	5 (2.9-7)	5.3 (1.9-7.2)
Protein, total (g/dL)	3-4.6	3.1 (1.3-4.6)	3 (2.5-4.6)
Albumin (g/dL) ^b	1.2-2.2	1.5 (0.5-2.6)	1.6 (1.2-2.3)
Albumin (PEP; g/dL) ^b	—	—	—
Globulin (g/dL) ^b	1.2-2.6	—	1.4 (1.3-2.3)
α -1 Glob (PEP; g/dL) ^b	1	—	—
α -2 Glob (PEP; g/dL) ^b	1	—	—
β Glob (PEP; g/dL) ^b	0.6	—	—
γ Glob (PEP; g/dL) ^b	—	—	—
Sodium (mEq/L)	122-139	138 (127-148)	138 (131-149)
Triglyceride (mg/dL)	0-425	—	—
Uric acid (mg/dL)	2.7-7.2	3.5 (0.9-8.5)	1.2 (0.8-3.9)
Vitamin A ($\mu\text{g/mL}$)	0.2-0.6	—	—
Zinc (ppm)	0.4-3.7	—	—

Continued

TABLE 4-10 Hematologic and Serum Biochemical Values of Reptiles. (cont'd)

Measurement	African spurred tortoise (<i>Centrochelys sulcata</i>) ^{117,376}	Leopard tortoise (<i>Stigmochelys pardalis</i>) ^{117,376}	Galapagos tortoise (<i>Chelonoidis nigra</i>) ³⁷⁶
Hematology			
PCV (%)	28 (9-43)	23 (8-37)	18 (7-29)
RBC (10 ⁶ /μL)	0.61 (0.08-1.15)	0.52 (0.15-1.06)	0.40 (0.16-0.63)
Hgb (g/dL)	7.7 (2.4-13.1)	16.1 (8.8-28)	5.5 (3.3-8.9)
MCV (fL)	418 (156-678)	488 (179-833)	535 (266-769)
MCH (pg)	116 (2.1-193)	83	160 (100-239)
MCHC (g/dL)	30 (20-40)	44 (42-46)	31 (24-38)
WBC (10 ³ /μL)	4.41 (0.87-13.23)	4.24 (0.6-10.0)	4.57 (0.71-17.5)
Heterophils (10 ³ /μL)	1.92 (0.23-7.43)	1.92 (0.11-4.87)	1.57 (0.10-6.76)
Lymphocytes (10 ³ /μL)	1.41 (0.17-6.06)	1.61 (0.05-4.74)	1.45 (0.04-6.56)
Monocytes (10 ³ /μL)	0.01 (0.01-0.37)	0.08 (0.02-0.62)	0.08 (0.02-0.33)
Azurophils (10 ³ /μL)	0.04 (0-0.84)	0.02 (0-0.51)	0.03 (0-0.52)
Eosinophils (10 ³ /μL)	0.10 (0.01-0.43)	0.15 (0.02-0.37)	0.09 (0.02-0.40)
Basophils (10 ³ /μL)	0.12 (0.01-0.36)	0.11 (0.01-0.34)	0.34 (0.03-1.38)
Chemistries			
ALP (U/L)	36 (10-70)	107 (21-278)	77 (27-235)
ALT (U/L)	9 (0-33)	8	3 (0-18)
Amylase (U/L)	1359 (399-2240)	—	22 (3-41)
AST (U/L)	108 (34-401)	54 (5-119)	40 (16-122)
Bilirubin, total (mg/dL)	0.1 (0-0.7)	0.1	0.3 (0-0.8)
BUN (mg/dL)	3 (1-6)	12 (1-36)	12 (3-35)
Calcium (mg/dL)	11.4 (7.8-21.2)	11.8 (6.5-18.3)	10.4 (6.6-17.8)
Chloride (mEq/L)	109 (93-124)	104 (90-119)	98 (83-112)
Cholesterol (mg/dL)	129 (36-283)	111 (9-239)	172 (42-450)
Creatine kinase (U/L)	407 (31-2088)	359 (223-704)	592 (35-2378)
Creatinine (mg/dL)	0.3 (0.1-0.4)	0.6	0.2 (0-0.4)
GGT (U/L)	14 (3-19)	—	4 (0-11)
Glucose (mg/dL)	107 (55-220)	75 (10-152)	98 (35-312)
Iron (μg/dL)	81 (80-82)	—	73 (8-593)
LDH (U/L)	977 (140-3264)	446 (346-546)	469 (71-1212)
Phosphorus (mg/dL)	3.8 (1.5-6.5)	2.7 (1.1-5.2)	3.7 (2.0-8.0)
Potassium (mEq/L)	6.1 (3.3-11.9)	5.4 (2.3-8.8)	4.8 (3.4-7.2)
Protein, total (g/dL)	3.8 (1.2-6.3)	3.3 (1.9-6.2)	4.7 (1.8-7.9)
Albumin (g/dL) ^b	1.5 (0-2.3)	1.6 (0.3-2.9)	1.6 (0.4-2.7)
Globulin (g/dL) ^b	2.3 (0.4-3.8)	2.6 (0.6-4.6)	3.1 (1.1-5.5)
Sodium (mEq/L)	139 (125-154)	132 (115-148)	130 (119-140)
α-tocopherol (μg/dL)	—	—	2 (1,2)
Triglyceride (mg/dL)	163 (53-388)	—	271 (29-1345)
Free T ₃	—	—	29
Uric acid (mg/dL)	4.6 (0.6-10.4)	2.5 (0.5-6.6)	1.7 (0.1-4.0)

TABLE 4-10 Hematologic and Serum Biochemical Values of Reptiles. (cont'd)

Measurement	Eastern box turtle (<i>Terrapene carolina</i>) ^{73,99,103,189,376}	Ornate box turtle (<i>Terrapene ornata</i>) ^{117,376}	Wood turtle (<i>Glyptemys insculpta</i>) ³⁷⁶
Hematology			
PCV (%)	24 (8-37)	23 (10-37)	25 (9-41)
RBC (10 ⁶ /μL)	0.56 (0.08-1.03)	0.62 (0.46-0.8)	—
Hgb (g/dL)	6.8 (2.6-11.0)	7.2 (6-9)	—
MCV (fL)	396 (117-750)	408 (350-463)	—
MCH (pg)	110 (30-207)	122 (108-136)	—
MCHC (g/dL)	29 (14-43)	33 (31-33)	—
WBC (10 ³ /μL)	5.48 (1.34-15.9)	5.76 (1.2-13.4)	5.20 (0.8-20.0)
Heterophils (10 ³ /μL)	1.61 (0.15-6.4)	2.01 (0.10-5.9)	—
Lymphocytes (10 ³ /μL)	1.61 (0.15-9.82)	2.19 (0.10-7.60)	3.15 (0.59-13.0)
Monocytes (10 ³ /μL)	0.19 (0.18-0.80)	0.13 (0.02-0.74)	—
Azurophils (10 ³ /μL)	0.03 (0-0.80)	0.03 (0-0.13)	0.08 (0-1.11)
Eosinophils (10 ³ /μL)	0.47 (0.42-3.01)	0.23 (0.03-1.32)	—
Basophils (10 ³ /μL)	0.55 (0.4-2.14)	0.25 (0.02-0.92)	—
Chemistries			
ALP (U/L)	77 (20-225)	61 (14-139)	71 (21-268)
ALT (U/L)	6 (0-20)	30 (25-33)	—
Amylase (U/L)	1033 (87-2526)	691 (2-1893)	—
AST (U/L)	64 (14-191)	61 (11-141)	79 (14-212)
Bilirubin, total (mg/dL)	0.1 (0.1-0.4)	0.3 (0.1-0.4)	—
BUN (mg/dL)	52 (6-121)	60 (4-154)	—
Calcium (mg/dL)	10.5 (6.8-23.2) ^d	10.3 (6.2-17.5)	11.8 (6.3-29.4)
Chloride (mEq/L)	106 (89-121)	108 (93-124)	—
Cholesterol (mg/dL)	205 (42-483)	201 (20-469)	—
Creatine kinase (U/L)	153 (23-747)	196 (0-777)	—
Creatinine (mg/dL)	0.2 (0-0.5)	1 (0.2-2.4)	—
Glucose (mg/dL)	48 (23-114)	67 (13-120)	53 (13-108)
LDH (U/L)	307 (20-1032)	362 (300-424)	—
Phosphorus (mg/dL)	3.5 (1.7-7.5)	3.3 (1.9-5.8)	3.2 (1.6-10)
Potassium (mEq/L)	4.7 (3.1-9.4)	4.7 (2.4-8.2)	—
Protein, total (g/dL)	3.20 (3.10-3.90)	4.0 (1.4-6.6)	4.7 (1.5-6.5)

Continued

TABLE 4-10 Hematologic and Serum Biochemical Values of Reptiles. (cont'd)

Measurement	Eastern box turtle (<i>Terrapene carolina</i>)	Ornate box turtle (<i>Terrapene ornata</i>)	Wood turtle (<i>Glyptemys insculpta</i>)
Protein, total (male; g/dL)	3.00 (1.80-5.20)	—	—
Protein, total (female; g/dL)	4.00 (2.20-6.20)	—	—
Haptoglobin	0.25 (0.27-0.38)	—	—
Albumin (g/dL) ^b	2.2 (1.2-3.2)	1.5 (0.2-2.8)	—
Pre-alb (PEP; g/dL) ^b	0 (0-0.002)	—	—
Albumin (PEP; g/dL) ^b	0.71-0.85	—	—
Globulin (g/dL) ^b	3.4 (2.5-4.7)	2.4 (0.6-4.3)	—
α-1 Glob (PEP; g/dL) ^b	0.25 (0.25-0.30)	—	—
α-2 Glob (PEP; g/dL) ^b	0.80 (0.76-0.92)	—	—
β Glob (PEP; g/dL) ^b	1.27 (1.27-1.55)	—	—
γ Glob (PEP; g/dL) ^b	0.26 (0.27-0.32)	—	—
A:G ratio	0.27-0.31	—	—
Sodium (mEq/L)	139 (120-155)	141 (129-154)	—
Uric acid (mg/dL)	0.7 (0.1-2.9)	0.6 (0-1.9)	1.0 (0-4.1)

Measurement	Pacific pond turtle (<i>Actinemys marmorata</i>) ³⁷⁶	Sliders (<i>Trachemys scripta spp.</i>) ^{65,111,117,168,376}	Painted turtle (<i>Chrysemys picta</i>) ^{111,168,376}
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Hematology

PCV (%)	24 (7-42)	26 (8-44)	25 (6-43)
RBC (10 ⁶ /μL)	0.69 (0.24-1.20)	0.84 (0.33-2.21)	0.57 (0.41-0.68)
Hgb (g/dL)	7.6 (3.0-12.6)	11.1 (10-12.2)	11.2 (10.7-11.7)
MCV (fL)	377 (200-634)	409 (179-697)	271 (183-365)
MCH (pg)	107 (19-186)	108	—
MCHC (g/dL)	27 (18-42)	30	—
WBC (10 ³ /μL)	5.94 (1.02-17.0)	6.73 (1.0-19.4)	9.49 (0.40-23.2)
Heterophils (10 ³ /μL)	1.83 (0.14-5.52)	2.33 (0.18-5.86)	2.30 (0.17-8.39)
Lymphocytes (10 ³ /μL)	2.46 (0.22-8.48)	2.28 (0.03-6.90)	2.60 (0.01-7.07)
Monocytes (10 ³ /μL)	—	0.18 (0.04-0.65)	—
Azurophils (10 ³ /μL)	0.04 (0-0.43)	0.05 (0-0.48)	0.05 (0-0.26)
Eosinophils (10 ³ /μL)	0.37 (0.02-1.81)	0.52 (0.01-3.06)	—
Basophils (10 ³ /μL)	0.62 (0.05-2.09)	1.07 (0.01-3.56)	1.95 (0.04-5.91)

Chemistries

ALP (U/L)	—	113 (30-372)	208
ALT (U/L)	—	14 (1-66)	—
Amylase (U/L)	—	493 (411-535)	—
AST (U/L)	105 (26-228)	141 (44-358)	132 (45-284)

TABLE 4-10 Hematologic and Serum Biochemical Values of Reptiles. (cont'd)

Measurement	Pacific pond turtle		
	<i>(Actinemys marmorata)</i>	Sliders (<i>Trachemys scripta</i> spp.)	Painted turtle (<i>Chrysemys picta</i>)
Bilirubin, total (mg/dL)	—	0.2 (0.1-0.5)	0.1
BUN (mg/dL)	—	23 (2-64)	37
Calcium (mg/dL)	10.0 (7.0-14.5)	12.6 (6.5-22.6)	11.7 (5.5-19.1)
Chloride (mEq/L)	—	98 (88-112)	96 (73-109)
Cholesterol (mg/dL)	—	162 (106-227)	—
Creatine kinase (U/L)	242 (63-747)	516 (108-2125)	352 (35-1608)
Creatinine (mg/dL)	—	0.3 (0.2-0.5)	—
GGT (U/L)	—	7 (0-21)	—
Glucose (mg/dL)	53 (4-113)	54 (21-143)	63 (10-133)
Iron (μg/dL)	—	—	—
LDH (U/L)	—	1713 (371-5763)	412
Lipase (U/L)	—	6 (1-15)	—
Magnesium (mEq/L)	—	2.2	4.8
Phosphorus (mg/dL)	3.6 (1.9-6.6)	4.0 (1.8-8.8)	3.6 (1.7-7.2)
Potassium (mEq/L)	4.3 (2.3-7.1)	3.8 (2.4-7.5)	3.6 (2.2-11.6)
Protein, total (g/dL)	4.4 (1.8-7.0)	4.8 (1.1-8.8)	4.4 (1.8-7.7)
Albumin (g/dL) ^b	1.7 (0.7-2.7)	1.8 (0.6-3.3)	1.3 (0-2.7)
Globulin (g/dL) ^b	2.8 (1.0-4.6)	3.2 (1.1-5.9)	3.0 (0.1-5.9)
Sodium (mEq/L)	135 (123-147)	134 (123-147)	137 (119-146)
Triglyceride (mg/dL)	—	304 (30-664)	—
Uric acid (mg/dL)	0.9 (0-3.1)	0.8 (0.1-1.9)	0.7 (0.1-1.8)

Measurement	Loggerhead sea turtle (<i>Caretta caretta</i>) ^{37,376}	Green sea turtle (<i>Chelonia mydas</i>) ^{38,370,376}	Hawksbill sea turtle (<i>Eretmochelys imbricata</i>) ^{h,376,392}
	Hematology		
PCV (%)	32 (18-40)	33 (23-45)	13-41
RBC (10 ⁶ /μL)	0.52 (0.22-1.22)	0.52 (0.21-0.97)	—
Hgb (g/dL)	10.7	10.7	—
MCV (fL)	416 (82-1027)	717 (320-1429)	—
MCH (pg)	55	55	—
MCHC (g/dL)	36	36	—
WBC (10 ³ /μL)	9.00 (5.00-12.50)	9.98 (3.76-21.7)	—
Heterophils (10 ³ /μL)	3.67 (0.35-7.16)	6.69 (1.57-15.7)	—
Lymphocytes (10 ³ /μL)	2.72 (0.30-4.83)	2.14 (0.94-4.34)	—
Monocytes (10 ³ /μL)	0.96 (0.22-1.84)	0.91 (0.23-1.81)	—
Azurophils (10 ³ /μL)	—	—	—
Eosinophils (10 ³ /μL)	1.15 (0.45-2.10)	0.12 (0-0.48)	—
Basophils (10 ³ /μL)	—	0.13 (0-1.94)	—

Continued

TABLE 4-10 Hematologic and Serum Biochemical Values of Reptiles. (cont'd)

Measurement	Loggerhead sea turtle (<i>Caretta caretta</i>)	Green sea turtle (<i>Chelonia mydas</i>)	Hawksbill sea turtle (<i>Eretmochelys imbricata</i>)
Chemistries			
ALP (U/L)	64 (11-254)	6-67	7-80
ALT (U/L)	—	32 (3-241)	1-23
Amylase (U/L)	—	534	—
AST (U/L)	154 (10-480)	74-245	74-245
Bilirubin, total (mg/dL)	—	0.03-0.2	0-10
BUN (mg/dL)	105 (19-162)	64 (13.9-173)	7-34
Calcium (mg/dL)	6.9 (2.2-11.5)	8-8.8	2.6-11.6
Chloride (mEq/L)	118 (103-137)	101-121	106-134
Cholesterol (mg/dL)	—	221 (142-354)	—
Creatine kinase (U/L)	899 (258-3586)	326-2729	14-6008
Creatinine (mg/dL)	—	0.25 (0.1-1.6)	—
GGT (U/L)	—	6 (0-21)	—
Glucose (mg/dL)	120 (66-177)	67-178	79-162
Iron (µg/dL)	—	362 (117-600)	6-67
LDH (U/L)	—	75-477	—
Lipase (U/L)	—	—	—
Magnesium (mEq/L)	—	4.8-12.2	3.4-7.1
Phosphorus (mg/dL)	9.3 (3.7-14.0)	4.9-11.1	1.9-8.7
Potassium (mEq/L)	3.9 (2.7-5.1)	3-7.1	3.0-5.3
Protein, total (g/dL)	3.3 (1.2-6.9)	2.1-6.2	1.3-5.1
Albumin (g/dL) ^b	1.5 (0.7-2.6)	0.7-1.8	0.3-1.4
Globulin (g/dL) ^b	2.2 (0.2-4.9)	1.5-4.7	0.8-4.8
Sodium (mEq/L)	153 (142-164)	139-158	146-159
Triglyceride (mg/dL)	—	492 (124-932)	—
Uric acid (mg/dL)	0.5 (0-1.2)	1.1 (0-2.7)	0.6 (0-1.8)

^aListed values are median followed by either min-max or a confidence interval in parentheses depending on reported methods and the authors' judgment from the available evidence, unless a single value indicating $n=1$, or a range that is not enclosed in parentheses indicating a reported reference interval.

^bAlbumin is measured by colorimetry (e.g., bromocresol green) and globulin value is calculated unless otherwise indicated (PEP = protein electrophoresis).

^cRemarkably high reference ranges for Ca (mean, 159 mg/dL; range, 30-337 mg/dL) and P (mean, 35 mg/dL; range, 8-69) have also been reported.⁸⁵

^dCan be elevated in gravid females^{189,286}

^eThese data were obtained from iguanas housed outdoors with unfiltered sunlight.

^fAdults.

^gCalculated from data.

^hJuveniles.

TABLE 4-11 Environmental, Dietary, and Reproductive Characteristics of Reptiles. ^{117,284,322}

Species	Environmental Preference			Method of Reproduction ^e	Gestation/ Incubation Period (days) ^f
	Temperature ^{a,c}	RH (%)	Diet ^d		
Snakes					
Ball (Royal) python (<i>Python regius</i>)	25-30°C (77-86°F)	70-80 (use humidity box) ^g	C	Ov	90
Boa constrictor (<i>Boa constrictor</i>)	28-34°C (82-93°F)	50-70 (use humidity box) ^g	C	V	120-240
Garter snake (<i>Thamnophis sirtalis</i>)	22-30°C (72-86°F)	60-80 (use humidity box) ^g	C	V	90-110
King snake (<i>Lampropeltis getulus</i>)	23-30°C (73-86°F)	50-70 (use humidity box) ^g	Op/c	Ov	50-60
Sand boa (<i>Eryx</i> sp.)	25-30°C (77-86°F)	20-30	C	V	120-180
Lizards					
Bearded dragon (<i>Pogona vitticeps</i>)	21-35°C (70-95°F)	— (use humidity box) ^g	I—young H—adult	Ov	65-90
Crested gecko (<i>Correlophus ciliatus</i>)	25-28°C (77-82°F)	50-70 (use humidity box) ^g	F/i	Ov	60-150
Leopard gecko (<i>Eublepharis macularius</i>)	25-30°C (77-86°F)	20-30 (use humidity box) ^g	I	Ov	55-60
Uromastyx/ spiny-tailed lizard (<i>Uromastyx</i> sp.)	26-49°C (80-120°F) Large cage for gradient	— (use humidity box) ^g	H/seeds	Ov	60-80
Veiled chameleon (<i>Chameleo calyptratus</i>)	20-30°C (75-95°F)	50-70 Need good ventilation	I	Ov	200
Water dragon (<i>Physignathus cocincinus</i>)	25-34°C (77-93°F)	80-90 Need water with filter ^h	I/om	Ov	90
Chelonians					
Common box turtle (<i>Terrapene carolina</i>)	24-29°C (75-84°F)	60-80 (use humidity box) ^g	C/f	Ov	50-90

Continued

TABLE 4-11 Environmental, Dietary, and Reproductive Characteristics of Reptiles. (cont'd)

Species	Environmental Preference			Method of Reproduction	Gestation/Incubation Period (days)
	Temperature	RH (%)	Diet		
Desert tortoise (<i>Gopherus agassizii</i>)	25-30°C (77-86°F)	— (use humidity box) ^g	H	Ov	84-120
Greek tortoise (<i>Testudo graeca</i>)	20-27°C (68-81°F)	30-50 (use humidity box) ^g	H/om	Ov	60
Painted turtle (<i>Chrysemys picta</i>)	23-28°C (73-82°F)	80-90 Need water with filter ^h	H/I/o	Ov	47-99
Red-eared slider (<i>Trachemys scripta elegans</i>)	22-30°C (72-86°F)	80-90 Need water with filter ^h	C	Ov	59-93
Russian tortoise (<i>Agriemys horsfieldii</i>)	21-32°C (70-90°F)	— (use humidity box) ^g	H	Ov	56-84

Crocodylian

American alligator (<i>Alligator mississippiensis</i>)	30-35°C (86-95°F)	80-90 Need water with filter ^h	C/p	Ov	62-65
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C, carnivorous; F, frugivorous; H, herbivorous; I, insectivorous; O, molluscivorous; Om, omnivorous; Op, ophiophagous; P, piscivorous; RH, relative humidity; V, viviparous; Ov, oviparous.

^aTemperatures shown are ideal ambient daytime temperature gradients. These should be allowed to fall by approximately 5°C (9°F) during the night. "Hot-spot" temperatures should generally be 5°C (9°F) greater than the highest temperature shown.

^bPreferred daytime temperature range for other commonly housed captive snakes are: rosy boa (*Lichanura trivirgata*) = 27-29.5°C (81-85°F); green tree python (*Morelia viridis*): 24-28°C (75-82°F); carpet python (*Morelia spilota*): 27-29.5°C (81-85°F); corn snake (*Pantherophis guttata*): 25-30°C (77-86°F); yellow rat snake (*Elaphe obsoleta*): 25-29°C (77-84°F); gopher/bullsnake (*Pituophis melanoleucus*): 25-29°C (77-84°F).

^cPreferred daytime temperature range for other commonly housed captive lizards are: day gecko (*Phelsuma* sp.): 29.5°C (85°F); chameleons (montane) (*Chamaeleo* spp.): 21-27°C (70-81°F); chameleons (lowland) (*Chamaeleo* spp.): 27-29°C (81-84°F); bearded dragon (*Pogona vitticeps*): 26.7-29.5°C (80-85°F); blue-tongued skink (*Tiliqua* sp.): 27-29.5°C (81-85°F); monitor lizards (*Varanus* spp.): 29-31°C (84-88°F); tegu (*Tupinambis* spp.): 27-30°C (81-86°F).

^dUppercase letters denote principal dietary requirements; lowercase denotes secondary preference.

^eTemperature-dependent.

^fCan have long hatch times dependent on incubation parameters.

^gThis simulates humid underground burrow. Use dark colored plastic container with cut entrance, moistened paper towels or sphagnum moss.

^hNeed to set up water component like fish tank with proper filter (use one for koi or turtles), pump, water quality testing, dechlorinator.

TABLE 4-12 Urinalysis Values of Chelonians. ^{116,163,203,205}

Measurement	Normal Values	Abnormal Values
Specific gravity	1.003-1.014 (mean, 1.008)	Up to 1.034
pH	Herbivores: alkaline Omnivores: 5-8	Acidic ^a
Color	Colorless to pale yellow with white urates	Dark yellow, yellow-brown, yellow-green
Turbidity	Clear	Cloudy
Protein	Trace proteinuria	Increased proteinuria
Glucose	Glucosuria up to 30 mg/dL	Glucosuria can be higher than 50 mg/dL with anorexia
Renal casts	None	Various types present
Calcium, phosphorus, ammonia, urea, creatinine	Detectable in urine	Significantly increased in urine of <i>Testudo</i> spp. with renal disease
AST, CK, LDH	Detectable in urine	Significantly increased in urine of <i>Testudo</i> spp. with renal disease
Crystals	Amorphous urates/ ammonium biurates	Many other crystals found in renal failure; uric acid crystals in gout; bilirubin and tyrosine crystals in liver disease

^aMay be associated with hibernation, anorexia, and improper diet.

TABLE 4-13 Selected Products and Guidelines Used in Force-Feeding Anorectic or Debilitated Reptiles. ^{a,b}

Agent	Guidelines	Species/Comments
Alfalfa pellets (e.g., iguana or rabbit pellets) or powder (Alfalfa Powder, NOW Foods)	Blend (1:4) with electrolyte solution or water; 20-30 mL/kg PO q48h (lizards) to q84h (chelonians) ^{36,359}	Herbivorous reptiles/administer via gavage or esophagostomy tube; may clog feeding tube; for iguanas, may gavage equal volume of water on alternate days until patient is stable and eating; ³⁵⁹ soaked pellets can also be hand-fed (especially by owner)
Baby foods	Vegetable; blend in with other food sources Meat (small amount); blend in with other food sources	Herbivorous reptiles/administer via gavage; for some species, some fruit baby food can be added Omnivorous species/administer by gavage
Commercial dry or moist diets, which are Genera specific (e.g., Fluker's, Zilla, Tetra, Zoo Med, etc.)	Blend (1:4) with electrolyte solution or water; 20-30 mL/kg or 3% body weight PO q48h (lizards) to q72h (chelonians)	Herbivorous, omnivorous, insectivorous reptiles/administer via gavage or esophagostomy tube; may clog feeding tube; for iguanas, may gavage equal volume of water on alternate days until patient is stable and eating; soaked pellets can also be hand-fed (especially by owner)

Continued

TABLE 4-13 Selected Products and Guidelines Used in Force-Feeding Anorectic or Debilitated Reptiles. (cont'd)

Agent	Guidelines	Species/Comments
Dog/cat food, canned (a/d, Hill's; Maximum-Calorie, Iams; Nutritional Recovery Formula, Eukanuba)	30 mL/kg PO q7-14d ^{117,197}	Carnivorous species/administer via gavage; although low protein (8.5%), some concern over high purine and vitamin A levels (probably OK unless concurrent renal disease); in dehydrated animals, dilute 1:1 with physiologic solution, pediatric oral human electrolyte solution (Pedialyte, Ross), or Gatorade (Gatorade); once stabilized, small whole animals (lubricated with egg white) can be force-fed
Electrolyte solutions (Pedialyte, Ross; Gatorade, Gatorade)	15-25 mL/kg PO q24h	Most species; no data with respect to costs/benefits
Emerald Omnivore, Herbivore, Carnivore, and Piscivore Critical Care Powder Formulas	Mix as labeled, generally to pancake batter consistency, feed small amount to start (see bag suggestion) once daily	Herbivorous, omnivorous, insectivorous, carnivorous, piscivorous reptiles/administer via gavage or esophagostomy tube; may clog feeding tube; typically follow the general feeding sequence: first feed 1% body weight, second feed 2% body weight, third feed 3% body weight
High protein powders (Carnivore Care, Oxbow Pet Products; Emerald Carnivore, Lafeber)	Mix as labeled, generally to pancake batter consistency, feed small amount to start (see bag suggestion) once daily	Insectivorous and carnivorous species/once reconstituted, can be mixed 1:1 with an alfalfa or timothy product for true omnivorous reptiles; administer via gavage
Vetark Professional Critical Care Formula (CCF) Powder	Mix as labeled	Herbivorous, omnivorous reptiles/administer via gavage or esophagostomy tube; may clog feeding tube

^aGeneral guidelines for force-feeding: generally provide nutrition following rehydration of patient; needs may vary with specific disease (e.g., low protein with renal disease); force-feeding volumes are frequently started at a low/modest level and gradually brought up to the desired level (for patients with severe disease/cachexia, transition should be very gradual); concurrent to force-feeding and hydrating a patient, highly palatable food items should be provided for voluntary food intake.

^bDietary fiber supplements (alfalfa pellets or powder; barley powder; purified cellulose) should be an integral part of enteral therapy for herbivorous reptiles.

TABLE 4-14 Guidelines for Tracheal/Pulmonary and Colonic Lavage in Reptiles.^{19,251,278}

Snakes	
Tracheal/pulmonary lavage	Anesthesia often not necessary in debilitated animals; pass red rubber catheter through glottis to premeasured distance; infuse with 5-10 mL/kg of tepid (29°C, 85°F), sterile 0.9% saline; massage and rock the snake's body to loosen debris; aspirate
Colonic lavage	Pass lubricated soft red rubber catheter into cloaca; infuse with 10-20 mL/kg of tepid (29°C, 85°F), sterile saline; massage coelomic cavity and gently aspirate
Lizards	
Tracheal/pulmonary lavage	General anesthesia is typically necessary; if possible, intubate with sterile endotracheal tube; pass sterile catheter inside lumen (premeasure distance to sample site); infuse 5-10 mL/kg of tepid (29°C, 85°F), sterile 0.9% saline and aspirate several times; not all fluid will be recovered
Colonic lavage	Pass lubricated soft red rubber catheter into cloaca without excessive force; infuse 10 mL/kg of tepid (29°C, 85°F), sterile saline and gently aspirate several times
Chelonians	
Tracheal/pulmonary lavage	Sedation or anesthesia usually necessary; intubate with sterile endotracheal tube if possible; pass radiomarked catheter into affected lung lobe; may be helpful to bend it in the direction of the lobe prior to insertion, though location cannot be assured without orthogonal radiographic evidence of placement; infuse with tepid (29°C, 85°F), sterile saline at 5-10 mL/kg; gently aspirate
Colonic lavage	Pass lubricated red rubber catheter into cloaca; infuse with tepid (29°C, 85°F), sterile saline at no more than 10 mL/kg; gently aspirate; repeat several times

TABLE 4-15 Venipuncture Sites Commonly Used in Reptiles.^{a,148,152,321,372,385}

Snakes	
Ventral caudal vein	Ventral aspect of tail caudal to cloaca under central scute; avoid hemipenes and anal sacs, can be difficult to collect from in boas, pythons, anacondas; may in rare cases lead to tail necrosis/paresis
Heart	Dorsal recumbency; insertion of needle under central abdominal scale at 45° angle caudal to heart; pericardial fluid contamination can occur
Lizards	
Ventral caudal vein	Ventral aspect of vertebral body under center of middle scale; avoid hemipenes and anal sacs; this vein can also be approached laterally by inserting needle under lateral process of vertebral body aiming toward midline; ventral approach may in rare cases lead to tail necrosis/paresis
Ventral abdominal vein	Vein is located on caudal to middle midline within inner surface of abdominal wall; insert 25-g needle (bent at 45° angle) cranially, at acute angle to skin and in midline of abdomen, just caudal to umbilicus; avoid urinary bladder in species that have one
Jugular vein	Veins are lateral and deep; insert needle caudal to tympanum; best tried in larger animals

Continued

TABLE 4-15 Venipuncture Sites Commonly Used in Reptiles. (cont'd)

Chelonians	
Jugular vein	Lymphatic contamination can be a concern with most locations of phlebotomy in chelonians, however, jugular considered less likely Right vein often larger than left; runs level with tympanum to base of neck with head extended; may require sedation
Subcarapacial vein and plexus	The sinus accessed with patient's head either extended or retracted; depending on conformation of carapace, needle may be bent up to 60° and positioned in midline just caudal to skin insertion of dorsal aspect of neck and ventral aspect of cranial rim of carapace; needle is advanced in caudodorsal direction, with slight negative pressure; can cause significant internal hemorrhage or paresis in some cases
Dorsal caudal vein	Close to carapace, dorsal to dorsal aspect of vertebral body; lymph dilution common
Brachial vein/plexus	Near triceps tendon at lateral aspect of radiohumeral joint (elbow), foreleg grasped/extended, triceps tendon palpated near caudal aspect of elbow joint, needle inserted ventral to tendon with syringe perpendicular to forearm
Interdigital vessels of rear flippers	Adult leatherback sea turtles, about 2.5 cm deep, near phalangeal junctions, best at P1-P2; along side of phalanx, 20°-30° angle to flipper surface
Crocodilians	
Ventral caudal vein	Ventral aspect of vertebral body under center of middle scale; avoid hemipenes and anal sacs; this vein can also be approached laterally by inserting needle under lateral process of vertebral body aiming toward midline; ventral approach may in rare cases lead to tail necrosis/paresis
Supravertebral vein	Position needle in dorsal midline, just caudal to occiput and perpendicular to skin surface, slowly advance needle with slight negative pressure; excessive penetration can cause spinal trauma

^aGenerally recommended to collect only 0.7% body weight in healthy reptiles, less in debilitated animals, so 0.7 mL total in 100 g animal.

TABLE 4-16 Treatment of Dystocia in Reptiles. ^{a,16,37,74,91,283,373}**Etiologies**

- Poor environmental conditions (improper thermal environment, lack of suitable nesting substrate, shallow nesting substrate; underground obstructions [e.g., roots or buried rocks], disturbance, lack of visual security, etc.)
- Social factors (e.g., competition, fighting, recent introduction of male)
- Dietary imbalances (e.g., calcium deficiency, hypovitaminosis A), malnutrition
- Endocrine imbalances
- Nutritional secondary hyperparathyroidism
- Uterine inertia
- Dehydration
- Renal disease
- Egg yolk coelomitis
- Cystic or cloacal calculi
- Infections (e.g., uterus)
- Anatomic anomalies of the reproductive tract, eggs, pelvis, or shell of chelonians
- Other (substrate ingestion, overfeeding, other illness, inadequate exercise)

TABLE 4-16 Treatment of Dystocia in Reptiles. (cont'd)

Diagnosis

- History and clinical signs (prolonged anorexia, lethargy, posterior paresis, straining/tenesmus, increased pacing/seeking, excavating nests without oviposition, straining to pass eggs, passage of a few eggs but not a full clutch, fluid discharge from cloaca)
- Knowledge of normal egg retention time or usual season for laying
- Physical examination (gentle palpation of inguinal or prefemoral fossa or caudal coelom; eggs may not be palpable)
- CBC (anemia, elevated or decreased WBCs)
- Plasma biochemical analysis (hyperproteinemia, elevated ALP activity, hypercalcemia [total calcium elevated], hypocalcemia [ionized Ca <1 mmol/L])
- Coelomic effusion aspirate and cytology—carefully avoid aspirating from the urinary bladder, oviducts, or eggs when collecting coelomic fluid samples
- Radiography (tortoise eggs have a calcified outer shell and appear radiographically similar to avian eggs; turtles, lizards, and snakes generally have soft-shelled eggs with soft-tissue density on radiographs)
- Ultrasound
- Coelioscopy—particularly to confirm coelomitis, salpingitis, or oviduct rupture; determine whether early surgical management is appropriate

Treatment

- If patient is stable, provide proper environmental conditions (appropriate thermal environment, humidity, nesting site, substrate material, substrate depth, and substrate moisture; minimal stimulus; isolation)
- Handle gently and infrequently
- Tepid (~29°C; ~85°F) water soak, 30-60 min q24h
- Rehydration—fluid therapy prn; do not administer fluids intracoelomically
- Alert, strong, stable, responsive females that are eating well will often oviposit without further therapy if given sufficient time
- Dextrose (SC, IV) may be of value in some cases
- Calcium (see Table 4-8; only if hypocalcemic; low Ca⁺⁺ not generally a problem in snakes)
 - Ca glycerophosphate/Ca lactate (Calphosn, Glenwood) (5 mg each/mL): 5 mg/kg SC, IM
 - Ca gluconate: 100-200 mg/kg SC, IM
- Oxytocin^b (see Table 4-7)
 - Generally administer 1 hr after Ca⁺⁺ injection
 - 1-10 U/kg IM, ICe in lizards and snakes (results are variable); 1-20 U/kg IM, IV, ICe for chelonians
 - Repeat dose q1h; response is more rapid after IV administration in turtles
- Arginine vasotocin^c (Sigma Chemical) (alternative to oxytocin) (see Table 4-7)
 - 0.01-1 µg/kg IV (preferred), ICe
- Dinoprostone gel (Prepodil, Upjohn) 0.9 mg/kg intracloacally followed 20 min later by prostaglandin F_{2α} (Lutalyse, Zoetis) 0.6 mg/kg IM
- Propranolol 1 mg/kg followed by prostaglandin F_{2α} 0.025 mg/kg^d
- Prostaglandin F_{2α} (Lutalyse, 5 mg/mL)
 - 1.5 mg/kg SC in turtles
 - Efficacy may improve if given 20 min after an α₂ agonist (dexmedetomidine 0.035 mg/kg or xylazine 8 mg/kg)
- Lubricate cloaca with water soluble gel
- Manual massage may be useful in some situations—avoid causing oviduct rupture or prolapse
- Salpingotomy may be required if declining clinical condition (i.e., anorexia, dehydration, lethargy)

^aAlthough most reptiles are oviparous, some, including garter snakes, water snakes, boas (not pythons), vipers, Jackson's chameleons, horned lizards, and Solomon Island prehensile-tailed skinks are viviparous.

^bUse only if *no* evidence of obstructive dystocia or broken eggs.

^cAppears to be more effective than oxytocin in many reptiles, but it is not commercially available for use in animals.

^dEffective in healthy *Sceloporus* sp., did not induce oviposition in iguanas; may be effective in chelonians.

TABLE 4-17 Treatment of Metabolic Bone Diseases in Reptiles.¹⁹⁴

Etiology

- Improper Ca:P ratio; lack of dietary Ca
- Lack of vitamin D₃
- Lack of UVA and UVB light spectrum
- Renal disease
- Other: low ambient temperature, protein deficiency, small intestinal disease, parathyroid disease, etc.

Clinical Signs

- Lethargy, reluctance to move
- Poor appetite or anorexia
- Weight loss or poor weight gain
- Softening of the mandible; shortened/rounded mandible and maxilla; symmetrical swelling of the mandible (fibrous osteodystrophy)
- Fibrous osteodystrophy of the long bones of the legs
- Difficulty in lifting body off ground when walking
- Pathologic fractures
- Ataxia, paresis, or paralysis of the rear legs due to collapsed vertebrae or vertebral luxation
- Osteoporosis
- Hypocalcemic muscle fasciculations and seizures
- Soft shell in chelonians
- Constipation
- Inability to evert/replace hemipenes

Diagnosis

- Dietary and environmental history
- Clinical signs
- Physical examination
- Radiography
- Serum Ca:P ratio; usually inverse (1:2+) with renal etiology
- Uric acid levels
- Ionized calcium levels
- Calcidiol (25-hydroxyvitamin D) levels (Michigan State University)
- UV meter readings of enclosure
- Dual energy x-ray absorptiometry (DEXA) scan
- Determination of glomerular filtration rate
- Renal nuclear medicine
- Renal biopsy

Treatment

- Provide species-correct environmental temperature ranges for day and night
- Correct diet as needed; usually changing to improve calcium:phosphorus ratio
- Use species-appropriate UVA/UVB lighting arrangement
 - Use fluorescent or mercury vapor bulbs, or light emitting plasma lamps
 - Provide areas to hide, as corneal and skin burns can occur
 - In general:
 - Desert-dwelling diurnal lizards/chelonians, high UVB levels (10% or full unfiltered sun, 6 hr)
 - Diurnal arboreal lizards/semiaquatic basking chelonians, moderate levels of UVB (5%, 4 hr)
 - Diurnal terrestrial lizards/chelonians from forested environment, low levels of UVB (5%, 2 hr)
 - Nocturnal lizards, low levels of UVB (2%, 2 hr)—focus more on oral vitamin D₃
 - Snakes seem to get adequate levels of calcium/cholecalciferol from ingestion of whole vertebrate prey (or earthworms); exceptions are diamond and green tree pythons, indigo snakes, some aquatic species, rough/smooth green snakes, other arboreal, diurnal snakes
 - Albino (amelanistic), hypomelanistic, snow, blizzard, pastel, tangerine, lavender, yellow, pied, anerythritic, leucistic, xanthochromistic, or any other genetic mutant with less than normal levels of melanin are more susceptible to UV light burns of the eyes and dorsal skin, so lower levels of UV supplementation (if any) should be provided, oral vitamin D₃ may need to be considered

TABLE 4-17 Treatment of Metabolic Bone Diseases in Reptiles. (cont'd)

- Force-feeding (following rehydration) (see Table 4-13)
 - Use species-appropriate diet, especially useful for immature animals as maintenance until improving and closer to adult size, esophageal feeding tube usually needed for chelonians to avoid beak fractures
- Ca supplementation options (see Table 4-8)—best to use human products
 - Calcium carbonate (400 mg calcium/g product)
 - Calcium citrate (210 mg calcium/g product)
 - Calcium phosphate
- Maintain hydration
 - Fluid therapy, as needed
 - Soak in warm water (shallow) for 10-20 min q12-24 h to encourage drinking and defecation (caution: head may need to be supported; do not leave unattended)
- Vitamin D₃ (see Table 4-8)
 - Best source is UVA/UVB exposure from sun or appropriate lamp
 - Some species may benefit from judicious oral supplementation
- Calcitonin to prevent further transfer of Ca from bone to blood (hormone therapies should always be performed cautiously)
 - 50 U/kg IM q7d × 2 treatments
 - Ca supplementation should be given prior to and during calcitonin therapy
 - Serum Ca should be within normal limits prior to calcitonin therapy; if Ca levels cannot be determined, administer calcium 7 days prior to calcitonin
- Gut-load invertebrates (crickets, mealworms, superworms, cockroaches) on high calcium diet (high calcium leafy greens, Mazuri Hi-Ca Cricket Diet) for several days before feeding to insectivores
- Feed high-calcium invertebrates such as phoenix worms, snails, and earthworms when appropriate for diet in insectivores
- Dusting invertebrates may be beneficial; but they often remove dust quickly, can make unpalatable, and be careful with dusts containing vitamins, avoid those with phosphorus
- Feed only leafy greens and other high calcium plants for herbivores, minimizing thicker vegetables and avoiding most fruits
- In mammals, condition considered painful, appropriate analgesics may be warranted
- Both short-term and long-term prognosis is often guarded at best
- Other
 - Handle gently
 - Remove climbing branches to prevent injuries

TABLE 4-18 Selected Sources of Diets and Other Commercial Products for Reptiles.^{a,b}**Foods and Supplements**

Fluker Farms	800-735-8537	www.flukerfarms.com	
Drs Foster and Smith	800-443-1160	www.drsfostersmith.com	
JurassiPet	706-343-6060	www.jurassipet.com	
Mazuri	800-227-8941	www.mazuri.com	
National Geographic/Petsmart	888-839-9638	www.petsmart.com/featured-shops/reptile/cat-36-catid-800506	
Oxbow Animal Health	800-249-0366	www.oxbowanimalhealth.com	

Continued

TABLE 4-18 Selected Sources of Diets and Other Commercial Products for Reptiles. (cont'd)

Pretty Pets	800-356-5020	www.prettybird.com	
Reliable Protein Products	480-361-3940	www.zoofood.com	
Repashy Superfoods	855-737-2749	www.store.repashy.com	
Rep-Cal	800-406-6446	www.repcal.com	
San Francisco Bay Brand	510-792-7200	http://sfbb.com	
Sticky Tongue Farms	951-244-3434	www.stickytonguefarms.com	
Tetra Fauna	800-423-6458	www.tetra-fish.com	
T-Rex Products	800-991-8739	www.t-rexproducts.com	
Wombaroo	(08)83911713 (Aust)	www.wombaroo.com.au/reptiles	
Zilla	888-255-4527	www.zilla-rules.com	
Zoo Med Laboratories	888-496-6633	www.zoomed.com	

Live/Frozen Foods for Carnivores

American Rodent Supply	317-899-1599	www.americanrodent.com	Frozen mice, rats
Backwater Reptiles	Unpublished	www.backwaterreptiles.com	Frozen mice, rats
Big Apple Herp	561-923-9510	www.bigappleherp.com	Frozen mice, rats, chicks, quail, rabbits
Big Cheese Rodents	800-887-0921	www.bigcheeserodents.com	Frozen mice, rats, chicks
The Gourmet Rodent	352-472-9189	www.gourmetrodent.com	Frozen mice, rats, rabbits, and chicks
Hoosier Mouse Supply	317-831-1219	www.hoosiermousesupply.com	Live (local) and frozen mice, rats
Layne Laboratories, Inc	Unpublished	www.laynelabs.com	Frozen mice, rats
Mack Natural Reptile Food	888-372-9570	www.macksnaturalreptilefood.com	Frozen mice, rats
Perfect Pets Inc	800-366-8794	www.perfectpet.net	Frozen mice, rats, hamsters, gerbils, guinea pigs, rabbits, chicks
Rodent Pro	812-867-7598	www.rodentpro.com	Frozen mice, rats, rabbits, guinea pigs, chicks, quail
T-Rex Products	800-991-8739	www.t-rexproducts.com	Frozen pinkies, fuzzies, small mice

TABLE 4-18 Selected Sources of Diets and Other Commercial Products for Reptiles. (cont'd)

Live Foods for Insectivores			
Arbico Organics	800-827-2847	www.arbico-organics.com	Live Tiny Wigglers, Tiny Wasp, Cocoon Capers, many other insects
Backwater Reptiles	Unpublished	www.Backwaterreptiles.com	Crickets, roaches, hornworms, mealworms, superworms, silkworms
Bassett's Cricket Ranch	800-634-2445	www.bccricket.com	Crickets, mealworms
Big Apple Herp	561-923-9510	www.bigappleherp.com	Butterworms, mealworms, waxworms, nightcrawlers
Fluker Farms	800-735-8537	www.flukerfarms.com	Crickets, mealworms, superworms, cockroaches, fruit flies, soldier worms
Ghann's Cricket Farm	800-476-2248	www.ghann.com	Crickets, soldier fly larvae, mealworms, superworms, wax worms
Grubco	800-222-3563	www.grubco.com	Crickets, superworms, mealworms, fly larvae, wax worms
Josh's Frogs	800-691-8178	www.joshsfrogs.com	Fruit flies, mealworms, hornworms, soldier fly larvae, roaches, rice flour beetles
Knutson's	800-248-9318	www.knutsonlivebait.com	Night crawlers, crickets, mealworms, wax worms
Millbrook Cricket Farm	800-654-3506	www.millbrookcrickets.com	Crickets, superworms
Mulberry Farms	760-731-6088	www.mulberryfarms.com	Silkworm larvae, soldier fly larvae, mealworms, superworms, waxworms, roaches
The Phoenix Worm Store		www.phoenixworm.com	Soldier fly larvae
Rainbow Mealworms	800-777-9676	www.rainbowmealworms.net	Crickets, mealworms, cockroaches
Reptile Food	Unpublished	www.reptilefood.com	Mealworms, giant mealworms, zophobas worms, waxworms, nightcrawlers, red worms, fruit flies, crickets
Russell's Cricket Farm	234-738-3663	www.livecrickets.com	Crickets, mealworms, superworms, roaches
Timberline Fresh	800-423-2248	http://timberlinefresh.com	Crickets, superworms, hornworms, waxworms, mealworms
Top Hat Cricket Farm	800-638-2555	www.tophatcrickets.com	Crickets, mealworms, superworms, hornworms, waxworms
Lights			
Exo Terra	800-724-2436	www.exo-terra.com	Ultraviolet, visible, infrared/heat
Fluker Farms	800-735-8537	www.flukerfarms.com	Incandescent, heat
General Electric	800-435-4448	www.gelighting.com	Incandescent, heat

Continued

TABLE 4-18 Selected Sources of Diets and Other Commercial Products for Reptiles. (cont'd)

Mac Industries, Inc	252-241-4584	www.reptileuv.com	Brightrite halogen, self-ballasted lamps, heat projector lamps, reptileUV
Philips	800-555-0050	www.lighting.philips.com	Incandescent, heat
Sylvania	978-777-1900	www.sylvania.com	350BL blacklights
T-Rex Products	800-991-8739	www.t-rexproducts.com	Mercury vapor UVB, incandescent, heat
Zilla	888-255-4527	www.zilla-rules.com	Incandescent, heat, UVB fluorescent, halogen
Zoo Med Laboratories	888-496-6633	www.zoomed.com	Incandescent, heat, mercury vapor UVB, fluorescent UVB

Heating Devices

Avitec	800-646-2473	www.avitec.com	Ceramic heat elements, infrared heat panels, fluorescent
The Bean Farm	877-708-5882	www.beanfarm.com	Heat tape, heat pads, cords, ceramic heaters
Big Apple Pet Supply	800-922-7753	www.bigappleherp.com	Ceramic bulbs, heat mats, heat tape, incandescent bulbs
Fluker Farms	800-735-8537	www.flukerfarms.com	Under-cage heat pads
Helix Controls	760-726-4464	www.helixcontrols.com	Thermostats, heat tape, heat panels
LLL Reptile	888-547-3784	http://lllreptile.com	Pearlco conical ceramic heat emitters
National Geographic/Petsmart	888-839-9638	www.petsmart.com/featured-shops/reptile/cat-36-catid-800506	Heat lamps
Zilla	800-255-4527	www.zilla-rules.com	Conical ceramic heat emitters, thermostats, heat mats
Zoo Med Laboratories	888-496-6633	www.zoomed.com	Thermostats, rheostats, heat pads, tape, cables, cermaic heat emitter, rock heater, under tank heater

Humidity Devices

Exo Terra (Hagen)	800-724-2436	www.exo-terra.com	Ultrasonic fogger, Monsoon rainfall
Humidifirst	561-752-1936	www.humidifirst.com	Mist Pac ultrasonic humidifiers
Zoo Med Laboratories	888-496-6633	www.zoomed.com	Ultrasonic fogger, Repti fogger, Habba mist, Hygro-Therm humidity controller

Environmental Sensing and Monitoring Devices

The Bean Farm	877-708-5882	www.beanfarm.com	Thermostats
Exo Terra (Hagen)	800-724-2436	www.exo-terra.com	Remote digital thermometers, hygrometers
Onset Computer Corp	800-564-4377	www.onsetcomp.com	Relative humidity, temperature

TABLE 4-18 Selected Sources of Diets and Other Commercial Products for Reptiles. (cont'd)

Raytek	800-227-8074	www.raytek.com	Digital infrared thermometer
Solartech	800-798-3311	www.solarmeter.com	Solarmeter 6.2 UVB meter
Zilla	800-255-4527	www.zilla-rules.com	Digital infrared thermometer
Zoo Med Laboratories	888-496-6633	www.zoomed.com	Hygro-Therm humidity/heat monitor and controller, ReptiTemp rheostat, many thermometer and humidity gauges

^aMany pet stores sell live and frozen food for reptiles, and many of the products listed.

^bNumerous sources of information were used to compile this table, particularly Internet sources.

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Chapter 5 **Birds**

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TABLE 5-1 Antimicrobial Agents Used in Birds.

Agent	Dosage	Species/Comments
Amikacin	—	Extended spectrum aminoglycoside; least nephrotoxic of the aminoglycosides; maintain hydration and avoid concurrent use of other nephroactive drugs ⁹⁰
	7 mg/kg IV q24h ³⁴²	Emus/PD; mean serum levels declined below a target trough of 4 µg/mL at 24 hr
	7.6 mg/kg IM q8h ³⁷⁴	Ostriches/PD; causes myositis; painful injection
	10 mg/kg IM q12h ⁵⁶⁶	Cranes
	10-15 mg/kg IM q24h ³³³	Raptors
	10-15 mg/kg IM q12h ⁴⁷³	Amazon parrots, cockatiels, cockatoos/PD
	10-15 mg/kg IM, IV q8-12h ³³³	Most species, including psittacines
	10-20 mg/kg IM, IV q8-12h ²⁹⁸	African grey parrots/PD
	15 mg/kg IM q12h, IV q8h ⁷²¹	Blue-fronted Amazon parrots/PD
	15-20 mg/kg/day divided q8-24h ⁶⁶	Red-tailed hawks/PD; use low end of dose range for smaller hawks
	15-20 mg/kg SC, IM, IV q8-12h ²⁰³	Passerines, pigeons/5 days maximum ⁶⁸⁶
	15-20 mg/kg IM q8-12h ⁶³⁷	Cockatiels/PD
	15-30 mg/kg IM q12-24h ^{203,822}	Most species, including passerines/ use in combination with other agents for <i>Mycobacterium</i> ; see Table 5-44
528 mg/L drinking water ⁸⁰⁶	Ratites/egg dip	
3 g/40 packet bone cement ⁸¹⁰	PMMA bead formation (1:14 ratio); same dose for all aminoglycoside beads	
Amoxicillin/clavulanate (Clavamox, Zoetis)	—	β-lactamase inhibitor ⁹⁰
	7-14 mg/kg IM q24h ¹¹²	Ostriches
	10-15 mg/kg PO q12h ⁸⁰⁶	Ratites
	60-120 mg/kg IM q8-12h ²⁰⁴	Collared doves/PD
	125 mg/kg PO q12h ^{255,607}	Most species, including pigeons, psittacines, raptors
	125 mg/kg PO q8h ⁵⁷⁵	Blue-fronted Amazon parrots/PD
	125 mg/kg PO q6h ¹⁴⁸	Psittacines
125-250 mg/kg PO q8-12h ²⁰⁴	Collared doves/PD	
Amoxicillin sodium	—	Broad-spectrum β-lactamase-sensitive penicillin ⁹⁰
	50 mg/kg IM q12-24h ^{198,202}	Pigeons/PD; Gram-positive bacteria
	100 mg/kg IM, IV q4-8h ⁶⁹⁷	Bustards/PD; administer q4h IM or q8h IV to maintain blood levels >2 mg/mL
	150 mg/kg IM q8h ⁶⁸⁹	Passerines, soft bills
250 mg/kg IM q12-24h ^{198,202}	Pigeons/PD; Gram-positive and Gram-negative bacteria	

TABLE 5-1 Antimicrobial Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Amoxicillin trihydrate	—	Broad-spectrum β -lactamase-sensitive penicillin; ³⁰ may have minimal activity for common Gram-negative infections of birds; higher doses are needed in birds to achieve the same peak levels as in mammals ²⁰⁶
	15-22 mg/kg PO q8h ⁸⁰⁶	Ratites
	20 mg/kg PO q12-24h ²⁰⁰	Pigeons/PD; mean half-life 66 min
	30 mg/kg IM q12h \times 5 days ¹¹²	Pigeons
	40-80 mg/kg PO q12h \times 5 days ¹¹²	Pigeons
	55-110 mg/kg PO q12h ³¹⁸	Pigeons
	100 mg/kg PO q12-24h ²⁰⁷	Pigeons/PD
	100 mg/kg PO q8h ⁵¹	Most species, including raptors
	100-150 mg/kg PO q12h ^{149a}	Raptors
	100-200 mg/kg PO, IM q4-8h ²⁰⁷	Pigeons
	150 mg/kg SC, IM q24h \times 5 days (administer q48h with long-acting preparation) ⁶⁹⁷	Pigeons
	150 mg/kg PO, IV ⁷⁵³	Pigeons/PD; <i>Streptococcus bovis</i>
	150-175 mg/kg PO q12h ¹⁴⁸	Passerines (towhees), psittacines
	150-175 mg/kg PO q4-8h ^{689,808}	Pigeons, psittacines
	65 mg/L drinking water ⁸⁰⁶	Ratites
	200-400 mg/L drinking water ³¹¹	Canaries/aviary use
500-800 mg/L drinking water ³¹⁸	Pigeons	
1500 mg/L drinking water \times 5 days ⁷⁵³	Pigeons/ <i>Streptococcus bovis</i>	
1500-4500 mg/L drinking water ¹⁴⁸	Psittacines	
300-500 mg/kg soft feed ³¹¹	Canaries/aviary use	
600 mg/kg soft feed ¹⁴⁸	Psittacines	
Ampicillin sodium	—	Broad-spectrum β -lactamase-sensitive penicillin ⁹⁰
	50 mg/kg IM q6-8h ²¹⁷	Amazon parrots/PD; localized infections
	100 mg/kg IM q4h ²¹⁷	Amazon parrots/PD
	150 mg/kg IM q12-24h ^{198,202}	Pigeons/PD
	150 mg/kg IM q12-24h ²⁰¹	Passerines, soft bills
150-200 mg/kg PO q8-12h ²¹⁷	Amazon parrots/PD; therapeutic levels not achieved in blue-naped Amazons at this dosage	

Continued

TABLE 5-1 Antimicrobial Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Ampicillin sodium (cont'd)	174 mg/kg PO q24h ¹⁷⁵ 528 mg/L drinking water ¹⁷⁵	Pigeons/PD; <i>Streptococcus bovis</i> Pigeons/PD; <i>Streptococcus bovis</i>
Ampicillin trihydrate	— 4-7 mg/kg SC, IM q8h ⁸⁰⁶ 11-15 mg/kg PO q8h ⁸⁰⁶ 15 mg/kg IM q12h ¹¹¹ 15-20 mg/kg SC, IM q12h ¹¹¹ 25 mg/kg PO q12-24h ^{198,202} 100 mg/kg PO q12-24h ^{198,202} 100 mg/kg IM q12h ⁵⁶⁶ 100 mg/kg IM q4h ³³³ 100-200 mg/kg PO q6-8h ³³³ 155 mg/kg IM q12-24h ²⁰⁷ 500 mg powder/L drinking water ³³³ 1000-2000 mg/L drinking water ³¹¹ 2000-3000 mg/kg soft feed ³¹¹	Broad-spectrum β -lactamase-sensitive penicillin; minimal activity for common Gram-negative infections of birds; poor gastrointestinal absorption; may be useful for treating sensitive gastrointestinal infections ⁶⁹⁷ Ratites (excluding emus) Ratites Raptors/PD Emus, cranes (PD) Pigeons/PD Pigeons/PD Cranes Most species, including psittacines Psittacines Pigeons/PD; amoxicillin preferred over ampicillin for IM use in pigeons Psittacines/ <i>Pseudomonas</i> Canaries/aviary use Canaries/aviary use
Azithromycin (Zithromax, Pfizer)	— 10-20 mg/kg PO q48h \times 5 treatments ¹²⁴ 40 mg/kg PO q48h \times 21 days ³⁰⁵ 40 mg/kg PO q24h \times 30 days ¹²⁴ 43-45 mg/kg PO q24h ³³³ 50-80 mg/kg PO q24h \times 3 days on, off 4 days, repeat up to 3 wk ⁶⁶⁷	Macrolide antibiotic; effective against most aerobic and anaerobic Gram-positive bacteria, may be effective against Gram-negative organisms; active against <i>Mycobacterium</i> (including atypical species), <i>Chlamydia</i> , and <i>Mycoplasma</i> ⁹⁰ Blue and gold macaws/PD; nonintracellular infections Cockatiels/PD; Chlamydia Blue and gold macaws/PD; intracellular infections (i.e., <i>Chlamydia</i>) Most species including psittacines, passerines/intracellular infections including mycobacterial sp.; used with ethambutol and rifabutin (see Table 5-44) Most species/mycobacterial sp.; do not use if hepatic or renal disease; can mix with lactulose (stable refrigerated for 3-4 wk)

TABLE 5-1 Antimicrobial Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Bacitracin methylene disalicylate (Solutracin 200, A.L. Laboratories; BMD Soluble, Alpharma)	50-400 mg/L drinking water ³³³ 100-500 mg/kg feed ¹¹²	Ratites/ <i>Clostridium perfringens</i> ; prepare daily Ostriches <3 mo of age
Carbenicillin (Geocillin, Roerig)	— 11-15 mg/kg IV q8h ⁸⁰⁶ 100 mg/kg PO q12h ⁵⁰⁸ 100 mg/kg IM q8h ⁴⁹ 100 mg/kg intratracheal q24h ¹³⁹ 100-200 mg/kg IM, IV q6-12h ³³³ 250 mg/kg IM q12h ⁶⁴⁷ 1058 mg/L drinking water ⁵⁰⁸	Broad-spectrum β -lactamase-sensitive penicillin with extended spectra including <i>Pseudomonas</i> , <i>Proteus</i> , and others ⁹⁰ Ratites Most species Most species Most species/ <i>Pseudomonas</i> respiratory infections Most species, including psittacines, passerines, soft bills, pigeons, cranes, raptors Raptors Most species
Cefadroxil	— 20 mg/kg PO q12h ⁸⁴³ 100 mg/kg PO q12h \times 7 days ^{318,685}	First-generation cephalosporin; limited activity against Gram-negative pathogens ⁹⁰ Ratites Most psittacines, pigeons/14-21 day therapy may be indicated for severe or deep pyodermas
Cefazolin	— 25-30 mg/kg IM, IV q8h ¹¹⁸ 25-50 mg/kg IM, IV q12h ⁶⁶⁷ 50-75 mg/kg IM q12h ⁶⁸⁵ 50-100 mg/kg PO, IM q12h ⁶¹⁹	First-generation cephalosporin; limited activity against Gram-negative pathogens ⁹⁰ Cranes Most species Most species Raptors
Cefotaxime	25 mg/kg IM q8h ⁸⁰⁹ 50-100 mg/kg IM q8-12h ⁵⁶⁶ 75-100 mg/kg IM q12h ³⁵⁸ 75-100 mg/kg IM, IV q4-8h ³³³ 100 mg/kg IM q8-12h ³¹⁸	Third-generation cephalosporin with broad-spectrum activity for many Gram-positive and Gram-negative pathogens; may penetrate cerebrospinal fluid in some species ⁹⁰ Ratites/young birds Cranes Raptors Most species, including soft bills, psittacines, passerines Pigeons
Cefovecin (Convenia, Zoetis)	10 mg/kg SC, IM, IV q1h ⁷¹⁵	Pigeons/PD; third-generation cephalosporin; ⁹⁰ not recommended for use in birds due to short half-life; cannot be used q14d as in dogs and cats

Continued

TABLE 5-1 Antimicrobial Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Cefoxitin	— 50-75 mg/kg IM, IV q6-8h ³³³ 50-100 mg/kg IM, IV q6-12h ³³³	Second-generation cephalosporin with a wide range of activity against many Gram-positive and Gram-negative bacteria ⁹⁰ Most species, including soft bills Psittacines
Ceftazidime	— 50-100 mg/kg IM, IV q4-8h ³³³	Third-generation cephalosporin; extensive activity against Gram-negative bacteria; may penetrate central nervous system ⁹⁰ Most species
Ceftiofur (Naxcel, Zoetis)	— 10 mg/kg IM q8-12h ⁷⁹⁵ 10 mg/kg IM q4h ⁷⁹⁵ 10-20 mg/kg IM q12h ³³³ 50 mg/kg IM q12h ³³³ 50-100 mg/kg q4-8h ³³³	Third-generation cephalosporin with activity against <i>Pasteurella</i> ⁹⁰ Orange-winged Amazon parrots/PD Cockatiels/PD; higher doses may be required for resistant infections Ratites Ostrich chicks Most species, including psittacines and passerines
Ceftiofur extended release formulation (Excede, Zoetis)	10 mg/kg IM ⁶⁹³ 10 mg/kg IM ^{403a} 20 mg/kg IM ⁶⁹³	Red-tailed hawks/PK; 10 mg/kg may allow targeted plasma levels for 36-45 hr Flamingos/PK; 10 mg/kg reached levels above MIC through 96 hr in 9/11 birds Red-tailed hawks/PK; may provide target plasma levels for 96 hr
Ceftriaxone	— 75-100 mg/kg IM q4-8h ³³³	Third-generation cephalosporin; effective against Gram-positive and Gram-negative bacteria including some activity against <i>Pseudomonas</i> ⁹⁰ Most species
Cephalexin	— 15-22 mg/kg PO q8h ⁸⁰⁶ 35-50 mg/kg PO, IM q6-8h ¹¹⁰ 35-50 mg/kg IM q2-3h ¹¹⁰ 40-100 mg/kg PO, IM q6-8h ³³³ 50 mg/kg PO q6h × 3-5 days ³³³	First-generation cephalosporin; active against many Gram-positive and some Gram-negative bacteria ⁹⁰ Ratites (excluding emus) Pigeons, emus, cranes, raptors, psittacines >500 g/dose psittacines q6h Psittacines <500 g Most species, including raptors, psittacines, passerines Raptors, pigeons

TABLE 5-1 Antimicrobial Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Cephalexin (cont'd)	100 mg/kg PO q8-12h ³¹⁸	Pigeons/14-21 day therapy may be indicated for severe or deep pyodermas
	100 mg/kg PO q4-6h ¹¹⁰	Pigeons, emus, cranes/PD
Cephalothin	—	First-generation cephalosporin; active against many Gram-positive and some Gram-negative bacteria ⁹⁰
	30-40 mg/kg IM, IV q6h ⁸⁰⁶	Ratites (excluding emus)
	100 mg/kg IM q8-12h ³⁵⁸	Raptors
	100 mg/kg IM, IV q6-8h ³³³	Most species, including psittacines, ratites
	100 mg/kg IM q6h ¹¹⁰ 100 mg/kg IM, IV q2-6h ²⁰³	Pigeons, emus, cranes/PD Passerines
Cephradine	—	First-generation cephalosporin; active against many Gram-positive and some Gram-negative bacteria ⁹⁰
	35-50 mg/kg PO q4-6h ⁶⁶⁶ 100 mg/kg PO q4-6h ⁶⁶⁶	Most species/14-21 day therapy may be indicated for severe or deep pyodermas Pigeons, emus, cranes
Chloramphenicol palmitate (oral suspension)	—	Phenicol; broad spectrum, including anaerobes, but causes blood dyscrasias in humans; ⁹⁰ because large differences in pharmacokinetics exist between birds and mammals, and even between avian species, extrapolation between species is not recommended; ²⁰⁶ not commercially available in the United States, but can be compounded
	25 mg/kg PO q8h × 5 days ¹¹²	Pigeons
	30-50 mg/kg PO q6-8h ³³³	Psittacines, including budgerigars
	35-50 mg/kg PO q8h × 3 days ⁸⁰⁶	Ratites
	50 mg/kg PO q6-12h ³³³	Raptors
	50-100 mg/kg PO q6-12h ³³³	Most species, including passerines
	250 mg/kg PO q6h ³¹⁸	Pigeons
	100-200 mg/L drinking water ⁶⁶⁷	Canaries
Chloramphenicol succinate	30 mg/kg IM q8h × 3-5 days ²⁵⁵	Raptors
	35-50 mg/kg SC, IM, IV q8h × 3 days ⁸⁰⁶	Ratites
	50 mg/kg IM q24h ¹³⁶	Eagles (PD)
	50 mg/kg IM q8-12h ²⁰³	Passerines
	50 mg/kg IM, IV q6-12h ^{136,333}	Most species, including budgerigars, passerines, pigeons, raptors

Continued

TABLE 5-1 Antimicrobial Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Chloramphenicol succinate (cont'd)	50 mg/kg IM q6h ¹³⁶ 50-80 mg/kg IM q12-24h ²⁰³ 60-100 mg/kg IM q8h ³²⁰ 100 mg/kg SC q8h ⁵⁶⁶ 100 mg/kg IM q6h ²⁰³ 200 mg/kg IM q12h × 5 days ³⁶⁴	Macaws, conures (PD) Passerines Pigeons Cranes Passerines Budgerigars/PD
Chlorhexidine	— 2.6-7.9 mL of 2% solution/L drinking water ⁶⁶⁸ 7.9 mL/L water ⁸⁰⁶	Biguanides; antiseptic activity against most Gram-positive and some Gram-negative bacteria; not bacterial spores ³⁵⁰ Most species/bacterial infection; topical application may be fatal to nun and parrot finches ⁵⁶⁷ Ratites/egg disinfectant spray at 104-108°F (40-42°C)
Chlorine (Na hypochlorite)	5 mg/L drinking water ⁶⁸⁵	Water disinfectant; 0.1 mL of 5.25% bleach/L approximates this concentration
Chlortetracycline (Aureomycin Soluble Powder, Cyanamid)	— 6-10 mg/kg IM q24h ³⁴⁰ 15-20 mg/kg PO q8h ⁸⁰⁶ 40-50 mg/kg PO q8h (w/grit), or q12h (w/o grit) ³³³ 100 mg/kg PO q6h ¹⁴⁸ 250 mg/kg PO q24h ³⁴⁰ 130-400 mg/L drinking water ^{318,697,804} 500 mg/L drinking water or nectar ³³³ 1000-1500 mg/L drinking water ³³³ 5000 mg/L drinking water × 45 days ¹⁴⁸ 100 mg/kg feed ⁸⁰⁴ 500 mg/kg feed ²⁰² 1000-2000 mg/kg soft mixed feed × 45 days ^{77,200,201} 5000 mg/kg soft feed × 45 days ¹⁴⁸ 0.5% pellets × 30-45 days ¹⁹⁹ 1% pellets × 30-45 days ¹⁹⁹	Broad-spectrum tetracycline with activity against a wide range of Gram-positive and Gram-negative bacteria including <i>Chlamydia</i> and <i>Mycoplasma</i> ⁹⁰ Raptors Ratites Pigeons/PD Psittacines Raptors Pigeons Most species/prepare fresh q8-12h Canaries, psittacines/prophylaxis against <i>Chlamydia</i> Psittacines/ <i>Chlamydia</i> Pigeons/ <i>Salmonella</i> Budgerigars/ <i>Chlamydia</i> Most psittacines, canaries Psittacines/ <i>Chlamydia</i> Small psittacines/reduce calcium content of diet to 0.7% Large psittacines/reduce calcium content of diet to 0.7%

TABLE 5-1 Antimicrobial Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Ciprofloxacin	—	Fluoroquinolone with wide spectrum against Gram-negative and some Gram-positive bacteria; activity against <i>Chlamydia</i> and <i>Mycoplasma</i> ⁹⁰
	3-6 mg/kg PO q12h ⁸⁰⁶	Ratites
	5-20 mg/kg PO q12h × 5-7 days ⁶⁸⁶	Pigeons
	10 mg/kg PO q12h × 7 days ²	Ostrich chicks
	10-20 mg/kg PO q12h ²⁵⁷	Raptors
	15-20 mg/kg PO, IM q12h ^{203,333,807}	Most species, including psittacines, passerines
	20-40 mg/kg PO, IV q12h ³³³	Most species, including psittacines, canaries, raptors
	50 mg/kg PO q12h ³⁶³	Raptors/PD
	80 mg/kg PO q24h ⁸²²	Most species/ <i>Mycobacterium</i> ; use in combination with other agents (see Table 5-44)
250 mg/L drinking water × 5-10 days ⁶⁸⁶	Pigeons	
Clarithromycin	—	Macrolide; effective against most aerobic and anaerobic Gram-positive bacteria, may be effective against Gram-negative organisms; active against <i>Mycobacterium</i> (including atypical species), <i>Chlamydia</i> , and <i>Mycoplasma</i> ; ⁹⁰ see Table 5-44
	10 mg/kg PO q24h ⁵⁴⁷	Penguins
	60 mg/kg q24h ⁴⁴⁶	Psittacines
	85 mg/kg PO q24h ⁶⁸⁸	Most species/mycobacterial sp.; allometrically scaled
Clindamycin	—	Lincosamide; broad spectrum against anaerobic bacteria, limited against aerobic pathogens; widely distributed to tissues including bone ⁹⁰
	5.5 mg/kg PO q8h ⁵²⁵	Ostriches
	12.5 mg/kg PO q12h ³¹²	Great horned owls/skin grafts; given in combination with enrofloxacin
	25 mg/kg PO q8h ²⁴⁰	Psittacines, raptors
	50 mg/kg PO q8-12h ²⁴²	Most species/7-10 day course recommended for raptors with osteomyelitis ⁷⁶
	100 mg/kg PO q24h × 3-5 days ³³³	Most species, including psittacines, passerines, raptors, pigeons/ <i>Clostridium</i>
	100 mg/kg PO q12h × 7 days ⁸⁰⁷	Psittacines
	150 mg/kg PO q24h ²⁹⁶	Pigeons, raptors/osteomyelitis
200 mg/L drinking water ¹⁵⁸	Pigeons	

Continued

TABLE 5-1 Antimicrobial Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Clofazimine (Lamprene, Novartis)	— 1-5 mg/kg PO q24h × 3-12 mo ³³³ 6-12 mg/kg PO q12h ³³³	Antimycobacterial agent Psittacines, raptors/ <i>Mycobacterium</i> ; use in combination with other agents (see Table 5-44) Most species/ <i>Mycobacterium</i> ; use in combination with other agents (see Table 5-44)
Cloxacillin	— 100-250 mg/kg PO, IM q24h ³³³ 250 mg/kg PO q12h × 7-10 days ⁷⁶	Narrow-spectrum β-lactamase- resistant penicillin inactive against many Gram-positive organisms ⁹⁰ Most species Raptors
Cycloserine (Seromycin, Lilly)	5 mg/kg PO q12-24h × 3-12 mo ³³³	Raptors/ <i>Mycobacterium</i> ; use in combination with other agents (see Table 5-44)
Danofloxacin mesylate (A180, Zoetis)	— 5 mg/kg PO, IM, IV ⁵¹²	Fluoroquinolone with wide spectrum against Gram-negative and some Gram-positive bacteria; activity against <i>Chlamydia</i> and <i>Mycoplasma</i> ⁹⁰ Hyacinth macaws
Doxycycline	— 2-3.5 mg/kg PO q12h ⁸⁰⁶ 7.5-8 mg/kg PO q12-24h ^{198,667} 10-20 mg/kg PO q24h × 3-5 days ¹¹² 25 mg/kg (w/grit) PO q12h ⁸⁷⁷ 25 mg/kg PO q12h ³⁸⁴ 25-50 mg/kg PO q12-24h ³³³ 35 mg/kg PO q24h × 21 days ³⁰⁵	Broad-spectrum tetracycline with activity against a wide range of Gram-positive and Gram-negative bacteria; drug of choice for <i>Chlamydia</i> and <i>Mycoplasma</i> ; products or foods containing Al, Ca, Mg, and Fe reduce or alter absorption; readily penetrates blood- brain barrier; ⁹⁰ 12.5-25 mg/kg PO q12-24h resulted in elevations in AST and serum bile acids as well as hepatocellular damage in lorikeets ⁸⁷⁶ Ratites Passerines, nectar feeders, pigeons/ PD; administer without grit ²⁰⁰ Pigeons Pigeons/PD Psittacines, raptors/some Gram- negative bacterial infections and possibly <i>Leucocytozoon</i> Most species, including parrots (African grey parrots, Amazon parrots, cockatoos, macaws) and pigeons/may cause regurgitation; use low end of dose range for macaws and cockatoos Cockatiels/PD; <i>Chlamydia</i>

TABLE 5-1 Antimicrobial Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Doxycycline (cont'd)	<p>40 mg/kg PO q24h¹⁷⁵</p> <p>130 mg/L drinking water¹⁴⁸</p> <p>200 mg/L drinking water²²¹</p> <p>250 mg/L drinking water²⁰⁰</p> <p>280 mg/L drinking water⁶²¹</p> <p>400 mg/L drinking water²²⁴</p> <p>500 mg/L drinking water^{148,175}</p> <p>500 mg/L drinking water⁵⁷⁷</p> <p>800 mg/L drinking water (mix the contents of 16 × 100 mg capsules with 2 L water)²⁴⁷</p> <p>250-300 mg/kg seed^{76,239}</p> <p>500 mg/kg wet weight seeds⁶²¹</p> <p>1000 mg/kg feed^{333,626}</p>	<p>Pigeons/PD; <i>Streptococcus bovis</i></p> <p>Psittacines</p> <p>Pigeons</p> <p>Canaries</p> <p>Cockatiels/see Table 5-40 for recipe</p> <p>Cockatiels/PD; spiral bacteria</p> <p>Psittacines, pigeons/<i>Streptococcus bovis</i> in pigeons</p> <p>Fruit doves/PD; erratic drug concentrations (while most birds reached or exceeded therapeutic drug levels, some birds did not)</p> <p>African grey parrots, Goffin's cockatoos/PD; protect solution from exposure to light; make fresh daily</p> <p>Budgerigars</p> <p>Cockatiels/PD; see Table 5-40 for recipe</p> <p>Large psittacines on dehulled seed (PD), macaws on corn (PD), canaries, large psittacines on soft feed (10 mg/mL syrup mixed into 29% kidney beans, 29% canned corn, 29% cooked rice, 13% dry oatmeal cereal)</p>
Doxycycline (Vibravenös, Pfizer)	—	<p>Broad-spectrum tetracycline with activity against a wide range of Gram-positive and Gram-negative bacteria;³⁰ drug of choice for <i>Chlamydia</i> and <i>Mycoplasma</i>; not available in the United States</p> <p>Psittacines</p> <p>Psittacines, pigeons</p> <p>Macaws</p> <p>Psittacines, including macaws, budgerigars</p> <p>Houbara bustards/PD; <i>Chlamydia</i></p>
Doxycycline (Pharmacist-compounded micronized doxycycline hyclate)	75-100 mg/kg IM q7d ⁶⁸⁹	<p>Cockatoos/aneecdotal reports of sudden death with compounded product; inadequate drug levels achieved in cockatiels at 100 mg/kg IM q10d;⁶²¹ adequate drug levels achieved with 100 mg/kg given IM in cockatoos, Amazon parrots and SC in African grey parrots, but severe soft-tissue reactions seen²⁴⁴</p>

Continued

TABLE 5-1 Antimicrobial Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Doxycycline hyclate (injection)	— 25-50 mg/kg slow bolus IV q24h × 3 days ⁶⁸⁹ 75-100 mg/kg SC, IM q5-7d ¹⁹⁸	Cardiovascular collapse associated with the propylene glycol carrier can occur after rapid IV injection ²⁶⁵ Psittacines Pigeons/PD
Doxycycline hyclate capsule	300 mg doxycycline mixed in soybean oil/kg low fat psittacine pellets ²⁵¹	Cockatiels/ <i>Chlamydia</i> and spiral bacterial infections; feed as sole diet for 47 days
Doxycycline (Doxirobe gel, Zoetis)	Topical ⁷⁶¹	Most species/apply to beak or pododermatitis lesions; use in conjunction with debridement; antibiotic is released for 28 days
Enrofloxacin	— 1.5-2.5 mg/kg PO, SC q12h ⁸⁰⁶ 2.2 mg/kg IV q12h ³⁴³ 5 mg/kg SC, IM q12h ⁸⁰⁷ 5 mg/kg PO, IM q12-24h ⁸⁰⁷ 5 mg/kg IM q12h × 2 days ⁸⁰⁶ 5-10 mg/kg SC, IM q24h ^{200,202} 5-10 mg/kg PO q8h ³³³ 5-15 mg/kg PO, SC, IM q12h ³³³ 5-20 mg/kg PO q12-24h × 5-10 days ³³³ 10 mg/kg PO q12h ¹¹³ 10 mg/kg PO, IV q24h ⁴³¹ 10-15 mg/kg PO, IM q12h × 5-7 days ³³³	Fluoroquinolone with wide spectrum against Gram-negative and some Gram-positive bacteria; activity against <i>Chlamydia</i> and <i>Mycoplasma</i> , ⁹⁰ administration may be associated with emesis; ⁶⁹⁷ given PO, the IM formulation produces therapeutic plasma concentration; ³⁵⁸ labeled for single IM use only; multiple IM dosages not recommended; best to avoid IV use in raptors; ³²⁴ some fluoroquinolones have been used in PMMA beads with success; ²¹³ joint deformities reported in squab chondrocytes with 200-800 mg/L drinking water; ⁴²⁵ however enrofloxacin has been commonly used at the recommended dosages without reports of adverse effects; ^{248,667} no detected effect on cartilage in day-old poultry chicks ⁶⁰¹ Ratites Emus/PD Cockatiels African grey parrots Ratites African grey parrots Passerines, pigeons (PD) Raptors, psittacines, pigeons/drug of choice for <i>Salmonella typhimurium</i> Pigeons Cockatiels Emus/PK Raptors

TABLE 5-1 Antimicrobial Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Enrofloxacin (cont'd)	10-20 mg/kg PO q24h ^{200,203}	Passerines, psittacines, pigeons (PD)
	15 mg/kg PO q24h ⁶⁰⁷	Psittacines
	15 mg/kg PO q12h ⁴⁶⁹	Ostrich chicks, pigeons (administration to adult birds led to therapeutic levels in crop milk)
	15 mg/kg PO, IM, IV q12h ²³⁴	Raptors/PD; IV administration in owls may result in weakness, tachycardia, vasoconstriction
	15 mg/kg PO, SC q12h ²⁴²	Most species
	15-30 mg/kg PO, IM q12h ²⁴⁶	African grey parrots/PD
	20 mg/kg PO, SC, IM q12h ³³³	Pigeons/administer parenterally, followed by oral treatment
	20-30 mg/kg PO q12-24h ²²¹	Pigeons
	30 mg/kg PO, IM q24h ⁸⁰⁸	Psittacines
	45 mg/kg PO q24h ³²⁰	Pigeons
	25-50 mg/L drinking water ⁹⁸	Cranes (sandhill)/did not provide sufficient plasma levels
	100-200 mg/L drinking water ^{194,686,697}	Psittacines, pigeons/PD; may need up to 300 mg/L to prevent recurrence of infection in pigeons ⁶⁹⁷
	190-750 mg/L drinking water ²⁴⁸	African grey parrots/PD
	200 mg/L drinking water ²⁴⁵	Psittacines/PD; maintains plasma concentrations adequate only for highly susceptible bacteria
	200 mg/L drinking water ²⁰¹	Canaries
	500 mg/L drinking water ⁴⁵⁸	Psittacines
	200 mg/kg soft feed ²⁰¹	Canaries
250 mg/kg feed ²⁰⁰	Budgerigars/PD	
250-1000 mg/kg feed q24h ³³³	Psittacines, passerines	
500 mg/kg feed ⁴⁵⁸	Psittacines, including Patagonian conures/PD; mix into steamed corn diet	
1000 mg/kg feed ⁴⁵⁸	Senegal parrots/PD; mix into steamed corn diet	
0.2 mg/mL saline, flush q24h × 10 days ⁷⁶	Raptors/nasal flush	
Erythromycin	—	Macrolides antibiotic; effective against most aerobic and anaerobic Gram-positive bacteria, may be effective against Gram-negative organisms; active against <i>Mycobacterium</i> (including atypical species), <i>Chlamydia</i> , and <i>Mycoplasma</i> ; ⁹⁰ IM injection may cause severe muscle necrosis ³³¹
	5-10 mg/kg PO q8h ⁸⁰⁶	Ratites

Continued

TABLE 5-1 Antimicrobial Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Erythromycin (cont'd)	10-20 mg/kg IM q24h ²⁰²	Passerines
	10-20 mg/kg PO q12h ⁶⁹⁷	Psittacines
	50-100 mg/kg PO q8-12h ²⁰²	Passerines
	60 mg/kg PO q12h ³⁴⁷	Most species
	71 mg/kg PO q24h ¹⁷⁵	Pigeons/PD; <i>Streptococcus bovis</i>
	100 mg/kg PO ⁸²³	Pigeons/PD; low plasma levels, but higher lung and trachea levels
	125 mg/kg PO q8h ³¹⁸	Pigeons
	125 mg/L drinking water ²⁰¹	Canaries
	132 mg/L drinking water (10 days on, 5 days off, 10 days on) ³³³	Most species, including canaries
	250-500 mg/L drinking water × 3-5 days ¹⁴⁸	Psittacines
Ethambutol	525-800 mg/L drinking water ³¹⁸	Psittacines
	1000 mg/L drinking water ^{175,823}	Pigeons/PD; <i>Streptococcus bovis</i> ; plasma levels low; one study reported that lung and trachea levels were sub-therapeutic
	1500 mg/L drinking water ⁶⁹⁷	Most species
	200 mg/kg soft feed ²⁰¹	Canaries, psittacines
	—	Anti-mycobacterial agent; use in combination with other agents (see Table 5-44)
Flumequine (Biocik, Amacol)	10 mg/kg PO q12h ⁵¹	Most species
	15-20 mg/kg PO q12h × 3-12 mo ³³³	Psittacines, raptors/ <i>Mycobacterium</i>
	15-30 mg/kg PO q12-24h ²⁰³	Passerines/ <i>Mycobacterium</i>
	30 mg/kg PO q24h ⁶⁸⁸	Most species/ <i>Mycobacterium</i>
Furazolidone (NF180, Hess and Clark)	—	Fluoroquinolone antibiotic with wide spectrum against Gram-negative and some Gram-positive bacteria; activity against <i>Chlamydia</i> and <i>Mycoplasma</i> , ⁹⁰ not available in the United States
	30 mg/kg PO, IM q8-12h ¹⁹⁸	Passerines, pigeons (PD)
Furazolidone (NF180, Hess and Clark)	—	Nitrofurantoin antibiotic, wide spectrum but potency is relatively low ⁹⁰ in birds linked with cardiomyopathy; therapeutic action is confined to the gastrointestinal tract
	15-20 mg/kg PO q24h ²⁰³	Passerines
	100-200 mg/L drinking water ⁶⁶⁷	Canaries
	200 mg/kg soft food ⁶⁶⁷	Canaries
	908 mg/kg feed ⁸⁰⁴	Pigeons/ <i>Salmonella</i>

TABLE 5-1 Antimicrobial Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Gentamicin	— 1-2 mg/kg IM q8h ⁸⁰⁶ 2.5 mg/kg IM q8h ⁸² 3-10 mg/kg IM q6-12h ²⁰³ 5 mg/kg IM q8h ^{109,164,375} 5-10 mg/kg IM q8-12h ⁶³⁷ 5-10 mg/kg IM q4h ^{109,691} 7 mg/kg q8h ³⁷⁴ 40 mg/kg PO q8-24h ²⁰³ 2-3 drops ophthalmic solution intranasal q8h ⁸⁰⁷	Extended spectrum aminoglycoside; potentially nephrotoxic; maintain hydration and avoid concurrent use of other nephroactive drugs; ^{81,82,90} avoid doses higher than 2.5-5 mg/kg q8-12h ^{82,250} Ratites (excluding emus)/use only as last resort Raptors/PD Passerines Emus/PD; cranes/PD ¹⁶⁴ Cockatiels/PD Pigeons/PD; ⁶⁹¹ <i>Salmonella</i> Ostriches/PD; use with caution Passerines/15-25 g Most species
Isoniazid	— 5-15 mg/kg PO q12h ³³³ 30 mg/kg PO q24h ⁸²²	Antimycobacterial agent; should be used in combination with other drugs (see Table 5-44) Most species, including passerines Most species
Kanamycin	— 10-20 mg/kg IM q12h ³³³ 13-65 mg/L drinking water × 3-5 days ³³³	Extended spectrum aminoglycoside; potentially nephrotoxic, maintain hydration and avoid concurrent use of other nephroactive drugs ⁹⁰ Most species, including passerines/enteric infections Most species/make fresh daily
Lincomycin	— 0.25-0.5 mL intraarticular q24h × 7-10 days ⁶⁹⁷ 25-50 mg/kg PO q12h ³¹⁵ 35-50 mg/kg PO q12-24h ²⁰³ 35-50 mg/pigeon PO q24h × 7-14 days ⁴⁹⁹ 50-75 mg/kg PO, IM q12h × 7-10 days ³³³ 100 mg/kg PO q24h ⁶⁶⁶ 100 mg/kg IM q12h ⁷⁷	Lincosamide antibiotic; broad spectrum against anaerobic bacteria; limited activity against aerobic organisms; wide distribution, including bone ⁹⁰ Raptors Raptors/musculoskeletal surgical repair Passerines Pigeons Psittacines, raptors/pododermatitis, osteomyelitis Raptors Psittacines

Continued

TABLE 5-1 Antimicrobial Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Lincomycin (cont'd)	100-200 mg/L drinking water ²⁰¹ Topical ³¹⁵	Canaries Raptors/mixture of 50 mg/mL lincomycin and 10 mg/mL tobramycin was used to flush the flexor tendon sheath
Lincomycin/spectinomycin (LS-50 Water Soluble, Zoetis; Linco-Spectin 100 Soluble Powder, Zoetis)	— 50 mg/kg PO q24h ³³³ ¼-½ tsp/L drinking water × 10-14 days ¹³⁹	Lincosamide in combination with an aminoglycoside; combination is effective against <i>Mycoplasma</i> ⁹⁰ Most species Most species/using soluble powder 16.7 g lincomycin and 33.3 g spectinomycin per 2.55 oz packet of powder
Marbofloxacin (Zeniquin, Zoetis)	— 2-3 mg/kg IV, IO q24h ^{278,279} 2.5-5 mg/kg PO q24h ¹²³ 5 mg/kg IM, IV ¹⁷⁶ 10-15 mg/kg PO, IM q12-24h ^{76,149a,277,697}	Fluoroquinolone with wide-spectrum against Gram-negative and some Gram-positive bacteria; activity against <i>Chlamydia</i> and <i>Mycoplasma</i> ⁹⁰ Raptors (buzzards, vultures)/PD Blue and gold macaws/PD Ostriches/PD Raptors, bustards (PO dosage is PD) ²⁷⁷
Meropenem	— 175 mg/kg IM q24h ⁷²²	Broad-spectrum β-lactamase-sensitive penicillin with extended spectra including <i>Pseudomonas</i> , and many anaerobes ⁹⁰ Pigeons/PD
Metronidazole	— 10 mg/kg IM q24h × 2 days ³³³ 10-30 mg/kg PO q12h × 10 days ⁸⁰⁸ 50 mg/kg PO q24h × 5-7 days ³³³ 50 mg/kg PO q12h × 30 days ⁶⁸⁵	Nitroimidazole antibiotic and antiprotozoal agent active against most anaerobes; penetrates blood-brain barrier; ⁹⁰ see Table 5-4 Psittacines Psittacines Most species, including raptors, psittacines/anaerobes Amazon parrots, cockatoos/ anaerobic and hemorrhagic enteritis
Minocycline	— 10 mg/kg PO q12h ⁵⁴⁷ 15 mg/kg PO q12h ⁶⁴³ 5000 mg/kg feed ¹³	Broad-spectrum tetracycline with activity against a wide range of Gram-positive and Gram-negative bacteria; drug of choice for <i>Chlamydia</i> and <i>Mycoplasma</i> ; readily penetrates blood-brain barrier ⁹⁰ Penguins Raptors Parakeets/use as antibiotic impregnated millet

TABLE 5-1 Antimicrobial Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Neomycin	— 5-10 mg/kg IM q12h ³⁴⁰ 10 mg/kg PO q24h ²⁰³ 10 mg/kg PO q8-12h ¹⁰⁸ 80-100 mg/L drinking water ⁶⁶⁷ Topical q6-12h ⁶⁶⁷	Aminoglycoside antibiotic; poorly absorbed from gastrointestinal tract; potentially nephrotoxic and ototoxic ⁹⁰ Raptors/toxic if overdosed Passerines Most species Canaries Most species/superficial wounds; cover with bandage; may be absorbed systemically and may cause ototoxicity and nephrotoxicity
Nitrofurazone	— 0.3 mg/L drinking water × 7 days ⁶⁶⁶ 0.6 mg/L drinking water × 7-10 days ⁶⁰⁸	Nitrofurantoin antibiotic; wide spectrum but potency is relatively low; ⁹⁰ may be hepatotoxic; do not use in finches or pigeons ⁶⁸⁶ Lories, mynahs/do not put in lory nectar Most species
Norfloxacin	— 3-5 mg/kg PO q12h ⁸⁰⁶	Fluoroquinolone with wide spectrum against Gram-negative and some Gram-positive bacteria; activity against <i>Chlamydia</i> and <i>Mycoplasma</i> ⁹⁰ Ratites
Oleandomycin	— 25 mg/kg IM q24h ²⁰³ 50 mg/kg PO q24h ²⁰³	Macrolide antibiotic; not available in the United States Passerines Passerines
Ormetoprim-sulfadimethoxine (Primor, Zoetis)	— 60 mg/kg PO q12h ³²⁰ 475-951 mg/L drinking water × 7-10 days ³²⁰	Potentiated sulfonamide combination antibiotic; broad spectrum ⁹⁰ Pigeons Pigeons
Oxytetracycline	— 2 mg/mL nebulization q4-6h ²¹¹ 5 mg/kg IM q12h ⁸⁴³ 10 mg/kg IM q3d ⁸⁰⁶ 16 mg/kg IM q24h ⁷⁹⁴	Broad-spectrum tetracycline with activity against a wide range of Gram-positive and Gram-negative bacteria; drug of choice for <i>Chlamydia</i> and <i>Mycoplasma</i> ; IM administration may cause muscle irritation or necrosis ⁹⁰ Parakeets/requires ultrasonic nebulizer; therapeutic concentrations of antibiotic were present in lung and trachea; not effective in treating systemic infections outside the respiratory tract Ratites Ratites Great horned owls/PD

Continued

TABLE 5-1 Antimicrobial Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Oxytetracycline (cont'd)	25-50 mg/kg PO, IM q8h × 5-7 days ⁷⁶	Raptors
	48 mg/kg IM q48h ³⁵⁸	Owls
	50 mg/kg IM q24h × 5-7 days ⁶⁹⁷	Psittacines
	50 mg/kg PO q6-8h ³¹⁸	Pigeons
	50-75 mg/kg SC ²⁴⁰	Goffin's cockatoos, blue and gold macaws
	50-100 mg/kg SC, IM q2-3d ^{203,249}	Cockatoos (PD), passerines
	50-200 mg/kg IM q3-5d ⁶⁹⁷	Raptors
	58 mg/kg IM q24h ⁷⁹⁴	Amazon parrots/PD
	80 mg/kg IM q48h ⁶⁹⁷	Pigeons <400 g
	200 mg/kg IM q24h ^{51,76}	Most species, including waterfowl/ <i>Pasteurella</i>
Penicillin benzathine/ procaine	—	Pigeons
	650-2000 mg/L drinking water × 5-14 days ¹⁴⁸	Psittacines
	300 mg/kg soft feed × 5-14 days ¹⁴⁸	Psittacines
	8 g/40 g packet bone cement ⁸¹⁰	PMMA beads (ratio 1:5)
	200 mg/kg IM q24h ⁵¹	Anecdotal reports suggest procaine penicillin should not be used in birds <1 kg BW because of possible toxic effects ⁸⁰⁷ Most species
Penicillin G	6 mg/kg IV ¹³⁷	Ostriches, emus/PD; rapidly eliminated; small volume of distribution
Penicillin procaine	—	Anecdotal reports suggest procaine penicillin should not be used in birds <1 kg BW; adverse reactions (possible toxic effects) described in finches, canaries, budgerigars, cockatiels ^{237,807}
Piperacillin	—	Broad-spectrum β-lactamase-sensitive penicillin with extended spectra including <i>Pseudomonas</i> , <i>Proteus</i> , and others; ⁹⁰ see piperacillin/tazobactam
	25 mg/kg IM ⁸⁰⁷	Ratites (chicks <6 mo of age)
	75-100 mg/kg IM q4-6h ^{807,808}	Amazon parrots
	100 mg/kg IM q12h ²⁰⁰	Psittacines/PD
	100 mg/kg IM q12h ¹	Ostrich chicks/administer concurrent with amikacin (20 mg/kg IM q12h)
	100 mg/kg IM, IV q8-12h ^{566,643,697}	Pigeons, raptors, cranes

TABLE 5-1 Antimicrobial Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Piperacillin (cont'd)	100 mg/kg IM q4-6h ⁶⁷⁴ 100-200 mg/kg IM, IV q6-12h ^{689,697} 200 mg/kg IM q8h ⁶⁶⁰ 200 mg/kg IM, IV q4-8h ^{242,689,807} 0.02 mL (4 mg) in macaw eggs; 0.01 mL (2 mg) in small eggs ⁵⁰⁷	Red-tailed hawks, great horned owls/PD Most species, including psittacines Budgerigars (PD), raptors Most species, including passerines Eggs/inject 200 mg/mL solution into air cell on days 14, 18, and 22
Piperacillin/tazobactam	— 100 mg/kg IM q3-4h ¹²⁵ 100 mg/kg IM, IV q8-12h ⁵⁵³	β-lactamase-protected penicillin combination; synergistic effect allows activity against organisms resistant to piperacillin alone; ⁹⁰ broad-spectrum activity Hispaniolan Amazon parrots/PK; to control infections attributed to susceptible bacteria with an MIC of ≤4 μg/mL Most species, including psittacines/ reports of good clinical response; recommended at 100 mg/kg IV q6h for severe polymicrobial bacteremia
Polymyxin B	— 10-15 mg/kg IM q24h ³⁴⁰ 50,000 U/L drinking water ³⁷⁷ 50,000 U/kg soft feed ³⁷⁷	Polypeptide antibiotic; toxicity limits use to topical preparations or PO for gastrointestinal infections; narrow spectrum against some Gram-negative bacteria ⁹⁰ Raptors/not absorbed if given PO Canaries Canaries
Povidone-iodine	Topical to lesions, then wash off ⁷⁶	Raptors/wound cleansing; antibacterial, antifungal activity
Rifabutin (Mycobutin, Pfizer)	15-45 mg/kg PO q24h ³³³	Antimycobacterial agent; use in combination with other agents (see Table 5-44)
Rifampicin	—	See rifampin
Rifampin	— 10-20 mg/kg PO q12-24h ^{203,697,807} 45 mg/kg PO q24h ^{752,822}	Most species/ <i>Mycobacterium</i> ; use with other agents (see Table 5-44); may cause/be associated with hepatitis, CNS signs, depression, and vomiting; yellow-orange urates observed in bustards ⁶⁹⁷ Most species, including passerines, psittacines/ <i>Mycobacterium</i> Most species, including Amazon parrots, cranes
Silver sulfadiazine	Topical q12-24h ^{226,667}	Most species/topical sulfonamide, specifically for burn wounds; ⁹⁰ ulcers; Amazon foot necrosis; bandage application preferred

Continued

TABLE 5-1 Antimicrobial Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Spectinomycin	10-30 mg/kg IM q8-12h ⁷⁷	Aminoglycoside antibiotic ⁹⁰
	25-35 mg/kg IM q8-12h ³¹⁹	Psittacines
	165-275 mg/L drinking water ³²⁰	Pigeons
	200-400 mg/L drinking water ²⁰¹	Pigeons
	400 mg/kg soft feed ²⁰¹	Canaries
Spiramycin	—	Macrolide antibiotic; effective against most aerobic and anaerobic Gram-positive bacteria; may be effective against Gram-negative organisms; active against <i>Mycobacterium</i> (including atypical species), <i>Chlamydia</i> , and <i>Mycoplasma</i> ; ⁹⁰ not available in the United States
	20 mg/kg IM q24h ³⁴⁰	Raptors
	250 mg/kg PO q24h ⁵⁰⁰	Most species, including raptors/poorly absorbed
	200-400 mg/L drinking water ²⁰¹	Canaries
	400 mg/kg soft feed ²⁰¹	Canaries
Streptomycin	—	Narrow-spectrum aminoglycoside; activity against Gram-negative aerobic bacteria ⁹⁰ and <i>Mycobacterium</i> ; use in combination with other agents (see Table 5-44)
	30 mg/kg IM q12h ⁵¹	Most species
Sulfachlorpyridazine	—	Potentiated sulfonamide combination antibiotic and antiprotozoal; broad spectrum ⁹⁰
	150-300 mg/L drinking water ⁶⁶⁷	Canaries
	400 mg/L drinking water × 7-10 days ⁶⁸⁴	Pigeons
Sulfadimethoxine	—	Potentiated sulfonamide combination antibiotic, broad spectrum; antiprotozoal ⁹⁰
	25-55 mg/kg PO q24h × 3-7 days ^{382,659}	Raptors/loading dose at higher end × 1 day
	50 mg/kg PO q24h ¹¹⁹	Cranes
	190-250 mg/L drinking water ⁵⁰⁰	Pigeons/loading dose 375 mg/L drinking water
	330-400 mg/L drinking water on day 1 followed by 200-265 mg/L × 4 days ³²⁰	Pigeons

TABLE 5-1 Antimicrobial Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Tetracycline	— 50 mg/kg PO q8h ^{203,667} 200-250 mg/kg PO q12-24h ⁶⁶⁶ 40-200 mg/L drinking water ³³³ 100 mg/L drinking water ⁶³⁹ 200 mg/L drinking water ⁶⁸⁵ 666 mg/L drinking water ⁶⁹⁷	Broad-spectrum tetracycline with activity against a wide range of Gram-positive and Gram-negative bacteria; drug of choice for <i>Chlamydia</i> and <i>Mycoplasma</i> ⁹⁰ Most species, including passerines Most species/gavage Most species, including game birds Rheas Pigeons Pigeons
Tiamulin (Denagard; Elanco)	— 25-50 mg/kg PO q24h ¹⁸⁰	Tiamulin fumarate antibiotic; activity against Gram-positive organisms including anaerobes ⁹⁰ Most species
Ticarcillin (Ticar, SmithKline Beecham)	— 75-100 mg/kg IM q4-6h ⁶⁸⁹ 150-200 mg/kg IV q2-4h ²⁰³ 200 mg/kg IM, IV q6-12h ³³³ 200 mg/kg IM q2-4h ⁷²¹	Broad-spectrum β -lactamase-sensitive penicillin with extended spectra including <i>Pseudomonas</i> and many anaerobes ⁹⁰ Amazon parrots Passerines, soft bills Most species, including pigeons, raptors/ <i>Pseudomonas</i> ²⁴⁰ Blue-fronted Amazon parrots/PD
Ticarcillin/clavulanate (Timentin, Glaxo SmithKline)	100 mg/kg IM, IV ¹⁴⁷ 200 mg/kg IM, IV q12h ⁶⁸⁵	Most species/frequency not reported Most species
Tilmicosin (Micotil 300 Injection, Provital-powder and Pulmotil AC-liquid, Elanco)	—	Macrolide antibiotic; effective against most aerobic and anaerobic Gram-positive bacteria; may be effective against Gram-negative organisms; active against <i>Mycobacterium</i> (including atypical species), <i>Chlamydia</i> , and <i>Mycoplasma</i> , ⁹⁰ handle with caution; potentially fatal to humans; ⁶¹⁴ see Table 6-1 for poultry dosages
Tobramycin	— 0.25-0.5 mL intraarticular flush q24h \times 7-10 days ⁷⁶ 2.5-5 mg/kg IM, IV q8-12h ¹⁴⁸ 10 mg/kg IM q12h \times 5-7 days ³³³ Topical	Extended spectrum; potentially nephrotoxic; maintain hydration and avoid concurrent use of other nephroactive drugs ⁹⁰ Raptors/septic arthritis Psittacine, passerines, raptors Raptors A mixture of lincomycin (50 mg/mL) and tobramycin (10 mg/mL) was used to flush the flexor tendon sheath ³¹⁵

Continued

TABLE 5-1 Antimicrobial Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Trimethoprim	— 10-20 mg/kg PO q8h ^{198,202,500}	Bacteriostatic activity against some Gram-positive and Gram-negative bacteria Psittacines, passerines, pigeons (PD)
Trimethoprim/sulfadiazine	— 8 mg/kg SC, IM q12h ⁵⁶⁶ 12-60 mg/kg PO q12h × 5-7 days ⁷⁶ 16-24 mg/kg PO q8-12h ⁵⁶⁶ 20 mg/kg SC, IM q12h ¹⁴⁸ 30 mg/kg PO q8h ³⁴¹ 30 mg/kg PO, IM, IV q12h ³¹⁴ 60 mg/kg PO q12h ³²⁰ 107 mg/L drinking water ⁸⁵ 475-950 mg/L drinking water × 7-10 days ³²⁰	Potentiated sulfonamide combination antibiotic; broad spectrum ⁹⁰ Cranes Raptors/useful for sensitive infections in neonates Cranes Psittacines Psittacines/combine with pyrimethamine for treatment of sarcocystosis Ostriches/PD Pigeons Galliformes Pigeons
Trimethoprim/sulfatroxazole	— 10-50 mg/kg PO q12h ²⁰³	Potentiated sulfonamide combination antibiotic; broad spectrum ⁹⁰ Passerines
Trimethoprim/sulfamethoxazole	— 8 mg/kg IM q12h ⁶⁹⁷ 10-50 mg/kg PO q24h ²⁰³ 20 mg/kg PO q8-12h ⁶⁹⁷ 21 mg/kg PO q12h ¹ 40-50 mg/kg PO q12h ²⁴² 48 mg/kg PO, IM q12h ³⁸⁴ 60 mg/kg PO q24h ¹⁹⁸ 60-72 mg/kg PO q12h ¹¹⁸ 75 mg/kg IM q12h ⁵¹ 100 mg/kg PO q12h ⁵¹ 144 mg/kg PO q8-12h ⁶⁸⁹ 360-400 mg/L drinking water × 10-14 days ⁶⁸⁴	Potentiated sulfonamide combination antibiotic; broad spectrum ⁹⁰ Psittacines Passerines Psittacines Ostriches Psittacines Raptors Pigeons/PD Cranes Most species/reduce dose if regurgitation occurs ²⁴⁰ Most species, including psittacines Most species Most species, including pigeons
Tylosin	—	Macrolide antibiotic; effective against most aerobic and anaerobic Gram-positive bacteria, may be effective against Gram-negative organisms; active against <i>Mycobacterium</i> (including atypical species), <i>Chlamydia</i> , and <i>Mycoplasma</i> ; potentially irritating to muscles when administered IM ⁹⁰

TABLE 5-1 Antimicrobial Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Tylosin (cont'd)	3-5 mg/kg IM, IV q12h ⁸⁰⁶	Ratites
	5-10 mg/kg PO q8h ⁸⁰⁶	Ratites
	15 mg/kg IM q8h ⁴⁶¹	Cranes/PD
	15-30 mg/kg IM q12h × 3 day ³³³	Raptors
	17 mg/kg IM q24h × 7 days ⁵²⁰	Emus/ <i>Mycoplasma</i>
	20-40 mg/kg IM q8h ⁶⁹⁷	Psittacines
	25 mg/kg IM q8h ⁴⁶¹	Emus/PD
	25 mg/kg IM q6h ⁴⁶¹	Pigeons, quail/PD
	30 mg/kg IM q12h ⁷⁶	Most species/ <i>Mycoplasma</i>
	50 mg/kg PO q24h ³³³	Passerines, pigeons
	50 mg/L drinking water ⁶⁸⁵	Most species
	250-400 mg/L drinking water ²⁰¹	Canaries
	300 mg/L drinking water × 6 wk ⁵⁵⁸	House finches/ <i>Mycoplasma</i>
	500 mg/L drinking water × 3-28 days ³³³	Pigeons, emus/ <i>Mycoplasma</i>
800 mg/L drinking water ³²⁰	Pigeons	
1000 mg/L drinking water × 21 days ⁵⁰¹	House finches/ <i>Mycoplasma</i> ; give in conjunction with ophthalmic ciprofloxacin	
2000 mg/L drinking water ³³³	Pigeons/ <i>Mycoplasma</i> , <i>Haemophilus</i>	

^aMost drug doses used in birds should be considered experimental. Patients should be monitored for adverse effects and treatment failure.²⁴⁰

TABLE 5-2 Antifungal Agents Used in Birds.

Agent	Dosage	Species/Comments
Acetic acid (vinegar)	16 mL/L drinking water ³⁷⁷	Most species/gastrointestinal yeast infections
Amphotericin B	—	Polyene macrolide antifungal agent; broad activity against various types of fungi, but susceptibility varies as to species; ineffective against dermatophytes; primary use is for systemic fungal infections ⁹¹
	1.5 mg/kg IV q8h × 3-7 days ^{333,644}	Most species
	1 mg/kg intratracheal q8-12h, dilute to 1 mL with sterile water ^{644,667}	Psittacines, raptors/aspergillosis
	1 mg/kg intratracheal q12h × 12 days, then q48h × 5 wk ⁷⁶	Raptors/syringeal aspergilloma

Continued

TABLE 5-2 Antifungal Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Amphotericin B (cont'd)	<p>100-109 mg/kg PO by gavage q12h × 10-30 days⁵²⁶</p> <p>0.05 mg/mL sterile water⁵²</p> <p>0.2 mL PO q12h × 10 days¹⁴⁸</p> <p>0.25-1 mL PO q24h × 4-5 days⁷⁶</p> <p>1000 mg/L drinking water × 10 days²²⁹</p> <p>Topical¹⁴⁸</p> <p>1.35 mg/kg topical q24h of a liposomally encapsulated formulation in a sterile, water-soluble lubricating gel⁸⁷</p> <p>7 mg/mL saline q12h⁸¹⁰</p> <p>1 mg/kg intrasessionally⁶²⁵</p>	<p>Budgerigars/<i>Macrorhabdus</i>; compound in simple syrup; resistance reported in budgerigars in Australia⁶⁰⁷</p> <p>Most species/nasal flush</p> <p>Budgerigars/<i>Macrorhabdus</i>; use IV formulation (5 mg/mL)</p> <p>Raptor neonates/candidiasis</p> <p>Budgerigars/<i>Macrorhabdus</i></p> <p>Apply 10% solution to oropharynx</p> <p>Hérons</p> <p>Most species/nebulization × 15 min</p> <p>Conures/pulmonary lesions; administered endoscopically with injection needle along with systemic therapy</p>
Amphotericin B (3% cream)	Topical to affected area q12h ⁶⁶⁷	Most species/mycoses
Clotrimazole	<p>—</p> <p>2 mg/kg intratracheal q24h × 5 days⁶⁸⁵</p> <p>Inject 10 mg/kg into air sacs⁶⁸⁵</p> <p>10 mg/mL saline flush⁶⁰⁷</p> <p>1% solution⁸¹⁰</p>	<p>Imidazole antifungal agent; variable sensitivity between yeasts and fungi; superficial mycoses and candidiasis⁹¹</p> <p>Psittacines/syringeal aspergilloma; apply with catheter directly into syrinx during anesthesia</p> <p>Psittacines/dilute in propylene glycol to 2.5 mg/mL; divide total dose between the 4 most accessible air sacs; toxic and may result in death in African grey parrots and other birds if injected into the viscera or IM⁶⁸⁵</p> <p>Most species/effective against <i>Aspergillus</i> at sites that can be flushed; nasal flush using 1% solution</p> <p>Nebulization × 30-60 min</p>
Enilconazole emulsion	<p>—</p> <p>6 mg/kg PO q12h¹³</p> <p>1 mg (0.5 mL)/kg intratracheal of a 1:10 dilution q24h × 7-14 days⁶⁹⁷</p> <p>200 mg/L drinking water¹³</p>	<p>Imidazole antifungal agent; variable sensitivity between yeasts and fungi; superficial mycoses and candidiasis;⁹¹ used topically and for nasal flush</p> <p>Eclectus parrots/glossal candidiasis; an elevation of AST was seen after 7 days of treatment</p> <p>Falcons/aspergillosis</p> <p>Canaries/cutaneous dermatophytosis</p>

TABLE 5-2 Antifungal Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Enilconazole emulsion (cont'd)	<p>Topical 1:10 dilution q12h × 21-28 days⁷⁶</p> <p>Topical or intratracheal 1:10-1:100 dilution⁷⁷</p> <p>3 topical soakings q3d⁶⁴⁴</p> <p>0.1 mL/kg in 5 mL sterile water, nebulize × 30 min, 5 days on, 2 off, up to 3 mo³³⁸</p>	<p>Raptors/cutaneous aspergillosis, candidiasis</p> <p>Psittacines/aspergillosis, candidiasis</p> <p>Raptors, ostriches/dermatophytosis</p> <p>Raptors/aspergillosis</p>
Fluconazole	<p>—</p> <p>2-5 mg/kg PO q24h × 7-10 days^{76,583}</p> <p>4-6 mg/kg PO q12h²³⁸</p> <p>5 mg/kg PO q24h⁶⁴¹</p> <p>10 mg/kg PO q48h⁶⁴¹</p> <p>5-10 mg/kg PO q24h⁵⁰</p> <p>8 mg/kg PO q24h × 30 days⁸⁰⁸</p> <p>10-20 mg/kg PO × 30 days³⁷⁷</p> <p>15 mg/kg PO q12h × ≥28 days⁶⁸⁷</p> <p>15 mg/kg PO q12h × 30 days following cessation of clinical signs¹⁰</p> <p>20 mg/kg PO q48h²³⁸</p> <p>25 mg/L nectar³²⁹</p> <p>50 mg/L drinking water × 14-60 days⁶⁸⁵</p> <p>100 mg/L drinking water × 8 days⁶⁴¹</p> <p>150 mg/L drinking water⁵⁰</p> <p>100 mg/kg soft food⁵⁰</p>	<p>Imidazole antifungal agent; variable sensitivity between yeasts and fungi; systemic mycoses and candidiasis; relatively good penetration into CSF;⁹¹ death observed in budgerigars at 10 mg/kg PO q12h (this dose was also ineffective against avian gastric yeast)⁶⁰⁷</p> <p>Most species, including raptors/gastrointestinal, systemic candidiasis; CNS, ocular mycoses</p> <p>Juvenile psittacines/candidiasis</p> <p>Cockatiels/candidiasis</p> <p>Gouldian finches/candidiasis</p> <p>Psittacines/cryptococcosis</p> <p>Red-tailed hawks, gyrfalcons/aspergillosis</p> <p>Pigeons/aspergillosis</p> <p>Psittacines/chronic nasal aspergillosis</p> <p>Psittacines/PD; mucosal, systemic yeast infections; 2-3 treatments for resistant candidiasis</p> <p>Hummingbirds/aspergillosis</p> <p>Most species/systemic mycoses; candidiasis</p> <p>Cockatiels/candidiasis</p> <p>Gouldian finches/candidiasis</p> <p>Gouldian finches/candidiasis</p>
Flucytosine	<p>—</p> <p>20-30 mg/kg PO q6h × 20-90 days³⁵⁸</p>	<p>Fluorinated pyrimidine antifungal agent; as resistance develops rapidly, not used as sole antifungal agent; effective against <i>Cryptococcus</i>, <i>Candida</i>, and <i>Aspergillus</i>; excellent CSF, aqueous humor penetration;⁹¹ use prophylactically in raptors (especially falcons) to prevent aspergillosis^a</p> <p>Raptors/aspergillosis</p>

Continued

TABLE 5-2 Antifungal Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Flucytosine (cont'd)	20-75 mg/kg PO q12h × 21 days ⁶⁹⁷	Psittacines/generalized yeast or fungal infections
	50 mg/kg PO q12h × 14-28 days ^{148,572}	Psittacines, passerines, raptors
	50-75 mg/kg PO q8h ⁶⁴⁴	Raptors/aspergillosis prophylaxis;
	75 mg/kg q12h × 5-7 days, then q24h × 14 days ⁶⁴⁴	consider treatment 1 wk prior to and 2 wk after move; used routinely for domestically raised gyrfalcons and gyrfalcon hybrids from age 45 days
	75-120 mg/kg PO q6h ⁵⁷²	Most species
	80-100 mg/kg PO q12h ⁸⁰⁶	Ratites
	100-250 mg/kg PO q12h ³⁸⁶	Psittacine neonates
Griseofulvin	250 mg/kg PO q12h × 14-17 days ⁷⁸²	Finches/endoventricular mycoses; can use with chlorhexidine in drinking water
	50-250 mg/kg feed ⁶⁶⁷	Psittacines, mynah birds
	—	Systemic antifungal agent; effective against common dermatophytes ⁹¹
Iodine, 1% solution	10 mg/kg PO q12h × 21 days ⁶⁹⁷	Pigeons/dermatophytosis; gavage
	30-50 mg/kg in drinking water q24h ⁸⁰⁶	Ostriches/mycotic dermatitis
Itraconazole	Topical ⁶⁴⁴	Most species/oral or cutaneous candidiasis
Itraconazole	—	Imidazole antifungal agent; variable sensitivity between yeasts and fungi; systemic mycoses and candidiasis; relatively good penetration into CSF; ⁹¹ commercially available suspension is recommended as a first choice; use caution using compounded formulations because bulk drug may not be bioavailable or stable ^{107,170}
	5-10 mg/kg PO q24h ⁵⁷⁴	Blue-fronted Amazon parrots/PD; aspergillosis; 10 mg/kg is required to achieve therapeutic concentrations in poorly perfused tissues; anorexia, depression, and toxicity reported at higher doses in African grey parrots. ^{239,607}
	5-10 mg/kg PO q12-24h × 10-14 days, then q48h ³⁵⁸	Raptors/aspergillosis prophylaxis ^a
	5-10 mg/kg PO q12h × 5 days, followed by q24h for a total of 14 days ⁶⁴⁴	Raptors/suggested for Class I aspergillosis (mild, vague signs with inconclusive diagnostics or without histologic confirmation)
	5-10 mg/kg PO q12h × 5 days, followed by q24h × 60-90 days ⁶⁴⁴	Raptors/Class II-IV aspergillosis
5-10 mg/kg PO q12h ^{394,666}	Passerines (towhees), penguins/aspergillosis prophylaxis in passerines; aspergillosis, candidiasis, and cryptococcosis in others	

TABLE 5-2 Antifungal Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Itraconazole (cont'd)	6 mg/kg PO q12h ⁴⁷⁵	Pigeons/PD; dosage will achieve fungicidal plasma concentrations
	6-8 mg/kg PO q12h × 5-7 days then q24h × 14 days ⁶⁴⁴	Raptors/prevention of aspergillosis; consider treating for 1 wk prior and 2 wk after move, and routinely for domestically raised gyrfalcons and gyrfalcon hybrids from age 45 days
	6-10 mg/kg PO ³⁷⁵	Ratites
	10 mg/kg PO q24h ^{333,383}	Red-tailed hawks (PD), gentoo penguins
	10 mg/kg PO q24h × 14-90 days with food ^{572,573,607}	Psittacines/use in combination with non-azoles
	10 mg/kg PO q12h × 21-60 days ^{148,782}	Finches/endoventricular mycoses; can use with chlorhexidine in drinking water
	15 mg/kg PO q12h up to 4-6 wk ³⁵⁸	Raptors/aspergillosis
	20 mg/kg PO q24h ¹⁰⁷	Penguins/PD
	26 mg/kg PO q12h ⁴⁷⁵	Pigeons/PD; fungicidal levels achieved in respiratory tissue; further toxicologic studies are required
200 mg/kg feed up to 100 days ⁶⁵⁷	Gouldian finches/PD; dermatomycoses; beads from capsules were mixed with small amount of oil and seed	
Ketoconazole	—	Imidazole antifungal agent; fungistatic; variable sensitivity between yeasts and fungi; systemic fungal infections ⁹¹
	5-10 mg/kg PO q24h ⁸⁰⁶	Ratites
	8 mg/kg PO q12h × 30 days ⁸⁵	Ostriches
	10-20 mg/kg PO q24h ⁸⁵	Ostriches
	15 mg/kg PO q12h ³⁸⁴	Raptors/candidiasis
	20 mg/kg PO q8h × 7-14 days ⁶⁰⁷	Psittacines/refractory candidiasis
	20 mg/kg PO q24h × 14 days ¹⁴⁸	Psittacines, passerines, raptors
	20-30 mg/kg PO q8h ³²⁶	Cockatoos
	20-40 mg/kg PO q12h × 15-60 days ⁶⁸⁶	Pigeons
	25 mg/kg PO q12h × 14 days ⁶⁹⁷	Ratites, raptors/aspergillosis
	30 mg/kg PO q12h × 7-14 days ⁴¹⁵	Amazon parrots/PD
50 mg/kg/day PO ¹⁵⁰	Toucans	
60 mg/kg PO q12h ⁸³⁷	Raptors, common buzzards (PD)/aspergillosis	
200 mg/L drinking water, nectar, or soft feed × 7-14 days ^{50,201,329}	Canaries, hummingbirds, Gouldian finches/dissolve crushed tablet in ½-1 tsp vinegar	

Continued

TABLE 5-2 Antifungal Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Miconazole	— 5 mg/kg intratracheal q12h × 5 days ³³³ 10 mg/kg IM q24h × 6-12 days ⁶⁹⁷ 20 mg/kg IV q8h ⁶⁹⁷ Topical to affected areas q12h ⁶⁴⁴	Imidazole antifungal agent, topical preparations for local dermatophytosis; ⁹¹ injectable product not available in the United States Psittacines/10 mg/mL solution diluted with saline; syringeal mycoses; use with flucytosine; clotrimazole may be an alternative Raptors/generalized aspergillosis Psittacines/candidiasis, cryptococcosis Most species/cutaneous fungal infections; used in conjunction with oral itraconazole; dermatophytosis
Nystatin	— 5000 U/bird PO q12h × 10 days ^{229,230} 20,000-100,000 U/bird PO q24h × 7 days ^{85,697} 100,000 U/kg PO q12h ^{319,384} 250,000-430,000 U/kg PO q12h ¹⁴⁸ 250,000-500,000 U/kg PO q12h ⁸⁰⁶ 300,000 U/kg PO q12h × 7-14 days ^{76,236} 300,000-600,000 U/kg PO q8-12h × 7-14 days ¹⁴⁸ 500,000 U/kg PO q8h × 5 days ¹⁵⁹ Topical q6h ³⁶² 25,000 U/L nectar ³⁶² 100,000 U/L drinking water ^{50,201} 200,000 U/kg soft feed ^{50,76}	Polyene macrolide antifungal agent; used topically or orally to treat GI candidiasis; can be effective against other yeast and fungi; poorly absorbed from the GI tract ⁹¹ Goldfinches/ <i>Macrorhabdus</i> ; ineffective in budgerigars Pigeons/candidiasis Pigeons, raptors Hummingbirds Ratites Most species Psittacines Toucannettes (safron)/candidiasis Hummingbirds/candidiasis; direct application using a cotton swab Hummingbirds Canaries, finches Canaries, finches
Povidone-iodine	Topical to lesions, then rinse ⁷⁶	Raptors/wound cleansing; antibacterial, antifungal activity
Sodium benzoate	1 tsp/L water × 5 wk ³⁵⁴	Budgerigars/cleared infection in nonbreeding birds; 0.5 tsp/L resulted in neurologic signs and death in breeding birds, likely due to increased water intake ³⁵⁴
Silver sulfadiazine	Topical to affected areas q12-24h ^{226,667}	Most species/bandage application preferred

TABLE 5-2 Antifungal Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
STA solution (salicylic acid 3 g, tannic acid 3 g, ethyl alcohol to 100 mL)	Topical ⁶⁹⁷	Fungal dermatitis
Terbinafine	— 10-15 mg/kg PO q12-24h ¹⁶⁹ 15 mg/kg PO q24h ⁶⁸ 15-30 mg/kg PO q12h ²⁴³ 22 mg/kg PO q24h ⁶⁹ 1 mg/mL solution via nebulization ²¹⁶	Allylamine antifungal used topically for dermatophytes; fungicidal; data are emerging to potentially support its use for systemic fungal infections; ⁹⁰ questionable therapeutic potential for the treatment of aspergillosis in avian species; higher dose or use in combination with itraconazole may be more effective ²⁴³ Most species Penguins/PD Most species Raptors/PD Hispaniolan Amazon parrots/raw powder maintained MIC concentrations for 4 hr vs. 1 hr for crushed tablets
Voriconazole	— 10 mg/kg PO q12h or 20 mg/kg q24h ⁷¹⁻⁷³ 10 mg/kg PO q8h ⁷²⁵ 12-18 mg/kg PO q12h ²⁵² 12.5 mg/kg PO q12h ⁷²⁰ 18 mg/kg PO q8h ³⁰⁶ 20 mg/kg PO q24h × 21 days ⁵⁸⁴	Imidazole antifungal agent; indicated for aspergillosis infections in humans; ⁵¹ used in avian species for the treatment of aspergillosis, but there are limited PK studies; some strains in pigeons found to be resistant; ⁷³ difficult to extrapolate drug doses between species; safety unproven in birds; increased anecdotal reporting of voriconazole toxicity in penguins; ^{359b} PO and IV solutions available; may need to adjust dose for long-term treatment to maintain therapeutic concentrations; ²⁴³ compounded suspensions stable up to 30 days at room temperature ⁵⁵⁶ Pigeons/PD Red-tailed hawks/PD African grey parrots/PD Falcons/PD; red-tailed hawks Amazon parrots/PD Many species

^aProphylactic use of antifungal agents may be indicated in newly captured or admitted birds of susceptible species, and in birds undergoing change of management or transfer of enclosure.⁶⁴⁴

TABLE 5-3 Antiviral and Immunomodulating Agents Used in Birds.

Agent	Dosage	Species/Comments
Acyclovir	— 20-40 mg/kg IM q12h ⁶⁸¹ 29 mg/bird PO q8h × 7 days ⁷⁶ 80 mg/kg PO q8h × 7 days ⁵⁶¹ 330 mg/kg PO q12h × 4-7 days ³⁸⁷ 330 mg/kg PO q12h × 7-14 days ³⁵⁸ 1000 mg/L drinking water ^{157,665} ≤400 mg/kg feed ¹⁵⁷	Antiviral agent; useful against DNA viral infections, particularly herpesvirus; available in topical and parenteral formulations; IM injection of the water-soluble sodium salt (IV formulation) may cause severe muscle necrosis; phlebitis and neurologic signs may occur with IV administration; most effective when administered before clinical signs begin; birds should be treated for a minimum of 7 days; the reconstituted solution is unstable and should be divided into aliquots and frozen ³³³ Psittacines/psittacine herpesvirus Pigeons/herpesvirus Quaker parakeets/PD; psittacine herpesvirus prophylaxis or treatment Psittacine neonates/psittacine herpesvirus Raptors/falcon and owl herpesvirus; may cause vomiting Quaker parakeets/herpesvirus; gavage Quaker parakeets/herpesvirus
Amantadine	— 1 mg/kg PO q24h × 3 wk ²⁸⁹	Antiviral agent; inhibits replication of influenza A viruses African grey parrots/no effect on avian bornavirus infection ²⁸⁹
Cyclosporine	10 mg/kg PO q12h ^{273,412}	Psittacines/immunosuppressant agent; palliative treatment of proventricular dilatation disease (3/6 cockatiels treated survived) ^{412,273}
Echinacea (Echinacea solution, Biobotania)	0.5 mL/kg per L drinking water q24h × 5 days ⁶⁹⁷ 1 mL/L drinking water ⁶⁶⁶	Psittacines/herbal immunostimulant Psittacines/use alcohol-free formulation
Imiquimod cream	— Apply topically 3 × /wk several hr before the morning feeding ⁴⁴⁵	Immune response inhibitor used to inhibit viral-induced tumor formation; has no direct antiviral activity Psittacines/cloacal papillomatosis; thought to boost host cell-mediated immunity; masses decreased in size in one report, but not in another; ⁴⁴³ complete remission did not occur in either
Interferon α_2	— 60-240 U/kg SC, IM q12h ⁷³¹ or 300-1200 U/kg PO q12h ⁶⁸⁵	Antiviral cytokine glycoprotein with immunomodulating and antiproliferative capabilities as well as antiviral activity Most species/stock solution: mix 1 mL (3,000,000 U/mL) with 100 mL sterile water (30,000 U/mL); can freeze as 2 mL vials up to 1 yr; mix 2 mL of stock into 1 L LRS (=60 U/mL); refrigerate up to 3 mo

TABLE 5-3 Antiviral and Immunomodulating Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Interferon α_2 (cont'd)	1500 U/kg PO q24h ¹³ 1,000,000 U IM q2-7d \times 3 treatments ⁷⁶²	Psittacines African grey parrots/circovirus; birds treated with poultry origin gamma interferon survived, those treated with α feline origin did not
	1000 U/L drinking water \times 14-28 days ⁶⁸⁴	Pigeons/circovirus
Propionibacterium Acnes, (ImmunoRegulin, Neogen)	0.13 mg/kg (up to 0.08 mg [0.2 mL] max) SC, IM days 1, 3, 7, 14, 28, 42, then q30d ⁴⁰	Psittacines/immunomodulatory drug; used to manage FIV infection in cats; anecdotally reported as an alternative therapy for chronic feather destructive disease ⁴⁰
Silymarin (milk thistle)	100-150 mg/kg PO divided q8-12h ¹⁰	Most species/hepatic antioxidant; used in patients with liver disease and as ancillary to chemotherapy; use an alcohol-free liquid formulation
Vaccines	—	See Table 5-47 (Vaccines Used in Birds)

TABLE 5-4 Antiparasitic Agents Used in Birds.

Agent	Dosage	Species/Comments
Albendazole (11.36%) (Valbazen, Zoetis)	—	Broad-spectrum anthelmintic; may be toxic in keas, some columbiformes and other spp. at 50-100 mg/kg ^{356,760}
	5.2 mg/kg PO q12h \times 3 days, repeat in 14 days ⁸⁰⁶	Ratites/flagellates, cestodes
	6 mg/kg PO once ¹⁷⁸	Ostriches/100% effective against <i>Libyostrongylus dentatus</i> and <i>L. douglassii</i>
	15-20 mg/kg PO once ³³³	Toucans
	20 mg/kg PO, repeat in 7 days ⁴⁸²	Cranes/effective against some trematodes
	25 mg/kg PO q24h \times 90 days, then repeat \times 120 days when signs returned ⁶¹⁰	Cockatoos/ <i>Encephalitozoon hellem</i> keratoconjunctivitis
	25-50 mg/kg PO q24h \times 3-4 days ⁷⁶⁰	Doves, rock partridges/ <i>Capillaria</i> ; toxicity occurred in some birds, use with caution
	50 mg/kg PO q24h \times 5 days ¹¹⁵	Amazon parrots/microsporidian keratoconjunctivitis
113-116 mg/23 kg q12h \times 3 days, repeat in 14 days ³⁸	Ratites/protozoal infections	

Continued

TABLE 5-4 Antiparasitic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Amprolium	—	Pyridimine derivative coccidiostat; although rarely encountered, efficacy can be reduced by high doses of thiamine; ⁷⁵⁹ resistance common; some coccidial organisms of mynahs, toucans have shown resistance ³⁸
	2.2 mg/kg PO ¹²²	Sandhill cranes/ineffective in preventing experimentally induced disseminated visceral coccidiosis
	15-30 mg/kg PO q24h × 1-5 days ¹⁹⁴	Most species/treatment should be repeated after 5 days due to coccidial prepatent period ¹⁹⁴
	30 mg/kg PO q24h ^{432b}	Merlins/thiamine deficiency
	30 mg/kg PO q24h × 5 days ^{38,432b}	Raptors
	5-100 mg/L drinking water × 5-7 days ^{38,747}	Most species/flock treatment
	50-100 mg/L drinking water × 5-7 days ^{171,194,333}	Most species, including passerines, parakeets
	60 mg/L drinking water ³³³	Cranes
	200 mg/L drinking water ³²¹	Pigeons/flock treatment
	250 mg/L drinking water × 7 days ³³³	Psittacines (keas)/ <i>Sarcocystis</i> ; use in combination with pyrimethamine and primaquine
	¼ tsp/L drinking water × 3-5 days ³³³	Pigeons/20% soluble powder
0.0125 mg/kg feed ⁴⁸²	Cranes/coccidiosis prophylaxis	
0.025 mg/kg feed × 14 days ⁴⁸²	Cranes/coccidiosis treatment	
115-235 mg/kg feed ³³³	Poultry/coccidia; <i>Sarcocystis</i> ; lower dose is prophylactic; higher dose is therapeutic	
Cambendazole (Equiben, Merial)	60-100 mg/kg PO q24h × 3-7 days ^{194,333}	Most species
	75 mg/kg PO q24h × 2 day ^{38,323}	Pigeons
Carbaryl 5% (Sevin Dust, Garden Tech)	Topical; light dusting of plumage or nest box litter (1-2 tsp) ^{38,482}	Most species/ants, ectoparasites; remove treated litter after 24 hr
Carnidazole (Spartrix, Wildlife Pharmaceuticals)	—	Treatment for <i>Trichomonas</i> , <i>Hexamita</i> , <i>Histomonas</i> ³⁸
	5 mg/bird PO ³³³	Doves (adults), pigeons (squabs)
	10 mg/bird PO ^{788a}	Pink pigeons (adults)/ <i>Trichomonas</i> ; squabs ≤ 18 days old administer 5 mg
	12.5-25 mg/kg PO once ^{38,135}	Pigeons, raptors/ <i>Trichomonas</i> , use lower dose with juvenile birds; combine with dimetridazole to treat flock
20 mg/kg PO once ³³³	Pigeons	

TABLE 5-4 Antiparasitic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Carnidazole (Spartrix, Wildlife Pharmaceuticals) (cont'd)	20 mg/kg q24h PO × 2 days ³³³ 20-25 mg/kg PO once ^{38,194,432b}	Raptors Raptors/single dose not always effective in falcons, bustards with advanced infections; use lower dose for juveniles
	20-30 mg/kg PO q24h × 1-2 days ^{38,135}	Most species, including pigeons, psittacines
	20-30 mg/kg PO q24h × 5 days ^{20,747}	Passerines/ <i>Trichomonas</i> ; house finches reliably cleared <i>Trichomonas gallinae</i> if caught prior to clinical signs
	30 mg/kg PO once ²⁵⁶	Raptors/ <i>Trichomonas</i>
	30 mg/kg PO q12-24h × 3 days ^{382,654}	Raptors/ <i>Trichomonas</i>
	30-50 mg/kg PO, repeat in 10-14 days ⁶⁶⁷	Cockatiels/ <i>Giardia</i>
	33 mg/kg PO, repeat in 14 and 28 days ⁵⁰	Society finches, Gouldian finches/flagellates; 0.5 mg/adult (based on 15 g); 0.25 mg/nestling (based on 7.5 g)
	50 mg/kg PO once ³⁵⁸ 120 mg/kg PO as single dose or divided over 2-5 days ⁸¹¹	Raptors American kestrels, screech owls/ <i>Trichomonas</i> infections resistant to treatment with lower doses
Chloroquine phosphate ^a	—	Generally used with primaquine for <i>Plasmodium</i> , <i>Haemoproteus</i> , and <i>Leucocytozoon</i> ; overdose can result in death ³⁸
	10 mg/kg PO q7d ³³³	Most species/preventive treatment for <i>Plasmodium</i> once bird is stable; use with primaquine (1 mg/kg PO q7d)
	10 mg/kg PO, then 5 mg/kg at 6, 12, 18 hr, then q24h × 10 days ^{38,826}	Magellanic penguins/upon diagnosis of <i>Plasmodium</i> ; if still positive on blood smear after this regime, continue with sulfadiazine-trimethoprim 40 mg/kg PO × 10 days
	10 mg/kg PO, then 5 mg/kg at 6, 24, 48 hr ¹²⁰	Raptors/use with 0.3 mg/kg primaquine (at 24 hr following the initial chloroquine dose) q24h × 7 days
	10-15 mg/kg PO q12h × 2 doses, then q24h ^{432b}	Raptors/ <i>Plasmodium</i> ; use with primaquine
	10-25 mg/kg PO, then 5-15 mg/kg at 6, 18, 24 hr ¹⁹⁴	Use in conjunction with primaquine
	20 mg/kg PO or IV, then 10 mg/kg at 6, 18, 24 hr; repeat q7d × 3-5 treatments ³³³	Raptors/ <i>Plasmodium</i> ; IV is recommended for initial dose in acute cases; use with 1 mg/kg primaquine q24h × 2 days

Continued

TABLE 5-4 Antiparasitic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Chloroquine phosphate ^a (cont'd)	25 mg/kg PO, then 15 mg/kg PO at 12, 24, 48 hr ^{38,333,714a} 60 mg/kg PO q24h × 7 days ³³³ 2000 mg/L drinking water q24h × 14 days ¹³⁵	Most species, including raptors/use with 0.75-1.3 mg/kg primaquine at 0 hr Raptors/ <i>Haemoproteus</i> ; use in conjunction with mefloquine and primaquine Passerines/juice covers bitter taste of drug
Chlorsulon (Curatrem, Merial)	— 20 mg/kg PO q2wk × 3 treatments ^{432b}	Benzenesulfonamide anthelmintic and flukicide Raptors
Clazuril (Appertex, Janssen)	— 2.5 mg/bird PO once; can repeat monthly ^{827a} 5 mg/kg PO once ¹³⁵ 5-10 mg/kg PO q24h × 2 days ^{340,432b} 5-10 mg/kg PO q72h × 3 treatments ^{38,149a,432b} 6.25 mg/kg PO once ³⁸ 7 mg/kg PO × 3 days, off 2 days, on 3 days ^{38,194} 30 mg/kg PO once ¹³⁵ 1.1 or 5.5 mg/kg feed ¹²²	Benzene-acetonitrile anticoccidial Pigeons/oocyst shedding commences 20 days post-treatment Pigeons Raptors Raptors Pigeons Most species Raptors Sandhill cranes/ineffective in preventing experimentally induced disseminated visceral coccidiosis
Coumaphos (Powder containing 3% w/v coumaphos 2% w/v propoxur 5% w/v sulphanilamide Negasunt, Bayer)	Topical dust onto feathers ³⁸ 20 mg/kg PO q14d × 3 treatments ^{38,432b,666}	Most species/ectoparasites; useful for fly-blown wounds, contains carbamate propoxur Psitacines, raptors/trematodes, cestodes
Crotamiton (Eurax, Westwood-Squibb)	Topical to affected areas ³⁸	Most species/mites (i.e., <i>Knemidokoptes</i>); use in combination with ivermectin
Cypermethrin (5%) (Max Con, Y-TEX)	Spray or dip with 2% solution ³⁸	Pigeons, ostriches/lice, mites; treatment of premises infested with <i>Dermanyssus</i> spp.
Deltamethrin	50 mg/L topical spray ³³³	Ostriches/lice; spray until runoff
Dichlorophene (Tapeworm tablets, Happy Jack)	100 mg PO q10d × 2 treatments, repeat in 10 days pm ⁴⁰²	Pigeons/cestodes; administer after a 12-hr fast
Diclazuril (Protazil, Merck)	— 5 mg/L drinking water ¹⁹⁴ 10 mg/kg PO q12h on days 0, 1, 2, 4, 6, 8, 10 ^{194,502}	Benzene-acetonitrile anticoccidial; some <i>Eimeria</i> resistance in poultry documented recently; ^{4,640} rotation suggested for long-term prevention Passerines/ <i>Toxoplasmosis</i> Passerines, including Hawaiian crows/ <i>Toxoplasma</i>

TABLE 5-4 Antiparasitic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Dimetridazole (Emtryl 40% powder, MedPet)	—	<i>Trichomonas</i> , <i>Giardia</i> , <i>Hexamita</i> , <i>Spironucleus</i> , <i>Histomonas</i> ; low therapeutic index; hepatotoxic to lories, some passerines (e.g., robins) and fledgling birds; ³⁸ not recommended for finches; highly toxic to geese, ducks, and pigeons; ⁷⁵⁹ not available in many countries (United States, European Union) because of human health risks; Canada has banned use in food-producing animals; ⁵⁴⁸ do not give during breeding season
	50 mg/kg PO q24h × 10 days ⁵³⁴	Falcons/ <i>Enterocytozoon bienersi</i>
	50 mg/kg PO or in drinking water q24h × 6 days ¹³⁵	Pigeons
	100 mg/L drinking water ²⁰¹	Canaries, finches
	200-400 mg/L drinking water × 5 days ^{194,333}	Psittacines/caution toxic if overdosed; do not use in finches and Pekin robins; use lower dose in lorikeets and mynahs ¹⁹⁴
	250 mg/L drinking water × 4-6 days ³³³	Gouldian finches/ <i>Cochlostoma</i> , <i>Trichomonas</i>
	265 mg/L drinking water ³³³	Pigeons
	300 mg/L drinking water × 10 days ³⁸	Bustards/prevention of <i>Trichomonas</i>
	400 mg/L drinking water × 3 days ³⁶¹	Pigeons/PD; bioavailability reduced with feed
	666 mg/L drinking water × 7-12 days ³⁸	Pigeons/ <i>Trichomonas</i> , <i>Giardia</i> , <i>Hexamita</i>
900 mg/L drinking water × 5 days, followed by 700 mg/L × 10 days ³⁸	Bustards/treatment of choice for <i>Trichomonas</i>	
¼-½ tsp/gal drinking water × 3-5 days ³²⁰	Pigeons/CNS symptoms if overdosed; because of variable water consumption, use lower dose in hot weather and higher dose in cool weather	
200-500 mg/kg feed ¹¹²	Ostriches (<3 mo of age)/ <i>Trichomonas</i>	
Doramectin (Dectomax, Zoetis)	1 mg/kg SC, IM, ^{38,432b} repeat in 2 wk ¹³⁵	Raptors, bustards/used to treat GI nematodes, lungworms, eyeworms, mites ³⁸
Doxycycline	20 mg/kg PO q12h × 10 days ²⁹⁵	Humboldt penguins/ <i>Plasmodium</i>
Febantel (Vercom, Bayer)	5 mg/kg PO ⁵⁰⁰	Ostriches
	20 mg/kg PO ⁵⁰⁰	Ostriches
	30 mg/kg PO once ^{34,194}	Pigeons/PD; ascarids; repeated doses required to eliminate <i>Capillaria obsignata</i>
	37.5 mg/kg PO once ³⁸	Pigeons

Continued

TABLE 5-4 Antiparasitic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Fenbendazole (Panacur, Merck)	—	Most species/anthelmintic effective against cestodes, nematodes, trematodes, <i>Giardia</i> , acanthocephalans; toxicity documented in pigeons and doves; ^{286,356,582,671} may be toxic for other species, including raptors, ⁶⁸⁵ vultures, ^{88,358} lories, ⁵⁶² storks, ^{88,840} pelicans; ⁴⁵⁷ can cause feather abnormalities if administered during molting; ³⁸ ineffective against finch ventricular worms; ³⁸ can be toxic to bone marrow causing leukopenia ¹⁹⁴
	8-10 mg/kg q24h × 3-4 days ¹⁹⁴	Most species
	10-20 mg/kg PO q24h × 3 days ¹³⁵	Pigeons/nematodes
	10-50 mg/kg PO, repeat in 14 days ^{358,364}	Raptors/nematodes, trematodes
	15 mg/kg PO ^{149b,333}	Ostriches/"wire worms," nematodes, cestodes
	15 mg/kg PO q24h × 5 days ³⁸	Psittacines
	15 mg/kg PO × 5 days, then off 5 days × 4 treatment periods ⁵¹⁰	Umbrella cockatoos/proventricular Spiruroidea
	15 mg/kg PO q3wk ^{149b}	Ratite chicks/nematodes; administer at this frequency until 4 mo old, then at adult prophylaxis dosing intervals
	15-25 mg/kg PO × 4-5 days ⁷⁴⁰	Tinamous
	15-45 mg/kg PO ³³³	Ostriches
	20 mg/kg PO q24h × 10-14 days ^{149a}	Raptors/filarids
	20-25 mg/kg PO q24h × 5 days ^{149a,256,432b,650}	Raptors/ <i>Capillaria</i>
	20-50 mg/kg PO q24h ^{38,333}	Psittacines, pigeons/ascaris in psittacines, treat once and repeat in 10 days; trematodes and microfilaria, treat for 3 days; <i>Capillaria</i> , treat for 5 days
	20-50 mg/kg PO q24h × 3 days, repeat in 2 wk ⁸³⁸	Penguins ^a
	20-50 mg/kg PO q24h × 3 days, repeat in 21 days ³⁵⁸	Raptors
	25 mg/kg PO, repeat in 14 days ^{144,749}	Most species, including owls/ascaris
	25 mg/kg PO q24h × 5 days, ¹³⁵ repeat in 10-14 days ³⁵⁸	Raptors/ <i>Capillaria</i> , spirurids
25 mg/kg PO q6wk ^{149b}	Ratites/cestode prophylaxis	
25-50 mg/kg PO once ¹⁹⁴	Most species	
30 mg/kg PO once ³⁸	Bustards	
30 mg/kg PO q24h × 5-8 days ¹⁶	Falcons/eliminated <i>Serratospiculoides</i> fecal eggs and larvae	

TABLE 5-4 Antiparasitic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Fenbendazole (Panacur, Merck) (cont'd)	33 mg/kg PO q24h × 3 days ¹⁴⁸	Psittacines, passerines, raptors/microfilaria, trematodes
	50 mg/kg PO q24h × 3-5 days ^{194,333,560,747}	Most species, including pigeons, Bali mynahs/nematodes, trematodes, <i>Giardia</i>
	50 mg/kg PO q24h × 5 days ⁴⁸²	Cranes/ <i>Capillaria</i> , gapeworms
	50 mg/kg PO q12h × 5 days ³³³	Cockatoos/filarid adulticide treatment; use with ivermectin (0.2 mg/kg once)
	50 mg/kg q24h × 5 days ²²⁰	Scops owls (fledglings)/treatment of <i>Gongylonema pulchrum</i> oral plaques
	50-100 mg/kg PO, repeat in 14 days ⁴⁸²	Cranes/intestinal strongyles, ascarids
	100 mg/kg PO once, repeat in 10-14 days ^{432b}	Raptors/ <i>Capillaria</i> , spirurids
	100 mg/kg PO q24h × 5 days ¹¹⁸	Cranes/ <i>Capillaria</i>
50 mg/L drinking water × 5 days ³³³	Finches	
125 mg/L drinking water × 5 days ³³³	Most species/nematodes	
Fipronil	—	Do not use spot-on preparation; use with caution in raptors, pigeons, passerines/ectoparasites; apply via pad to base of neck, tail base, and under each wing; avoid plumage during application; alcohol may create dry, brittle feathers; do not soak bird; do not exceed 7.5 mg/kg; in zebra finches ⁴⁰⁶ and wild ²⁸¹ species; significant toxicity reported from mortality to sublethal effects such as cytotoxic effects, ¹⁸⁹ impaired immune function, ⁴⁶⁴ and reduced growth and reproductive success, ⁴⁰⁷ often at concentrations well below those associated with mortality; ^{281,407} environmental contamination and secondary intoxication are of concern ^{281,405}
	3 mg/kg spray on skin once ¹⁹⁴	
	7.5 mg/kg; spray on skin once, repeat in 30 days prn ^{38,135,256,747}	
Flubendazole (Flutelmium 7.5%, Janssen-Cilag)	30-60 mg/kg feed × 7 days ³³³	Tinamous; follow VFD guidelines
Hydroxychloroquine sulfate	—	Antimalarial
	830 mg/L drinking water × 6 wk ³³³	Pigeons/ <i>Plasmodium</i>
Hygromycin B (Hygromix 8, Elanco)	—	Aminoglycoside antibiotic used as anthelmintic feed additive; follow VFD guidelines

Continued

TABLE 5-4 Antiparasitic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Imidocarb dipropionate (Imizol, Merck)	— 5-7 mg/kg IM once, repeat in 7 days ^{704,851}	Antiprotozoal effective against <i>Babesia</i> Raptors/ <i>Babesia</i> ; some cases require a total of 3 treatments
Iprnidazole (Ipropran, Roche)	— 130 mg/L drinking water × 7 days ³³³ 250 mg/L drinking water × 3-7 days ³³³	<i>Giardia</i> , <i>Trichomonas</i> , <i>Histomonas</i> ; not available in the United States; 61 g/2.65 oz Most species, including pigeons Psittacines, pigeons
Ivermectin	— 0.2 mg/kg PO, SC, IM once, can repeat in 10-14 days ^{38,135,320,375,482,571,747} 0.2 mg/kg IM once ^{173,178} 0.2-0.4 mg/kg PO, SC, repeat 7-14 days ⁸³⁸ 0.2-1 mg/kg PO, SC, IM q14d × 2-3 treatments ^{432b} 0.2 mg/kg SC, topical on skin; can repeat 1-2 wk for 3-4 applications ^{135,171,205,738} 0.4 mg/kg SC once ³³³ 0.4 mg/kg IM q7d × 7 treatments ⁶⁹⁴ 0.5-1 mg/kg PO, IM once ³²⁰ 1 mg/kg SC, repeat in 7 days ⁷⁰⁰	All species/most nematodes, acanthocephalans, leeches, most ectoparasites (including <i>Knemidokoptes</i> , <i>Dermanyssus</i>); can dilute with water or saline for immediate use; dilute with propylene glycol for extended use; parenteral ivermectin may be toxic to finches and budgerigars; ³³³ brain inflammation detected as an adverse effect in king pigeons; ¹³² suspected toxicity reported in a nanday conure at 0.2 mg/kg ⁶⁰⁰ Most species, including psittacines, passerines, pigeons, raptors, guinea fowl, ratites, cranes/use in combination with fenbendazole at 50 mg/kg PO q12h × 5 days for microfilaria in cockatoos ³³³ Ostriches/only 60% effective against <i>Libyostrongylus dentatus</i> and <i>L. douglassii</i> Penguins Raptors Canaries, finches/quill mites, <i>Knemidokoptes</i> ; dilute to 0.02% solution with propylene glycol, can apply directly to lesions on cere, legs; also effective against the tracheal mite <i>Ptilonyssus morofskyi</i> ²⁴ Raptors, passerines/ <i>Capillaria</i> in towhees Golden eagles/required additional treatment with selamectin to achieve eradication of a novel <i>Micknemidokoptes</i> spp. mite Pigeons Falcons/ <i>Serratospiculum</i>

TABLE 5-4 Antiparasitic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Ivermectin (cont'd)	2 mg/kg IM once ⁷⁹²	Falcons/ <i>Capillaria</i> ; no adverse effects observed at this dose
	0.8-1 mg/L drinking water ²⁰¹	Canaries
	1 drop (0.05 mL) to skin q7d × 3 treatments ³⁸	Pigeons, passerines/ <i>Knemidokoptes</i> , <i>Dermanyssus</i>
Levamisole (Tramisol, Schering-Plough)	—	Many species/nematodes; immunostimulant; low therapeutic index (toxic reactions, deaths reported); do not use in debilitated birds; ³⁸ IM administration may cause severe toxicity; limb paralysis, vomiting, dyspnea reported in a parakeet; do not use in white-faced ibis or in lories; withhold food before treatment to prevent regurgitation ³³³
	1.5 mg/kg split into 2 doses and administered topically in eyes ⁵³²	Ostriches/PD; effective against <i>Philophthalmus gralli</i>
	2-5 mg/kg SC, IM, repeat in 10-14 days × 3 treatments ³⁸	Psittacines/immunostimulant
	7.5 mg/kg PO, SC ¹¹²	Ostriches
	7.5 mg/kg IM once; can repeat in 7 days ³⁸	Pigeons
	10-20 mg/kg PO, SC q24h × 2 days ^{149a,358}	Raptors
	10-20 mg/kg SC once ^{38,333,432b}	Most species
	15-20 mg/bird PO once, repeat in 10 days ¹³⁵	Pigeons
	20 mg/kg PO once ³⁸	Psittacines, pigeons, raptors
	20-40 mg/kg IM once ^{194,432b}	Raptors
	20-50 mg/kg PO × 1-3 days ³⁸	Psittacines/low therapeutic index
	25 mg/kg PO once ⁴⁸²	Crane chicks/ <i>Capillaria</i> , intestinal strongyles, ascarids
	30 mg/kg PO q3wk ^{149b}	Ratite chicks/administer at this dosage until 4 mo of age, then reduce to adult prophylaxis interval thereafter
	30 mg/kg PO q10d ^{149b}	Ratites/cestodes, nematodes
	40 mg/kg PO once ^{38,432b,482}	Psittacines, pigeons, raptors, cranes/ <i>Capillaria</i> , intestinal strongyles, ascarids
100-200 mg/L drinking water × 3 days, repeat in 2 wk ^{35,194}	Psittacines, passerines, raptors	
264-396 mg/L drinking water × 1-3 days ³³³	Most species, including pigeons	
300-400 mg/L drinking water for 24 hr, repeat in 7 days ³⁸	Pigeons/loft treatment for capillariasis, ascariasis	
375 mg/L drinking water as sole water source for 24 hr, repeat in 7 days ³⁸	Pigeons	

Continued

TABLE 5-4 Antiparasitic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Mebendazole (Telmin Suspension, Telmintic Powder, Schering-Plough)	5-6 mg/kg PO q24h × 3-5 days, repeat in 21 days ³³³	Pigeons
	5-7 mg/kg PO ⁸⁰⁶	Ostriches
	10 mg/kg PO q12h × 5 days ³³³	Canaries/avoid use during breeding season
	10-25 mg/kg q12h × 5 days ¹⁹⁴	Most species
	20 mg/kg PO q24h × 10-14 days ^{38,149a,432b}	Raptors/filarids
	25 mg/kg PO q12h × 5 days ¹⁵⁹	Psittacines, ramphastids (toucans)/nematodes; may not be effective for proventricular and ventricular parasites
	25 mg/kg PO q12h × 5 days, repeat q30d ³⁵⁸	Raptors/intestinal nematodiasis
Mefloquine HCl (Lariam, Hoffman-LaRoche)	—	Antimalarial; active against erythrocytic and tissue schizonts of some <i>Plasmodium</i> ^{659,793}
	30 mg/kg PO q12h × 1 day, then q24h × 1-2 days ^{385,432b,793,851}	Raptors
	30 mg/kg PO q12h × 1 day, then q24h × 2 days, then q7d ^{432b}	Raptors/long-term administration up to 6 mo reported
	30 mg/kg PO q7d ²⁹⁵	Penguins/ <i>Plasmodium</i> routine prevention during insect season
	50 mg/kg PO q24h ⁵⁴¹	Raptors/ <i>Haemoproteus</i> ; used in conjunction with chloroquine at doses up to 60 mg/kg
Melarsomine dihydrochloride (Immiticide, Merial)	—	Organic arsenical
	0.25 mg/kg IM q24h × 4 days ¹³⁵	Raptors/ <i>Leucocytozoon</i>
Melarsomine dihydrochloride (M)/ivermectin (I)	(M) 0.25 mg/kg IM q24h × 2 days followed 10 days later with (I) 1 mg/kg IM ⁷⁹⁰	Falcons/ <i>Serratospiculum</i> ; reduced clinical signs and eliminated shedding of embryonated eggs
Mepacrine HCl	—	Nonsteroidal antiinflammatory used as an antiprotozoal for <i>Giardia</i> in humans
	0.24 mg/kg PO q12h ¹⁹⁴	Canaries/ <i>Plasmodium</i>
Metronidazole	—	Most species/antiprotozoal, including alimentary tract protozoa (especially flagellates such as <i>Giardia</i> , <i>Histomonas</i> , <i>Spironucleus</i> , <i>Trichomonas</i>); resistance identified in racing pigeons ⁶⁸²
	10-20 mg/kg IM q12-24h × 2 days ³³³	Pigeons, psittacines
	10-30 mg/kg PO, IM q12h × 10 days ^{38,808}	Psittacines

TABLE 5-4 Antiparasitic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Metronidazole (cont'd)	20-25 mg/kg PO q12h ⁸⁰⁶	Ratites
	25 mg/kg PO q12h × 2-10 days ³³³	Psittacine neonates
	25-50 mg/kg PO q12-24h × 5-10 days ³³³	Companion birds/treatment, control, or prevention of <i>Giardia</i> , <i>Trichomonas</i> , and <i>Hexamita</i>
	25-50 mg/kg PO q12-24h ³³³	Pigeons/use lower dose with twice daily dosing
	30 mg/kg PO via gavage once ^{228,747}	Passerines, including finches/ <i>Cochlosoma</i>
	30 mg/kg PO q12h × 5-10 days ⁵⁰	Raptors, Gouldian finches, psittacines/ <i>Trichomonas</i>
	30-50 mg/kg PO q24h × 3-5 days ⁶⁵⁴	Raptors/ <i>Trichomonas</i>
	40 mg/kg PO q24h ³³³	Rheas
	40 mg/kg PO q24h × 7 days ³³³	Budgerigars/ <i>Trichomonas</i>
	40-50 mg/kg PO q24h × 5-7 days ¹³⁵	Pigeons
	50 mg/kg PO q12-24h ¹⁹⁴	Most species/ <i>Trichomonas</i> , <i>Giardia</i> , <i>Cochlosoma</i>
	50 mg/kg PO q24h × 5-7 days ^{38,149a,256,358}	Raptors/ <i>Trichomonas</i> , <i>Giardia</i>
	50 mg/kg PO q12h × 5 days ^{135,400}	Pigeons, passerines, raptors
	50-100 mg/kg PO q24h ^{432b}	Raptors
	100 mg/kg PO q24h × 3 days ⁷⁰²	Falcons/ <i>Trichomonas</i>
	100-150 mg PO total dose divided over 5 days ³⁸	Pigeons
	40 mg/L drinking water ²²⁸	Finches/ <i>Cochlosoma</i>
	40-80 mg/L drinking water × 3 days ¹⁹⁴	Most species/ <i>Trichomonas</i> , <i>Giardia</i> , <i>Cochlosoma</i>
	100 mg/L drinking water ³³³	Canaries
	200 mg/L drinking water × 7 days ¹³⁵	Passerines
370 mg/L drinking water ³³³	Passerines/protozoal sinusitis	
400 mg/L drinking water × 5-15 days ³³³	Passerines/protozoal sinusitis	
1057 mg/L drinking water ³³³	Pigeons	
1250 mg/L drinking water × 7-10 days ³³³	Ratites	
100 mg/kg soft feed ³³³	Canaries	
Milbemycin oxime	2 mg/kg PO once ¹⁹⁴	Budgerigars, African finches, and European finches may be more sensitive
Monensin (Coban 45, Elanco)	—	Ionophore antibiotic anticoccidial feed additive
	94 mg/kg feed ¹²¹	Cranes/coccidia (including disseminated visceral coccidiosis)
	99 mg/kg feed ^{122,482}	Sandhill cranes/prevented experimentally induced disseminated visceral coccidiosis

Continued

TABLE 5-4 Antiparasitic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Moxidectin (ProHeart, Zoetis)	— 0.2 mg/kg PO ^{135,700} 0.2 mg/kg IM once ¹⁵⁹ 0.2 mg/kg IM once ¹⁷⁸ 0.2-0.4 mg/kg PO, IM once ¹⁹⁴ 0.5 mg/kg PO ^{38,432b} 0.5-1 mg/kg PO ¹³⁵ 1 mg/bird topically once, or can repeat q10d × 2 treatments ³³³	Falcons/ <i>Serratospiculum</i> , <i>Capillaria</i> , acanthocephalans, <i>Paraspiralatus</i> <i>sakeri</i> , and <i>Physaloptera alata</i> ³⁸ Raptors/nematodes Ramphastids (toucans)/repeat if necessary Ostriches/100% effective against <i>Libyostrongylus dentatus</i> , <i>L. douglassii</i> Raptors Raptors/ <i>Capillaria</i> Budgerigars/ <i>Knemidokoptes</i> ; no adverse effects seen at this dose in this species
Niclosamide (Yomesan, Bayer)	— 50-100 mg/kg PO, repeat in 10-14 days ^{194,333} 100 mg/kg PO q6wk ^{149b} 220 mg/kg PO, repeat in 10-14 days ³³³ 250 mg/kg PO q14d prn ¹¹⁷ 500 mg/kg PO q7d × 4 wk ³³³	Cestodes, trematodes; rarely used since praziquantel is more efficacious; may be toxic for geese and some Anseriformes; not available in the United States Ostriches Ostriches/cestode prophylaxis Most species Cranes Finches
Ormetoprim-sulfadimethoxine (Primor, Zoetis)	0.015% ormetoprim and 0.026% sulfadimethoxine in food × 3 wk ⁴⁸²	Cranes/coccidiosis
Oxfendazole (Benzelmin, Syntex)	5 mg/kg PO once ³³³ 5 mg/kg PO q6wk ^{149b} 5 mg/kg PO q3wk ^{149b} 10-40 mg/kg PO once ^{194,494,768} 15-25 mg/kg PO once ¹⁵⁹ 20 mg/kg PO once ³⁴⁰	Ostriches/nematodes Ratites/cestode, nematode prophylaxis Ratite chicks/nematodes; administer at this frequency until 4 mo of age, then reduce to adult prophylactic dosing interval Most species, including finches/ nematodes Ramphastids (toucans)/repeat in 15 days prn Raptors
Paromomycin	—	Highest efficacy of all drugs tested thus far against <i>Cryptosporidium</i> ; oocyst output decreased by 67%-82% in chickens, ⁷⁵⁸ may result in secondary bacterial or mycotic infections; use with caution if ulcerative bowel lesions are suspected because renal toxicity may occur; ³³³ ineffective against <i>Histomonas</i> ³⁵⁷

TABLE 5-4 Antiparasitic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Paromomycin (cont'd)	100 mg/kg PO q12h × 7 days ^{1,194,256} 1000 mg/kg soft food or hulled millet ³³³	Most species, including macaw chicks, falcons/mix a 250 mg capsule with 10 mL water to facilitate dosing; poorly absorbed Gouldian finches/ <i>Cryptosporidium</i> ; may predispose to fungal infections
Permethrin	Dust plumage lightly ³⁸	Pigeons/lice, fleas
Permethrin, high-cis (Harker's Louse Powder, Harkers)	Topical application ³⁸	Raptors, psittacines/ectoparasites
Piperazine (Wazine, Fleming Laboratories)	— 35 mg/kg PO q24h × 2 days ³³³ 50-100 mg/kg PO once ^{333,759} 100 mg/kg PO, repeat in 14 days ^{333,494} 100-250 mg/kg PO once ¹⁹⁴ 250 mg/kg PO once ³³³ 79 mg/L drinking water × 2 days ³³³ 1000 mg/L drinking water × 3 days ^{333,494} 1000-2000 mg/L drinking water × 1-2 days ^{135,333} 3700 mg/L drinking water × 12 hr, repeat in 14-21 days ¹³⁵	Most species/ascaris, oxyurids; less efficacious than fenbendazole; seldom used in companion birds Pigeons/ascarids Emus, ostriches Raptors Ascarids, resistance common Psittacines, pigeons Pigeons/ascarids Raptors, pigeons Game birds, pigeons Passerines
Piperonyl butoxide/pyrethrin (Ridmite Powder, Johnson)	Dust plumage, repeat in 10 days ^{38,194} Dust plumage, repeat in 21 days ³⁸	Psittacines Raptors
Piperonyl butoxide/pyrethrin/methoprene (Avian Insect Liquidator, Vetafarm)	Apply to plumage, spray cages, aviaries, bird rooms, and surroundings ³⁸	Most species/fleas, lice, mosquitoes, moths, and some mites
Ponazuril (Marquis 5% paste; Bayer)	— 20 mg/kg q24h × 7 days ⁸²⁵	Triazine coccidiocidal drug; metabolite of toltrazuril Falcons/respiratory <i>Cryptosporidium baileyi</i>
Praziquantel (Droncit, Bayer)	— 1 mg/kg PO ³⁸ 5-10 mg/kg PO, repeat after 2-4 wk ^{38,149a,432b} 5-10 mg/kg PO, SC q24h × 14 days ^{333,358} 6 mg/kg PO, IM, repeat in 10-14 days ⁴⁸² 7.5 mg/kg PO ⁵²⁵	Most species/cestodes, trematodes; injectable form toxic in finches and associated with depression, death in some species ^{38,333} Bustards/well tolerated Psittacines, passerines, raptors Raptors/trematodes Cranes/cestodes, trematodes Ostriches

Continued

TABLE 5-4 Antiparasitic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Praziquantel (Droncit, Bayer) (cont'd)	7.5 mg/kg SC, IM repeat in 2-4 wk ^{135,148}	Most species, except finches
	9 mg/kg IM, repeat in 10 days ^{38,333}	Psittacines/cestodes
	10 mg/kg PO, SC, IM once; repeat in 7 days ²⁵⁶	Raptors/cestodes, trematodes
	10 mg/kg SC, IM q24h × 3 days, then PO × 11 days ^{358,808}	Psittacines, raptors/trematodes
	10 mg/kg IM q24h × 3 days, then PO q24h × 11 days ²⁸²	Toucans/trematodes
	10 mg/kg PO, SC, IM q24h × 14 days ¹⁵⁹	Toucans/trematodes; follow with 6 mg/kg PO q24h × 14 days ³³³
	10-20 mg/kg PO, repeat in 10-14 days ^{38,135,194,321}	Most species
	15-20 mg/kg PO, SC, IM, repeat in 2 wk as necessary ⁸³⁸	Penguins/user higher dose PO
	25 mg/kg PO, IM, repeat in 10-14 days ^{562,747}	Passerines, including Bali mynahs/cestodes
	30-50 mg/kg PO, SC, IM, repeat in 14 days ^{747,838}	Passerines, raptors/cestodes; use lower dose in passerines
	12 mg crushed and baked into 9" × 9" × 2" cake ³³³	Finches/withhold regular feed
Primaquine ^a	—	Pigeons, raptors, game birds, penguins ^a /hematozoa (i.e., <i>Plasmodium</i> , <i>Haemoproteus</i> , <i>Leucocytozoon</i>); use in conjunction with chloroquine; dosage based on amount of active base rather than total tablet weight
	0.3 mg/kg PO (at 24 hr following the initial chloroquine dose) q24h × 7 days ³³³	Raptors/use with chloroquine (10 mg/kg at 0 hr, then 5 mg/kg at 6, 24, 48 hr)
	0.3 mg/kg PO q24h × 10 days ^{295,838}	Penguins ^a / <i>Plasmodium</i> ; use with chloroquine (10 mg/kg at 0 hr, then 5 mg/kg at 6, 18, 24 hr)
	0.3-1 mg/kg PO q24h × 3-10 days ¹⁹⁴	Most species/ <i>Atoxoplasma</i> , <i>Sarcocystis</i> ; use with chloroquine
	0.75 mg/kg PO q3-7days ²⁹⁵	African and Humboldt penguins ^a /during vector season, depending on institution
	0.75 mg/kg PO q24h × 5 days ⁷⁹¹	Falcons/ <i>Haemoproteus tinnunculi</i>
	0.75-1 mg/kg PO once ⁷⁵⁰	Raptors/ <i>Plasmodium</i> ; use with chloroquine (25 mg/kg at 0 hr, then 15 mg/kg at 12, 24, and 48 hr); palliative therapy
	1 mg/kg PO on day 2, then q24h × 3 days ¹⁰⁶	Magellanic penguins ^a / <i>Plasmodium</i> , use with chloroquine (10 mg/kg at 0, 6, 12, 18, 24 hr on day 1, then 5 mg/kg q24h × 3 days)

TABLE 5-4 Antiparasitic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Primaquine ^a (cont'd)	1 mg/kg PO q7d ⁶⁵⁵	Most species/use with chloroquine (10 mg/kg q7d) as a preventive regimen for birds recovering from <i>Plasmodium</i> infection
	1 mg/kg PO q24h × 2 days, repeat q7d × 3-5 treatments to prevent relapse ⁶⁵⁵	Raptors/ <i>Plasmodium</i> ; use with chloroquine (20 mg/kg IV initially, followed by 10 mg/kg PO at 6, 18, 24 hr)
	1 mg/kg at 0, 24 hr then q24h × 10-14 days ^{295,851}	African penguins, ^a raptors/upon diagnosis of <i>Plasmodium</i> , administer with mefloquine 30 mg/kg PO at 0, 12, 24, 48 hr
	1 mg/kg PO q24h × 45 days ⁸⁴⁵	Psittacines (keas)/ <i>Sarcocystis</i> ; use in combination with amprolium, enrofloxacin, and pyrimethamine
	1.25 mg/kg PO q24h × 10-14 days ⁵⁹⁸	Medium sized (3-5 kg) penguins ^a / upon diagnosis with <i>Plasmodium</i> with chloroquine 10 mg/kg PO q24h × 10-14 days; then 5 mg/kg PO q12h × 3 days; some institutions stop here, others continue primaquine and chloroquine 5 mg/kg PO q24h
	1.25 mg/kg PO q24h (March until October, Northern hemisphere) ^{295,838}	African and Humboldt penguins ^a / prophylactic therapy against <i>Plasmodium</i>
	3.75 mg/kg PO q3-7days (March until October; Northern hemisphere) ²⁹⁵	African and Humboldt penguins ^a / prophylactic therapy against <i>Plasmodium</i>
	4 mg PO q48h ⁸³⁸	Medium sized (3-5 kg) penguins ^a / during vector season (or year round, depending on location of institution) in capsule with sulfadiazine 125 mg and folic acid 0.4 mg
Pyrantel pamoate	—	Intestinal nematodes; poorly absorbed, so increased safety margin ¹⁹⁴
	4.5 mg/kg PO, repeat in 10-14 days ^{38,482,856}	Cranes, psittacines, including cockatoo chicks ⁸⁵⁶
	5-7 mg/kg PO ⁸⁰⁶	Ostriches
	7 mg/kg PO, repeat in 14 days ¹⁴⁴	Most species
	7-20 mg/kg PO, repeat in 14 days ³⁵⁸	Raptors
	7-25 mg/kg PO once ¹⁹⁴	Nematodes
	20 mg/kg PO once ^{38,149a,432b}	Raptors
	20-25 mg/kg PO ³²¹	Pigeons
70 mg/kg PO once ¹⁵⁹	Ramphastids (toucans)/repeat if necessary	
148 mg/L drinking water ³³³	Psittacines, pigeons/medication floats	

Continued

TABLE 5-4 Antiparasitic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Pyrethrins (0.15%) (Adams, Pfizer)	Dust plumage lightly to moderately prn ^{194,333,482}	Most species, including psittacines, pigeons/ectoparasites
Pyrimethamine	— 0.25-0.5 mg/kg PO q12h ^{432b} 0.25-0.5 mg/kg PO q12h × 30 days ^{38,149a} 0.5 mg/kg PO q12h × 14-28 days ^{135,194} 0.5 mg/kg PO q12h × 45 days ⁸⁴⁵ 0.5-1 mg/kg PO q12h × 2-4 days, then 0.25 mg/kg PO q12h × 30 days ³³³ 0.5-1 mg/kg PO q12h × 30 days ⁵⁸⁰ 100 mg/kg feed ³³³	<i>Toxoplasma, Atoxoplasma, Sarcocystis</i> ; may be effective for <i>Leucocytozoon</i> ; supplement with folic or folinic acid Raptors Raptors/ <i>Sarcocystis, Toxoplasma</i> Most species/use for 28 days for <i>Leucocytozoon</i> in raptors Psittacines (keas)/ <i>Sarcocystis</i> ; use in combination with amprolium and primaquine Companion birds/ <i>Sarcocystis</i> ; use in combination with trimethoprim-sulfa 5 mg/kg IM q12h or 30-100 mg/kg PO q12h × 7 days Eclectus, Amazon parrots/use with trimethoprim-sulfadiazine (30 mg/kg) Most species
Quinacrine HCl ^a (Atabrine, Sanofi)	— 5-10 mg/kg PO, IM q24h ^{432b} 5-10 mg/kg PO q24h × 7-10 days ^{38,194,382} 7.5 mg/kg PO q24h × 10 days ^{38,333} 26-79 mg/L drinking water × 10-21 days ^{38,321}	Most species/ <i>Atoxoplasma, Plasmodium</i> ; chloroquine and primaquine are preferred; overdosage may cause hepatotoxicity Raptors/ <i>Plasmodium</i> Most species/use higher doses for <i>Lankesterella, Plasmodium</i> Most species/ <i>Atoxoplasma</i> Pigeons
Rafoxanide (Flukex, Univet; Ranide, MSD)	10 mg/kg PO ¹⁹⁴	Raptors/trematodes, cestodes; not available in the United States
Resorantel (Terenol-S, Intervet)	130 mg/kg PO ^{149b,333}	Ostriches/highly effective against <i>H. struthionis</i> when administered with or without fenbendazole
Ronidazole (Ronivet-S, Vetafarm)	— 2.5 mg/kg PO × 6 days ³²¹ 6-10 mg/kg PO q24h × 6-10 days ³³³ 10-20 mg/kg PO q24h × 7 days ¹³⁵ 12.5 mg/kg PO q24h × 6 days ³⁸ 50-400 mg/L drinking water × 5 days ¹³⁵ 60 mg/L drinking water ²²⁸	Antiprotozoal used against trichomoniasis; toxicity documented with overdose in drinking water in society finches ⁸⁶¹ Pigeons Most species Pigeons Pigeons Passerines Finches/ <i>Cochlosoma</i>

TABLE 5-4 Antiparasitic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Ronidazole (Ronivet-S, Vetafarm) (cont'd)	<p>100-200 mg/L drinking water × 7 days³³³</p> <p>100-600 mg/L drinking water × 3-5 days³²¹</p> <p>400 mg/L drinking water × 5-7 days (Bailey, 2016)²⁰¹</p> <p>600 mg/L drinking water × 5-7 days³⁸</p> <p>1000 mg/L drinking water q24h¹³⁵</p> <p>400 mg/kg soft feed²⁰¹</p>	<p>Cockatiels, pigeons/higher dosage required for resistant strains in pigeons</p> <p>Pigeons</p> <p>Canaries, pigeons/flock treatment; <i>Trichomonas</i>; preventive dose³⁸</p> <p>Pigeons/<i>Trichomonas</i>; flock treatment</p> <p>Pigeons/equivalent to 12.5 mg/kg/day</p> <p>Canaries</p>
Selamectin (Revolution, Zoetis)	<p>—</p> <p>23 mg/kg topically, repeat in 3-4 wk⁸³</p> <p>23 mg/kg topically q7d × 4 treatments⁶⁹⁴</p>	<p>No adverse effects, including neurologic signs, were seen in healthy zebra finches with doses up to 92 mg/kg⁸⁴</p> <p>Budgerigars/<i>Knemidokoptes</i> improvement in 13/14 birds at 4 wk, with no neurologic signs identified but monitor for weight loss</p> <p>Golden eagle/treatment for <i>Micnemidocoptes</i> spp.; no evidence of toxicity at this dosage</p>
Sulfachlorpyrazine (ESB3, Novartis)	<p>—</p> <p>1 g of 30% powder/L drinking water × 5 days, off 3 days, on 5 days, then repeat cycle × 4 treatments; administer treatment 3 × annually⁵⁶²</p>	<p>Coccidiostat; affects the intestinal stages of <i>Atoxoplasma</i>,²⁰¹ not available in the United States, but can be obtained through the Bali mynah Species Survival Plan⁵⁶²</p> <p>Bali mynahs/<i>Atoxoplasma</i>; significantly reduced or totally cleared oocyst shedding for extended time; it is uncertain if the drug is safe to use when parents are feeding chicks; supplement with vitamin B₆</p>
Sulfachlorpyridazine (Vetisulid, Boehringer-Ingelheim)	<p>—</p> <p>100-400 mg/L drinking water × 3-5 days/wk; repeat¹⁹⁴</p> <p>150-300 mg/L drinking water;²⁰¹ 5 days/wk × 2-3 wk¹⁷¹</p> <p>300 mg/L drinking water × 5 days, off 3 days, on 5 days, then repeat cycle × 4 treatments; administer treatment 3 × annually^{562,747}</p>	<p>Coccidiostat; used as replacement for sulfachlorpyrazine in the United States; contraindicated with dehydration, liver disease, renal disease;¹⁹⁴ treatment >2 wk may require folic acid supplementation¹⁹⁴</p> <p>Passerines/repeat after 5 days to allow for prepatent period of coccidia</p> <p>Passerines, including canaries/may need to treat for months for systemic coccidiosis</p> <p>Passerines, including Bali mynahs/<i>Atoxoplasma</i></p>

Continued

TABLE 5-4 Antiparasitic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Sulfachlorpyridazine (Vetisulid, Boehringer- Ingelheim) (cont'd)	300 mg/L drinking water × 7-10 days ³²¹	Pigeons
	300-1000 mg/L drinking water × 3 days, off 2 days, then repeat course ¹³⁵	Pigeons
	400 mg/L drinking water × 30 days ³³³	Cockatiels, budgerigars/mixture is stable for up to 5 days if refrigerated; change daily; mix well
	400-500 mg/L drinking water × 5 days, off 2 days, on 5 days ³³³	Most species
Sulfadimethoxine (12.5%)	20 mg/kg PO q12h ³³³	Most species/treatment and prophylaxis of coccidian; contraindicated with dehydration, liver disease, renal disease; ¹⁹⁴ treatment >2 wk may require folic acid supplementation ¹⁹⁴
	20-50 mg/kg PO q12h × 3-5 days/wk; repeat treatment ¹⁹⁴	Passerines/repeat after 5 days to allow for prepatent period of coccidia ¹⁹⁴
	25 mg/kg PO q12h × 5 days ³²¹	Most species
	25-50 mg/kg PO q24h × 3 days ³³³	Raptors
	25-50 mg/kg PO q24h × 3 days, off 2 days, then q24h × 3 days ³⁵⁸	Raptors
	25-55 mg/kg PO q24h × 3-7 days ⁶⁵²	Raptors/ <i>Eimeria</i> , <i>Sarcocystis</i>
	50 mg/kg PO once, then 25 mg/kg PO q24h × 7-10 days ³⁵⁸	Raptors
	50 mg/kg PO q24h × 5 days, off 3 days, on 5 days ⁸⁰⁸	Psittacines
	50 mg/kg PO q24h × 14 days ⁴⁸²	Cranes/coccidiosis
	250 mg/kg IM q24h × 3 days, off 2 days, on 3 days ¹⁰⁵	Pigeons/PK, PD; close to toxic level
	250-500 mg/L drinking water × 5-7 days/week; repeat treatment ¹⁹⁴	Passerines/repeat after 5 days to allow for coccidial prepatent period ¹⁹⁴
	330-400 mg/L drinking water × 1 day then 200 mg/L × 4 days ³²¹	Pigeons/supplement with vitamin B for 5 days
Sulfadimidine sodium (33.3%)	—	Contraindicated with dehydration, liver disease, renal disease; ¹⁹⁴ treatment >2 wk may require folic acid supplementation ¹⁹⁴
	40-50 mg/kg PO q24h × 7 days or 3 days on, 2 days off ¹³⁵	Pigeons
	50-150 mg/kg PO, IM q12h × 3-5 days/wk; repeat treatment ¹⁹⁴	Passerines/repeat after 5 days to allow for coccidial prepatent period ¹⁹⁴
	50-150 mg/kg PO, IM q24h × 5-7 days ³³³	Raptors/coccidia; lack of efficacy reported in merlins ³³³
	3300-6600 mg/L drinking water × 5 days ¹⁹⁴	Passerines/repeat after 5 days to allow for coccidial prepatent period ¹⁹⁴
	3330-6660 mg/L drinking water × 3-5 days on, 2 days off repeated twice ³⁸	Pigeons/coccidia; may be effective against <i>Toxoplasma</i>

TABLE 5-4 Antiparasitic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Sulfamethazine (Sulmet, Boehringer-Ingelheim)	— 50-65 mg/pigeon PO × 3 days, off 2-3 days, repeat × 2-3 days ⁴²⁶ 50-65 mg/pigeon PO × 5 days ^{321,426} 75 mg/kg PO q24h × 3 days, off 2 days, on 3 days ³³³ 75-185 mg/kg PO q24h × 3 days ¹⁹⁴ 125 mg/L drinking water × 3 days, off 2 days, on 3 days ³³³ 400 mg/L drinking water once, then 200-270 mg/L × 4 days ³²¹	See sulfonamides; coccidiostat; contraindicated with dehydration, liver disease, renal disease; ¹⁹⁴ treatment >2 wk may require folic acid supplementation ¹⁹⁴ Pigeons Pigeons/supplement vitamin B for 5 days ³²¹ Parakeets Passerines/repeat after 5 days to allow for prepatent period ¹⁹⁴ Most species Pigeons
Sulfaquinoxaline (Sulquin 6-50, Zoetis)	— 100 mg/kg PO q24h × 3 days, off 2 days, on 3 days ^{194,333} 250 mg/L drinking water × 5-7 days ¹⁹⁴ 500 mg/L (1.8 mL/L) drinking water × 6 days, off 2 days, on 6 days ⁶⁸⁶	Sulfonamide used for prevention and treatment of coccidiosis; contraindicated with dehydration, liver disease, renal disease; ¹⁹⁴ treatment >2 wk may require folic acid supplementation ¹⁹⁴ Lories, pigeons, passerines Passerines/repeat after 5 days to allow for prepatent period of coccidia Pigeons
Sulfonamides	—	Competitively inhibit para-aminobenzoic acid, required by schizonts for folic acid synthesis; ⁴²⁶ contraindicated with dehydration, liver disease, or bone marrow suppression; gastrointestinal upset, regurgitation are common, especially in macaws; use for longer than 2 wk may require vitamin B (folic acid) supplementation
Tetracycline (T)/ furaltadone (F)	400 mg (T) + 400 mg (F)/L drinking water for 7 days	Pigeons/indicated for trichomoniasis, hexamitiasis; avoid in adults feeding young less than 10 days of age
Thiabendazole	— 40-100 mg/kg PO q24h × 7 days ^{38,194,333}	Most species/nematodes (especially <i>Syngamus trachea</i>), acanthocephalans; generally less efficacious than fenbendazole; may be toxic to cranes and ratites ³⁸ Most species

Continued

TABLE 5-4 Antiparasitic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Thiabendazole (cont'd)	50 mg/kg PO, repeat in 14 days ³³³ 100 mg/kg PO once, repeat in 10-14 days ^{38,333,482} 100 mg/kg PO q24h × 7-10 days ³³³ 100-200 mg/kg PO q12h × 10 days ^{149a} 100-500 mg/kg PO once ^{38,194,333} 250-500 mg/kg PO, repeat in 10-14 days ^{38,808} 425 mg/kg feed × 14 days ¹²⁰	Ostriches Raptors, cranes/intestinal strongyles, ascarids Most species/gapeworms, ascarids Raptors/nematodes; may interfere with egg laying Most species Most species, including psittacines/ascarids Cranes
Toltrazuril (Baycox, Bayer)	— 7 mg/kg PO q24h × 2-3 days ^{350,384} 7-15 mg/kg q24h × 3 days ¹⁹⁴ 10 mg/kg PO q24h × 2 days ⁶⁵² 10 mg/kg PO q48h × 3 treatments ³⁸ 12.5 mg/kg PO q24h × 14 days ^{562,747} 12.5 mg/kg PO q24h × 2 days, off 5 days, repeat prn ³⁶⁸ 12.5 mg/kg PO q24h × 2 days in hand-feeding, then 45 mg/L drinking water × 2 days, repeat prn ⁵⁰⁹ 15-25 mg/kg PO q24h × 2 days ^{38,432b} 15-25 mg/kg PO q48h × 3 treatments ^{432b} 20-35 mg/kg PO once ^{194,827a}	Coccidiocidal; ⁴²⁶ efficacious for refractory coccidiosis; has been successful in reducing mortality from <i>Atoxoplasma</i> in canaries and other passerines and may affect systemic stages of the disease; ⁵⁶² not very effective against <i>Atoxoplasma</i> when given in water; bitter taste, mixing with soft drink (i.e., cola) increases palatability; ³⁸ 2.5% solution is very alkaline and should not be gavaged directly into the crop ⁴²⁶ Budgerigars, raptors Passerines/ <i>Atoxoplasmosis</i> Raptors/preferred treatment for <i>Caryospora</i> Raptors/treatment of choice for coccidiosis in falcons Passerines including Bali mynahs/ <i>Atoxoplasma</i> ; dosage is based on a limited number of clinical cases Blue-crowned laughing thrush/PD; reduced clinical signs and all intestinal stages of <i>Isospora</i> spp. within 7 days, white blood cell effects within 3 mo Cirl buntings/PD; reduced intestinal stages of <i>Isospora</i> spp., 72/75 affected birds released Raptors Raptors Pigeons/higher dose prevents shedding up to 4 wk; lower dose is minimum dose required to suppress oocyst shedding

TABLE 5-4 Antiparasitic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Toltrazuril (Baycox, Bayer) (cont'd)	25 mg/kg q24h × 2 days ⁴⁸⁶	Pigeons/PD; not effective against <i>S. chalchasi</i> when administered on day 0, 10, or 40 postinoculation
	25 mg/kg PO q7d × 3 treatments ^{135,256}	Raptors/ <i>Caryospora</i> , coccidiosis
	2 mg/L drinking water × 2 consecutive days/wk ¹⁴⁸	Psittacines
	5 mg/L drinking water × 2 days, repeat in 14-21 days ¹⁶³	Lories/10 mg/L administered during second course of treatment
	20 mg/kg in drinking water × 2 days ⁴²⁶	Pigeons
	25 mg/L drinking water × 2 days, repeat in 14-21 days ⁴⁶³	Cockatiels, passerines, including goldfinches, manikins, siskins/coccidia
	25-75 mg/L drinking water × 5 days ¹⁹⁴	Canaries/ <i>Atoxoplasma</i> spp.
	75 mg/L drinking water × 2 days/wk × 4 wk ¹⁷¹	Passerines
	75 mg/L drinking water × 5 days ³²³ 125 mg/L drinking water × 5 days ³⁸	Pigeons Pigeons
Trimethoprim/sulfadiazine	—	See sulfonamides
	5 mg/kg IM q12h ³³³	Companion birds/ <i>Sarcocystis</i> ; use in conjunction with pyrimethamine (0.5-1 mg/kg PO q12h × 2 days, then 0.25 mg/kg PO q12h × 30 days)
	30 mg/kg PO q8-12h ^{78,358}	Most species, including psittacines, raptors/ <i>Sarcocystis</i> (treat for at least 6 wk); coccidia
	30-100 mg/kg PO q12h × 7 days ³³³	Companion birds/ <i>Sarcocystis</i> ; use in conjunction with pyrimethamine (0.5-1 mg/kg PO q12h × 2 days, then 0.25 mg/kg PO q12h × 30 days)
	60 mg/kg PO, SC q12h × 3 days, off 2 days, on 3 days ³⁸	Raptors/coccidia
80 mg (trimethoprim) + 40 mg (sulfadiazine)/mL drinking water ⁸⁵⁴	Canaries/ <i>Toxoplasma gondii</i>	
Trimethoprim/sulfamethoxazole	10-50 mg/kg q24h ⁷⁴⁷	Passerines
	16-24 mg/kg (based on trimethoprim) PO q12-24h ⁴⁸²	Cranes/coccidiosis
	25 mg/kg PO q24h ³³³	Toucans, mynahs/coccidia
	30 mg/kg PO q12-24h ¹³⁵ 480 mg/L drinking water q24h ¹³⁵	Passerines/antiprotozoal Pigeons/antiprotozoal

^aBecause adult penguins regurgitate food to chicks, usage of these regimens must be considered carefully during chick rearing.

TABLE 5-5 Chemical Restraint/Anesthetic/Analgesic Agents Used in Birds.^{a,b}

Agent	Dosage	Species/Comments
Acepromazine	— 0.1-0.2 mg/kg IV ³³³ 0.25-0.5 mg/kg IM ³³³	Phenothiazine tranquilizer; see etorphine and ketamine for combinations Ratites/most commonly used in combination with other anesthetics; rarely used in other bird species
Alfaxalone (Alfaxan, Jurox)	— 2 mg/kg IV ⁸³¹ 10 mg/kg IM ³⁴⁷ 25 mg/kg IM ³⁴⁷ 20 mg/kg IM ⁵⁷⁹	Not to be confused with dosing information for alfaxalone/alfadalone (Saffan, Schering-Plough); this is a completely new formulation, so doses cannot be extrapolated from older literature using alfaxalone/alfadalone; see dexmedetomidine for combination Flamingos/induction; induction significantly shorter and quality smoother than with isoflurane alone; decreased isoflurane maintenance requirements but produced moderate cardiorespiratory effects not seen in isoflurane-only group; recovery times similar with both groups, without significant differences in quality or length Quaker parrots/lower dose significantly longer induction time (13.5 ± 4.5 min) compared to higher dose (6.0 ± 1.3 min), while recovery time significantly longer in the high-dose group (86.2 ± 13.4 min) than the low-dose group (44.4 ± 10.8 min); muscle tremors and hyperexcitation evident in both groups Yellow legged gulls/loss of righting reflex only achieved in 1/6 birds after 20 min; could not intubate; some birds manifested adverse effects like muscle twitches, wing and tail flapping, and opisthotonus
Alfaxalone (A)/fentanyl (F)	(A) 20 mg/kg + (F) 20 μ g/kg IM ⁵⁷⁹	Yellow legged gulls/loss of righting reflex only achieved in 2/6 birds after 12.5 min; could not intubate; significant reduction in respiratory rate; some birds manifested adverse effects like muscle twitches, wing and tail flapping, and opisthotonus
Alfaxalone (A)/fentanyl (F)/midazolam (Mi)	(A) 20 mg/kg + (F) 20 μ g/kg + (Mi) 1 mg/kg IM ⁵⁷⁹	Yellow legged gulls/loss of righting reflex achieved in 6/6 birds after 20 min; could not intubate; significant heart rate and respiratory rate reduction; a number of birds manifested adverse effects like muscle twitches, wings and tail flapping, and opisthotonus

TABLE 5-5 Chemical Restraint/Anesthetic/Analgesic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Alfaxalone (A)/ midazolam (Mi)	(A) 10 mg/kg + (Mi) 1 mg/kg IM ⁸⁴⁷ (A) 20 mg/kg + (Mi) 1 mg/kg IM ⁵⁷⁹	Quaker parrots/lower induction time than same dose (A) alone (6.5 ± 2.9 min) but significantly longer recovery time (103.5 ± 15.1 min); reduced muscle tremors and hyperexcitability Yellow legged gulls/loss of righting reflex in 5/6 birds after 8 min; a number of birds manifested adverse effects like muscle twitches, wings and tail flapping, and opisthotonus
Alphachloralose (Fisher Scientific)	— 250-430 mg/cup of bait ³³³	Chloral derivative of glucose which depresses cortical centers of the brain; induces hypothermia; low therapeutic index in chickens suggests only marginally safe in domestic species or for field applications where dosage difficult to control ³³³ Cranes, American crows/immobilization; 160-210 mg/4.5 kg sandhill crane; cranes could generally be approached within 1-2 hr of feeding and releasable 8-22 hr later
Atipamezole (Antisedan, Zoetis)	— 2.5-5 \times medetomidine dose IM, IV ^{711,713} 0.25-0.5 mg/kg IM ^{333,355,618,711,713} 0.4 mg/kg $\frac{1}{2}$ IV, $\frac{1}{2}$ SC ⁴³⁵ 6 mg/kg intranasally ⁸²⁹	α_2 -adrenergic antagonist; 1:1 volume reversal of dexmedetomidine is general rule; although the same effect is expected as with medetomidine (no longer available) ⁷⁹⁹ Psittacines, pigeons, raptors/righting reflex regained 2-10 min after administration Most species, including psittacines, pigeons Ostriches Ring-necked parakeets/dose divided evenly between nares and given slowly; significantly reduced recumbency time after detomidine administration
Atropine sulfate	— 0.01-0.02 mg/kg SC, IM, IV ³³³ 0.04-0.1 mg/kg SC, IM, IV, IO, intratracheal ³³³	Anticholinergic agent Most species/preanesthetic Most species/bradycardia; higher doses with CPR
Azaperone (Stresnil, Elanco)	— 0.73 mg/kg IM ⁸⁰⁶ 1-4 mg/kg IM, IV ³³³	Butyrophenone neuroleptic agent; see metomidate for combination; not available in the United States Ratites/sedation Ostriches/premedication, sedation
Benzocaine	Topical anesthesia ³³³	Small birds/minor wound repair

Continued

TABLE 5-5 Chemical Restraint/Anesthetic/Analgesic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Bupivacaine HCl	— 2 mg/kg infused SC ³³³	Local anesthetic agent; 4-6 hr duration of action in mammals; may be shorter acting in some birds; recommend minimizing dose to limit potential toxic effects; see bupivacaine combination ³³³
Buprenorphine HCl	— 0.1 mg/kg IM ⁵⁸⁸ 0.1-0.6 mg/kg IM ^{128,300} 0.25 mg/kg IM q7h ⁵⁸⁹ 0.25 mg/kg IM ⁵⁰⁵ 0.25-0.5 mg/kg IM ²⁷⁰	Partial μ -opioid agonist ^c African grey parrots/PD; ineffective for analgesia American kestrels/PK, PD; resulted in thermal antinociception for ≥ 6 hr African grey parrots/PD; dose required to reach human analgesic plasma concentrations; analgesic effect not evaluated at this dose Red-tailed hawks/PD; did not change any scored pain behaviors Pigeons/PD; dose-dependent increased withdrawal time from noxious stimulus for 2-5 hr
Buprenorphine (Simbadol, Zoetis)	0.3 mg/kg SC q24h ^{332b} 1.8 mg/kg SC q48h ^{332b}	Concentrated formulation; not to be confused with compounded sustained-release product, as dosing may differ Red-tailed hawks/PK; plasma concentrations of >1 ng/mL were maintained for these time periods
Buprenorphine sustained release (Bup-SR, ZooPharm)	1.8 mg/kg SC, IM q24h ⁷⁰⁹	Compounded sustained-release product; not to be confused with concentrated formulation, as dosing may differ American kestrels/PK, PD; thermal antinociceptive response for 12-24 hr
Butorphanol tartrate	— 0.05-0.25 mg/kg IV ⁸⁰⁶ 0.5 mg/kg IM, IV q1-4h ⁶⁶³ 0.5-4 mg/kg IM, IV q1-4h ^{162,270,410,588,663,707,746}	Opioid agonist-antagonist; ^c PO bioavailability $<10\%$ in Hispaniolan Amazon parrots; PO route not recommended; ⁷⁰⁷ butorphanol combination follows; see dexmedetomidine, ketamine, and xylazine for combinations Ratites Raptors/PK: $t_{1/2}$ IM, IV very short (approx. 1-2 hr); more rapid clearance and shorter $t_{1/2}$ when given IV medial metatarsal vein than IV median ulnar vein Most species, including psittacines/no isoflurane-sparing effects detected in harlequin ducks when administered IM 15 min prior to induction ⁵³³

TABLE 5-5 Chemical Restraint/Anesthetic/Analgesic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Butorphanol tartrate (cont'd)	1-2 mg/kg IM ^{161,162}	African grey parrots, cockatoos, blue-fronted Amazon parrots/PD; significantly reduced ED ₅₀ of isoflurane for African greys and cockatoos but not for Amazon parrots; African grey parrots had more significant reduction of withdrawal response to electrical stimulus at 2 mg/kg
	1-6 mg/kg IM ^{303a}	American kestrels/PD; did not cause thermal antinociception suggestive of analgesia; sex-dependent responses were identified
	2-5 mg/kg IM, IV q2-3h ^{410,707,746}	Hispaniolan Amazon parrots/PK; low mean plasma concentrations at 2 hr postinjection; PD: withdrawal from electrical stimuli reduced after 2 mg/kg IM; effective pre-emptive analgesia with sevoflurane anesthesia for endoscopy ⁴¹⁰
	3 mg/kg (premedication) + 75 µg/kg/min IV CRI (maintenance) ⁴⁵³ 3-6 mg/kg IM ⁵⁸⁸	Psittacines/PD; significantly reduced isoflurane MAC Hispaniolan Amazon parrots/PD; electrical stimuli to assess withdrawal thresholds
Butorphanol (B)/midazolam (Mi)	(B) 1 mg/kg IM + (Mi) 0.5 mg/kg IM ⁴²⁹	Psittacines/induction time and isoflurane concentration were reduced in the B + Mi group; induction quality scores were improved in the B + Mi group and no adverse effects on anesthesia and cardiovascular stability were observed
Carfentanil (Wildnil, Wildlife Pharmaceuticals)	—	Super-potent opioid agonist; ^c carfentanil combination follows; not generally recommended for use in birds; no longer commercially available in the United States
	0.024 mg/kg IM ³³³	Ostriches (free-ranging)/darted from helicopter
	0.03 mg/kg IM ³³³	Ratites
Carfentanil (C)/xylazine (X)	(C) 3 mg + (X) 150 mg IM per ostrich ⁵³⁰	Ostriches (free-ranging)/darted from helicopter
Desflurane (Suprane, Baxter)	—	Fluorine halogenated ether; fast induction, rapid recovery; ³³⁷ currently no studies evaluating its use in any avian species
Detomidine (Dormosedan, Zoetis)	—	α ₂ -adrenergic agonist
	12 mg/kg intranasally ⁹²⁹	Ring-necked parakeets/dose divided into each nare and given slowly; sedation <3 min but did not allow dorsal recumbency or manipulation; reversal with atipamezole significantly reduced time to recovery

Continued

TABLE 5-5

Chemical Restraint/Anesthetic/Analgesic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Detomidine (Dormosedan, Zoetis) (cont'd)	12-15 mg intranasally ⁸³⁰	Canaries/dose divided into each nare and given slowly; higher dose prolonged sedation but could not place in dorsal recumbency; prolonged duration of effect (257.5 ± 1.5 min); completely reversed with yohimbine intranasally
Dexmedetomidine HCl (Dexdomitor, Zoetis)	— 25 µg/kg IM ⁷¹³ 75 µg/kg IM ⁷¹³	α ₂ agonist; active optical enantiomer of racemic compound medetomidine; ½ the dose of medetomidine but same volume due to concentration has been used as a general guideline; ^d although the same effects would be expected as with medetomidine (not commercially available, but can be compounded); limited data on the efficacy and safety of dexmedetomidine in birds to date; dexmedetomidine combinations follow Common buzzards/adequate restraint to prevent reaction to handling but did not allow for intubation; loss of righting reflex = 3.5 ± 1 min; no arrhythmias, excitement, or major adverse effects noted; complete reversal with atipamezole Common kestrels/adequate restraint to prevent reaction to handling but did not allow for intubation; loss of righting reflex = 7 ± 1.2 min; no arrhythmias, excitement, or major adverse effects noted; complete reversal with atipamezole
Dexmedetomidine (D)/alfaxalone (A)	(D) 0.4 mg/kg + (A) 20 mg/kg IM ⁸⁷²	Domestic doves/time to loss of consciousness = 102 ± 48 sec, loss of righting reflex = 240 ± 135 sec; 2 birds could not undergo endoscopic procedure; 1 bird died due to prolonged recovery; significant variability in heart rate and respiratory rate; not recommended at these doses for minimally invasive procedures
Dexmedetomidine (D)/midazolam (Mi)	(D) 80 µg/kg + (Mi) 5 mg/kg intranasally ³⁵⁵	Pigeons/PD; effective immobilization 20 to 30 min after intranasal administration; birds tolerated postural changes without resistance; significant decreases in heart rate and respiratory rate that persisted until the end of sedation; atipamezole antagonized sedation and cardiorespiratory side effects within 10 min
Dexmedetomidine (D)/ketamine (K)/butorphanol (B)	(D) 0.4 mg/kg + (K) 40 mg/kg + (B) 1 mg/kg IM ⁸⁷²	Domestic doves/mean time to loss of consciousness and loss of righting reflex was 79.6 ± 44.4 sec and 162.6 ± 102.3 sec, respectively; all birds experienced a prolonged recovery period (>1 hr); significant variability in heart rate and respiratory rate; not recommended at these doses for minimally invasive procedures

TABLE 5-5 Chemical Restraint/Anesthetic/Analgesic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Dexmedetomidine (D)/ thiafentanil oxalate (Th)/ tiletamine-zolazepam (Tz)	— (D) 0.2 mg +(Th) 7 mg +(Tz) 100 mg IM per bird ⁷⁹⁸	Ultra-short-acting opioid agonist (Th) not currently available in the United States; α_2 agonist (D); dissociative anesthetic (Tz) Greater rheas/anesthesia administered via remote injection; smooth induction/recovery; respiratory depression in 1/8 birds but recovered with reversal
Diazepam	— 0.05-0.5 mg/kg IV ³³³ 0.1-0.3 mg/kg IV ^{333,375} 0.2-0.5 mg/kg IM ¹⁹⁵ 0.25-0.5 mg/kg IM, IV q24h \times 2-3 days ⁷⁷⁹ 0.5 mg/kg PO ³³³ 0.5-1 mg/kg IM, IV q8-12h ³⁸ 0.8 mg/kg intranasally ²⁵ 1-2 mg/kg IV ³³³ 2.5-4 mg/kg PO ³³³ 5 mg/kg PO ³³³ 5 mg/kg IV ^{262,333} 6 mg/kg IM ⁸¹² 10 mg/kg IM ⁶²³	Benzodiazepine; used alone for sedation, seizure control, tranquilization, and/or appetite stimulation; IM administration may cause severe muscle irritation and absorption may be delayed; reversal with flumazenil; see ketamine for combinations Most species Ratites/tranquilization; smooth anesthetic recovery Most species/premedication; onset in 15-20 min Raptors/appetite stimulant Passerines/calms fractious species while improving acceptance to a novel captive diet; oral solution (1 mg/mL, Roxane Laboratories) works best Raptors/sedation; anticonvulsant Ostriches (juvenile)/slower onset (4.3 ± 0.4 min) than midazolam (2.9 ± 1.2 min); moderate sedation was achieved for standing chemical restraint, with the maximum duration effect of 9.2 ± 2.5 min Ostriches/administer just prior to recovery from tiletamine/zolazepam to counter its undesirable effects Most species/sedation Ostriches/standing sedation Emus, rheas/sedation Rock partridges/decrease in cloacal temperature; prolonged recoveries (149 ± 8.3 min) Zebra finches/deep sedation, dorsal recumbency achieved in minutes and lasted for several hours; reversed completely with flumazenil

Continued

TABLE 5-5 Chemical Restraint/Anesthetic/Analgesic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Diazepam (cont'd)	12 mg/kg intranasally ⁸²⁹	Ring-necked parakeets/dose divided into each nare and given slowly; time to onset 3.5 ± 1.2 min, dorsal recumbency 11.0 ± 6.4 min; not sedate enough for any manipulation; flumazenil intranasally significantly reduced recumbency time
	12.5-15.6 mg/kg intranasally ⁸³⁰	Canaries/dose divided into each nare and given slowly; dorsal recumbency for approx. 35 min; flumazenil intranasally significantly reduced recumbency time
	13 ± 1 mg/kg intranasally ⁸⁰	Finches/onset of sedation significantly slower (1.8 ± 0.2 min) compared with midazolam (1.0 ± 0.3 min); longer duration of dorsal recumbency observed after diazepam (68 ± 12.7 min) than with midazolam (32.0 ± 8.1 min); diazepam produced significantly longer duration of sedation (182.0 ± 18.4) than midazolam (74.2 ± 8.7)
	13.6 ± 1.1 mg/kg intranasally ⁶⁹⁵	Budgerigars/onset of sedation significantly longer after diazepam (2.8 ± 0.88 min) than midazolam (1.3 ± 0.44 min); diazepam produced significantly longer duration of sedation (165.4 ± 19.2 min) than midazolam (71.6 ± 8.9 min); adequate sedation for diagnostic, minor therapeutic procedures
Diprenorphine	0.04-0.06 mg/kg IV ⁷⁰³	Ostriches/opioid antagonist
Dobutamine	—	β ₁ -adrenergic agonist, with weak β ₂ activity, and selective α ₁ activity; used to treat anesthetic-induced hypotension
	15 μg/kg/min IV ⁷¹⁸	Hispaniolan Amazon parrots/PD; significant increase in direct arterial pressure within 4-7 min
Dopamine HCl	—	Catecholamine neurotransmitter activating dopamine receptors; inotropic vasopressor used to treat anesthetic-induced hypotension
	7-10 μg/kg/min IV ⁷¹⁸	Hispaniolan Amazon parrots/PD; significant increase in direct arterial pressure within 4-7 min; greater effects on direct arterial pressures than dobutamine
Etorphine HCl (M-99, Wildlife Pharmaceuticals)	—	Super-potent opioid agonist; ^c may be inadequate when used as sole agent; ³⁷⁵ see etorphine combinations
	0.025 mg/kg IM ³³³	Ostriches
Etorphine (E)/ acepromazine (A)	(E) 0.04-0.07 mg/kg + (A) 0.19 mg/kg IM ⁷⁰³	Ostriches (10-12 mo of age)
	(E) 3.6 mg/bird + (A) 15 mg/bird IM ⁷⁰³	Ostriches

TABLE 5-5 Chemical Restraint/Anesthetic/Analgesic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Etorphine (E)/acepromazine (A)/xylazine (X)	(E) 0.04 mg/kg + (A) 0.16 mg/kg + (X) 0.66 mg/kg IM ⁷⁰³	Ostriches/sedation for simple procedures lasting 10-20 min
Etorphine (E)/ketamine (K)	(E) 6-12 mg/bird IM + (K) 200-300 mg/bird IM ³³³	Ostriches (adults)
Fentanyl citrate	— 20 µg bolus + 0.2-0.5 µg/kg/min IV CRI ^{332b,593} 20 µg bolus + 1.5-6 µg/kg/min IV CRI ^{332b} 0.02 mg/kg IM ³⁵¹ 0.2 mg/kg SC ³⁵¹	Short-acting µ-opioid agonist ^c Red-tailed hawks/PD; reduced isoflurane MAC 31%-55% in a dose-related manner, without significant effects on heart rate, blood pressure, pACO ₂ , or pAO ₂ Hispaniolan Amazon parrots/PK; PD; reduced isoflurane in a dose-related manner similar to red-tailed hawks but with much higher dosages; significant decreases in heart rate, indirect blood pressure; monitor closely Cockatoos/PK; PD; rapid absorption, elimination; no effect withdrawal to thermal, electrical stimulus Cockatoos/PK; PD; some analgesia; large dose and volume; hyperactivity first 15-30 min in some birds
Fentanyl (F)/midazolam (M)	(F) 30 µg bolus + (M) 1-2 mg/kg IM then (F) 30 µg/kg/h IV CRI + (M) 1 mg/kg/h IV CRI ⁵⁷⁸	Wild birds/partial IV anesthesia (PIVA) with isoflurane anesthesia for orthopedic surgery; recovery = 63.2 ± 24.0 min with excellent quality; no significant change in HR detected
Flumazenil	— 0.02-0.1 mg/kg IM, IV ^{6,333} 0.05 mg/kg intranasally ⁴⁹⁰ 0.13 mg/kg intranasally ⁸²⁹ 0.25-0.31 mg/kg intranasally ⁸³⁰ 0.3 mg/kg IM ⁶²³	Benzodiazepene antagonist Most species Hispaniolan Amazon parrots Ring-necked parakeets/dose divided evenly between nares and given slowly; significantly reduced recumbency time Canaries/dose divided evenly between nares and given slowly; significantly reduced recumbency time Zebra finches/smooth, complete recovery after deep sedation with diazepam
Gabapentin	— 3 mg/kg PO q24h ⁷⁴⁵ 10 mg/kg PO q12h ^{193,194}	GABA analogue; used to treat human neuropathic pain Senegal parrots/analgesia; used with fluoxetine so difficult to determine sole efficacy; bird appeared sedated 3 days after initiation of administration Little corella/long-term (>90 days) analgesia; sole analgesic for self-mutilation; no adverse effects noted

Continued

TABLE 5-5 Chemical Restraint/Anesthetic/Analgesic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Gabapentin (cont'd)	11 mg/kg PO q12h ⁷³⁴ 11 mg/kg PO q8h ⁸⁶⁴ 15 mg/kg PO q8h ⁴³	Prairie falcons/long-term (>90 days) analgesia; adjunct to multimodal therapy for self-mutilation; bird exhibited neurologic signs, diarrhea when dosed at 110 mg/kg, but no adverse effects at 82 mg/kg Great horned owls/PK; maintained plasma concentrations >2 µg/mL approx. 8 hr Hispaniolan Amazon parrots/PK; maintained plasma concentrations ≥ human analgesic concentration approx. 8 hr
Glycopyrrolate	— 0.01-0.02 mg/kg IM, IV ³³³ 0.04 mg/kg IV ⁸⁰⁶	Anticholinergic agent; slower onset than atropine Most species/preanesthetic; rarely indicated Ratites
Hydromorphone	0.1-0.6 mg/kg IM q3-6h ^{303b,304} 0.1, 0.3, and 0.6 mg/kg IM ⁷⁰⁸	American kestrels/PK; PD: doses of 0.1, 0.3, and 0.6 mg/kg IM significantly increased thermal foot withdrawal responses; appreciable sedation with 0.6 mg/kg Cockatiels/PD; doses did not significantly increase thermal foot withdrawal responses; 0.3 and 0.6 mg/kg produced mild sedation ⁷⁰⁸
Isoflurane	— 0.5%-4% (usually 1.5%-2%) ³³³ 1%-3% ⁷³² 1.115% ⁷⁴⁸ 1.3% ^{470,471} 1.46 ± 0.30% ¹³⁰	Inhalant anesthetic agent of choice in birds; dose-dependent hypotension with all inhalants; raptors, macaws may be more likely to exhibit isoflurane-induced arrhythmias; ³³³ no significant differences in ventilation or O ₂ transport between dorsal and lateral recumbency in red-tailed hawks ³³⁴ Ostriches/use following preanesthetic medication Cinereous vultures/dose-dependent increases in heart rate and ETCO ₂ and decreases in direct blood pressure and respiratory acidosis during spontaneous ventilation Emus/PD; minimum anesthetic concentration Cranes, ducks/minimum anesthetic concentration Crested serpent eagles/minimum anesthetic concentration; time-related increase in ETCO ₂ and decreases in body temperature and respiratory rates

TABLE 5-5 Chemical Restraint/Anesthetic/Analgesic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Isoflurane (cont'd)	<p>1.44 ± 0.07%¹⁶² 1.8 ± 0.4%⁹³</p> <p>2.05 ± 0.45%⁵⁹³</p> <p>3%-5%³³³</p> <p>3%-5% induction, 1.5%-2.5% maintenance³³³</p>	<p>Cockatoos/PD; ED₅₀</p> <p>Pigeons/PD; minimum anesthetic concentration; dose-dependent hypercapnia, hypotension, mild hypothermia and 2nd- and 3rd-degree atrioventricular blocks</p> <p>Red-tailed hawks/PD; minimum anesthetic concentration</p> <p>Ostriches/when used without preanesthetic medication</p> <p>Most species</p>
Ketamine HCl	<p>—</p> <p>5 mg/kg IV q10min prn³⁷⁵</p> <p>5-30 mg/kg IM, IV^{38,333}</p> <p>10-50 mg/kg SC, IM, IV^{195,333}</p> <p>25 mg/kg IM³³³</p> <p>50 mg/kg IO³⁹³</p> <p>50-100 mg/kg PO in bait^{33,76,149a}</p>	<p>Dissociative anesthetic; seldom used as sole agent because of poor muscle relaxation and prolonged (up to 3 hr), violent recovery; may produce excitation or convulsions in pigeons, gallinules, water rails, golden pheasants, Hartlaub's turacoos, ratites, and vultures;^{375,705} may fail to produce general anesthesia in some species including great horned owls, snowy owls, Cooper's hawks, sharp-shinned hawks; See dexmedetomidine and etorphine for combinations; ketamine combinations follow</p> <p>Ratites/maintenance</p> <p>Raptors/sedation</p> <p>Psittacines, pigeons, ratites, waterfowl/restraint 30-60 min; smaller species require a higher dose; large birds tend to recover more slowly</p> <p>Emus/may need to supplement 5-9 mg/kg IV q10min</p> <p>Pigeons/provided effective anesthesia</p> <p>Raptors/sedation to catch an escaped bird; place in a 30 g piece of meat</p>
Ketamine (K)/acepromazine (A)	(K) 10-25 mg/kg + (A) 0.5-1 mg/kg IM ⁸⁴⁶	Most species/high dose for birds <250 g
Ketamine (K)/diazepam (D)	<p>(K) 2-5 mg/kg IV + (D) 0.25 mg/kg IV³³³</p> <p>(K) 3-8 mg/kg + (D) 0.5-1 mg/kg IM³⁴⁰</p> <p>(K) 5-30 mg/kg + (D) 0.5-2 mg/kg IV³³³</p> <p>(K) 8-15 mg/kg + (D) 0.5-1 mg/kg IM³⁴⁰</p>	<p>Ostriches/ketamine may be given 15-30 min after diazepam</p> <p>Eagles, vultures</p> <p>Most species/psittacines and pigeons lower end of range is preferred</p> <p>Falcons</p>

Continued

TABLE 5-5 Chemical Restraint/Anesthetic/Analgesic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Ketamine (K)/diazepam (D) (cont'd)	(K) 10 mg/kg + (D) 0.2 mg/kg IM ³¹	Pigeons/rapid induction with an increase in anesthesia duration; good muscle relaxation and a smooth, slow recovery
	(K) 10 mg/kg + (D) 0.5 mg/kg IM ⁵⁸⁶	Amazon parrots/PD; significantly reduced sevoflurane MAC
	(K) 10-40 mg/kg IV + (D) 1-1.5 mg/kg IM, IV ⁶⁵³	Raptors, waterfowl/induction or surgical anesthesia (rapid bolus may produce apnea, arrhythmia, and increased risk of death)
	(K) 20-40 mg/kg IM + (D) 1-1.5 mg/kg IM ³³¹	Birds >250 g
	(K) 20 mg/kg + (D) 1 mg/kg IV ¹⁵⁹	Toucans/short procedures (15-20 min)
Ketamine (K)/butorphanol (B)/medetomidine (Me)	—	Medetomidine no longer available, but can be compounded; see dexmedetomidine
	(K) 3 mg/kg + (B) 1 mg/kg + (Me) 40 µg/kg IM ⁸⁶⁵	Psittacines/premedication or supplement to isoflurane; reduces isoflurane requirement and improves ventilation
	(K) 50 mg + (B) 50 µg + (Me) 50 µg IM per pigeon ²⁹	Pigeons/PD; satisfactory anesthesia in 7/8 pigeons; heart rate, respiratory rate decreased within 10 min following Me + B injection; arrhythmias in 3/8 pigeons; cloacal temperature decreased gradually during anesthesia
Ketamine (K)/medetomidine (Me)	—	Unreliable level of sedation in pigeons at (K) 5 mg/kg + (Me) 80 µg/kg IM; ⁶¹⁸ medetomidine not currently available, but can be compounded
	(K) 1.5-2 mg/kg + (Me) 60-85 µg/kg IM, IV ³³³	Pigeons/sedation
	(K) 2 mg/kg + (Me) 80 µg/kg IM ⁴³⁵	Ostriches/sedation
	(K) 2-4 mg/kg + (Me) 25-75 µg/kg IV ³⁶⁶	Raptors
	(K) 2.5-7 mg/kg + (Me) 50-100 µg/kg IV ³⁶⁷	Large psittacines
	(K) 3-5 mg/kg + (Me) 50-100 µg/kg IM ³⁶⁶	Raptors
	(K) 3-7 mg/kg + (Me) 75-150 µg/kg IM ³⁶⁷	Large psittacines
(K) 25 mg/kg + (Me) 100 µg/kg IM ⁶⁵⁸	Psittacines/anesthesia	
Ketamine (K)/midazolam (Mi)	(K) 10-40 mg/kg + (Mi) 0.2-4 mg/kg SC, IM ^{194,333,531}	Most species, including psittacines
	(K) 40-50 mg/kg + (Mi) 3.65 mg/kg intranasally ³²⁹	Ring-necked parakeets/dose divided into each nare and given slowly; onset of action <3 min, dorsal recumbency for 70.7 ± 46.7 min recovery times reduced with flumazenil intranasally

TABLE 5-5 Chemical Restraint/Anesthetic/Analgesic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Ketamine (K)/midazolam (Mi)/butorphanol (B)	(Mi) 0.2 mg/kg + (B) 0.4 mg/kg IM followed by (K) 8.7 ± 0.5 mg/kg IV ³⁶	Ostriches/PD; anesthesia; followed by intubation and isoflurane anesthesia
Ketamine (K)/tiletamine/zolazepam (Tz)	(K) 15 mg/kg + (Tz) 10 mg/kg IM ⁴²⁷	Raptors/anesthesia
Ketamine (K)/xylazine (X)	—	Often associated with cardiac depressive effects and rough recoveries
	(K) 0.45 mg/kg + (X) 25 mg/kg IM ⁵⁰⁰	Ostriches
	(K) 2-3 mg/kg IV + (X) 5-10 mg/kg IM ¹¹²	Ostriches
	(K) 2-5 mg/kg IV + (X) 0.25 mg/kg IV ¹¹²	Ostriches
	(K) 2.2-3.3 mg/kg + (X) 2.2 mg/kg IM ³⁷⁵	Ratites/administer xylazine 10-15 min before ketamine
	(K) 4.4 mg/kg + (X) 2.2 mg/kg IV ^{358,440}	Psittacines, raptors
	(K) 5 mg/kg + (X) 1 mg/kg IM ⁹⁵	Ostriches
	(K) 8 mg/kg IV + (X) 4 mg/kg IM ¹⁵	Ostriches/ketamine administered 20 min after xylazine; as an adjunct to isoflurane anesthesia produced sufficient surgical plane of anesthesia
	(K) 10 mg/kg + (X) 0.5-1 mg/kg IM ^{14,503}	Ratites, turkey vultures
	(K) 10-15 mg/kg + (X) 2 mg/kg IM ⁵³¹	Owls
	(K) 10-30 mg/kg + (X) 2-6 mg/kg IM ⁵³¹	Psittacines/birds <250 g require dose at higher end of range
	(K) 20 mg/kg + (X) 1-2 mg/kg IV slow bolus ¹⁵⁹	Toucans
	(K) 25 mg/kg + (X) 2.5 mg/kg IM ⁵³¹	Cockatiels
	(K) 25-30 mg/kg + (X) 2 mg/kg IM ⁵³¹	Falcons, hawks
	(K) 30 mg/kg + (X) 6.5 mg/kg IM ⁵³¹	Budgerigars
	(K) 40-50 mg/kg + (X) 10 mg/kg intranasally ⁸²⁹	Ring-necked parakeets/dose divided evenly between nares and given slowly; time to sedation, 7.7 ± 1.4 min; dorsal recumbency, 12.2 ± 14.1 min; yohimbine IM shortened recovery
Ketamine (K)/xylazine (X)/acepromazine (A)	(K) 34 mg/kg + (X) 0.2 mg/kg + (A) 0.1 mg/kg IM ³⁷⁵	Ostriches
Lidocaine	—	Local anesthetic agent with a duration of action in mammals of 90-200 min; ¹⁵² previous reports state that the dose of lidocaine used in birds should be ≤ 3.3 mg/kg, ³³³ a recent study in chickens showed 6 mg/kg IV was not associated with adverse cardiovascular effects ¹⁰⁰

Continued

TABLE 5-5 Chemical Restraint/Anesthetic/Analgesic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Lidocaine (cont'd)	1-3 mg/kg ³³³ 1 mg/kg perineurally each nerve ²⁰⁸ 2 mg/kg perineurally ¹⁶⁷	Most species Raptors/sciatic-femoral nerve block under inhalant anesthesia Hispaniolan Amazon parrots/brachial plexus block via palpation or ultrasound-guided; onset of block tended to be faster when ultrasonography was used but neither technique produced an effective block
Medetomidine ^d (Domitor, Pfizer)	— 60-85 µg/kg IM ⁴ 150-350 µg/kg IM ³⁹	No longer commercially available; can be compounded; dosages listed here as a general guide for possible dexmedetomidine dosing; α ₂ -adrenergic agonist; 80-2000 µg/kg IM was associated with inadequate sedation in the pigeon, ^{618,711} 100 µg/kg IM did not immobilize ostrich chicks; ⁸²⁴ see ketamine and thiafentanil for combinations; see dexmedetomidine for more details Psittacines Raptors
Meperidine HCl	— 1-4 mg/kg IM ^{667,806}	Short-acting opioid agonist ^c Most species, including ratites (at 1 mg/kg/sedation; analgesia
Midazolam HCl	— 0.1-2 mg/kg IM, IV ⁶ 0.15 mg/kg IV ³⁷⁵ 0.2 mg/kg SC, IM ³⁸ 0.3-0.4 mg/kg IM ^{375,503} 0.4 mg/kg intranasally ²⁵ 0.4 mg/kg IV ³⁷⁵	Benzodiazepine; shorter acting than diazepam, water soluble; see butorphanol, dexmedetomidine, and ketamine for combinations Most species/premedication at lower doses, onset approx. 15 min when administered IM Ostriches/rapid sternal recumbency in adults Psittacines/for use in combination with ketamine Ostriches, emus/premedication; sedation of adult emus Ostrich (juvenile)/significantly shorter onset time (2.9 ± 1.2 min) compared with diazepam (4.3 ± 0.4 min) with longer duration of sedation; moderate sedation for standing chemical restraint, with maximum duration effects of 7.0 ± 1.4 min; deep sedation achieved with 0.8 mg/kg intranasally with sternal recumbency for 21.7 ± 4.9 min Emus

TABLE 5-5 Chemical Restraint/Anesthetic/Analgesic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Midazolam HCl (cont'd)	0.5-1 mg/kg IM, IV q8h ³⁸ 2 mg/kg intranasally ⁴⁹¹	Raptors/anticonvulsant Hispaniolan Amazon parrots/mild to moderate sedation in 3 min; reduced vocalizations, struggling and defensive behaviors for 15 min; reversed with flumazenil intranasally
	2 mg/kg IM ⁸¹⁴ 5 mg/kg intranasally ³⁵⁵	Canada geese/sedation for 15-20 min Pigeons/PD; minimal side effects on vital functions but caused inadequate immobilization of pigeons for restraint in dorsal recumbency
	2 mg/kg intranasally ^{714b}	Wild macaws/PD; provided approximately 20 min of sedation in 80% of macaws
	7.3-8.8 mg/kg intranasally ^{829,830}	Ring-necked parakeets/dose divided into each nare and given slowly; time to onset, 3 min; dorsal recumbency, 57.7 ± 24.4 min; flumazenil intranasally significantly reduced recovery time
	12.5-15.6 mg/kg intranasally ⁸³⁰	Canaries/dose divided into each nare and given slowly; time to onset, <3 min; dorsal recumbency, 17.1 ± 5 min; flumazenil intranasally significantly reduced recovery time
	13 ± 1 mg/kg intranasally ⁸⁰	Finches/time to onset of sedation significantly faster (1.0 ± 0.3 min) than xylazine or diazepam; shorter duration of dorsal recumbency observed (32.00 ± 8.09 min) compared with diazepam (68.2 ± 12.7 min); significantly shorter duration of sedation (74.2 ± 8.7 min) than diazepam (182.00 ± 18.37 min) and xylazine (360.2 ± 41.31 min); no complications noted
	13.2 ± 1.3 mg/kg intranasally ⁶⁹⁵	Budgerigars/time to onset of sedation significantly shorter (1.3 ± 0.44 min) than xylazine (2.6 ± 0.89 min) and diazepam (2.8 ± 0.88 min); sedation significantly shorter (71.60 ± 8.9 min) than with xylazine and diazepam; adequate sedation for diagnostic and minor therapeutic procedures
Morphine sulfate	—	Opioid agonist; ^c early work in chickens demonstrated confusing clinical dosage results
Nalbuphine HCl	—	Opioid partial κ -agonist and partial μ -antagonist; ^c due to its low abuse potential, this opioid is currently not a DEA scheduled substance at the time of writing

Continued

TABLE 5-5 Chemical Restraint/Anesthetic/Analgesic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Nalbuphine HCl (cont'd)	12.5 mg/kg IM q2-3h ^{397,710a}	Hispaniolan Amazon parrots/PK; PD; excellent IM bioavailability; little sedation and no adverse effects; rapidly cleared after IM and IV dosing; thermal foot withdrawal threshold values increased ≥ 3 hr; higher dosages (25, 50 mg/kg IM) did not significantly increase withdrawal values
Naloxone HCl	— 0.01 mg/kg IV ³⁶ 2 mg IV q14-21h ³³³	Opioid antagonist; shorter acting than naltrexone Ostriches Most species, including psittacines
Naltrexone HCl	— 300-330 mg IM, IV ^{396,500,630}	Opioid antagonist; longer acting than naloxone Ostriches/opioid antagonist
Nitrous oxide	—	Sufficient oxygen must be provided to avoid hypoxic mixtures; may cause some cardiovascular depression; ³³⁷ do not use in birds with normal subcutaneous air pockets (e.g., pelicans, hornbills) or in birds with marginal respiratory reserves ^{5,337}
Nitrous oxide (N)/ isoflurane (I)/ vecuronium (V)	(N) 0.3 L/kg/min of oxygen and (1:1, min 33% O ₂) + (I) 1-2.4% + (V) 0.2 mg/kg IV ^{416,418a}	Most species/mydriasis and anesthesia; gases are administered via air sac cannulation; vecuronium effective up to 256 min in pigeons
Pentobarbital sodium	— 13.3 mg/kg IV ⁵⁰⁰	Short-acting barbiturate; see Table 5-17 for other indications Emus/premedicate with diazepam
Propofol	— 1-5 mg/kg IV ¹⁹⁵ 1.33 mg/kg IV ^{38,358} 2.9-4.7 mg/kg IV (induction); 0.4-0.55 mg/kg/min IV (maintenance) ³³⁵ 3 mg/kg IV (induction); 0.2 mg/kg/min IV (maintenance) ⁴³⁵ 3.7 mg/kg IV (induction); 0.3 mg/kg/min IV (maintenance) ⁷⁹	IV sedative-hypnotic agent; intubation, ventilation, and supplemental oxygen is strongly recommended ^{479,723} Many species/give slowly for induction to minimize apnea; intubation and IPPV required Psittacines, raptors Red-tailed hawks, great horned owls/PK; PD; minimal blood pressure effects, but ventilation significantly reduced; prolonged recoveries with moderate-to-severe excitatory CNS signs may occur in these species at these doses Ostriches/PD; anesthesia King penguins/rapid and smooth induction and calm recovery

TABLE 5-5 Chemical Restraint/Anesthetic/Analgesic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Propofol (cont'd)	4 mg/kg IV (induction); 0.5 mg/kg/min IV (maintenance) ⁴⁸⁸	Barn owls/anesthesia
	5 mg/kg IV (induction); 0.5 mg/kg/min IV (maintenance) ⁷²³	Wild turkeys/PD; anesthesia
	5 mg/kg IV (induction); 1 mg/kg/min IV (maintenance) ⁴³⁷	Hispaniolan Amazon parrots/PD; recovery times (15.4 ± 15.2 min) were prolonged when compared with isoflurane; 6/10 birds had agitated recoveries; light anesthetic plane in 8/10 birds
	14 mg/kg IV ^{235,358}	Pigeons, raptors/anesthesia; 2-7 min duration; severe respiratory depression and apnea documented in pigeons
Sevoflurane	2.35% ⁶⁰⁵	Thick-billed parrots/PD; minimum anesthetic concentration when using mechanical stimulation; minimum anesthetic concentration was much higher (4.24%) when using electrical stimulus
	3 ± 0.6% ⁹⁴	Pigeons/PD; minimum anesthetic concentration; SAP decreased significantly, PECO ₂ increased significantly despite an increase in respiratory rate; sinus arrhythmias were detected in 2 birds; time to tracheal intubation and recovery were 2.5 ± 0.7 and 6.4 ± 1.7 min, respectively; recovery was rapid and uneventful in all birds
	6% induction; 3.5% maintenance ²¹⁹	Crested caracara/PD; smooth induction/ recovery; reduced respiratory rate and arterial blood pressures
	Incremental increases up to 7% prn (induction) ^{410,627}	Psittacines/anesthesia; similar to isoflurane; provides more rapid recovery; less incidence of ataxia during recovery ^{337,416,627}
Thiafentanil oxalate (T)/ medetomidine (Me)	— (T) 0.175 mg/kg + (Me) 0.092 mg/kg IM ¹⁶³	Ultra-short-acting opioid agonist ^C (T); α ₂ agonist (Me); neither drug currently available in the United States Emus (adults)/anesthesia via remote injection; rapid induction (6.8 min) and recovery (3.2 min)
Tiletamine/zolaze-pam (Telazol, Zoetis)	—	Dissociative anesthetic associated with prolonged, rough recoveries; see dexmedetomidine and ketamine for combinations; tiletamine/zolazepam combinations follow

Continued

TABLE 5-5 Chemical Restraint/Anesthetic/Analgesic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Tiletamine/zolaze-pam (Telazol, Zoetis) (cont'd)	1-8 mg/kg IV ^{375,531}	Ratites (adults)/induction and/or short procedures
	2-12 mg/kg IM ^{455,770}	Ratites (adults)/induction and/or short procedures; ²⁶³ recommend 3-5 mg/kg IM for captive birds and 5 mg/kg IM for free-ranging birds
	4-25 mg/kg IM ^{149a,719,824}	Most species, including psittacines, raptors, ostriches, flamingos/sedation
	5-10 mg/kg IM ^{38,76,358,396,427,440,441}	Ostrich (chicks), raptors, psittacines/good immobilization
	9-30 mg/kg IM ⁷¹⁹	Owls, wood partridges/restraint
	10 mg/kg IM ^{427,719}	Raptors
	15-22 mg/kg IM ^{531,719}	Budgerigars, emus
	40-80 mg/kg PO ^{149a}	Raptors
	80 mg/kg in feed ^{370,870}	Eurasian buzzards/sufficient in most birds to allow safe handling after 30-60 min; birds receiving drug in powder form reached a deeper plane of anesthesia more quickly
Tiletamine-zolazepam (Tz) thiafentanil oxalate (Th)/ dexmedetomidine (D)	—	Ultra-short-acting opioid agonist ^c (Th) not currently available in the United States; α_2 agonist (D); dissociative anesthetic (Tz)
	(Th) 7 mg + (D) 0.2 mg + (Tz) 100 mg IM per bird ⁷⁹⁹	Greater rheas/anesthesia administered via remote injection, smooth induction/recovery; respiratory depression in 1/8 birds but recovered when reversed
Tolazoline HCl (Tolazine, Akorn)	—	α_2 -adrenergic antagonist
	1 mg/kg IV ³⁹⁶ 15 mg/kg IV ¹⁴	Ostriches Turkey vultures
Tramadol HCl	—	Synthetic analog of codeine with opioid, α -adrenergic, and serotonergic receptor activity; O-desmethytramadol (M1) metabolite is more potent μ -opioid agonist in mammals
	5 mg/kg PO, IV q12h ^{755a,756} 5 mg/kg PO q2-9h ^{303c}	Bald eagles/PK; similar plasma concentrations to humans for analgesia but analgesia not evaluated; PO bioavailability in bald eagles higher than in humans, dogs; ⁷⁵⁶ sedation evident after multiple dosing; monitor for sedation and reduce dose and/or frequency prn American kestrels/PD

TABLE 5-5 Chemical Restraint/Anesthetic/Analgesic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Tramadol HCl (cont'd)	8-11 mg/kg PO q12h ^{755a,757} 10 mg/kg PO q24h ^{403b} 30 mg/kg PO q6h ^{710b,755b}	Red-tailed hawks/PK; only 3 birds; 15 mg/kg PO q12h data model suggested more frequent dosing to achieve human analgesic plasma tramadol concentrations; analgesia not evaluated; ^{755a} birds sedated after multiple dosing; monitor for sedation and reduce dose and/or frequency prn ^{755a} African penguins/PK: maintained plasma concentrations for 24 hr Hispaniolan Amazon parrots/PK; PD; similar plasma concentrations to humans for analgesia; effectively reduced thermal withdrawal response for 6 hr
Xylazine	— 0.2-1 mg/kg IM ^{375,630} 1-2.2 mg/kg IM, IV ³⁸ 1-20 mg/kg IM, IV ³⁵⁸ 20 mg intranasally ⁸²⁹ 24-30 mg intranasally ⁸³⁰ 25.6 ± 2.2 mg/kg intranasally ⁵⁹⁵	α ₂ -adrenergic agonist; not recommended by itself for tranquilization and seldom used in pet birds due to adverse effects—excitement, convulsions, bradycardia, arrhythmias, bradypnea, hypoxemia, hypercarbia, and death when used alone; reversible with yohimbine, atipamezole; most useful in ratites; ⁷⁰⁵ see carfentanil, etorphine, and ketamine for combinations Ratites/calming sedation Raptors, psittacines/in combination with ketamine (1:3 or 1:5); still widely used in raptors in some countries Raptors/sedation Ring-necked parakeets/time to onset, 7.9 ± 2.8 min but sedation not adequate for manipulation; reversed with yohimbine intranasally Canaries/heavy sedation; prolonged sedation but could not place in dorsal recumbency at either dose; reversed with yohimbine intranasally Budgerigars/time to onset 2.6 ± 0.9 min; significantly longer sedation than midazolam or diazepam; quality of sedation insufficient to perform clinical procedures
Xylazine (X)/butorphanol (B)	(X) 1.06-2.75 mg/kg + (B) 0.1-0.55 mg/kg IM ⁴⁵⁵	Ratites, including rheas/sedation, premedication; higher doses were needed in rheas
Yohimbine HCl (Yobine, Akorn)	—	α ₂ -adrenergic antagonist; excitement and mortality observed at doses > 1 mg/kg ³³⁷

Continued

TABLE 5-5 Chemical Restraint/Anesthetic/Analgesic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Yohimbine HCl (Yobine, Akorn) (cont'd)	0.1-0.2 mg/kg IV ³⁸	Psittacines, raptors
	0.1-0.2 mg/kg IM, IV ³⁵⁸	Raptors
	0.1-1 mg/kg ³³³	Most species
	0.11-0.275 mg/kg IM, IV once ³³⁹	Budgerigars
	0.125 mg/kg IV ^{375,396,630}	Ratites
	12 mg/kg intranasally ⁸²⁹	Ring-necked parakeets/dose divided evenly between nares and administered slowly; successful reversal of xylazine intranasally
	12-15 mg/kg intranasally ⁸³⁰	Canaries/dose divided evenly between nares and administered slowly; successful reversal of xylazine and detomidine

^aFor other analgesic recommendations, refer to Table 5-6 (nonsteroidal antiinflammatory agents).

^bThe anesthetic agents of choice in most avian species are the inhalant agents, isoflurane and sevoflurane.

^cAll opioid agonists and agonist-antagonists may cause respiratory depression; profound bradypnea may occur with potent opioid agonists.

^dThe effects of the volume:volume use of the dexmedetomidine and medetomidine may not be equivalent, so the dose of dexmedetomidine may need to be adjusted based on clinical response.

TABLE 5-6 Nonsteroidal Antiinflammatory Agents Used in Birds.^{a-c}

Agent	Dosage	Species/Comments
Acetaminophen	5 mg/L drinking water ³³³	Most species/antipyretic, analgesic; overdosage may be associated with hepatotoxicity
Aspirin (acetylsalicylic acid)	—	Contraindicated with tetracycline, insulin, or allopurinol therapy ⁵
	5 mg/kg PO q8h ³³³	Most species
	25 mg/kg IV ^{32,33}	Ostriches, pigeons/PK; rapid clearance except longer $t_{1/2}$ in pigeon
	50 mg/kg PO q8h ²¹²	Psittacines
	150 mg/kg PO ³³³	Psittacines
	325 mg/250 mL drinking water ³³³	Most species/make fresh q8-12h; alters taste of water (may not be well accepted)
Carprofen	—	Caution should be used when administering to <i>Gyps</i> vultures ^{165,261} and pigeons ⁸⁷⁴
	1-2 mg/kg PO, IM, IV q12-24h ^{149a,358}	Most species, including raptors

TABLE 5-6 Nonsteroidal Antiinflammatory Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Carprofen (cont'd)	2-10 mg/kg IM q24h up to 7 days ⁸⁷⁴	Pigeons/PD; 2, 5, and 10 mg/kg associated with increases in plasma AST, ALT, mottled yellow livers, pale muscle injection sites, and histologic changes in the kidney, liver (lipidosis, necrosis, portal hepatitis), and muscle injection sites
	2-10 mg/kg SC, IM ^{38,212,333} 3 mg/kg IM q12h ⁵⁹²	Psittacines, passerines, raptors Hispaniolan Amazon parrots/PD; markedly reduced arthritis pain 2 hr postadministration, but short-term effect thus more frequent dosing recommended
	5-10 mg/kg PO, IM ³³³	Raptors/postoperative analgesia
Celecoxib (Celebrex, Pfizer)	10-20 mg/kg PO q24h × 6-24 wk ^{140,168}	Psittacines/clinical proventricular dilatation disease; clinical improvement may be seen within 7-14 days; compounded formulation of 10 mg/mL stable for approximately 90 days at room temperature ¹⁹⁶
Diclofenac	— 12.5 mg PO once ³⁸	Recent massive mortalities in three vulture species lead to banning of diclofenac in India, Pakistan, and Nepal; severe renal lesions suggested toxicity of the kidneys or the renal supportive vascular system; ^{165,514,543,564,786} diclofenac toxicity has also been reported in Steppe eagles in India ⁷³³ and is suspected in other species; aceclofenac is rapidly metabolized to diclofenac in cattle, thus should also be avoided for its potential toxicity ²⁷² Pigeons/arthritis
Dimethylsulfoxide (DMSO) (90%) (Domoso, Zoetis)	1 mL/kg topical to affected area q4-7d ³³³	Most species/antiinflammatory, analgesic; systemic absorption; use gloves during application
Dipyron	20-25 mg/kg SC, IM, IV q8-12h ⁸⁰⁶	Ratites/analgesic for intestinal disorders; antipyretic
Flunixin meglumine	—	Potential nephrotoxicity; hydration is essential; use only for short duration (<5 days); ^{149b} 5 mg/kg led to renal ischemia and necrosis in Siberian cranes; ⁵⁸⁷ histologic lesions occurred in budgerigars administered 5.5 mg/kg and severity increased with duration of therapy; ⁵⁹⁹ histologic glomerular changes were demonstrated in bobwhite quail given doses as low as 0.1 mg/kg (severity of lesions was directly correlated to dose); ⁴¹¹ avoid in <i>Gyps</i> vultures; ^{165,261} IM administration caused muscle necrosis in ducks; ⁴⁸¹ regurgitation may occur after administration ³⁸⁵
	0.2 mg/kg IM ⁸⁰⁶	Ratites
	0.5 mg/kg IM ³³⁷	Most species, including psittacines
	1-10 mg/kg IM, IV q24h ^{331,358,371,649}	Most species, including raptors, psittacines
	1.1 mg/kg IV ^{32,33} 1.1 mg/kg IM q12h ^{1,3}	Ostriches, pigeons/PK; ostrich $t_{1/2}$ = 10 min Ostriches/myositis ³

Continued

TABLE 5-6 Nonsteroidal Antiinflammatory Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Flunixin meglumine (cont'd)	1.5 mg/kg IM q24h × 3 days ¹¹²	Ostriches
	5 mg/kg IV ⁵⁴⁰	Budgerigars, Patagonian conures/PK: elimination half-life and mean residence time rapid and similar in both spp.
	5.5 mg/kg IM q24h × 3 or 7 days ⁵⁹⁹	Budgerigars/some renal changes at 3 days; 6/8 birds had tubular necrosis at 7 days
Ibuprofen	—	Avoid in <i>Gyps</i> vultures ¹⁶⁵
	5-10 mg/kg PO q8-12h ²¹²	Psittacines/use pediatric suspension for small birds
Ketoprofen	—	Avoid in <i>Gyps</i> vultures, mortalities reported at clinical doses; ^{261,544} 7/11 Cape Griffon vultures administered 5 mg/kg PO died within 48 hr ⁵⁴⁶
	1 mg/kg IM q24h × 1-10 days ^{38,76}	Raptors
	1-5 mg/kg IM q12h ⁶⁴⁸	Raptors
	2.5 mg/kg IM q24h × 3 or 7 days ⁵⁹⁹	Budgerigars/low frequency of glomerular congestion, degeneration/dilation of tubules occurred at 3-7 day treatment
Meloxicam	—	No reported mortalities in over 700 cases of 60 species of birds, including <i>Gyps</i> vultures, ^{165,786,787} but few studies to date evaluating renal effects of higher doses; ^{190,524b,744} the combination of avian bornavirus challenge and meloxicam treatment resulted in severe disease and death in cockatiels, whereas challenge alone or meloxicam treatment alone were not lethal within the duration of this study ^{352,353}
	0.1 mg/kg IM q24h × 3 or 7 days ⁵⁹⁹	Budgerigars/mild glomerular congestion and tubular degeneration at 3 and 7 days
	0.5 mg/kg PO q12h × 14 days ^{524b}	African grey parrots/PD; mild to no hematological or biochemical changes, and no histologic lesions in 9 of 10 birds after 14 days of treatment
	0.5 mg/kg IV ³²	Ostriches, pigeons/PK; variable distribution, ostrich had more rapid $t_{1/2}$ (0.5 hr) than other species studied
	0.5 mg/kg PO, IV ⁴³³	Red-tailed hawks, great horned owls/PK; significant differences in pharmacokinetics between species strongly discourages extrapolation between species; hawks had shortest half-life (0.49 hr) of any species recorded to date; once daily dosing not applicable at this dose in these species
	0.5 mg/kg PO, IM q8-12h ⁸⁷⁵	Lesser flamingos/PK; PO had higher bioavailability and longer elimination half-life than IM, but the plasma concentrations may be insufficient to provide analgesia; IM administration achieved the desired plasma concentration but would require more frequent administration

TABLE 5-6 Nonsteroidal Antiinflammatory Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Meloxicam (cont'd)	<p>0.5-1 mg/kg PO q12h⁸⁵⁷</p> <p>0.5 mg/kg IM q6-8h⁸⁹ – 1.5 mg/kg SC q8-12h⁴⁵⁶</p> <p>0.5-2 mg/kg PO, IM q12h × 9 days¹⁸⁸</p> <p>0.5-3 mg/kg PO q8-12h^{89,456}</p> <p>1 mg/kg PO, IM, IV^{524a}</p> <p>1 mg/kg PO, IM, IV q12h^{146,521}</p> <p>1.6 mg/kg PO q12h × 15 days¹⁹⁰</p> <p>2 mg/kg PO, IM⁵⁴⁵</p> <p>2, 10, 20 mg/kg PO q12h × 7 days⁷⁸⁵</p>	<p>Ring-necked parakeets/PK; no analgesic evaluation</p> <p>Caribbean (American) flamingos/PK</p> <p>Pigeons/PD; 0.5 mg/kg dose ineffective in minimizing postoperative orthopedic pain; 2 mg/kg provided quantifiable analgesia that appeared safe under experimental conditions</p> <p>Caribbean (American) flamingos/PK; oral bioavailability only 45% when compared with SC administration; fasting status may change absorption;⁴⁵⁶ results in these two studies differ significantly (possibly associated with fasting vs. nonfasting or other differences in the population); higher dose than 0.5 mg/kg may be required for PO administration;⁸⁹ selecting a dose midway between the two extremes may be the most reasonable</p> <p>African grey parrots/PK; slower absorption and lower bioavailability than IM (40%)</p> <p>Hispaniolan Amazon parrots/PD; improved weight-bearing on arthritic limb compared with lower doses; PO lower bioavailability than parenteral; PO did not attain plasma concentrations similar to humans for analgesia; concentrations similar to humans for analgesia for IM, IV for 6 hr</p> <p>Hispaniolan Amazon parrots/PD; no apparent negative changes in several renal, gastrointestinal, or hemostatic variables in healthy birds</p> <p>Cape Griffon vultures/PD; rapid metabolism and short elimination $t_{1/2}$ (<45 min) suggests low potential for drug accumulation</p> <p>American kestrels; histologic evaluation showed a significant correlation between hepatic lipidosis and meloxicam dose; 2/9 birds developed gastric ulcers at highest dose</p>
Phenylbutazone	<p>—</p> <p>3.5-7 mg/kg PO q8-12h²¹²</p> <p>10-14 mg/kg PO q12h⁸⁰⁶</p> <p>20 mg/kg PO q8h³³³</p>	<p>Caution with use in <i>Gyps</i> vultures; mortalities associated with use^{165,261}</p> <p>Psittacines</p> <p>Ratites</p> <p>Raptors</p>
Piroxicam	<p>—</p> <p>0.5 mg/kg PO q12h³³³</p> <p>0.5-0.8 mg/kg PO q12h³³³</p>	<p>Indicated for chronic osteoarthritis; has been used to treat pain associated with chronic degenerative joint disease in cranes and other species</p> <p>Psittacines</p> <p>Whooping cranes/acute myopathy, chronic degenerative joint disease</p>

^aUnless otherwise noted, drugs provide analgesic, antipyretic, and antiinflammatory effects.^bNonsteroidal antiinflammatory agents may potentially cause gastrointestinal upset and hemorrhage, as well as adverse renal effects ranging from fluid retention to renal failure.^cFor other analgesic recommendations, refer to Table 5-5.

TABLE 5-7 Hormones and Steroids Used in Birds.

Agent	Dosage	Species/Comments
Adrenocorticotrophic hormone (ACTH)	1-2 U/kg IM ³³³ 16-26 U/bird IM ^{466,871} 50-125 µg/bird IM ³³³	Psittacines/ACTH stimulation test Psittacines/obtain baseline sample, administer ACTH, then sample in 1-2 hr; stress of handling and venipuncture may invalidate results Pigeons
Boldenone undecylenate (Equipoise, Zoetis)	1.1 mg/kg IM q21d ⁸⁰⁶	Ratites/anabolic steroid
Buserelin (Receptal, Intervet India)	0.5-1 µg/kg q48h up to 3 treatments ³⁸ 8 µg/kg IM ⁴⁶⁷	Psittacines/used to suppress chronic egg-laying Cockatiels, sulfur-crested cockatoos/increased circulating testosterone after single injection
Buserelin acetate depot (Suprefact, Sanofi Aventis Canada)	10 µg/kg SC implant ¹⁵³	Budgerigars/when administered in inguinal region increased reproductive activity and egg laying
Cabergoline	10-50 µg/kg q12-24h ³⁸	Psittacines/egg laying
Calcitonin	4 U/kg IM q12h × 14 days ³³³ 10 µg/kg IM ⁸⁶³	Most species/reduce hypercalcemia (caused by cholecalciferol rodenticide toxicity) Pigeons/significant reduction in plasma calcium over 5 days
Chorionic gonadotropin (hCG)	500-1000 U/kg IM on day 1, 3, 7 q3-6wk prn ³³³	Most species/inhibits egg laying; administer on days 3 and 7 if hen lays after day 1
Delmadinone	1 mg/kg ³⁸	Antiandrogen sometimes effective for neurotic regurgitation in budgerigars
Deslorelin (Suprelorin, Virbac)	— 4.7 mg implant placed SC intrascapularly ⁷⁸⁴	GnRH agonist available as 4.7 mg and 9.4 mg long-term implants; also used for long-term management of ovarian neoplasia in cockatiels ^{399,551} and Sertoli cell tumors in budgerigars; ⁷⁷⁴ anecdotal evidence of decreased efficacy over time with repeated administration; ²⁷ to date, only approved for use in adrenocortical disease in ferrets in the United States Cockatiels/suppressed egg laying for ≥180 days; 5/13 implanted birds laid first egg between 192 and 230 days following implant placement; no difference in egg shape, color, shell quality or number of eggs per clutch was observed between treated and control groups

TABLE 5-7 Hormones and Steroids Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Deslorelin (Suprelorin, Virbac) (cont'd)	4.7 mg implant placed IM ¹⁵⁴ 5 mg/kg implant SC ⁵³⁷	Domestic pigeons/effectively controlled egg laying for at least 49 days; significantly reduced serum LH concentrations in males and females compared to pretreatment levels for 56 and 84 days, respectively Male zebra finches/transiently suppressed testosterone concentrations, reversible when implant removed
Desmopressin	4.6 µg/kg IM q12h ⁷⁶⁶	African grey parrots/long-term treatment of central diabetes insipidus; dosage adjusted as needed up to 24 µg/kg 16 mo after initial diagnosis
Dexamethasone ^a	0.2-1 mg/kg IM, IV once or q12-24h × 2-7 days, then q48h × 5 days ^{38,333} 2-4 mg/kg IM, IV q12-24h ^{38,333} 2-8 mg/kg SC, IM, IV q12-24h ⁵⁶⁶	Most species Most species, including ratites/shock, trauma Cranes/reduce doses for long-term therapy
Dexamethasone sodium phosphate ^a	2-4 mg/kg SC, IM, IV q6-24h ^{38,333}	Most species, including raptors/head trauma, shock, hyperthermia; higher dose for shock, head trauma, and endotoxemia
Diethylstilbestrol diphosphate (Stilphostrol, Bayer)	0.025-0.075 mg/kg IM ³³³ 0.4 mg/L drinking water ³³³	Most species/narrow therapeutic index Most species
Dinoprost tromethamine	—	See prostaglandin F _{2α}
Dinoprostone	—	See prostaglandin E ₂
Estradiol benzoate	— 0.3-0.5 mg/kg PO q24h × 1 mo ³⁴⁵ 10-15 mg/kg IM q7d × 4 treatments ³⁴⁵	Estrogens have been associated with severe adverse reactions in mammals; ⁶¹⁵ anemia, hypercholesterolemia, and hyperlipidemia were observed in penguins ³⁴⁵ Penguins/induces molt Penguins/induces molt
Flumethasone (Flucort, Glenmark) ^a	1-1.5 mg/kg PO, SC, IM, IV ⁸⁰⁶	Ratites/glucocorticoid; antiinflammatory
Glipizide	1 mg/kg PO q12h ^{359a}	Most species
Hydrocortisone ^a	3-4.5 mg/kg PO q12h ⁸⁰⁶ 10 mg/kg IM, IV ³³³ 40-50 mg/kg IV q24h ⁸⁰⁶	Ratites Psittacines, passerines, raptors Ratites

Continued

TABLE 5-7 Hormones and Steroids Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Insulin	0.002 U/bird IM q12-48h ³³³	Budgerigars/NPH insulin
	0.01-0.1 U/bird IM q12-48h ³³³	Amazon parrots/NPH insulin
	0.1-0.5 U/bird IM q24h or prn ³³³	Toco toucans
	0.2-10.7 U/kg SC, IM q12h ⁴⁸	Bali mynah/PZI insulin: commercial and compounded products used with differing results, so increase/change dose/product with caution
	0.5-3 U/kg IM ³³³	Psittacines/NPH insulin
Lecirelin (Dalmarelin; Selecta, Germany; Vetcare, Finland; Fatro, Ireland, Israel, Italy, Netherlands; Ufamed, Switzerland; Reprorelin; Vetoquinol, France)	1.4 U/kg IM q12-24h ^{333,377}	Cockatiels, toco toucans/NPH insulin
	2 U/bird IM ³³³	Toco toucans/ultralente or PZI insulin; adjust dose or frequency based on glucose curves
Leuprolide acetate (Lupron Depot, TAP Pharmaceuticals; Lupron Kit, Florida Infusion Pharmacy [single-dose leuprolide acetate available from Professional ArtsPharmacy, Baltimore, MD])	—	Synthetic GnRH agonist depot drug; prevents ovulation; may be indicated in some cases of sexually related feather picking or mutilation; ²⁸⁵ variable results obtained; in treating reproductive diseases, administration before onset of egg laying may be more successful than treatment during breeding; single report of anaphylaxis following chronic administration in 2 elf owls; ⁷⁷⁷ rarely seen in humans unless impurities in formulation
	(No. of days for desired effect) × (52 or 156 µg/kg) = dosage IM ⁵¹⁷	Cockatiels/PD
	100 µg/kg q14d × 3 treatments ^{333,372}	Most species/feather-damaging behavior
	200-800 µg/kg IM q2-6wk ^{333,378}	Most species
	375 µg/bird IM ^{39,518}	Cockatiels/inhibits ovulation
	400-1000 µg/kg IM q2-3 wk ⁴⁸⁹	Psittacines
	500 µg/kg IM q14d ³⁶⁷	Psittacines (>300 g)/for most problems, begin with 3 treatments
	750 µg/kg IM q14d ³⁶⁷	Psittacines (≤300 g)/for most problems, begin with 3 treatments

TABLE 5-7 Hormones and Steroids Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Leuprolide acetate (cont'd)	800 µg/kg IM ⁴⁰⁹ 1250 µg/kg IM once ³⁴⁵	Hispaniolan Amazon parrots/ hormonal effects may taper off between 7 and 21 days after administration Penguins/induced molt in 1 of 2 birds dosed
Levothyroxine (l-thyroxine)	— 5-200 µg/kg PO q12h ⁶⁷⁸ 20 µg/kg PO q12-24h ^{38,135,333} 25 µg q24h × 7 days, then 50 µg q24h × 7 days, then 75 µg q24h × 7 days, then 50 µg q24h × 7 days, then 25 µg q24h × 7 days ³⁵⁸	May induce molt; monitor blood levels and body weight Amazon parrots Most species, including psittacines, pigeons, and raptors Raptors (750-1000 g)/induces molt; scale dose up or down by up to 50% for larger or smaller birds
Medroxyprogesterone acetate	— 5-25 mg/kg SC, IM, repeat q4-6wk prn ^{316,333} 5-50 mg/kg SC, IM q4-6wk ³⁸ 15-30 mg/kg IM q7d × 4-5 treatments ⁶⁵⁶ 30 mg/kg SC, repeat in 90 days prn ³³³ 1000 mg/kg feed ³³³	This agent is not recommended; previously used for sexually related feather picking or chronic egg laying; high incidence of adverse effects, including lethargy, polydipsia, polyphagia, polyuria, immunosuppression, weight gain, liver disease, thromboembolism, diabetes mellitus, salpingitis, sudden death ²⁸⁵ Psittacines/suppresses ovulation; antipruritic (feather picking in male parrots) Psittacines/higher dosages recommended for smaller birds (e.g., 50 mg/kg for 150 g bird) ⁵⁰⁰ Penguins/induces molt 60-90 days postinjection Most species Pigeons/inhibits ovulation
Megestrol acetate	—	Progestin; adverse effects can be severe (diabetic-like); not generally recommended, so dosages are not provided
Methylprednisolone acetate ^a	0.5-1 mg/kg PO, IM ³³³ 200 mg/bird IM, repeat prn ⁸⁰⁶	Most species/allergies (Amazon foot necrosis); ⁶⁶⁶ use orally once weekly, then taper to once monthly, then stop Ratites (adults)

Continued

TABLE 5-7 Hormones and Steroids Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Nandrolone laurate (Laurabolin, Intervet)	— 0.2-2 mg/kg IM once ³³³ 0.4 mg/kg SC, IM q21d ⁴³⁸	Testosterone derivative; used in the treatment of chronic, debilitating disease; may be hepatotoxic Most species Psittacines, raptors, bustards
Oxytocin	— 0.5-5 U/kg, may repeat q30min ³³³ 5-10 U/kg IM once ³³³ 20-30 U/bird IM q24h × 2 treatments ⁸⁰⁶	Use of oxytocin should be preceded by calcium administration for egg binding; contraindicated unless uterovaginal sphincter is well dilated and uterus is free of adhesions; used alone to stop uterine bleeding ³³³ Most species, including raptors Psittacines/in some cases, multiple injections are recommended Ratites (adults)/egg binding
Prednisolone (prednisone) ^a	0.5-1 mg/kg IM, IV ³³³ 1-1.25 mg/kg PO q48h ⁸⁰⁶ 2 mg/kg IM, IV q12-24h ⁵⁶⁶ 2-4 mg/kg IM, IV ³⁵⁸	Most species Ratites Cranes/shock, trauma, chronic lameness Raptors/shock
Prednisolone sodium succinate (Solu-Delta-Cortef, Zoetis) ^a	0.5-1 mg/kg IM, IV ³³³ 1.5-2 mg/kg IM q12h ⁸⁰⁶ 2-4 mg/kg IM, IV once ³³³ 5-8.5 mg/kg IV q1h ⁸⁰⁶ 10-20 mg/kg IM, IV q15min pm ³³³	Psittacines/antiinflammatory Ratites/immunosuppression (see prednisolone for prolonged therapy) Psittacines/shock; trauma; endotoxemia; immunosuppression Ratites/shock Most species/head trauma; cardiopulmonary resuscitation
Prednisone	—	See prednisolone
Prostaglandin E ₂ (dinoprostone) (Prepidil Gel, Pfizer)	0.02-0.1 mg/kg applied topically to uterovaginal sphincter ³³³	Most species, including psittacines, raptors/dystocia; relaxes uterovaginal sphincter; lower dosage may be effective; freeze into aliquots
Prostaglandin F _{2α} (Dinoprost tromethamine) (Lutalyse, Zoetis)	0.02-0.1 mg/kg IM, intraclacal once ⁶⁹⁷	Most species, including psittacines, raptors, and waterfowl/dystocia; may be helpful when the egg is located distally and the uterovaginal sphincter is dilated; can result in uterine rupture, bronchoconstriction, hypertension, death

TABLE 5-7 Hormones and Steroids Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Somatostatin	0.003 mg/kg SC q12h ³⁹¹	Toucans (sulfur-breasted)/diabetes mellitus; some clinical improvement observed, hyperglycemia and elevated glucagon levels persisted
Tamoxifen citrate	— 2 mg/kg PO q24h given on 2 consecutive days per wk for 38-46 wk ⁴⁷⁸ 40 mg/kg IM ³⁴⁵	Nonsteroidal antiestrogen Budgerigars/effects suggested by change in cere color from white/brown to blue; leukopenia was the most significant adverse effect Penguins/induces molt
Testosterone	— 2-8 mg/kg SC, IM once ³⁸ 8-8.5 mg/kg IM q7d prn ¹³ 10-15 mL stock solution/L drinking water × 5 days-2 mo ³³³	Anabolic steroid; may adversely affect spermatogenesis; contraindicated with hepatic or renal disease ¹³⁸ Most species/stimulates sexual behavior in the male; baldness in canaries Most species, including psittacines/anemia due to debilitation; increases libido; use with caution Canaries/finish molt or regain singing; stock solution: 100 mg parenteral suspension/30 mL drinking water (3333 mg/L); mix fresh daily
Thyroid releasing hormone	15 µg/kg IM once ³³³	Most species
Thyroid stimulating hormone (thyrotropin; TSH)	0.1 U/bird IM (Bovine) ³²² 0.2 U/kg IM (Human) ²⁹¹ 1 U/kg IM (Human) ^{290,291,871} 1-2 U/kg IM (Human) ⁴⁶⁵	Cockatiels/3-24-fold higher T ₄ 6 hr after receiving TSH Macaws/PD; T ₄ doubled in 6/11 birds 4 hr after receiving TSH Hispaniolan parrots, blue-fronted Amazon parrots, African grey parrots, pigeons/PD; T ₄ doubled in Hispaniolan and blue-fronted parrots 6 hr after receiving TSH Psittacines/obtain blood at 0 hr, then 4-6 hr after TSH stimulation

^aSteroid administration may predispose birds to aspergillosis and other mycoses.³⁵⁸ Administration may also be associated with the development of polyuria/polydipsia/polyphagia, increased protein catabolism, glucosuria, and diabetes mellitus. Toxic levels may be attained even with topical application.³⁴⁴ Administration should ideally not exceed 5 days. Rapid onset, shorter-acting drugs are generally less likely to cause serious adverse effects.

TABLE 5-8 Nebulization Agents Used in Birds.^a

Agent	Dosage	Species/Comments
<i>N</i> -acetyl-L-cysteine 10%-20% (Mucomyst, Bristol)	— 22 mg/mL sterile water until dissipated ³³³	See other antimicrobials and drugs for combinations Most species/mucolytic agent; tracheal irritation and reflex bronchoconstriction reported in mammals; use is preceded by bronchodilators in mammals ⁶⁶²
Amikacin	5-6 mg/mL sterile water or saline × 15 min q8-12h ³³³	Most species/discontinue if polyuria develops
Aminophylline	3 mg/mL sterile water or saline × 15 min ³³³	Most species/bronchial and pulmonary vasculature smooth muscle relaxation; incompatible with amikacin, cephalothin, clindamycin, erythromycin, oxytetracycline, methylprednisone, penicillin G, tetracycline; consult with specialized references for more information ⁶¹⁵
Amphotericin B (Fungizone, Squibb)	— 0.1-1 mg/mL sterile water × 15-60 min q12-24h ^{37,53,333,838} 0.25 mg/mL saline × 15 min q12h ³²⁹	May lead to hypokalemia; corticosteroids may exacerbate this effect, ⁶¹⁵ minor systemic absorption with aerosol administration; can be nebulized long-term; ⁶¹⁵ mix with sterile water, may precipitate with saline and other electrolytic solutions Most species including birds of prey, penguins, and parrots (0.5-1 mg/mL q30-40 min is usually used) Hummingbirds/low efficacy; may cause weight loss
Amphotericin B liposome (AmBisome, Astellas Pharma)	1-4 mg/mL sterile water × 15-60 min ⁵⁵	Most species; do not mix with saline or other drugs
Carbenicillin (Geocillin, Roerig)	20 mg/mL saline × 15 min q12h ³³³	Psittacines
Cefotaxime	10 mg/mL saline × 10-30 min q6-12h ⁵³	Most species
Chloramphenicol	13 mg/mL saline ³³³	Most species/human health concerns; the development of aplastic anemia reported in humans; prohibited by the FDA for use in food animals
Clotrimazole (1%) (Lotrimin, Schering)	10 mg/mL propylene glycol or polyethylene glycol × 30-45 min q24h × 3 days, off 2 days, repeat prn for up to 4 mo ^{53,333} 10 mg/mL polyethylene glycol × 30-60 min ³³³ 5%-10% clotrimazole in propylene glycol with 5% DMSO × 1 hr ⁵⁴⁵	Most species/treatment of aspergillosis; can be toxic to psittacines at this dose Raptors, psittacines/used in combination with systemic antifungals Raptors
Dexamethasone sodium phosphate	0.16 mg/mL in saline ⁵¹¹	Eclectus parrot/tracheal stent placement

TABLE 5-8 Nebulization Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Doxycycline hyclate (Vibramycin, Zoetis)	13 mg/mL saline ^{53,333}	Psittacines
Enilconazole (Imaverol, Janssen; Clinafarm, Schering)	0.2 mg/5 mL saline q12h × 21 day ³³³	Most species, including raptors, psittacines
	10 mg/mL sterile water ^{53,333}	Most species/antifungal
	50 mg in 25 mL saline × 30-45 min q12h ³⁷	Raptors
Enrofloxacin	10 mg/mL saline ^{37,53,333}	Most species
Erythromycin	5-20 mg/mL saline × 15 min q8h ³³³	Most species
F10	1:250 dilution ³⁷	Raptors/prevention and treatment of aspergillosis
	0.2% superconcentrate ⁸²⁸	Falcons/using a fogging system, prevention and treatment of aspergillosis
Gentamicin	3-6 mg/mL saline or sterile water and 1-2 mL acetylcysteine (20%) × 20 min q8h ^{37,53,333}	Most species, including cranes and raptors
Itraconazole	1%-10% nanoparticulate suspension × 30 min ⁶⁸³	Japanese quail/PD; reached high lung levels
	4% nanoparticulate suspension × 30 min q24h ⁸⁶⁰	Japanese quail/PD; less effective than 10% in experimental aspergillosis
	10% nanoparticulate suspension × 30 min q24h ⁸⁶⁰	Japanese quail/PD; experimental aspergillosis, blocked lethality in low spore load group and delayed disease progression in high spore load group
Lincomycin	250 mg/mL water ³³³	Most species
	250 mg aerosolized drug/m ³ chamber × 15-30 min ¹²⁹	Chickens/PD; antibiotic; therapeutic concentrations in blood, lungs, and trachea for up to 24 hr
Miconazole (Daktarin, Janssen)	Nebulize 15 min q8h × 10 days ³³³	Raptors/aspergillosis
Oxytetracycline	2 mg/mL × 60 min q4-6h ³³³	Parakeets/PD; therapeutic concentrations in lungs and trachea, low plasma concentrations
Piperacillin	10 mg/mL saline × 10-30 min q6-12h ^{37,53,333}	Most species
Polymyxin B sulfate	66,000 U/mL saline ³³³	Psittacines/poorly absorbed from respiratory epithelium
Praziquantel	56.8-85.2 mg in 100% oxygen × 5-15 min q24h ¹⁸⁵	Blue-crowned motmots, fairy bluebirds/treatment of air sac flukes, decreased parasite burden
Sodium chloride	0.9% or 3% (hypertonic)	Viscosity of respiratory secretions may be decreased by hydration, mucolytic properties ³³³
Spectinomycin (Spectam, Ceva)	13 mg/mL saline ³³³	Most species
Sterile water	—	Viscosity of respiratory secretions may be decreased by hydration ³³³

Continued

TABLE 5-8 Nebulization Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Sulfadimethoxine	13 mg/mL saline ³³³	Most species
Terbinafine	1 mg/mL crushed pills in sterile water × 15 min ²¹⁶	Hispaniolan Amazon parrots/PD; plasma levels above MIC for 1 hr; solution concentration was lower than expected at 0.9 mg/mL
	1 mg/mL raw powder in sterile water × 15 min ²¹⁶	Hispaniolan Amazon parrots/PD; plasma levels above MIC for 4 hr
Terbutaline	0.01 mg/kg with 9 mL saline ^{53,333}	Psittacines/bronchodilation
Tylosin	10 mg/mL saline × 10-60 min q12h ³³³	Most species
	20 mg/mL DMSO or distilled water × 1 hr ^{460,461}	Most species, pigeons, quail/PD
	20 mg/mL DMSO and 0.5 mL saline ³³³	Psittacines
Voriconazole	10 mg/mL of saline 0.9% × 15 min ⁷¹	Pigeons/PD; low plasma concentrations; no measurable drug in the lungs 1 hr after nebulization; plasma and lung levels below MIC for <i>Aspergillus</i>
	10 mg/mL saline × 15-30 min q8-12h ⁵³	Most species

^aNebulization is an adjunctive therapy indicated for rhinitis, sinusitis, tracheitis, pneumonia, airsacculitis, and syringeal aspergilloma, where there is air movement occurring in the patient's disease state; optimal particle size for deposition in the trachea is 2-10 μm; optimal particle size for peripheral airways and air sacs is 0.5-5 μm; treatments of 30-45 min repeated q4-12h are recommended (longer nebulization periods of 1 to several hours may be required^{720,796}); caution: do not overhydrate airways.³³³ Saline or propylene glycol can be used as a carrier.⁷²⁰ A variety of nebulizers exist, including air jet nebulizer (most commonly used) and ultrasonic nebulizers. Air jet nebulizers are better to nebulize viscous liquid.⁵³ Pressurized metered-dose inhalers are air jet nebulizers and should be used with a holding chamber (e.g., Aerokat[®]).⁵³

TABLE 5-9 Agents Used in the Treatment of Toxicologic Conditions of Birds.

Agent	Dosage	Species/Comments
Atropine sulfate	—	Antidote for muscarinic effects of organophosphate/carbamate (acetylcholinesterase inhibitors) toxicosis; does not treat nicotinic effects
	0.01-0.02 mg/kg SC, IM ³³³	Most species/facilitates bronchodilation in acutely dyspneic animals; treatment of choice for anticholinesterase-induced respiratory distress
	0.03-0.05 mg/kg SC, IM, IV q8h ⁸⁰⁶	Ratites
	0.04-0.1 mg/kg IM ³³³	Psittacines/bronchodilation in acutely dyspneic animals; treatment of choice for anticholinesterase-induced respiratory distress
	0.1 mg/kg IM, IV q3-4h ³³³	Raptors, waterfowl

TABLE 5-9 Agents Used in the Treatment of Toxicologic Conditions of Birds. (cont'd)

Agent	Dosage	Species/Comments
Atropine sulfate (cont'd)	0.2-0.5 mg/kg IM, IV q3-4h ³³³	Most species, including pigeons, raptors/cholinesterase inhibitors toxicosis
	0.5 mg/kg IM, IV q6-8h ⁶⁵¹	Raptors/cholinesterase inhibitors toxicosis
Bismuth sulfate (Bismusal, Bimeda)	1-2 mL/kg PO ³³³	Most species/weak adsorbent, demulcent; may be useful for toxin removal
Botulinum type C antitoxin (100 U/mL) (National Wildlife Health Center)	1 mL IP ⁴⁹⁸ once	Waterfowl/not commercially available; produced for experimental use in migratory birds
Botulinum antitoxin	0.05-1 mL/day ⁶⁹⁹	Most species
Calcium EDTA (edetate calcium disodium)	—	Preferred initial chelator for lead and zinc toxicosis; may cause renal tubular necrosis in mammals; maintain hydration and monitor patient for PU/PD; SC, IM absorbed well; ⁶¹⁵ poorly effective at removing lead in soft tissues; combine with DMSA in severe cases ⁶⁵¹
	10-40 mg/kg IM q12h × 5-10 days ⁶⁹⁹	Raptors, most species
	20-70 mg/kg IV ¹⁷⁴	Most species/empirical diagnosis; signs should resolve for up to 48 hr; diluted 1:4 in saline
	30 mg/kg SC q24h × 5 days ⁶¹³	Vultures
	30-35 mg/kg IM q12h × 3-5 days, off 3-4 days, repeat prn ³³³	Most species
	35-50 mg/kg SC diluted with saline ⁶⁵¹	Raptors
	40 mg/kg IM q12h ¹⁸⁷	Cockatiels/PD; reduces lead levels when used alone or with DMSA
	50 mg/kg IM q12h × up to 23 days ⁷⁰¹	Raptors/no deleterious effects observed
100 mg/kg IM q12h × 5-25 days ⁶⁹⁹	Falcons/no observed deleterious effects	
Charcoal, activated	—	Adsorbs toxins from the intestinal tract; may be mixed with hemicellulose to act as a bulk laxative to aid in the passage of ingested toxins; administration prior to cathartic use may help bind small particles of heavy metal; ⁶¹³ see magnesium hydroxide for combination

Continued

TABLE 5-9 Agents Used in the Treatment of Toxicologic Conditions of Birds. (cont'd)

Agent	Dosage	Species/Comments
Charcoal, activated (cont'd)	52 mg/kg PO once ⁵¹⁹ 1-3 g/kg ⁸⁵⁹ 2-8 g/kg PO ³³³	A component of oiled bird treatment; alternatively, may use bismuth Most species Most species
Deferiprone (Ferriprox, Apotex)	50 mg/kg PO q12h × 30 days ^{333,849} 50 mg/kg PO q12h ⁸⁴⁸ 75 mg/kg PO q24h × 90 days ⁷¹²	Toucans, pigeons/iron chelation; may produce rust-colored urates Pigeons/PK Hornbills/PD; <i>n</i> = 3
Deferoxamine mesylate	— 20 mg/kg PO, IM q4h until recovery ³³³ 40 mg/kg IM q24h × 7 days ⁵⁵⁹ 50 mg/kg IM q12h × 14 days ²⁷⁴ 100 mg/kg SC, IM q24h up to 3.5 mo ^{151,438,789} 100 mg/kg SC q24h × 16 wk ⁵⁶⁹	Iron chelator for hemochromatosis; may take 3 mo to see response; may cause reddish discoloration of urine; avoid in birds with renal disease; combine with a low-iron diet; ^{333,438} poorly absorbed from the gastrointestinal tract ⁶¹⁵ Most species Bali mynahs Macaws Most species, including toucans European starlings/PD
Dimercaprol (BAL in Oil, Becton Dickinson)	2.5-5 mg/kg IM q4h × 2 days, then q12h × 10 days or until recovery ³³³ 25-35 mg/kg PO q12h × 3-5 wk ³³³	Most species/heavy metal toxicosis; arsenical compound toxicosis; occasionally used for lead, mercury, and gold intoxication (if ingestion <2 hr); ^{333,615} crosses blood-brain barrier, nephrotoxic, and painful upon injection ^{651,859} Most species/give 5 days/wk
Dimercaptosuccinic acid (DMSA or succimer) (DMSA, Aldrich; Chemet, Bock Pharmacal)	— 25-35 mg/kg PO q12h × 5 day/wk × 3-5 wk ³³³ 25-35 mg/kg PO q24h × 10 days ³³³ 30 mg/kg PO q12h × ≥7 days ³⁴⁹	Oral chelator for lead or zinc; may be effective for mercury toxicity; does not chelate lead from bones; combine with Ca-EDTA in severe cases ^{333,859} Most species, including raptors/lead toxicosis Psittacines, raptors/lead and zinc toxicosis Most species/lead toxicosis

TABLE 5-9 Agents Used in the Treatment of Toxicologic Conditions of Birds. (cont'd)

Agent	Dosage	Species/Comments
Dimercaptosuccinic acid (DMSA or succimer) (DMSA, Aldrich; Chemet, Bock Pharmacal) (cont'd)	35 mg/kg PO q12h × 34 weeks ⁴⁷⁷ 40 mg/kg PO q12h × 21 days ¹⁸⁷	Budgerigars/PD; prevented experimental lead toxicosis Cockatiels/PD; lead toxicosis; reduces lead levels when used alone or in combination with CaEDTA; 80 mg/kg resulted in death in >60% of cockatiels
Diphenhydramine	2 mg/kg PO, IM q12h ⁷⁶⁵	Macaws/used to treat extrapyramidal effects of clomipramine/haloperidol
Grit	3-5 pieces ²¹⁰ 80 particles of fine grit (silica 0.2 mm) or 20 particles of coarse grit (silica, 1-2 mm) ⁴⁷⁷	Most species/reduce size of metal particles Budgerigars/PD; experimental lead particle administration, faster elimination time than controls but not statistically significant
Magnesium hydroxide (M)/activated charcoal (C)	(M) 10-12 mL + (C) 1 tsp powder ³³³	Most species/cathartic; ^a adsorbent
Magnesium sulfate (Epsom salts)	500-1000 mg/kg PO q12-24h × 1-3 days ³³³	Raptors, waterfowl/cathartic used in lead toxicosis to reduce lead absorption; ^a give 30 min after activated charcoal treatment or can cause lethargy ³³³
Peanut butter	1 mL combined with mineral oil (2:1) ⁴⁷⁷	Budgerigars/PD; cathartic; ^a experimental lead particle administration, faster elimination time than controls but not statistically significant
Penicillamine (Cuprimine, Merck)	— 30 mg/kg PO q12h × ≥ 7 days ³⁴⁹ 30-55 mg/kg PO q12h × 7-14 days ³³³ 50-55 mg/kg PO q24h × 1-6 wk ³³³ 55 mg/kg PO q12h × 10 days ⁶⁹⁹	Preferred chelator for copper toxicosis; may be used for lead, zinc, and mercury toxicosis; ³³³ significant gastrointestinal side effects (emesis) ⁶¹⁵ Most species/initially supplemented with CaEDTA once in severe neurologic disease Most species, including raptors, waterfowl Most species, including psittacines, raptors/use in combination with CaEDTA for several days followed by penicillamine × 3-6 wk ⁷¹³ Most species
Phytonadione	—	See vitamin K

Continued

TABLE 5-9 Agents Used in the Treatment of Toxicologic Conditions of Birds. (cont'd)

Agent	Dosage	Species/Comments
Pralidoxime (2-PAM) (Protopam, Wyeth-Ayerst)	— 10-100 mg/kg IM q24-48h or repeat once q6h ³³³ 100 mg/kg IM once ⁷³⁵ 100 mg/kg IM once ⁷³⁶	Administer within 24-36 hr of organophosphate intoxication; use lower dose in combination with atropine; ³³³ contraindicated for some carbamate poisoning ⁶⁵¹ Psittacines, raptors, waterfowl Raptors/monocrotophos toxicosis Goslings/PD; experimental diazinon toxicosis; lower dosages (25-50 mg/kg) were less effective
Psyllium (Metamucil)	1 mL of a solution made of ½ tsp diluted in 60 mL of water ⁴⁷⁷	Budgerigars/PD; cathartic; ^a experimental lead particle administration, similar elimination time than controls
Sodium sulfate (Glauber's salt) (GoLyteLy, Brintree; Anhydrous sodium sulfate, ACS Grade, Fisher Scientific)	— 500 mg/kg PO q48h ¹⁸⁷ 500-2000 mg/kg PO ³³³ 2000 mg/kg PO q24h × 2 days ³³³	Cathartic; ^a contraindicated with impaired gastrointestinal function; maintain hydration ³³³ Cockatiels/PD; did not result in further decrease in lead concentrations when given to birds receiving CaEDTA alone or in combination with DMSA Most species Most species
Succimer (Chemet, Bock Pharmacal)	—	See dimercaptosuccinic acid (DMSA)
Tea (black tea leaves) (Ceylon CO ₂ -decaffeinated tea leaves, Frontier Natural)	8 g/kg diet ⁷²⁷	Starlings/hepatic iron concentrations did not increase significantly in starlings on an iron-enriched diet when supplemented with tea leaves; tea containing approximately 20% (by weight) condensed tannins were blended directly into the food mixture (8 g/kg diet)
Tetanus antitoxin (equine)	50 U IV over 15 min ⁶¹	Falcons/tetanus
Vitamin K ₁	0.2-2.2 mg/kg IM q4-8h until stable, then q24h PO, IM × 14-28 days ^{333,651} 2.5 mg/kg SC q12h ⁵³⁸	Most species, including raptors/rodenticide anticoagulant toxicosis Red-tailed hawks/secondary brodifacoum toxicosis

^aCathartics increase gastrointestinal motility and are used to evacuate the gut and prevent absorption of toxins.

TABLE 5-10 Psychotropic and Antiepileptic Agents Used in Birds.^a

Agent	Dosage	Species/Comments
Amitriptyline	— 1-5 mg/kg PO q12-24h ³³³ 1.5-4.5 mg/kg ⁸³⁵ 2 mg/kg PO q24h ²²³ 9 mg/kg ⁶³⁵	Tricyclic antidepressant; inhibits serotonin and norepinephrine reuptake; strong antihistamine effect ^{497,818} Most species/feather-damaging behavior, anxiety, phobia; ⁴⁹⁷ severe extrapyramidal side effects encountered in a blue and gold macaw at 5 mg/kg PO ⁵⁵ African grey parrots, cockatoos/PK; erratic plasma concentrations generally below therapeutic levels Psittacines/minimum of 30 days African grey parrots, cockatoos/PK; good levels but unpredictable half-life, toxicity in 1/3 African grey parrots
Buspirone HCl	0.5 mg/kg PO q12h ³⁸⁹	Anxiolytic; used to control behavior interpreted as paradoxical anxiety caused by clomipramine
Carbamazepine	3-10 mg/kg PO q24h ³³³ 166 mg/L drinking water ³³³	Most species/anticonvulsant, analgesic; may cause bone marrow suppression (including aplastic anemia and agranulocytosis) and hepatotoxicity; combination with chlorpromazine or haloperidol recommended for initial treatment during the first 2 wk ³³³
Chlorpromazine	— 0.1-0.2 mg/kg IM once ³³³ Mix 1 mL stock solution/120 mL drinking water or 0.2-1 mL/kg stock PO q12-24h prn ³³³	Phenothiazine; dopamine antagonist ³³³ used in some cases of feather picking; correct underlying problems and discontinue within 30 days; efficacy diminishes in 14-30 days when given PO; may cause ataxia, regurgitation, drowsiness ³³³ Cockatoos, ringneck parakeets/use with carbamazepine following removal of Elizabethan collar; mild sedation and decreases obsessive behaviors Most species/stock solution: crush five 25 mg tablets and mix with 31 mL simple syrup; start at low dose initially; mild sedation
Clomipramine	—	Most selective for serotonin reuptake inhibition among tricyclic antidepressants; antihistamine; may cause regurgitation, drowsiness; adverse effects in mammals include cardiac conduction abnormalities, tachyarrhythmias, postural hypotension, dry mucous membranes, urinary retention, constipation, and lowering of the seizure threshold; ³⁸⁹ anecdotal reports of death in birds possibly associated with preexisting arrhythmias; ³³³ wait 2-3 wk before adjusting dose; ³³³ reports of illness, extrapyramidal signs, and death reported in macaws; ⁷⁶⁵ indicated for compulsive disorders, feather-damaging behavior, and anxiety; ^{497,818} contraindicated for aggressive behaviors ⁴⁹⁷

Continued

TABLE 5-10 Psychotropic and Antiepileptic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Clomipramine (cont'd)	0.5-1 mg/kg PO q12-24h ³³³	Psittacines/feather-damaging behavior; self-mutilation; start with low dose and gradually increase over 4-5 days
	1 mg/kg PO q24h or divided q12h × 6 wk ⁶³⁶	Psittacines/feather-damaging behavior; occasional regurgitation and drowsiness observed; 2/11 birds decreased feather picking ⁶³⁶
	1-2 mg/kg PO q24h ³³³	Psittacines/begin with 1 mg/kg and increase if needed
	3 mg/kg PO q12h ⁷³⁰	Cockatoos/PD; placebo-controlled clinical trial; no appreciable deleterious side effects; no significant differences between baseline and post-treatment bloodwork or body weight; significant decrease in feather-damaging behavior at 3 and 6 wk
	4-8 mg/kg PO q12h ³⁸⁹	African grey parrots/behavior interpreted as paradoxical anxiety; combine with anxiolytic therapy (buspirone)
Clonazepam	0.5 mg/kg PO q12h ⁶²	African grey parrot/antiepileptic; developed tolerance after 7 mo
Delmadinone (Tardak, Pfizer)	1 mg/kg IM once ³³³	Psittacines/sexual behavior problems; not available in the United States
Deslorelin (Suprelorin, Virbac)	4.7 mg implant ²⁵⁴	Parrots, birds of prey/decrease reproduction-related behavior
Diazepam	—	Benzodiazepine sedative; anxiolytic/stress-associated feather picking; useful as sole agent or in combination with phenobarbital for seizure control
	0.25-0.5 mg/kg IM, IV q24h × 2-3 days ⁷⁷⁹	Raptors/appetite stimulant
	0.5 mg/kg PO ²⁸⁰	'Amakihi/calm fractious species while improving acceptance to a novel captive diet; oral solution (1 mg/mL; Roxane Laboratories) worked best
	0.5-0.6 mg/kg IM ³³³	Most species/facilitates acceptance of Elizabethan collar, especially in lovebirds
	0.5-1.5 mg/kg IM, IV q8-12h ³³³	Most species/control of seizures
	2.5-4 mg/kg PO q6-8h ³³³	Psittacines/sedation
	10-20 mg/L drinking water ³³³	Most species
1 mg/kg/h IV, CRI, decrease after 12-24 hr without seizures ¹⁸⁶	Most species	
Diphenhydramine	—	Antihistamine; mild hypnotic effects; suspected allergic feather picking
	2 mg/kg PO, IM q12h ⁷⁶⁵	Blue and gold macaw/treatment of extrapyramidal side effects of a haloperidol/clomipramine combination
	2-4 mg/kg PO q12h ^{333,497}	Most species
	2 mg/L drinking water ^{333,497}	Most species

TABLE 5-10 Psychotropic and Antiepileptic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Doxepin	— 0.5-1 mg/kg PO q12h ³³³ 1-2 mg/kg PO q12h ³³³	Tricyclic antidepressant; antihistamine; dose may be increased at 14-day intervals; ³³³ may cause sedation ³³³ Most species/feather picking Psittacines/anxiety; pruritis
Fluoxetine	— 0.4-4 mg/kg PO q24h ³³³ 1 mg/kg PO q24h ^{333,728} 1-4 mg/kg q24h, up to 20 mg/kg ⁴⁹⁷ 2-3 mg/kg PO q12-24h ³³³	Selective serotonin reuptake inhibitor; antidepressant; adjunctive treatment for depression-induced feather picking, compulsive disorders, phobia, aggression ⁴⁹⁷ Psittacines/compulsive feather picking Psittacines Parrots Most species, including psittacines
Gabapentin	11 mg/kg PO q8h ⁸⁶⁴ 15 mg/kg PO q8h ⁴³ 20 mg/kg PO q12h ⁶²	Great horned owl/PK Hispaniolan Amazon parrots/PK African grey parrot/seizures
Haloperidol (Haldol, McNeil)	— 0.1-0.2 mg/kg PO q12-24h ³³³ 0.1-0.4 mg/kg PO q12-24h ³³³ 0.2-0.9 mg/kg PO q24h ^{333,497} 1-2 mg/kg IM q14-21d ³³³ 6.4 mg/L drinking water × 7 mo ³⁶⁰	Butyrophenone dopamine antagonist tranquilizer; may work best with self-mutilators; ⁸¹⁸ may cause anorexia, depression, hypotension, bradycardia, ataxia, sedation. ⁸¹⁸ extrapyramidal signs and/or death reported in various species of macaw; ^{447,765} Quaker parrots and cockatoos may be more sensitive to side effects ⁸¹⁸ Birds weighing > 1 kg Psittacines/dose may be increased in increments of 0.1 mg/kg if no response is seen in 5-7 days and no adverse effects are observed Most species/stereotypic preening behavior Most species, including psittacines African grey parrots/feather picking
Hydroxyzine	— 2 mg/kg PO q12h ³³³ 2-2.2 mg/kg PO q8h ^{333,428,497} 30-40 mg/L drinking water ³³³	Antihistamine with mild sedative effects Most species/pruritis Most species/feather picking Most species
Leuprolide acetate	100-1000 µg/kg q2wk for 3 treatments ⁴⁹⁷ 500 µg/kg; BW >300 g ⁴⁹⁷ 750 µg/kg; BW ≤300 g ⁴⁹⁷	Parrots/hormonal feather-damaging behavior Parrots/sexual behaviors Parrots/sexual behaviors
Levetiracetam	5.4-190 mg/kg PO q8-12h ⁸³⁴ 50 mg/kg PO q8h ⁷¹⁷ or 100 mg/kg PO q12h ⁷¹⁷ 50-100 mg/kg PO q8h ⁶²	African grey parrots/PK; population PK; short half-life (2.3 hr); no dose recommendation, but q8h recommended Hispaniolan Amazon parrots/PK African grey parrot/seizures; therapeutic drug monitoring was performed

Continued

TABLE 5-10 Psychotropic and Antiepileptic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Lorazepam	— 0.1 mg/kg PO q12h ³³³	Benzodiazepine with anxiolytic and sedative effects Macaws/aggression; feather picking; use alone or with haloperidol
Megestrol acetate (Ovaban, Schering)	— 2.5 mg/kg PO q24h × 7 days then 1-2 ×/wk ³³³	Progestin providing nonspecific calming effects; side effects can be severe (diabetic-like); seldom used ⁴³³ Psittacines/feather picking; reproductively associated behavior problems
Naloxone HCl	2 mg/kg IV ³³³	Psittacines/opioid antagonist; may be used to determine the response of stereotypic behavior to antagonist therapy; reduction of the behavior should be observed within 20 min
Naltrexone HCl	1.5 mg/kg PO q8-12h × 1-18 mo ³³³	Most species/opioid antagonist; feather-damaging behavior; self-mutilation; contraindicated in patients with liver disease; may need to increase dosage 2-6 × to be effective; dissolve tablet in 10 mL sterile water; preservative does not go into solution
Nortriptyline (Pamelor, Sandoz)	16 mg/L drinking water (2 mg/120 mL) ^{333,497}	Most species/tricyclic antidepressant; feather-damaging behavior; seldom used; decrease dose or discontinue if hyperactivity develops; taper dose to discontinue
Paroxetine	1-2 mg/kg PO q24h ^{333,497} 3 mg/kg PO q24h ³⁹⁵ 4 mg/kg PO q12h, bulk chemical compounded in water ⁸²⁰	Macaws, ibis/selective serotonin reuptake inhibitor (SSRI); feather-damaging behavior; self-mutilation; generally requires long-term therapy; fewer side effects than tricyclic antidepressants and other SSRIs ⁸¹⁸ Waldrapp ibis African grey parrots/PK; slow absorption and low oral bioavailability; bioavailability increased with repeated dosing; commercial oral suspension (Seroxat) resulted in nondetectable plasma levels; large individual differences
Phenobarbital sodium	— 1-5 mg/kg IV bolus ³³³	Barbiturate anticonvulsant; mild sedative effect; long-term seizure management; adjust dosage based on blood levels; may cause deep sedation and inability to perch; hepatotoxic; oral formulations may not reach therapeutic plasma levels in parrots ^{62,620} Most species/status epilepticus; begin at low end of dosage range and increase for refractory seizures

TABLE 5-10 Psychotropic and Antiepileptic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Phenobarbital sodium (cont'd)	1-7 mg/kg PO q8-12h ³³³	Most species/feather picking; mild sedative effect
	2 mg/kg PO q12h ⁶²	African grey parrot/antiseizure, therapeutic drug monitoring did not show detectable plasma level
	2-7 mg/kg PO q12h ³³³	Most species, including Amazon parrots/seizures; self-mutilation
	17 mg/kg PO ⁶²⁰	African grey parrots/PD; used diluted commercial intravenous solution and compounded suspension, plasma levels below therapeutic levels
	50-80 mg/L drinking water ³³³	Most species, including Amazon parrots/idiopathic epilepsy
Potassium bromide	—	Long-term seizure management; use as sole agent or in conjunction with phenobarbital; monitor blood levels which may take up to several weeks to establish steady state; not available in approved dosage forms in North America; may be obtained from chemical companies or compounding pharmacies; for a concentration of 250 mg/mL, add distilled water as needed to 25 g of potassium bromide for a final volume of 100 mL
	25 mg/kg PO q24h ³³³	Most species
	50-80 mg/kg PO q24h ³³³	Pigeons
	75 mg/kg PO ³³³	Psittacines
	80 mg/kg PO q24h ⁹⁵	Umbrella cockatoo/serum drug levels ranged from 1.7-2.2 mg/mL
	80 mg/kg PO q12h × 3 days, then 20-200 mg/kg PO q12h ⁶²	African grey parrot/antiseizure; therapeutic drug monitoring showed plasma level below therapeutic levels (<0.7 mg/mL)
Zonisamide	20 mg/kg PO q8h ⁶²	African grey parrot/antiseizure; therapeutic drug monitoring performed
	20 mg/kg PO q12h ⁷⁰⁶	Hispaniolan Amazon parrots, chickens/PD; 2/8 chickens of multiple escalating dose study developed immune-mediated anemia
	19.8-80 mg/kg PO q8-12h ⁸³⁴	African grey parrots/PK; population PK; half-life was highly variable (10.9 ± 18 hr), no dose recommendation but q8-12h recommended

^aThe use of psychotropic agents in birds is controversial because safety, efficacy, and pharmacologic effects are poorly documented;⁸¹⁸ anxiolytics or tricyclic antidepressants may be useful for stereotypic behaviors or mutilation; selective serotonin reuptake inhibitors may prove helpful for compulsive behaviors; consider metabolic scaling when calculating dosages; these treatments should be used as components of a structured behavior-change strategy.

TABLE 5-11 Nutritional/Mineral Support and Supplementation Used in Birds.

Agent	Dosage	Species/Comments
Biotin	0.05 mg/kg PO q24h × 30-60 days ³³³	Raptors/beak and nail regrowth
Brewer's yeast	30 mg/bird in feed ³³³	Pigeons/brittle plumage; use daily during molt
Calcium	— 3-7 mg/kg feed (0.3%-0.7%) ¹⁷⁷ 3-10 mg/kg feed (0.3%-1%) ³³³ 3.5 mg/kg feed (0.35%) ⁴²² 8.5 mg/kg feed (0.85%) ⁴²²	Recommended dietary levels; ^a higher dietary levels than in commercial food were found in wild macaw chicks (1.4%) ¹⁰³ Maintenance diet for most birds Laying parrots Egg-laying cockatiels Egg-laying budgerigars
Calcium borogluconate (10%)	10 mg/kg PO q24h ⁷⁶⁴ 50-100 mg/kg IM, IV ³³³ 100-500 mg/kg SC, IV (slow) once ³³³ 300 mg/kg IV ³³³	African grey parrots/hypocalcemia; in addition to UV _B supplementation and diet correction Psittacines/20% solution Raptors/hypocalcemia Goshawks
Calcium chloride	150-200 mg/kg IM, IV (slow) q8h ³³³	Hypocalcemia; seldom used
Calcium gluconate	— 23 mg/kg PO q24h ³³³ 25 mg/kg PO ³³³ 150 mg/kg PO q12h ³³³ 750 mg/L drinking water ³³³	Most species/hypocalcemia, calcium supplementation Psittacines (neonates) Most species, including raptors Most species Most species
Calcium gluconate (10%)	— 5-10 mg/kg IV slowly to effect ³³³ 5-10 mg/kg SC, IM q12h prn ³³³ 10-100 mg/kg IM ³³³ 25-50 mg/kg SC, IV (slow) ³³³ 50-100 mg/kg IM (diluted), IV (slow) ³³³ 50-150 mg/kg IV over 15-20 minutes ⁵⁴ 100-300 mg/kg SC diluted 1:1-2 with fluids ⁵⁵ 100-500 mg/kg SC, IV (slow) once ³³³ 1 mL/30 mL (3300 mg/L) drinking water ³³³	Hypocalcemia; dilute 1:1 with saline or sterile water for IM or IV injections Psittacines/hypocalcemic tetany Psittacines Psittacines/acute presentation of hypocalcemia Pigeons Most species, including psittacines, pigeons, raptors Ionized hypocalcemia, hyperkalemia Most species Raptors/hypocalcemia Psittacines/calcium supplementation
Calcium lactate/calcium glycerophosphate (Calphosan, Glenwood)	5-10 mg/kg IM q7d prn ³³³ 50-100 mg/kg IV (slow bolus) once ³³³	Most species, including raptors/hypocalcemia African grey parrots

TABLE 5-11 Nutritional/Mineral Support and Supplementation Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Calcium levulinatate	75-100 mg/kg IM, IV ³³³	Most species/hypocalcemia
L-carnitine	1000 mg/kg feed ¹⁷⁹	Budgerigars/PD; lipomas; average lipoma size decreased significantly
Dextrose (50%)	50-100 mg/kg IV (slow bolus) to effect ³³³ 500-1000 mg/kg IV (slow bolus) ³³³	Psittacines/hypoglycemia; can dilute with fluids Hypoglycemia; can dilute with fluids
Diatrizoate meglumine sodium (37% iodine) (Renografin-76, Solvay)	— 122 mg/kg IM ³³³	Parenteral treatment of goiter is generally reserved for emergency situations Budgerigars/thyroid hyperplasia
Essential fatty acids	0.5 mL/kg PO q24h × 50 days or indefinitely ³³³	Raptors/pruritic dermatitis (atopy)
Fatty acids (omega-3, omega-6)	0.1-0.2 mL/kg of flaxseed oil to corn oil mixed at a ratio of 1:4 PO or added to food; ratio of omega-6:omega-3 is 4-5:1 ³³³ 0.11 mL/kg q24h in a 5:1 ratio of omega-6:omega-3 ³³³ 10% flaxseeds ⁶⁰⁴ α -linolenic acid, 0.2%-4% of daily energy ⁶⁰³	Psittacines, pigeons/glomerular disease; used to reduce thromboxane A ₂ synthesis in platelets and glomerular cells; adjunct therapy for arthritis, feather picking, mutilators, and neoplasia; 2-4 wk of therapy are required to recognize effects; may increase dietary vitamin E requirements; consider supplementation with chronic use Psittacines/glomerulonephritis, pancreatitis Quaker parrots/PD; shift in HDL subgroups, higher plasma phospholipid omega-3 fatty acids Quaker parrots/PD; no change in blood cholesterol compared to control group, changes in polyunsaturated fatty acid blood profile
Hemicellulose (Metamucil, Searle)	— 0.5 tsp/60 mL hand-feeding formula or baby food gruel ³³³ 1 Tbs/60 mL water q24h ⁸⁰⁶ 1 mL of solution of ½ tsp diluted in 60 mL of water ⁴⁷⁷	For bulk in diet; facilitates defecation in bowel deficit disorders and other conditions Psittacines/bulk diet to delay absorption of an ingested toxin Ostrich chicks/impaction Budgerigars/no difference from controls in elimination rate of ventricular lead particles
Inositol	20 g/kg of food ^{569,570}	Starlings/PD; not effective to decrease liver stored iron but prevented an increase in stored iron concentration

Continued

TABLE 5-11 Nutritional/Mineral Support and Supplementation Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Iodine (Lugol's iodine)	0.2 mL/L drinking water daily ³³³ 2 parts iodine + 28 parts water; 3 drops into 100 mL drinking water ³³³	Most species/thyroid hyperplasia Budgerigars/thyroid hyperplasia
Iodine (sodium iodide 20%)	— 2 mg (0.01 mL)/bird IM prn ³³³ 60 mg (0.3 mL)/kg IM ³³³	Parenteral treatment of goiter is generally reserved for emergency situations or initial treatment of severe thyroid dysplasia; continue with oral therapy when improvement is noted Budgerigars Most species/thyroid hyperplasia
Iron	20-60 mg/kg feed ^{333,438,468,569}	Species susceptible to iron storage disease/levels recommended for a low-iron diet
Iron dextran	10 mg/kg IM, repeat in 7-10 days prn ³³³	Most species, including raptors, waterfowl/iron deficiency anemia; use cautiously in species in which iron storage disease is common (e.g., toucans, mynahs, starlings, birds of paradise, other passerines)
<i>Lactobacillus</i> (Bene-Bac, Pet-Ag)	1 pinch/day/bird ³³³	Psittacines/stimulation of normal gastrointestinal flora regrowth
<i>Lactobacillus acidophilus</i>	0.25 g/dose mixed with diet, 2.5-6 × 10 ⁶ CFU/dose ⁸⁰⁵ 1 tsp/L hand-feeding formula ³³³	Neonatal cockatiels/PD; increased growth rate in birds receiving the gel form, no effect in birds receiving the powder form; no overall benefit noted Most species
Magnesium sulfate	20 mg/kg IM ⁴⁰⁴	African grey parrot/dietary hypomagnesemia and seizures
Niacin (nicotinic acid)	50 mg/kg PO q8h ³³³	Psittacines/yolk emboli; give with gemfibrozil (30 mg/kg PO)
Pancreatic enzyme powder (Viokase-V Powder, Fort Dodge)	— 2-5 g/kg ³³³ ½ tsp/kg feed ³³³ ½ tsp/60-120 g lightly oil-coated seed ³³³ ½ tsp/30-120 mL hand-feeding formula prn ³³³	Most species/exocrine pancreatic insufficiency; maldigestion; mix with food and let stand 30 min ³³³ Most species Most species Most species Psittacine neonates
Phytonadione	—	See vitamin K ₁
Potassium chloride (KCl)	0.5 mEq/kg PO q12h ⁵⁵	Most species/hypokalemia
Selenium (Seletoc, Schering)	0.05-0.1 mg Se/kg IM q14d ³³³ 0.06 mg Se/kg IM q3-14d ³³³	Most species/neuromuscular diseases (capture myopathy, white muscle disease, some cardiomyopathies); may be useful in some cockatiels with jaw, eyelid, and tongue paralysis

TABLE 5-11 Nutritional/Mineral Support and Supplementation Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Sodium chloride (buffered salt tablet)	450 mg PO daily ³³³	Penguins/prevents atrophy of salt gland; may not be needed ⁸³⁸
Tannic acid	20 g/kg feed ^{569,570}	Starlings/PD; not effective to decrease liver-stored iron but prevented an increase in stored iron concentration
Tea (black Ceylon decaffeinated)	8 g/kg feed ⁷²⁷	Starlings/PD; effectively limited iron absorption
Vitamin A (Aquasol A Parenteral, Astra)	— 200 U/kg IM ³³³ 2000 U/kg PO, IM ³³³ 5000 U/kg IM q24h × 14 days, then 250-1000 U/kg q24h PO ³³³ 20,000 U/kg IM ³³³ 33,000 U/kg (10,000 U/300 g) IM q7d ³³³ 50,000 U/kg IM q7d ³³³ 1 mL/135 kg IM ³³³	1 μg = 14 U; 1 μg retinol = 3.3 U; 1 μg beta-carotene = 1.7 U; 3000 μg/kg dietary vitamin A after 269 days induced increased plasma retinol, splenic hemosiderosis and altered vocalization patterns in cockatiels; ⁴²³ toxicosis may follow oversupplementation ^{423,583} Raptor juveniles/supplemental therapy for pox infection Psittacines/adjunctive therapy for pox infection Psittacines/adjunctive therapy for respiratory or epithelial disease Most species/hypovitaminosis A; maximum dose; improves skin healing Most species/hypovitaminosis A Psittacine neonates Ostriches/hypovitaminosis A
Vitamin B1 (thiamine)	— 1-2 mg/kg PO q24h ³³³ 1-2 mg/kg IM q24h ³³³ 1-3 mg/kg IM q7d ³³³ 1-50 mg/kg PO q24h × 7 days or indefinitely ³³³ 2 mg/kg IM ⁸⁰⁶ 3-30 mg/kg IM q7d ³³³ 4 mg/kg IM once, then 2 mg/kg PO q12h × 5 days ¹¹⁶	Thiamine deficiency; requirements may be higher if thiaminase is present in diet ^b Raptors, penguins, cranes/daily supplement Vultures, raptors, cranes, penguins/CNS signs Most species, including raptors Raptors Ratites/curly toe paralysis Raptors/stimulates appetite, hematopoiesis; neuromuscular disease; liver disease; supportive therapy; adjunct to sulfa therapy Juvenile goshawks/thiamine deficiency with neurologic signs

Continued

TABLE 5-11 Nutritional/Mineral Support and Supplementation Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Vitamin B ₁ (thiamine) (cont'd)	1-2 mg/kg feed ³³³ 25-30 mg/kg fish (wet basis) ⁷⁴ 2850 mg/L drinking water q7d ³³³	Vultures Piscivorous species/recommended level of supplementation Pigeons
Vitamin B ₁₂ (cyanocobalamin)	0.25-0.5 mg/kg IM q7d ³³³ 2-5 mg/bird SC	Most species, including psittacines, raptors/anemia Pigeons/vitamin B ₁₂ deficiency
Vitamin B complex	—	Usually dosed based on thiamine (see vitamin B ₁); death has been reported in falcons following injections, which was attributed to an overdose of vitamin B ₆ (pyridoxine); ⁶⁹⁹ has been used to treat folate and cobalamin dietary deficiency in a hyacinth macaw ²⁹⁹
Vitamin C (ascorbic acid)	20-50 mg/kg IM q1-7d ³³³ 150 mg/kg PO q24h ³¹³	Most species, including raptors/nutritional support; supplemental therapy for pox infection Willow ptarmigan chicks/PD; supplemental daily requirements over 265 mg/kg diet
Vitamin D ₃ (Vital E-A + D, Schering)	3300 U/kg (1000 U/300 g) IM q7d prn ³³³ 5000 U IM once, then 200 U PO q24h × 88d ⁴²⁴ 6600 U/kg IM once ³³³	1 µg = 40 U; macaws are more susceptible to toxic side effects; vitamin D ₂ is poorly effective in birds ¹⁷⁷ Most species/hypovitaminosis D ₃ ; hypervitaminosis D may occur with excessive use Red-legged seriema chicks/hypovitaminosis D, in combination with UV _B supplementation Most species
Vitamin E (Vitamin E20, Horse Health Products; Bo-SE, Schering Plough)	— 0.06 mg/kg IM q7d ³³³ 0.06 mg/kg IM ²⁸⁰⁶ 15 mg/kg PO once ⁴⁸⁷ 70 mg/kg IM q24h for up to 5 days ⁸⁷³ 200-300 mg/kg IM ³³³ 200-400 mg/bird PO q24h ³³³	1 mg d α-tocopherol acetate = 1.5 U; 1 mg dL α-tocopherol acetate = 1.1 U; injectable vitamin E may have lower efficacy than oral ⁴⁸⁷ Psittacines/hypovitaminosis E Ratites/prevention or treatment of capture myopathy Swainson's hawks/PK; administer without food Pelicans/hypovitaminosis E; steatitis Ostrich chicks Great blue herons

TABLE 5-11 Nutritional/Mineral Support and Supplementation Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Vitamin E (Vitamin E20, Horse Health Products; Bo-SE, Schering Plough) (cont'd)	73.5 mg/kg fish (wet basis) ⁸⁷³	Pelicans/supplementation; excessive supplementation (550-10,560 U/kg) has been associated with coagulopathy in pink-backed pelicans ⁵⁵⁷
	100 mg/kg fish (wet basis) ^{74,873}	Piscivorous species/recommended level of supplementation
	4400-8800 mg/kg feed ³³³	Ostrich chicks/hypovitaminosis E
Vitamin E/ γ -linolenic acid (2%), linoleic acid (71%) (Derm Caps, DVM Pharmaceuticals)	0.1 mL/kg PO q24h ³³³	Most species/feather picking; use liquid from gel caps
Vitamin K1 (phytonadione)	0.025-2.5 mg/kg IM q12h ³³³	Most species
	0.2-2.2 mg/kg IM q4-8h until stable, then q24h \times 14 days ³³³	Most species, including raptors/rodenticide toxicity
	2.5 mg/kg SC q12h ⁵³⁸	Red-tailed hawk/treatment of brodifacoum toxicosis
	2.5 mg/kg IM q24h until hemostasis, then q7d prn ³³³	Psittacines/vitamin K responsive disorders; hematochezia; coagulopathy
	5 mg/kg IM q24h for several days ⁸⁰⁶	Ratites/coagulopathy
	10-12.5 mg/kg SC q12h \times 4 days ⁸⁷³	Pelicans/coagulopathy
	10-20 mg/kg IM q12-24h ³³³	Psittacines
	0.1 mg/kg feed ³³³	Turkeys/PD; as effective as 1-2 mg/kg in reducing plasma prothrombin time
5 mg/kg feed ³³³	Budgerigars/vitamin K responsive bleeding disorders; mix contents of gel cap into small grain seed mix and coat seed lightly	

^aGrains and seeds commonly fed to parrots contain calcium levels of approximately 0.02%-0.1% DM.

^bFood items known to contain appreciable amounts of thiaminase include clams, herring, smelt, and mackerel.⁷⁴

TABLE 5-12 Ophthalmologic Agents Used in Birds.^a

Agent	Dosage	Species/Comments
Amphotericin B	125 μ g/5 mL sterile water subconjunctival ¹⁵⁶	Ducks (ornamental)/candidiasis of third eyelid
Amphotericin B ointment (4%) (formulated)	Topical q24h ¹⁵⁶	Ducks (ornamental)/candidiasis of third eyelid; administered in conjunction with systemic antifungal therapy
Atracurium	0.05 μ L intracameral ¹²⁷	Great horned owls/mydriasis for cataract surgery
	0.01 mg intracameral ⁵⁵	Parrots/mydriasis for cataract surgery

Continued

TABLE 5-12 Ophthalmologic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Atropine (0.4%-0.5%)	0.6 mg/bird topical ⁶³³ Topical ³³³	Cockatoos/PD; partial mydriasis; some birds have iridal smooth muscle; may cause ocular irritation, weakness, shallow breathing; dilute with 0.9% saline ^a Ratites/partial mydriasis; use in combination with curariform drugs; some ratites have iridal smooth muscle ^a
Atropine (1%)	1 drop topical ⁴⁶²	Double-crested cormorants/PD; no mydriasis when used alone
Bacitracin/neomycin/polymyxin B sulfate	Small bead topical ³³³	Most species/antibiotic; corneal ulcers, conjunctivitis; excessive amounts will cause eye wiping and soiled plumage
Chloramphenicol ophthalmic drops	1 drop topical q6-8h ³³³	Pigeons/antibiotic
Ciprofloxacin HCl (0.3%) (Ciloxan, Alcon)	1 drop topical q4-8h ³³³ 1 drop topical q12h; use in conjunction with tylosin 1 mg/mL drinking water × 21-77 days ⁵⁰¹	Most species/antibiotic; corneal ulcers, conjunctivitis (e.g., <i>Chlamydia</i> , <i>Mycoplasma</i>) House finches/PD; <i>Mycoplasma gallisepticum</i> conjunctivitis
Demecarium bromide (0.125%)	1 drop topical ³³³	Most species/topical anesthetic; allows removal of <i>Thelazia</i>
Dexamethasone (0.1%) ophthalmic drops	— 1 drop topical q4-8h ³³³	Pigeons/PD; ophthalmic administration results in significant adrenocortical suppression for 24 hours at 4 μg/drop ⁸⁴⁴ Raptors/traumatic anterior uveitis without corneal ulceration
Diclofenac	1 drop topical q12h ⁵⁵	Most species/caution in species susceptible to toxicosis (<i>Gyps</i> vultures, pigeons) ⁵⁶³
Edetate disodium ophthalmic drops	1 drop several times daily ³³³	Most species/used to treat calcific keratopathy
Fumagillin (Fumidil B; Mid-Continent Agrimarketing)	1 drop topical q2h ¹¹⁵ 0.114 mg/mL drops q2-3h until 1 wk postclinical signs ⁷⁵¹ 60 mg in sterile water topical ⁷⁵¹	Amazon parrots/fungal and microsporidial keratoconjunctivitis in combination with oral albendazole Lovebirds/ <i>Encephalitozoon hellem</i> conjunctivitis; use in combination with albendazole Most species/filter solution to remove bacteria before applying
Gentamicin sulfate	1 drop topical q4-8h ³³³ 1 drop topical q12h × 21 days ⁸⁴²	Most species/antibiotic; corneal ulcers; causes irritation House finches/PD; mycoplasmosis treatment, in combination with oral enrofloxacin, was not effective
Isoflurane	1%-2% maintenance ³³³ 1%-2.4% maintenance by air sac perfusion ^{120,418b}	Most species/mydriasis ^a Most species/mydriasis, ^a ocular surgery

TABLE 5-12 Ophthalmologic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Miconazole (Monistat IV, Janssen)	1 drop topical q2h ¹¹⁵	Amazon parrots/fungal keratitis
Miconazole vaginal cream (2%) (Monistat, Ortho-McNeal)	Topical ⁷ Topical q24h × 7d ⁴⁰¹	Most species/antifungal Ring-billed gulls/third eyelid candidiasis
Natamycin (Natacyn, Alcon)	1 drop topical q6h ³³³	Most species/antifungal; gradually taper off
Neomycin/polymixin B/dexamethasone (0.1%)	1 drop topical q8-24h ¹²⁷	Great horned owl/post cataract surgery
Neomycin/polymyxin B/gramicidin	1 drop topical q2-8h ³³³	Most species/antibiotic; corneal ulcers; conjunctivitis
Oxybuprocaine (0.45%)	Topical ⁴²¹	Pigeons, buzzards/topical anesthetic of choice due to reliable effect with minimal side effects
Oxytetracycline/polymyxin B (Terramycin, Zoetis)	Small bead topical ³³³	Most species/antibiotic; conjunctivitis; excessive amounts will cause eye-wiping and soiled plumage
Phenylephrine (2.5%)	Topical ³³³	Ratites/partial mydriasis; use in combination with curariform drugs; some ratites have iridal smooth muscle ^a
Phenylephrine (4%-5%)	— 6 mg/bird topical ⁶³³ Topical ⁴⁶²	4%-5% ophthalmic solution is not available in the United States Cockatoos/PD; partial mydriasis; ^a some birds have iridal smooth muscle; may cause ocular irritation, weakness, shallow breathing; dilute with 0.9% saline Cormorants/PD; mydriasis; use in combination with vecuronium bromide and atropine
Phenylephrine (10%)	2 drops topical, diluted to 1% ^{275,276,852}	Various species/diagnosis of Horner's syndrome
Pimaricin (Natacyn, Alcon)	1 drop topical q6h, taper after 14-21 days ³³³	Most species/polyene antifungal
Prednisolone acetate	—	Pigeons/PD; ophthalmic administration results in significant adrenocortical suppression for 4 hr at 35 μg/drop ⁸⁴⁴
Prednisolone acetate (1%)	1 drop topical q4-8h ³³³	Raptors/traumatic anterior uveitis without corneal ulceration
Prednisolone acetate (0.12%)	1 drop topical q4h ³³⁰	Macaw/treatment of uveitis and hyphema secondary to lymphoma
Proxymetacaine (proparacaine) (0.5%)	Topical ⁴²¹ 1 drop/eye topical ⁷⁷³	Topical anesthetic Hispaniolan Amazon parrots/PD; at 10 minutes: no difference in phenol red thread test values, lower Schirmer tear test values

Continued

TABLE 5-12 Ophthalmologic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Rocuronium bromide (1%)	20 μ L/eye ⁶⁰²	Hispaniolan Amazon parrots/PD; mydriasis from 20 to 360 min; some birds had transient palpebral paresis
	0.12 mg/eye ⁴⁷	European kestrels/PD; maximal mydriasis at 90 min, onset of action 20 min, duration of action 250 min
	0.15 mg/eye ⁴¹	Hispaniolan Amazon parrots/PD; mydriasis starting at 5-10 min and lasting 360 min
	0.2 mg/eye ⁴⁵	Little owls/PD; maximal mydriasis at 40 min, onset of action 20 min, duration of action 290 min
	0.35-0.7 mg/eye ⁴⁶	Tawny owls/PD; maximal mydriasis at 60-80 min (depending on dose), onset of action 20 min, duration of action 240 min
	0.4 mg/eye ⁴⁵	Common buzzards/PD; maximal mydriasis at 90 min, onset of action 20 min, duration of action 240 min
Tetracaine (6%)	Topical ⁴²¹	Topical anesthetic
Tissue plasminogen activator (rTPA) (activase)	400 μ L via injection ²²	Great horned owls/hyphema
	25 μ g intracameral ⁵⁵	Prevention of hyphema post-cataract surgery
Tissue plasminogen activator (rTPA) (TNKase Tenecteplase, Genetech)	50 μ g via injection ⁴¹⁹	Raptors/hyphema (use paracentesis into the anterior eye chamber); intraocular hemorrhage (use intravitreal injection)
Tobramycin	1 drop topical q6-12h ⁵⁵	Most species
Triamcinolone (Vetalog, Fort Dodge)	0.075 mg/kg subconjunctival ¹²⁷	Great horned owls/cataract surgery
	0.1-0.25 mL subconjunctival ³³³	Raptors/traumatic anterior uveitis without corneal ulceration in patients where restraint is a concern
d-Tubocurarine (Curarin-Asta, Asta-Werke)	—	Mydriatic agent; ^a recommended for therapeutic use only; administer into anterior chamber; high risk of intraocular injury; topical application has no effect ^{418a}
	0.01-0.03 mL of 0.3% solution, intracameral ^{120,418b,536}	Most species, including pigeons, raptors/dilation within 15 min, duration 4-12 hr
Tylosin	Topical (mix powder 1:10 with sterile water) ⁷	Cockatiels/conjunctivitis; use in conjunction with systemic treatment
Vecuronium bromide	—	Mydriatic agent; may cause respiratory paralysis or shallow breathing, ataxia, death (especially when applied bilaterally); ⁵¹⁶ neostigmine may counteract systemic effects ^a
	0.096 mg/bird of 0.08% solution topical ⁶³³	Cockatoos, blue-fronted Amazon parrots, African grey parrots/PD

TABLE 5-12 Ophthalmologic Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Vecuronium bromide (cont'd)	0.16 mg/eye (0.4% solution) ⁴⁶²	Doubled crested cormorants/PD; mydriasis; combination with atropine and phenylephrine provided more consistent and longer mydriasis
	0.18-0.22 mg/kg topical ⁶³³	African grey parrots/PD
	0.18-0.29 mg/kg topical ⁶³³	Cockatoos/PD
	0.24-0.28 mg/kg topical ⁶³³	Blue-fronted Amazon parrots/PD
	0.96 mg/bird topical ⁶³³	Cockatoos/use caution with bilateral application
	1 drop of 0.4% solution topical ⁸⁵³	Cormorants, loons/dilation at 30-45 min; duration >2 hr
	2 drops of 0.4% solution topical q15min × 3 treatments ⁵¹⁶	Kestrels/PD; maximal effect in 65 ± 12 min
0.5% solution topical ^{333,516}	Raptors/duration 1 hr	
Vecuronium (V)/nitrous oxide (N)/isoflurane (I)	(V) 0.2 mg/kg IV + 1:1 ratio of oxygen to 33% (N) at 0.3 L/kg/min + (I) 1%-2.4% ³³³	Most species/mydriasis and anesthesia; gases are administered via air sac cannulation; vecuronium effective up to 256 min in pigeons ⁴

^aVariable amounts of skeletal muscle are present in the avian iris, giving birds voluntary control over pupil dilation. In many avian patients, the pupils are best dilated by restraining the animal in a dark room. Consensual pupillary light reflex is generally absent in birds.

TABLE 5-13 Oncologic Agents and Radiation Therapy Used in Birds.

Agent	Dosage	Species/Comments
Acemannan	2 mg/kg intralesional q7d × 4 treatments ³³³	Cockatoos/use prior to surgical debulking in fibrosarcoma
Asparaginase (Elspar, Merck)	400 U/kg IM q7d ³³³	Cockatoos/lymphosarcoma; premedicate with diphenhydramine
	1650 U/kg SC once ⁶⁹²	Great horned owl/sarcoma; associated with severe bone marrow suppression
Carboplatin	5 mg/kg IV, IO over 3 min ^{233,484}	Sulphur-crested cockatoos (PD), budgerigars/mix with 5% dextrose to 400 mg/L; renal adenocarcinoma (leg paresis showed improvement over 2 mo; mass continued to grow); mix with saline
	5 mg/kg intralesional ³³³	Amazon parrots/squamous cell carcinoma; mix with sesame oil or plasma at a concentration of 10 mg/mL
	5 mg/kg IO q4wk × 3 doses ⁸⁶⁸	Green-winged macaw/pancreatic adenocarcinoma
	15 mg/kg IV q5wk × 4 doses ¹³³	Mallard duck/sertoli cell tumor, survival of 13 months
	17.2 mg/kg q3-10wk × 4 doses ⁵⁶⁸	Amazon parrot/choanal squamous cell carcinoma, survival of 9 months

Continued

TABLE 5-13 Oncologic Agents and Radiation Therapy Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Carboplatin (cont'd)	24 mg/kg q4wk × 4 doses ⁸⁶⁸	Amazon parrot/cutaneous squamous cell carcinoma, survival of 1 year
	27 mg/kg q4wk × 4 doses ⁸⁶⁸	Cockatiel/cutaneous squamous cell carcinoma, survival of 3 mo
	125 mg/m ² IV (slow bolus) q14-21d ⁸⁶⁶	Amazon parrot/bile duct carcinoma; dilute with 5% dextrose ^a
Chlorambucil (Leukeran, GlaxoSmithKline)	1 mg/bird PO 2 ×/wk ⁵⁵⁵	Pekin duck/lymphocytic leukemia or lymphosarcoma; responded to treatment initially, but was euthanized 1 mo after presentation because of respiratory distress and hemorrhages
	1 mg/kg PO 2 ×/wk ³¹⁰	Green-winged macaw/chronic lymphocytic leukemia, in combination with chlorambucil, died after 29 weeks
	1.5 mg/kg PO q72h ²⁷¹	Starling/chronic lymphocytic leukemia; follow up of 6 mo
	2 mg/kg PO 2 ×/wk ⁶⁷³	Umbrella cockatoo/cutaneous lymphosarcoma
Cisplatin	0.2 mg/kg intralesional ²²⁷	Black-footed penguin/choanal squamous cell carcinoma; remission for 13 mo
	Intralesional (undisclosed dose) ⁶³⁵	Blue and gold macaw/facial fibrosarcoma; in combination with radiation therapy; remission for 29 mo
	1 mg/kg IV over 1 hr ^{231,232}	Cockatoos/PK; may cause nephrotoxicity; administer IV fluids 1 hr before and 2 hr after infusion
	17.5 mg/m ² intralesional q7d × 4 treatments ⁴⁰⁸	African grey parrot/multiple integumentary squamous cell carcinomas, did not seem effective
Cyclophosphamide	200 mg/m ² IO q7d ³³³	Cockatoo/lymphosarcoma ^a
	300 mg/m ² PO once ⁶⁹²	Great horned owl/sarcoma; ^a dose associated with severe bone marrow suppression
Deslorelin implant	4.6 mg SC q4-6mo ³⁹⁹	Cockatiels/ovarian adenocarcinoma
Diphenhydramine	2 mg/kg IO once ³³³	Cockatoo/before chemotherapy
Doxorubicin	2 mg/kg IV ^{283,284}	Cockatoos/PD; may produce mild transient inappetence; frequency was not determined; PK of metabolite doxorubicinol showed no toxicity ²⁸⁴
	30 mg/m ² IO q2d ³³³	Cockatoo/lymphosarcoma; ^a premedicate with diphenhydramine
	60 mg/m ² IV q30d ¹⁹⁷	Blue-fronted Amazon parrot/osteosarcoma; ^a premedicate with diphenhydramine 30 min before; dilute with saline and give over 30 min (anesthesia recommended); remission for 20 mo

TABLE 5-13 Oncologic Agents and Radiation Therapy Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Hexyl ether pyropheophorbide-a (Photochlor, Roswell Park Cancer Institute)	0.3 mg/kg IV ^{780,783}	African rose-ringed parakeet, hornbill/ photosensitizing agent; use 24 hr prior to photodynamic therapy
L-carnitine	1000 mg/kg of food ¹⁷⁹	Budgerigars/PD; lipoma size decrease
Leuprolide acetate	1500-3000 µg/kg IM q2-3wk ³⁹⁹	Cockatiels/ovarian adenocarcinoma
Methylprednisolone	2 mg IM once ²¹	African grey parrot/bronchial carcinoma
Porfimer sodium (Photofrin, QLT PhotoTherapeutics)	3 mg/kg IV ⁶⁸⁰	Cockatiel/photodynamic therapy
Prednisone	1 mg/kg PO q24h ³¹⁰ 1.6 mg/kg PO q24h ⁶⁹²	Green-winged macaw/chronic lymphocytic leukemia; in combination with prednisone; drug was discontinued after 6 wk because of thrombocytopenia Great horned owl/sarcoma
Radiation therapy	1 Gy at 2.5 Gy/min × 3-4 doses ¹⁶⁶ 2.5 Gy fractions, total dose of 50 Gy ³⁰¹ 4 Gy fractions, total doses of 48, 60, or 72 Gy ⁴⁴ 4 Gy fractions q48h over 22 days, total dose of 40 Gy ⁴³⁴ 4 Gy fractions 3d/wk × 4 wk, total dose of 48 Gy; then booster dose of 8 Gy 5 wk later ⁴⁹² 4 Gy fractions 4d/wk, total dose of 40 Gy ²⁶⁶ 4 Gy fractions 3d/wk, total dose of 44 Gy ⁶³⁵ 4 Gy fractions 3d/wk, total dose of 40 Gy ⁵⁹⁰ 4 Gy fractions 3d/wk × 6 wk, total dose of 68 Gy ²⁵⁹ 5 Gy fractions q3-4d over 3 wk, total dose of 30 Gy ^{12b} 8 Gy fraction q7d × 4 treatments, total dose of 32 Gy ^{788b} 10 Gy fractions at 0, 7, and 21 days, 2 additional doses 1 mo later, total dose of 50 Gy ⁸	Military macaws/PD; radiation of normal choana; delivered dose was slightly lower (0.94-0.97 Gy) than calculated Thick-billed parrot/beak melanoma; 2.5 mo survival Ring necked parakeets/PD; radiation of normal skin and crop; no adverse radiation effects detected Blue and gold macaw/wing fibrosarcoma; in combination with cisplatin chemotherapy; remission observed over 2 mo until 15 mo Buffon's macaw/squamous cell carcinoma of the beak; no evidence of tissue or tumor damage Budgerigar/metacarpal hemangiosarcoma; complete tumor regression observed; death 8 wk later from metastasis Blue and gold macaw/facial fibrosarcoma; in combination with intralesional cisplatin; erythema over the tumor site; 29 mo remission African grey parrot/pericocular lymphoma; 2 mo survival Umbrella cockatoo/intraocular osteosarcoma; 2 mo survival time Blue and gold macaw/periorbital lymphoma; mass regression; 3 mo survival time African grey parrot/beak squamous cell carcinoma; 4 mo survival time American flamingo/cutaneous squamous cell carcinoma; no tumor reduction

Continued

TABLE 5-13 Oncologic Agents and Radiation Therapy Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Silymarin (milk thistle)	100-150 mg/kg PO divided q8-12h ³³³	Hepatic antioxidant/protectant; use in patients with liver disease and as ancillary to chemotherapy; use a low-alcohol or alcohol-free liquid formulation
Strontium (Sr-90 ophthalmic applicator)	100 Gy/area × 1-3 areas ⁵⁵² 100 Gy/area × 4 areas, repeated 1 wk later ⁶¹²	Budgerigars, cockatiels/uropygial squamous cell carcinoma; good response at 2-9 mo follow up African grey parrots/uropygial squamous cell carcinoma; good response at 6 mo
Vincristine sulfate	0.1 mg/kg IV q7-14d ⁶⁷³ 0.5 mg/m ² IV, then 0.75 mg/m ² q7d × 3 treatments ⁵⁵⁵ 0.75 mg/m ² IO q7d × 3 treatments ³³³	Cockatoo/monitor CBC weekly; complete remission Pekin duck/lymphoma; lymphocytic leukemia ^a Cockatoo/lymphosarcoma ^a

^aBody weight (kg) = surface area (m²); 0.5 kg = 0.06 m²; 1 kg = 0.1 m²; 2 kg = 0.15 m²; 3 kg = 0.2 m²; 4 kg = 0.25 m²; 5 kg = 0.29 m².

TABLE 5-14 Antimicrobial-Impregnated Polymethylmethacrylate (PMMA) Agents Used in Birds.^{a,333,484}

Agent	Dosage	Species/Comments
Amikacin	1.25-2.5 g/20 g polymer powder ²²²	PD/elution of amikacin from PMMA beads was greater when the powdered form was used compared with liquid amikacin
Bone cement (Surgical Simplex P Radiopaque Bone Cement, Howmedica)	—	Polymer powder and liquid monomer for use in making antibiotic impregnated beads
Cefazolin	1-2 g/20 g polymer powder ³³³	
Cefotaxime	2 g/20 g polymer powder ³³³	
Ceftazidime	2 g/20 g polymer powder ³³³	
Ceftiofur (Naxcel, Pfizer)	2 g/20 g polymer powder ²²²	Studies show elution for approximately 7 days only ¹⁴⁵
Ciprofloxacin	—	Release for 360 days ⁸⁰³
Clindamycin	—	PMMA beads with clindamycin had adequate drug levels for more than 90 days ^{485,660}
Enrofloxacin	—	Raptors/pododermatitis ⁶⁶⁰
Gentamicin	1 g powder or solution/20 g polymer powder ²²²	PD/elution concentration remained greater than MIC for common pathogens for 30 days; powder and liquid forms of gentamicin had similar elution rates from PMMA

TABLE 5-14 Antimicrobial-Impregnated Polymethylmethacrylate (PMMA) Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Gentamicin (cont'd)	1 mL of 50 mg/mL solution/20 g polymer powder ⁶⁶⁰ Ratio PMMA:gentamicin of 20 ⁶³⁴	Raptors/pododermatitis Good elution for at least 21 days
Gentamicin (Septopal, Merck)	Premade beads ³³³	Commercially available in Europe; not available in the United States
Hydroxyapatite cement (BoneSource, Osteogenics)	—	Polymer powder used as an alternative to bone cement; absorbs into muscle and tissue; osteoconductive in bone; fabricates with water which aids in formulation with liquid antibiotics ²²²
Itraconazole	16% itraconazole-impregnated PMMA fed as grit stones ⁷⁶⁹	Indian peafowl/PD; antifungal agent; when used as grit, therapeutic levels achieved in 2 days and decreased over 7 days; beads from capsules mix into PMMA uniformly before hardening; PMMA cut into 1-g size pieces (grit stone size) after hardening
Meropenem	Ratio PMMA:meropenem of 5:1 ³⁵	Elution for 15 days
Metronidazole	Ratio PMMA:metronidazole of 20-40:1 ⁶³⁴	Good elution for at least 21 days
Oxytetracycline	4.5 mL of 200 mg/mL solution/20 g polymer powder ⁶⁶⁰	Raptors/pododermatitis
(R) Rifampin/(P) pefloxacin (Pelwin, 5% soluble powder, Wockhardt)	1 part (R) + 1 part (P) is finely ground in equal volumes in a mortar and pestle; thoroughly mix with 5 parts PMMA powder ⁶⁶⁰	Rifampin powder taken from oral capsules; pefloxacin powder obtained from the preparation intended for oral use in poultry
(R) Rifampin/(P) piperacillin	1 part (R) + 1 part (P) is combined and finely ground in a mortar and pestle; thoroughly mix with 5 parts PMMA powder ⁶⁶⁰	Rifampin powder taken from oral capsules; piperacillin powder taken from parenteral preparation prior to reconstitution
Tobramycin	—	Release for 220 days ⁴⁸⁵

^aAntimicrobial-impregnated polymethylmethacrylate (PMMA) is used to elute antimicrobial agents for long-term treatment of infected lesions. Following are guidelines for its use and preparation:

- Choose antibiotic based on culture and sensitivity.
- Mix 1-2 g of sterile antibiotic powder with 40-60 g of PMMA powder. Add approximately 2 Tbs to antibiotic at a time. The use of liquid antibiotic reduces the mechanical strength of the bead.
- Shake mixture well (for at least 2 min) to make it homogeneous.
- Add liquid monomer as usual.
- The dough is placed in a catheter tip syringe and extruded, rolled into beads, and placed onto steel surgical wire. Dough may also be injected into a red rubber catheter that may be cut into variable sizes. The smaller the bead, the greater the elution of antibiotic.
- Gas sterilization or UV radiation is recommended; beads are aerated for at least 24 hr at room temperature.
- The wound is aggressively debrided and beads are placed within it; the wound is then closed and the beads are left within the site until the wound is no longer infected.³³³
- In human medicine, beads are removed after 2-6 wk. Despite their antibiotic release, beads act as a surface to which bacteria preferentially adhere, grow, and potentially develop antibiotic resistance.¹⁵⁶ Beads are difficult to remove if left in place for more than 14 days.⁵⁸¹

TABLE 5-15 Agents Used in the Treatment of Oiled Birds.

Agent	Dosage	Species/Comments
Bismuth subsalicylate	2-5 mg/kg PO once ⁵¹⁹	Adsorbent; gavage; alternatively, can use activated charcoal
Charcoal, activated (Toxiban, Vet-A-Mix)	52 mg/kg PO once ⁵¹⁹	Adsorbent; gavage; alternatively, can use bismuth subsalicylate
Charcoal, activated/electrolyte slurry (Toxiban, Vet-A-Mix)	50 mL/kg by gavage ⁸⁰²	3 bottles of charcoal slurry (3.75 g/kg) added to 250 mL of electrolyte solution
Detergent (Dawn, Procter & Gamble)	1%-5% bath ⁵¹⁹	Submerge bird up to mid-neck region; rinse with water; use water at 103-105°F (39-41°C) and 40-60 psi (pounds per square inch); water should be soft(ened); ^{519,527} sea water may also be used ⁵⁰⁶
Fluid therapy	—	See Table 5-36 for guidelines
Iron dextran	10 mg/kg IM q5-7d ⁵¹⁹	If PCV <25%
Lactulose	0.3 mL/kg PO q12h ⁵⁰⁴	Prophylactic laxative
Oral electrolyte solutions (Pedialyte; Ross Labs)	30 mL/kg by gavage ⁸⁰²	Most species/at field stabilization site
Papaya enzyme	1 tablet PO q12h ⁵⁰⁴	Prophylactic laxative
Thiamine (vitamin B ₁)	25-30 mg/kg fish ⁵¹⁹	Piscivorous species

TABLE 5-16 Agents Used in Bird Emergencies.^a

Agent	Dosage	Species/Comments
Aminophylline	4 mg/kg PO q6-12h ³³³ 4 mg/kg IM q12h ⁷⁴² 10 mg/kg IV q3h ³³³	Can give orally after initial response Pionus parrots/smoke inhalation injury Use for pulmonary edema
Atropine sulfate	0.02 mg/kg IM, IV, IO ⁴⁵² 0.2 mg/kg IM, IV, IO ³³³ 0.5 mg/kg IM, IV, IO, intratracheal ³³³	CPR, bradycardia Bradycardia CPR
Blood homologous transfusion	—	Administer over 1-4 hr; use filter; ¹⁰⁹ half-life of 8-10 days; heterologous blood transfusion may not be effective ^{181,184}
Calcium gluconate	1-5 mg elemental calcium/kg/h ⁵⁴ 50-150 mg/kg IM, IV (slow bolus) ^{54,333,452}	CRI for ionized hypocalcemia Hypocalcemia; dilute 50 mg/mL; hyperkalemia; facilitates potassium movement across cell membranes
Dexamethasone Na phosphate	2-6 mg/kg IM, IV q12-24h ³³³	Head trauma (until signs abate); shock (one dose); hyperthermia (until stable)

TABLE 5-16 Agents Used in Bird Emergencies. (cont'd)

Agent	Dosage	Species/Comments
Dextrose (50%)	50-100 mg/kg IV (slow bolus to effect) ³³³	Hypoglycemia; can dilute with fluids
	500-1000 mg/kg IV (slow bolus) ^{333,628}	Hypoglycemia; can dilute with fluids
	0.25 mL/kg after 1:1 dilution with saline ⁴⁵²	Hypoglycemia
	0.5 mL/kg over 15 min ⁵⁴	Hypoglycemia
Dextran 70	10-20 mL/kg IV ³³³	Most species/colloid for the adjunctive treatment of hypovolemic shock
Dobutamine	5-15 µg/kg/min ⁷¹⁸	Hispaniolan Amazon parrots/PD; less effective than dopamine
Dopamine	5-10 µg/kg/min ⁷¹⁸	Hispaniolan Amazon parrots/PD; more effective than dobutamine
Doxapram	2 mg/kg IV, IO ⁴⁵²	CPR, respiratory arrest
	5-10 mg/kg IM, IV once ³³³	Raptors/respiratory depression or arrest
	20 mg/kg IM, IV, IO ³³³	CPR; respiratory depression
Epinephrine (1:1000)	0.01 mg/kg ⁴⁵²	CPR
	0.5-1 mL/kg IM, IV, IO, intratracheal ³³³	CPR; bradycardia
Fluids	10-25 mL/kg IV, IO ³³³	Bolus over 5-7 min, see Table 5-37 (fluid therapy)
Hemoglobin glutamer-200 (Oxyglobin, OPK Biotech)	—	Hemoglobin polymer; hemoglobin replacement product; anemia treatment; currently unavailable, but under FDA testing by new manufacturer (Dechra)
	3-10 mL/kg IV (slow) ³³³	Most species
	5 mL/kg IV ⁴⁵⁴	Mallard ducks/PD; no difference in mortality rate from crystalloid fluids in a hemorrhagic shock model (but a trend of decreased mortality)
Hetastarch	10 mL/kg IV ³³³	Raptors
	5 mL/kg IV ⁴⁵⁴	Mallard ducks/PD; no difference in mortality rate from crystalloid fluids in a hemorrhagic shock model
	10-15 mL/kg IV (slow) q8h ³³³ × 1-4 treatments	Most species, including raptors/hypoproteinemia; hypovolemia
Insulin/dextrose 50%	20 mL/kg/day; 5 mL/kg bolus may be repeated twice ⁵⁴	Hypovolemia; half-life: 25 hr
	0.5 U/kg + 2 g dextrose/insulin unit ⁵⁴	Hyperkalemia
Mannitol	0.25-2 g/kg IV (slow bolus) q24h ³³³	Raptors/cerebral edema; anuric renal failure
Oxyglobin	—	See Hemoglobin glutamer-200
Pentastarch	20 mL/kg/day; 5 mL/kg IV bolus ⁵⁴	Hypovolemia, half-life: 2.5 hr

Continued

TABLE 5-16 Agents Used in Bird Emergencies. (cont'd)

Agent	Dosage	Species/Comments
Potassium chloride (KCl)	Maintenance: 15-20 mEq/L Moderate hypoK: 40 mEq/L Severe hypoK: 60 mEq/L ⁵⁴	Supplement IV/IO fluids; hypokalemia; do not exceed 0.5 mEq/kg/h
Prednisolone Na succinate (Solu-Delta-Cortef, Upjohn)	10-20 mg/kg IM, IV q15min prn ³³³ 15-30 mg/kg IV ³³³	Head trauma; CPR Raptors
Sodium bicarbonate	1 mEq/kg IV q15-30min to maximum of 4 mEq/kg total dose ³³³ 5 mEq/kg IV, IO once ³³³ 0.3 × BW(kg) × Base excess, IV bolus ⁵⁴	Metabolic acidosis CPR Most species/metabolic acidosis; give over 30-60 min
Terbutaline	0.01 mg/kg PO, IM q6h ³³³ 0.1 mg/kg PO q12-24h ³³³	Psittacines/ α_2 -selective smooth muscle bronchodilator Macaws, Amazon parrots/bronchodilator; obstructive pulmonary disease, pneumonitis
Vasopressin	0.8 U/kg ⁴⁵²	CPR

^bBecause of the presence of peripheral vasoconstriction, subcutaneous administration is not adequate for patients in shock.

TABLE 5-17 Euthanasia Agents Used in Birds.^a

Agent	Dosage	Species/Comments
Carbon dioxide (CO ₂)	70% ³³³	Most species/danger to person administering gas; compressed gas is the only recommended source ⁴⁴²
Carbon monoxide (CO)	Minimum 6% concentration in a closed container ³³³	Most species/unconsciousness occurs rapidly; inexpensive; ³³³ danger to person administering gas; compressed gas recommended
Isoflurane	Saturated cotton ball in closed container or face mask ³³³	Most species/very rapid induction; wing flapping and vocalizing may occur
Methoxyflurane	Saturated cotton ball in closed container or face mask ³³³	Most species/induction may be slower than with isoflurane
Pentobarbital sodium	0.2-1 mL/kg IV, ICe ³³³	Most species/birds may react unpredictably with IV administration; ICe administration is smooth, quiet; proper carcass disposal is advised as secondary poisoning of wild scavenging birds may occur; ^{336,690,832} induces significant histopathologic changes that may impair interpretation (especially for lungs) ^{294,632}
Potassium chloride	1-2 mEq/kg IV ⁴⁴² 3-10 mEq/kg ⁶³²	Most species/must be provided in conjunction with prior general anesthesia Parrots/PD; no histologic artifacts; death in 0.5-1.1 min; performed under isoflurane anesthesia

^aThe American Veterinary Medical Association accepts inhalant anesthetic overdose, carbon monoxide, carbon dioxide, KCl (after anesthesia), and barbiturate overdose as humane euthanasia methods.⁴⁴² Cervical dislocation and decapitation are conditionally acceptable for research and poultry. Thoracic compression is commonly used for wild passerine birds.⁵⁹¹

TABLE 5-18 Miscellaneous Agents Used in Birds.

Agent	Dosage	Species/Comments
2-deoxy-2-fluoro-d-glucose (fluodeoxyglucose F18 injection, Siemens)	128.5 ± 20.2 MBq (3.5 ± 0.5 mCi) ³⁸⁰ 37 MBq (1 mCi) ⁷⁵⁴	Bald eagles/PD; PET scan Amazon parrots/PD; PET scan
Acetic acid (apple cider vinegar)	15 mL/qt drinking water	Most species/intestinal dysbiosis
Acetylsalicylic acid (aspirin)	5 mg/kg PO q48h ⁶²	Most species, African grey parrots/ anti-thrombotic agent
Allopurinol	— 10-30 mg/kg PO q12-24h ³³³ 25 mg/kg PO q24h ^{476,617} 830 mg/L drinking water ³³³ 1 mL stock solution/30 mL drinking water mixed fresh several times daily (300 mg/L) ³³³	Xanthine oxidase inhibitor/use in treatment of gout is controversial: 50 mg/kg given to red-tailed hawks was toxic leading to marked elevations in plasma oxypurinol, xanthine, and hypoxanthine with secondary renal dysfunction ⁴⁷⁶ Most species/gout Red-tailed hawks/PD; no significant effect on plasma uric acid levels Most species Budgerigars/decrease initial dose to 25% recommended dose in severe cases and gradually increase over several days; use with colchicine in severe cases; stock solution: 100 mg tablet/10 mL sterile water
Aloe vera	Topical ³³³	Most species/antiinflammatory; antithromboxane activity; beneficial in treating burns, electrical injury, or dying skin flaps; ^a see heparin for combination
Aluminum hydroxide	30-90 mg/kg PO q12h ³³³	Most species/antacid; phosphate binder
Aminoloid (Aminoloid, Schering)	0.25-0.75 mg/kg IM, repeat in 10-14 days ³³³	Raptors/induction of molt
Aminopentamide hydrogen sulfate (Centrine, Fort Dodge)	0.05 mg/kg SC, IM q12h up to 5 doses ³³³ 0.11 mg/kg SC, IM q8-12h × 1 day, then q12h × 1 day, then q24h × 1 day ³³³	Most species/regurgitation Most species/regurgitation
Aminophylline	4 mg/kg PO, IM q6-12h ³³³ 5 mg/kg PO, IV q12h ⁴⁵⁰ 8-10 mg/kg PO, IM, IV q6-8h ^{333,806}	Most species/bronchodilator; need to prepare as a suspension daily Psittacines Most species, including ratites/may be diluted prior to injection; initial doses may be given IV; subsequent doses given PO once response is observed
Ammonium solution	Topical prn ³³³	Most species/analgesic; antipruritic; antiinflammatory; can use on fresh wounds; avoid overuse ^a

Continued

TABLE 5-18 Miscellaneous Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Arginine vasopressin	24 µg/kg IM q12h ⁷⁶⁶	African grey parrots/central diabetes insipidus; oral administration was not effective
Arginine vasotocin	0.5-4 µg/kg intranasal q12h ⁴³⁹	African grey parrots/central diabetes insipidus
Armor All Protectant (Armor All Protectant Corp)	Topical to affected plumage ³³³	Most species/soften sticky-trap glue covered plumage; use detergent (Dawn) to remove Armor All
Atenolol	5-10 mg/kg PO q12-24h ⁵⁸	Most species
Atorvastatin (Lipitor, Pfizer)	10-20 mg/kg PO q12h ⁵⁵	Parrots/hypercholesterolemia; needs to be compounded from tablets
Barium sulfate	— 15 mL/kg PO of 1:1 barium 60% and hand feeding formula ⁶³ 20 mL/kg PO of barium 25% ⁸³³ 20-25 mL/kg PO via gavage ³³³ 25-50 mL/kg PO ³³³	Dilute 72% suspension 1:1 with water; dilute 92% suspension 1:2 with water; 60% suspension effective in Amazon parrots; ^{63,218} more dilute concentrations (20%-25%) can also be used; ⁸³³ administer ½ volume diluted barium and ½ volume air for double contrast study of crop ³³³ Amazon parrots/PD; contrast fluoroscopy Amazon parrots/PD; contrast fluoroscopy, radiography Most species Most species/smaller species require relatively more contrast media; African grey parrots, 25 mL/kg; Quaker parakeets and budgerigars, 50 mL/kg Amazon parrots/PD; contrast fluoroscopy, radiography
Benazepril	0.5 mg/kg PO q24h ^{18b,206}	Parrots
Bismuth subsalicylate	1-2 mL/kg PO q12h ³³³	Most species/weak adsorbent, demulcent
Bromhexine HCl	1.5 mg/kg IM q12-24h ³³³ 3-6 mg/kg IM ³³³ 6.5 mg/L drinking water ³³³ 1200 mg/L drinking water ³³³	Most species/expectorant Most species, including psittacines, passerines, raptors Psittacines Most species
Cimetidine	— 3-5 mg/kg PO, IV q8h ⁸⁰⁶ 5 mg/kg PO, IM q8-12h ³³³ 5-10 mg/kg IM q12h ⁸⁰⁶	Prototype histamine-2 blocker used to reduce gastrointestinal acid production Ratites Psittacines/proventriculitis; gastric ulceration Ratites

TABLE 5-18 Miscellaneous Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Cisapride	— 0.5-1.5 mg/kg PO q8-12h ³³³	Gastrointestinal prokinetic agent, stimulates motility in mammals; ⁶¹⁵ not commercially available in the United States; can be compounded Most species
Citrate phosphate dextrose adenine solution (CPDA)	1 part CPDA:5-6 parts whole blood ^{288,333,530}	Most species/anticoagulant for blood collection for transfusion; not for extended storage of whole blood; ⁵³⁰ a cryopreservation study has also been published ²⁸⁸
Citric acid	5000 mg/L drinking water ³³³	Most species/reduces the effect of calcium and magnesium on the absorption of tetracyclines
Colchicine	— 0.01 mg/kg PO q12h ³³³ 0.04 mg/kg PO q12-24h ³⁴⁷ 0.2 mg/kg PO q12h ³³³	Unique antiinflammatory used in the treatment of gout or hepatic fibrosis/cirrhosis; ⁶¹⁵ may potentiate gout formation in some cases ³³³ Juvenile macaws/gout Most species/gradually increase to q12h Psittacines
Copper sulfate (Cu-7, Searle)	Topical ³³³	Most species/ulcerative dermatitis ^a
Cyclosporine	10 mg/kg PO q12h ³⁵³ 10 mg/kg IV ⁸¹³ 10-20 mg/kg PO q24h ⁵⁵	Cockatiels/PD; ineffective at preventing avian bornaviral lesions Pekin ducks/PK; low plasma levels and high clearance Most species/no detectable plasma level in a single African grey parrot case
Digoxin	— 0.01-0.02 mg/kg PO q12h ³³³ 0.02 mg/kg PO q24h × 5 days ³⁰⁹ 0.05 mg/kg PO q24h ⁸⁵⁸ 0.066 mg/kg IV q12h ⁵⁹⁴ 0.13 mg/L drinking water ³³³	Toxic reactions include depression, ataxia, vomiting, diarrhea; contraindicated with renal or liver disease; monitoring of serum digoxin, potassium, magnesium, calcium, and ECG is recommended; induced arrhythmias in pigeons at 0.2 mg/kg/day ³³³ Psittacines, passerines, raptors/congestive heart disease Budgerigars, sparrows (PD)/produces a plasma concentration of 1.6 µg/mL (within mammalian therapeutic range); this dose led to signs of toxicity in a mynah ⁶⁷⁹ Quaker parakeets/PK; congestive heart failure; cardiomyopathy Pekin ducks/PK; short half-life Psittacines, passerines, raptors/congestive heart disease

Continued

TABLE 5-18 Miscellaneous Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Dimethylsulfoxide (90%)	1 mL/kg topical to affected area q4-7d ³³³	Most species/antiinflammatory, analgesic; systemic absorption; use gloves during application ^a
Diocetyl sodium sulfosuccinate	33 mL/L drinking water ³³³	Psittacine chicks/constipation; use only if chick is drinking
Diphenhydramine	1-4 mg/kg PO q8-12h ³³³ 2 mg/kg IV, IO once ³³³ 20-40 mg/L drinking water ³³³	Most species/hypersensitivity; pruritus; anxiety; may cause hypotension Cockatoos/use prior to chemotherapy Most species
Diphenoxylate with atropine (Lomotil, Searle)	2-2.5 mg/kg PO q8h ⁸⁰⁶	Ratites/opiate; gastrointestinal motility modifier
EDTA-tromethamine or EDTA-Tris	IT, intranasal, or wound lavage ³³³	Most species/potentiates the effect of antibiotics on resistant bacteria; ²²⁵ 1.2 g EDTA + 6.05 g Tris added to 1 L sterile water, pH adjusted to 8 with a dilute solution of sodium hydroxide, autoclaved × 15 min; Tris-EDTA may also be added to chlorhexidine solution ²⁶
Enalapril	0.2-0.5 mg/kg q24h ³³³ 1.25 mg/kg PO q8-12h ⁵⁹⁶ 2.5-5 mg/kg PO q12h ⁵⁹⁷ 5 mg/kg PO q24h ³³³	Most species Pigeons, Amazon parrots/PD Amazon parrot/right-sided heart failure; long-term therapy Lovebirds
Ferric subsulfate	Topical ³³³	Most species/hemostasis of bleeding nail or beak tip; will cause necrosis if used on open skin lesions
Furosemide	— 0.1-2 mg/kg PO, SC, IM, IV q6-24h ^{58,333,595,806} 0.15 mg/kg IM ³³³ 1-5 mg/kg IM q2-12h ²³⁴ 1-10 mg/kg PO q8-12h ²³⁴ 2-6 mg/kg PO, IM ³³³ 40 mg/L drinking water ³³³	Diuretic; overdose can cause dehydration and electrolyte abnormalities Most species, including psittacines, raptors, pigeons, mynahs, ratites; lories are extremely sensitive ³³³ Psittacine neonates/pulmonary congestion Parrots/acute treatment of congestive heart failure Parrots/maintenance treatment of congestive heart failure Raptors Most species/congestive heart failure; can be used with digoxin and ACE inhibitors
Gadopentate dimeglumine (Magnevist, Berlex)	0.25 mmol/kg IV ⁶⁷⁷	Pigeons/PD; contrast agent for magnetic resonance imaging
Gallium-67 citrate (Ga-67)	0.5 mCi (microcuries)/bird IV ³⁹²	Green-winged macaws/ radiopharmaceutical used for detection of infection and inflammatory lesions; requires a gamma camera for imaging

TABLE 5-18 Miscellaneous Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Gemfibrozil	30 mg/kg PO q8h ³³³	Psittacines/lipid regulating agent; yolk emboli; sometimes effective in controlling signs; gradual improvement may be seen over weeks to months; give with niacin
Gentian violet (crystal violet)	Topical ³³³	Raptors/wound management ^a
Glipizide	— 0.5 mg/kg PO q12h ³³³ 1.25 mg/kg PO q24h ³³³ 2 mg/kg PO q8-12h ⁵⁵	Sulfonylurea antidiabetic; contraindicated in ketotic patients; patients should be maintained at trace glucosuria to prevent hypoglycemia ³³³ Cockatiels/diabetes mellitus; did not reduce blood glucose in a Bali mynah ⁴⁸ Most species/diabetes mellitus; did not reduce blood glucose in a macaw ²⁷⁴ Cockatiels/diabetes mellitus; reduced blood glucose and fructosamine in one case
Glycosaminoglycan	—	See polysulfated glycosaminoglycan
Guaifenesin	0.8 mg/kg PO q12h ⁶¹¹	Severe macaws/expectorant, bronchodilation
Heparin	2 U/mL whole blood ¹⁸¹	Cockatiels, conures/anticoagulant for blood transfusions
Heparin/aloë vera	Topical to affected area ³³³	Most species/antiinflammatory; dilute 1000 U heparin/150 mg aloë vera ^a
Hyaluronidase	5 U/kg IV q12h × 1-3 days then 2 × /wk prn ³³³ 75-150 U/L fluids ³³³ Few drops to the lumen of feather shaft at the base ³⁴⁰	Psittacines/egg-yolk related disease; egg yolk visually apparent in blood or serum; dilute with an equal or greater quantity of isotonic NaCl Most species/increases absorption rate of fluids Raptors/flight feather pulling
Hydroxyzine	2-2.2 mg/kg PO q8h ³³³ 34-40 mg/L drinking water ³³³	Amazon parrots/allergic pruritus; feather picking; self-mutilation Most species/respiratory allergy; feather picking
Iohexol (Omnipaque, Sanofi Winthrop)	2-3 mL/kg IV over 3-5 sec ^{66,67} 25-30 mL/kg PO ²¹⁸ 50 mL/kg PO ³³³	Most parrots/PD; angiography; CT contrast; distribution of contrast is extremely fast in vascular system Cockatoos, Amazon parrots/gavage; radiographic gastrointestinal iodinated contrast media; 1:1 dilution with water can also be used Quaker parakeets, budgerigars
Isoxsuprine	5-10 mg/kg PO q24h × 20-40 days ³³³ 10 mg/kg PO q24h ⁷⁴¹	Raptors/peripheral vasodilator; wingtip edema Amazon parrots/atherosclerosis

Continued

TABLE 5-18 Miscellaneous Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Kaolin/pectin	2 mL/kg PO q6-12h ³³³ ≤15 mL/kg PO, repeat prn ³³³	Psittacine neonates/intestinal protectant, anti-diarrheal Raptors
Lactulose	— 150-650 mg/kg (0.2-1 mL/kg) PO q8-12h ³³³ 200 mg/kg (0.3 mL/kg) PO q8-12h ³³³	Does not treat liver disease; reduces blood ammonia levels; exerts osmotic effect in birds with caeca through fermentation to acetic and lactic acid ⁶¹⁵ Most species, including psittacines/hepatic encephalopathy Psittacine neonates
Magnesium hydroxide (M)/activated charcoal (C)	(M) 10-12 mL + (C) 1 tsp powder PO ³³³	Most species/cathartic; adsorbent
Magnesium sulfate (Epsom salts)	— 0.25-1 g/kg PO q24h × 1-2 days ³³³ ¼ tsp/bird PO ⁸⁰⁶ 2 Tbs/bird PO ⁸⁰⁶	Purgative, cathartic; may cause lethargy; ³³³ see peanut butter for combination Most species, including raptors Ratite juveniles/obstipation Ratite adults/obstipation
Mannitol	— 0.25-2 g/kg q24h IV (slow bolus) ³³³ 1500 mg/kg IV q6h ⁸⁰⁶	Osmotic diuretic used to treat cerebral edema, especially after head trauma; may be used with furosemide; also used to treat glaucoma Most species, including raptors Ratites
Maropitant	1 mg/kg SC, IM ⁵⁵	Parrots
Methocarbamol	32.5 mg/kg PO q12h ³³³ 50 mg/kg IV (slow bolus) ³³³	Cranes (demoiselle), swans/capture myopathy Most species, including demoiselle cranes, swans/muscle relaxation; capture myopathy; may be given q12h for muscle relaxation
Metoclopramide	— 0.1 mg/kg IV ⁸⁰⁶ 0.5-1 mg/kg PO, IM, IV q8-12h ³³³ 1 mg/kg IM ⁹⁷ 2 mg/kg IM, IV q8-12h ³³³ 12.5 mg/kg PO ⁸⁰⁶	Gastrointestinal motility disorders; regurgitation; slow crop motility; extrapyramidal signs may be seen as an adverse effect ⁵⁵ Ostriches Most species, including psittacines/gastrointestinal ileus; regurgitation Amazon parrots/PD; no alterations in motility observed Raptors, waterfowl/crop stasis; ileus Ratites/gastrointestinal disorders
Mexiletine	4-8 mg/kg PO q12-24h ⁵⁵	Parrots

TABLE 5-18 Miscellaneous Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Mineral oil	— ≤ 5 mL/kg via gavage or per cloaca ³³³ 5-10 mL/kg PO via gavage ³³³ 15 mL/kg PO via gavage ⁸⁰⁶	Cathartic; used to aid passage of grit and other foreign bodies; administer directly into the crop because oral administration may result in aspiration pneumonia; see peanut butter for combination Most species, including psittacines, raptors Most species, including psittacines/cathartic Ratite adults/impaction
Nicarbazin (Ovocontrol, Innolytics)	— Formulated pellets provided at baiting stations ³³³	Inhibits sperm receptor sites on the vitelline membrane to prevent fertilization of eggs; check federal and state permit requirements prior to use Pigeons, waterfowl/egg hatch control
Peanut butter	Peanut butter and mineral oil (2:1) ³³³ Dilute peanut butter and magnesium sulfate ³³³ 1 mL combined with mineral oil (2:1) ⁴⁷⁷	Most species/add to diet; cathartic Most species/add to diet; cathartic; dilute with water Budgerigars/PD; cathartic; ^a experimental lead particles administration; faster elimination time than controls but not statistically significant
Pentoxifylline	15-25 mg/kg PO q8-12h ^{495,841} 30 mg/kg PO q12h × 5 days ^{55,60}	Most species/frostbite Most species/improve peripheral perfusion; peripheral arterial disease; raptor wingtip edema
Perflutren lipid microspheres (Definity, Lantheus Medical)	0.1 mL/bird IV ⁶⁷ 0.1 mL/bird IV diluted with 0.9 mL NaCl ⁶⁵	Most birds/ultrasound contrast agent; necessitates a mechanical activating device Red-tailed hawks/PD; lasted several min in cardiac chambers
Pimobendan	0.25 mg/kg PO q12h ¹⁰¹ 0.25 mg/kg PO q12h ^{57,726,819} 6-10 mg/kg PO q12h ²³⁴ 10 mg/kg PO q12h ³⁰²	Harris hawks/congestive heart failure; therapeutic drug monitoring performed Parrots Parrots Hispaniolan Amazon parrots/PK
Policosanol	0.3-2 mg PO q25h ²⁵³	Psittacines/hyperlipidemia; use was reported in 2 birds
Polysulfated glycosaminoglycan (PSGAG) (Adequan, Luitpold)	— 5 mg/kg IM q7d ³³³	Used for osteoarthritis in a variety of birds; coagulopathies including 3 deaths reported in 4 birds following IM injection ⁴ Pekin ducks/degenerative joint disease

Continued

TABLE 5-18 Miscellaneous Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Polysulfated glycosaminoglycan (PSGAG) (Adequan, Luitpold) (cont'd)	10 mg/kg IM, intrarticular q7d × 3 mo ^{333,781} 500 mg/bird IM q4d × 7 treatments ⁸⁰⁶	Most species, including pheasants, vultures, cranes/noninfectious or traumatic joint dysfunction; 250 mg/mL for intraarticular use; 500 mg/mL for IM use Ratites
Povidone-iodine	Topical, wash off within 5 min ³³³	Raptors/wound cleansing
Probenecid	— 125 mg/kg PO q6h ³³³	Not currently recommended for the treatment of gout; may exacerbate the condition ³³³ Macaw chicks/antigout
Probucol (Lorelco, Marion Merrell Dow)	1 drop stock/300 g PO q12h × 2-4 mo ³³³	Most species/low density lipoprotein-cholesterolemia; contains iron: use cautiously in species susceptible to hemochromatosis; may increase bile acids; use with low-fat diet; prepare stock: crush 250-mg tablet/7.5 mL lactulose
Propentofylline (Vivitonin, Hoechst)	5 mg/kg PO q12h × 20-40 days ³³³	Raptors/wingtip edema; dry gangrene syndrome
Propranolol	0.04 mg/kg IV (slow) ³³³ 0.2 mg/kg IM ³³³	Most species/supraventricular arrhythmia, atrial flutter, fibrillation
Psyllium (Metamucil, Procter & Gamble)	0.5 tsp/60 mL hand feeding formula ³³³ 1 mL of a solution made of ½ tsp diluted in 60 mL of water ⁴⁷⁷ 1 Tbs/60 mL water/bird PO, up to 120 mL/day ⁸⁰⁶	Most species/bulk diet; can use mineral oil as alternative or in addition to psyllium Budgerigars/PD; cathartic; ^a experimental lead particles administration, similar elimination time than controls Ratite chicks/impaction
Rosuvastatin	10-25 mg/kg PO ⁶⁴	Hispaniolan Amazon parrots/PD; low plasma levels
Sodium benzoate	1 tsp/L (5 mL/L) ³⁵⁴	Budgerigars/treatment of macrorrhombodosis; may be toxic to chicks and breeding birds due to increase water consumption
Sildenafil	2.5 mg/kg PO q8h ⁹⁹	Amazon parrots/pulmonary hypertension treatment
Silymarin (milk thistle)	10-100 mg/kg PO q24h × 21 days ²⁹⁷ 50-75 mg/kg PO q12h ³³³ 100-150 mg/kg PO divided q8-12h ³³³	Pigeons/PD; no demonstrable hepatoprotective effect in experimental hepatitis Most species Most species/hepatic antioxidant; use in patients with liver disease and as ancillary to chemotherapy; use a low-alcohol or alcohol-free liquid formulation

TABLE 5-18 Miscellaneous Agents Used in Birds. (cont'd)

Agent	Dosage	Species/Comments
Skin-So-Soft (Avon)	Topical to affected plumage ³³³	Most species/softens and removes sticky-trap glue from plumage; use Dawn dish detergent to remove Skin-So-Soft product ^a
Sodium tetradecyl sulfate	2 mg/kg diluted at 5% topical ⁵⁹	Most species/fibrotic agent; topical administration in cervicocephalic diverticulum in case of hyperinflation
Spirolactone	1 mg/kg PO q12h ^{58,726}	Parrots/diuretic
Sucralfate	25 mg/kg PO q8h ³³³	Most species, including raptors/oral, esophageal, gastric, duodenal ulcers; give 1 hr before food or other drugs ³³³
^{99m} Tc-technetium-disofenin	1 mCi (microcuries) ¹⁸³ in a commercial liquid or solid diet PO	African grey parrots/radionucleotide used for gastrointestinal scintigraphy
^{99m} Tc-technetium-mebrofenin	1.5-2 mCi ^{297,307}	Pigeons/PD; liver scintigraphy
^{99m} Tc-technetium-diethylenetriaminepenta-acetic acid (DTPA)	42 ± 0.16 MBq (1.158 ± 0.164 mCi [microcuries])/bird IV ⁴⁹³	Pigeons/PD; radiopharmaceutical agent of choice for the assessment of renal function
Terbutaline	0.01 mg/kg PO, IM q6h ⁴⁵⁰ 0.1 mg/kg PO q12-24h ³³³	Psittacines/ α_2 -selective smooth muscle bronchodilator Macaws, Amazon parrots/bronchodilator; obstructive pulmonary disease; pneumonitis
Theophylline	2 mg/kg PO q12h ⁶¹¹ 5-10 mg/kg PO q12h ⁵⁵ 10 mg/kg PO q12h ⁵⁵	Severe macaws/bronchodilation Blue and gold macaws/chronic obstructive pulmonary disease Amazon parrots/syringeal masses
Tincture of iodine	Topical ³³³	Raptors/wounds; inexpensive; readily available in developing countries ^a
Trilostane	1 mg/kg PO q24h ⁸¹⁷	Senegal parrots/Cushing's disease
Trypsin-balsam of Peru-castor oil (Granulex, Pfizer)	Topical ³³³	Most species/digests necrotic tissue (may have debriding action); may have analgesic effects; may cause local inflammation and pyogenic reaction; do not use for long-term management ^a
Tyrod's solution	Offer in place of drinking water ³³³	Cockatiels/restores renal-medullary gradient; add 8 g NaCl, 0.13 g CaCl ₂ , 0.2 g KCl, 0.1 g MgCl ₂ , 0.05 g Na ₂ HPO ₄ , 1 g NaHCO ₃ , 1 g glucose to 1 L water
Urate oxidase (Uricozyme, Sanofi Winthrop)	100-200 U/kg IM q24h ^{616,617}	Red-tailed hawks, pigeons/PD; significantly lowered plasma uric acid, including postprandial plasma uric acid
Ursodeoxycholic acid	15 mg/kg PO q24h ⁵⁵	Most species
Vegetable oil	15 mL/kg PO ⁸⁰⁶	Ratites/impaction
Yeast cell derivatives (Preparation H, WhiteHall)	Topical q24h ³³³	Most species/pododermatitis; stimulation of epithelialization; one of the four commercial products contains 1% hydrocortisone ^a

^aMany topical agents contain oils that adhere to plumage. These agents should be used sparingly and generally in nonfeathered regions to prevent losing the insulative properties of the plumage.

TABLE 5-19 Hematologic and Biochemical Values of Selected Psittaciformes.

Measurement	African Grey Parrot (<i>Psittacus</i> spp.) ^{155,269}	Amazon Parrots (<i>Amazona</i> spp.) ^{155,269}	Orange-winged Amazon Parrot (<i>Amazona amazonica</i>) ^{327b}
Hematology			
PCV (%)	45-53	41-53	51 (42-60)
RBC (10 ⁶ /μL)	2.84-3.62	2.45-3.18	2.47 (2.40-3.67)
Hgb (g/dL)	12.7-15.9	12.2-15.9	—
MCV (fL)	144-155	160-175	166 (138-193)
MCH (pg)	36.4-43.9	47.2-56.8	—
MCHC (g/dL)	25.4-28.1	29.1-31.9	—
WBC (10 ³ /μL)	6-13	6-17	8 (0.7-16)
Heterophils 10 ³ /μL (%)	4.64-7.52	3.81-8.73	3.07 (0.71-7.24)
	45-73	31-71	—
Lymphocytes 10 ³ /μL (%)	1.96-5.15	2.40-6.48	4.55 (0-10.8)
	19-50	20-54	—
Monocytes 10 ³ /μL (%)	0-0.21	0.12-0.36	0.38 (0.09-0.86)
	0-2	1-3	—
Eosinophils 10 ³ /μL (%)	0-0.10	0.12-0.24	0.05
	0-1	1-2	—
Basophils 10 ³ /μL (%)	0-0.1	0-0.12	—
	0-1	0-1	—
H:L ratio	—	—	—
Chemistries			
ALP (U/L)	20-160	15-150	46 (18-120)
ALT (U/L)	5-12	5-11	—
Amylase (U/L)	210-530	205-510	—
AST (U/L)	109-305	141-437	168 (125-375)
Bile acid (μmol/L)			
RIA	13.7-73.6	10.3-79.3	—
Colorimetric	12-96	33-154	20 (8-88)
BUN (mg/dL)	3-5.4	—	1 (0-2)
Calcium (mg/dL)	7.7-11.3	8.2-10.9	9.1 (7.7-10.4)
Chloride (mEq/L)	—	—	110 (105-114)
Cholesterol (mg/dL)	160-425	180-305	237 (110-363)
CK (U/L)	228-322	125-345	341 (182-1459)
Creatinine (mg/dL)	0.1-0.4	0.1-0.4	—
GGT (U/L)	1-10	—	—
Glucose (mg/dL)	206-275	221-302	266 (213-371)
LDH (U/L)	145-465	155-425	—

TABLE 5-19 Hematologic and Biochemical Values of Selected Psittaciformes. (cont'd)

Measurement	African Grey	Orange-winged Amazon	
	Parrot (<i>Psittacus</i> spp.)	Amazon Parrots (<i>Amazona</i> spp.)	Parrot (<i>Amazona amazonica</i>)
Lipase (U/L)	35-350	35-225	—
Phosphorus (mg/dL)	3.2-5.4	3.1-5.5	3.1 (1.2-5.0)
Potassium (mEq/L)	2.9-4.6	3-4.5	3.2 (1.3-5.0)
Protein, total (g/dL)	3.2-5.2	3-5.2	4.2 (3.4-4.9)
Albumin (g/dL)	1.22-2.52	1.79-2.81	—
Globulin (g/dL)	—	—	—
A:G ratio	1.02-2.59	1.21-2.29	—
Prealbumin (g/dL)	0.30-0.92	0.6-1.23	—
α -globulin (g/dL)	0.06-0.20 (α_1)	0.09-0.23 (α_1)	—
β -globulin (g/dL)	0.10-0.28 (α_2)	0.20-0.42 (α_2)	—
γ -globulin (g/dL)	0.49-0.88	0.33-0.89	—
γ -globulin (g/dL)	0.21-0.81	0.21-0.72	—
Sodium (mEq/L)	157-165	125-155	150 (146-154)
Triglycerides (mg/dL)	45-145	49-190	14 (69-234)
Uric acid (mg/dL)	2.7-8.8	2.1-8.7	1.6 (1.9-12.7)

Measurement	Budgerigar Parakeet (<i>Melopsittacus undulatus</i>) ^{155,269,346}	Caique (<i>Pionites</i> spp.) ^{155,269}	Cockatiel (<i>Nymphicus hollandicus</i>) ^{155,269}
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Hematology

PCV (%)	44-58	47-55	43-57
RBC ($10^6/\mu\text{L}$)	3.77-4.6	—	3.1-4.4
Hgb (g/dL)	12.4-16.9	—	10.2-14.7
MCV (fL)	116-127	—	126-142
MCH (pg)	23.1-30.9	—	26.4-35.8
MCHC (g/dL)	19.8-23.9	—	20.4-25.2
WBC ($10^3/\mu\text{L}$)	3-10	8-15	5-11
Heterophils $10^3/\mu\text{L}$ (%)	2.68-4.55	4.68-8.64	3.68-5.76
Lymphocytes $10^3/\mu\text{L}$ (%)	40-75	39-72	46-72
Lymphocytes $10^3/\mu\text{L}$ (%)	1.47-4.02	2.4-7.32	2.08-4.8
Monocytes $10^3/\mu\text{L}$ (%)	20-45	20-61	26-60
Monocytes $10^3/\mu\text{L}$ (%)	0-0.13	0-0.24	0-0.08
Eosinophils $10^3/\mu\text{L}$ (%)	0-2	0-2	0-1
Eosinophils $10^3/\mu\text{L}$ (%)	0	0-0.12	0-0.16
Basophils $10^3/\mu\text{L}$ (%)	0	0-1	0-2
Basophils $10^3/\mu\text{L}$ (%)	0-0.13	0-0.12	0-0.08
H:L ratio	0-1	0-1	0-1
H:L ratio	—	—	—

Continued

TABLE 5-19 Hematologic and Biochemical Values of Selected Psittaciformes. (cont'd)

Measurement	Budgerigar Parakeet (<i>Melopsittacus undulatus</i>)	Caique (<i>Pionites</i> spp.)	Cockatiel (<i>Nymphicus hollandicus</i>)
Chemistries			
ALP (U/L)	10-80	—	20-250
ALT (U/L)	—	—	5-11
Amylase (U/L)	302-560	244-290	205-490
AST (U/L)	55-154	193-399	160-383
Bile acid ($\mu\text{mol/L}$)			
RIA	20-65	11.8-56.7	11.7-80.7
Colorimetric	32-117	12-112	44-108
BUN (mg/dL)	3-5.2	—	2.9-5
Calcium (mg/dL)	6.4-11.2	7.1-11.5	7.3-10.7
Chloride (mEq/L)	—	—	—
Cholesterol (mg/dL)	145-275	—	140-360
CK (U/L)	54-252	134-427	58-245
Creatinine (mg/dL)	0.1-0.4	—	0.1-0.4
GGT (U/L)	1-10	—	1-30
Glucose (mg/dL)	254-399	167-366	249-363
LDH (U/L)	154-271	—	120-455
Lipase (U/L)	—	—	30-280
Phosphorus (mg/dL)	3-5.2	—	3.2-4.8
Potassium (mEq/L)	2.2-3.7	—	2.4-4.6
Protein, total (g/dL)	2-3	2.4-4.6	2.4-4.8
Albumin (g/dL)	—	0.96-2.04	0.78-1.75
Globulin (g/dL)	—	—	—
A:G ratio	—	1.09-2.76	1.01-2.19
Prealbumin (g/dL)	—	0.33-0.89	0.59-1.24
α -globulin (g/dL)	—	0.05-0.17 (α_1)	0.05-0.32 (α_1)
	—	0.13-0.38 (α_2)	0.07-0.39 (α_2)
β -globulin (g/dL)	—	0.34-0.99	0.34-0.81
γ -globulin (g/dL)	—	0.13-0.50	0.15-0.60
Sodium (mEq/L)	139-159	—	130-153
Triglycerides (mg/dL)	—	—	45-200
Uric acid (mg/dL)	3-8.6	3.4-12.2	3.5-11

TABLE 5-19 Hematologic and Biochemical Values of Selected Psittaciformes. (cont'd)

Measurement	Cockatoos (Cacatuidae) ^{269,365}	Conures (<i>Aratinga</i> and <i>Pyrrhura</i> spp.) ^{155,269}	Eclectus Parrot (<i>Eclectus</i> <i>roratus</i>) ^{155,269}
Hematology			
PCV (%)	40-54	42-54	45-55
RBC ($10^6/\mu\text{L}$)	2.44-3.34	2.9-4.5	2.5-3.7
Hgb (g/dL)	11.1-16.0	12-16	11.1-13.9
MCV (fL)	158-175	90-190	157-170
MCH (pg)	40.4-53.7	28-55	37.5-44.6
MCHC (g/dL)	25.8-31.5	—	22.69-27.53
WBC ($10^3/\mu\text{L}$)	5-13	5-13	9-15
Heterophils $10^3/\mu\text{L}$ (%)	4.68-7.49	4.22-6.91	5.75-8.75
	45-72	44-72	46-70
Lymphocytes $10^3/\mu\text{L}$ (%)	2.08-5.20	2.11-4.89	2.87-7.12
	20-50	22-51	23-57
Monocytes $10^3/\mu\text{L}$ (%)	0-0.2	0-0.09	0-0.12
	0-2	0-1	0-1
Eosinophils $10^3/\mu\text{L}$ (%)	0-0.2	0-0.09	0-0.12
	0-2	0-1	0-1
Basophils $10^3/\mu\text{L}$ (%)	0-0.1	0-0.09	0-0.12
	0-1	0-1	0-1
H:L ratio	—	—	1-2
Chemistries			
ALP (U/L)	15-255	80-250	—
ALT (U/L)	6-12	5-13	5-11
Amylase (U/L)	200-510	100-450	200-645
AST (U/L)	117-314	178-307	148-378
Bile acid ($\mu\text{mol/L}$)			
RIA	10.3-79.1	8.3-85.2	9.7-87.5
Colorimetric	34-112	32-105	30-110
BUN (mg/dL)	3-5.1	2.5-5.4	3.5-5
Calcium (mg/dL)	8.3-10.8	7.9-10.8	7.9-11.4
Chloride (mEq/L)	—	—	—
Cholesterol (mg/dL)	135-355	120-400	130-350
CK (U/L)	106-305	154-355	118-345
Creatinine (mg/dL)	0.1-0.4	0.1-0.4	0.1-0.4
GGT (U/L)	1-45	1-15	1-20
Glucose (mg/dL)	214-302	217-323	220-294
LDH (U/L)	220-550	120-390	200-425
Phosphorus (mg/dL)	2.5-5.5	2-10	2.9-6.5
Potassium (mEq/L)	2.5-4.5	3.4-5	3.5-4.3

Continued

TABLE 5-19 Hematologic and Biochemical Values of Selected Psittaciformes. (cont'd)

Measurement	Cockatoos (<i>Cacatuidae</i>)	Conures (<i>Aratinga</i> and <i>Pyrrhura</i> spp.)	Eclectus Parrot (<i>Eclectus roratus</i>)
Protein, total (g/dL)	3-5	2.8-4.6	3-5
Albumin (g/dL)	1.11-2.28	1.01-1.94	1.23-2.26
Globulin (g/dL)	—	—	—
A:G ratio	1.06-2.54	1.08-2.73	1.09-2.50
Prealbumin (g/dL)	0.29-0.83	0.39-1.12	0.31-1.18
α -globulin (g/dL)	0.07-0.16 (α_1)	0.07-0.17 (α_1)	0.08-0.19 (α_1)
	0.09-0.26 (α_2)	0.18-0.43 (α_2)	0.10-0.30 (α_2)
β -globulin (g/dL)	0.39-0.89	0.30-0.81	0.46-0.89
γ -globulin (g/dL)	0.18-0.61	0.12-0.55	0.17-0.63
Sodium (mEq/L)	130-155	135-149	130-145
Triglycerides (mg/dL)	45-200	50-300	—
Uric acid (mg/dL)	2.9-11.0	3.0-11.4	2.5-8.7

Measurement	Grey-Cheeked Parakeet (<i>Brotogeris pyrrhoptera</i>) ²⁶⁹	Jardine's Parrot (<i>Poicephalus gulielmi</i>) ¹⁵⁵	Lories and Lorikeets ^{155,269}
Hematology			
PCV (%)	45-56	41-53	47-55
RBC ($10^6/\mu\text{L}$)	—	3.03-4.47	3.3-4
Hgb (g/dL)	—	—	10.8-14.8
MCV (fL)	—	—	128-140
MCH (pg)	—	—	27.5-31.4
MCHC (g/dL)	—	—	20.3-23.1
WBC ($10^3/\mu\text{L}$)	4-12	4.1-12.6	8-13
Heterophils $10^3/\mu\text{L}$ (%)	3.74-5.64	—	4.21-6.48
	45-68	55-75	39-60
Lymphocytes $10^3/\mu\text{L}$ (%)	1.83-3.98	—	2.38-7.45
	22-48	25-45	22-69
Monocytes $10^3/\mu\text{L}$ (%)	0-0.08	—	0-0.22
	0-1	0-2	0-2
Eosinophils $10^3/\mu\text{L}$ (%)	0-0.08	—	0-0.11
	0-1	0-1	0-1
Basophils $10^3/\mu\text{L}$ (%)	0-0.08	—	—
	0-1	0-1	0-1
H:L ratio	—	—	—
Chemistries			
ALP (U/L)	—	80-156	—
ALT (U/L)	—	5-12	—
Amylase (U/L)	—	100-425	20-65
AST (U/L)	189-388	150-278	141-369

TABLE 5-19 Hematologic and Biochemical Values of Selected Psittaciformes. (cont'd)

Measurement	Grey-Cheeked Parakeet (<i>Brotogeris pyrrhoptera</i>)	Jardine's Parrot (<i>Poicephalus gularis</i>)	Lories and Lorikeets
Bile acid ($\mu\text{mol/L}$)			
RIA	—	10.2-61.7	20-65
Colorimetric	15-81	—	20-97
BUN (mg/dL)	—	2.8-5.6	—
Calcium (mg/dL)	8.0-11.6	7.0-12.8	8-12
Chloride (mEq/L)	—	—	—
Cholesterol (mg/dL)	96-249	100-300	100-257
CK (U/L)	164-378	110-310	178-396
Creatinine (mg/dL)	—	—	—
GGT (U/L)	—	1-15	—
Glucose (mg/dL)	210-385	199-348	200-400
LDH (U/L)	154-356	119-335	124-302
Phosphorus (mg/dL)	—	2-6.8	—
Potassium (mEq/L)	—	3-4.5	—
Protein, total (g/dL)	2.5-4.5	2.8-4	1.9-4.1
Albumin (g/dL)	—	1.17-1.92	1.3-2.1
Globulin (g/dL)	—	—	0.9-2.4
A:G ratio	—	1.32-2.56	1-2.3
Prealbumin (g/dL)	—	0.12-0.42	—
α -globulin (g/dL)	—	0.07-0.16 (α_1)	—
—	—	0.08-0.22 (α_2)	—
β -globulin (g/dL)	—	0.38-0.84	—
γ -globulin (g/dL)	—	0.12-0.47	—
Sodium (mEq/L)	—	133-153	—
Tryglycerides (mg/dL)	—	60-130	—
Uric acid (mg/dL)	0.3-12	2.5-12	2-11.9

Measurement	Lovebirds (<i>Agapornis</i> spp.) ^{155,269}	Macaws (<i>Ara</i> and <i>Anodorhynchus</i> spp.) ^{155,269}	Parrotlets (<i>Forpus</i> spp.) ²⁶⁹
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Hematology

PCV (%)	44-55	42-56	48-55
RBC ($10^6/\mu\text{L}$)	3.25-3.95	2.7-4.5	—
Hgb (g/dL)	10.8-14.8	15-17	—
MCV (fL)	128-140	125-170	—
MCH (pg)	27.5-31.4	36-55	—
MCHC (g/dL)	20.3-23.1	29-35	—

Continued

TABLE 5-19 Hematologic and Biochemical Values of Selected Psittaciformes. (cont'd)

Measurement	Lovebirds (<i>Agapornis</i> spp.)	Macaws (<i>Ara</i> and <i>Anodorhynchus</i> spp.)	Parrotlets (<i>Forpus</i> spp.)
WBC ($10^3/\mu\text{L}$)	7-16	10-20	5-13
Heterophils $10^3/\mu\text{L}$ (%)	3.33-9.21	7.6-11.4	4.84-6.51
	40-75	50-75	55-74
Lymphocytes $10^3/\mu\text{L}$ (%)	3.34-6.20	3.50-8.06	2.11-4.4
	20-53	23-53	19-70
Monocytes $10^3/\mu\text{L}$ (%)	0-0.12	0-0.15	0-0.09
	0-1	0-1	0-1
Eosinophils $10^3/\mu\text{L}$ (%)	0-0.23	0	0-0.09
	0-2	0	0-1
Basophils $10^3/\mu\text{L}$ (%)	0-0.23	0-0.15	0-0.09
	0-6	0-1	0-1
H:L ratio	—	—	—

Chemistries

ALP (U/L)	10-90	20-230	—
ALT (U/L)	5-13	5-12	—
Amylase (U/L)	90-400	150-550	—
AST (U/L)	125-377	105-324	110-224
Bile acid ($\mu\text{mol/L}$)			
RIA	8.5-77.1	7.6-60	—
Colorimetric	12-90	7-100	—
BUN (mg/dL)	2.8-5.5	3-5.6	—
Calcium (mg/dL)	7.2-10.6	8.2-10.9	—
Chloride (mEq/L)	—	—	—
Cholesterol (mg/dL)	95-335	100-390	—
CK (U/L)	58-337	101-300	—
Creatinine (mg/dL)	0.1-0.4	0.5-0.6	—
GGT (U/L)	2.5-18	1-30	—
Glucose (mg/dL)	246-381	228-325	252-384
LDH (U/L)	105-355	70-350	—
Lipase (U/L)	30-320	30-250	—
Phosphorus (mg/dL)	2.8-4.9	—	—
Potassium (mEq/L)	2.1-4.8	2-5	—
Protein, total (g/dL)	2.4-3.6	2.6-5.0	—
Albumin (g/dL)	0.98-1.68	1.12-2.43	—
Globulin (g/dL)	—	—	—
A:G ratio	1.06-2.09	1.08-2.55	—
Prealbumin (g/dL)	0.37-0.68	0.24-0.80	—
α -globulin (g/dL)	0.08-0.17 (α_1)	0.07-0.18 (α_1)	—
	0.12-0.37 (α_2)	0.15-0.45 (α_2)	—
β -globulin (g/dL)	0.33-0.78	0.34-0.85	—
γ -globulin (g/dL)	0.12-0.38	0.15-0.58	—

TABLE 5-19 Hematologic and Biochemical Values of Selected Psittaciformes. (cont'd)

Measurement	Lovebirds (<i>Agapornis</i> spp.)	Macaws (<i>Ara</i> and <i>Anodorhynchus</i> spp.)	Parrotlets (<i>Forpus</i> spp.)
Sodium (mEq/L)	125-155	140-165	—
Triglycerides (g/L)	45-200	—	—
Uric acid (mg/dL)	2.5-12	2.9-10.6	4.1-12

Measurement	Pionus Parrots (<i>Pionus</i> spp.) ^{155,269}	Quaker Parakeet (<i>Myopsitta</i> <i>monachus</i>) ^{155,269}	Senegal Parrot (<i>Poicephalus</i> <i>senegalus</i>) ^{155,269}
Hematology			
PCV (%)	44-54	30-58	45-60
RBC ($10^9/\mu\text{L}$)	2.4-4	—	2.4-4
Hgb (g/dL)	11-16	—	12.3-14.0
MCV (fL)	85-210	—	139-151
MCH (pg)	26-54	—	33.1-39.4
MCHC (g/dL)	24-31	—	23.4-27.4
WBC ($10^3/\mu\text{L}$)	5-13	8-17	6-14
Heterophils $10^3/\mu\text{L}$ (%)	0.48-7.10	—	4.70-7.81
	55-74	0-24	44-73
Lymphocytes $10^3/\mu\text{L}$ (%)	1.82-6.72	—	2.35-7.49
	19-70	74-90	22-70
Monocytes $10^3/\mu\text{L}$ (%)	0-0.10	—	0-0.11
	0-1	1-4	0-1
Eosinophils $10^3/\mu\text{L}$ (%)	0-0.10	—	0-0.21
	0-1	0-2	0-2
Basophils $10^3/\mu\text{L}$ (%)	0-0.10	—	0-0.11
	0-1	0-6	0-1
H:L ratio	—	—	—
Chemistries			
ALP (U/L)	80-290	70-300	70-300
ALT (U/L)	5-12	5-11	5-11
Amylase (U/L)	200-500	100-400	190-550
AST (U/L)	140-359	225-375	183-352
Bile acid ($\mu\text{mol/L}$)			
RIA	6.1-62.7	9.6-83.2	13.8-87.4
Colorimetric	15-92	21-90	20-94
BUN (mg/dL)	3-5.4	2.9-5.4	2.9-5.4
Calcium (mg/dL)	7.8-10.8	7-10.0	7.6-10.7
Chloride (mEq/L)	—	—	—
Cholesterol (mg/dL)	130-295	110-295	130-340
CK (U/L)	169-354	110-311	100-330
Creatinine (mg/dL)	0.1-0.4	0.1-0.4	0.1-0.4

Continued

TABLE 5-19 Hematologic and Biochemical Values of Selected Psittaciformes. (cont'd)

Measurement	Pionus Parrots (<i>Pionus</i> spp.)	Quaker Parakeet (<i>Myopsitta monachus</i>)	Senegal Parrot (<i>Poicephalus senegalus</i>)
GGT (U/L)	1-18	1-15	1-15
Glucose (mg/dL)	228-312	229-318	220-284
LDH (U/L)	125-380	120-300	150-350
Lipase (U/L)	30-250	25-225	32-250
Phosphorus (mg/dL)	2.9-6.6	2.9-6.5	—
Potassium (mEq/L)	3.5-4.6	2.8-4.6	3-5
Protein, total (g/dL)	3.6-5.2	3.0-4.8	2.8-4.2
Albumin (g/dL)	—	0.92-2.48	1.19-1.81
Globulin (g/dL)	—	—	—
A:G ratio	0.6-1.9	1.07-2.38	1.41-2.66
Prealbumin (g/dL)	1.52-2.37	0.91-2.46	0.55-0.99
α-globulin (g/dL)	0.08-0.23 (α ₁) 0.11-0.36 (α ₂)	0.08-0.21 (α ₁) 0.22-0.45 (α ₂)	0.08-0.15 (α ₁) 0.11-0.25 (α ₂)
β-globulin (g/dL)	0.40-0.95	0.37-0.79	0.32-0.87
γ-globulin (g/dL)	0.23-0.69	0.19-0.77	0.15-0.45
Sodium (mEq/L)	145-155	140-155	130-155
Triglycerides (mg/dL)	60-225	50-200	45-145
Uric acid (mg/dL)	2.0-7.9	3.5-11.5	2.5-7.8

TABLE 5-20 Hematologic and Biochemical Values for Juveniles of Selected Psittaciformes.

Measurement	Mean ± SD (Range)				
	Cockatoos (<i>Cacatua</i> spp.) ¹⁴² (9 species) (n = 152) ^a	Umbrella Cockatoo (<i>Cacatua alba</i>) ¹⁴² (n = 111) ^a	Macaws (<i>Ara</i> spp.) ¹⁴³ (7 species) (n = 113) ^a	Blue and Gold Macaw (<i>Ara ararauna</i>) ¹⁴³ (n = 43) ^a	Eclectus Parrot (<i>Eclectus roratus</i>) ¹⁴¹ (n = 111) ^a
Hematology					
PCV (%)	39.7 ± 9 (25-59)	39.3	41.7 ± 8.4 (25-55)	40 ± 7.7	43.8 ± 8.4 (26-58)
RBC (10 ⁶ /μL)	2.53 ± 0.63 (1.5-4)	2.54	2.9 ± 0.8 (1.5-4.5)	2.7 ± 0.7	2.69 ± 0.67 (1.5-4)
Hgb (g/dL)	11.4 ± 2.9 (6.5-17)	11.6	12.3 ± 3.3 (7-17)	11 ± 2.9	12.5 ± 3 (6.5-18)
WBC (10 ³ /μL)	12.9 ± 6.3 (5.5-25)	16.6	19.2 ± 6.9 (7-30)	18.9 ± 5.6	13.7 ± 6.3 (5.5-25)
Heterophils (%)	50.8 ± 11.7 (27-74)	54.1	55.3 ± 10 (37-75)	52 ± 10	53.9 ± 11.4 (35-75)
Bands (%)	1.3 ± 2.3 (0-7)	1.31	0.6 ± 1.7 (0-5)	0.1 ± 0.7	0.5 ± 1.5 (0-5)
Lymphocytes (%)	41.2 ± 11.9 (17-65)	38.1	39 ± 10 (20-60)	42 ± 10	39.5 ± 11.5 (20-65)
Monocytes (%)	5.8 ± 3.4 (0-12)	5.35	4.4 ± 2.9 (1-10)	4.3 ± 2.7	5 ± 2.7 (1-11)
Eosinophils (%)	0	0.02	0 ± 0.2 (0-1)	0	0.1 ± 0.3 (0-1)
Basophils (%)	0.9 ± 1.1 (0-4)	1.03	0.5 ± 1 (0-3)	0.9 ± 1.3	1.1 ± 1 (0-3)

Continued

TABLE 5-20 Hematologic and Biochemical Values for Juveniles of Selected Psittaciformes. (cont'd)

Measurement	Mean ± SD (Range)				
	Cockatoos (<i>Cacatua</i> spp.) (9 species) (n = 152)	Umbrella Cockatoo (<i>Cacatua alba</i>) (n = 111)	Macaws (<i>Ara</i> spp.) (7 species) (n = 113)	Blue and Gold Macaw (<i>Ara ararauna</i>) (n = 43)	Eclectus Parrot (<i>Eclectus roratus</i>) (n = 111)
Chemistries					
ALP (U/L)	579 ± 239 (200-1000)	440	970 ± 397 (290-1600)	1200 ± 390	489 ± 159 (200-900)
ALT (U/L)	2 ± 3 (0-13)	2.1	3 ± 2 (0-9)	4 ± 3	4 ± 3 (0-10)
AST (U/L)	143 ± 79 (50-400)	136	104 ± 31 (60-180)	101 ± 24	140 ± 58 (65-260)
BUN (mg/dL)	2 ± 2.2 (0-6)	1.6	2.4 ± 2.3 (0-6)	1.9 ± 2.2	1.7 ± 2.4 (0-6)
Calcium (mg/dL)	9.6 ± 0.7 (8-11)	9.8	9.9 ± 0.5 (8.5-10.8)	10 ± 0.5	9.3 ± 0.4 (8.5-10.2)
Chloride (mEq/L)	110 ± 6 (97-120)	111	106 ± 6 (96-118)	104 ± 5	111 ± 5 (100-120)
Cholesterol (mg/dL)	251 ± 105 (100-500)	291	165 ± 62 (75-300)	164 ± 67	268 ± 80 (125-450)
CK (U/L)	510 ± 235 (140-1000)	517	550 ± 312 (180-1100)	540 ± 267	616 ± 472 (200-1600)
Creatinine (mg/dL)	0.4 ± 0.1 (0.2-0.7)	0.4	0.4 ± 0.1 (0.3-0.6)	0.4 ± 0.1	0.4 ± 0.1 (0.2-0.5)
GGT (U/L)	2.6 ± 1.7 (0-6)	2.7	1.8 ± 1.2 (0-4)	1.7 ± 1.2	4 ± 2 (0-7)
Glucose (mg/dL)	253 ± 24 (200-300)	244	281 ± 30 (225-330)	288 ± 31	258 ± 18 (220-300)
LDH (U/L)	371 ± 285 (150-1000)	325	138 ± 84 (35-275)	144 ± 98	228 ± 101 (100-400)
Phosphorus (mg/dL)	6.1 ± 1.1 (3.5-8)	5.6	6.5 ± 1 (4.6-6.9)	6.6 ± 0.9	6.8 ± 1.2 (4.5-9)
Potassium (mEq/L)	3.6 ± 0.7 (2.5-5.5)	3.5	2.9 ± 0.8 (2-4.2)	2.7 ± 0.6	2.8 ± 0.7 (2-4.6)
Protein, total (g/dL)	2.8 ± 0.7 (1.5-4)	3	2.6 ± 0.6 (1.5-3.5)	2.5 ± 0.7	2.9 ± 0.5 (1.8-3.8)
Albumin (g/dL)	1.1 ± 0.3 (0.3-1.6)	1.7	1.2 ± 0.3 (0.6-1.7)	1.2 ± 0.3	1.3 ± 0.3 (0.8-1.8)
Globulin (g/dL)	1.7 ± 0.5 (0.8-2.5)	0.9	1.3 ± 0.6 (0.8-1.9)	1.3 ± 0.6	1.5 ± 0.3 (0.8-2.2)
A:G ratio	0.6 ± 0.2 (0.4-1)	0.6	0.8 ± 0.3 (0.5-1)	0.8 ± 0.2	0.9 ± 0.2 (0.6-1.1)
Sodium (mEq/L)	145 ± 6 (135-155)	145	145 ± 6 (135-156)	142 ± 6	148 ± 6 (138-158)
Uric acid (mg/dL)	2.9 ± 2.3 (0.2-8.5)	2.7	2.3 ± 2.1 (0.2-6)	1.9 ± 2.5	2 ± 1.6 (0.2-6.5)

^an = Number of blood samples (multiple blood samples were obtained from some individuals over time).

TABLE 5-21 Hematologic and Biochemical Values of Selected Passeriformes.

Measurement	Canary (<i>Serinus canaria</i>) ^{26,7}	Mynah ^a (<i>Gracula religiosa</i>) ²⁶
PCV (%)	45-56	47.6 ± 4.9
RBC (10 ⁶ /μL)	2.5-3.8	3.8 ± 0.4
Hgb (g/dL)	12-16	14.3 ± 1.2
MCV (fL)	90-210	126 ± 11.7
MCH (pg)	26-55	38.4 ± 3.6
MCHC (g/dL)	22-32	30.1 ± 1.5
WBC (10 ³ /μL)	3-10	20.8 ± 5.8
Heterophils 10 ³ /μL (%)	—	—
	50-80	43.8 ± 8
Lymphocytes 10 ³ /μL (%)	—	—
	20-45	48.7 ± 7.5
Monocytes 10 ³ /μL (%)	—	4.6 ± 4.1
	0-1	—
Eosinophils 10 ³ /μL (%)	—	4.1 ± 2.5
	0-2	—
Basophils 10 ³ /μL (%)	—	0.8 ± 0.7
	0-1	—
H:L ratio	—	—
ALP (U/L)	20-135	—
ALT (U/L)	—	—
AST (U/L)	14-345	130-350
Bile acid (μmol/L)	—	—
RIA	23-90	—
Colorimetric	—	—
Calcium (mg/dL)	5.5-13.5	9-13
Chloride (mEq/L)	—	—
Cholesterol (mg/dL)	150-400	—
CK (U/L)	55-350	—
Creatinine (mg/dL)	0.1-0.4	0.1-0.6
GGT (U/L)	1-14	—
Glucose (mg/dL)	205-435	190-350
LDH (U/L)	120-450	600-1000
Phosphorus (mg/dL)	2.9-4.9	—
Potassium (mEq/L)	2.2-4.5	0.3-5.1
Protein, total (g/dL)	2.8-4.5	2.3-4.5
Albumin (g/dL)	—	—
Globulin (g/dL)	—	—
A:G ratio	—	—
Sodium (mEq/L)	135-165	136-152
Uric acid (mg/dL)	4-12	4-10

^aValues reported in captive adult males.

TABLE 5-22 Hematologic and Biochemical Values of Selected Ratites.

Measurement	Emu (<i>Dromaius novaehollandiae</i>) ^{375,668}	Ostrich (<i>Struthio camelus</i>) ^{448,449}	Rhea (<i>Rhea spp.</i>) ^{3,192}
Hematology			
PCV (%)	40-60	32 ± 3	29-59
RBC (10 ⁶ /μL)	2.5-4.5	1.7 ± 0.4	—
Hgb (g/dL)	—	12.2 ± 2.0	64-170 (126)
MCV (fL)	—	174 ± 42	—
MCH (pg)	—	—	—
MCHC (g/dL)	—	33 ± 5	44.4-45.7 (45.1)
WBC (10 ³ /μL)	8-25	5.5 ± 1.9	4.1-25.7 (11.8)
Heterophils 10 ³ /μL (%)	—	—	—
	45-75	63 ± 8	—
Lymphocytes 10 ³ /μL (%)	—	—	—
	20-40	34 ± 7	—
Monocytes 10 ³ /μL (%)	—	—	—
	0-2	3 ± 1	—
Eosinophils 10 ³ /μL (%)	—	—	—
	0-1	0.3 ± 0.5	—
Basophils 10 ³ /μL (%)	—	—	—
	0-1	0.2 ± 0.5	—
H:L ratio	—	—	—
Chemistries			
ALP (U/L)	—	575 ± 248	—
AST (U/L)	80-380	131 ± 31	20-192
Bile acid (μmol/L)			
RIA	6-45	—	—
Colorimetric	—	—	—
Calcium (mg/dL)	8.8-12.5	9.2	2.6-8.2
Chloride (mEq/L)	—	100 ± 16	—
Cholesterol (mg/dL)	68-170	108	—
CK (U/L)	100-750	688 ± 208	0-2640
Creatinine (mg/dL)	0.22	0.32	—
GGT (U/L)	—	1.5 ± 2.9	—
Glucose (mg/dL)	100-290	250	37.8-158.6
LDH (U/L)	310-1200	1565 ± 660	269-1640
Phosphorus (mg/dL)	3.8-7.2	3.7	—
Potassium (mEq/L)	3.5-6.5	3 ± 0.8	—
Protein, total (g/dL)	3.4-5.6	3.7 ± 0.7	3.4-6.2
Albumin (g/dL)	1-2.5	—	—
Sodium (mEq/L)	—	147 ± 34	—
Uric acid (mg/dL)	4.5-14	8.2	—

^aNumbers in parentheses represent the mean.

TABLE 5-23 Hematologic and Biochemical Values of Selected Piciformes and Columbiformes.

Measurement	Toco Toucan (<i>Ramphastos toco</i>) ^{65,160,269}	Pigeon (<i>Columba livia</i>) ^{474,724}
Hematology		
PCV (%)	45-60 (46)	49 ± 3.8
RBC (10 ⁶ /μL)	2.5-4.5 (2.5)	—
Hgb (g/dL)	14.6-18.2 (16.4)	—
MCV (fL)	176-214 (196)	—
MCH (pg)	53-76 (65)	—
MCHC (g/dL)	31-39 (35)	—
WBC (10 ³ /μL)	4-10 (5.5)	8348 ± 4813
Heterophils 10 ³ /μL (%)	—	1369 ± 1031
	35-65	—
Lymphocytes 10 ³ /μL (%)	—	5877 ± 4099
	25-50	—
Monocytes 10 ³ /μL (%)	—	225 ± 232
	—	—
Eosinophils 10 ³ /μL (%)	—	9 ± 25
	0-4	—
Basophils 10 ³ /μL (%)	—	120 ± 130
	0-5	—
H:L ratio	—	—
	—	—
Chemistries		
ALP (U/L)	—	160-780
ALT (U/L)	—	19-48
AST (U/L)	130-330	45-123
Bile acid (μmol/L)		
RIA	—	—
Colorimetric	20-40	22-60
BUN (mg/dL)	—	2.4-4.2
Calcium (mg/dL)	10-15	7.6-10.4
Chloride (mEq/L)	—	101-113
Cholesterol (mg/dL)	—	—
CK (U/L)	—	110-480
Creatinine (mg/dL)	0.1-0.4	0.3-0.4
GGT (U/L)	—	0-2.9
Glucose (mg/dL)	220-350	232-369
LDH (U/L)	200-400	30-205
Phosphorus (mg/dL)	—	1.8-4.1
Potassium (mEq/L)	—	3.9-4.7

Continued

TABLE 5-23 Hematologic and Biochemical Values of Selected Piciformes and Columbiformes. (cont'd)

Measurement	Toco Toucan (<i>Ramphastos toco</i>)		Pigeon (<i>Columba livia</i>)
Protein, total (g/dL)	3-5		2.1-3.3
Albumin (g/dL)	—		1.3-2.2
Globulin (g/dL)	—		0.6-1.2
A:G ratio	—		1.5-3.6
Sodium (mEq/L)	—		141-149
Uric acid (mg/dL)	4-14		2.5-12.9

^aNumbers in parentheses represent the mean.

TABLE 5-24 Hematologic and Biochemical Values of Selected Raptors.

Measurement	Bald Eagle (<i>Haliaeetus leucocephalus</i>) ³⁷⁹	Golden Eagle (<i>Aquila chrysaetos</i>) ^{3,332a,550}
Hematology		
PCV (%)	35-57	35-47 (41)
RBC ($10^6/\mu\text{L}$)	2.60-4.05	1.9-2.7 (2.4)
Hgb (g/dL)	—	12.1-15.2 (13.8)
MCV (fL)	—	160-184 (174)
MCH (pg)	—	56.3-62.7 (58.9)
MCHC (g/dL)	—	32.3-35.9 (34)
WBC ($10^3/\mu\text{L}$)	4.1-27.3	5.9-24 (12.3)
	—	—
Heterophils $10^3/\mu\text{L}$ (%)	50-93	—
	—	49-86
Lymphocytes $10^3/\mu\text{L}$ (%)	4-38	—
	—	14-38
Monocytes $10^3/\mu\text{L}$ (%)	0-4	—
	—	0-9
Eosinophils $10^3/\mu\text{L}$ (%)	—	—
	0-9	1-5
Basophils $10^3/\mu\text{L}$ (%)	—	—
	0-1	0-1
H:L ratio	—	—
Fibrinogen (g/L)	—	2-4.1 (2.9)
Chemistries		
ALP (U/L)	—	15-36
ALT (U/L)	—	—
AST (U/L)	131-956	95-210

TABLE 5-24 Hematologic and Biochemical Values of Selected Raptors. (cont'd)

Measurement	Bald Eagle (<i>Haliaeetus leucocephalus</i>)	Golden Eagle (<i>Aquila chrysaetos</i>)
Bile acid ($\mu\text{mol/L}$)		
RIA	—	—
Calcium (mg/dL)	8.2-10.4	7.4-9.5
Chloride (mEq/L)	—	—
Cholesterol (mg/dL)	—	—
CK (U/L)	190-1797	—
GGT (U/L)	—	—
Glucose (mg/dL)	246-431	250-408
LDH (U/L)	—	320-690
Phosphorus (mg/dL)	—	1.9-3.6
Potassium (mEq/L)	—	—
Protein, total (g/dL)	2.2-4.6	2.5-3.9
Albumin (g/dL)	1.09-2.05	1-1.4
Globulin (g/dL)	0.19-0.59	—
A:G ratio	0.57-1.59	—
Sodium (mEq/L)	—	—
Uric acid (mg/dL)	1.8-15.3	4.4-12

^aNumbers in parentheses represent the mean.

Measurement	Red-tailed Hawk (<i>Buteo jamaicensis</i>) ⁶⁹⁸	Harris Hawk (<i>Parabuteo unicinctus</i>) ^{3,114,373,698}
PCV (%)	31-43	32-44
RBC ($10^6/\mu\text{L}$)	2.4-3.6	2.13-2.76
Hgb (g/dL)	10.7-16.6	10.1-16.7
MCV (fL)	150-178	147-163
MCH (pg)	46-57.4	45.4-51.1
MCHC (g/dL)	297-345	30.1-33.0
WBC ($10^3/\mu\text{L}$)	19.1-33.4	4.8-10
Heterophils $10^3/\mu\text{L}$ (%)	—	—
	35 \pm 11	2.3-6.7
Lymphocytes $10^3/\mu\text{L}$ (%)	—	—
	44 \pm 9	0.6-2.4
Monocytes $10^3/\mu\text{L}$ (%)	—	—
	6 \pm 3	0.2-1.5
Eosinophils $10^3/\mu\text{L}$ (%)	—	—
	13 \pm 4	0-0.8
Basophils $10^3/\mu\text{L}$ (%)	—	—
	Rare	0-1.6
H:L ratio	—	—
Fibrinogen (g/L)	—	—

Continued

TABLE 5-24 Hematologic and Biochemical Values of Selected Raptors. (cont'd)

Measurement	Red-tailed Hawk (<i>Buteo jamaicensis</i>)	Harris Hawk (<i>Parabuteo unicinctus</i>)
Chemistries		
ALP (U/L)	22-138	15-36
ALT (U/L)	3-50	—
AST (U/L)	76-492	95-210
Bile acid (μmol/L)		
RIA	8.4-10.2	—
Calcium (mg/dL)	10-12.8	8.4-10.6
Chloride (mEq/L)	118-129	113-119
Cholesterol (mg/dL)	—	—
CK (U/L)	—	224-650
GGT (U/L)	0-20	2-6.9
Glucose (mg/dL)	292-390	220-283
LDH (U/L)	0-2640	160-563
Phosphorus (mg/dL)	1.9-4	3-4.4
Potassium (mEq/L)	2.6-4.3	0.8-2.3
Protein, total (g/dL)	3.9-6.7	3.1-4.6
Albumin (g/dL)	—	1.4-1.7
Globulin (g/dL)	—	2.1-2.9
A:G ratio	—	0.45-0.55
Sodium (mEq/L)	143-162	155-171
Uric acid (mg/dL)	8.1-16.8	9-13.2
Sharp-shinned Hawk (<i>Accipiter striatus</i>)³²² Turkey Vulture (<i>Cathartes aura</i>)^{3,698}		
Hematology		
PCV (%)	44-52	51-58 (54)
RBC (10 ⁶ /μL)	—	2.4-2.9 (2.7)
Hgb (g/dL)	—	15.7-17.3 (16.3)
MCV (fL)	—	194-224 (204)
MCH (pg)	—	58.6-65 (61.7)
MCHC (g/dL)	—	28.6-32 (30.2)
WBC (10 ³ /μL)	7.7-16.8	10.5-31.9 (20.1)
Heterophils 10 ³ /μL (%)	—	—
Lymphocytes 10 ³ /μL (%)	16-24	59-64
Monocytes 10 ³ /μL (%)	—	—
Eosinophils 10 ³ /μL (%)	54-75	8-18
Basophils 10 ³ /μL (%)	—	—
H:L ratio	0-3	0-1
	5-11	3-4
	—	—
	0-1	0
	—	—

TABLE 5-24 Hematologic and Biochemical Values of Selected Raptors. (cont'd)

Measurement	Sharp-shinned Hawk (<i>Accipiter striatus</i>)	Turkey Vulture (<i>Cathartes aura</i>)
Chemistries		
ALP (U/L)	—	—
ALT (U/L)	—	—
AST (U/L)	—	—
Bile acid (μmol/L)		
RIA	—	—
Calcium (mg/dL)	—	—
Chloride (mEq/L)	—	—
Cholesterol (mg/dL)	—	—
CK (U/L)	—	—
GGT (U/L)	—	—
Glucose (mg/dL)	—	—
LDH (U/L)	—	—
Phosphorus (mg/dL)	—	—
Potassium (mEq/L)	—	—
Protein, total (g/dL)	2.4-3.2	—
Albumin (g/dL)	—	—
Globulin (g/dL)	—	—
A:G ratio	—	—
Sodium (mEq/L)	—	—
Uric acid (mg/dL)	—	—

Measurement	American Kestrel (<i>Falco sparverius</i>) ²⁰⁹	Gyr Falcon (<i>Falco rusticolus</i>) ⁶⁹⁸	Peregrine Falcon (<i>Falco peregrinus</i>) ^{373,629,698}
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Hematology			
PCV (%)	43 ± 3.2	49 ± 2	37-53
RBC (10 ⁶ /μL)	—	—	3-4
Hgb (g/dL)	—	—	118-188
MCV (fL)	14.5-57	—	118-176
MCH (pg)	11-33	—	40-48.4
MCHC (g/dL)	24-58	—	319-352
WBC (10 ³ /μL)	9.8 ± 4.9	4.6 ± 1.7	3.3-21 (13 ± 3)
Heterophils 10 ³ /μL (%)	—	—	—
Lymphocytes 10 ³ /μL (%)	47 ± 3	51 ± 5	65 ± 12
Monocytes 10 ³ /μL (%)	46 ± 3	45 ± 5	35 ± 13
Eosinophils 10 ³ /μL (%)	—	—	—
Basophils 10 ³ /μL (%)	2 ± 0.2	1 ± 1	0
	—	—	—
	1 ± 0.2	1 ± 1	0
	—	—	—
	2 ± 0.2	Rare	0

Continued

TABLE 5-24 Hematologic and Biochemical Values of Selected Raptors. (cont'd)

Measurement	American	Gyr Falcon (<i>Falco</i>	Peregrine Falcon (<i>Falco</i>
	Kestrel (<i>Falco sparverius</i>)	<i>rusticolus</i>)	<i>peregrinus</i>)
Chemistries			
ALP (U/L)	232 ± 72	257	97-350
ALT (U/L)	41 ± 33	—	19-54
AST (U/L)	77 ± 29	97	20-52
Bile acid (μmol/L)			
RIA	—	—	20-118
Calcium (mg/dL)	7.1 ± 0.8	9.6	8.4-10.2
Chloride (mEq/L)	108 ± 33	125	121-134
Cholesterol (mg/dL)	—	—	175-401
CK (U/L)	1739 ± 734	402	357-850
GGT (U/L)	—	—	0-7
Glucose (mg/dL)	305 ± 40	318	11-16
LDH (U/L)	—	—	625-1210
Phosphorus (mg/dL)	3 ± 0.9	—	3.4
Potassium (mEq/L)	2.2 ± 0.7	—	1.6-3.2
Protein, total (g/dL)	3.2 ± 0.5	2.89	2.5-4
Albumin (g/dL)	1 ± 0.2	—	0.8-1.3
Globulin (g/dL)	1.2 ± 0.4	—	1.6-2.8
A:G ratio	0.9 ± 0.4	—	0.4-0.6
Sodium (mEq/L)	158 ± 3	160	152-168
Uric acid (mg/dL)	9 ± 6	13.9	4.4-22
Hematology			
	Barn Owl	Barred Owl	Great-horned Owl (<i>Bubo virginianus</i>) ^{c,17,18a}
	(<i>Tyto alba</i>) ^{a,17,18a}	(<i>Strix varia</i>) ^{c,17,18a}	
PCV (%)	48 ± 4 (41-57)	44 ± 4 (38-52)	43 ± 4
RBC (10 ⁶ /μL)	2.4 ± 0.4 (1.6-3.3)	3.0 ± 0.9 (1.0-4.7)	2.6 ± 0.5
Hgb (g/dL)	—	—	—
MCV (fL)	202 ± 29 (135-270)	156 ± 38 (77-236)	164 ± 28
MCH (pg)	—	—	—
MCHC (g/dL)	—	—	—
WBC (10 ³ /μL) PBT	13.1 ± 5.9 (5.0-28.8)	18.9 ± 7.4 (2.6-33.7)	18.3 ± 9.2 (4.2-42.4)
NHT	8.3 ± 5.0 (2.5-22.1)	6.6 ± 2.9 (2.3-13.9)	17.1 ± 9.6 (4.8-42.6)
EST	12.4 ± 6.1 (3.8-28.6)	16.5 ± 3.6 (8.8-23.0)	20.0 ± 6.2 (7.2-33.0)
Heterophils 10 ³ /μL (%)	6.9 ± 2.8 (3.2-15.0)	4.7 ± 1.8 (0.5-8.6)	9.9 ± 5.8 (2.0-25.5)
	56 ± 15 (26-85)	28 ± 12.5 (10-52)	54 ± 12 (28-79)
Lymphocytes 10 ³ /μL (%)	3.1 ± 2.1 (0.3-8.6)	9.6 ± 5.5 (0.9-22.7)	3.4 ± 2.3 (0.4-9.7)
	23 ± 10 (2-41)	48 ± 15 (18-80)	18 ± 8 (4-37)

TABLE 5-24 Hematologic and Biochemical Values of Selected Raptors. (cont'd)

Measurement	Barn Owl (<i>Tyto alba</i>)	Barred Owl (<i>Strix varia</i>)	Great-horned Owl (<i>Bubo virginianus</i>)
Monocytes 10 ³ /μL (%)	1.0 (0.1-1.3) 7 ± 5 (0-17)	2.5 ± 1.8 (0.2-7.6) 12 ± 6 (3-29)	2.1 ± 1.4 (0.2-6.7) 11 ± 4 (2-20)
Eosinophils 10 ³ /μL (%)	1.6 ± 1.5 (0.2-7.4) 12 ± 7 (2-34)	2.1 ± 2.2 (0.4-4.3) 11 ± 4 (1-20)	2.6 ± 2.4 (0.4-8.2) 15 ± 8 (2-33)
Basophils 10 ³ /μL (%)	0.3 ± 0.3 (0.0-1.1) 2 ± 2 (2-34)	0.2 ± 0.2 (0.0-4.4) 1 ± 1 (1-3)	0.3 ± 0.4 (0.2-2.9) 2 ± 2 (2-33)
H:L ratio	38 ± 4.5 (0.8-22.2)	0.7 ± 0.7 (0.1-2.7)	4.2 ± 4.2 (1.0-19.7)
Fibrinogen (g/L)	—	—	—

Chemistries

ALP (U/L)	—	—	—
ALT (U/L)	—	—	—
AST (U/L)	151 (93-263)*	88-358 [†]	55-277 [†]
Bile acid (μmol/L)			
Colorimetric	17.0 (1.0-55.0)*	6.4-54 [‡]	4.2-48.9 [‡]
Calcium (mg/dL)	9.16 (4.80-18.8)*	7.44-12.24 [†]	6.4-12 [‡]
Chloride (mEq/L)	115 (112-120)*	108-122 [‡]	111-127 [†]
Cholesterol (mg/dL)	262 (190-352)*	159-267 [†]	117-281 [†]
CK (U/L)	1243 (158-3415)*	22-3657 [‡]	27-1544 [‡]
GGT (U/L)	0 (0-388)*	0-2 [‡]	0-6 [‡]
Glucose (mg/dL)	245 (187-425)*	283-405 [†]	292-448 [†]
LDH (U/L)	173 (76-640)*	63-2103 [‡]	106-747 [‡]
Phosphorus (mg/dL)	3.12 (1.85-4.39)*	2.78-8.02 [‡]	1.76-8.23 [‡]
Potassium (mEq/L)	4.1 (2.2-6.7)*	1.7-4.9 [†]	2.3-5.7 [†]
Protein, total (g/dL)	3.4 (2.4-4.6)*	2.9-5.0 [‡]	3.0-5.1 [‡]
Albumin (g/dL)	1.9 (1.3-2.3)*	1.2-1.8 [‡]	1.2-1.8 [‡]
Globulin (g/dL)	1.5 (1.0-2.4)*	1.7-3.4 [‡]	1.5-3.3 [‡]
A:G ratio	1.4 (0.7-1.6)*	0.5-0.8 [‡]	0.4-1.0 [‡]
Sodium (mEq/L)	158 (153-166)*	154-169 [†]	151-172 [†]
Uric acid (mg/dL)	11.74 (5.49-18.06)*	1.29-18.05 [†]	3.09-17.80 [‡]

Measurement	Eastern Screech Owl (<i>Megascops asio</i>) ^{c,17,18a}	Eurasian Eagle Owl (<i>Bubo bubo</i>) ^{c,17,18a}	Northern Saw-whet Owl (<i>Aegolius acadicus</i>) ^{c,17,18a}
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Hematology

PCV (%)	47 ± 3 (40-54)	50 ± 9 (NA)	48 ± 5 (NA)
RBC (10 ⁶ /μL)	3.4 ± 7 (1.7-4.8)	2.0 ± 0.3 (NA)	2.8 ± 0.5 (NA)
Hgb (g/dL)	—	—	—
MCV (fL)	145 ± 26 (89-200)	—	176 ± 29 (NA)

Continued

TABLE 5-24 Hematologic and Biochemical Values of Selected Raptors. (cont'd)

Measurement	Eastern Screech Owl (<i>Megascops asio</i>)	Eurasian Eagle Owl (<i>Bubo bubo</i>)	Northern Saw-whet Owl (<i>Aegolius acadicus</i>)
MCH (pg)	—	—	—
MCHC (g/dL)	—	—	—
WBC ($10^3/\mu\text{L}$) PBT	15.4 ± 6.3 (1.2-28.1)	20.9 ± 14.4 (6.6-64.7)	6.3 ± 3.1 (NA)
NHT	8.4 ± 3.9 (3.1-19.8)	17.2 ± 11.6 (3.0-56.6)	5.7 ± 2.5 (NA)
EST	15.2 ± 6.3 (1.8-28.5)	20.4 ± 12.6 (6.2-65.8)	11.6 ± 3.6 (NA)
Heterophils $10^3/\mu\text{L}$ (%)	4.0 ± 1.6 (0.4-7.3)	10.9 ± 8.3 (2.3-48.9)	1.8 ± 0.8 (NA)
	27 ± 10 (6-47)	51 ± 12 (24-76)	29 ± 10 (NA)
Lymphocytes $10^3/\mu\text{L}$ (%)	6.0 ± 3.6 (0.9-15.9)	4.0 ± 2.1 (1.5-12.0)	2.4 ± 1.9 (NA)
	38 ± 13 (12-65)	23 ± 11 (5-50)	35 ± 15 (NA)
Monocytes $10^3/\mu\text{L}$ (%)	2.3 ± 1.1 (0.5-5.0)	1.7 ± 1.3 (0.3-5.6)	0.8 ± 0.4 (NA)
	15 ± 6 (3-27)	9 ± 4 (0-17)	13 ± 3 (NA)
Eosinophils $10^3/\mu\text{L}$ (%)	2.8 ± 1.8 (0.4-7.9)	4.0 ± 5.9 (NA)	±0.7 (NA)
	18 ± 8 (5-39)	16 ± 10 (4-46)	22 ± 10 (NA)
Basophils $10^3/\mu\text{L}$ (%)	0.3 ± 0.4 (0.0-1.3)	0.2 ± 0.3 (0.0-0.9)	±0.1
	2 ± 2 (0-6)	1 ± 1 (NA)	1 ± 2
H:L ratio	0.9 ± 0.8 (0.8-15.8)	2.9 ± 1.9 (0.6-9.9)	1.2 ± 1.2
Fibrinogen (g/L)	—	—	—
Chemistries			
ALP (U/L)	—	—	—
ALT (U/L)	—	—	—
AST (U/L)	108-647 [‡]	—	248 (127-411)*
Bile acid ($\mu\text{mol/L}$)			
Colorimetric	4-59 [‡]	—	50 (21-61)*
Calcium (mg/dL)	4.9-12.4 [†]	—	9.4 (5.6-10.4)*
Chloride (mEq/L)	106-119 [†]	—	113 (92-114)*
Cholesterol (mg/dL)	168-336.3 [†]	—	307.67 (193.5-491.5)*
CK (U/L)	5-1174 [‡]	—	377(19-4299) *
GGT (U/L)	0-10 [‡]	—	0 (0-4)*
Glucose (mg/dL)	282.6-455.4 [†]	—	318.6 (271.8-347.4)*
LDH (U/L)	62-2984 [‡]	—	140 (6-308)*
Phosphorus (mg/dL)	1.2-8.5 [‡]	—	3.96 (2.79-5.26)*
Potassium (mEq/L)	1.2-6.2 [†]	—	3.0 (2.6-3.6)*
Protein, total (g/dL)	2.5-4.3 [‡]	—	3.0 (2.7-3.7)*
Albumin (g/dL)	1.3-2.6 [†]	—	2.1 (1.9-2.7)*
Globulin (g/dL)	0.9-2.2 [†]	—	0.9 (0.4-1.5)*
A:G ratio	0.6-1.9 [†]	—	2.3 (1.3-6.5)*
Sodium (mEq/L)	152-165 [†]	—	153 (129-155)*
Uric acid (mg/dL)	2.84-26.30 [‡]	—	9 (2.63-12.6)*

TABLE 5-24 Hematologic and Biochemical Values of Selected Raptors. (cont'd)

Measurement	Great Gray Owl (<i>Strix nebulosa</i>) ^{c,17,18a}	Short-eared Owl (<i>Asio flammeus</i>) ^{c,17,18a}	Snowy Owl (<i>Bubo scandiacus</i>) ^{c,17,18a}
Hematology			
PCV (%)	50 ± 5 (39-61)	48 ± 6 (NA)	49 ± 6 (NA)
RBC (10 ⁶ /μL)	2.8 ± 0.3 (2.1-3.4)	2.6 ± 0.6 (NA)	3.3 ± 0.7 (NA)
Hgb (g/dL)	—	—	—
MCV (fL)	181 ± 26 (127-236)	181 ± 29 (NA)	142 ± 23 (NA)
MCH (pg)	—	—	—
MCHC (g/dL)	—	—	—
WBC (10 ³ /μL) PBT	11.1 ± 6.0 (1.8-26)	11.0 ± 7.3 (NA)	9.6 ± 5.4 (NA)
NHT	4.8 ± 2.5 (1.7-11.4)	6.0 ± 3.6 (NA)	6.7 ± 6.5 (NA)
EST	13.0 ± 4.6 (2.7-21.7)	12.4 ± 5.5 (NA)	10.2 ± 5.7 (NA)
Heterophils 10 ³ /μL (%)	3.6 ± 2.6 (1.0-12.2)	3.5 ± 2.9 (NA)	4.5 ± 3.4 (NA)
	34 ± 12 (9-58)	30 ± 14 (NA)	46 ± 19 (NA)
Lymphocytes 10 ³ /μL (%)	4.3 ± 3.0 (0.4-12.3)	5.0 ± 3.4 (NA)	3.3 ± 2.8 (NA)
	37 ± 15 (5-69)	47 ± 15 (NA)	34 ± 17 (NA)
Monocytes 10 ³ /μL (%)	1.6 ± 1.0 (0.2-4.7)	1.1 ± 1.1 (NA)	0.9 ± 0.4 (NA)
	14 ± 4 (5-23)	9 ± 5 (NA)	11 ± 5 (NA)
Eosinophils 10 ³ /μL (%)	1.4 ± 1.6 (0.7-11.9)	1.2 ± 0.8 (NA)	0.8 ± 1.0 (NA)
	12 ± 8 (0-42)	13 ± 8 (NA)	8 ± 5 (NA)
Basophils 10 ³ /μL (%)	0.2 ± 0.2 (0.0-0.9)	0.2 ± 0.3 (NA)	0.0 ± 0.1 (NA)
	2 ± 2 (0-7)	2 ± 2 (NA)	1 ± 2 (NA)
H:L ratio	1.3 ± 1.1 (0.2-5.8)	0.9 ± 1.0 (NA)	2.6 ± 3.6 (NA)
Fibrinogen (g/L)	—	—	—
Chemistries			
ALP (U/L)	—	—	—
ALT (U/L)	—	—	—
AST (U/L)	125-467 [‡]	213 (121-431)*	215 (171-301)*
Bile acid (μmol/L)			
Colorimetric	6-81 [‡]	19 (4-94)*	27 (8-78)*
Calcium (mg/dL)	2.88-11.88 [‡]	6.72 (3.6-9.6)*	8.84 (7.32-11.12)*
Chloride (mEq/L)	107-121 [‡]	114 (104-122)*	113 (109-121)*
Cholesterol (mg/dL)	139.32-284.06 [‡]	206.3 (174.2-278.6)*	261.6 (152.48-839.8)*
CK (U/L)	1-574 [‡]	29 (0-265)*	203 (20-3338)*
GGT (U/L)	0-10 [‡]	0 (0-3)*	0 (0-5)*
Glucose (mg/dL)	245-378 [‡]	319 (261-360)*	338 (218-468)*
LDH (U/L)	65-353 [‡]	180 (92-530)*	209 (132-861)*

Continued

TABLE 5-24 Hematologic and Biochemical Values of Selected Raptors. (cont'd)

Measurement	Great Gray Owl (<i>Strix nebulosa</i>)	Short-eared Owl (<i>Asio flammeus</i>)	Snowy Owl (<i>Bubo scandiaca</i>)
Phosphorus (mg/dL)	0.50-8.18 [†]	2.60 (0.93-7.12)*	5.51 (1.64-7.77)*
Potassium (mEq/L)	2.1-4.8 [†]	3.7 (2.9-5.3)*	3.8 (1.5-5.5)*
Protein, total (g/dL)	2.7-4.1 [‡]	2.7 (2.1-3.3)*	3.6 (2.6-4.7)*
Albumin (g/dL)	1.5-2.4 [†]	1.4 (1.0-1.7)*	1.4 (0.8-1.9)*
Globulin (g/dL)	1.0-2.6 [‡]	1.3 (1.0-1.6)*	1.8 (1.3-3.4)*
A:G ratio	0.6-1.9 [‡]	1.1 (0.8-1.4)*	0.8 (0.4-1.3)*
Sodium (mEq/L)	152-168 [‡]	157 (151-161)*	158 (156-170)*
Uric acid (mg/dL)	3.33-21.37 [‡]	7.09 (2.56-25.28)*	11.42 (5.51-22.33)*

^aNumbers in parentheses represent the mean.

^bWBC count and differentials for Harris hawk are absolute values.

^cHematology: Mean and SD (reference interval); *PBT*, phloxine B technique; *NHT*, Natt and Herrick technique; *EST*, estimation from the smear technique. Differential counts were computed from the phloxine B technique. Reference intervals were calculated by the robust method or robust method after Box-Cox transformation; *NA*, insufficient sample size for reference interval calculation ($n < 20$). Biochemistry:

*Median (range) ($10 < n < 20$). Reference intervals were not reported when $n < 10$.

[†]Robust technique ($n > 20$, Gaussian distribution). [‡]Robust technique with Box-Cox transformation ($n > 20$, non-Gaussian distribution).

TABLE 5-25 Biologic and Physiologic Values of Selected Avian Species.^{a,12a,30,142,143,191,192,214,260,327,328,377,414,542,675,737,778,836}

Species	Incubation Period (days) ^b	Fledgling Age (days)	Weaning Age (days)		Sexual Maturity	Lifespan in Captivity (Maximum) (years)	Body Weight (g) ^c
			Parent-raised	Hand-reared			
Psittaciformes							
African grey parrot	26-28 ^d	50-65	100-120	75-90	4-6 yr	50-60	454 (370-534)
Amazon parrot	24-29 ^e	45-60	90-120	75-90	4-6 yr	>50 (80)	f
Australian parakeet	18-19	30-45	50-65	—	1-3 yr	10-12	30-110
Budgerigar parakeet	16-18	22-26	30-40	30	6-9 mo	5-10 (18)	30
Cockatiel	18-20	32-38	47-52	42-49	6-12 mo	10-12 (30)	80-90
Cockatoo, galah	22-24	45-55	90-120	80-90	1 yr	40-60	g
Cockatoo, large	h	60-80	120-150	95-120	5-6 yr	50-60	g
Cockatoo, medium	h	45-60	90-120	75-100	3-4 yr	40-60	g
Conure	i	35-40	45-70	60	2-3 yr	25-40	80-100 ^j
Eclectus parrot	26-28	72-80	120-150	100-110	4 yr	20-40 (80)	432 (347-512)
Lory/lorikeet	21-27	42-50	62-70	50-60	2 yr	20-30	—
Lovebirds	18-24	30-35	45-55	40-45	6-12 mo	15-30	42-48
Macaw, large	26-28	70-80	120-150	95-120	5-7 yr	75-100	k
Macaw, small	23-26	45-60	90-120	75-90	4-6 yr	50-80	k
Ring-neck parakeet, Indian	22-23	40-45	55-65	—	3 yr	18-25	115

Continued

TABLE 5-25 Biologic and Physiologic Values of Selected Avian Species. (cont'd)

Species	Incubation Period (days)	Fledgling Age (days)	Weaning Age (days)		Sexual Maturity	Lifespan in Captivity (Maximum) (years)	Body Weight (g)
			Parent-raised	Hand-reared			
Passeriformes							
Canary	12-14	14	21	—	<1 yr	6-12	12-30
Mynah	14-15	30	60	—	2-3 yr	12	180-260
Zebra or society finch	12-16	18-20	25-28	—	9-10 mo	4-7	10-16
Columbiformes							
Dove, common ground	12->14	18	—	—	1 yr	4-8	30
Dove, mourning	13-14	12-14	—	—	—	—	120
Pigeon (rock dove)	16-19	28-35	35	—	1 yr	4-8 (>20)	240-300
Ratites							
Emu	50-57	—	Precocial	—	3-5 yr	30	40-45 kg
Ostrich	41-43	—	Precocial	—	4 yr	80	120-160 kg
Rhea	36-41	—	Precocial	—	1.5-2 yr	—	25 kg

^aGuidelines only; data vary between references. For raptors, see Table 5-26.

^bBrotogeris parakeets, 22; Pionus parrot, 25-26; Psittacula parakeets, 23-26; Quaker parakeet, 23; Senegal parrot, 24-25.

^cBourke's parakeet, 40 (35-50); kakariki parakeet, 95-100; Princess of Wales parakeet, 108 (100-129); red-rumped parakeet, 65 (60-69).

^dCongo, 28; Timneh, 26.

^eGreen-cheeked, blue-fronted, 26; spectacled (white-fronted), 24; yellow-naped, yellow-fronted, yellow-crowned, double yellow-headed, 28-29.

^fBlue-crowned, 740 (618-998); blue-fronted, 432 (361-485); double yellow-headed, 568 (463-694); Mexican red-headed, 360 (343-377); yellow-naped, 596 (476-795).

^gBare-eyed, 331; greater sulphur-crested, 806; Leadbeater's (Major Mitchell's), 423 (381-474); lesser sulphur-crested, 303; Moluccan, 808; rose-breasted, 299; triton, 559; umbrella, 552.

^hBare-eyed, 23-24; citron-crested, 25-26; greater sulphur-crested, 27-28; Leadbeater's (Major Mitchell's), 26; lesser sulphur-crested, 24-25; Moluccan, 28-29; palm, 28-30; triton, 27-28; umbrella, 28.

ⁱBlue-crowned, 23-24; orange-fronted, 30; Nanday, 21-23; Patagonian, 24-25; sun, 27-28.

^jQueen of Bavaria, 262 (252-276).

^kBlue and gold, 1021; green-winged, 1179; hyacinth, 1355 (1197-1466); military, 788; red-fronted, 458; scarlet, 1103.

TABLE 5-26 Biologic and Physiologic Values of Selected Raptors. [75,134,214,257,317,698,737](#)

Species	Clutch Size	Incubation Period (days)	Interval Between Eggs (days)	Start of Incubation	Fledging (days)	Sexual Maturity (yr)	Longevity (yr)	Body Weight	
								Male	Female
American kestrel	3-7	29-31	—	—	30-31	—	2-7	103-120 g	126-166 g
Bald eagle	1-3	34-36	—	—	70-98	—	—	4.1 kg	5.8 kg
Barn owl	2-9	30-31	2-3	First egg	70-75	7	—	441-470 g	490-570 g
Barred owl	2-4	28-33	—	—	6	—	—	630 g	800 g
Black vulture	1-3	37-48	—	—	80-94	—	—	^a	^a
Common kestrel	3-6	27-29	1-2	Second to third egg	—	7	—	136-252 g	154-314 g
Cooper's hawk	3-6	32-36	—	—	27-34	—	—	220-410 g	330-680 g
Eurasian buzzard	2-4	36-38	4	First to second egg	—	2-3	—	0.55-0.85 kg	0.7-1.2 kg
Eurasian eagle owl	2-4	34-36	2-3	First to second egg	6	2-3	50-60	1.5-2.8 kg	1.8-4.2 kg
Golden eagle	1-3	43-45	—	—	6	>5	50-60	2.5-4 kg	3.25-6.35 kg
Gyrffalcon	3-5	34-36	—	—	49-56	—	—	0.96-1.3 kg	1.3-2.1 kg
Harris hawk	2-5	3	2-3	Penultimate or last egg	43-49	>3	20-30	0.7 kg	1 kg
Merlin	2-7	28-32	—	—	30-35	7	10-14	150-210 g	189-255 g
Northern goshawk	3-5	35-38	2-3	First to second egg	35-42	>3	15-20	0.5-1.2 kg	0.8-1.5 kg
Northern sparrow hawk	4-6	3	2-3	Third to fourth egg	—	1-2	—	—	—

Continued

TABLE 5-26 Biologic and Physiologic Values of Selected Raptors. (cont'd)

Species	Clutch Size	Incubation Period (days)	Interval Between Eggs (days)	Start of Incubation	Fledging (days)	Sexual Maturity (yr)	Longevity (yr)	Body Weight	
								Male	Female
Osprey	2-4	32-43	—	—	48-59	—	—	^b	^b
Peregrine falcon	3-4	29-32	2-3	Penultimate or last egg	35-42	>3	15-20	440-750 g	910-1500 g
Prairie falcon	2-7	29-33	—	—	35-42	—	—	500-650 g	700-975 g
Screech owl, eastern	3-4	—	—	—	—	—	—	158-184 g	180-220 g
Screech owl, western	2-6	21-30	—	—	6	—	—	131-210 g	157-250 g
Sharp-shinned hawk	3-8	32-35	—	—	24-27	—	—	82-125 g	144-208 g
Snowy owl	3-9	30-33	2-3	First egg	6	7	—	1.6 kg	1.1-2 kg
Turkey vulture	1-3	38-41	—	—	66-88	—	—	^c	^c

^a1.7-2.3 kg; weights of males and females were not listed separately.

^b1-2.1 kg; weights of males and females were not listed separately, but females are generally 25% heavier than males.

^c0.8-2.3 kg; weights of males and females were not listed separately, but females are slightly heavier than males.

TABLE 5-27 Quick Reference to Abnormalities of the Standard Avian Hematology Profile.²⁶⁸

Parameter	Increases	Decreases
PCV/RBC	Dehydration <ul style="list-style-type: none"> Increased total protein Erythrocytosis (polycythemia) <ul style="list-style-type: none"> Normal or low total protein Primary rare Secondary to respiratory or cardiovascular disease 	Regenerative anemia <ul style="list-style-type: none"> Polychromasia (10%), reticulocytes, immature RBC Hemorrhagic: Trauma, parasites, coagulopathies, ulcerated neoplasms, gastrointestinal ulcers Hemolytic: Septicemia, hemoparasites, toxicities, immune-mediated Presence of Heinz bodies, agglutination of RBC Nonregenerative anemia <ul style="list-style-type: none"> Hypoplastic: Inflammatory infectious, myelosuppressive drugs, iron deficiency, food restriction, folic acid deficiency
Heterophils	Inflammatory processes <ul style="list-style-type: none"> Bacterial (including <i>Mycobacterium</i>) and fungal infections Excess corticosteroids <ul style="list-style-type: none"> Endogenous production Exogenous administration Birds with a high heterophil: lymphocyte ratio may mount a greater leukocytic response	Infection <ul style="list-style-type: none"> Bacterial and viral (i.e., PBFD) Poor sample preparation, collection, and storage
Lymphocytes	Chronic antigenic stimulation Neoplasia: lymphocytic leukemia Stress response (acute)	Stress response (chronic) Immunosuppressive drugs Viral infection Endotoxemia/septicemia
Monocytes	Granulomatous and/or chronic inflammation (e.g., bacterial, fungal, parasitic) Neoplasia	—
Eosinophils	Gastrointestinal parasitism Type IV hypersensitivity reactions	Corticosteroids Stress response (chronic)
Basophils	Early inflammatory responses Type I hypersensitivity reaction Anaphylactic reaction Induced molting	—
Thrombocytes	—	Vitamin K deficiency Rodenticide toxicity Aflatoxicosis Septicemia-associated DIC (as with polyomavirus and reovirus) Hepatic disease or failure

TABLE 5-28 Quick Reference to Abnormalities of the Standard Avian Biochemical Profile.^{a,269}

Parameter	Increases		Decreases	
	Nonmedical	Medical	Nonmedical	Medical
ALP (U/L)	Juveniles have higher levels	Hyperparathyroidism induced osteoclastic activity (fractures); egg laying; hepatic disease; enteritis; aflatoxicosis	—	Dietary zinc deficiency
ALT (U/L)	Seasonal variation in raptors; sample hemolysis	—	Seasonal variation in raptors	—
Amylase (U/L)	—	Pancreatitis; gastrointestinal disease; zinc toxicity	—	—
AST (U/L)	Rare; severe lipemia; 300-1000	Liver, muscle, or heart damage; vitamin E/selenium, methionine deficiency; 300-15,000	—	<50; end-stage liver disease
Bile acids (μmol/L)	Lipemia; sample hemolysis, such samples should not be analyzed	Loss of liver function, even with normal enzymes	Lipemic samples that are chemically treated	Response to therapy; liver cirrhosis; microhepatica
Calcium (mg/dL)	Lipemia (or cloudy from other causes); protein elevations; bacterial contamination	Hormonal disorders; egg production; metabolic disease; excess dietary vitamin D; dehydration; osteolytic neoplasia	EDTA; bacterial contamination; young birds have lower levels	<8; metabolic and nutritional disorders; lead poisoning; glucocorticoid administration; low albumin; African grey parrot hypocalcemia
Cholesterol (mg/dL)	Postprandial; ⁵³⁰ high fat diet; carnivorous diet	Metabolic disease; hepatic lipodosis; bile duct obstruction; hypothyroidism; starvation	—	Liver, metabolic disease
CK (U/L)	>300; healthy birds up to 1000	600-25,000; muscle or heart damage; CNS disease (seizures); vitamin E/selenium deficiency; chlamydiosis; lead toxicity; IM injections	<10; bacterial contamination	Rare
Creatinine (mg/dL)	—	Not useful in birds	—	Not useful in birds
Glucose (mg/dL)	Improper dilution; postprandial; posthandling	Stress, 400-600; diabetes, 800-1500; corticosteroids	<100; unseparated blood; bacterial contamination	<100; hepatic dysfunction; septicemia; neoplasia; aspergillosis
LDH (U/L)	Sample hemolysis	300-15,000; liver, heart, or muscle damage; hepatitis; muscle damage	<50	End-stage liver disease

Lipase (U/L)	—	Acute pancreatitis	—	—
Phosphorus (mg/dL)	Postprandial; sample hemolysis	Severe renal disease; nutritional secondary hyperparathyroidism; hypoparathyroidism	EDTA	Hypovitaminosis D; malabsorption; chronic glucocorticoid therapy
Potassium (mEq/L)	Hemolysis; dietary supplementation	Adrenal disease; metabolic disease; severe tissue damage; renal disease; acidosis; dehydration; hemolytic anemia	—	Adrenal disease; metabolic disease; diuretic therapy; alkalosis; overhydration; dietary deficiency
Protein, total (g/dL)	Lipemia; non-temperature compensated refractometer	Inflammation; dehydration; chronic infection; gamma globulinopathy; lympho-proliferative disease; myelosis	Non-temperature compensated refractometer	Chronic hepatopathy; malabsorption; renal disease; blood loss; neoplasia; starvation/malnutrition
Sodium (mEq/L)	Dietary supplementation	Dehydration; salt poisoning	—	Renal disease; overhydration
Sorbitol dehydrogenase (U/L)	—	Hepatitis	—	—
Uric acid (mg/dL)	5-15; severe lipemia; dirty nail clip; carnivorous birds have higher levels	Renal disease; gout; dehydration; postprandial; ovulation; tissue damage; starvation; hypervitaminosis D	Overhydration of patient; juvenile levels are lower	End-stage liver disease

^aThe ranges given are not absolute and are to be used as a guide for interpretation of a wide range of avian species.

TABLE 5-29 Blood Gases of Selected Avian Species.^a

Parameter	<i>Amazona aestiva</i> ^b (n = 35) ⁵⁸⁵	<i>Falco rusticolus</i> ^c (n = 30) ⁶³¹	<i>Psittacus spp.</i> ^d (n = 46) ⁵²³
pH _{37°C}	7.45 ± 0.05	7.49 ± 0.08	7.32 ± 0.08
PCO ₂ (mmHg)	22.1 ± 4	35.5 ± 6.1	29.3 ± 6.1
PO ₂ (mmHg)	98.1 ± 7.6	111.8 ± 20.5	37.9 ± 3.8
HCO ₃ (mmol/L)	14.8 ± 2.8	22.5 ± 4.0	15 ± 2.4
TCO ₂ (mmol/L)	—	23.3 ± 4.0	16.0 ± 2.7
BE _{ecf} (mmol/L)	7.9 ± 3.1	0.9 ± 4.9	17-0
Na (mmol/L)	147.4 ± 2.2	148 ± 1.8	141-159
K (mmol/L)	3.5 ± 0.5	3.3 ± 0.3	3.6 ± 0.5
iCa (mmol/L)	0.8 ± 0.3	1.0 ± 0.1	1.1 ± 0.1
SO ₂ (%)	96.2 ± 1.1	98.6 ± 1.0	68.4 ± 10.1
Hct (%)	38.7 ± 6.2	42.1 ± 4.0	—
Hgb (g/dL)	13.2 ± 2.1	14.3 ± 1.4	—
Glu (mg/dL)	—	317 ± 17	247 ± 25
Temperature (°C)	41.8 ± 0.6	41.2 ± 0.5	41.6 ± 0.4
pH _{Temp°C}	—	7.4 ± 0.1	7.3 ± 0.1
PCO ₂ (mmHg) _{Temp°C}	—	35.5 ± 6.1	35.7 ± 7.5
PO ₂ (mmHg) _{Temp°C}	—	140.3 ± 21.1	52.5 ± 5.6

^aPCO₂, partial pressure carbon dioxide; PO₂, partial pressure of oxygen; HCO₃, bicarbonate concentration; TCO₂, total carbon dioxide concentration; SO₂, hemoglobin saturated with oxygen.

^bi-STAT EC7⁺ cartridges. Mean and SD. Arterial sample under manual restraint.

^ci-STAT CG8⁺ cartridges. Mean and SD. Venous sample under isoflurane anesthesia with O₂.

^di-STAT EC8⁺ and CG8⁺ cartridges. Mean and SD, or range. Venous sample under manual restraint.

TABLE 5-30 Lipoprotein Panel of Selected Avian Species.

Parameter ^a	<i>Amazona spp.</i> ^b (n = 29) ⁶⁴²	African grey parrot (n = 20) ⁷⁶³	Pionus parrot (n = 29) ⁷⁶³
Cholesterol (mg/dL)	238 (87-364)	222-297	100-116
Triglycerides (mg/dL)	156 (10-300)	104-190	270-301
HDL (mg/dL)	109 (75-148)	161-176	172-177
LDL (mg/dL)	92 (2-182)	24-100	75-103
VLDL (mg/dL)	31 (2-60)	—	—
LDL:HDL (mg/dL)	0.75 (0.18-1.28)	—	—
Non-HDL-LDL (mg/dL)	1.08 (0.24-1.82)	—	—

^aHDL, high-density lipoprotein; LDL, low-density lipoprotein; VLDL, very low-density lipoprotein.

^bMean and 90% confidence intervals.

TABLE 5-31 T₄ Values of Selected Avian Species.^{a,155,465,472,871}

Species	Baseline T ₄ (nmol/L) ^b	Post-TSH (nmol/L) ^{c,d}
African grey parrot	3.83-27.03 ^{155,377}	—
	1.83 ± 0.57 ⁴⁶⁵	11.97 ± 3.73 ⁴⁶⁵
	≤1.93 ⁸⁷¹	23.04 ± 13.26 ⁸⁷¹
Amazon parrot	1.29-14.16 ¹⁵⁵	—
	10.54 ± 8.88 ⁴⁶⁵	35.26 ± 20.5 ⁴⁶⁵
	5.53 ± 0.36 (red-lored) ⁸⁷¹	78.64 ± 44.79 ⁸⁷¹
	≤1.93 (blue-fronted) ⁸⁷¹	98.33 ± 26.38 ⁸⁷¹
Budgerigar	6.44-27.03 ¹⁵⁵	—
Canary	9.01-41.18 ¹⁵⁵	—
Cockatiel	9.01-30.89 ¹⁵⁵	—
Cockatoo	15.24 ± 8.7 ⁴⁶⁵	50.19 ± 7.28 ⁴⁶⁵
	17.54 ± 8.4 ⁴⁶⁵	45.17 ± 16.94 ⁴⁶⁵
Conure	6.44-25.74 ¹⁵⁵	—
	2.27 ± 0.99 ⁴⁶⁵	17.37 ± 9.92 ⁴⁶⁵
Eclectus parrot	3.86-25.74 ¹⁵⁵	—
Jardine's parrot	2.57-19.31 ¹⁵⁵	—
Lory	3.86-15.44 ¹⁵⁵	—
Lovebird	2.57-55.34 ^{155,377}	—
Macaw, blue and gold	4.39 ± 2.29 ⁴⁶⁵	15.91 ± 8.16 ⁴⁶⁵
Macaw, scarlet	1.72 ± 0.66 ⁴⁶⁵	8.31 ± 3.99 ⁴⁶⁵
Pigeon	6.05-35.01 ^{155,377,472}	—
Pionus parrot	6.44-24.45 ¹⁵⁵	—
Quaker parrot	5.15-27.03 ¹⁵⁵	—
Senegal parrot	6.44-29.6 ¹⁵⁵	—

^a0.5 μg/dL = 6.5 nmol/L = 5 ng/mL.²⁹¹ To convert thyroxine from μg/dL to nmol/L, multiply by 12.87.⁴⁷²

^bT₄ levels will vary with the time of day and year, with higher levels measured in the winter. Physiologic states such as molting or reproductive activity may also alter the ratio of T₄ to T₃ released. The half-life of thyroid hormones is much shorter in birds than in mammals; therefore it is difficult to accurately measure single hormone levels.⁵¹³

^cThe canine radioimmunoassay (RIA) kit does not accurately measure total T₄ below 6.5 nmol/L.²⁹¹ Results of high-sensitivity total T₄ testing in parrots ranged from 2 to 6 nmol/L. This high sensitivity test is available through the University of Tennessee Clinical Endocrinology Laboratory (865-974-5638).²⁹²

^dLow-dose TSH (0.2 U/kg).

TABLE 5-32 Approximate Resting Respiratory Rates of Selected Avian Species and by Weight.^{149a,257,688}

Species	Respiratory Rate (breaths/min) ^a
Amazon parrot	15-45
Budgerigar	60-75
Canary	60-80
Cockatiel	40-50
Cockatoo	15-40
Conure, large	30-45
Conure, small	40-50
Finch	90-110
Lovebird	50-60
Macaw	20-25
Raptor	10-20
Toucan	15-45

Weight (g)	Respiratory Rate (breaths/min) ^a
100	40-52
200	35-50
300	30-45
400	25-30
500	20-30
1000	15-20

^aRestraint can increase respiratory rate 1.5-2 × the resting rate.

TABLE 5-33 Urinalysis Values Reported in Birds.^{102,606}

Parameter	Reference Range	Pigeon ^{a,308}	Falcon ⁸⁰¹	Ostrich ⁵³⁹
Specific gravity (g/mL)	1.005-1.020	—	—	—
pH	6.4-8 Laying hens and carnivorous birds may have more acidic urine; cloacal contents may alter urine pH	5.5-6.9	5-7	7.6 ± 1.5
Protein (g/dL)	Negative to trace	0.11-1.99	0.3 ± 0.2	2.6 ± 1.5
Glucose (mg/dL)	Negative to trace	—	24.3 ± 39.6	Negative
Ketones	Negative; ketonuria is sometimes present in migratory birds	—	Negative	Negative
Bilirubin	Negative	—	—	Negative
Urobilinogen	Negative	—	—	Negative

^a95% confident interval.

TABLE 5-34 Values Reported for Selected Ophthalmic Diagnostic Tests in Avian Species.^{a,b,70,376,430,432a,522,661,771,773,855}

Species	Tear Production		Intraocular Pressure (mmHg)	
	Phenol Red Thread Test (mm/15 sec)	Schirmer Tear Test (mm/min)	Applanation Tonometry	Rebound Tonometry
Psittacine birds				
Amazon parrots, blue-fronted	21.9 ± 2.3 ^c	—	8.3 ± 1.1 ^c	—
Amazon parrots, Hispaniolan	12.5 ± 5.0	7.9 ± 2.6	—	—
Amazon parrots, orange-winged	12.6 ± 2.6 ^c	—	9.7 ± 1.7 ^c	—
Raptors				
Bald eagle	—	14 ± 2	21.5 ± 1.7	—
Barn owl	19.5 ± 7.2	3.6 ± 2.2	18.0 ± 6.6	11.5 ± 4.7
Common buzzard	16.0 ± 7.7	13.7 ± 4.4	19.4 ± 3.9	29.9 ± 6.1
Cooper's hawk	—	—	16.0 ± 1.8	10.7 ± 1.4
Eastern screech owl	—	—	9.3 ± 2.6	6.3 ± 1.3
Eurasian eagle owl	—	—	9.3 ± 1.8	10.5 ± 1.6
Eurasian scops owl	11.8 ± 5	1.0 ± 0.5	14.5 ± 3.9	—
Golden eagle	—	—	21.5 ± 3	—
Great horned owl	—	—	9.9 ± 2.4	9.9 ± 2.4
Kestrel, American	—	—	8.5 ± 4.4	6.8 ± 1.7
Kestrel, common	29.6 ± 4.7	5.8 ± 4	11.9 ± 3.3	11.6 ± 2.7
Northern goshawk	—	—	—	21.2 ± 2.4
Peregrine falcon	—	—	—	15.3 ± 6.1
Red-tailed hawk	—	—	20.3 ± 2.8	19.8 ± 4.9
Snowy owl	—	9.8 ± 2.4	—	9.1 ± 1.9
Swainson's hawk	—	—	20.8 ± 2.3	—
Tawny owl	—	4.3	9.4 ± 1.8	11.1 ± 3.1
Turkey vulture	—	—	15.0 ± 2.1	11.7 ± 1.0

^aMean ± SD values reported.^bFor ultrasonographic ocular measurements, see references.^cMedian ± S-IQR.

TABLE 5-35 Checklist of Supportive Care Procedures Used in Companion Bird Medicine.⁹⁶

Supportive care is an essential component of companion bird medicine.

1. **Minimize handling and other stressors**
2. House the bird in a **warm, quiet**, well-ventilated environment
 - Ensure minimal to no disturbance
 - Debilitated birds are often fluffed and ruffled and require supplemental heat 86°F (30°C)
3. **Fluid therapy** (see [Table 5-36](#) and [Table 5-37](#))
4. Provide analgesia when indicated (see [Table 5-5](#) and [Table 5-6](#))
5. Supplement vitamins as needed
 - Vitamin A, vitamin E/selenium
 - Vitamin B complex in selected cases of injury, anorexia, cachexia, CNS disorders, or blood loss
6. Antibiotics (see [Table 5-1](#))
 - To control primary infections and for injured or debilitated birds where secondary infections may result
7. Iron dextran
 - Iron deficiency or following hemorrhage
8. Normal photoperiod (or subdued lighting, if needed)
9. Oxygen
 - Dyspnea, hypoxia, or severe pneumonia and air sacculitis
10. Maintain body weight
 - Weigh once or twice daily if possible
 - Offer favorite foods and avoid changing diet while ill
11. Gavage or tube feeding^a
 - Malnourishment, anorexia, cachexia, and dehydration
 - High carbohydrate formula is initially recommended
 - High-protein/high-calorie formulas may be used to increase body weight during recovery

^aCrop volume may be estimated as 5% BW or 50 mL/kg.

TABLE 5-36 Fluid Therapy Recommendations for Birds.

When evaluating a patient for fluid therapy, the following factors should ideally be considered: hydration status, electrolyte balance, acid-base status, hematologic and biochemical values, and caloric balance.

- Warm fluids to 100–102°F (38–39°C) to help prevent or correct hypothermia
- Use caution when giving dextrose parenterally; 5% dextrose is a good choice for simple dehydration; however, it can exacerbate problems significantly if used concurrent to significant electrolyte loss^{496,767}
- When given orally, dextrose is rapidly absorbed from the intestinal tract without creating an influx of fluid into the intestinal lumen and secondary dehydration^{496,767}
- Potassium chloride can be diluted in fluids to correct for potassium depletion based on electrolyte analysis (0.1–0.3 mEq/kg)⁸⁰⁸
- Hetastarch at 10–15 mL/kg IV q8h for up to four treatments or dextrans may be effective for hypoproteinemia; synthetic colloids should be used with caution in patients suffering from congestive heart failure or renal failure^{529,772}

Total parenteral nutrition may also be considered.^{180,182}

Maintenance and Deficit Replacement^{289,358,529,628}

- Determine fluid deficit:
Fluid deficit (mL) = body weight (g) × % dehydration
- Determine daily maintenance:
Daily maintenance is estimated at 50 mL (range: 40–60 mL/kg/day in many avian species); the smallest passerines drink 250–300 mL/kg daily⁴⁸³
- If possible, replace 50% of the deficit in the first 12–24 hr, and the remainder over the next 24–48 hr; some clinicians recommend replacing 20%–25% of the deficit in the first 4–6 hr, and the remaining volume during the next 24–72 hr

TABLE 5-37 Routes of Administration and Maximum Suggested Volumes of Fluids Which Can Be Administered to Psittacines.^{326,646,767}

Route	Maximum Suggested Volume of Fluid ^a
Gavage	<ul style="list-style-type: none"> Administer up to 5 mL/100 g bird^b Initial volume should be much less in critically ill and anorectic patients (begin with ½ - ⅓ of estimated crop volume) Crop volume may be up to 10% BW in neonatal birds
Subcutaneous	50 mL/kg ^{c,d}
Intravenous or intraosseous bolus	Administer up to 10 mL/kg (ideally over a 5-10 min period); in emergencies, could go as high as 25 mL/kg (see Table 5-16)

^aCombinations of routes (PO, SC, and IV/IO) are recommended if large fluid volumes are administered.

^bCrop volume may be estimated at 5% of body weight (BW).

^cVolumes of 10-15 mL/kg may be comfortably given per subcutaneous injection site, although up to 25 mL/kg per site may be given. Overdistension of the area may compromise blood supply to the area and reduce absorption.⁷⁶⁷

^dHyaluronidase (Wydase, Wyeth-Ayerst) (1 mL [150 U]/L fluids) may be used in most species to increase the absorption rate of fluids.³⁸⁵

TABLE 5-38 Suggested Volumes and Frequency of Gavage Feeding in Anorectic Birds.^{628,689}

Species	Volume (mL) ^{a,b}	Frequency ^a
Finch	0.1-0.5	q4h
Budgerigar	0.5-3	q6h
Lovebird	1-3	q6h
Cockatiel	1-8	q6h
Conure, small	3-12	q6h
Conure, large	7-24	q6-8h
Amazon parrot	5-35	q8h
Cockatoo	10-40	q8-12h
Macaw	20-60	q8-12h

^aAdjust volume and frequency as crop accommodates larger volumes.

^bGenerally 3%-5% of body weight.³²⁵

TABLE 5-39 Calculation of Enteral Feeding Requirements for Birds.⁶²⁴

When dealing with a debilitated patient that must be tube fed more than once or twice, it is always prudent to make sure you are meeting its caloric requirements.

Basal metabolic rate (BMR) (kcal/day) = $kW^{0.75}$

Maintenance energy requirements (MER) (kcal/day) = $(1.5 \times \text{BMR})$

k = kcal/kg/day constant (nonpasserines = 78, passerines = 129)

- Calculate MER
- Adjust the MER value for debilitated patients, taking their specific clinical condition into account
For instance, an adjustment for sepsis is made by multiplying by 1.5.

Most manufacturers of critical care diets provide information on caloric content (see below); if they do not, call them and ask (see Table 5-41).

Product (Manufacturer)	Protein (%)		Fat (%)		Fiber (%)		CHO (NFE) ^a (%) Dry Matter Basis	Caloric Content (kcal)
	Label Claim (min)	Dry Matter Basis	Label Claim (min)	Dry Matter Basis	Label Claim (max)	Dry Matter Basis		
a/d Canine/Feline Critical Care (Hill's)	8.5	44.2	6.6	30.4	0.5	1.3	15.4	1.3/mL
Carnivore Care (Oxbow)	45	—	32	—	3	—	—	0.8/mL ^b
CliniCare Canine/Feline Liquid Diet (Abbott)	8.2	35.1	5.1	22.2	0.1	0.4	29.5	1/mL
Emeraid Carnivore (Lafeber)	37.8	—	34	—	4.5	—	—	5.14 kcal/g dry weight; 1.67 kcal/mL when prepared as directed
Emeraid Herbivore (Lafeber) ^c	19	—	9.5	—	32	—	—	3.04 kcal/g dry weight; 1 kcal/mL when prepared as directed
Emeraid Omnivore (Lafeber)	20	—	9.5	—	0.5	—	—	4.06 kcal/g dry weight; 2.39 kcal/mL when prepared as directed
Emeraid Nutri-Support (Lafeber)	18.5	—	5	—	1	—	—	2.5
Exact Baby Bird Hand Feeding Formula (Kaytee)	22	—	9	—	5	—	—	3.9/g
Exact Macaw Hand Feeding Formula (Kaytee)	19	—	13	—	5	—	—	4.1/g
Formula AA Acute Care (Roudybush)	20	—	10	—	5	—	—	3.5/g DW
Maximum-Calorie Veterinary Formula (Iams)	14	—	12	—	1	—	—	2.1/mL
Recovery Formula (Harrison's)	35	—	19	—	1	—	—	3.9/g

^aCarbohydrate nitrogen-free extract.

^b24 kcal/Tbs of powder.

^cFed in combination with Emeraid Omnivore to geese and swans.

TABLE 5-40 Doxycycline Recipes Used in Psittacines.^{241,621}**Medicated water for cockatiels:**

1. Mix doxycycline with tap water to a final concentration of 280 mg/L (0.28 mg/mL) using a magnetic stir bar and plate
2. Prepare daily for 45 days
3. No calcium supplementation should be provided

Medicated seed for cockatiels:

1. Combine 60% hulled millet and 40% hulled sunflower seed with 6.25 mL sunflower oil/kg seed; mix well
2. Mix doxycycline with seeds at 500 mg/kg wet weight using an electric mixer
3. Prepare daily for 45 days
4. No calcium supplementation should be provided

Medicated seed for budgerigars:

1. Create a 1:4 mixture of hulled oat groat and hulled millet
2. Mix well
3. Add approximately 6 mL sunflower oil/kg seed (enough to coat seeds, but not dripping)
4. Mix well
5. Add the contents of doxycycline hyclate capsules aseptically (300 mg drug/kg seed)
6. Prepare daily for 45 days
7. No calcium supplementation should be provided

TABLE 5-41 Selected Sources of Formulated and Medicated Diets for Companion and Aviary Birds

<p>Avi-Sci, Inc^a 4477 South Williams Road St. Johns, MI 48879, USA www.avi-sci.com</p> <p>Harrison's Bird Foods 7108 Crossroads Blvd, Suite 325 Brentwood, TN 37027, USA www.harrisonsbirdfoods.com/</p> <p>Kaytee Products, Inc 521 Clay St, PO Box 230 Chilton, WI 53014, USA www.kaytee.com/</p> <p>Lafeber Co 24981 N 1400 East Rd Cornell, IL 61319, USA www.lafebervet.com/</p> <p>L'Avian Plus D & D Commodities Ltd. PO Box 359 Stephen, MN 56757, USA www.lavianplus.com</p> <p>Mazuri Diets PMI Nutrition International LLC PO Box 66812 St. Louis, MO 63166-6812, USA www.mazuri.com/</p>	<p>Pretty Bird International, Inc^a 31008 Fox Hill Ave Stacy, MN 55079, USA www.prettybird.com/</p> <p>Rolf C. Hagen, Inc^a 50 Hampden Rd Mansfield, MA 02048, USA www.hagen.com/usa/index</p> <p>Roudybush Foods^a 340 Hanson Way Woodland, CA 95776, USA www.roudybush.com/</p> <p>Scenic Bird Food Marion Zoological 2003 E. Center Circle Plymouth, MN 55441, USA www.marionzoological.com/bird/</p> <p>Zeigler Bros, Inc^a PO Box 95 Gardners, PA 17324, USA www.zeiglerfeed.com</p> <p>ZuPreem Diets Premium Nutritional Products, Inc PO Box 2094 Mission, KS 66201, USA www.zupreem.com/</p>
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^aSource of medicated feeds.

TABLE 5-42 Selected Nutritional Recommendations for Wild Bird Rehabilitation. ^{104,214,215,258,737,a}

Aquatic Birds, Including Wading Birds and Seabirds

- Live-prey eating birds like pelicans and herons may not recognize familiar food in an unfamiliar presentation; offer live fish in large tubs, such as a small child's pool, but be prepared to force-feed as needed

Hummingbirds

- It is extremely challenging to meet the nutritional needs of hummingbirds; hummingbirds must constantly replenish energy sources to survive; nectar from plants as well as protein from insects (an estimated 100 mg) are both critical daily dietary requirements
- Nektar-Plus (Nekton) will provide adequate nutritional support, including protein
- Insects, such as *Drosophila* fruit flies, may be released into the enclosure⁵⁷⁶

Raptors

- Rehydrate first (see [Table 5-36](#) and [Table 5-37](#)); this is particularly important in birds of prey because the raptor's digestive process requires copious secretions
- For debilitated birds, tube feed a diet rich in protein and fat; offer an enteral tube feeding product (see [Table 5-39](#)), ground whole prey (less feet, fur or feathers, gastrointestinal tract), or small amounts of quail breast meat soaked in oral electrolytes
- Feed whole prey after establishing normal gastrointestinal time; offer food the bird will recognize as prey such as eviscerated fish, rats, mice, and/or quail; to increase the chances of self-feeding, offer a variety of foods
- Feed juvenile raptors a whole animal diet of mice or rats supplemented with vitamins; for young nestlings, remove the fur, toenails, and the gastrointestinal tract, then dice the remainder of the body to create a fine "mush"

Songbirds

- Determine if the bird is an omnivore, herbivore, nectarivore, or insectivore and offer a variety of foods; use a good identification book like *The Sibley Guide to Birds*⁷³⁷ paired with a resource like *The Birder's Handbook*²¹⁴ to determine preferred foods
- Offer a variety of foods, such as high-quality birdseed, mealworms, and tiny pieces of fresh fruit and vegetables, in a shallow container or lid
- Presentation of food promotes self-feeding; place earthworms in a pan of soil for thrushes, offer berries still attached to a branch to a mockingbird
- Swifts and swallows may take a live insect on a forcep
- Woodpeckers may eat mealworms trapped in peanut butter spread on bark

^aSee [Tables 14-1](#) for more details.

TABLE 5-43 Management of Dystocia or Egg Binding in Birds.**Definition**

- Dystocia or egg binding—obstructive or nonobstructive abnormal oviposition

Etiology—Often Multifactorial

- Environmental stressors
- Nutritional: dehydration, hypocalcemia, low-protein diet, and/or general malnutrition
- Egg-related: abnormal egg size and shape or position
- Hen-related: systemic disease, salpingitis, oviduct perforation, torsion or scarring, and/or neoplasia

Diagnosis

- History/clinical signs/physical findings: nonspecific signs of illness, respiratory distress, persistent tail bobbing, \pm blood from vent or in droppings, coelomic distension \pm palpable egg
- Complete blood/chemistry panel
- Radiography/ultrasonography

Treatment

- Stabilize the patient
 - Warm, dark, humidified environment
 - Administer warmed fluids, SC, IV, or IO if dehydrated
 - Dextrose: 50% bolus IV or IO; 2.5% in fluids SC if hypoglycemic
 - Calcium gluconate: 50-100 mg/kg IM or SC if hypocalcemic
 - Nutritional support required in most cases
- Medical management
 - Oxytocin: 5 U/kg IM, may repeat q30min
 - Prostaglandin E₂: 0.1 mL/100 g (1 mL/kg) intracloacal on uterovaginal sphincter
- Surgical management
 - Attempt after 12-24 hr unless patient is obstructed and requires faster intervention
 - Sedation with oxygen supplementation or general anesthesia must be used
 - Use caution when manipulating egg; do not press cranially when stabilizing the egg, as this will compromise respiration; instead, gentle laterolateral digital pressure to direct egg caudally
 - Cloacal ovocentesis
 - 18g-20g needle regardless of patient size
 - Visualize egg/oviductal opening using lubricated speculum or cotton applicators and focal light source
 - Insert needle into egg and aspirate contents while stabilizing egg
 - Gently implode egg with laterolateral digital pressure
 - Extract fragments with curved hemostats
 - Percutaneous ovocentesis
 - 18g-20g needle
 - Stabilize egg against left side of body, then aseptically prepare area
 - Insert needle and aspirate contents
 - Gently implode egg with laterolateral digital pressure if it does not collapse
 - Salpingotomy or salpingohysterectomy

TABLE 5-44 Protocols Used in Treating Mycobacteriosis in Birds.^{a,b}

Agent	Drug Combinations and Dosages									
	1 ^{c,821}	2 ⁵¹	3 ⁸²¹	4 ⁸²¹	5 ⁸²¹	6 ^{d,76}	7 ⁴⁴⁴	8 ²⁰²	9 ⁸²²	10 ⁶⁸⁸
Azithromycin	—	—	—	—	—	—	—	45 mg/kg PO q24h	—	43 mg/kg PO q24h
Ciprofloxacin	—	—	—	—	80 mg/kg PO q24h	—	—	—	—	15 mg/kg PO q12h ^e
Clarithromycin	—	—	—	—	—	—	55 mg/kg PO q24h	85 mg/kg PO q24h	—	—
Clofazimine	—	—	—	—	—	1.5 mg/kg PO q24h	—	—	6 mg/kg PO q24h	—
Cycloserine	—	—	—	—	—	5 mg/kg PO q12h	—	—	—	—
Enrofloxacin	—	—	30 mg/kg PO q24h	30 mg/kg PO q24h	—	10-15 mg/kg PO, IM q12h	6 mg/kg PO q24h	—	—	—
Ethambutol	30 mg/kg PO q24h	10 mg/kg PO q12h	30 mg/kg PO q24h	30 mg/kg PO q24h	30 mg/kg PO q24h	20 mg/kg PO q24h	30 mg/kg PO q24h	15-30 mg/kg PO q12-24h	30 mg/kg PO q24h	30 mg/kg PO q24h
Isoniazid	30 mg/kg PO q24h	—	—	—	—	—	—	—	—	—
Rifabutin	—	—	15 mg/kg PO q24h	—	—	—	45 mg/kg PO q24h	15-45 mg/kg PO q24h	—	15 mg/kg PO q24h
Rifampin	45 mg/kg PO q24h	15 mg/kg PO q12h	—	45 mg/kg PO q24h	45 mg/kg PO q24h	—	—	—	45 mg/kg PO q24h	—
Streptomycin	—	30 mg/kg IM q12h	—	—	—	—	—	—	—	—

^aBecause of its zoonotic potential, controversy exists concerning whether to treat pet and aviary birds for *Mycobacterium avium*. Because *M. avium* isolates from birds differ from human isolates in antibiotic susceptibility, serovars, and genetic sequencing, pet birds are an unlikely source of *M. avium* in people (except immunosuppressed individuals). Nevertheless, veterinarians who treat birds with this disease do so at their own risk. The veterinarian should be aware that treatment is often lifelong for the bird and that treatment does not necessarily prevent shedding.^{51,76,202,444,688,821}

^bEmpirical evaluation of multidrug therapy found that azithromycin (43 mg/kg), rifampin (45 mg/kg), and ethambutol (30 mg/kg) were ineffective in ring-necked doves (*Streptopelia risoria*) naturally infected with avian mycobacteriosis. Culture and sensitivity results indicated resistance to all drugs except for azithromycin.⁶⁹⁶

^cMix into dextrose powder, administered with a small amount of food.⁸²¹

^dRecommended for use in raptors.⁷⁶

^eEnrofloxacin (15 mg/kg PO q12h), clofazimine (6 mg/kg PO q12h), or amikacin IM, IV can be used in lieu of ciprofloxacin with ethambutol, rifabutin, and azithromycin.⁶⁸⁸

TABLE 5-45 Suggested Chemotherapeutic Protocols Used in Birds.**C.O.P. PROTOCOL FOR LYMPHOSARCOMA²⁶⁴**

- Prednisone 25 mg/m² PO q24h
- Cyclophosphamide 200 mg/m² IO q7d
- Vincristine 0.75 mg/m² IO q7d × 3 treatments
- Doxorubicin 30 mg/m² IO q21d
- L-asparaginase 400 U/kg IM q7d
- Interferon α 15,000 U/m² SC q2d × 3 treatments
- Diphenhydramine 2 mg/kg IO before doxorubicin and L-asparaginase treatments
- Dexamethasone 1 mg/kg IM before doxorubicin and L-asparaginase treatments

PROTOCOL FOR LYMPHOCYTIC LEUKEMIA OR LYMPHOSARCOMA^{a,555}

- Vincristine sulfate 0.5 mg/m² IV initial dose, then 0.75 mg/m² q7d × 3 treatments
- Prednisone 1 mg/454 g PO q12h
- Chlorambucil 1 mg/bird PO 2 × /wk

PROTOCOL FOR CUTANEOUS LYMPHOSARCOMA^{b,673}

- Vincristine 0.1 mg/kg IV q7-14d
- Chlorambucil 2 mg/kg PO 2 × /wk

PROTOCOL FOR OSTEOSARCOMA^{c,197}

- Diphenhydramine 30 min before doxorubicin treatment (route and dose not given)
- Doxorubicin 60 mg/m² is diluted into 6 mL sterile saline and administered IV over 30 min in an anesthetized patient via an angiocatheter in the jugular vein q30d
- Do not extravasate doxorubicin; doxorubicin may cause myelosuppression and cardiac toxicity; monitor the CBC
- Electrocardiography during treatment is recommended

^aDosages are for a Pekin duck (*Anas platyrhynchos domesticus*).^bDosages are for an umbrella cockatoo (*Cacatua alba*).^cDosages are for a blue-fronted Amazon parrot (*Amazona aestiva*).

TABLE 5-46 Drug Dosages and Volumes Suggested for Cardiopulmonary Resuscitation (CPR) and in Critical Birds.^a

Emergency Drug	Dose	15 g	30 g	40-50 g	100 g	200 g	300 g	400 g	500 g	750 g	1 kg
		(Canary; Finch)	(Budgerigar)	(Lovebird)	(Conure; Cockatiel)	(Mynah)	(Pigeon; Sulphur-crested Cockatoo)	(African Grey Parrot; Eclectus Parrot)	(Umbrella Cockatoo)	(Greater Sulphur-crested Cockatoo)	(Blue and Gold Macaw)
Atropine (0.2-0.5 mg/mL)	0.5 mg/kg	0.006-0.015 mL	0.012-0.03 mL	0.015-0.05 mL	0.04-0.1 mL	0.08-0.2 mL	0.12-0.3 mL	0.16-0.4 mL	0.2-0.5 mL	0.3-0.75 mL	0.4-1 mL
Calcium gluconate (10%) (100 mg/mL)	50-100 mg/kg	0.007-0.015 mL	0.015-0.03 mL	0.02-0.05 mL	0.05-0.1 mL	0.1-0.2 mL	0.15-0.3 mL	0.2-0.4 mL	0.25-0.5 mL	0.375-0.75 mL	0.5-1 mL
Dexamethasone sodium phosphate (4 mg/mL)	2-4 mg/kg	0.007-0.015 mL	0.015-0.03 mL	0.02-0.05 mL	0.05-0.1 mL	0.1-0.2 mL	0.15-0.3 mL	0.2-0.4 mL	0.25-0.5 mL	0.375-0.75 mL	0.5-1 mL
Dextrose (50%) (diluted with saline)	0.25 mL/kg (slow)	0.004 mL	0.008 mL	0.01-0.125 mL	0.025 mL	0.05 mL	0.075 mL	0.1 mL	0.12 mL	0.18 mL	0.25 mL
Epinephrine (1:1000; 1 mg/mL)	0.1 mg/kg	0.001 mL	0.003 mL	0.005 mL	0.01 mL	0.02 mL	0.03 mL	0.04 mL	0.05 mL	0.075 mL	0.1 mL
Isotonic crystalloid fluids (bolus)	10 mL/kg	0.15 mL	0.3 mL	0.4-0.5 mL	1 mL	2 mL	3 mL	4 mL	5 mL	7.5 mL	10 mL
7.5% NaCl	3 mL/kg	0.04 mL	0.09 mL	0.12-0.15 mL	0.3 mL	0.6 mL	0.9 mL	1.2 mL	1.5 mL	2.1 mL	3 mL
6% Hetastarch	5 mL/kg bolus (20 mL/kg/day)	0.07 mL	0.15 mL	0.2-0.25 mL	0.5 mL	1 mL	1.5 mL	2 mL	2.5 mL	3.75 mL	5 mL

Mannitol (20%) (200 mg/mL)	0.5-2 mL/ kg	0.0075- 0.03 mL	0.015-0.06 mL	0.02-0.1 mL	0.05-0.2 mL	0.1-0.4 mL	0.15-0.6 mL	0.2-0.8 mL	0.25-1 mL	0.375-1.5 mL	0.5-2 mL
Prednisolone sodium succinate (10 mg/mL)	10-20 mg/ kg	0.015- 0.03 mL	0.03-0.06 mL	0.04-0.1 mL	0.1-0.2 mL	0.2-0.4 mL	0.3-0.6 mL	0.4-0.8 mL	0.5-1 mL	0.75-1.5 mL	1-2 mL
Sodium bicarbonate (1 mEq/mL)	5 mEq/kg	0.075 mL	0.15 mL	0.2-0.25 mL	0.5 mL	1 mL	1.5 mL	2 mL	2.5 mL	3.75 mL	5 mL
Vasopressin (20 U/mL)	0.8 U/kg IV, IO	—	—	—	0.004 mL	0.008 mL	0.012 mL	0.016 mL	0.02 mL	0.03 mL	0.04 mL

^aDose in mL/kg body weight, IV, IO, or IM. If weight is not available, base CPR on approximate weight of species closest in size.

TABLE 5-47 Vaccines Used in Birds (Non-Poultry). ^{113,126,320,381,396,478,498,528,567,608,664,670,676,808,862}

Species	Agent	Dosage	Initial	Booster	Comments
See comments	West Nile virus (West Nile-Innovator, Zoetis; Equine killed vaccine; (Recombitek-equine rWNV vaccine, Merial; equine recombinant DNA vaccine)	0.5-1 mL IM	Repeat q3-4wk for 2-3 treatments	3 wk	Environmental control is generally considered most important; however, West Nile virus vaccine has been administered to many types of birds, including Ciconiiformes, Columbiformes, Coraciiformes, Passeriformes, Phoenicopteriformes, Psittaciformes, and raptors (including falcons); an antibody response has been documented inconsistently (flamingos, penguins); ^{131,172,565,568,739} hemolytic anemia reported in lories immunized a year after first set of immunizations ⁶⁰⁹
Raptors	Paramyxovirus-1 (V.P. Vaccin Nobilis Lasota, Intervet)	Intranasally or added to drinking water	—	Booster in 3-4 wk; protects approximately 6 mo	Hitchner B1 and Lasota strain poultry vaccines in drinking water appear to be effective; may see mild palpebral swelling for a few days ³⁸¹
Pigeons, racing	Paramyxovirus-1 (V.P. Vaccin Nobilis Lasota, Intervet)	Apply 1-2 drops in nostrils or eyes	2-4 wk before shows/races	6-8 wk	MLV; poor immune response
	—	Add to drinking water	—	8 wk	1 bottle is administered to entire flock (>100 birds), divided evenly in drinking water for 24 hr; poor immune response
	Paramyxovirus-1/Pox, pigeon (Columbovac, Solvay Duphar)	0.2 mL SC ^{a,76}	4 wk of age	—	Killed vaccine; poor immunologic response to pox

Psittacines	Polyomavirus (Psittimune APV, Creative Science)	0.25 mL/bird (that will weigh <200 g at maturity) SC ⁶²⁴	35-50 days of age; chicks may be safely vaccinated as young as 10-20 days of age, degree of protection uncertain ⁵⁷⁰	2-3 wk, then annually	May cause discoloration, thickening, or granuloma of skin at vaccination site
	—	0.5 mL/bird (that will weigh >200 g at maturity) SC ⁶²⁴	—	Last booster should be given at least 2 wk before leaving aviary ⁶⁶⁹	May be indicated in the face of an outbreak, ^{b,670} registered with the United States Department of Agriculture ⁶⁷⁶
Emus ⁷⁹⁷	Eastern and western equine encephalitis and tetanus (Equiloid, Fort Dodge)	Same dosage as recommended for the target species (horses) IM	6 wk to 3 mo of age	Repeat 3-4 wk later, then booster annually or biannually before and after breeding season (March/ Sept) ⁷⁹⁷	—

^aVaccinating birds during an outbreak may allow humans to theoretically serve as mechanical vectors.⁶⁶⁴

^bChoose subcutaneous injection site carefully in pigeons to avoid bleeding; cranial to thigh or lower 1/3 of neck on dorsal midline.

TABLE 5-48 Blood Pressure Values Reported in Birds.

Species	Direct or Indirect	Mean Arterial Pressure (mmHg)	Systolic Arterial Pressure (mmHg)	Diastolic Arterial Pressure (mmHg)
Psittacines	Indirect in conscious birds ⁴⁵¹	—	120-180	—
	Indirect in birds under isoflurane anesthesia ⁴⁵¹	—	90-180	—
Hispaniolan Amazon parrots ^a (<i>n</i> = 16)	Direct in birds under isoflurane anesthesia using the wing ⁹	155 ± 18 (112-185)	163 ± 18 (119-200)	148 ± 18 (106-171)
	Direct in birds under isoflurane anesthesia using the leg ⁹	152 ± 28 (97-190)	159 ± 28 (113-206)	144 ± 30 (83-181)
	Indirect in birds under isoflurane anesthesia using the wing ⁹	140 ± 25 (104-197)	—	—
	Indirect in birds under isoflurane anesthesia using the leg ⁹	145 ± 28 (96-196)	—	—
Falcons (<i>n</i> = 45)	Indirect in birds under isoflurane anesthesia ⁴⁵⁹	202 ± 27.57	—	—
Red-tailed hawks (<i>n</i> = 6)	Indirect in birds under sevoflurane anesthesia ^{b,869}	155 ± 27	181 ± 25	—
	Indirect in conscious birds ⁸⁶⁹	190 ± 38	236 ± 42	—
	Direct in birds under sevoflurane anesthesia ⁸⁶⁹	159 ± 25 (102-216)	178 ± 27 (124-251)	143 ± 24 (78-198)
Bald eagles (<i>n</i> = 17)	Direct in conscious birds ⁸⁶⁹	201 ± 29 (154-262)	238 ± 39 (161-301)	180 ± 31 (142-254)
	Direct in spontaneously breathing birds under general anesthesia ³⁸⁸	MAP was significantly elevated with isoflurane when compared to sevoflurane	176 ± 14.4 on isoflurane over 40 min 128.8 ± 15-163 ± 13.5 on sevoflurane over 40 min	139.2 ± 14.4 on isoflurane over 40 min 129.2 ± 15.2-147.1 ± 13.8 on sevoflurane over 40 min
	Indirect in conscious birds ¹¹	123.5 ± 61.9	—	—
	Indirect in conscious birds ⁹³	—	155 ± 21	—
Pigeons (<i>n</i> = 7)	Indirect under isoflurane anesthesia	—	87 ± 11	—
Chicken (<i>n</i> = 40)	Direct in birds under general anesthesia ⁴¹³	136 (114-158)	141 (118-163)	131 (109-153)
Pekin ducks (<i>n</i> = 72)	Direct in birds under general anesthesia ⁴³⁶	143 (111-174)	165 (138-192)	121 (85-157)

^aThere was substantial disagreement between direct systolic arterial blood pressure and indirect blood pressure measurements obtained with the Doppler probe from the wing and from the leg of the Hispaniolan parrot (*Amazona ventralis*); attempts to obtain indirect blood pressure measurements with an oscillometric unit were unsuccessful.⁹

^bIndirect blood pressure measured using an oscillometric unit was unreliable; indirect blood pressure measurements using a Doppler probe and cuff 3 were closer to direct mean arterial pressure measured from the superficial ulnar artery.

TABLE 5-49 Selected Arrhythmias and Some Documented Causes in Birds.⁵⁶

Arrhythmias	ECG Changes	Causes
Excitability Disturbances		
Respiratory sinus arrhythmia	Slowing of HR during expiration	Physiologic
Sinus bradycardia	Low HR, normal sinus rhythm	Vagal stimulation, atropine, anesthesia, hypokalemia, hyperkalemia, vitamin E deficiency, vitamin B ₁ deficiency, acetylcholinesterase inhibitors
Sinus tachycardia	High HR, normal sinus rhythm	Sympathetic, catecholamine stimulation
Atrial tachycardia	Series of fast atrial extrasystoles	Atrial distension, ectopic foci
Atrial fibrillation	No normal P waves, irregular SS intervals	Atrial enlargements, cardiac disease
Ventricular premature contraction (VPC)	Wide, bizarre QRS unrelated to P	Ectopic foci, hypokalemia, vitamin B ₁ deficiency, vitamin E deficiency, PMV-1, AI, myocardial infarction
Ventricular tachycardia	Series of VPC	Similar causes as for VPCs
Ventricular fibrillation	Chaotic ventricular depolarization	Myocardial hypoxia, shock, severe disorders
Conduction Disturbances		
1st-degree AV block	Long PR intervals	Anesthetics, increased vagal tone
2nd-degree AV block	Long PR intervals, some P without QRS	Anesthetics, increased vagal tone, occasionally normal in pigeons, parrots, raptors
3rd-degree AV block	Escape ventricular rhythm (slow and bizarre QRS), no consistent PR	Severe cardiomegaly
Bundle branch block	Short PR, bizarre and widened QRS	Lead, myopathy, myocarditis, uncommon in birds

TABLE 5-50 ECG Measurements Reference Values on Lead II in Selected Avian Species (Amplitude in mV, Interval/Duration in Sec).^{a,58}

Species	African Grey parrot	Amazon Parrot	Bald Eagle	Chicken	Cockatoo	Macaw	Pekin Duck	Racing Pigeon	Red-tailed Hawk
<i>n</i>	45	37	20	72	31	41	50	60	11
Heart rate	340-600	340-600	50-160	180-340	259-575	255-555	200-360	160-300	80-220
P amplitude	0.25-0.55	0.25-0.60	0.050-0.325	—	0.13-0.53	0.03-0.47	—	0.4-0.6	-0.1-0.175
P duration	0.012-0.018	0.008-0.017	0.030-0.060	0.035-0.043	0.009-0.025	0.009-0.021	0.015-0.035	0.015-0.020	0.020-0.035
PR interval	0.040-0.055	0.042-0.055	0.070-0.110	0.073-0.089	0.039-0.071	0.040-0.068	0.04-0.08	0.045-0.070	0.050-0.090
S amplitude	0.9-2.2	0.7-2.3	0.150-1.450	0.10-1.0	0.27-1.59	0.27-1.43	0.35-1.03	1.5-2.8	0.300-0.900
QRS duration	0.010-0.016	0.010-0.015	0.020-0.040	0.02-0.028	0.014-0.026	0.002-0.030	0.028-0.044	0.013-0.016	0.020-0.030
T amplitude	0.18-0.6	0.3-0.8	0.050-0.200	0.03-0.28	0.17-0.97	0.12-0.80	0.04-0.40	0.3-0.8	0.000-0.300
QT interval	0.048-0.080	0.050-0.095	0.110-0.165	—	0.065-0.125	0.053-0.109	0.08-0.12	0.060-0.075	0.080-0.165
MEA	-79 to -103	-90 to -107	-30 to -150	-91 to -120	-73 to -89	-76 to -87	-160 to 95	-83 to -99	-50 to -110

^aTo obtain a 95% reference interval, all published results in the form of mean \pm SD were reported as mean \pm 2SD and in the form of mean \pm sem were reported as mean \pm 2 sem \sqrt{n} , when only the range or a 95% reference interval was published, it was reported as is.

TABLE 5-51 Echocardiographic Reference Intervals (mm) in Selected Avian Species Obtained in the Horizontal Four-Chamber View.^{a,58}

Parameter	African Grey Parrots	Amazon Parrots	Cockatoos	Diurnal Raptors ^b	Pigeons (Parasternal)
<i>n</i>	60	10	10	100	50
Left ventricle					
Systole length	18.4-26	16.5-25.7	16.4-21.6	9.1-20.3	15.9-19.9
Systole width	4.8-8.8	4.3-9.1	3.0-9.8	4.1-8.5	4.4-6.0
Diastole length	20.2-27.8	17.7-26.5	16.7-23.1	11.0-21.8	17.3-22.9
Diastole width	6.6-10.6	6.4-10.4	5.3-11.3	5.3-10.1	6.2-8.6
FS (%)	13.8-31.4	14.4-31.2	11.6-39.6	—	—
Right ventricle					
Systole length	6.4-12.0	5.8-13.0	7.9-12.7	7.3-18.1	—
Systole width	1.0-4.6	1.7-4.5	7.9-12.7	0.9-3.3	
Diastole length	7.7-15.3	7.7-12.9	6.7-15.9	8.9-18.9	8.3-11.5
Diastole width	2.6-7.0	2.6-7.8	2.5-4.5	0.9-4.1	3.0-5.0
FS (%)	17.0-64.6	26.7-41.5	12.7-53.9	—	—
Aorta					
Systole diameter	2.8-4.4	2.0-4.0	—	—	—
Diastole diameter	2.8-5.2	2.2-4.6	—	2-3.6	2.8-3.2

^aTo obtain a 95% reference interval, all published results in the form of mean \pm SD were reported as mean \pm 2SD and in the form of mean \pm sem were reported as mean \pm 2sem \sqrt{n} , when only the range or a 95% reference interval was published, it was reported as is. FS, fractional shortening. Echocardiographic measurements may not be reliable and clinically useful.

^bEuropean diurnal raptors included common buzzard, European sparrowhawk, northern goshawk, and black kite.

TABLE 5-52 Spectral Doppler Echocardiographic Reference Intervals (m/s) in Selected Avian Species Obtained in the Horizontal Four-Chamber View.^{a,28,595,775,776}

Species	<i>n</i>	Left Diastolic Inflow	Right Diastolic Inflow	Aortic Systolic Outflow
African grey parrots	—	0.27-0.51	—	0.63-1.15
Amazon parrots	—	0.12-.24	0.12-0.32	0.67-0.99
Barn owls	10	0.14-0.26	0.10-0.34	0.84-1.32
Cockatoos	—	0.02-0.62	—	0.40-1.16
Common buzzard	10	0.16-0.28	0.13-0.25	1.04-1.68
Falcons	15	0.18-0.38	0.17-0.37	1.07-1.43
Harris' hawks	10	0.13-0.25	0.15-0.27	0.75-1.43
Macaws	—	0.40-0.68	—	0.55-1.07

^aTo obtain a 95% reference interval, all published results in the form of mean \pm SD were reported as mean \pm 2SD and in the form of mean \pm sem were reported as mean \pm 2sem \sqrt{n} , when only the range or a 95% reference interval was published, it was reported as is. Parrots were anesthetized; raptors were awake.

TABLE 5-53 Guidelines for Selection of Psychotherapeutic Agents for Birds. ^{92,497,729,743}

1. Perform a complete medical and behavioral workup:
 - Obtain a detailed medical and behavioral history.
 - Perform careful physical examination, looking for evidence of feather dysplasia or skin abnormalities.
 - Collect a minimum database that includes complete blood count, plasma biochemistry panel, radiographs, psittacine beak and feather disease testing, as well as paired (affected/nonaffected) skin/feather follicle biopsy when indicated.
2. Once a medical problem has been ruled out or treated, assuming the problem does not abate, form a **behavioral diagnosis**:
 - It is not enough to determine the bird is feather picking; identify “why” the bird is feather picking; use of “antecedent, behavior, and consequence” data can be particularly helpful.
 - Many behavioral problems are multifactorial in origin.
3. Formulate a treatment plan that incorporates:
 - Environmental modification:
 - Improve the nutritional plane and basic husbandry.
 - Provide environmental enrichment where appropriate.
 - Behavioral modification techniques:
 - Focus on what you want the bird to do and reward the bird for that and/or engage in stimulating behavior that will accomplish that goal. Do not punish or deprive the bird.
 - Offer behavioral alternatives with emphasis in developing foraging behaviors for treats or food of increasing complexity, and training of basic skills.
 - Behavioral pharmacotherapy can be a useful component of treatment.
 - Whenever possible, consult with a behaviorist, preferably a member of the American College of Veterinary Behaviorists.
4. **Behavioral pharmacotherapy**, general principles:
 - These drugs may help the bird be more open to change, thereby reducing stress and increasing the chances of success.
 - Most behavioral drugs act by exerting effects on neurotransmitters (NT) in the central nervous system (CNS).
 - Serotonin (5-HT) affects mood, sleep patterns, and appetite; also plays a role in the suppression of impulses; low levels or an imbalance between serotonin and other hormones may be associated with maladaptive behaviors.
 - Norepinephrine (NE) plays an important role in attentiveness, sleeping, dreaming, and learning.
 - Gamma-aminobutyric acid (GABA) is a major inhibitory NT.
 - Behavioral drugs are classified based on their first clinical use in humans or on their structure and effects (tricyclics, selective serotonin reuptake inhibitors); major groups include anxiolytics, antipsychotics, and antidepressants, but their use may be more generalized outside of these broad areas.
 - A number of factors must be considered when selecting a psychotropic agent: the proposed mechanism of action, indications and contraindications, common side effects and the potential for other adverse effects, drug cost, and ease of administration; also consider the bird species, its age and underlying health, as well as reproductive status; see information that follows or consult a veterinary behavior text or a general formulary for more detailed information.

- Drugs commonly selected for:
 - Conditions of *fear, phobia, or anxiety* include benzodiazepines and buspirone; antidepressants may also be used for generalized anxiety and separation anxiety.
 - Obsessive-compulsive disorders such as stereotypical behaviors^a include TCAs and SSRIs.
 - Stereotypy that involves self-injurious behavior include opioid antagonists (i.e., naltrexone), SSRIs, TCAs, and, in select cases, haloperidol.
 - Antipruritic effects include the TCAs; doxepin, followed by amitriptyline, have the most potent antihistaminic activity.^b
 - Aggression, both hierarchical and anxiety-induced, are the SSRIs.
 - Ancillary treatments may include opioid analgesics (Table 5-5), NSAIDs (Table 5-6), hormonal agents (Table 5-7), and/or essential fatty acid supplements when indicated.
- 5. How much to give, how often, and for how long?**
- Many of the doses in Table 5-10 are based on anecdotal experience or case reports; the few empirical studies referenced use small sample sizes.
 - Warn your client that, in many instances, dosing may be by trial and error; for instance, after giving an antidepressant for 4-8 weeks, it may be necessary to adjust the dose, or in some instances to change drugs.
 - Combination therapy can sometimes enhance drug effectiveness:
 - Benzodiazepines (BZDs) may be combined with antidepressants, but reduce the BZD dose to minimize the risk of CNS depression; this combination may be particularly helpful when psychotherapy is first started because it takes weeks for antidepressants to exert an effect.
 - Unless both dosages are decreased, avoid combining drugs that both increase serotonin levels since there is the risk of causing serotonin syndrome.^c
 - Administer antidepressants for a minimum of 6-8 weeks.
 - Monitor blood work regularly.
 - When and if a beneficial result is achieved, it may be prudent to continue treatment for at least 2-6 months.
 - The process of weaning a bird off of medication may also require trial and error; one technique is to reduce the effective dose by 25% every 3 weeks; if signs relapse, return to the lowest effective dose; taper drug dosages over a minimum of 3 weeks.
- 6. Client education**
- Determine beforehand how you will document treatment response; identify target signs that can be monitored by the owner with respect to intensity, duration, and frequency.
 - Prepare clients for the possibility of trial and error dosing, possible side effects, the duration of treatment that may be necessary, and the length of time before onset of desired effects.
 - Extra-label drug use.
-

Characteristics	Anxiolytics			Antidepressants	
	Benzodiazepenes	Bupirone	Antipsychotics	Tricyclic Compounds (TCAs)	Selective Serotonin Reuptake Inhibitors (SSRIs)
Range of effects	Mild sedation, ^d to anxiolysis, to hypnosis as dose increases	Calming	Reduce motor activity	A variety including potent antihistaminic activity and some sedation	A variety of actions including a mood-stabilizing effect
Specific examples	Diazepam Lorazepam Midazolam High potency: Alprazolam Clorazepate	—	Haloperidol	Amitriptyline Clomipramine Imipramine	Fluoxetine Paroxetine Sertraline
Disadvantages	Can interfere with learning and affect behavioral modification	Delayed onset of action (2-4 wk)	See below	Delayed onset of action (2-4 wk)	Delayed onset of action (3-6 wk)
Potential adverse effects	Sedation, ataxia, ^d paradoxical excitation; rare fatal idiopathic hepatic necrosis in cats given diazepam PO	Few to mild; confusion, nausea, anorexia	Extrapyramidal signs: tremors, dystonia, dyskinesia or akathisia; transient anorexia and regurgitation	Anticholinergic signs ^e	Uncommon and transient; anorexia most common ^f and serotonin syndrome is the most serious ^c
Contraindications and precautions	Liver or renal disease; aggression; consider potential for human abuse	Severe renal or hepatic disease	—	Discontinue slowly to prevent withdrawal responses; may lower seizure threshold in humans	—
Taste	Benign, although a bitter aftertaste has been described for diazepam	—	—	Lingering bitter taste	Odorless, tasteless tablets

^aStereotypies are repetitive behaviors such as circling or pacing, or in some instances, feather-destructive behavior.

^bThe antihistaminic activity of doxepin is 800 times that of diphenhydramine.

^cSerotonin syndrome may cause muscle tremors, rigidity, agitation, hyperthermia, vocalization, hypertension or hypotension, tachycardia, seizures, coma, and death.

^dMild sedative effects create a risk of bird falling from perch; tolerance to sedation may develop over time.

^eA variety of anticholinergic signs have been reported in mammals, including dry mouth, fatigue, variable degrees of sedation, constipation, tremor, hypotension, arrhythmias, weight gain, mydriasis, and vomiting; sedation and regurgitation are reported most commonly in birds.⁴⁹⁷

^fOther possible adverse effects with SSRIs include diarrhea, increased agitation, irritability, insomnia, and in rare instances, vomiting.

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Chapter 6 Backyard Poultry and Waterfowl

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Note: Many poultry species are considered food-producing animal *species*, and as such, these species are regulated by the U.S. Food and Drug Administration (FDA).¹⁶⁶ Even if the individual animal of any of these species is never used for food, it is still regulated by the FDA. The FDA prohibits the use of certain drugs, with no allowable extra-label drug use, in any food-producing animal species. These prohibited drugs are clearly identified in the tables, and the doses are provided in case they are needed for a similar but non-food-producing animal species (e.g., Attwater's prairie chicken), and listings should in no way be misconstrued as an endorsement of using FDA-prohibited drugs in any food-producing animal species. Please refer to the appropriate tables at the end of this chapter regarding the definitions of prohibited drugs, extra-label drugs, labeled drugs, and drugs needing a Veterinary Feed Directive prior to choosing a drug and dose. Please refer to the Food Animal Residue Avoidance Databank at www.farad.org and other sources listed in Table 6.25 for meat and egg withdrawal times. Please be aware that most drug dosages are listed in standard international units (SI), such as mg/kg, but some dosages may be in conventional units, such as mg/lb, mg/gallon, or grams/ton to match the dose on the label.

TABLE 6-1 Antimicrobial Agents Used in Backyard Poultry and Waterfowl.^{a-c}

Agent	Dosage	Species/Comments
Amikacin	10 mg/kg SC, IM q8h × 14 days ⁸⁵	Ring-necked pheasants/PD; renal toxicosis appeared at 11 days; uric acid levels abnormal up to 7 days after cessation
	20 mg/kg IM q8h ⁴⁵	Chickens/PD
	5.3 mg/kg IV RLP once ^{137b}	Chickens/pododermatitis; regional limb perfusion (RLP) into medial metatarsal vein with a tourniquet placed proximal to hock joint for 15 min ^{137b}
Amoxicillin/clavulanate (Clavamox, Zoetis)	125 mg/kg PO q8h ¹⁷³	Poultry
	500 mg/L drinking water ¹⁷⁹	Chickens/PD
Amoxicillin trihydrate	15 mg/kg/day PO × 3 days ⁴⁸	Chickens, turkeys
	20 mg/kg PO ⁹²	Chickens, turkeys/no frequency listed
	15 mg/kg body weight in drinking water × 3-5 days ¹²³	Chickens not laying eggs for human consumption ¹²³
	15-20 mg/kg body weight in drinking water × 3-5 days ¹²³	Turkeys not laying eggs for human consumption ¹²³
	20 mg/kg body weight in drinking water × 3 consecutive days ¹²³	Ducks not laying eggs for human consumption ¹²³
	330 mg/L drinking water, provide on alternate days × 3 treatments ²⁷	Waterfowl
1 g/3 L of drinking water, provide on alternate days × 3 treatments ¹⁶	Waterfowl	

Continued

TABLE 6-1 Antimicrobial Agents Used in Backyard Poultry and Waterfowl. (cont'd)

Agent	Dosage	Species/Comments
Ampicillin trihydrate	55-110 mg/kg IM q8-12h ⁶⁹	Poultry
	170 mg/L drinking water ^{16,69}	Game birds
	250 mg/8 oz of drinking water ¹⁶	Galliformes
	1000 mg/L drinking water ^{16,69}	Galliformes/flock use
Apramycin (Apralan, Elanco)	—	Therapeutic levels not achieved in Japanese quail at 50 mg/kg IV; ⁸⁷ not available in the United States
	250-500 mg/L drinking water ^{16,69}	Game birds, poultry/primarily used against <i>Salmonella</i> spp.
Bacitracin methylene disalicylate (Solu-Tracin 200, Solu-Tracin 50, BMD Soluble 50%, Zoetis)	100-400 mg/gal drinking water ^{30a}	Chickens, turkeys
	220 mg/L ²⁷	Quail/ <i>Clostridium perfringens</i> ; prepare daily
	400 mg/gal drinking water ^{30a}	Poultry
	55-220 mg/kg feed ⁶⁹	Quail
Bacitracin methylene disalicylate (BMD 60, BMD 50 Granular A, BMD 30 Granular A, BMD 30 BMD 50, Zoetis)	4-200 g/ton feed ^{30a}	Chickens, turkeys
	4-50 g/ton feed ¹⁶⁵	Pheasant, turkeys (growing)/no use class stated or implied; increased rate of weight gain and improved feed efficiency
	5-20 g/ton feed ¹⁶⁵	Quail (not over 5 wk)/increased rate of weight gain and improved feed efficiency
	10-25 g/ton feed ¹⁶⁵	Chicken/layers, first 7 mo of production; aid in increased egg production and improved feed efficiency; feed continuously as the sole ration for the first 7 mo of egg production
	40-50 g/ton feed ¹⁶⁵	Chickens (broilers, replacements)/ increased rate of gain and improved feed efficiency; no limitations ¹⁶⁵
	50 g/ton feed ¹⁶⁵	Prevention of necrotic enteritis; feed as sole ration
	100-200 g/ton feed × 5-7 days ¹⁶⁵	Aid in control of necrotic enteritis; feed as sole ration; start at first signs of disease; vary dose based on severity
	200 g/ton feed ¹⁶⁵	Quail (growing)/prevention of ulcerative enteritis; feed continuously as the sole ration
200 g/ton feed ¹⁶⁵	Turkeys (growing)/aid in the control of transmissible enteritis	

TABLE 6-1 Antimicrobial Agents Used in Backyard Poultry and Waterfowl. (cont'd)

Agent	Dosage	Species/Comments
Bacitracin methylene disalicylate (Pennitracin MD 50G, Zoetis)	4-50 g/ton of feed ¹⁶⁵	Chickens (broiler, replacement), turkeys (growing), pheasants (growing)/administer continuously throughout feeding period for increased rate of weight gain and improved feed efficiency
	5-20 g/ton of feed ¹⁶⁵	Quail (growing)/administer continuously through 5 wk of age for increased rate of weight gain and improved feed efficiency
Bacitracin zinc (Baciferin 10, 25, 50, 40, Zoetis)	4-50 g/ton feed ^{30a,165}	Chickens, turkeys, pheasants (growing)/for increased rate of weight gain and improved feed efficiency
	5-20 g/ton of feed ¹⁶⁵	Quail (growing)/for increased rate of weight gain and improved feed efficiency; feed to starting quail through 5 wk of age ¹⁶⁵
	10-25 g/ton of feed ¹⁶⁵	Chickens (laying)/for improved feed efficiency and increased egg production
Cefazolin	22-110 mg/kg IM q8-12h ⁶⁹	Poultry/restricted drug ^b
Cefovecin (Convenia, Zoetis)	10 mg/kg SC, IM, IV q1h ^{162a}	Chickens/PK; not recommended for use in birds due to short half-life Poultry/restricted drug ^b
Cefquinome	5 mg/kg IM q24h ¹⁷⁸	Ducks/no effect PO Poultry/restricted drug ^b
Ceftiofur (Naxcel, Zoetis)	0.08-0.2 mg SC once ^{30a,166}	Chickens (1- to 3-day-old chicks)/as a single SC injection in the neck for the control of early mortality associated with <i>Escherichia coli</i> organisms; restricted drug ^b
	0.17-0.5 mg SC once ^{30a,166}	Turkeys (1- to 3-day-old poults)/as a single SC injection in the neck for the control of early mortality associated with <i>E. coli</i> organisms; ^{165,166} restricted drug ^b
	0.16 mg/chick SC q24h ¹⁵⁶	Chickens (chicks)/PK; treatment of early mortality associated with <i>E. coli</i> Poultry/restricted drug ^b
	0.17-0.5 mg/poult SC q24h ¹⁵⁶	Turkeys, poultry/restricted drug ^b
	2-4 mg/kg SC q24h ³¹	Ducks, poultry/restricted drug ^b
	2.8-5.8 mg/kg SC q24h ¹⁵⁶	Turkeys (poults)/PK; treatment of early mortality associated with <i>E. coli</i> Poultry/restricted drug ^b
	10 mg/kg IM q72h ⁶⁹	Guinea fowl/PD Poultry/restricted drug ^b

Continued

TABLE 6-1 Antimicrobial Agents Used in Backyard Poultry and Waterfowl. (cont'd)

Agent	Dosage	Species/Comments
Ceftriaxone	100 mg/kg IM q4h ⁸⁰	Chickens/PK; not approved for food animal products in the United States Poultry/restricted drug ^b
Cephalexin	35-50 mg/kg IM q2-3h ⁶⁹	Quail, ducks/PD Poultry/restricted drug ^b
	55-110 mg/kg PO q12h ⁶⁹	Poultry/ <i>Mycoplasma</i> , <i>Haemophilus</i> ; restricted drug ^b
Cephalothin	100 mg/kg IM q2-3h ^{16,69}	Quail, ducks/PD; not approved for food animal products in the United States Poultry/restricted drug ^b
Chloramphenicol palmitate (oral suspension)	50 mg/kg PO q6-12h ⁶⁹	Galliformes (turkeys), chickens ⁹ Poultry/restricted drug ^c
Chloramphenicol succinate	22 mg/kg IM, IV q3h ^{41a}	Ducks/PD Poultry/restricted drug ^c
	50 mg/kg IM q24h ³²	Peafowl Poultry/restricted drug ^c
	50 mg/kg IM, IV q6-12h ³²	Chickens, turkeys, geese (PK), ducks Poultry/restricted drug ^c
	79 mg/kg IM q12h ³²	Turkeys/PK Poultry/restricted drug ^c
Chlortetracycline bisulfate (Aureomycin Soluble Powder, Zoetis)	25 mg/lb body weight in drinking water ¹⁶⁶	Turkeys/control of complicating bacterial organisms associated with bluecomb (transmissible enteritis, coronaviral enteritis); prepare fresh solution daily as a sole source of chlortetracycline; do not slaughter animals for food within 24 hours of treatment; do not use for more than 14 days ¹⁶⁶
	40-120 mg/L drinking water ⁶⁹	Galliformes (game birds)
	100-400 mg/gal drinking water ^{30a}	Turkeys
	100-1000 mg/gal drinking water ^{30a}	Chickens
	200-400 mg/gal drinking water ¹⁶⁶	Chickens/control of infectious synovitis caused by <i>Mycoplasma synoviae</i> ; prepare fresh solution daily as sole source of chlortetracycline; do not slaughter animals for food within 24 hr of treatment; do not use for more than 14 days; do not use in laying chickens ¹⁶⁶

TABLE 6-1 Antimicrobial Agents Used in Backyard Poultry and Waterfowl. (cont'd)

Agent	Dosage	Species/Comments
Chlortetracycline bisulfate (Aureomycin Soluble Powder, Zoetis) (cont'd)	400 mg/gal drinking water ¹⁶⁶	Turkeys (growing)/control of infectious synovitis caused by <i>Mycoplasma synoviae</i> ; prepare fresh solution daily as sole source of chlortetracycline; do not slaughter animals for food within 24 hr of treatment; do not use for more than 14 days ¹⁶⁶
	400-800 mg/gal drinking water ¹⁶⁶	Chickens/control of chronic respiratory disease (CRD) and air sac infections caused by <i>Mycoplasma gallisepticum</i> and <i>E. coli</i> ; prepare fresh solution daily as sole source of chlortetracycline; do not slaughter animals for food within 24 hr of treatment; do not use for more than 14 days; do not use in laying chickens ¹⁶⁶
	1000 mg/gal drinking water ¹⁶⁶	Chickens/control of mortality due to fowl cholera caused by <i>Pasteurella multocida</i> ; prepare fresh solution daily as sole source of chlortetracycline; do not slaughter animals for food within 24 hr of treatment; do not use for more than 14 days; do not use in laying chickens ¹⁶⁶
	1000 ppm (18.2 g/kg) in feed for 45 days ¹⁶ 2500 mg/kg feed ¹⁸⁰ and 2500 mg/L drinking water ^{30a,180}	Waterfowl Chickens, turkeys/PD; simultaneous medication of feed and water required to reach therapeutic level
Chlortetracycline (Aureomycin granular, Zoetis)	25 mg/lb body weight q24h × 7-14 days ¹⁶⁵	Turkeys/control of complicating bacterial organisms associated with bluecomb
	10-50 g/ton of feed ¹⁶⁵	Chickens, turkeys (growing)/increase rate of weight gain, feed efficiency
	100-200 g/ton of feed × 7-14 days ¹⁶⁵	Chickens/control of infectious synovitis caused by <i>Mycoplasma synoviae</i>
	200 g/ton of feed × 7-14 days ¹⁶⁵	Turkeys/control of infectious synovitis caused by <i>Mycoplasma synoviae</i>
	200-400 g/ton of feed × 7-14 days ¹⁶⁵	Chickens/control of CRD and air sac infection caused by <i>Mycoplasma gallisepticum</i> and <i>E. coli</i>

Continued

TABLE 6-1 Antimicrobial Agents Used in Backyard Poultry and Waterfowl. (cont'd)

Agent	Dosage	Species/Comments
Chlortetracycline (Aureomycin granular, Zoetis) (cont'd)	200-400 g/ton of feed not more than 21 days ¹⁶⁵	Ducks/control and treatment of fowl cholera caused by <i>Pasteurella multocida</i> ; feed in complete ration to provide from 16-62 mg/kg of body weight per day depending on age and severity of disease ¹⁶⁵
	400 g/ton of feed × 7-14 days ¹⁶⁵	Turkeys/control of <i>Hexamita meleagridis</i> Turkeys (poult not over 4 wk of age)/reduction of mortality due to paratyphoid caused by <i>Salmonella typhimurium</i>
	500 g/ton of feed × 5 days ¹⁶⁵	Chickens/reduce mortality due to <i>E. coli</i> infections
Chlortetracycline (ChlorMax, Aureomycin granular, Zoetis)	200-600 mg/kg feed ⁶⁹	Galliformes
	300-400 mg/kg feed ²⁷	Waterfowl/colibacillosis, <i>Chlamydia</i> , <i>Salmonella</i>
	1000 mg/kg feed ⁶⁹	Waterfowl
	10-400 g/ton feed ^{30a} 10-500 g/ton feed ^{30a}	Turkeys Chickens
Ciprofloxacin	2 mg/kg IV ¹²¹	Chicks/no toxic effects observed; prohibited drug ^c
	5 mg/kg/day PO × 5 days ⁵⁵	Chickens/PD; prohibited drug ^c
	10-20 mg/kg PO q12h ⁴⁶	Chickens/prohibited drug ^c
Clindamycin	100 mg/kg PO q24h × 3-5 days ⁶⁹	Quail/ <i>Clostridium</i>
Danofloxacin mesylate (A180, Zoetis)	5 mg/kg PO, IM, IV ^{46,152}	Chickens/PD; higher therapeutic efficacy of water medication for enrofloxacin compared to danofloxacin can be expected when given at 5 mg/kg, ⁸⁴ prohibited drug ^c
	50 mg/L in drinking water × 3 days ^{113,152}	Chicks/ <i>Mycoplasma</i> ; prohibited drug ^c
Doxycycline (Vibramycin, Zoetis)	8-25 mg/kg PO q12h ²⁷	Waterfowl
	20 mg/kg/day PO × 3 days ¹⁷⁷	Chickens
	25-50 mg/kg/day PO ¹⁷³	Poultry
	35 mg/kg/day PO × 7 days max ¹⁷³	Poultry
	50 mg/kg PO q12h × 3-5 days ^{16,69}	Waterfowl/45 days for chlamydiosis
	100 mg/L drinking water ⁵¹	Chickens/PD
	265-525 mg/L drinking water ⁶⁹ 250-300 mg/kg seed ⁶⁹	Poultry/ <i>Mycoplasma</i> , <i>Haemophilus</i> ; can use in combination with tylosin Waterfowl

TABLE 6-1 Antimicrobial Agents Used in Backyard Poultry and Waterfowl. (cont'd)

Agent	Dosage	Species/Comments
Enrofloxacin	—	IM formulation has an extremely alkaline pH and should not be given repeatedly; best to avoid IV use in birds; fluoroquinolones may be used in PMMA beads with success; ⁴³ prohibited drug ^c
	5 mg/kg/day PO × 5 days ⁵⁵	Chickens/PD; accumulates in eggs; prohibited drug ^c
	10 mg/kg PO q12h × 4 days ^{10,12}	Chickens/PK; high efficacy for intestinal salmonellosis; prohibited drug ^c
	10-15 mg/kg PO, IM q12h × 5-7 days ¹⁶	Waterfowl/prohibited drug ^c
	50 mg/kg via nebulization × 4 hr (day 1, AM), then 25 mg/kg × 4 hr/day × 4 days ¹⁶⁴	Muscovy, Pekin ducklings/ <i>Riemerella (Pasteurella)</i> ; prohibited drug ^c
	26 mg/L drinking water ²⁷	Galliformes/prohibited drug ^c
	50 mg/L drinking water ^{71,81}	Chickens, turkeys/PK; prohibited drug ^c
Erythromycin	50-100 mg/L drinking water ⁶⁹	Game birds/prohibited drug ^c
	200-800 mg/L drinking water ⁶⁹	Chickens/no detected effect on cartilage in day-old chicks; ⁶⁹ prohibited drug ^c
	25.5 mg/kg PO q24h × 5 days ¹¹¹	Chickens/ <i>Mycoplasma</i> spp.; do not use in hens laying eggs for human consumption
	55-110 mg/kg PO q12h ⁶⁹ 102 mg/L drinking water ⁴² 92.5-185 g/ton feed ^{30a}	Poultry/ <i>Mycoplasma</i> , <i>Haemophilus</i> Chicks/PD Chickens, turkeys/do not use high dose level (185 g/ton) in layers
Erythromycin phosphate (Gallimycin, Cross VetPharm Group)	500 mg/gal drinking water × 5-7 days ¹⁶⁵	Chickens (broilers, replacements)/aid control of chronic respiratory disease (5 days) and aid control of infectious coryza due to <i>Haemophilus gallinarum</i> ; do not use in replacement pullets over 16 wk of age; do not use in chickens producing eggs for human consumption; solutions older than 3 days should not be used ¹⁶⁵

Continued

TABLE 6-1 Antimicrobial Agents Used in Backyard Poultry and Waterfowl. (cont'd)

Agent	Dosage	Species/Comments
Erythromycin thiocyanate (Gallimycin, Cross VetPharm Group)	25.5 mg/kg PO q24h × 5 days ¹¹¹	Chickens/ <i>Mycoplasma</i> spp.; do not use in hens laying eggs for human consumption
	4.6-18.5 g/ton feed ¹⁶⁵	Chickens/growth promotion and feed efficiency
	9.25-18.5 g/ton of feed ¹⁶⁵	Turkeys (not over 12 wk of age)/ growth promotion and feed efficiency
	18.5 g/ton of feed ¹⁶⁵	Chickens (laying)/aids in increasing egg production; no limitations are included in the CFR for this species when using this product in this amount
	92.5 g/ton feed ¹⁶⁵	Chickens, turkeys/aid in the prevention of chronic respiratory disease during periods of stress (2 days before and 3-6 days after stress); aid in the prevention of infectious coryza (7-14 days); withdraw 24 hr before slaughter
	92.5-185 g/ton feed ^{30a}	Chickens, turkeys/do not use high dose level (185 g/ton) in layers
Furazolidone (NF180, Hess and Clark)	185 g/ton feed × 5-8 days ¹⁶⁵	Chickens, turkeys/aid in the prevention and reduction of lesions and in lowering severity of chronic respiratory disease; do not use in birds producing eggs for food purposes; withdraw 48 hr before slaughter
	220-440 mg/kg feed ²⁷	Waterfowl/ <i>Salmonella</i> Poultry/prohibited drug ^{c,54,166}
Gentamicin sulfate (Garasol, Intervet)	0.2 mg SC ^{30a}	Chickens/35-day meat withdrawal time; Turkeys/65-day meat withdrawal time
	5 mg/kg IM q8h ^{35,69}	Pheasants/PK
	10 mg/kg IM q6h ^{35,69}	Quail/PK
Lincomycin HCl (Lincocin, Upjohn)	64 mg/gal drinking water ^{30a}	Chickens
	2 g/L drinking water × 5-7 days ¹⁶	Waterfowl
Lincomycin hydrochloride monohydrate (Lincomix, Zoetis)	2 g/L drinking water × 5-7 days ⁶⁹	Waterfowl/ <i>Pasteurella</i> , <i>Mycoplasma</i> tenosynovitis
	2 g/ton feed ^{30a}	Chickens
	2-4 g/ton of feed ¹⁶⁵	Chickens (broilers)

TABLE 6-1 Antimicrobial Agents Used in Backyard Poultry and Waterfowl. (cont'd)

Agent	Dosage	Species/Comments
Lincomycin/spectinomycin (LS-50 Water Soluble, Upjohn; Linco-Spectin 100 Soluble Powder, Upjohn)	2.5-5 mg/chick IM once ⁶³	Chickens (chicks)/PD; may prevent <i>E. coli</i> and <i>Staphylococcus aureus</i> infections; injectable form not available in the United States
	528 mg/L drinking water for first 5 days of life ⁶⁴	Turkey poults/PD; <i>Mycoplasma</i> airsacculitis
	750 mg/L drinking water × 3-7 days ^{16,27}	Waterfowl/ <i>Mycoplasma</i> synovitis, sinusitis
Lincomycin hydrochloride monohydrate/spectinomycin sulfate tetrahydrate (LS 50 Water Soluble Powder, Zoetis)	2 g/gal drinking water first 5-7 days of age ¹⁶⁵	Chicken (up to 7 days old)/aid in control of airsacculitis
	750 mg/L drinking water × 3-7 days ²⁷	Waterfowl
Marbofloxacin (Zeniquin, Zoetis)	2 mg/kg PO q24h ¹¹	Chickens (broilers)/PD; prohibited drug ^{c,54,166}
	3-12 mg/kg PO q24h ⁶⁶	Turkeys/PK; prohibited drug ^{c,54,166}
Metronidazole	—	Poultry/prohibited drug ^{c,54,166}
Miporamycin	100 mg/kg feed × 5 days ^{69,151}	Poultry/macrolide; under development; make preparation fresh daily
Neomycin	80-264 mg/L drinking water ²⁷	Waterfowl
	126 mg/L drinking water ⁶⁹	Galliformes
	70-220 mg/kg feed × 14-21 days ^{27,69}	Waterfowl, galliformes/ <i>Clostridium</i> , necrotizing enteritis
Neomycin sulfate (Neomycin 325 Soluble Powder, Zoetis)	10 mg/lb (22 mg/kg) body weight per day in drinking water × 2-5 days ¹⁶⁶	Turkeys (growing)/for the control of mortality associated with <i>E. coli</i> ¹⁶⁶
Nitrofurantoin	26 mg/L drinking water × 5-7 days ²⁷	Galliformes/prohibited drug ^{c,167}
	50-200 mg/kg feed × 5-7 days ²⁷	Galliformes/ <i>Clostridium</i> , <i>Salmonella</i> ; prohibited drug ^{c,167}
Nitrofurazone	—	Poultry/prohibited drug ^{c,167}
Norfloxacin (Noroxin, Merck; Vetriflox 20% Oral Solution, Laveit)	8 mg/kg PO q24h ¹²	Chickens/PD; prohibited drug ^{c,167}
	10 mg/kg PO q24h ^{16,86}	Chickens, geese/PD; prohibited drug ^{c,167}
	10 mg/kg PO q6-8h ^{16,86}	Turkeys/PD; prohibited drug ^{c,167}
	15 mg/kg in water over 2-4 hr ¹³⁹	Turkeys/PD; once-per-day pulse dosing was more efficacious than continuous dosing in the water; prohibited drug ^{c,167}
	20-40 mg/kg PO q24h × 5 days ⁹⁶	Chickens/prohibited drug ^{c,167}
	100 mg/L drinking water × 5 days ¹³⁹	Chickens/PD; prohibited drug ^{c,167}
	175 mg/L drinking water × 5 days ¹³⁸	Chickens/prohibited drug ^{c,167}

Continued

TABLE 6-1 Antimicrobial Agents Used in Backyard Poultry and Waterfowl. (cont'd)

Agent	Dosage	Species/Comments
Novobiocin sodium	15-30 mg/kg PO q24h ¹⁵¹	Poultry/effective against some gram-positive cocci
	220-385 mg/kg feed ⁶⁹	Poultry, waterfowl
Novobiocin (AlbamiX Feed Medication, Zoetis)	4-5 mg/lb body weight/day in feed ¹⁶⁶	Turkeys/aid in the treatment of breast blisters associated with susceptible staphylococcal infections ¹⁶⁶
	5-8 mg/lb body weight/day in feed ¹⁶⁶	Turkeys/aid in the control of recurring outbreaks of fowl cholera caused by susceptible strains of <i>Pasteurella multocida</i> following initial treatment with 7-8 mg/lb body weight/day ¹⁶⁶
	6-7 mg/lb body weight/day in feed × 5-7 days ¹⁶⁶	Chickens/aid in the treatment of breast blisters associated with susceptible staphylococcal infections; administer as sole ration feed that contains not less than 200 g/ton of feed; not for laying chickens ¹⁶⁶
	10-14 mg/lb body weight/day in feed × 5-7 days ¹⁶⁶	Chickens/treatment of susceptible staphylococcal infections; administer as sole ration in feed that contains not less than 350 g/ton of feed; not for laying chickens ¹⁶⁶
Oleandomycin	—	Macrolide; not available in the United States
Orbifloxacin (Orbax, Intervet)	15-20 mg/kg PO q24h ⁷⁰	Japanese quail/PK ⁷⁰ Poultry/prohibited drug ^{c,168}
Ormetoprim-sulfadimethoxine (Primor, Zoetis)	200-800 mg/kg feed ²⁷	Waterfowl/colibacillosis
Oxytetracycline	5 mg/kg SC, IM q12-24h ²⁰	Chickens (chicks)/PD
	23 mg/kg IV q6-8h ¹⁵⁵	Pheasants/PK
	43 mg/kg IM q24h ¹⁵⁵	Pheasants/PD
	200 mg/kg IM q24h ⁶⁹	Waterfowl/ <i>Pasteurella</i>
	2500 mg/L drinking water and 2500 mg/kg feed ^{69,180}	Chickens (PD), turkeys (PD), waterfowl/simultaneous medication of feed and water required to reach therapeutic level
Oxytetracycline (Liquamycin injectable, Terramycin Soluble Powder, Zoetis)		Chickens (broilers, breeders), turkeys/ <i>Mycoplasma gallisepticum</i> , <i>Mycoplasma synoviae</i> , <i>E. coli</i> , and <i>Pasteurella multocida</i> ; treatment must be discontinued at least 5 days prior to slaughter; do not administer to laying hens unless the eggs are used for hatching only; in light turkey breeds, no more than 55 mg/kg of body weight is administered; treatment not to exceed a total of 4 consecutive days ¹⁶⁵

TABLE 6-1 Antimicrobial Agents Used in Backyard Poultry and Waterfowl. (cont'd)

Agent	Dosage	Species/Comments
Oxytetracycline (Liquamycin injectable, Terramycin Soluble Powder, Zoetis) (cont'd)	6.25 mg/chick or poult/day SC diluted 1 part drug to 3 parts sterile water ¹⁶⁵	Chickens, turkeys (1 day to 2 wk of age)
	12.5 mg/pullet or poult/day SC diluted 1 part drug to 3 parts sterile water ¹⁶⁵	Chickens, turkeys (2-4 wk of age)
	25 mg/chicken/day SC ¹⁶⁵	Chickens (4-8 wk of age)
	50 mg/chicken or poult/day SC ¹⁶⁵	Chickens (8 wk of age), turkeys (4-6 wk of age)
	100 mg/chicken or poult/day SC ¹⁶⁵	Chickens (adult), turkeys (6-12 wk of age)
	200 mg/poult/day SC undiluted ¹⁶⁵	Turkeys (12 wk of age and older)
Oxytetracycline (Terramycin Soluble Powder, Zoetis)	50-100 mg injected into swollen sinus; may be repeated in 5-7 days ¹⁶⁵	Turkeys/infectious sinusitis; treat concurrently with SC doses described above
	25 mg/lb body weight × 7-14 days ¹⁶⁶	Turkeys (growing)
	200-400 mg/gal drinking water × 7-14 days ¹⁶⁶	Turkeys (not laying eggs for human consumption)
	200-800 mg/gal drinking water × 7-14 days ¹⁶⁶	Chickens
Penicillin	37 g/15 L drinking water × 5-7 days ¹⁶	Waterfowl/pasteurellosis and other sensitive bacterial infections
	50,000 U/kg IM ²⁷	Waterfowl/ <i>Erysipelas</i> , new duck disease
Penicillin G (Penicillin G Potassium, Zoetis)	1,500,000 U/gal drinking water × 5 days ¹⁶⁶	Turkeys/not laying eggs for human consumption
Penicillin procaine	100 mg/kg IM q24-48h ⁷³	Turkeys/PD
Sarafloxacin (Saraflox, Abbott)	10 mg/kg PO q8h ¹⁶	Chickens/prohibited drug ^{c,168}
	20-40 mg/L drinking water × 5 days ¹⁶	Chickens/colibacillosis; prohibited drug ^{c,168}
	30-50 mg/L drinking water × 5 days ¹⁶	Turkeys/colibacillosis; prohibited drug ^{c,168}
Spectinomycin	0.5 g/gal drinking water ¹⁶⁶	Chickens (floor-raised broilers)/use first 3 days of life × 3 days; 1 day following each vaccination ¹⁶⁶
	1 g/gal drinking water ¹⁶⁶	Chickens (broilers)/use first 3-5 days of life ¹⁶⁶
	2 g/gal drinking water ¹⁶⁶	Chickens (growing)/use first 3 days of life × 3 days; use 1 day following each vaccination ¹⁶⁶
Streptomycin	22-33 mg/kg PO ¹⁶⁵	Chickens/not laying eggs for human consumption
	25-50 mg/kg IM q24h ¹⁶	Chickens/PD
	0.6-0.9 g/gal drinking water for up to 5 days ¹⁶⁵	Chickens/not laying eggs for human consumption

Continued

TABLE 6-1 Antimicrobial Agents Used in Backyard Poultry and Waterfowl. (cont'd)

Agent	Dosage	Species/Comments
Sulfachloropyridazine/trimethoprim (Cosumix Plus, Ciba)	400 mg/kg feed ¹⁶	Geese
Sulfadimethoxine	0.938 g/gal (0.025%) × 6 days ¹⁶⁶ 1.875 g/gal (0.05%) × 6 days ¹⁶⁶	Turkeys (meat)/fowl cholera; do not administer to turkeys over 24 wk of age; withdraw 5 days prior to slaughter ¹⁶⁵ Chickens (broilers and replacements)/fowl cholera and infectious coryza; do not administer to chickens over 16 wk of age; withdraw 5 days prior to slaughter ¹⁶⁶
Sulfamethazine (SMZ, Cross VetPharm Group)	128-187 mg/kg body weight/day in drinking water ¹⁶⁵ 110 to 273 mg/kg body weight/day in drinking water ¹⁶⁶	Chickens/not laying eggs for human consumption ¹⁶⁵ Turkeys/not laying eggs for human consumption ¹⁶⁶
Sulfaquinoxaline (Sulquin 6-50, Zoetis; Sul-Q-Nox, S. Q., Huvepharma)	0.04% in drinking water × 2-3 days ¹⁶⁶ 250-500 mg/kg feed ²⁷	Chickens, turkeys/acute fowl cholera due to <i>P. multocida</i> ; fowl typhoid due to <i>Salmonella gallinarum</i> Waterfowl/avian cholera, new duck disease
Tetracycline	40-200 mg/L drinking water ²⁷ 100-600 mg/kg feed ^{27,69}	Game birds Game birds
Tiamulin (Denagard; Elanco)	12.5 mg/kg PO q24h × 3 days ⁷⁵ 30 mg/kg PO q24h × 7 days ⁶⁹ 60 mg/kg PO q24h × 7 days ⁶⁹ 225-250 mg/L drinking water × 3-7 days ⁶⁹ 1000 mg/L water ⁶⁹ 300-400 mg/kg feed × 7 days ⁶⁹	Poultry/intestinal spirochetosis; adverse effects, including death, if administered with ionophores Poultry (adults) Poultry (chicks) Poultry Poultry eggs/dip Game birds
Tiamulin/chlortetracycline (Tetramutin, Elanco)	1-1.5 mg/kg feed × 7 days ¹⁴⁹	Chickens/ <i>Mycoplasma</i> ; <i>Brachyspira</i> -related diseases; may be used with salinomycin at low doses of 60 mg/kg without signs of incompatibility ⁶⁹
Tilmicosin (Micotil 300 Injection, Provital-powder and Pulmotil AC-liquid, Elanco)	30 mg/kg PO q24h ² 100-500 mg/L drinking water × 5 days ^{79,82}	Poultry/PK; not labeled for use in poultry ⁶⁹ Poultry chicks/ <i>Mycoplasma</i>

TABLE 6-1 Antimicrobial Agents Used in Backyard Poultry and Waterfowl. (cont'd)

Agent	Dosage	Species/Comments
Tobramycin	2.5-5 mg/kg IM, IV q12h ⁶⁹	Pheasants
Trimethoprim/sulfadiazine	107 mg/L drinking water ⁶⁹	Galliformes
Trimethoprim/sulfamethoxazole	20-50 mg/kg PO q12h ¹⁷³	Ducks
	50 mg/kg PO q12h ¹⁷³	Chickens
	400 mg/kg feed ⁶⁹	Geese
Tylosin (Tylan, Elanco)	6.6-11 mg/kg SC ⁶⁹	Galliformes
	10-40 mg/kg IM q6-8h ⁶⁹	Poultry
	20-30 mg/kg IM q8h × 3-7 days ^{16,69}	Waterfowl/ <i>Mycoplasma</i>
	25 mg/kg IM q6h ⁹⁴	Quail/PK
	851-1419 mg/gal (225-375 ppm) in drinking water × 5 days ¹⁶⁶	Chickens/control mortality caused by necrotic enteritis ¹⁶⁶
	2000 mg/gal (528 ppm) in drinking water × 1-5 days ¹⁶⁶	Chickens (broiler and replacement chicks)/chronic respiratory disease ¹⁶⁶
	2000 mg/gal (528 ppm) in drinking water × 2-5 days ¹⁶⁶	Turkeys/infectious sinusitis associated with <i>Mycoplasma gallisepticum</i> ¹⁶⁶
	500 mg/L drinking water × 3-28 days ^{69,79,152}	Galliformes, waterfowl/ <i>Mycoplasma</i>
	2.5 g/5 L drinking water × 3 days ¹⁶	Waterfowl
	2000 mg/L drinking water ⁶⁹ 200 mg/kg feed ⁶⁹	Poultry/ <i>Mycoplasma</i> , <i>Haemophilus</i> Galliformes
100 mg/10 mL saline nasal flush × 10 days ¹⁶	Waterfowl/ <i>Mycoplasma</i>	
Virginiamycin (Stafac, Phibro)	22 mg/kg feed ¹⁵¹	Poultry
	5-20 g/ton feed ¹⁶⁵	Chickens (broilers)
	10-20 g/ton feed ¹⁶⁵	Turkeys (growing)

^aMany poultry species are considered food-producing animal *species*, and as such, these species are regulated by the U.S. Food and Drug Administration (FDA).¹⁶⁶ Even if the individual animals of any of these species are never used for food, they are still regulated by the FDA. The FDA prohibits the use of certain drugs, with no allowable extra-label drug use, in any food-producing animal species. These prohibited drugs are clearly identified in the tables, and the doses are provided in case they are needed for a similar but non-food-producing animal species (e.g., Attwater's prairie chicken), and listings should in no way be misconstrued as an endorsement of using FDA-prohibited drugs in any food-producing animal species. Please refer to the appropriate tables at the end of this chapter regarding the definitions of prohibited drugs, extra-label drugs, labeled drugs, and drugs needing a Veterinary Feed Directive prior to choosing a drug and dose. Please refer to the Food Animal Residue Avoidance Databank at www.farad.org and other sources listed in Table 6.25 for meat and egg withdrawal times.⁵⁴

^bThe FDA restricts the extra-label use of the cephalosporin class of antibiotics, except for cephapirin, in food-producing animal species, such as chickens and turkeys.^{54,166,169}

^cThe FDA prohibits the use of chloramphenicol, clenbuterol, diethylstilbestrol (DES), fluoroquinolone-class antibiotics, glycopeptides (all agents, including vancomycin), medicated feeds, nitroimidazoles (all agents, including dimetridazole, ipronidazole, metronidazole, and others), and nitrofurans (all agents, including furazolidone, nitrofurazone, and others), with no allowable extra-label drug use, in any food-producing animal species.^{54,166}

TABLE 6-2 Antifungal Agents Used in Backyard Poultry and Waterfowl.^a

Agent	Dosage	Species/Comments
Copper sulfate ("bluestone")	Dissolve 0.5 lb copper sulfate and 0.5 cup vinegar in 1 gal of water for a "stock" solution; dispense stock solution at the rate of 1 oz per gal for the final drinking solution; ¹¹⁴ alternate method of preparing the solution: dissolve 1 oz copper sulfate and 1 Tbs of vinegar in 15 gal water. ¹¹⁴	Poultry/mycosis (thrush) in the crop; "follow-up" treatment after flushing crop with Epsom salt solution ¹¹⁴
Epsom salts	1 tsp Epsom salt in 1 oz water to flush crop ¹¹⁴ 1 lb Epsom salt per 5 gal water × 1 day ¹¹⁴ 1 lb Epsom salt per 15 lb feed ¹¹⁴	Chicken/mycotic ingluvitis; individual dose Poultry/to flush digestive system of toxins Poultry/laxative or flush prior to copper sulfate treatment; give the Epsom salt feed mixture as the sole feed source for a 1-day period
Fluconazole	100 mg/kg PO q24h ⁶⁹	Chickens/avian gastric yeast
Flucytosine (Ancobon, Roche)	60 mg/kg PO q12h ⁶⁹ 150 mg/kg PO q12h ⁶⁹	Galliformes, swans/birds >500 g; syringeal aspergilloma Galliformes, swans/birds <500 g; syringeal aspergilloma
Itraconazole	— 5 mg/kg PO q24h ⁶⁹ 5-10 mg/kg PO q12h ⁶⁹ 10 mg/kg PO q24h × 7-10 days ¹⁶ 10 mg/kg PO q12h 4-6 wk ¹⁶ 16% itraconazole-impregnated PMMA fed as grit stones in 1-g pieces ¹⁴⁸	Study using SC controlled-release gel formulation in ducks showed unacceptable tissue and plasma levels of the drug ¹⁶⁰ Galliformes, swans/aspergillosis Waterfowl Waterfowl/prophylactic dose Waterfowl/therapeutic dose Indian peafowl/PD; therapeutic levels achieved in 2 days and decreased over 7 days
Ketoconazole	12.5 mg/kg PO q24h × 30 days ⁶⁹	Swans/candidiasis
Nystatin	300,000 U/kg PO q12h × 7-14 days ^{16,69}	Waterfowl
Parconazole (Parcomyc, Janssen-Cilag)	30-60 mg/kg feed ⁶⁹	Guinea fowl/candidiasis; prophylaxis; not available in the United States
Voriconazole	10 mg/kg PO, IV q12h ²² 40 mg/kg PO q24h ¹⁵⁹	Chickens/PK Quail/PD

^aMany poultry species are considered food-producing animal *species*, and as such, these species are regulated by the U.S. Food and Drug Administration (FDA).¹⁶⁶ Even if the individual animals of any of these species are never used for food, they are still regulated by the FDA. The FDA prohibits the use of certain drugs, with no allowable extra-label drug use, in any food-producing animal species. These prohibited drugs are clearly identified in the tables, and the doses are provided in case they are needed for a similar but non-food-producing animal species (e.g., Attwater's prairie chicken), and listings should in no way be misconstrued as an endorsement of using FDA-prohibited drugs in any food-producing animal species. Please refer to the appropriate tables at the end of this chapter regarding the definitions of prohibited drugs, extra-label drugs, labeled drugs, and drugs needing a Veterinary Feed Directive prior to choosing a drug and dose. Please refer to the Food Animal Residue Avoidance Databank at www.farad.org and other sources listed in Table 6.25 for meat and egg withdrawal times.

TABLE 6-3 Antiviral and Immunomodulating Agents Used in Backyard Poultry and Waterfowl.^a

Note: The U.S. Food and Drug Administration (FDA) restricts the extra-label use of adamantane and neuraminidase inhibitors in all poultry, including ducks, because of the potential resistance production against avian influenza.^{54,166}

Agent	Dosage	Species/Comments
Acyclovir	10 mg/kg IM q24h × 5-14 days starting 3 days post-exposure ⁶⁹	Chickens/Marek's disease
Famciclovir	25 mg/kg PO q12h ^{16,69,163}	Ducklings/PD; duck hepatitis; toxic effects were not reported
Levamisole	1.25-2.5 mg/kg PO, SC ⁶⁹	Poultry
Penciclovir (Denavir, Novartis)	10 mg/kg IP q24h × 12-24 wk ⁹¹	Ducks/PD; herpesviruses; duck hepatitis B virus; viral levels were significantly reduced; no toxic effects observed; dissolve in 2 mL of 1% DMSO

^aMany poultry species are considered food-producing animal *species*, and as such, these species are regulated by the U.S. Food and Drug Administration (FDA).¹⁶⁶ Even if the individual animals of any of these species are never used for food, they are still regulated by the FDA. The FDA prohibits the use of certain drugs, with no allowable extra-label drug use, in any food-producing animal species. These prohibited drugs are clearly identified in the tables, and the doses are provided in case they are needed for a similar but non-food-producing animal species (e.g., Attwater's prairie chicken), and listings should in no way be misconstrued as an endorsement of using FDA-prohibited drugs in any food-producing animal species. Please refer to the appropriate tables at the end of this chapter regarding the definitions of prohibited drugs, extra-label drugs, labeled drugs, and drugs needing a Veterinary Feed Directive prior to choosing a drug and dose. Please refer to the Food Animal Residue Avoidance Databank at www.farad.org and other sources listed in Table 6.25 for meat and egg withdrawal times.

TABLE 6-4 Antiparasitic Agents Used in Backyard Poultry and Waterfowl.^{a,b}

Agent	Dosage	Species/Comments
Albendazole (11.36%) (Valbazen, Zoetis)	10 mg/kg PO once ³⁴ 47 mg/kg PO once, then repeat in 4 wk ⁶⁹	Poultry/PK Chickens/lower ascarid <i>Heterakis</i> fecal counts than nontreated
Amprolium	13-26 mg/kg PO ⁶² 575 mg/L drinking water ²⁷ ¼ tsp/L drinking water × 3-5 days ⁶⁹ 115-235 mg/kg feed ⁶⁹ 125 mg/kg feed ^{137a}	Chickens/PK, PD; bioavailability almost 4 times greater in fasted birds Poultry/using a 9.6% solution Poultry/20% soluble powder Poultry, pheasants/coccidia; <i>Sarcocystis</i> ; lower dose is prophylactic; higher dose is therapeutic Turkeys/31 of 33 <i>Eimeria</i> isolates were resistant
Carbaryl 5% (Sevin Dust, Bayer)	—	No longer approved for use in poultry
Chloroquine phosphate	5 mg/kg PO q24h or in feed ⁶⁹ 2000 mg/L drinking water q24h × 14 days ⁶⁹	Game birds/generally used with primaquine for <i>Plasmodium</i> , <i>Haemoproteus</i> , and <i>Leucocytozoon</i> ; overdose can result in death ¹⁶ Game birds/juice covers bitter taste of drug

Continued

TABLE 6-4 Antiparasitic Agents Used in Backyard Poultry and Waterfowl. (cont'd)

Agent	Dosage	Species/Comments
Clazuril (Appertex, Janssen)	3 mg/kg PO once, or \times 5 days ⁵⁷ 5-10 mg/kg PO q72h \times 3 treatments ^{16,69} 5-10 mg/kg PO q24h \times 3 days, off 2 days, on 3 days ⁶⁹	Chickens/PK; drug detected in eggs after multiple dosing Waterfowl/coccidiosis Poultry
Clopidol	0.0125%-0.025% in feed (113.5 or 227 g/ton feed) ^{30a} 0.0125%-0.025% in feed ^{30a} 125 mg/kg feed ^{137a} 125-250 mg/kg feed ⁶⁹	Turkeys/leucocytozoonosis prevention Chickens (broilers and layer replacements)/coccidiosis prevention; do not feed to chickens over 16 wk of age Turkeys/16 of 33 <i>Eimeria</i> isolates showed partial to complete resistance Game birds/coccidiosis, <i>Leucocytozoon</i> , <i>Plasmodium</i>
Clorsulon (Curatrem, Merial)	20 mg/kg PO q14d \times 3 treatments ⁶⁹ 20 mg/kg PO 3 \times /wk \times 14 days ⁶⁹	Waterfowl/trematodes, cestodes Waterfowl/trematodes, cestodes
Cypermethrin (5%) (Max Con, Y-TEX)	60-120 mg/chicken topically over dorsal neck ^{4a}	Chickens/effective against <i>Triatoma infestans</i>
Decoquinatate (Deccox, Alpharma)	20-40 mg/kg feed ^{61,151}	Chickens/ <i>Eimeria</i> ; very effective in isolates studied
Diatomaceous earth (kitchen/food grade)	2% in feed, feed continuously ¹⁰⁶	Chickens/lowers numbers of <i>Heterakis</i> and <i>Capillaria</i>
Diclazuril (Clinicox 0.5%, Huvepharma AD; DiClosol 1%, Pharmaswede)	— 5 mg/L drinking water \times 6 days ⁶⁹ 5-10 mg/L drinking water \times 2 days ⁴⁴ 0.5-1 mg/kg feed ^{29,44} 1 mg/kg feed ^{137a}	Benzene-acetonitrile anticoccidial; some <i>Eimeria</i> resistance in poultry documented recently; ^{1a,137a} rotation suggested for long-term prevention Chickens/reduced oocyst viability and virulence Chickens/effective in preventing disease and reducing total oocysts, lesions, and mortality in infected birds with mixed <i>Eimeria</i> infections Chickens, turkeys/coccidia Turkeys/21 of 33 <i>Eimeria</i> isolates were partially or completely resistant
Dimetrida-zole ^b (Emtryl 40% powder, Rhone Merieux)	200-400 mg/L drinking water \times 5 days ⁶⁹	Game birds/ <i>Trichomonas</i> , <i>Giardia</i> , <i>Hexamita</i> , <i>Spironucleus</i> , <i>Histomonas</i> ; low therapeutic index; highly toxic to geese, and ducks; ⁶⁹ not available in many countries (United States, European Union) because of human health risks; Canada has banned use in food-producing animals; ¹²⁴ prohibited drug ^b

TABLE 6-4 Antiparasitic Agents Used in Backyard Poultry and Waterfowl. (cont'd)

Agent	Dosage	Species/Comments
Dimetrída-zoleb (Emtryl 40% powder, Rhone Merieux) (cont'd)	800 mg/L drinking water ⁶⁹	Poultry, game birds/prohibited drug ^b
	185-187.5 mg/kg feed ⁶⁹	Poultry, game birds/prohibited drug ^b
	200-400 mg/kg feed ⁶⁹	Chickens/highly effective against <i>Histomonas</i> ; prohibited drug ^b
Dinitolmide (Zoamix, Alpharma)	40-187 mg/kg feed ⁶⁹	Chickens, turkeys/coccidia
Fenbendazole (Safeguard, Ralston Purina; Panacur, Intervet)	—	Anthelmintic effective against cestodes, nematodes, trematodes, <i>Giardia</i> , acanthocephalans; can cause feather abnormalities if administered during molting ¹⁶
	1.5-3.9 mg/kg PO q24h × 3 days ^{16,153}	Chickens/PK, PD; <i>Capillaria</i>
	5-15 mg/kg q24h × 5 days ¹⁶	Waterfowl
	10-50 mg/kg PO once; repeat in 10 days ¹⁰⁶	Chickens/ <i>Ascaris</i> spp.
	10-50 mg/kg PO q24h × 5 days ¹⁰⁶	Chickens/ <i>Capillaria</i> and other nematodes
	12 mg/kg PO ⁶⁹	Partridges, pheasants/ <i>Syngamus</i> , <i>Heterakis</i> , <i>Ascaridia</i>
	20 mg/kg PO once ^{16,69}	Waterfowl, ¹⁶ pheasants/cestodes, nematodes, acanthocephalans; reduced <i>Heterakis</i> and <i>Eimeria</i> in pheasants
	20-100 mg/kg PO once ¹⁰⁶	Chickens/nematodes other than <i>Capillaria</i>
	125 mg/L of drinking water × 5 days ¹⁰⁶	Chickens/nematodes other than <i>Capillaria</i>
	53 mg/kg in feed × 5-7 days ⁶⁹	Game birds/nematodes, trematodes
	79 mg/kg feed (75 ppm) × 3 days ^{d,114}	Chickens, quail
80 mg/kg feed ¹⁵³	Chickens/PK, PD; <i>Capillaria</i>	
375 mg/kg feed × 1 day ^{c,114}	Chickens/ <i>Capillaria</i> , <i>Heterakis</i> , <i>Ascaridia</i> , <i>Syngamus</i>	
14.5 g/ton feed (16 ppm) × 6 days ¹⁰⁶	Bobwhites (280-g size)/will treat about 1000 birds ¹¹⁴	
	Turkeys (growing)/ <i>Ascaridia dissimilis</i> and <i>Heterakis gallinarum</i>	
Flubendazole (Flutelmium 7.5%, Janssen-Cilag)	30 mg/kg feed × 7 days ¹⁶	Poultry
	60 mg/kg feed × 7-14 days ^{16,69}	Partridges, pheasants
Halofuginone	—	Not available in the United States
	1.3-2.72 mg/kg feed ²⁷	Turkeys/coccidia; not approved for birds intended for food
	2.7 mg/kg feed ²⁷	Chickens/coccidia, <i>Plasmodium</i>

Continued

TABLE 6-4 Antiparasitic Agents Used in Backyard Poultry and Waterfowl. (cont'd)

Agent	Dosage	Species/Comments
Hygromycin B (Hygromix 8, Elanco)	— 8-12 g/ton feed ¹⁰⁶ 9-13 mg/kg feed ⁶⁹ 18-26 mg/kg feed × 2 mo ⁶⁹	Aminoglycoside antibiotic used as anthelmintic feed additive Chickens/ <i>Ascaridia</i> , <i>Heterakis</i> , <i>Capillaria</i> Game birds/ascarids, cecal worms; some efficacy against <i>Capillaria</i> Game birds/cecal worms
Ivermectin	— 0.2 mg/kg PO, SC, IM once, can repeat in 10-14 days ^{16,69}	Most nematodes, acanthocephalans, leeches, most ectoparasites (including <i>Knemidokoptes</i> , <i>Dermanyssus</i>); can dilute with water or saline for immediate use; dilute with propylene glycol for extended use Guinea fowl, waterfowl
Lasalocid (Avatec, Alpha)	67-125 mg/kg feed continuously ^{69,151}	Game birds, chickens/coccidia
Levamisole	— 13 g/25 gal drinking water × 1 day; can repeat in 5-7 days ¹¹⁴ 52 g/100 gal drinking water × 1 day; can repeat in 5-7 days ^{9,114} 52 g/3 L water stock solution that is then added at 30 mL stock solution/ 3.8 L drinking water × 1 day; can repeat in 5-7 days ¹¹⁴ 20-25 mg/kg SC ⁶⁹ 20-50 mg/kg PO, SC once ¹⁶ 25-30 mg/kg ¹⁰⁶ 40 mg/kg PO once ^{47,69} 265-525 mg/L drinking water × 1 day, repeat in 7-14 days ⁶⁹	Nematodes; immunostimulant; low therapeutic index (toxic reactions, deaths reported); do not use in debilitated birds; ¹⁶ IM administration may cause severe toxicity ⁶⁹ Poultry/ <i>Capillaria</i> , <i>Heterakis</i> , and <i>Ascaridia</i> ; solution contains 0.5 g of levamisole per 3.8 L of water ¹¹⁴ Poultry/ <i>Capillaria</i> , <i>Heterakis</i> , and <i>Ascaridia</i> ; solution contains 0.5 g of levamisole per 3.8 L of water ¹¹⁴ Poultry/ <i>Capillaria</i> , <i>Heterakis</i> , and <i>Ascaridia</i> ; solution contains 0.5 g of levamisole per 3.8 L of water ¹¹⁴ Game birds Waterfowl Chicken/ <i>Ascaridia dissimilis</i> , <i>H. gallinarium</i> , <i>Capillaria obsingnata</i> Chickens/PK; <i>Capillaria</i> ; significantly higher bioavailability, volume of distribution, and total body clearance in laying hens ⁴⁷ Game birds, poultry
Maduramicin ammonium (Cygro, Alpha)	5-6 mg/kg feed ⁶⁹	Chickens, turkeys/coccidia; not available in the United States

TABLE 6-4 Antiparasitic Agents Used in Backyard Poultry and Waterfowl. (cont'd)

Agent	Dosage	Species/Comments
Mebendazole (Telmin Suspension, Telmintic Powder, Schering-Plough)	5-15 mg/kg PO q24h × 2 days ^{16,69} 1.2 mg/kg feed × 14 days ⁶⁹	Broad-spectrum ovicidal anthelmintic; primarily used for <i>Capillaria</i> ¹⁶ Waterfowl/nematodes Waterfowl/nematodes
Metronidazole ^b	— 25 mg/kg PO q12h × 10 days ²⁷ 30 mg/kg PO q12h ³⁶ 50 mg/kg PO ²⁷ 110 mg/kg PO q12h ⁶⁹ 400 mg/L drinking water × 5-15 days ⁶⁹ 200-400 mg/kg feed ⁶⁹	Antiprotozoal, including alimentary tract protozoa (especially flagellates such as <i>Giardia</i> , <i>Histomonas</i> , <i>Spironucleus</i> , <i>Trichomonas</i>); prohibited drug ^{64,166} Turkeys/ <i>Trichomonas</i> ; prohibited drug ¹⁶⁶ Poultry/PK, PD; prohibited drug ¹⁶⁶ Waterfowl/flagellates; prohibited drug ¹⁶⁶ Poultry/ <i>Histomonas</i> ; prohibited drug ¹⁶⁶ Game birds, passerines/protozoal sinusitis; prohibited drug ¹⁶⁶ Chickens/highly effective against <i>Histomonas</i> but reduced weight gains at higher dosage; prohibited drug ¹⁶⁶
Milbemycin oxime (Interceptor, Novartis)	2 mg/kg PO, repeat in 28 days ⁶⁹	Galliformes/nematodes
Monensin (Coban 45, Elanco)	— 53-94 mg/kg feed × 10 wk ^{29,69} 73 mg/kg feed × 10 wk ²⁷ 94 mg/kg feed ⁶⁹ 94-108 mg/kg feed × 8 wk ⁶⁹ 99.2 mg/kg feed ^{137a}	Ionophore antibiotic anticoccidial feed additive; keep away from horses (toxic) Turkeys Quail Quail, cranes/coccidia (including disseminated visceral coccidiosis) Chickens Turkeys/23 of 33 <i>Eimeria</i> isolates were resistant
Narasin (Monteban 45, Elanco)	20-80 mg/kg feed ¹⁵¹	Chickens/prophylactic coccidiostat; toxic to turkeys
Nicarbazin (Nicarb 25%, Merck AgVet)	20-125 mg/kg feed ¹⁵¹	Chickens/prophylactic coccidiostat
Oregano essential oil (Orego-Stim 5% Meriden AnimalHealth Ltd)	500 ppm in feed ¹¹⁶	Chickens (growing)/PD; coccidiostat; lower oocysts per gram of feces and displayed lower coccidiosis lesion scores in upper and middle regions of intestine than controls ¹¹⁶
Phenylarsonic acid (Merck European Laboratories)	22-45 mg/kg ²⁷	Chickens, turkeys/ <i>Histomonas</i> prevention; not recommended or approved for game birds; not available in the United States

Continued

TABLE 6-4 Antiparasitic Agents Used in Backyard Poultry and Waterfowl. (cont'd)

Agent	Dosage	Species/Comments
Piperazine (Wazine, Fleming Laboratories)	—	Ascarids, oxyurids; less efficacious than fenbendazole; resistance is widespread ¹⁰⁶
	45-200 mg/kg PO once ⁶⁹	Waterfowl/ <i>Tetrameres</i> , <i>Capillaria</i>
	50 mg/bird PO ¹⁰⁶	Chickens (<6 wk old)
	50-100 mg/kg PO once ⁶⁹	Chickens
	100 mg/bird PO ¹⁰⁶	Chickens (≥6 wk old), turkeys (<12 wk old)
	100-400 mg/bird PO ⁶⁹	Turkeys
	100-500 mg/kg PO once, repeat in 10-14 days ⁶⁹	Game birds
	200 mg/bird PO ¹⁰⁶	Turkeys (≥12 wk old)
Praziquantel	1000 mg/L drinking water; repeat in 10-14 days ¹⁶	Gallinaceous birds/should be completely consumed within a few hours because only relatively high concentrations of the drug eliminate worms ¹⁰⁶
	1000-2000 mg/L drinking water × 1-2 days ⁶⁹	Game birds
	1600-2600 mg/L drinking water ²⁷	Waterfowl/ <i>Tetrameres</i> , <i>Capillaria</i>
Praziquantel	5-10 mg/kg PO, SC q24h × 14 days ^{27,69}	Waterfowl/trematodes
	8.5 mg/kg IM ⁶⁹	Chickens/cestodes, trematodes ^{16,69}
	10 mg/kg PO ⁶⁹	Chickens
	10 mg/kg PO, SC q24h × 14 days ¹⁶	Waterfowl/trematodes
	10-20 mg/kg PO, repeat in 10 days ^{16,69}	Waterfowl/cestodes, trematodes ⁶⁹
	10-20 mg/kg SC, repeat in 10 days ⁶⁹	Waterfowl/cestodes
Primaquine	11 mg/kg SC once ⁶⁹	Chickens
	—	Game birds/hematozoa (i.e., <i>Plasmodium</i> , <i>Haemoproteus</i> , <i>Leucocytozoon</i>); use in conjunction with chloroquine; dosage based on amount of active base rather than total tablet weight
Pyrimethamine (Fansidar, Roche)	0.03 mg/kg PO q24h × 3 days ⁶⁹	Game birds
	0.25-0.5 mg/kg PO q12h × 30 days ⁶⁹	Waterfowl/ <i>Sarcocystis</i> , <i>Toxoplasma</i>
	0.5 mg/kg PO q12h × 30 days ⁶⁹	Waterfowl/ <i>Sarcocystis</i>
	0.25-0.5 mg/kg PO q12h × 30 days ¹⁶	Waterfowl
Pyrimethamine/sulfaquinoxaline (Microquinox, C-Vet Livestock Products)	1 mg/kg feed ⁶⁹	Game birds
	60 mg/L drinking water, 3 days on, 2 days off, 3 days on ¹⁶	Waterfowl/coccidiosis
Robenidine HCl (Bio-Cox, Alpharma)	33 mg/kg feed ⁶⁹	Chickens

TABLE 6-4 Antiparasitic Agents Used in Backyard Poultry and Waterfowl. (cont'd)

Agent	Dosage	Species/Comments
Sulfadiazine/ trimethoprim (DiTrim, Zoetis)	60 mg/kg PO q12h × 3 days ¹⁶⁶	Waterfowl/coccidiosis
Sulfadimethoxine (12.5%)	250 mg/L drinking water × 5 days ⁶⁹	Turkeys (meat)/coccidiosis
	500 mg/L drinking water × 6 days ⁶⁹	Chickens (broilers and replacements)/ coccidiosis
	0.938 g/gal (0.025%) × 6 days ¹⁶⁶	Turkeys (meat)/coccidiosis
	1.875 g/gal (0.05%) × 6 days ¹⁶⁶	Chickens (broilers and replacements)/ coccidiosis
Sulfadimethoxine/ ormetoprim (Rofenaid, Hoffmann-La Roche)	10 mg/kg feed ⁶⁹	Game birds/coccidiosis, <i>Leucocytozoon</i> , <i>Sarcocystis</i>
	320-525 mg/L drinking water ⁶⁹	Poultry
Sulfamethazine (Sulmet, Boehringer- Ingelheim)	125-185 mg/kg PO q24h × 2 days, then 64-94 mg/kg × 4 days ⁶⁹	Chickens
Sulfaquinoxaline (Sulquin 6-50, Solvay)	0.04% in drinking water × 2-3 days, off 3 days, then use 0.025% × 2 days (repeat 0.025% × 2 days if needed) ¹⁶⁶	Chickens/coccidiosis caused by <i>Eimeria tenella</i> , <i>E. necatrix</i> , <i>E. acervulina</i> , <i>E. maxima</i> , and <i>E. brunetti</i> ; do not change litter unless absolutely necessary; do not give flushing mash; medicated chickens must actually consume enough medicated water to provide a recommended dosage of approximately 22-99 mg/kg/day depending on the age, class of animal, ambient temperature, and other factors; do not give to chickens within 10 days of slaughter for food; do not medicate chickens producing eggs for human consumption; make fresh drinking water daily ¹⁶⁶
	0.025% in drinking water × 2 days, off 3 days, give 2 days, off 3 days and on 2 days more; repeat if necessary ¹⁶⁶	Turkeys/coccidiosis caused by <i>Eimeria meleagriditis</i> and <i>E. adenoides</i> ; ¹⁶⁶ must consume enough medicated water to provide approximately 77-121 mg/kg/day depending on age, class of animal, ambient temperature; do not give to turkeys within 10 days of slaughter for food; do not use in turkeys producing eggs for human consumption
	250 mg/L drinking water × 6 days, off 2 days, on 6 days ⁶⁹	Turkeys
	400 mg/L (1.4 mL/L) drinking water × 6 days, off 2 days, on 6 days ⁶⁹	Chickens
	225 mg/kg feed continuously ⁶⁹	Turkeys
450 mg/kg feed continuously ⁶⁹	Chickens	

Continued

TABLE 6-4 Antiparasitic Agents Used in Backyard Poultry and Waterfowl. (cont'd)

Agent	Dosage	Species/Comments
Thiabendazole	— 425 mg/kg feed × 14 days ⁶⁹	Nematodes, acanthocephalans; generally less efficacious than fenbendazole; may be toxic to diving ducks ¹⁶ Pheasants
Tinidazole (Fasigyn, Pfizer)	200-400 mg/kg feed ⁶⁹	<i>Giardia</i> , <i>Trichomonas</i> , <i>Entamoeba</i> Chickens/ <i>Histomonas</i> ; depressed weight gain on higher dosage
Toltrazuril (Baycox, Bayer)	— 12.5 mg/L drinking water × 2 days ⁶⁹ 25 mg/L drinking water × 2 days ⁴⁴ 25 mg/L drinking water × 2 days, repeat in 5 days ⁶⁹	Coccidiocidal, ⁶⁹ efficacious for refractory coccidiosis; 2.5% solution is very alkaline and should not be gavaged directly into the crop ⁶⁹ Waterfowl Chickens/effective in preventing disease and reducing total oocysts, lesions, and mortality in infected birds with mixed <i>Eimeria</i> infections Geese
Trimethoprim/sulfachlorpyridazine (1:5 ratio; Cosumix Plus, Novartis)	400 mg/kg feed ⁶⁹	Geese
Trimethoprim/sulfadiazine	60 mg/kg PO, SC q12h × 3 days, off 2 days, on 3 days ¹⁶	Waterfowl/coccidiosis
Trimethoprim/sulfamethoxazole	320-525 mg/L drinking water ^{16,69}	Poultry/coccidiosis

^aMany poultry species are considered food-producing animal *species*, and as such, these species are regulated by the U.S. Food and Drug Administration (FDA).¹⁶⁶ Even if the individual animals of any of these species are never used for food, they are still regulated by the FDA. The FDA prohibits the use of certain drugs, with no allowable extra-label drug use, in any food-producing animal species. These prohibited drugs are clearly identified in the tables, and the doses are provided in case they are needed for a similar but non-food-producing animal species (e.g., Attwater's prairie chicken), and listings should in no way be misconstrued as an endorsement of using FDA-prohibited drugs in any food-producing animal species. Please refer to the appropriate tables at the end of this chapter regarding the definitions of prohibited drugs, extra-label drugs, labeled drugs, and drugs needing a Veterinary Feed Directive prior to choosing a drug and dose. Please refer to the Food Animal Residue Avoidance Databank at www.farad.org and other sources listed in Table 6.25 for meat and egg withdrawal times.

^bThe FDA prohibits the use of chloramphenicol, clenbuterol, diethylstilbestrol (DES), fluoroquinolone class antibiotics, glycopeptides (all agents, including vancomycin), medicated feeds, nitroimidazoles (all agents, including dimetridazole, ipronidazole, metronidazole, and others), and nitrofurans (all agents, including furazolidone, nitrofurazone, and others), with no allowable extra-label drug use, in any food-producing animal species.^{54,166}

^c375 mg/kg feed × 1 day is equivalent to 1 oz of 10% Safeguard or 10% Panacur per 15-20 lb feed.¹¹⁴

^d79 mg/kg feed × 3 days is equivalent to 1.2 oz of 10% Safeguard or 10% Panacur in 100 lb feed or a 4-oz packet of Worm-A-Rest Litter Pack (Ralston Purina) in 50 lb feed or a 5-lb bag of Worm-A-Rest Mix Pack in 495 lb feed.¹¹⁴

^eDissolve a 52-g (1.84-oz) packet of Tramisol Cattle and Sheep Wormer per 100 gal of drinking water.¹¹⁴

^fDissolve a 13-g (0.46-oz) packet of Tramisol Sheep Drench Powder per 25 gal of drinking water.¹¹⁴

TABLE 6-5 Chemical Restraint/Anesthetic/Analgesic Agents Used in Backyard Poultry and Waterfowl.^{a-c}

Agent	Dosage	Species/Comments
Alphachloralose (Fisher Scientific)	30 mg/kg PO once ¹⁸ 250-430 mg/cup of bait ^{27,69}	Canada geese/immobilization of nuisance geese; prepare suspension in corn oil, inject into individual bread baits, and hand-toss to target individuals; onset approximately 60 min, duration up to 24 hr; low therapeutic index in chickens suggests only marginally safe in domestic species or for field applications where dosage difficult to control ⁹⁵ Waterfowl (including Canada geese)/immobilization
Alphaxalone/alphadolone (Saffan, Schering-Plough)	36 mg/kg IP ⁶⁹	Waterfowl/immobilization; relatively low therapeutic index
Atipamezole (Antisedan, Zoetis)	— 2.5-5 × medetomidine dose IM, IV ^{69,100} 0.18-0.28 mg/kg IV ⁹⁹ 0.25-0.38 mg/kg IM ¹⁰⁰ 1.3-1.6 mg/kg IV ⁶⁹	α ₂ adrenergic antagonist; 1:1 volume reversal of dexmedetomidine and medetomidine is general rule; although the same effects would be expected as with medetomidine (no longer available but can be compounded), there are no data available on the efficacy of this volume of atipamezole reversal of dexmedetomidine in birds Geese/righting reflex regained 2-10 min after administration; for reversal of dexmedetomidine and medetomidine (no longer commercially available but can be compounded) Mallard ducks Mallard ducks Chickens
Atropine sulfate	0.1 mg/kg IM, IV q3-4h ¹⁶	Waterfowl
Bupivacaine HCl	1.94 mg/kg IV ¹¹² 2 mg/kg infused SC ¹⁰³ 2-8 mg/kg perineurally ²¹ 2-10 mg/kg infused into incision site ⁶⁹ 3 mg/0.3 mL saline injected intraarticular ⁶⁹ 5 mg/kg (with 10 μg/kg epinephrine) perineurally ⁶⁹ 50:50 mixture with dimethyl sulfoxide topically ⁶⁹	Chickens/TD ₅₀ ; dose with 50% probability of a clinically significant change in blood pressure in isoflurane-anesthetized chickens Mallard ducks/PD; high plasma levels at 6 and 12 hr post-administration, so delayed toxicity is possible Mallard ducks/variable effectiveness for brachial plexus nerve block Eider ducks/high bupivacaine dose toxicity or cumulative toxicity of bupivacaine and ketoprofen may have occurred Chickens/arthritis Chickens/unsuccessful brachial plexus nerve block Chickens/topical anesthesia; applied to amputated beaks

Continued

TABLE 6-5 Chemical Restraint/Anesthetic/Analgesic Agents Used in Backyard Poultry and Waterfowl. (cont'd)

Agent	Dosage	Species/Comments
Buprenorphine HCl	0.05-1 mg/kg intraarticular ^{56a}	Chickens/PD; no significant antinociceptive effects
Butorphanol tartrate	0.5-2 mg/kg IM ¹¹⁸	Harlequin ducks/no isoflurane-sparing effects detected when administered 15 min prior to induction; ¹¹⁸ 4 mg/kg IM caused severe adverse cardiopulmonary effects in Guinea fowl ⁵⁰
	2 mg/kg IM q8-12h ¹⁷³	Chicken/as part of bimodal pain therapy with PO carprofen
Butorphanol (B)/midazolam (Mi)	(B) 1 mg/kg + (Mi) 1 mg/kg ⁶⁹	Chickens/adequate sedation for lateral recumbency
Detomidine (Dormosedan, Zoetis)	0.3 mg/kg IM ^{69,171}	Chickens, rock partridges/marked sedation; significant decrease in HR and RR, decrease in cloacal temperature, and prolonged recoveries (260 ± 17.6 min) in partridges
Diazepam	0.5-1 mg/kg IM, IV q8-12h ¹⁶	Waterfowl/sedation; anticonvulsant; IM administration may cause severe muscle irritation, and absorption may be delayed
	6 mg/kg IM ¹⁷¹	Rock partridges/decrease in cloacal temperature; prolonged recoveries (149 ± 8.3 min)
Fentanyl citrate	0.5-1 mg/kg intraarticular ^{56a}	Chickens/PD; no effect on pain behavior
	5 mg/kg transdermal (intrascapular skin) ¹⁷⁴	Guinea fowl/PK; plasma concentrations greater than those reported to be analgesic for dogs for at least 7 days; no longer available in the United States
	25 µg/h patch for 72 hr ^{41b}	Chickens/PK; wide variability; placed over plucked skin on dorsum; reached human therapeutic levels by 2-4 hr post-application ^{41b}
Flumazenil	0.018-0.028 mg/kg IV ⁹⁹	Mallard ducks
	0.05 mg/kg intranasally ^{69,100}	Mallard ducks
	0.1 mg/kg IM ³⁹	Quail/PD; reversed midazolam in 1.4-1.8 min
Isoflurane	1.3% ^{97,98}	Ducks/minimum anesthetic concentration
	1.15% ¹⁰⁸	Chickens/minimum anesthetic concentration
	1.1% ± 0.1% ⁴⁹	Chickens/minimum anesthetic concentration
Ketamine HCl	15-25 mg/kg IM, IV ⁶⁹	Waterfowl/seldom used as sole agent because of poor muscle relaxation and prolonged (up to 3 hr), violent recovery; ⁶⁹ may produce excitation or convulsions in golden pheasants; ⁶⁹ may fail to produce general anesthesia in some species, including waterfowl ⁶⁹
	20-50 mg/kg SC, IM, IV ⁶⁹	Waterfowl/restraint 30-60 min; smaller species require a higher dose; large birds tend to recover more slowly

TABLE 6-5 Chemical Restraint/Anesthetic/Analgesic Agents Used in Backyard Poultry and Waterfowl. (cont'd)

Agent	Dosage	Species/Comments
Ketamine (K)/diazepam (D)	(K) 10-40 mg/kg IV + (D) 1-1.5 mg/kg IM, IV ⁶⁹	Waterfowl/induction or surgical anesthesia; rapid bolus may produce apnea, arrhythmia, and increased risk of death
	(K) 75 mg/kg IM + (D) 2.5 mg/kg IV ⁶⁹	Chickens/diazepam given 10 min after ketamine; pain reflexes elicited at all times; recovery in 90-100 min
	(K) 75 mg/kg IM + (D) 2.5 mg/kg IV ¹⁰⁷	White leghorn cockerels/diazepam administered 5 min before ketamine for typhlectomy; smooth induction/recovery, some limb contracture, hypothermia, hypoxia, hypercapnia
Ketamine (K)/medetomidine (Me)	(K) 1.5-2 mg/kg + (Me) 60-85 µg/kg IM, IV ⁶⁹	Waterfowl/sedation; medetomidine no longer available but can be compounded; see dexmedetomidine ⁶⁹
	(K) 5-10 mg/kg + (Me) 100-200 µg/kg IM, IV ⁶⁹	Geese
Ketamine (K)/medetomidine (Me)/midazolam (Mi)	(K) 10 mg/kg + (Me) 50 µg/kg + (Mi) 2 mg/kg IV ^{99,100}	Mallard ducks/PD; medetomidine not currently available but can be compounded; anesthesia of 30-min duration; reverse with atipamezole, flumazenil intranasally; regimen considered unsafe due to acidosis, bradypnea, apnea, and in 1/12 birds, death ¹⁰⁰
Ketamine (K)/midazolam (Mi)	(K) 50 mg/kg IV + (Mi) 2 mg/kg IM ¹⁰⁷	Chickens (white leghorn cockerels)/midazolam administered 5 min before ketamine for typhlectomy; hypoxia, hypercapnia, torticollis, dyspnea, salivation noted; prolonged recovery (92-105 min)
Ketamine (K)/xylazine (X)	(K) 10 mg/kg + (X) 2 mg/kg IV ¹⁰⁷	Chickens (white leghorn cockerels)/for typhlectomy; smooth induction/recovery; optimal to excellent surgical anesthesia
	(K) 20 mg/kg + (X) 1 mg/kg IV ^{69,98}	Pekin ducks/bradypnea, acidemia, hypoxemia, moderate hyperthermia
	(K) 25 mg/kg + (X) 1 mg/kg IM ¹⁵⁴	Guinea fowl/lateral recumbency 1-6 min; adequate anesthesia; arousal in 1.4 ± 0.7 min after yohimbine administration
Ketamine (K)/xylazine (X)/diazepam (D)	(K) 25 mg/kg + (X) 3 mg/kg + (D) 4 mg/kg IM ¹¹⁷	Roosters/use with caution; significant decreases in HR, RR, cloacal temperatures; prolonged recoveries (up to 4 hr)
Ketamine (K)/xylazine (X)/midazolam (Mi)	(K) 15 mg/kg + (X) 2.5 mg/kg + (Mi) 0.3 mg/kg IM ³	Guinea fowl/midazolam improved anesthetic quality
Lidocaine	2.5 mg/kg IV (give over 20 sec) ³⁷	Chickens/PK; under isoflurane anesthesia
	15 mg/kg (with 3.8 µg/kg epinephrine) perineurally ²¹	Mallard ducks/variable effectiveness for brachial plexus nerve block
	20 mg/kg (with 10 µg/kg epinephrine) perineurally ⁶⁹	Chickens/unsuccesful brachial plexus nerve block

Continued

TABLE 6-5 Chemical Restraint/Anesthetic/Analgesic Agents Used in Backyard Poultry and Waterfowl. (cont'd)

Agent	Dosage	Species/Comments
Medetomidine	250-350 µg/kg PO ⁶⁹	Chickens/sedation; 60 µg given to male birds, 40 µg given to female birds; average time of sedation was 6 min; not commercially available but can be compounded
Methohexital sodium (Brevital, JHP Pharmaceuticals)	4-8 mg/kg IV ⁶⁹ 5-10 mg/kg IV ⁶⁹	Poultry Ducks
Metomidate HCl (Hypnodil, Janssen)	4 g/cup of bait (usually corn) ⁶⁹	Turkeys (wild)
Midazolam HCl	2 mg/kg IM ⁶⁹ 2-6 mg/kg IM ³⁹ 4-6 mg/kg IM ⁶⁹ 5 mg/kg IV ³³	Canada geese/sedation for 15-20 min Quail/PD; mild to heavy sedation Waterfowl Turkeys, chickens, ring-necked pheasants, bobwhites/PK; rapid absorption, $t_{1/2}$ = 0.42, 1.45, 1.90, and 9.71 hr for turkeys, chickens, bobwhites, and pheasants, respectively
Morphine sulfate	1-3 mg/kg intraarticular ^{56a} 2.5-3 mg/kg SC, IM q4h ⁶⁹ 2 mg/kg IV ¹⁴⁵ 10-20 mg/kg IM ⁵²	Chickens/PD; no analgesic effect for arthritis noted; early work in chickens demonstrated confusing clinical dosage results ⁶⁹ Galliformes/analgesia Chickens/PK; plasma concentrations greater than MEC for humans for 2 hr Japanese quail/PD; exhibited antinociceptive effects on foot withdrawal and pressure tests; no effect on locomotion, eating, or drinking at these doses
Propofol	5 mg/kg IV (induction); 0.5 mg/kg/min IV (maintenance) ¹⁴³ 6-14 mg/kg (induction); boluses prn ⁶⁹ 8 mg/kg IV (induction); 0.85 mg/kg/min IV (maintenance) ¹¹⁹ 8-10 mg/kg IV (induction); 1-4 mg/kg IV boluses prn (maintenance) ^{99,100,102} 15 mg/kg IV (induction); 0.8 mg/kg/min IV (maintenance) ¹⁰¹	Wild turkeys/PD; anesthesia; intubation, ventilation, and supplemental oxygen strongly recommended ^{69,143} Eider ducks/anesthesia with inhalant, bupivacaine, ketoprofen; significant mortality but high-dose bupivacaine toxicity or cumulative bupivacaine/ketoprofen toxicity may have occurred Swans (mute)/PD Mallard ducks, canvasback ducks/PD; anesthesia Canvasback ducks/PD; some excitement during induction; 2 deaths; significant reduction in ventilation

TABLE 6-5 Chemical Restraint/Anesthetic/Analgesic Agents Used in Backyard Poultry and Waterfowl. (cont'd)

Agent	Dosage	Species/Comments
Ropivacaine (Ropi 0.75%, Cristália Chemical & Pharmaceutical)	7.5 mg/kg perineurally ²⁶	Chickens/15 min to effect for brachial plexus nerve block; approximately 110 min anesthesia; no toxic effects noted at this dose
Sevoflurane	2.21 ± 0.32% ¹²²	Chickens/PD; minimum anesthetic concentration; dose-dependent hypotension noted
Tiletamine/zolazepam (Telazol, Zoetis)	4-25 mg/kg IM ⁶⁹ 6.6 mg/kg IM ⁶⁹ 9-30 mg/kg IM ⁶⁹	Waterfowl/sedation; dose generally decreases as body weight increases in waterfowl Swans Wood partridges/restraint
Tramadol HCl	7.5 mg/kg PO ¹⁹	Peafowl/PK; only 2/6 birds reached human tramadol analgesic concentrations; 5/6 maintained 0-desmethyl-tramadol (M1) concentrations above human analgesic concentrations for 10-12 hr and 3/6 for 24 hr; analgesia not evaluated
Xylazine	1 mg/kg IV ⁹⁸ 1-20 mg/kg IM, IV ²⁷ 10 mg/kg IM ¹⁷¹	Pekin ducks Waterfowl/sedation Rock partridges/good sedation; significant decrease in respiratory rate; decrease in cloacal temperature; prolonged recoveries (205 ± 22.2 min)
Yohimbine HCl (Yobine, Lloyd)	— 0.1-0.2 mg/kg IV ^{27,69} 1 mg/kg IV ¹⁵⁴	α ₂ adrenergic antagonist; excitement and mortality observed at doses >1 mg/kg ⁶⁹ Waterfowl Guinea fowl/excitement and mortality observed in birds at doses >1 mg/kg ⁶⁹

^aThe anesthetic agents of choice in most avian species are the inhalant agents isoflurane and sevoflurane.

^bAll opioid agonists and agonist antagonists may cause respiratory depression; profound bradypnea may occur with potent opioid agonists.

^cMany poultry species are considered food-producing animal *species*, and as such, these species are regulated by the U.S. Food and Drug Administration (FDA).¹⁶⁶ Even if the individual animals of any of these species are never used for food, they are still regulated by the FDA. The FDA prohibits the use of certain drugs, with no allowable extra-label drug use, in any food-producing animal species. These prohibited drugs are clearly identified in the tables, and the doses are provided in case they are needed for a similar but non-food-producing animal species (e.g., Attwater's prairie chicken), and listings should in no way be misconstrued as an endorsement of using FDA-prohibited drugs in any food-producing animal species. Please refer to the appropriate tables at the end of this chapter regarding the definitions of prohibited drugs, extra-label drugs, labeled drugs, and drugs needing a Veterinary Feed Directive prior to choosing a drug and dose. Please refer to the Food Animal Residue Avoidance Databank at www.farad.org and other sources listed in Table 6.25 for meat and egg withdrawal times.

TABLE 6-6 Nonsteroidal Antiinflammatory Agents Used in Backyard Poultry and Waterfowl.^{a,b}

Agent	Dosage	Species/Comments
Acetaminophen	10 mg/kg IM q24h × 7 days ⁷⁶	Chicken/no adverse clinical signs, normal serum creatinine and uric acid, no gross or histopathologic changes in kidneys observed
Aspirin (acetylsalicylic acid)	25 mg/kg IV ^{14,15} 50 mg/kg PO ^{134a} 50 mg/kg IV ^{134a} 100-200 mg/kg IM ⁷⁴ Dissolve five (5-grain) aspirin tablets in 1 gal of water (=324 mg/gal of drinking water) ¹¹⁴	Chickens, ducks, turkeys Chickens, turkeys/PK; mean residue time 7 hr and 4.5 hr, respectively; ^{134a} chickens/400 mg/kg PO × 14 days led to decreased weight gain and ventricular ulceration ^{133,134a} Chickens, turkeys/PK; mean residue time 6 hr and 3.3 hr, respectively Chickens/partially reduced arthritic behaviors after 1 hr Poultry/offer solution free choice to obtain a dosage rate of about 55 mg/kg body weight/day ¹¹⁴
Carprofen	1 mg/kg SC ¹¹⁰ 5-8 mg/kg PO q12h ¹⁷³ 15-25 mg/kg SC ²⁵ 30 mg/kg IM ⁷⁴ 40 mg/kg body weight provided in feed ³⁸	Chickens/Improved locomotion for at least 90 min post-injection Chickens Chickens/PD; therapeutically effective treatment of induced articular pain at 6 hr Chickens/PD; arthritis painful behaviors reduced 1 hr post-treatment only with this high dose Chickens/analgesia; dosage required to reach similar mammalian therapeutic plasma concentrations (8.3 µg/mL), but much lower plasma concentrations (0.28 µg/mL) provided some analgesia
Diclofenac	—	Chickens/toxic at dose of 2.5 mg/kg IM q24h × 7 days; severe clinical signs of renal toxicity and high mortality with increased serum creatinine and uric acid concentrations ⁷⁶
Flunixin meglumine	— 1.1 mg/kg IV ¹⁴ 3 mg/kg IM ⁷⁴ 5 mg/kg IM ¹⁰⁵	Potential nephrotoxicity; histologic glomerular changes were demonstrated in bobwhite quail given doses as low as 0.1 mg/kg (severity of lesions was directly correlated to dose); ⁸³ IM administration caused muscle necrosis in mallard ducks ¹⁰⁵ Chickens, ducks, turkeys, and chickens had long half-life, but ostrich $t_{1/2}$ = 10 min Chickens/PD; arthritis behaviors reduced 1 hr after treatment Mallard ducks/PD; reduced thromboxane activity for 12 hr; muscle necrosis at injection site

TABLE 6-6 Nonsteroidal Antiinflammatory Agents Used in Backyard Poultry and Waterfowl. (cont'd)

Agent	Dosage	Species/Comments
Flunixin meglumine (cont'd)	5 mg/kg IV ¹⁷⁶ 1.3 mg/kg IV RLP once ^{137b}	Chickens/PK; $t_{1/2} = 3$ hr Chickens/pododermatitis; regional limb perfusion (RLP) into medial metatarsal vein with a tourniquet placed proximal to hock joint for 15 min ^{137b}
Ketoprofen	1 mg/kg IM q24h × 1-10 days ^{14-16,69}	Waterfowl/arthritis
	2 mg/kg PO, SC, IM, IV ^{59,60}	Japanese quail/PK, PD; poor bioavailability and rapid clearance after PO or IM administration
	2-5 mg/kg PO, IM, IV q12-24h ⁶⁹	Eider ducks/high mortality in male ducks may be due to high bupivacaine dose or cumulative toxicity of bupivacaine and ketoprofen
	3 mg/kg IM q24h × 5 days ¹¹⁵	Chickens/no adverse clinical signs; normal creatinine, uric acid, ALT, AST
	5 mg/kg IM q12h ^{104,105}	Mallard ducks/PD; inhibited thromboxane for approximately 12 hr
Meloxicam	5-10 mg/kg IM, IV ^{27,69}	Waterfowl
	12 mg/kg IM ⁷⁴	Chickens/reduced arthritic pain behaviors for 12 hr
	0.5 mg/kg IV ^{14,15}	Chickens, ducks, turkeys/PK; variable distribution
	1 mg/kg PO, IM q12h ¹⁷³	Chicken
	1 mg/kg PO once ¹⁴⁶	Chickens/PK; $t_{1/2} = 2.8$ hr; drug detected in egg white up to 4 days and egg yolk up to 8 days after dosing
Tepoxalin	1-1.5 mg/kg PO q12-24h ¹⁷³	Chicken
	2 mg/kg IM q12h × 14 days ¹⁴⁴	Japanese quail/PD; unremarkable histologic and minimal biochemical changes
Tepoxalin	3-5 mg/kg SC ²⁵	Chickens/PD; therapeutically effective treatment of induced articular pain at 6 hr
	30 mg/kg PO, IV ⁴⁰	Chickens/PK; rapidly metabolized, $t_{1/2} = 2.8$ hr and 1 hr, respectively ⁴⁰

^aNonsteroidal antiinflammatory agents may potentially cause gastrointestinal upset and hemorrhage as well as adverse renal effects ranging from fluid retention to renal failure.

^bMany poultry species are considered food-producing animal *species*, and as such, these species are regulated by the U.S. Food and Drug Administration (FDA).¹⁶⁶ Even if the individual animals of any of these species are never used for food, they are still regulated by the FDA. The FDA prohibits the use of certain drugs, with no allowable extra-label drug use, in any food-producing animal species. These prohibited drugs are clearly identified in the tables, and the doses are provided in case they are needed for a similar but non-food-producing animal species (e.g., Attwater's prairie chicken), and listings should in no way be misconstrued as an endorsement of using FDA-prohibited drugs in any food-producing animal species. Please refer to the appropriate tables at the end of this chapter regarding the definitions of prohibited drugs, extra-label drugs, labeled drugs, and drugs needing a Veterinary Feed Directive prior to choosing a drug and dose. Please refer to the Food Animal Residue Avoidance Databank at www.farad.org and other sources listed in Table 6.25 for meat and egg withdrawal times.

TABLE 6-7 Hormones and Steroids Used in Backyard Poultry and Waterfowl.^a

Agent	Dosage	Species/Comments
Estradiol benzoate	1 mg/kg IM q24h × 12 days ⁷²	Mallard ducks/induces molt
Levonorgestrel depot form (Levonorgestrel, Sigma Chemical)	40 mg/kg SC ^{53,157}	Japanese quail, turkeys/halts egg laying but may cause ovostasis if already in oviduct; repeat in 60 days in turkeys
Levothyroxine (l-thyroxine)	200-400 µg/bird PO q24h × 14 days ¹⁵⁰	Chickens/induces molt
Oxytocin	3-5 U/kg IM, may repeat q30min ⁶⁹	Waterfowl
Prostaglandin E ₂ (dinoprostone) (Prepidil Gel, Upjohn)	0.02-0.1 mg/kg applied topically to the uterovaginal sphincter ⁶⁹	Waterfowl/dystocia; relaxes uterovaginal sphincter; lower dosage may be effective; freeze into aliquots
Prostaglandin F _{2α} (Dinoprost tromethamine) (Lutalyse, Upjohn)	0.02-0.1 mg/kg IM, intracloacal once ¹⁶	Waterfowl/dystocia
Tamoxifen citrate	40 mg/kg IM ^{72,147}	Galliformes, ducks/induces molt

^aMany poultry species are considered food-producing animal *species*, and as such, these species are regulated by the U.S. Food and Drug Administration (FDA).¹⁶⁶ Even if the individual animals of any of these species are never used for food, they are still regulated by the FDA. The FDA prohibits the use of certain drugs, with no allowable extra-label drug use, in any food-producing animal species. These prohibited drugs are clearly identified in the tables, and the doses are provided in case they are needed for a similar but non-food-producing animal species (e.g., Attwater's prairie chicken), and listings should in no way be misconstrued as an endorsement of using FDA-prohibited drugs in any food-producing animal species. Please refer to the appropriate tables at the end of this chapter regarding the definitions of prohibited drugs, extra-label drugs, labeled drugs, and drugs needing a Veterinary Feed Directive prior to choosing a drug and dose. Please refer to the Food Animal Residue Avoidance Databank at www.farad.org and other sources listed in Table 6.25 for meat and egg withdrawal times.⁵⁴

TABLE 6-8 Nebulization Agents Used in Backyard Poultry and Waterfowl.^{a,b}

Agent	Dosage	Species/Comments
Ceftriaxone	40 mg/mL sterile water ^{69,80}	Poultry/PD; prohibited drug ^{54,166}
	40 mg/mL sterile water and DMSO ⁸⁰	Poultry/PD; 1 g ceftriaxone in 10 mL sterile water, plus 15 mL DMSO; prohibited drug ^{54,166}
	200 mg/mL sterile water and DMSO ⁸⁰	Poultry/PD; 4 g ceftriaxone in 10 mL sterile water, plus 10 mL DMSO; prohibited drug ^{54,166}
Lincomycin	250 mg aerosolized drug/m ³ chamber × 15-30 min ²⁸	Chickens/PD; antibiotic; therapeutic concentrations in blood, lungs, and trachea for up to 24 hr

TABLE 6-8 Nebulization Agents Used in Backyard Poultry and Waterfowl. (cont'd)

Agent	Dosage	Species/Comments
Oxytetracycline	1 g/m ³ of air using a DeVilbiss ultrasonic nebulizer, or 0.075 g/m ³ of air using a Fogmaster fogger ¹⁷²	Turkey poults
Tylosin	20 mg/mL DMSO or distilled water × 1 hr ^{93,94}	Quail/PD

^aMany poultry species are considered food-producing animal *species*, and as such, these species are regulated by the U.S. Food and Drug Administration (FDA).¹⁶⁶ Even if the individual animals of any of these species are never used for food, they are still regulated by the FDA. The FDA prohibits the use of certain drugs, with no allowable extra-label drug use, in any food-producing animal species. These prohibited drugs are clearly identified in the tables, and the doses are provided in case they are needed for a similar but non-food-producing animal species (e.g., Attwater's prairie chicken), and listings should in no way be misconstrued as an endorsement of using FDA-prohibited drugs in any food-producing animal species. Please refer to the appropriate tables at the end of this chapter regarding the definitions of prohibited drugs, extra-label drugs, labeled drugs, and drugs needing a Veterinary Feed Directive prior to choosing a drug and dose. Please refer to the Food Animal Residue Avoidance Databank at www.farad.org and other sources listed in Table 6.25 for meat and egg withdrawal times.

^bNebulization is an adjunctive therapy indicated for rhinitis, sinusitis, tracheitis, pneumonia, airsacculitis, and syringeal aspergilloma, where there is air movement occurring in the patient's disease state; optimal particle size for deposition in the trachea is 2-10 µm; optimal particle size for peripheral airways is 0.5-5 µm; treatments of 30-45 min repeated q4-12h are recommended; caution: do not overhydrate airways.⁶⁹

TABLE 6-9 Agents Used in the Treatment of Toxicologic Conditions of Backyard Poultry and Waterfowl.^a

Agent	Dosage	Species/Comments
Atropine sulfate	0.1 mg/kg IM, IV q3-4h ^{16,69}	Waterfowl/acetylcholinesterase toxicosis
Botulinum type C antitoxin (100 U/mL) (National Wildlife Health Center)	1 mL IP ^{69,109}	Waterfowl/not commercially available; produced for experimental use in migratory birds ⁶⁹
Calcium EDTA (edetate calcium disodium)	10-40 mg/kg IM, IV q12h × 5-10 days ¹⁶ 25-50 mg/kg IV q12h ⁶⁹	Waterfowl Geese
Deferiprone (Ferriprox, Apotex)	50 mg/kg PO q12h × 30 days ^{69,175}	Chickens/PK; iron chelation; may produce rust-colored urates; supplemental zinc may be indicated; ⁶⁹ an orphan drug in the United States
Magnesium sulfate (Epsom salts)	500-1000 mg/kg PO q24h × 1-3 days ^{16,69}	Waterfowl/cathartic used in lead toxicosis to encourage passage of heavy-metal particles ¹⁶
Melatonin	10 mg/kg in feed ¹²⁸	Chickens/afatoxin exposure; liver and kidney damage greatly reduced in chicks administered aflatoxin and melatonin concurrently for 21 days ¹²⁸
Penicillamine (Cuprimine, Merck)	30-55 mg/kg PO q12h × 7-14 days ⁶⁹ 55 mg/kg PO q12h × 7-14 days ¹⁶	Waterfowl Waterfowl

Continued

TABLE 6-9 Agents Used in the Treatment of Toxicologic Conditions of Backyard Poultry and Waterfowl. (cont'd)

Agent	Dosage	Species/Comments
Pralidoxime mesylate (2-PAM) (Protopam, Wyeth-Ayerst)	10-100 mg/kg IM q24-48h or repeat once after 6 hr ⁶⁹	Waterfowl
	100 mg/kg IM, repeat once after 6 hr ¹⁶	Waterfowl

⁶⁹Many poultry species are considered food-producing animal *species*, and as such, these species are regulated by the U.S. Food and Drug Administration (FDA).¹⁶⁶ Even if the individual animals of any of these species are never used for food, they are still regulated by the FDA. The FDA prohibits the use of certain drugs, with no allowable extra-label drug use, in any food-producing animal species. These prohibited drugs are clearly identified in the tables, and the doses are provided in case they are needed for a similar but non-food-producing animal species (e.g., Attwater's prairie chicken), and listings should in no way be misconstrued as an endorsement of using FDA-prohibited drugs in any food-producing animal species. Please refer to the appropriate tables at the end of this chapter regarding the definitions of prohibited drugs, extra-label drugs, labeled drugs, and drugs needing a Veterinary Feed Directive prior to choosing a drug and dose. Please refer to the Food Animal Residue Avoidance Databank at www.farad.org and other sources listed in Table 6.25 for meat and egg withdrawal times.

TABLE 6-10 Nutritional/Mineral Support Used in Backyard Poultry and Waterfowl.

Nutritional and mineral support are uncommon in poultry fed commercially prepared diets that are formulated for their particular physiologic state. To determine if you have a potential nutrient deficiency, at least 5% of your flock should display deficiency signs.¹³²

Agent	Dosage	Species/Comments
Biotin	150 mg/ton ⁸⁹	Poultry/biotin deficiency
Calcium	—	Recommended dietary levels
	4-8 mg/kg feed (0.4%-0.8%) ¹²⁵	Growing Muscovy ducks
	8 mg/kg feed (0.8%) ¹²⁵	Growing Japanese quail
	8-10 mg/kg feed (0.8%-1%) ¹²⁵	Growing chickens
	18.8-32.5 mg/kg feed (1.88%-3.25%) ¹²⁵	Laying chickens/3.25% recommended for hens that lay eggs daily
	22.5 mg/kg feed (2.25%) ¹²⁵	Laying turkeys
Folic acid	50-100 µg IM ¹³	Poultry chicks/treatment of deficiency; anemia improved in 4 days
	1 mg/kg of feed ⁸⁹	Poultry/folic acid deficiency
Iron dextran	10 mg/kg IM, repeat in 7-10 days pm ^{16,69}	Waterfowl/iron deficiency anemia
Niacin	30 mg/kg of feed ⁸⁹	Chickens/niacin deficiency
	55-70 mg/kg of feed ⁸⁹	Poultry/niacin deficiency

TABLE 6-10 Nutritional/Mineral Support Used in Backyard Poultry and Waterfowl. (cont'd)

Agent	Dosage	Species/Comments
Pantothenic acid	12 mg/kg of feed ⁸⁹	Poultry/pantothenic acid deficiency
	2 mg (calcium pantothenate) + 0.5 mg riboflavin in 50 gal (190 L) water × 2-3 day ⁸⁹	Poultry/pantothenic acid deficiency
Riboflavin	10 mg/kg of feed ⁸⁹	Poultry/riboflavin deficiency
Thiamine	4 mg/kg of feed ⁸⁹	
Vitamin B ₁₂	Up to 20 mcg/g of feed × 1-2 wk	Poultry/vitamin B ₁₂ deficiency
Vitamin C (ascorbic acid)	150 mg/kg PO q24h ⁶⁵	Willow ptarmigan chicks/PD; supplemental daily requirements over 265-mg/kg diet
Vitamin D3	11-30 min of direct sunlight/day ⁶⁹	Chickens/sufficient for endogenous synthesis of vitamin D
Vitamin E/γ-linolenic acid (2%), linoleic acid (71%) (Derm Caps, DVM Pharmaceuticals)	4000 mg linolenic acid/kg feed ¹²⁰	Japanese quail/PD; reduces essential fatty acid deficient hepatic lipidosis
Vitamin K ₁ (phytonadione)	0.1 mg/kg feed ⁷⁷	Turkeys/PD; as effective as 1-2 mg/kg in reducing plasma prothrombin time
Vitamin K ₁ (menadione)	1-4 mg/ton of feed ⁸⁹	Poultry/for vitamin K deficiency, double the dose

TABLE 6-11 Ophthalmologic Agents Used in Backyard Poultry and Waterfowl.^a

Agent	Dosage	Species/Comments
Amphotericin B	125 μg/5 mL sterile water subconjunctival ⁶⁹	Ducks (ornamental)/candidiasis of third eyelid
Amphotericin B ointment (4%) (formulated)	Topical q24h ⁶⁹	Ducks (ornamental)/candidiasis of third eyelid; administered in conjunction with systemic antifungal therapy
Ivermectin	0.005-0.05 mg topical q24h × 10 days ¹⁶¹	Chicken/PD; conjunctival oxyspirurid (nematode) infection; no adverse effects were seen with topical use

^aVariable amounts of skeletal muscle are present in the avian iris, giving birds voluntary control over pupil dilation. In many avian patients, the pupils are best dilated by restraining the animal in a dark room.

TABLE 6-12 Oncologic Agents Used in Backyard Poultry and Waterfowl.^a

Agent	Dosage	Species/Comments
Chlorambucil (Leukeran, GlaxoSmithKline)	1 mg/bird PO 2 ×/wk ¹²⁶	Pekin ducks/lymphocytic leukemia or lymphosarcoma; responded to treatment initially, but was euthanized 1 mo after presentation because of respiratory distress and hemorrhages
Prednisone	1 mg/kg PO q12h ¹²⁶	Ducks/lymphoma; lymphocytic leukemia
Vincristine sulfate	0.5 mg/m ² IV, then 0.75 mg/m ² q7d × 3 treatments ¹²⁶	Ducks/lymphoma; lymphocytic leukemia

^aMany poultry species are considered food-producing animal *species*, and as such, these species are regulated by the U.S. Food and Drug Administration (FDA).¹⁶⁶ Even the individual animals of any of these species are never used for food, they are still regulated by the FDA. The FDA prohibits the use of certain drugs, with no allowable extra-label drug use, in any food-producing animal species. These prohibited drugs are clearly identified in the tables, and the doses are provided in case they are needed for a similar but non-food-producing animal species (e.g., Attwater's prairie chicken), and listings should in no way be misconstrued as an endorsement of using FDA-prohibited drugs in any food-producing animal species. Please refer to the appropriate tables at the end of this chapter regarding the definitions of prohibited drugs, extra-label drugs, labeled drugs, and drugs needing a Veterinary Feed Directive prior to choosing a drug and dose. Please refer to the Food Animal Residue Avoidance Databank at www.farad.org and other sources listed in Table 6.25 for meat and egg withdrawal times.⁵⁴

TABLE 6-13 Euthanasia Agents Used in Backyard Poultry and Waterfowl.^a

Agent	Dosage	Comments
Argon	90% Argon with 2% residual oxygen ^{8,136a}	Chickens/little to no aversion; ^{8,136a} conditionally acceptable method of euthanasia by the American Veterinary Medical Association (AVMA) if used ⁸
Carbon dioxide (CO ₂)	— >40% ^{8,140}	Chickens/renders the bird unconscious prior to death; unconscious motor activity such as flapping of wings may damage tissues for necropsy and may be disconcerting to the observer; ⁸ conditionally acceptable method of euthanasia by AVMA if used properly ⁸ Chickens
Carbon monoxide (CO)	Minimum 6% concentration in a closed container ^{8,140}	Causes rapid unconsciousness; inexpensive; ⁶⁹ conditionally acceptable method of euthanasia by AVMA if used properly ⁸
Inhalant anesthetics (ex., isoflurane, sevoflurane)	Saturated cotton ball in closed container or face mask; ^{130a,140} high concentrations (5% or more) using vaporizer are preferred ⁸	Rapid induction; wing flapping and vocalizing may occur, less tissue damage compared with other methods; ^{88,135} conditionally acceptable by AVMA as a sole method of euthanasia if high concentrations used and safety considerations to personnel followed; ⁸ can also be used to render birds unconscious prior to other methods of euthanasia ^{8,127}
Nitrogen	100% gas exposure ⁸	Conditionally acceptable method of euthanasia by AVMA if used properly

TABLE 6-13 Euthanasia Agents Used in Backyard Poultry and Waterfowl. (cont'd)

Agent	Dosage	Comments
Pentobarbital sodium	0.2-1 mL/kg IV ⁸	Acceptable method by AVMA to give IV either conscious or unconscious (under anesthesia); conditionally acceptable method to give intraosseous or intracoelomically only if unconscious or under anesthesia; unacceptable to administer IM due to the low pH, which causes pain; ^{8,129} birds may react unpredictably with IV administration ⁸
Potassium chloride	1-2 mmol/kg IV ^{8,17}	Conditionally acceptable method by AVMA to give IV only if unconscious or under anesthesia ⁸

^aThe 2013 AVMA Guidelines for Euthanasia state that methods regarded as “Acceptable with Conditions” are equivalent to “Acceptable” methods of euthanasia.⁸ The AVMA acceptable method is administering a pentobarbital euthanasia solution IV in either an awake or unconscious bird. The AVMA conditionally acceptable methods include inhalant anesthetic overdose, argon, nitrogen, CO, CO₂, cervical dislocation, decapitation, KCl, gunshot, and exsanguination as long as the conditions are met.⁸

TABLE 6-14 Miscellaneous Agents Used in Backyard Poultry and Waterfowl.

Agent	Dosage	Species/Comments
9,10 Anthraquinone (Flight Control, Environmental Biocontrol)	12.6 mL/L water, sprayed q7d on dry, grassy areas where geese frequent ⁶⁹	Nuisance Canada geese/deterrent if ingested; birds become nauseated and subsequently avoid the area that contains an ultraviolet dye readily detected by the avian eye
Digoxin	0.0035 mg/kg IV q24h ⁶⁹ 0.0049 mg/kg IV q12h ⁶⁹ 0.01 mg/kg PO q24h × 6 wk ⁶⁹ 0.019 mg/kg IV q12h ⁶⁹	Turkeys Poultry Chickens/ascites syndrome; reduced ascites; no apparent toxicity Pekin ducks
Doxapram	10 mg/kg IV once ¹⁶	Waterfowl
Hemoglobin glutamer-200 (Oxyglobin, OPK Biotech)	— 5 mL/kg IV ⁹⁰ 15 mL/kg IV ⁶⁹	Currently not available in the United States Mallard ducks/PD Chickens/PD; hemoglobin levels fell to near zero by 50 min post-administration
Methocarbamol	32.5 mg/kg PO q12h ⁶⁹ 50 mg/kg IV (slow bolus) ⁶⁹	Swans/capture myopathy Swans/muscle relaxation; capture myopathy; may be given q12h for muscle relaxation
Metoclopramide	2 mg/kg IM, IV q8-12h ⁶⁹	Waterfowl/crop stasis; ileus
Nicarbazin (OvoControl, Innolytics)	Formulated pellets provided at baiting stations	Waterfowl/egg-hatch control; inhibits sperm receptor sites on the vitelline membrane to prevent fertilization of eggs; check federal and state permit requirements prior to use
Polysulfated glycosaminoglycan (PSGAG) (Adequan, Luitpold)	5 mg/kg IM q7d ⁶⁹ 10 mg/kg IM, intraarticular q7d × 3 mo ⁶⁹	Pekin ducks/degenerative joint disease Pheasants/noninfectious or traumatic joint dysfunction; 250 mg/mL for intraarticular use; 500 mg/mL for IM use

TABLE 6-15 Hematologic and Serum Biochemical Values of Selected Galliformes.

Measurement	Chicken (<i>Gallus gallus</i>) ⁷⁸	Quail (<i>Coturnix</i> spp.) ^{a,78,142}	Ring-Necked Pheasant (<i>Phasianus colchicus</i>) ^{141,181}	Turkey (<i>Meleagris gallopavo</i>) ⁷⁸
Hematology				
PCV (%)	23-55	30-45	—	30-46
RBC (10 ⁶ /μL)	1.3-4.5	4-5.2	1.2-3.5	1.7-3.7
Hgb (g/dL)	7-18.6	10.7-14.3	8-11.2	8.8-13.4
MCV (fL)	100-139	60-100	—	112-168
MCH (pg)	25-48	23-35	—	32-49.3
MCHC (g/dL)	20-34	28-39	—	23-35
WBC (10 ³ /μL)	9-32	12.5-24.6	18-39	16-25.5
Heterophils (%)	15-50	25-50	12-30	29-52
Lymphocytes (%)	29-84	50-70	63-83	35-48
Monocytes (%)	0.1-7	0.5-3.8	2-9	3-10
Eosinophils (%)	0-16	0-15	0	0-5
Basophils (%)	0-8	0-1.5	0-3	1-9
H:L ratio	0.2-1.7	0.4-1	0.14-0.48	0.6-1.5
Chemistries				
ALT (U/L)	—	6.5-9.6	—	—
AST (U/L)	—	402-422	—	—
Calcium (mg/dL)	13.2-23.7	—	—	11.7-38.7
Cholesterol (mg/dL)	86-211	—	—	81-129
Creatinine (mg/dL)	0.9-1.8	0.01-0.08	—	0.8-0.9
GGT (U/L)	—	1.7-1.9	—	—
Glucose (mg/dL)	227-300	259-312	—	275-425
Phosphorus (mg/dL)	6.2-7.9	—	—	5.4-7.1
Potassium (mEq/L)	3-7.3	1.4	—	6-6.4
Protein, total (g/dL)	3.3-5.5	3.4-3.6	4.5-5.1	4.9-7.6
Albumin (g/dL)	1.3-2.8	1.3-1.5	2.6-2.7	3-5.9
Globulin (g/dL)	1.5-4.1	—	1.9-2.1	1.7-1.9
Sodium (mEq/L)	131-171	180	—	149-155
Uric acid (mg/dL)	2.5-8.1	5.4-5.5	5.6-6	3.4-5.2

^aExcept for phosphorus, protein (total), and sodium, biochemistry values are reported in 16-wk-old Japanese quail.

TABLE 6-16 Hematologic and Serum Biochemical Values of Selected Anseriformes (Waterfowl).

Measurement	Canada Goose (<i>Branta canadensis</i>) ^{24,78}	Mallard Duck (<i>Anas platyrhynchos</i>) ¹⁸¹	Wood Duck (<i>Aix sponsa</i>) ²⁴
Hematology			
PCV (%)	38-58	39-49	46 ± 3
RBC (10 ⁶ /μL)	1.6-2.7	2-3.8	2.8 ± 0.2
Hgb (g/dL)	12.7-19.1	7.4-15.6	15 ± 1
MCV (fL)	145-210	148-200	164 ± 14
MCH (pg)	53.7-70	—	—
MCHC (g/dL)	28-32	29-32	33 ± 4
WBC (10 ³ /μL)	13-21.8	23.4-24.8	25.6 ± 5.7
Heterophils (%)	39	26-38	—
Lymphocytes (%)	46	54-63	—
Monocytes (%)	6	1-4	—
Eosinophils (%)	2	0.2-0.4	—
Basophils (%)	7	0-4	—
H:L ratio	0.5-0.9	0.4-2	0.4-0.7
Chemistries			
ALP (U/L)	72 ± 43	—	160-780
ALT (U/L)	43 ± 11	—	19-48
AST (U/L)	75 ± 17	—	45-123
Bile acid (μmol/L)			
RIA	—	—	22-60
Colorimetric	—	—	—
Calcium (mg/dL)	10.2 ± 0.7	—	7.6-10.4
Chloride (mEq/L)	105 ± 4	—	101-113
Cholesterol (mg/dL)	172 ± 28	—	—
CK (U/L)	—	—	110-480
Creatinine (mg/dL)	0.8 ± 0.3	—	0.3-0.4
GGT (U/L)	2 ± 3	—	0-2.9
Glucose (mg/dL)	210 ± 31	—	232-269
LDH (U/L)	301 ± 80	—	30-205
Phosphorus (mg/dL)	2.8 ± 0.9	—	1.8-4.1
Potassium (mEq/L)	3.4 ± 0.6	—	3.9-4.7
Protein, total (g/dL)	4.8 ± 0.7	—	2.1-3.3
Albumin (g/dL)	2.1 ± 0.2	—	1.5-2.1
Globulin (g/dL)	2.8 ± 0.6	—	0.6-1.2
A:G ratio	0.76 ± 0.13	—	1.5-3.6
Sodium (mEq/L)	142 ± 4	—	141-149
Uric acid (mg/dL)	8.3 ± 2.3	—	2.5-12.9

TABLE 6-17 Biologic and Physiologic Values of Selected Galliformes.^{67,68,78}

Species	Incubation Period (days)	Fledgling Age (days)	Weaning Age (days)		Sexual Maturity	Lifespan in Captivity (Maximum) (years)	Body Weight (g)
			Parent-Raised	Hand-Reared			
Galliformes							
Bobwhite quail	—	—	Precocial	—	—	6	—
Peafowl	—	12	Precocial	—	—	20	—
Pheasant, ring-necked	22-24	—	Precocial	—	1 yr	10-18	1150

TABLE 6-18 Biologic and Physiologic Values of Selected Anseriformes (Waterfowl) Species.⁶⁹

Species	Clutch Size	Incubation Period (days)	Fledgling (days)	Sexual Maturity (yr)	Longevity (yr)	Weight (kg)		Respiratory Rate (breaths per minute)	Heart Rate (beats per minute)
						Male	Female		
Bar-headed goose	4-6	27	—	2	15-20	2-3	2-3	13-40	80-150
Canada goose	4-10	25-30	40-73	—	—	—	—	—	—
Common eider	3-6	25-30	65-75	1	10-15	2.25	2.12	30-95	180-230
European goldeneye	9-11	27-32	—	1	10-15	0.99-1.16	0.7-0.8	30-95	180-230
European wigeon	7-11	23-25	—	1	10-15	0.7	0.64	30-95	180-230
Hawaiian goose	3-5	29	—	2	15-20	2.2	1.9	13-40	80-150
Mallard ^d	8-12	23-29	42-60	1	10-15	1.26	1.1	30-95	180-230
Mandarin duck	9-12	28-30	—	1	10-15	0.44-0.55	0.44-0.55	30-95	180-230
Muscovy duck	8-15	35	—	1	10-15	2-4	1.1-1.5	30-95	180-230
Mute swan	4-8	35-40	—	5	25-30	12.2	8.9	13-40	80-150
Pink-footed goose	3-5	26-27	—	2	15-20	2.6	2.35	13-40	80-150
Red-breasted goose	3-7	23-25	—	2	15-20	1.3-1.6	1.15	13-40	80-150
Tufted duck	6-14	23-25	—	1	10-15	1.1	1.05	30-95	180-230

^dExcept for the Muscovy, all breeds of domestic duck are descended from the mallard (*Anas platyrhynchos*).

TABLE 6-19 Selected Nutritional Recommendations for Wild Bird Rehabilitation.^{6,9}**Waterfowl**

- Offer domestic waterfowl, mallard ducks, and Canada geese cracked corn, scratch grains, leafy greens, and nonmedicated waterfowl or poultry diet.
- Swans, particularly trumpeter swans, may refuse to eat for 3 or more days; place the swan in an isolated area, with a slurry of food and fresh greens; do not disturb unless absolutely necessary.
- Offer water in a dish or bucket deep enough to allow the bird to submerge its entire neck before its bill touches the bottom of the container.
- Do not use galvanized metal containers because the zinc may leach into food and water.
- For ducklings, goslings, and cygnets, offer nonmedicated waterfowl or chick starter in shallow dishes and scattered on the floor of the enclosure.
- Tiny pieces of bright fruit, like strawberries, or small, live mealworms may stimulate self-feeding in a hospital setting.

TABLE 6-20 Veterinary Feed Directive (VFD) Order Information.^{6,7}

- Note: A VFD is used for drugs given in the food or water of food animals that are given *exactly* per label instructions in regard to dose, concentration, frequency, duration, and so forth and is *not* for extra-label drug use. A VFD is valid up to 6 mo.
- For your convenience, a Veterinary Feed Directive Order fillable form and detailed information can be found on the American Veterinary Medical Association's Web site at www.avma.org/KB/Resources/Pages/VFDInstructions.aspx.⁷
- According to the U.S. Food and Drug Administration (FDA), a valid VFD Order is needed for any feed additive given to a food animal and must be associated with a Valid Client Patient Relationship (VCP), and it must contain the following:⁶
 - Veterinarian information (name, address, phone) with signature
 - Client information (name, address, phone)
 - Name of the drug, drug concentration, indications for use, and duration of use
 - Dose, withdrawal time
 - Where animals are located (premises) and type (species) and number of animals
 - Date issued, expiration date, indication for use
 - Specified verbiage: "Use of feed containing this VFD drug in a manner other than as directed on the labeling (extra-label use) is not permitted"

TABLE 6-21 Partial List of Antimicrobials Transitioning From Over-the-Counter (OTC) to Veterinary Feed Directive (VFD) Status (as of January 2016).^{16,9}

- Chlortetracycline (CTC)
- Chlortetracycline/sulfamethazine
- Chlortetracycline/sulfamethazine/penicillin
- Hygromycin B
- Lincomycin
- Oxytetracycline
- Oxytetracycline/neomycin
- Penicillin/sulfadimethoxine/ormetoprim
- Tylosin
- Tylosin/sulfamethazine
- Virginiamycin

Note: Apramycin, erythromycin, neomycin (alone), oleandomycin, sulfamerazine, and sulfaquinoxaline are also approved for use in feed and are expected to transition to VFD status but are not marketed at this time. If they return to the market after January 1, 2017, they will require a VFD.

TABLE 6-22 Serologic Tests for Poultry.^{23,170}

Test	Test Type ^a	Sample Needed
Avian adenovirus	FA	Tissues
Avian encephalomyelitis	ELISA	Serum
Avian encephalomyelitis	PCR	Tissues
Avian hemorrhagic enteritis	ELISA	Serum
Avian influenza	AGID	Serum
Avian influenza	AGID (egg yolk)	Egg
Avian influenza	ELISA	Serum
Avian influenza	FA	Serum
Avian influenza	PCR	Tissues
Avian influenza	H5 and H7 Typing	Nasal swab
Avian influenza screen	PCR	Tissues, nasal swab, cloacal swab
Avian pneumovirus	PCR	Tissues, tracheal swab, cloacal swab
Avian pneumovirus—type C	PCR	Liver, spleen, heart, kidney, nasal swab
Avian reovirus	ELISA	Serum
<i>Bordetella avium</i>	ELISA	Serum
Chicken profile testing	—	Serum
<i>Chlamydia psittaci</i>	Culture	Affected tissues (heart, liver, spleen, feces)
<i>Chlamydia psittaci</i>	FA	Affected tissues (heart, liver, spleen)
<i>Chlamydia</i> spp.	PCR	Affected tissues
Day-old monitoring	Pathology	1-day-old poultry
Eastern equine encephalitis (EEE) Virus	RT-PCR	Brain tissues, blood
<i>Erysipelothrix</i> spp.	Culture	Affected tissues (kidney, heart, liver, spleen, lung, joint swab, skin)
Exotic Newcastle disease	PCR	Tissues, nasal swab, cloacal swab
Fungal culture	Culture	Affected tissues, poultry litter
Infectious bronchitis virus	ELISA	Serum
Infectious bronchitis virus	PCR	Lung, trachea, kidney swab
Infectious bursal disease virus	ELISA	Serum
Infectious bursal disease virus	PCR	Spleen, bursa
Infectious laryngotracheitis virus	PCR	Trachea, lung
Influenza virus—type A	AGID	Serum
Influenza virus—type A	FA	Affected tissues
Influenza virus—type A screen	PCR	Swabs, tissues
Lead	—	Whole blood
<i>Mycoplasma gallisepticum</i>	ELISA	Serum
<i>Mycoplasma gallisepticum</i>	HI	Serum
<i>Mycoplasma gallisepticum</i>	PCR	Tissues (swab)
<i>Mycoplasma gallisepticum</i>	SPT	Serum
<i>Mycoplasma iowae</i>	PCR	Tissues
<i>Mycoplasma meleagridis</i>	ELISA	Serum

Continued

TABLE 6-22 Serologic Tests for Poultry. (cont'd)

Test	Test Type	Sample Needed
<i>Mycoplasma meleagridis</i>	HI	Serum
<i>Mycoplasma meleagridis</i>	PCR	Tissues
<i>Mycoplasma meleagridis</i>	SPT	Serum
<i>Mycoplasma</i> spp.	Culture	Affected tissues (lung, tracheal wash, nasal swab, joint swab, air sac)
<i>Mycoplasma</i> spp.	PCR	Choanal swab
<i>Mycoplasma synoviae</i>	ELISA	Serum
<i>Mycoplasma synoviae</i>	HI	Serum
<i>Mycoplasma synoviae</i>	PCR	Tissue
Mycotoxin screen (aflatoxin B ₁ , zearalenone, ochratoxin D, vomitoxin)	—	Stomach contents, feed
Newcastle disease virus (paramyxovirus—type 1)	HI	Serum
Newcastle disease virus screen	PCR	Tissues, swabs
<i>Ornithobacterium rhinotracheale</i>	Culture	Affected tissues (lung, tracheal wash, nasal swab, air sac swab)
<i>Ornithobacterium rhinotracheale</i>	SPT	Serum
Paramyxovirus—type 2	HI	Serum
Paramyxovirus—type 3	HI	Serum
Paramyxovirus—type 7	HI	Serum
<i>Pasteurella multocida</i>	ELISA	Serum
<i>Salmonella enteritidis</i> —phage typing ^b	—	—
<i>Salmonella enteritidis</i> —rapid test	Culture	Pool 50 eggs
<i>Salmonella enteritidis</i> —serotyping confirmation ^b	—	—
<i>Salmonella enteritidis</i> —egg culture BAM method ^b	—	Egg
<i>Salmonella pullorum</i>	MAT	Serum
<i>Salmonella pullorum</i>	SPT	Serum
<i>Salmonella pullorum</i>	STT	Serum
<i>Salmonella pullorum</i> or <i>Salmonella enteritidis</i>	Culture	Tissues
<i>Salmonella</i> spp.	Culture	Affected tissues, feces, feed, water, swabs
<i>Salmonella</i> spp.	Environmental culture	Environmental
<i>Salmonella typhimurium</i>	MAT	Serum
<i>Salmonella typhimurium</i>	STT	Serum
Turkey profile	—	Serum
West Nile virus	PCR	Brain, blood

^aAGID, Agar gel immunodiffusion; ELISA, enzyme linked immunosorbent assay; FA, fluorescent antibody; FDA, Food and Drug Administration; HI, hemagglutinin inhibition; MAT, modified agglutination test; PCR, polymerase chain reaction; RT-PCR, reverse transcriptase polymerase chain reaction; SPT, skin puncture test; STT, standard tube test.

^bFollowing a positive test for *Salmonella enteritidis*, state and federal authorities are contacted, and additional testing will be performed by those agencies to further an epidemiologic investigation.

TABLE 6-23 Definitions of the Various Designations of Drugs in Food-Producing Animals According to the U.S. Food and Drug Administration (FDA) as They Pertain to Poultry.^{5,166}

Designation	Definition	Example
Prohibited, group 1	Drugs with no allowable extra-label uses in any food-producing animal species ^{166,168}	Chloramphenicol, clenbuterol, diethylstilbestrol (DES), fluoroquinolone-class antibiotics, glycopeptides (all agents, including vancomycin), medicated feeds, nitroimidazoles (all agents, including dimetridazole, ipronidazole, metronidazole, and others), nitrofurans (all agents, including furazolidone, nitrofurazone, and others)
Prohibited, group 2	Drugs with restricted extra-label uses in food-producing animal species ¹⁶⁶	Adamantane and neuraminidase inhibitors (in all poultry, including ducks), cephalosporin-class of antibiotics except cephapirin (in all classes of chickens and turkeys), gentian violet (prohibited from use in food or feed of food-producing animals), and indexed drugs (some exceptions for minor use species); extra-label drug use (ELDU) restrictions apply to all production classes of major food animal species (no ELDU for purpose of disease prevention; no ELDU that involves unapproved dose, treatment duration, frequency, or administration route; and agent must be approved for that species and production class); ELDU restrictions <i>do not apply</i> to minor-use food animal species
Extra-label drug use (ELDU)		<p>Use in another species: trimethoprim sulfamethoxazole directly orally to a duck</p> <p>Use for a different indication: erythromycin administered as per label instructions but for pododermatitis rather than chronic respiratory disease</p> <p>Use at a different dose or frequency: administering spectinomycin for more than the first 3 days of life</p> <p>Use via a different route of administration: erythromycin directly orally, not in food or drinking water</p> <p>Contact www.farad.org for information regarding potential meat and egg withdrawal</p>
Labeled drug	Used exactly as written on the label, including the species, duration, dose, concentration, frequency, route, and indication	Erythromycin (erythromycin thiocyanate, Gallimycin, Cross VetPharm Group Ltd.): 185 g/ton of feed, to aid in the prevention and reduction of lesions and in lowering severity of chronic respiratory disease; feed for 5 to 8 days; do not use in birds producing eggs for food purposes; withdraw 48 hr before slaughter

TABLE 6-24 Water and Feed Consumption Rates for Backyard Poultry.

Estimated water consumption rates per 100 birds based on age and use. Estimated feed consumption rates for chickens based on weight of food eaten per day expressed as a percentage of body weight.¹⁵⁸

Use (Age)	Weight (kg)	Water per 100 birds (L)	Feed Expressed as %BW
Hens (non-laying)	—	19	—
Hens (laying)	—	19-28	—
Chickens (4 wk)	—	7.6	—
Chickens (8 wk)	—	15.5	—
Chickens (12 wk)	—	21	—
—	0.23	—	14
—	0.45	—	11.4
—	0.68	—	9.7
—	1.59	—	6.7
—	2.5	—	5.0

TABLE 6-25 Sources of Information on Meat and Egg Withdrawal for Backyard Poultry and Waterfowl.

These sources of information are provided rather than quoting meat and egg withdrawal times because of frequently changing regulations. The status of any medication should be checked prior to administration.⁵⁴

Source	Comments
www.farad.org ⁵⁴	Provides information on labeled drug meat and egg withdrawal times as well as an interactive section (VetGram) to ask about estimated meat and egg withdrawal times on extra-label drugs
www.animaldrugsatfda.fda.gov/adafda/views/#/home/previewsearch ¹⁶⁵	Food and Drug Administration website listing all animal drug products approved for safety and effectiveness (a.k.a., the “Green Book”); updated monthly
“Pharmacokinetics of Veterinary Drugs in Laying Hens and Residues in Eggs; a Review of the Literature” ⁵⁸	Extensive review article on meat and egg withdrawal for many labeled and extra-labeled drugs
<i>Poultry Medications Formulary</i> ; www.poultrymeds.cvpSERVICE.com/catindex/main ¹³¹	A continually updated resource on meat and egg withdrawal times for labeled drugs

TABLE 6-26 Values Reported for Selected Ophthalmic Diagnostic Tests in Avian Species.

Species	Intraocular Pressure (mmHg) by Rebound Tonometry	Phenol Red Thread Test (mm/15 sec ± STD)
Helmeted guinea fowl, 15-40 mo old ^{136b}	9.1 ± 0.9	-16.5 ± 1.3
Chicken, 3 wk old ^{134b}	17.5 ± 0.1	

TABLE 6-27 Selected Vaccines Used in Backyard Poultry.

Disease	Vaccine	Route ^a	Age Administered	Comments
Avian encephalomyelitis	Attenuated	DW	8 wk	Chickens/vaccinate layer/breeder flocks to prevent vertical transmission; may be given in DW up to 4 wk prior to start of production ^{130b}
	Attenuated	WW	9-15 wk	Chickens/vaccinate breeders to prevent vertical transmission ^{1b,4b,130b}
Coccidiosis	Live attenuated	PO	1 day+	Chickens, turkeys/controversial results; to use properly, must allow chick access to its own feces to develop cell-mediated immunity by re-exposure to the attenuated strain; for the same reason, do not concurrently treat with anticoccidial drugs; mainly used in breeders or heavily infected flocks ^{4b,56b,130b}
Fowl cholera	Live attenuated	WW, PO	6 wk	Chickens/not typically given to backyard poultry ^{4b,30b}
Fowl cholera bacterin		SC	8 and 12 wk	Chickens/killed preparation; may require 2 injections; not typically used in backyard flocks ^{130b}
Fowl pox	Live vaccine of chick embryo origin	WW	> 4 wk	Chickens/used in backyard flocks if there has been a previous problem with this disease; if given <6 wk of age, will not ensure lasting immunity, so repeat at 12-16 wk of age; ^{162b} not typically given to backyard flocks unless there is a past history of the disease; control mosquitos and reduce stress with good management practices ^{130b}
			2-3 mo	Turkeys/WW vaccine can cause vaccine reaction on head, so use "thigh-stick" route ^{4b}
	Tissue culture origin	WW	1 day+	Chickens/can be used in chicks as young as 1 day of age ^{130b}
	Pigeon pox	WW	—	Chickens/mild vaccine that can be used at any age ^{130b}
Hemorrhagic enteritis	Live attenuated	—	4-5 wk	Turkeys/reduces clinical signs of disease ^{4b,130b}
Infectious laryngotracheitis		—	6 wk	Chickens/do not develop permanent immunity until at least 6 wk of age; not typically given to backyard flocks unless there is a past history of the disease ^{130a}

Continued

TABLE 6-27 Selected Vaccines Used in Backyard Poultry. (cont'd)

Disease	Vaccine	Route	Age Administered	Comments
Marek's disease	HVT ^b serotype 3	SC, OV	1 day or in ovo	Chickens/typically given at hatchery; most common Marek's vaccine used in backyard flocks ^{130b}
	Serotype 2	—	1 day	Chickens/naturally avirulent isolates ^{130b}
	Rispens	—	1 day	Chickens/nononcogenic strains of serotype ^{130b}
Newcastle's disease	Type B	IN, DW, or spray	1 day, 14 days, and 6 wk	Chickens/usually given in combination with IBV vaccine; common to monitor response to vaccine by HI or ELISA testing; not typically given to backyard flocks ^{130b}
	Type B	IN, DW, or spray	3 wk	Turkeys/followed by LaSota strain vaccine at 8 wk ^{130b}
	LaSota	IN, DW, or spray	16-18 wk, q60d during production	Laying chickens/usually administered as a combination vaccine with IBV; can develop upper respiratory vaccine reaction; not typically given to backyard flocks ^{130b}
Newcastle disease and infectious bronchitis combination		DW, IO, IN	10, 35, and 84 days	Chickens/not typically given to backyard flocks due to varying strains of IBV and morbidity from live IBV vaccine; in layer/breeder flocks, repeat at 3-mo intervals ^{130b}

^aDW, Drinking water; IN, intranasal; IO, intraocular; OV, in ovo; PO, per os; SC, subcutaneous; WW, wing web (chickens).

^bHVT, Turkey herpesvirus vaccine.

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Chapter 7 Sugar Gliders

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TABLE 7-1 Antimicrobial and Antifungal Agents Used in Sugar Gliders.

Agent	Dosage	Comments
Amikacin sulfate	3 mg/kg IM, SC q12h ¹⁹ 10 mg/kg IM, SC q12h × 5 days ²¹	Severe Gram-negative infections
Amoxicillin	30 mg/kg PO, SC q12-24h ^{18,19,21}	
Amoxicillin/clavulanic acid	12.5 mg/kg PO, SC divided q12h ^{18,19,21}	
Cefovecin sodium (Convenia, Zoetis)	—	Not recommended due to high interspecies variability in PD
Cephalexin	30 mg/kg PO, SC divided q12h ^{19,21,24}	
Chloramphenicol	50 mg/kg PO q12h ¹⁸	
Ciprofloxacin	10 mg/kg PO q12h ¹⁹	
Clindamycin	5.5-10 mg/kg PO q12h ¹⁸	
Enrofloxacin	2.5-5 mg/kg PO, SC IM q12-24h ²¹ 5 mg/kg PO, SC, IM q12h ²⁵	Tissue necrosis may occur when administered parenterally; dilute for SC injection
Gentamicin	1.5-2.5 mg/kg SC, IM q12h ^{18,21} 2 mg/kg SC, IM divided q12-24h ¹⁹	Not recommend due to nephrotoxicity; use amikacin instead
Griseofulvin	20 mg/kg PO q24h × 30-60 days ²¹	Dermatophytes; fungistatic
Itraconazole	5-10 mg/kg PO q12-24h ¹⁹ 5-10 mg/kg PO q24h ¹⁸	
Lincomycin	30 mg/kg PO, SC, IM q24h ^{18,21}	Dose can be divided q12h
Marbofloxacin	2-5 mg/kg PO, SC, IM q24h ¹⁸	
Metronidazole	25 mg/kg PO q12-24h × 7-10 days ^{19,21} 80 mg/kg PO q24h ¹⁸	CNS toxicity possible at high doses or if underlying hepatic disorder; compound at 5 mg/mL in tutti-frutti flavor ³
Nystatin	2000 U/kg PO q12h ³ 5000 U/kg PO q8h ²¹	Candidiasis
Penicillin	22,000-25,000 U/kg SC, IM q12-24h ^{18,19,21}	
Trimethoprim/sulfamethoxazole	10-20 mg/kg PO q12-24h ²¹ 15 mg/kg PO q12h ¹⁹ 50 mg/kg PO q24h ²⁵	

TABLE 7-2 Antiparasitic Agents Used in Sugar Gliders.

Agent	Dosage	Comments
Carbaryl powder (5%)	Topical ^{19,21}	Ectoparasites; use sparingly; can be used in nest boxes
Fenbendazole	20-50 mg/kg PO q24h × 3 days, repeat in 14 days ^{18,19,21}	Roundworms, hookworms, whipworms; cestodes; lower end of dosage range may be preferable

Continued

TABLE 7-2 Antiparasitic Agents Used in Sugar Gliders. (cont'd)

Agent	Dosage	Comments
Ivermectin	0.2 mg/kg SC, repeat in 10-14 days ^{19,21} 0.2-0.4 mg/kg PO, SC, repeat at 14 and 28 days ¹⁸	Roundworms, hookworms, whipworms; mites Mites, nematodes
Levamisole	10 mg/kg PO ²¹	
Metronidazole	25 mg/kg PO q12h ¹⁹ 25 mg/kg/day PO, repeat in 14 days ⁷ 80 mg/kg PO q24h ¹⁸	Intestinal protozoa; compound at 5 mg/mL in tutti-frutti flavor ³ CNS toxicity possible at high doses or if underlying hepatic disorder
Piperazine	50 mg/kg PO q24h ¹⁸ 100 mg/kg PO ⁷	GI nematodes; safe in pregnant animals
Praziquantel	5-10 mg/kg PO, SC, repeat in 10-14 days ²³	Cestodes, trematodes
Pyrethrin powder	Topical ⁷	Ectoparasites; use products safe for kittens
Selamectin (Revolution, Zoetis)	6-18 mg/kg topically, repeat in 30 days ^{3,19}	Ectoparasites

TABLE 7-3 Chemical Restraint/Anesthetic Agents Used in Sugar Gliders.

Agent	Dosage	Comments
Acepromazine	—	See butorphanol, ketamine for combinations
Atropine	0.01-0.02 mg/kg SC, IM ^{18,19} 0.02-0.04 mg/kg SC, IM, IV ⁷	
Bupivacaine	1-2 mg/kg (local infiltrate) ¹⁸	Local anesthesia
Buprenorphine	—	Buprenorphine combination follows
Buprenorphine (Bu)/midazolam (Mi)/meloxicam (Mel)	(Bu) 0.01 mg/kg + (Mi) 0.1 mg/kg + (Mel) 0.2 mg/kg IM ²²	Give preemptively for the reduction of postsurgical self-mutilation
Butorphanol (Torbugesic, Fort Dodge)	—	Butorphanol combination follows
Butorphanol (B) + acepromazine (A)	(B) 1.7 mg/kg + (A) 1.7 mg/kg PO ⁵	Postoperative sedation and analgesia to prevent self-trauma to incision site
Dexmedetomidine (Dexdomitor, Pfizer)	—	α -2 agonist that is the active optical enantiomer of racemic compound medetomidine; ½ the dose of medetomidine should be administered; limited data on safety or efficacy available
Diazepam	0.5-2 mg/kg PO, IM, SC ^{7,19}	Sedative, anticonvulsant; avoid parenteral injection if possible (use midazolam instead)

TABLE 7-3 Chemical Restraint/Anesthetic Agents Used in Sugar Gliders. (cont'd)

Agent	Dosage	Comments
Glycopyrrolate	0.01-0.02 mg/kg SC, IM, IV ¹⁹	Controls salivation during sedation
Isoflurane	5% induction; 1%-3% maintenance ^{19,21}	Anesthetic of choice
Ketamine	— 20 mg/kg IM ¹⁹ 30-50 mg/kg IM ²¹	Ketamine combinations follow
Ketamine (K)/ acepromazine (A)	(K) 10 mg/kg + (A) 1 mg/kg SC ¹⁹ (K) 30 mg/kg + (A) 2 mg/kg SC, IM ²¹	Postoperative sedation and analgesia to prevent self-trauma to incision site For immobilization
Ketamine (K)/ medetomidine (Me)	(K) 2-3 mg/kg + (Me) 0.05-0.1 mg/kg SC, IM ^{19,21}	For immobilization (see medetomidine)
Ketamine (K)/ midazolam (Mi)	(K) 10-20 mg/kg + (Mi) 0.35-0.5 mg/kg SC, IM ^{19,21}	
Ketamine (K)/ Xylazine (X)	(K) 10-25 mg/kg + (X) 5 mg/kg SC, IM ²¹	
Lidocaine	< 4 mg/kg local infiltration or topical ⁸	Local anesthesia; dilute to avoid toxicity from accidental overdosing
Medetomidine	—	No longer commercially available, but can be obtained through various compounding services; see dexmedetomidine; see ketamine for combination
Midazolam	— 0.1-0.5 mg/kg IM, SC, intranasal ^{5,18,19,21,26}	See buprenorphine, ketamine for combinations Anxiolytic; anticonvulsant, preanesthetic; sedation
Sevoflurane	1%-5% to effect ¹⁹	Anesthesia
Tiletamine/zolazepam	—	Do not use; has caused neurological syndromes and death in squirrel gliders at 10 mg/kg ¹⁹
Xylazine	—	See ketamine for combination
Yohimbine	0.2 mg/kg SC, IM ¹⁹	Reversal of xylazine

TABLE 7-4 Analgesic Agents Used in Sugar Gliders.

Agent	Dosage	Comments
Buprenorphine	0.01-0.03 mg/kg PO, SC, IM q8-12h ^{4,19} 0.05 mg/kg IM ¹⁵	
Butorphanol	0.1-0.5 mg/kg SC, IM q6-8h ^{19,21}	
Meloxicam	0.2 mg/kg PO, SC q24h ¹⁹ 0.1-0.2 mg/kg PO, SC q12-24h ⁷ 0.5 mg/kg PO q24h ¹⁵	Nonsteroidal antiinflammatory

TABLE 7-5 Miscellaneous Agents Used in Sugar Gliders.

Agent	Dosage	Comments
Calcitonin	50-100 U/kg ²¹ SC	Nutritional osteodystrophy; ensure serum calcium levels are normal prior to use; salmon origin
Calcium gluconate	150 mg/kg PO q24h ^{4,21}	Nutritional osteodystrophy; calcium deficiency
Calcium gluconate	100 mg/kg SC q12h × 3-5 days; dilute in saline to 10 mg/mL ⁴	Nutritional osteodystrophy; calcium deficiency
Cisapride	0.25 mg/kg q8-24h PO, SC ^{4,21}	Gastrointestinal prokinetic
Dexamethasone	0.1-0.6 mg/kg SC, IM, IV ¹⁹ 0.2 mg/kg SC, IM, IV q12-24h ²¹ 0.5-2 mg/kg SC, IM, IV ¹²	Antiinflammatory; allergies Shock
Doxapram	2 mg/kg SC, IM, IV ¹⁹	Respiratory stimulant; can also place under tongue
Enalapril	0.22-0.44 mg/kg PO q24h ^{16,19,21} 0.5 mg/kg PO q24h ¹⁸	Vasodilator for the treatment of heart failure and hypertension; can compound at 1 mg/mL in tutti-frutti flavor ¹⁶
Epinephrine	0.003 mg/kg IV ^{16,19}	Stimulates heart; antagonizes effects of histamine; raises blood sugar
Fluoxetine (Prozac, Eli Lilly)	1-5 mg/kg PO q8h ¹⁴ 2-5 mg/kg PO q12h ¹³	Self-mutilation; use liquid form
Furosemide	1-4 mg/kg PO, SC, IM q8h ¹⁸ 1-5 mg/kg PO, SC, IM q6-12h ^{4,7,19}	Diuretic
L-carnitine	100 mg/kg PO q12h ²¹	
Maropitant citrate (Cerenia, Zoetis)	0.2 mg/kg SC q24h ⁵	Dilute 1:20 with sterile water; cannot store diluted drug
Metoclopramide	0.05-0.1 mg/kg PO, SC, IM q6-12h prn ²¹	Gastrointestinal prokinetic
Pimobendan	0.3-0.5 mg/kg PO q12h ¹⁸	Positive inotropic and vasodilatory effect; administration with food may reduce bioavailability
Prednisolone	0.1-0.2 mg/kg PO, SC, IM q24h ^{18,19,21} 0.2 mg/kg PO q12h ¹⁷	Antiinflammatory
Vitamin A	500-5000 U/kg IM ¹⁹	
Vitamin B complex	0.01-0.2 mL/kg SC, IM ^{19,21} 10 U/kg PO, Sca ³	Use small animal formulation; dilute; stings on injection Neurological conditions
Vitamin E	10 U/kg SC ³ 25-100 U/animal/day ²¹	
Vitamin K	2 mg/kg SC q24-72h ¹⁹	

TABLE 7-6 Hematologic and Serum Biochemical Values of Sugar Gliders.^a

Measurement	<i>Sugar Gliders: A Complete Veterinary Care Guide^{3,b}</i>	<i>International Species Information System⁸</i>	<i>Merck Veterinary Manual¹</i>
Hematology			
PCV (%)	51-54 (62)	43 ± 4 (24)	45-53
RBC (10 ⁶ /μL)	8.31-8.83 (53)	7.8 ± 0.9 (20)	5.1-7.2
Hgb (g/dL)	15.8-16.9 (53)	15.4 ± 1.6 (21)	13-15
MCH (pg)	18.8-19.4 (53)	19.9 ± 1.3 (20)	18.2-20.6
MCHC (g/dL)	30.6-31 (53)	35.1 ± 2 (21)	30-33
MCV (fL)	60-68 (54)	56.8 ± 5.4 (20)	—
WBC (10 ³ /μL)	5.49-9.31 (62)	7.7 ± 5.5 (23)	5-12.2
Neutrophils (10 ³ /μL)	1.46-2.2 (61)	1.2 ± 1 (23)	1.5-3
Lymphocytes (10 ³ /μL)	3.69-7.16 (62)	6.2 ± 5.1 (23)	2.8-9.2
Monocytes (10 ³ /μL)	0.11-0.17 (45)	0.19 ± 0.17 (18)	0.06-0.2
Eosinophils (10 ³ /μL)	0.09-0.28 (10)	0.18 ± 0.24 (16)	0.02-0.14
Basophils (10 ³ /μL)	0.03-0.06 (8)	0.04 (1)	0
NRBC/100 WBC	—	2 ± 1 (7)	—
Platelets (10 ³ /μL)	292-400 (53)	728 ± 176 (3)	—
Chemistries			
ALP (U/L)	89-115 (75)	231 ± 93 (7)	—
ALT (U/L)	97-137 (81)	67 ± 38 (16)	50-106
AST (U/L)	54-100 (38)	70 ± 65 (17)	46-179
Bilirubin, total (mg/dL)	0.12-0.7 (72)	0.3 ± 0.2 (15)	—
Calcium (mg/dL)	8.5-8.9 (97)	7.4 ± 2.9 (7)	6.9-8.4
Chloride (mEq/L)	106-109 (94)	105 ± 3 (5)	—
Cholesterol (mg/dL)	112-124 (78)	159 ± 49 (6)	—
CPK (U/L)	1081-1637 (47)	639 ± 477 (5)	210-589
Creatinine (mg/dL)	0.5-0.6 (100)	0.7 ± 0.3 (8)	0.2-0.5
Glucose (mg/dL)	153-172 (85)	135 ± 75 (17)	130-183
LDH (U/L)	—	246 ± 33 (3)	—
Phosphorus (mg/dL)	4.4-6.1 (62)	6.7 ± 2.0 (6)	3.8-4.4
Potassium (mEq/L)	4.6-5.5 (93)	3.3 ± 0.7 (5)	3.3-5.9
Protein, total (g/dL)	6.7-7 (92)	6.0 ± 0.6 (15)	5.6-6.9
Albumin (g/dL)	3.1-4.6 (99)	3.8 ± 0.7 (8)	3-3.5
Globulin (g/dL)	2.9-3.1 (92)	2.3 ± 0.8 (7)	2.2-3.6
Sodium (mEq/L)	139-143 (92)	142 ± 4 (5)	135-145
Urea nitrogen (mg/dL)	15-18 (100)	19 ± 11 (16)	—

^aSample size is presented in parentheses.

^bValues shown are the 95% reference intervals after outliers were removed; blood was collected from the cranial vena cava; glucose levels were measured immediately after collection.

TABLE 7-7 Biologic and Physiologic Values of Sugar Gliders.^{2,3,8,24}

Parameter	Normal Values
Average life span (wild)	
Male	4-5 years
Female	5-7 years
Maximum reported life span	
Captivity	15 years
Wild	9 years
Colony size (wild)	7 (avg) (1 dominant male, 2 subordinate males, 4 adult females)
Colony size (captivity)	Minimum 2 (more is better)
Adult weight	Male, 100-160 g Female, 80-135 g
Body length	16-21 cm (avg 17 cm)
Tail length	16.5-21 cm (avg 19 cm)
Heart rate	200-300 beats/min
Respiratory rate	16-40 breaths/min
Cloacal temperature	36.2°C ± 0.4°C (97.2°F ± 0.7°F)
Torpor cloacal temperature	≤15°C (59°F)
Thermoneutral zone	27-31°C (81-88°F)
Basal metabolic rate	2.54 (weight in kg) ^{0.75}
Estrus cycle	
Type	Seasonally polyestrous
Length	29 days
Gestation period	15-17 days
Litter size	1-4 (usually 2)
Birth weight	0.2 g
Pouch emergence	50-74 days (usually 60 days)
Weaning age	85-120 days (usually 100 days)
Dispersal from nest	7-10 months
Sexual maturity	Male, 12-14 months; female 8-12 months

TABLE 7-8 Urinalysis Values of Sugar Gliders.³

Measurement	Avg	Reference Interval ^{a,b}
Specific gravity	1.030	1.020-1.040 (103)
pH	6.2	6-6.3 (98)
Protein (mg/dL)	12	9.5-14.6 (82)

^aValues shown are the 95% reference intervals after outliers were removed; analysis performed using IDEXX Vetlab UA™.

^bSample size is presented in parentheses.

TABLE 7-9 Growth and Development of Sugar Gliders.^{2,4,6}**Stage 1: In Pouch**

Age (days)	Weight (g)	Head (mm)	Leg (mm)	Key Developmental Characteristics
1	0.2	—	—	Mouth and forelimbs most developed feature
20	0.8	11	6	Ears free from head; papillae of mystacial vibrissae (whiskers) visible
30	1.6	14	9	—
35	2	—	—	Mystacial vibrissae erupt; ears pigmented
40	3.2	17	12	Start to pigment on shoulders; eye slits present
50	6.2	20	16	Typical detachment from teat and emergence from pouch at 50-60 days

Stage 2: Out of Pouch (OOP)^{a,b}

Age (weeks)	Weight (g)	Key Developmental Characteristics
1	8-18	Dorsal stripe developing; little to no fur; slick tail; closed eyes
2	12-22	Eyes open at approximately 17-21 days; fur lengthens
3	17-29	Very fine fur, except abdominal area; tail still slick; eyes still closed
4	18-35	Fur becoming more prominent; tail beginning to fluff; weaning begins
5	19-39	Complete fur coverage; light fur on abdominal area; tail continues to fill out
6	20-45	Tail fully fluffed out; abdominal area fully furred; mostly weaned
7	21-60	Very active at night; eating mainly solid foods
8	23-75	Fully self-sufficient and weaned

^aOn a practical level, estimating an exact out of pouch (OOP) date is often problematic because of the nocturnal nature of the animal and protectiveness of parents; joeys often exhibit wide weight differentials at the same age; the most reliable method for estimating age is to visually assess key distinguishing characteristics of their physical development, especially the abdominal area and tail.³

^bOnce joey is observed out of pouch, age is typically measured in weeks.¹

TABLE 7-10 Dietary Components for Sugar Gliders in Captivity.³

Common presentations	Obesity, malnutrition, and osteodystrophy often caused by nutritional inconsistencies of homemade diets and excessive sweet and fatty items
Daily consumption	15%-20% of body weight
Pelleted kibble	Nutritionally-balanced, commercial sugar glider kibble (Glide-R-Chow™ [www.sugarbears.com], NutriMax™ [www.vetspride.com]), VitaSmart Sugar Glider Formula & Vita Prima™ Sunscription Exotics Sugar Glider Formula (www.vitakraftsunseed.com)
Fresh fruits and vegetables	Apples, apricots, bananas, berries, corn, grapes, green beans, kiwifruit, mangos, melons, oranges, papaya, peas, sweet potatoes, squash, and watermelon
Supplement	Calcium-based multivitamin supplement formulated specifically for sugar gliders (Glide-A-Mins™ [www.sugarbears.com], VitaMax™ [www.vetspride.com])
Treats ^a	Must be strictly controlled; applesauce, yogurt, and limited invertebrates such as mealworms, grasshoppers, moths, fly pupae, and crickets

Continued

TABLE 7-10 Dietary Components for Sugar Gliders in Captivity. (cont'd)

Bottled or filtered water	Refresh drip water bottle daily; introduction of weighted container such as small ashtray may also be necessary for young joeys
Blossoms and branches	<i>Eucalyptus</i> , <i>Banksia</i> , <i>Leptospermum</i> , <i>Grevillea</i> , <i>Acacia</i> , <i>Melaleuca</i> , <i>Callistemon</i> , and <i>Hakea</i>

^aSugar gliders will preferentially eat sweet/fatty items to excess and to the exclusion of more nutritious foods, so they should not be presented with too wide a selection of foods.

TABLE 7-11 Suggested Sugar Glider Diets.^{3,11}**Diet 1³**

75%: Nutritionally balanced, commercial sugar glider kibble: 1-2 oz (28-56 g)/day/animal; available free choice in cage at all times (Glide-R-Chow™ [www.sugarbears.com], NutriMax™ [www.vetspride.com])

25%: Fresh fruits and vegetables: approximately ¼ of an apple, or the equivalent in mixed fruits/vegetables per animal per day; introduce each evening and remove leftovers in morning; apples, apricots, bananas, berries, corn, grapes, green beans, kiwifruit, mangos, melons, oranges, paw paw (papaya), peas, sweet potatoes, squash, and watermelon

Calcium-based multivitamin supplement: Sprinkle lightly on fruits/vegetables every other day; can also be mixed into applesauce or fruit baby food and hand-fed daily to promote bonding (Glide-A-Mins™ [www.sugarbears.com], VitaMax™ [www.vetspride.com])

Treats: Not to exceed 5% of daily diet; introduce gradually and individually, checking for diarrhea; treat items must be strictly controlled and may include fruits, applesauce, yogurt, and invertebrates such as mealworms, grasshoppers, moths, fly pupae, and crickets

Diet 2^{a-c,9}

50%: Leadbeater's mixture (150 mL warm water; 150 mL honey; 1 shelled, hard-boiled egg; 25 g high protein baby cereal; 1 tsp vitamin/mineral supplement)

- Mix warm water and honey
- In separate container, blend egg until homogenized
- Gradually add honey/water, then vitamin powder, then baby cereal, and blend after each addition until smooth
- Keep refrigerated until served

50%: Insectivore/omnivore diet (e.g., Mazuri Brand, Purina Mills, St. Louis, MO; Reliable Protein Products, Palm Desert, CA; ZuPreem, Mission, KS)

Diet 3^{d,9}

- Apple: 3 g; banana/corn: 3 g; grapes/kiwifruit: 3 g; orange with skin: 4 g; pear: 2 g; rockmelon/melon/paw paw (papaya): 2 g
- Sweet potato: 3 g
- Dog kibble: 1.5 g
- Fly pupae: 1 tsp
- Leadbeater's mix (see Diet 2): 2 tsp
- Day-old chick (1 day/week)
- Large insects or mealworms (when available)

^aInsects can be added to this diet to help prevent dental problems.

^bFeed fresh portions in evening; chop items together to reduce only favorite foods being selected; can offer treats (meats, diced fruits with multiple vitamin/mineral powder, bee pollen, worms, and crickets or other gut-loaded insects) at approximately 5% of daily intake.

^cPelleted sugar glider food (e.g., Marion Zoological, Plymouth, MN) might be preferable to other dry omnivore diets.

^dRecipe feeds two animals; without native foods (e.g., North America), add calcium carbonate to this diet.

TABLE 7-12 Feed Estimates for Hand-Rearing Sugar Gliders.^{a-d,6}

Age (days)	Feed (mL/day)	Wombaroo Possum Milk Replacer
20	0.7	Formula "<0.8"
30	1.1	Formula "<0.8"
40	1.8	Formula "<0.8"
50	3	Formula "<0.8"
51-53	4 (3 mL ["<0.8"] + 1 mL [">0.8"])	Transition from Formula "<0.8" to Formula ">0.8"
54-56	4 (2 mL ["<0.8"] + 2 mL [">0.8"])	Transition from Formula "<0.8" to Formula ">0.8"
57-59	4 (1 mL ["<0.8"] + 3 mL [">0.8"])	Transition from Formula "<0.8" to Formula ">0.8"
60	3	Formula ">0.8"
70	4	Formula ">0.8"
80	6	Formula ">0.8"
90	7	Formula ">0.8"
100	8	Formula ">0.8"

^aUsing Table 7.9, estimate the age of the sugar glider using developmental characteristics and weight measurements. Feed the volume listed according to the estimated age of the sugar glider. In emaciated joeys, the head and leg measurement is a more accurate method to determine age than the animal's weight.

^bNote that marsupial milk changes in composition and energy as the joey develops. Therefore, there are two formulas of Wombaroo Possum Milk Replacer that are used for hand-rearing sugar gliders. Formula "<0.8" is for younger joeys; Formula ">0.8" is for gliders out of the pouch. When a joey has fully emerged from the pouch, it then uses Formula ">0.8" entirely.

^cWombaroo Possum Milk Replacer "<0.8" and ">0.8" is available in the United States from the Exotic Nutrition Co, Newport News, VA; (866) 988-0301; exoticdiet@cox.net or from Perfect Pets Inc., Belleville, MI; (800) 366-8794; www.wombaroo.com.

^dFor hand-rearing procedures, refer to Barnes¹ and Ness and Booth.²⁰

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Chapter 8 **Hedgehogs**

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TABLE 8-1 Antimicrobial Agents Used in Hedgehogs.

Agent	Dosage	Comments
Amikacin	2.5-5 mg/kg IM q8-12 h ³⁶ 1 mg per 4 g powder ³⁵	Make sure animal is hydrated; do not use in animals with renal disease ⁴⁴ Polymethylmethacrylate (PMMA) beads
Amoxicillin	15 mg/kg PO, SC, IM q12h ^{19a,54}	Palatable to most hedgehogs ¹³
Amoxicillin/clavulanic acid (Clavamox, Pfizer)	12.5 mg/kg PO q12h ^{40,56}	Palatable to most hedgehogs ¹³
Ampicillin	10 mg/kg IM q12h ^{19a,23,54}	Not recommended or use with caution ²⁷
Ceftiofur sodium	20 mg/kg SC q12-24h ³⁶ 1 g per 20 mL powder ³⁵	Polymethylmethacrylate (PMMA) beads
Cephalexin	25 mg/kg PO q8h ³⁶	May make stools loose ²⁷
Chloramphenicol	30 mg/kg IM q12h ^{19a,23} 30-50 mg/kg PO, SC, IM, IV q12h ⁵⁴ 50 mg/kg PO, SC, IM q12h ^{18,19a,23}	Acute salmonellosis; potentially toxic to humans—have dosage giver avoid contact with medication ⁴⁴
Chlorhexidine	Topical ⁵⁴ q8-12h ²⁷	Bacterial dermatitis; traumatic skin lesions; wound treatments; soaking (e.g., appendages); use properly diluted
Chlorhexidine shampoo	2%-3% shampoo ³⁶	Bacterial, mycotic dermatitis
Chlortetracycline	5-20 mg/kg PO q12h ⁴⁰	
Ciprofloxacin	5-20 mg/kg PO q12h ⁴⁰	
Clarithromycin	5.5 mg/kg PO q12h ⁴⁰	
Clindamycin	5.5-10 mg/kg PO q12h ^{36,56}	Anaerobes; dental disease
Doxycycline	2.5-10 mg/kg PO, SC, IM q12h ⁴⁰	Concentration of active drug declines rapidly after 7 days in compounded formulation ⁴³
Enrofloxacin	2.5-5 mg/kg PO, IM q12h ⁵¹ 5-10 mg/kg PO, SC, IM q12h ^{18,54}	Avoid IM administration Dilute if administering SC; avoid IM administration ⁵¹
Erythromycin	10 mg/kg PO, IM q12h ^{19a,23}	Penicillin-resistant Gram-positive cocci; <i>Mycoplasma</i> ; <i>Pasteurella</i> ; <i>Bordetella</i>
Gentamicin	2 mg/kg SC, IM q8h ¹⁸	Rarely indicated; best to avoid; nephrotoxic
Gentamicin ophthalmic drops	Topical to cornea or conjunctiva ³⁶ q8h ²⁷	Corneal abrasions or conjunctivitis; use as in dog or cat
Metronidazole	20 mg/kg PO q12h ^{36,40}	Anaerobes
Mupirocin (2%) (Muricin, Dechra)	Topical to cutaneous lesions q12-24h prn ³⁶	Bacterial dermatitis or traumatic skin lesions
Neomycin, polymyxin B, bacitracin ophthalmic ointment	Topical to cornea or conjunctiva ³⁶ q8-12h ²⁷	Corneal abrasions or conjunctivitis; use as in dog or cat

TABLE 8-1 Antimicrobial Agents Used in Hedgehogs. (cont'd)

Agent	Dosage	Comments
Neomycin, thiabendazole, dexamethasone solution (Tresaderm, Merial)	Topical to cutaneous lesions or ear canal q12h prn ³⁶	Bacterial, mycotic dermatitis; otitis externa; antiinflammatory
Nystatin, neomycin, thioestrepton, triamcinolone cream (Panalog, Fort Dodge)	Topical to cutaneous lesions q12-24h prn ³⁶	Bacterial, mycotic dermatitis; antiinflammatory
Orbifloxacin (Orbax suspension, Intervet)	10-20 mg/kg PO q12-24h ¹⁶	
Oxytetracycline	25-50 mg/kg PO q24h × 5-7 days ^{11,13,36}	<i>Bordetella</i> ; may be administered in food
Oxytetracycline ophthalmic ointment (Terramycin, Pfizer)	Topical to cornea or conjunctiva ³⁶ q8-12h ²⁷	Corneal abrasions or conjunctivitis; use as in dog or cat
Penicillin G	40,000 U/kg SC, IM q24h ^{19a,40}	
Piperacillin	10 mg/kg SC q8-12h ³⁶	
Spiramycin	15 mg/kg PO × 8 days ^{19a}	Gingivitis; frequency not listed; not available in the United States
Sulfadimethoxine	2-20 mg/kg PO, SC, IM q24h ^{18,19a}	May have slight nephrotoxicity ²⁷
Trimethoprim/sulfa	30 mg/kg PO, SC, IM q12h ^{18,51}	Respiratory infections; trimethoprim/sulfamethoxazole is available in injectable form
Tylosin	10 mg/kg PO, SC q12h ²³	<i>Mycoplasma</i> ; <i>Clostridium</i> ; do not administer IM (causes muscle necrosis)

TABLE 8-2 Antifungal Agents Used in Hedgehogs.

Agent	Dosage	Comments
Chlorhexidine	2%-3% shampoo ³⁶	Dermatophytosis
Enilconazole (Imaverol, Janssen)	Topical q24h ⁵⁶ 100 mg/mL water topically q4d ⁴²	Dermatophytosis; dilute 1:50 Dermatophytosis
Griseofulvin (microsize)	— 25 mg/kg PO q12h ^{19a} 50 mg/kg PO q24h ^{19a,54} × 14-21 days ³⁸	Skin and deep mycoses; long-term therapy
Itraconazole	5-10 mg/kg PO q12-24h ³⁶ 10 mg/kg PO q12h ⁶ 10 mg/kg PO q24h ¹²	Systemic mycoses European hedgehogs/ dermatophytosis Cutaneous paecilomycosis
Ketoconazole	10 mg/kg PO q24h × 6-8 wk ^{19a,54}	Mycoses; use long term
Lime sulfur	Topical ¹⁷	Dermatophytosis
Nystatin	30,000 U/kg PO q8-24h ³⁶	Yeast infections
Terbinafine	100 mg/kg PO q12h ⁶	European hedgehogs/ dermatophytosis

TABLE 8-3 Antiparasitic Agents Used in Hedgehogs.

Agent	Dosage	Comments
Amitraz (Mitaban, Pfizer)	0.3% topical q7d × 2-3 treatments ^{34,36}	Mites (<i>Caparinia</i> , <i>Chorioptes</i> , etc.); may dilute; use with caution
Fenbendazole	10-15 mg/kg PO q14d × 2-3 treatments ⁵⁴ 10-30 mg/kg PO q24h × 5 days ²³ 25 mg/kg PO q10d ³⁶	Nematodes Nematodes (i.e., <i>Crenosoma</i> , <i>Capillaria</i>) Nematodes
Fipronil spray (Frontline, Merial)	Topical, repeat in 10 days ^{27,33}	Mites; apply 1 spray over dorsum
Flea products (feline)	Topical ¹⁷	Use sparingly
Imidacloprid	½ puppy/kitten dose topical q30d ¹³	Fleas; apply to quilled areas behind head
Imidacloprid 10% + moxidectin 1%	0.1 mL/kg ²⁸	<i>Caparinia</i>
Ivermectin	0.2 mg/kg PO, SC q14d × 3 treatments ⁵⁴ 0.2 mg/kg SC q21d ^{9b} 0.2-0.4 mg/kg PO, SC q10-14d × 3-5 treatments ^{20,40} 0.5 mg/kg PO, SC q14d × 3 treatments ⁷ <1 mg/kg ²⁷ PO, SC	Mites (<i>Caparinia</i> , etc.); nematodes; a pyrethrin-based shampoo q7d × several treatments is often needed concurrently for full response <i>Caparinia</i> mites Ectoparasites Mites; resistance to the lower doses of ivermectin has been noted For resistant <i>Chorioptes</i>
Levamisole (1%)	10 mg/kg SC, ¹¹ repeat q48h; repeat prn q14d ^{19a}	Nematodes, including lungworms
Lufenuron	½ puppy/kitten dose PO q30d ¹³	Fleas
Mebendazole	15 mg/kg PO, repeat q14d ²⁷ 25 mg/animal <500 g q12h; 50 mg/animal >500 g q24h PO × 5 days, repeat q14-21 ²⁷	Nematodes; do not use in animals with hepatic disease <i>Capillaria</i> , <i>Crenosoma</i> , <i>Brachylaemus</i> , <i>Hymenolepsis</i> , <i>Physaloptera</i>
Metronidazole	25 mg/kg PO q12h × 5 days ^{17,54}	Intestinal protozoa
Moxidectin (Cydectin, Bayer)	0.3 mg/kg SC q10d ⁴²	Notoedric mange
Permethrin (1%)	Topical ⁵⁵	Mites; apply once via fine mist; change bedding
Praziquantel	7 mg/kg PO, SC, repeat q14d ^{17,54}	Cestodes, trematodes
Selamectin (Revolution, Pfizer)	6 mg/kg topically ³ 6-18 mg/kg topically q30d × 2 treatments ²²	Ectoparasites; higher dose may be required External mites
Sulfadimethoxine	2-20 mg/kg PO, ^{19a} SC, IM ²³ q24h × 2-5 days, off 5 days, on 2-5 days ^{19a} 10 mg/kg PO q24h × 5-7 days ³⁶	Coccidia Coccidia
Sulfadimidine	100-200 mg/kg SC q24h × 3 days ¹¹	Coccidia
Toltrazuril	10 mg/kg PO q24h × 2 treatments then repeated q7d × 3 wk ²¹	Coccidia (<i>Eimeria</i>)

TABLE 8-4 Chemical Restraint/Anesthetic Agents Used in Hedgehogs.

Agent	Dosage	Comments
Acepromazine	0.1-1 mg/kg PO, SC, IM ¹³	Sedative; hypotension may occur when used alone; atropine pretreatment may alleviate this effect
Atipamezole (Antisedan, Zoetis)	0.3-0.5 mg/kg IM ⁵⁶ 1 mg/kg SC, IM, IV, IP ^{4,27}	Reversal of medetomidine and dexmedetomidine
Atropine	0.01-0.05 mg/kg SC, IM ^{21,40}	Preanesthetic to decrease hypersalivation
Buprenorphine	—	See midazolam for combination
Butorphanol	—	See midazolam for combination
Dexmedetomidine (Dexdomitor, Zoetis)	0.02 mg/kg IM ³²	Avoid use in ill or debilitated animals; reversible with atipamezole
Diazepam	— 0.5-2 mg/kg IM ⁵¹	Diazepam combination follows Mild sedation; may be given with ketamine for anesthesia; seizures; midazolam preferred for IM use
Diazepam (D)/ketamine (K)	(D) 0.5-2 mg/kg + (K) 5-20 mg/kg IM ⁷	Anesthesia; do not use in neck area where there is brown fat; ²³ midazolam preferred for IM use
Enflurane	To effect ⁴⁰	Anesthesia; not commonly used; isoflurane or sevoflurane preferred
Fentanyl	—	See medetomidine for combination
Isoflurane	3%-5% induction ⁵⁴ 0.5%-3% maintenance ^{53,54}	Anesthetic of choice; generally occurs in an induction chamber or mask By mask or endotracheal tube
Ketamine	— 5-20 mg/kg IM ⁵¹	See diazepam and medetomidine for combinations; combinations follow Sedation; anesthesia; do not use in neck area where there is brown fat; ²³ may use in combination with midazolam (or less preferably diazepam) or an α_2 agonist; recovery may be prolonged and/or rough
Ketamine (K)/medetomidine (M)	(K) 5 mg/kg + (M) 0.1 mg/kg IM ^{40,56}	Anesthesia; (M) reverse with atipamezole (0.3-0.5 mg/kg IM); see medetomidine ^a
Ketamine (K)/midazolam (Mi)	(K) 3-10 mg/kg + (Mi) 0.5-1 mg/kg IM ³²	
Medetomidine	— 0.05-0.1 mg/kg IM ^{36,56} 0.2 mg/kg SC, IM ⁵	Medetomidine ^a combination follows; not commercially available, but can be obtained through select compounding pharmacies; recommend equal volume of dexmedetomidine, but no reports of safety or efficacy available Light sedation; reverse with atipamezole (0.3-0.5 mg/kg IM) Heavy sedation; reverse with atipamezole (0.3-0.5 mg/kg IM)
Medetomidine (M)/ketamine (K)/fentanyl (F)	(M) 0.2 mg/kg + (K) 2 mg/kg + (F) 0.1 mg/kg SC ⁴	Anesthesia; good muscle relaxation; (M) reversed with atipamezole (1 mg/kg IM) and (F) reversed with naloxone (0.16 mg/kg IM); see medetomidine ^a

Continued

TABLE 8-4 Chemical Restraint/Anesthetic Agents Used in Hedgehogs. (cont'd)

Agent	Dosage	Comments
Midazolam	— 0.25-0.5 mg/kg IM ³¹ 0.5-1.0 mg/kg IM ³²	Midazolam combinations follow; it is the preferred benzodiazepine for IM use Preanesthetic
Midazolam (Mi)/ buprenorphine (Bup)	(Mi) 0.25-0.5 mg/kg + (Bup) 0.03 mg/kg IM ³¹	Painful or stressful procedures
Midazolam (Mi)/ butorphanol (But)	(Mi) 0.25-0.5 mg/kg + (But) 0.4 mg/kg IM ³¹ (Mi) 0.5-1 mg/kg + (But) 0.2-0.5 mg/kg IM ³²	Stressful procedures; also see butorphanol comments in Table 8.5
Naloxone	0.1-0.16 mg/kg SC, IM q6-8h ^{4,27}	Reversal of fentanyl
Sevoflurane	To effect ⁴⁰	Anesthesia; may provide more rapid induction and plane changes than isoflurane
Tiletamine/ zolazepam (Telazol, Zoetis)	1-5 mg/kg IM ⁵⁴	Sedation; anesthesia; recovery may be prolonged and/or rough; rarely indicated because gas anesthesia is preferred
Xylazine	0.5-1 mg/kg IM ⁵¹	Anesthesia; may be given with ketamine; rarely indicated because gas anesthesia is preferred
Yohimbine	0.5-1 mg/kg IM ⁴⁰	Reversal of xylazine

^aDexmedetomidine (0.5 mg/mL) is an α -2 agonist that is the active optical enantiomer of racemic compound medetomidine; 1/2 the dose of medetomidine (1 mg/mL) but same volume; although the same effects would be expected as with medetomidine (not commercially available, but can be obtained through various compounding services), there is no data on the efficacy and safety of dexmedetomidine in hedgehogs, and, to date, it appears to have been seldom used clinically in this species; the effects of the v/v use of the two drugs may not be equivalent, so the dose of dexmedetomidine may need to be adjusted based on clinical response.

TABLE 8-5 Analgesic Agents Used in Hedgehogs.

Agent	Dosage	Comments
Buprenorphine	0.01 mg/kg SC, IM q6-8h ^{11,53,56} 0.01-0.5 mg/kg SC, IM q8-12h ²⁴	Analgesia; higher dose will likely be required Analgesia
Butorphanol	0.05 mg/kg q8h SC prn ²³ 0.05-0.1 mg/kg SC, IM q8-12h ²⁴ 0.2-0.4 mg/kg SC, IM q6-8h ^{53,54}	Analgesia; when compared with other opiate analgesics, this drug appears to be less useful in small animals for treating moderate to severe pain and has to be dosed more frequently Analgesia Analgesia

TABLE 8-5 Analgesic Agents Used in Hedgehogs. (cont'd)

Agent	Dosage	Comments
Carprofen	1 mg/kg PO, SC q12-24h ²⁷	Nonsteroidal, antiinflammatory
Dexamethasone	0.1-1.5 mg/kg IM ^{19a}	Glucocorticoid; inflammation; allergies
Flunixin meglumine	0.3 mg/kg SC q24h ²⁴	Nonsteroidal, antiinflammatory; arthritis; chronic inflammation; higher dose may be required
Hydromorphone	0.1 mg/kg SC ⁴⁹	Preoperative analgesia
Meloxicam	0.08 mg/kg PO q24h ⁴⁹ 0.2 mg/kg PO, SC q24h ^{26,27,57}	Nonsteroidal, antiinflammatory
Methylprednisolone	1-2 mg/kg SC ³⁶	Glucocorticoid; antiinflammatory
Naloxone	0.1-0.16 mg/kg SC, IM q6-8h ^{4,27}	Reversal of fentanyl
Prednisolone	2.5 mg/kg PO, SC, IM q12h prn ^{19a,40}	Glucocorticoid; allergies
Tramadol	2-4 mg/kg PO q12h	Synthetic μ -receptor opiate-like agonist
Triamcinolone	0.2 mg/kg SC, IM ¹³	Glucocorticoid; antiinflammatory; no frequency given

TABLE 8-6 Miscellaneous Agents Used in Hedgehogs.

Agent	Dosage	Comments
Acyclovir	40-100 mg/kg PO q24h ²¹	Herpes simplex infection
Aluminum hydroxide	100 mg/kg PO with each syringe feeding ⁴⁵	Renal failure; hyperphosphatemia
Atropine	0.05-0.2 mg/kg SC ¹³	Bradycardia
Bupivacaine	1.1 mg/kg diluted with saline 1:12 ⁴⁹	Surgical site infiltration
Calcium gluconate (10%)	50 mg/kg IM ³⁶	Hypocalcemia
Calcium gluconate (23%)	100-150 mg/kg IV ³¹	
Carnivore Care (Oxbow)	2-3 mL PO ²⁶ Mix 1:1 with Critical Care Fine Grind ¹ (Oxbow)	Gavage feed; may require slight sedation
Cimetidine	10 mg/kg PO q8h ³⁶	Treatment of gastric ulcers
Doxapram	2-10 mg/kg IV, IP ^{13,31}	Respiratory stimulant; use with caution as use may increase CNS oxygen demand ⁴⁴
Emerald Carnivore (Lafeber)	3 mL/100 g BW q6h	Mix 1:1 with Emerald Omnivore per label

Continued

TABLE 8-6 Miscellaneous Agents Used in Hedgehogs. (cont'd)

Agent	Dosage	Comments
Enalapril	0.5 mg/kg PO q24h ³⁶	Vasodilator; heart failure
Epinephrine	0.003 mg/kg IV ³¹	Cardiac arrest
Erythropoietin (Epoen, Amgen)	100 U/kg SC q48-72h ³⁶	Chronic anemia
Famotidine	1 mg/kg SC q24h ⁴⁵	Prevention or treatment of gastric ulcers
Furosemide	2.5-5 mg/kg PO, SC, IM q8h ^{40,56} 2-4 mg/kg PO, SC q8h ¹⁵	Edema; diuretic Congestive heart failure
Glycopyrrolate	0.01-0.02 mg/kg SC ¹³	Bradycardia
Hetastarch	5 mL/kg IV ³¹	Give over 5-10 min
Hyaluronidase	100-150 U/L ³⁶	Add to SC fluids; may facilitate fluid absorption
Iron dextran	25 mg/kg IM ⁵⁶	Anemia
Lactated Ringer's solution (LRS)	— 1-15 mL/kg IV ³¹ 25 mL/kg SC q12h ⁵⁷ 50-100 mL/kg/day ²⁶	Fluid replacement; dehydration; shock
Lactobacilli	2.5 mL/kg q24h ^{19a}	May aid in restoring gastrointestinal flora
Lactulose	0.3 mL/kg PO q8-12h ³⁶	Hepatic disease; constipation ²⁷
Lysine	250-500 mg/kg PO q24h ²¹	Herpes simplex
Metoclopramide	0.2-0.5 mg/kg PO, SC ³⁶	Regurgitation; antiemetic; GI motility enhancer ²⁷
Milk thistle (Silybum marianum)	4-15 mg/kg PO q12h ²¹	Hepatoprotectant
Pimobendan	0.3 mg/kg PO q12h ¹⁵	Congestive heart failure
Sucralfate	10 mg/kg PO q8-12h ⁴⁰	Gastrointestinal ulcers
Theophylline	10 mg/kg PO, IM q12h ³⁶	Bronchodilator
Trilostane	2 mg/kg PO q24h ²¹	Hyperadrenocorticism
Vitamin A	400 U/kg IM q24h × 10 days ^{19a}	Skin disorders; excessive quill loss
Vitamin B complex	1 mL/kg SC, IM once ^{23,40}	CNS signs; paralysis of unknown origin; anorexia; use small animal formulation
Vitamin C	50-200 mg/kg PO, SC q24h ^{19a} 1 g ascorbic acid/L drinking water ^{19a}	Deficiency; infections; gingivitis Change daily; not recommended; alternative routes of supplementation preferred; use oral pills or powder ²⁷

TABLE 8-7 Hematologic and Serum Biochemical Values of Hedgehogs.

Measurement	Reference Range ¹⁹	Reference Range ⁴¹
Hematology		
PCV (%)	36 ± 7 (22-64)	42.0 ± 0.9 (33.5-47.0)
RBC (10 ⁶ /μL)	6 ± 2 (3-16)	5.0 ± 0.1 (4.3-6.0)
Hgb (g/dL)	12 ± 2.8 (7-21.1)	13.1 ± 0.3 (10.7-14.9)
MCV (fL)	67 ± 9 (41-94)	87.8 ± 1.8 (76.3-99.8)
MCH (pg)	22 ± 4 (11-31)	27.1 ± 0.7 (22.5-31.4)
MCHC (g/dL)	34 ± 5 (17-48)	30.9 ± 0.5 (27.7-35.2)
Platelets (10 ³ /μL)	226 ± 108 (60-347)	Not reported
WBC (10 ³ /μL)	11 ± 6 (3-43)	15.0 ± 0.7 (11.5-21.7)
Neutrophils (10 ³ /μL)	5.1 ± 5.2 (0.6-37.4)	9.5 ± 0.5 (6.1-14.6)
Lymphocytes (10 ³ /μL)	4 ± 2.2 (0.9-13.1)	5.2 ± 0.4 (3.3-8.9)
Monocytes (10 ³ /μL)	0.3 ± 0.3 (0-1.6)	0.2 ± 0.1 (0-0.8)
Eosinophils (10 ³ /μL)	1.2 ± 0.9 (0-5.1)	0.2 ± 0 (0-0.3)
Basophils (10 ³ /μL)	0.4 ± 0.3 (0-1.5)	0.1 ± 0 (0-0.2)
Chemistries		
ALP (U/L)	51 ± 21 (8-92)	22.4 ± 1.0 (18.2-25.5)
ALT (U/L)	53 ± 24 (16-134)	22.8 ± 1.4 (15.2-28.8)
Amylase (U/L)	510 ± 170 (244-858)	Not reported
AST (U/L)	34 ± 22 (8-137)	33.5 ± 3.5 (19.0-65.6)
Bilirubin, total (mg/dL)	0.3 ± 0.3 (0-1.3)	Not reported
BUN (mg/dL)	27 ± 9 (13-54)	47.1 ± 2.3 (34.3-57.3)
Calcium (mg/dL)	8.8 ± 1.4 (5.2-11.3)	9.7 ± 0.3 (8.6-11.4)
Chloride (mEq/L)	109 ± 10 (92-128)	Not reported
Cholesterol (mg/dL)	131 ± 25 (86-189)	132.5 ± 5.3 (100-150)
Creatine kinase (U/L)	863 ± 413 (333-1964)	Not reported
Creatinine (mg/dL)	0.4 ± 0.2 (0-0.8)	0.7 ± 0.1 (0.5-1.0)
GGT (U/L)	4 ± 1 (0-12)	Not reported
Glucose (mg/dL)	89 ± 30	86.1 ± 4.7 (60-125)
LDH (U/L)	441 ± 258 (57-820)	Not reported
Phosphorus (mg/dL)	5.3 ± 1.9 (2.4-12)	Not reported
Potassium (mEq/L)	4.9 ± 1 (3.2-7.2)	Not reported
Protein, total (g/dL)	5.8 ± 0.7 (4-7.7)	6.0 ± 0.2 (4.6-6.9)
Albumin (g/dL)	2.9 ± 0.4 (1.8-4.2)	3.4 ± 0.2 (2.7-3.9)
Globulin (g/dL)	2.7 ± 0.5 (1.6-3.9)	2.6 ± 0.2 (1.9-3.6)
Sodium (mEq/L)	141 ± 9 (120-165)	Not reported
Triglycerides (mg/dL)	38 ± 22 (10-96)	37.8 ± 2.3 (30.8-46.2)

TABLE 8-8 Biological and Physiological Values of Hedgehogs.^{1,13,16,20,29,39,47,52,54,60}

Parameter	Biological and Physiological Values
Weight	Male, 400-600 g Female, 300-400 g
Life span	Avg 4-6 years, may live 8 years
Temperature, rectal	95.7-98.6°F (35.4-37°C)
Preferred environmental temperature	75-85°F (24-29°C) Temperatures <60°F (16°C) induce torpor state
Adult dental formula	2 (I3/2:C1/1:P3/2:M3/3) = 36; variations have been noted
Gastrointestinal system	Simple stomach; no cecum; transit time 12-16 hours
Heart rate	180-280 beats/min
Respiratory rate	25-50 breaths/min
Age at sexual maturity	Male, 6-8 months Female, 2-6 months
Reproductive life span	Male, throughout life Female, 2-3 years
Gestation	34-37 days
Milk composition	Protein, 16 g/100 g; carbohydrate, trace; fat, 25.5 g/100 g
Litter size	Avg 3-4 (range 1-7)
Birth weight	10-18 g
Eyes open	14-18 days
Deciduous teeth eruption	Begins on day 18; all deciduous teeth erupt by 9 weeks
Permanent teeth eruption	Begins at 7-9 weeks
Age at weaning	4-6 weeks (start eating solids at 3 weeks)
Endotracheal tube size	14 g over-the-needle IV catheter to 2.0 mm
Esophagostomy tube size	8 Fr

TABLE 8-9 Suggested Diets for Hedgehogs.^{9b,20,23,27,47,51}

The exact nutritional requirements of hedgehogs are unknown. Diets for captive animals have been developed taking into consideration their omnivorous nature, simple gastrointestinal tract, ability to digest chitin, poor digestibility of cellulose, propensity toward obesity, and lack of reports of specific nutritional problems (with the exception of lactose intolerance).

Hedgehogs in captivity will thrive on a base diet composed of approximately 30%-50% protein (dry matter basis) and 10%-20% fat. Because scientific studies regarding hedgehog nutritional needs are lacking, commercial diets appear to be the most balanced diet that a pet owner can offer. If a commercial hedgehog food is not used, a premium commercial feline (adults may use "lite" adult cat foods), ferret, or insectivore diets may be used. Dry foods may be advantageous to help with dental health as periodontal disease is fairly common in hedgehogs. It is inappropriate to use these commercial diets as a sole nutrition source. Supplement with small portions of cooked egg, pinky mice, vegetable and meat jarred human baby foods, gut-loaded crickets and mealworms,⁴ chopped vegetables, and fruits. Dairy products, such as cottage cheese and milk, should be avoided, however, because of reports of lactose intolerance.

TABLE 8-9 Suggested Diets for Hedgehogs. (cont'd)

In general, pets should not be fed ad libitum as obesity is very common. Approximately 1-2 Tbs of food daily is a reasonable starting point for adults, with growing animals and reproductively active females being fed the usual diet ad libitum, and calcium-rich foods should be supplemented. Young or pregnant/lactating hedgehogs can also use kitten or ferret formulations. Hedgehogs are generally nocturnal eaters. Fresh water should be provided ad libitum in a shallow dish; animals can also learn to drink from sipper bottles.

In addition to the main diet, 1-2 tsp of varied moist foods (e.g., canned cat or dog food, cooked meat or egg, low-fat cottage cheese) and approximately ½ tsp of fruit (e.g., banana, grape, apple, pear, berries) or vegetables (e.g., beans, cooked carrots, squash, peas, tomatoes, leafy greens) should also be provided daily.^b One key to balanced nutrition is to provide variety. Acceptable treats include mealworms, earthworms, waxworms, crickets, and cat treats; these may be hidden in the bedding to promote foraging behavior as environmental enrichment.

^aMealworms are high calorie, low calcium and should be limited to 6-10 smaller mealworms 2-3 times a week; 1-2 crickets (more if hedgehog is pregnant or lactating) can be fed insectivore diet plus some of the fruit/vegetable mixture for a minimum of 3 days after purchase before being fed to the hedgehog; other types of commercially available insects can also be fed. Insects can be dusted with a calcium supplement before feeding to hedgehogs.

^bAn alternative fruit/vegetable mix: chop together ½ tsp diced leafy dark greens (spinach, kale, leaf lettuce), ¼ tsp diced carrot, ¼ tsp diced apple, ¼ tsp diced banana, ¼ tsp diced grape or raisin, ¼ tsp vitamin/mineral powder (Vionate or crushed feline vitamin tab).

TABLE 8-10 Hand-Rearing Orphaned Hedgehogs.^{20,31,47,52}

1. Leave neonates with the mother if possible for the first 24-72 hours for colostrum ingestion.
2. In cases of lactation failure or abandonment by the female, fostering the pups to another dam with similarly aged pups is generally successful.
3. Feed a canine milk replacer with added lactase (Lactaid, McNeil Nutritionals) using a 1-cc syringe with a catheter tip or an eye dropper.
4. Neonates should be fed as much as they will consume every 2-4 hours for about 3 weeks, then the time between feedings can be gradually lengthened; the newborns should gain 1-2 g/day during the first week, about 3-4 g/day during the second week, 4-5 g/day during the third and fourth weeks, and 7-9 g/day until they are 60 days old; at 4-6 weeks, parent- or hand-raised young should be weaned by offering canned dog or cat food, minced beef, or freshly molted mealworms; hand-rearing hedgehogs is often associated with high mortality.
5. The ambient temperature should be maintained at 90-95°F (32-35°C) for the first few weeks.
6. Manual stimulation is required for defecation and should be performed after each meal by massaging the ventrum and perineal area with a cloth or swab moistened in warm water.

TABLE 8-11 Common Injection and Venipuncture Sites in Hedgehogs.^{16,25,26,37}

Injection Sites	Comments
Subcutaneous	5-10 mL/site; flank at junction of furred skin and spined mantle; SC under mantle requires 1.5- to 3-inch needle
Intramuscular	0.5 mL/site; anterior thigh, triceps; may require sedation; orbicularis up to 1 mL/site
Intravenous	Lateral saphenous, jugular
Intraperitoneal	5-10 mL; requires sedation for access; caudal right abdominal quadrant; useful for fluid administration
Intraosseous	0.5-1 mL slow bolus; requires anesthesia for tibial placement; rarely used

TABLE 8-11 Common Injection and Venipuncture Sites in Hedgehogs. (cont'd)

Venipuncture Sites	Comments
Saphenous	0.5-1 mL; requires sedation; common site for catheterization with 24g-26g catheter
Jugular	0.5-1 mL; requires sedation; easier in thin animals; not visible or palpable; blind stick
Cephalic	Requires sedation; common site for catheterization with 24g-26g catheter
Cranial vena cava	Requires sedation; risk of cardiac puncture

TABLE 8-12 Preventive Medicine in Hedgehogs.²⁵

- Prevent obesity; have owners weigh hedgehogs at least monthly
- Dental prophylaxis—routine brushing, scaling
- Nails need periodic trimming
- Annual (or semi-annual) physical examination, including fecal flotation and direct smear
- No routine vaccines recommended
- Prevent chilling; provide heated environment with dry bedding
- Microchip for personal identification

TABLE 8-13 Common Differential Diagnoses Based on Physical Examination Findings.^{2,10,13,14,16,21,22,27,30,46,59}

- Ataxia: brain neoplasia, herpes simplex infection, intervertebral disk disease, wobbly hedgehog syndrome
- Cutaneous/subcutaneous masses: cutaneous hemangiosarcoma, mammary neoplasia, mast cell tumor, thyroid tumor
- Dermatitis/quill loss: bacterial pyoderma, fungal dermatophytosis, mange (*Caparinia*, *Chorioptes*, *Notoedres*)
- Dyspnea: cardiomyopathy, mitral valve disease, bacterial pneumonia, pulmonary metastases
- Gastroenteritis: bacterial (*Salmonella*), lymphosarcoma, parasitic
- Hematuria: bacterial cystitis, endometrial polyps, endometrial sarcoma, uterine spindle cell tumor
- Oral cavity masses: odontogenic fibroma, spindle cell carcinoma, squamous cell carcinoma

TABLE 8-14 Confirmed Zoonotic Diseases Carried by Hedgehogs.^{48,50,58}

- Bacterial: *Salmonella* spp., *Yersinia pseudotuberculosis*, *Mycobacterium marinum*
- Viral: Herpesvirus, including human herpes simplex
- Mycotic: *Trichophyton metagrophytes* var. *erinacei*, *Microsporium* spp.

TABLE 8-15 Common Vocalizations in Hedgehogs.¹³

Snorting/huffing; hissing/grunting	Aggressive or warning sounds produced by sharp vibrating exhalations through the nostrils; generally made when the animal is disturbed, when it encounters another animal, or when it is in the process of rolling up
Screaming	Severe distress call given when the animal is in distress or pain
Twittering/whistling	High-pitched sounds of neonates; whistling stimulates contact by the dam
Clucking	High-pitched contact call of the dam to neonates; also made by courting males
Snuffling	Made as hedgehogs search for food
Inaudible sounds	Hedgehogs can make and hear sounds in the 40- to 90-kHz range, above the range of human hearing

TABLE 8-16 Cardiac Measurements in Hedgehogs.^{a,8}

Radiographic Measurements ^b	Mean ± SD (Range)
AB/CD	1.38 ± 0.11 (1.24-1.59)
AB/H	0.88 ± 0.07 (0.74-1.01)
AB/R5-7	1.89 ± 0.29 (1.55-2.73)
CD/H	0.63 ± 0.04 (0.58-0.7)
VHS	8.16 ± 0.48 (7.25-8.75)
L/W	1.4 ± 0.11 (1.16-1.55)
L/C	1.64 ± 0.25 (1.38-2.13)
W/T	0.6 ± 0.03 (0.55-0.66)
W/C	1.17 ± 0.17 (1-1.45)
Echocardiographic Measurements ^c	Mean ± SD (Range)
IVSd (cm)	0.15 ± 0.01 (0.13-0.17)
IVSs (cm)	0.22 ± 0.02 (0.19-0.24)
LVIDd (cm)	0.74 ± 0.05 (0.67-0.84)
LVIDs (cm)	0.58 ± 0.03 (0.54-0.65)
LVFWd (cm)	0.16 ± 0.01 (0.14-0.18)
LVFWs (cm)	0.23 ± 0.02 (0.19-0.27)
FS (%)	21.45 ± 2.5 (17.4-26.8)
EPSS (cm)	0.11 ± 0.02 (0.09-0.14)
AO (cm)	0.36 ± 0.02 (0.31-0.4)
LA (cm)	0.56 ± 0.04 (0.51-0.62)
LA/AO (cm)	1.55 ± 0.16 (1.37-1.92)
LVOT Vmax (m/sec)	0.489 ± 0.108 (0.296-0.662)
RVOT Vmax (m/sec)	0.335 ± 0.094 (0.236-0.512)
R-wave amplitude (mV)	0.22 ± 0.11 (0.08-0.5)
QRS duration (sec)	0.03 ± 0 (0.03-0.03)
Mean electrical axis	-10 ± 13 (-28 to 8)
Heart rate (beats/min)	200 ± 48 (100-260)

^a*n* = 13; 5 male, 8 female; age range 6 mo-5 yr, 7 < 1 yr, 6 > 1 yr.

^b*AB*, apicobasilar length of heart; *CD*, maximum width of heart perpendicular to *AB*; *H*, vertical depth of thorax from ventral border of spine to dorsal border of sternum at level of tracheal bifurcation; *R5-7*, distance from 5th rib cranial edge to 7th rib caudal edge; *VHS*, vertebral heart score; *L*, heart length; *W*, maximum width perpendicular to *L*; *C*, length of clavicle; *T*, thoracic width at level of 6th rib articulation with vertebral column.

^c*IVSd*, interventricular septal thickness in diastole; *IVSs*, interventricular septal thickness in systole; *LVIDd*, left ventricular internal diameter in diastole; *LVIDs*, left ventricular internal diameter in systole; *LVFWd*, left ventricular free wall thickness in diastole; *LVFWs*, left ventricular free wall thickness in systole; *FS*, fractional shortening; *EPSS*, E-point-to-septal separation length; *AO*, aortic diameter in diastole; *LA*, left atrium internal dimension; *LVOT*, maximum velocity of left ventricular outflow; *RVOT*, maximum velocity of right ventricular outflow.

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Chapter 9 Rodents

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TABLE 9-1 Antimicrobial and Antifungal Agents Used in Rodents.^a

Agent	Dosage	Comments
Amikacin	5-15 mg/kg SC, IM, IV q8-12h ⁸⁴ 15 mg/kg IM q12h ⁷⁹ 16 mg/kg SC, IM, IV divided q8-24h ⁹⁰	All species/also administer fluid therapy Guinea pigs/high peak dosing regimen as efficacious as divided regimen All species/also administer fluid therapy
Amoxicillin	— 25 mg/kg PO q12h ⁸² 10-15 mg/kg PO q12h ¹¹³ 100-150 mg/kg IM, SC ⁸⁴ 0.25 mg/mL drinking water for 7 days ⁷³	Do not use orally in hamsters, guinea pigs, chinchillas; may cause enterocolitis ² Rats Rats Rats, mice Mice/only effective against highly susceptible bacteria; plasma levels reached <300 ng/mL ⁷³
Amoxicillin/ clavulanic acid	20 mg/kg PO q12h ⁹⁰	Mice, rats
Amphotericin B	0.11 mg/kg SC q24h ^{84,90} 0.43 mg/kg PO q24h ^{84,90} 1.25-2.5 mg/kg SC q24h ⁸⁴	Mice/use with caution; may cause renal toxicity Mice/candidiasis Guinea pigs/cryptococcosis
Ampicillin	— 6-30 mg/kg PO q8h ⁸⁴ 20-100 mg/kg PO, SC, IM q8h ⁸⁴ 20-250 mg/kg PO q12h ¹¹³ 25 mg/kg SC, IM q12h ⁸⁴ 50-200 mg/kg PO q12h ⁸⁴	Do not use orally in hamsters, guinea pigs, chinchillas; may cause enterocolitis ² Gerbils Gerbils Rats Rats, mice Rats, mice
Azithromycin	15-30 mg/kg PO q24h ^{31,90} 30 mg/kg PO q24h ^{8,20} 50 mg/kg PO q12h for 14 days ⁸⁴	Most species, including guinea pigs, chinchillas, hamsters Chinchillas Rats, mice
Captan powder	1 tsp/2 cups dust ⁴⁹	Chinchillas/fungicide to prevent spread of dermatophytes between cagemates; add to dust box
Cephalexin	15 mg/kg SC, IM q12h ³³ 15 mg/kg SC q12h ³³ 20 mg/kg PO q8h ¹¹³ 25 mg/kg IM q12-24h ^{84,113} 25 mg/kg SC q24h ⁹⁰ 60 mg/kg PO q12h ⁹⁰	Rats, mice Guinea pigs Rats Guinea pigs Hamsters, gerbils Mice
Chloramphenicol	30-50 mg/kg PO q8-12h ^{31,90} 200 mg/kg PO q12h ⁸⁴ 0.5 mg/mL drinking water ⁸⁴ 0.83 mg/mL drinking water ⁸⁴ 1 mg/mL drinking water ⁸⁴	Most species Mice Mice Gerbils Guinea pigs

TABLE 9-1 Antimicrobial and Antifungal Agents Used in Rodents. (cont'd)

Agent	Dosage	Comments
Chlortetracycline	10 mg/kg SC, IM q12h ⁹⁰	Rats
	20 mg/kg PO, SC, IM q12h ⁹⁰	Hamsters, gerbils
	25 mg/kg PO, SC, IM q12h ⁹⁰	Mice
	50 mg/kg PO q12h ⁹⁰	Chinchillas
Ciprofloxacin	5-25 mg/kg PO q12-24h ^{84,90}	Chinchillas, guinea pigs/may cause arthropathies in young of any species
	10 mg/kg PO q12h ⁸⁴	Rats, mice
	10-20 mg/kg PO q12h ⁸⁴	Hamster
Clarithromycin	15 mg/kg PO q12h ⁷	Chinchillas
Clindamycin	7.5 mg/kg SC q12h ⁹⁰	Most species/can cause diarrhea; do not give orally; avoid or use with caution in chinchillas and guinea pigs; excellent bone penetration
Doxycycline	2.5-5 mg/kg PO q12h ⁹⁰	All species/pneumonia; may give in combination with enrofloxacin; do not use in young and pregnant animals
	70-100 mg/kg SC, IM q7d ⁹⁰	Mice, rats/use long-acting formulation
	0.05 mg/mL drinking water for 7 days ⁷³	Mice/failed to achieve effective plasma concentrations.
Enilconazole	Dip in a 0.2% (1:50) solution q7d ^{2,84}	Dermatophytosis
	0.2% solution topical q3-4d ³¹	All species/dermatophytosis
Enrofloxacin	—	Very high doses may cause arthropathies in young if given for a prolonged time; limit SC, IM injections; SC injections can be diluted in NaCl or lactated Ringer's solution
	5-20 mg/kg PO, SC, IM q12-24h ^{2,84,90}	Most species/may combine with doxycycline for chronic respiratory infections in rats
	10 mg/kg SC q12h ³³	Most species
	0.25 mg/mL drinking water × 7 days ⁷³	Mice/failed to achieve effective plasma concentrations; remains stable for 7 days
Enrofloxacin (E)/doxycycline (D)	10 mg/kg (E) + 5 mg/kg (D) PO q12h ⁸³	Rats/chronic respiratory infection
Erythromycin	—	Do not use orally in chinchillas, guinea pigs; use with caution in hamsters and gerbils ⁹⁰
	10 mg/kg PO q24h ¹¹³	Rats, chronic respiratory disease
	20 mg/kg PO q12h ^{84,90}	Mice, rats, hamsters
	0.13 mg/mL drinking water ⁸⁴	Hamsters/outbreaks of proliferative ileitis; use with caution: can cause enterotoxemia; equivalent to 500 mg/gal drinking water
Gentamicin	—	Use cautiously; nephrotoxic; ensure adequate hydration; can be used topically in nostrils for upper respiratory tract infections; consider use of amikacin instead
	2-5 mg/kg SC, IM q24h ⁸⁴	All species
	4-24 mg/kg SC, IM q12h ²	All species
	20 mg/kg SC q24h ²	Rats

Continued

TABLE 9-1 Antimicrobial and Antifungal Agents Used in Rodents. (cont'd)

Agent	Dosage	Comments
Griseofulvin	—	Dermatophytosis; do not use in pregnant animals; can cause diarrhea, leukopenia, anorexia
	15-50 mg/kg PO q24h × 14-28 days ⁹⁰	Guinea pigs
	25 mg/kg PO q24h ⁹⁰	Most species
Itraconazole	2.5-10 mg/kg PO q24h ^{84,90}	Most species, in guinea pigs less effective than terbinafine for treatment of dermatophytosis ⁸⁵
	5 mg/kg PO q24h ³¹	Guinea pigs/dermatophytosis; consider pulse therapy, 7 days on/off until culture negative ³¹
	50-150 mg/kg PO q24h ^{84,90}	Mice/blastomycosis
Ketoconazole	10-40 mg/kg PO q24h × 14 days ⁹⁰	All species/systemic mycoses; candidiasis
Lime sulfur dip	Dip q7d × 4 treatments ⁹⁰	All species/dermatophytosis; dilute 1:40 with water
Marbofloxacin	2-5 mg/kg PO, SC, IM q24h ⁸⁴	All species/do not give during lactation, pregnancy, or while growing; injectable can be given orally
	4 mg/kg PO, SC q24h ⁹⁰	
Metronidazole	—	Use with caution in chinchillas; objectionable taste may result in reduced food consumption
	10-20 mg/kg PO q12h ⁹⁰	Most species
	10-40 mg/kg PO q24h ⁹⁰	Mice, rats
	20-60 mg/kg PO q8-12h ²	Prairie dogs
	2.5 mg/mL drinking water × 5 day ¹⁴	Mice
Neomycin	—	No absorption following oral administration, therefore not effective against systemic infections; extremely nephrotoxic following parenteral administration
	15 mg/kg PO q12h ⁸⁴	Chinchillas, guinea pigs
	25 mg/kg PO q12h ⁸⁴	Mice, rats, hamsters
	0.5 mg/mL drinking water ⁸⁴	Hamsters
	2 mg/mL drinking water ³³	Mice, rats
	2.6 mg/mL drinking water ⁸⁴	Mice, rats, gerbils
Nystatin	60,000-90,000 U/kg PO q12h × 7-10 days ⁸⁴	Gastrointestinal mycoses; not absorbed from gastrointestinal tract
Oxytetracycline	5 mg/kg IM q12h, or 10-20 mg/kg PO q8h ⁸⁴	Guinea pigs
	15 mg/kg IM q12h, or 50 mg/kg PO q12h ⁸⁴	Chinchillas
	10 mg/kg PO q8h ¹⁴	Gerbils
	10-20 mg/kg PO q8h ⁸⁴	Mice, rats/Tyzer's disease (mice); <i>Mycoplasma pneumoniae</i> (rats)
	20-25 mg/kg IM q8-12h ⁸⁴	Hamsters, gerbils
	100 mg/kg SC q24h ¹⁰⁴	All species
	0.25-1 mg/mL drinking water ¹⁴	Hamsters, mice, rats, gerbils

TABLE 9-1

Antimicrobial and Antifungal Agents Used in Rodents. (cont'd)

Agent	Dosage	Comments
Oxytetracycline (cont'd)	200 mg/L drinking water for 30 days ¹¹³	Rats/prophylactic treatment
	400 mg/L drinking water for 10 days ¹¹³	Rats/curative treatment
	3 g/L drinking water ¹⁰⁴	Chinchillas, guinea pigs
Penicillin G	22,000 U/kg SC, IM q24h ⁹⁰	Rats
Penicillin G (benzathine and procaine)	22,000 U/kg SC, IM q24h ^{84,90}	Most species
	50,000 U/kg SC q3-5d ^{69,72}	Chinchillas, guinea pigs, degus
Sulfonamide/trimethoprim combinations	15-30 mg/kg PO, SC, IM 12-24h ^{84,90}	Most species
	25 mg/kg PO q12h ¹¹³	Rats
	50-100 mg/kg PO, SC q24h ⁸⁴	Gerbils, rats, mice
	0.8 mg/mL drinking water ⁷³	Mice/failed to achieve effective plasma concentrations; remains stable for 7 days
Terbinafine	10-30 mg/kg PO q24h × 4-6 wk ⁹⁰	Most species/antifungal
	20 mg/kg PO q24h ⁸⁵	Guinea pigs/PD; dermatophytosis; more effective than itraconazole
Tetracycline	10 mg/kg PO q8-12h ⁹⁰	Guinea pigs, chinchillas/use with caution ⁹⁰
	10 mg/kg PO, SC q24h ³¹	Guinea pigs
	20 mg/kg PO q12h ²	Most species
	20 mg/kg PO, IM q24h ²	Gerbils
	30 mg/kg PO q6h ²	Hamsters
	0.2-0.5 mg/mL drinking water for 7-10 mL days ¹¹³	Rats
	0.4 mg/mL drinking water ²	Hamsters
	0.6 mg/mL drinking water ²	Mice
	0.7 mg/mL drinking water ²	Guinea pigs/toxicity reported ⁷³
0.1%-0.5% feed × 14 days ²	Rats	
Trimethoprim/sulfonamides	—	See Sulfonamide/trimethoprim combinations
Tylosin	2-10 mg/kg PO, SC q12h ⁹⁰	Hamsters, gerbils/use with caution
	10 mg/kg PO, SC q12h ^{84,90,115}	Chinchillas, guinea pigs, mice, rats/toxicity reported in guinea pigs
	10 mg/kg PO q24h × 5 days ¹¹³	Rats
	0.5 mg/mL (500 mg/L) drinking water ¹⁵	Gerbils, hamsters, mice, rats/PD in rats; ¹⁸ toxicity in hamsters reported ³
Vancomycin	20 mg/kg PO q24h ⁴⁶	Tyzzler's disease

⁹⁰Oral antibiotic treatment can result in enteritis and antibiotic-associated clostridial enterotoxemia, especially when antibiotics with a primary Gram-positive spectrum are given. Chinchillas, guinea pigs, and hamsters are most susceptible. Also, direct toxicity due to streptomycin and dihydrostreptomycin occurs in gerbils, guinea pigs, hamsters, and mice. Procaine, included in some penicillin preparations, can be toxic to mice. Guinea pigs and chinchillas are highly susceptible to the ototoxic effects of chloramphenicol and aminoglycosides at dosages above those recommended clinically. Antibiotics implicated in antibiotic-associated clostridial enterotoxemia following oral administration include:^{49,97}

- Chinchillas: penicillins (including ampicillin, amoxicillin), bacitracin, cephalosporins, clindamycin, erythromycin, lincomycin.
- Guinea pigs: penicillins (including ampicillin, amoxicillin), cefazolin, clindamycin, erythromycin, lincomycin, dihydrostreptomycin, streptomycin, bacitracin, chlortetracycline, oxytetracycline, tetracycline, tylosin.
- Hamsters: penicillins (including ampicillin, amoxicillin), bacitracin, cephalosporins, clindamycin, erythromycin, lincomycin, vancomycin, dihydrostreptomycin, streptomycin, tylosin.

TABLE 9-2 Antiparasitic Agents Used in Rodents.

Agent	Dosage	Comments
Albendazole	5 mg/kg PO q12h ¹⁰ 25 mg/kg PO q12h × 2 days ⁹⁰	Guinea pigs Chinchillas/giardiasis
Amitraz	1.4 mL/L (0.007%) topical q7-14d × 3 treatments ^{2,84,90} 0.3% solution topically q7-14d × 3-6 treatments ^{84,90} 1.4 mL/L topical, repeat q14d ¹¹³	Gerbils, hamsters/demodocosis; apply with cottonball, brush; use with caution; not recommended in young Guinea pigs/mites Rats
Carbaryl powder (5%)	Topical q7d × 3 treatments ⁹⁰	Guinea pigs/ectoparasites
Dimetridazole	20-50 mg/kg PO q24h × 7 days ¹⁰ 1.2-10 mg/mL drinking water for 5 days ⁹⁹ 500 mg/L drinking water ^{10,103} 1 g/L drinking water for 40 days ¹⁰ 4 g/L drinking water for 7 days ^{10,113}	Guinea pigs/ <i>Trichomonas</i> , <i>Giardia</i> Mice/trichomoniasis, but not effective; use metronidazole or tinidazole instead ⁹⁹ Degus, hamsters/ <i>Trichomonas</i> , <i>Giardia</i> Chinchillas, degus, chipmunks, squirrels/ <i>Giardia</i> Rats, mice/ <i>Giardia</i> , <i>Hexamita</i>
Doramectin	0.2-0.5 mg/kg SC q7-14d for 2-3 treatments ¹⁰	Most species
Emodepside/ praziquantel (Profender, Bayer)	0.07-0.7 mL/kg topical ⁸¹	Mice/PD; nematodes; cestodes; contains 21.4 mg/mL of emodepside and 85.9 mg/mL of praziquantel
Fenbendazole	20 mg/kg PO q24h for 5 days ^{10,113} 20-50 mg/kg PO q24h × 5 days ^{2,84,90} 25-150 ppm in feed for 5 days ¹¹³ 50 ppm in feed for 5 days ¹¹³ 300 ppm in feed for 5 days ¹¹³	Rats, guinea pigs All species/giardiasis; a lower dose is generally preferred; higher end for giardiasis only ⁸⁴ Mice/ <i>Oxyurids</i> Mice/ <i>Hymenolepis diminata</i> Mice/ <i>Rodentolepis nana</i>
Fipronil	7.5 mg/kg topically q30-60d ⁸⁴ 1-2 spray pumps topical, repeat 1-2 × q7-10d ³¹	Most species/fleas, ticks, and lice Guinea pigs
Imidacloprid	20 mg/kg topically q30d ^{84,90}	Most species/flea control
Imidacloprid 10%/ moxidectin 1% (Advocate, Bayer)	0.1 mL/animal ⁵²	Guinea pigs/ectoparasites (i.e., fleas, biting lice, mites)
Ivermectin	0.2-0.4 mg/kg PO, SC q7-14d ⁹⁰ 0.2-0.5 mg/kg SC, PO q7-14d ⁸⁴ 0.3 mg/kg PO q24h ¹¹¹ 0.4 mg/kg SC q7d ¹¹¹ 0.4 mg/kg SC, repeat q14d ²⁷	Most species/ectoparasites; preferred dosage appears to be 0.4 mg/kg q7d (higher doses have also been reported); for <i>Demodex</i> , use q7d Most species Hamsters/PD; demodicosis Hamsters/notoedric mites Guinea pigs/PD; <i>Trixacarus caviae</i>

TABLE 9-2 Antiparasitic Agents Used in Rodents. (cont'd)

Agent	Dosage	Comments
Ivermectin (cont'd)	Spray animals or topical drops ⁹	Mice/clinical trial for mite control; ⁹ use 1% ivermectin diluted 1:100 with 1:1 propylene glycol:water (0.1 mg/mL); sprayed onto mice or topical behind ear
	8 mg/L drinking water × 4 days/ wk × 5 wk ⁶⁰	Mice/pinworms
	25 mg/L drinking water × 4 days/ wk × 5 wk ⁶⁰	Rats/pinworms
	48 mg/L drinking water × 3 days ³⁴	Rats/pinworms, <i>Giardia</i> , <i>Hymenolepis</i>
Levamisol	25 mg/kg SC ¹⁰	Guinea pigs
Lime sulfur dip	Dip q7d × 6 wk ⁹⁰	All species/ectoparasites; dilute 1:40 with water
Mebendazole	20 mg/kg PO ¹⁰	Guinea pigs
	40 mg/kg PO q7d × 21 days ²	Mice, rats/pinworms
	50-60 mg/kg PO q12h × 5 days ¹⁰	Chinchillas, degus, chipmunks
Metronidazole	10-20 mg/kg PO q12h, or 40 mg/ kg q24h ⁸⁴	Guinea pigs, chinchillas/use with caution in chinchillas; objectionable taste may result in reduced food intake
	20-40 mg/kg PO q24h ⁸⁴	Rats, mice, gerbils, hamsters
	20-50 mg/kg PO q8h ⁹⁰	Gerbils, hamsters
	25 mg/kg PO q12h ¹⁰	Guinea pigs, chinchillas
	50-60 mg/kg PO q12h for 5 days ¹¹³	Rats
	2.5 mg/mL drinking water × 5 days ^{2,10,99}	Rats, mice/trichomoniasis
Moxidectin	—	See Imidacloprid
Niclosamid	100 mg/kg PO 2 × q7d ¹⁰	Guinea pigs/ <i>Hymenolepis</i> spp.
Nitenpyram (Capstar, Novartis)	1 mg/kg PO once ⁸⁴	Most species/fleas, flystrike; safe in pregnant animals ⁸⁴
Permethrin	0.25% dust in cage ⁷⁴	All species/ectoparasites
Piperazine adipate	500 mg/kg PO q24h ⁹⁰	Chinchillas
	3-5 mg/mL drinking water × 7 days, off 7 days, on 7 days ⁹⁰	Hamsters, gerbils
	4-7 mg/mL drinking water × 3-10 days ⁹⁰	Guinea pigs, mice, rats
Piperazine citrate	100 mg/kg PO q24h × 2 days ⁹⁰	Chinchillas
	4-5 mg/mL drinking water × 7 days, off 7 days, on 7 days ⁸⁴	Rats, mice
	4-7 g/L drinking water ¹⁰	Guinea pigs
	10 mg/mL drinking water × 7 days, off 7 days, on 7 days ^{84,90}	Guinea pigs, hamsters
Ponazuril	30 mg/kg PO q48h × 2 treatments ³⁸	Prairie dogs/ <i>Eimeria</i>

Continued

TABLE 9-2 Antiparasitic Agents Used in Rodents. (cont'd)

Agent	Dosage	Comments
Praziquantel	5-10 mg/kg PO, SC q10d × 2 treatments ³¹	Guinea pigs
	6-10 mg/kg PO, SC, repeat in 10 days ^{31,90}	All species/cestodes, trematodes
	30 mg/kg PO q14d × 3 treatments ⁸⁴	Gerbils, mice, rats
	140 ppm in feed for 7 days ²	Mice
Pyrantel pamoate	50 mg/kg PO ^{84,90}	Most species/gastrointestinal nematodes
Pyrethrin powder	Topical 3 × /wk ⁹⁰	Gerbils, hamsters, mice, rats/ectoparasites
	Topical q7d × 3 treatments ⁹⁰	Chinchillas, guinea pigs/ectoparasites
Pyrethrin shampoo (0.05%)	Shampoo q7d × 4 treatments ⁹⁰	Hamsters, gerbils, mice, rats/fleas
Ronidazole	400 mg/L drinking water ^{10,113}	Rats, mice, gerbils
Selamectin	15 mg/kg topically once ²⁷	Guinea pigs/PD; <i>Trixacarus caviae</i>
	15-30 mg/kg topically q21-28d × 2 treatments (q14d for <i>Demodex</i>) ^{29,31}	Most species/use 30 mg/kg for <i>Sarcoptes</i>
Sulfadimethoxine	15-100 mg/kg PO q24h × 3 days, 5 days break, then treat for 3 more days ¹⁰	Guinea pigs
	25-50 mg/kg PO q24h × 10 days ⁹⁰	Most species
	50 mg/kg PO once, then 25 mg/kg q24h × 10-20 days	All species/coccidiosis
Sulfamerazine	1 mg/mL drinking water ⁹⁰	Most species/coccidiosis
	1.5 mg/L drinking water for 10 days ¹⁰	Chinchillas, degus, chipmunks, squirrels/coccidia
Sulfamethazine	1 mg/mL drinking water × 4 days, then 4 days off, repeat for 3 more treatments ¹⁰	Chinchillas, degus, chipmunks, squirrels/coccidia
	1-5 mg/mL drinking water ²	All species/coccidiosis
Sulfamethoxyypyrazine	25 mg/kg PO q24h × 3-5 days ¹⁰	Guinea pigs
Sulfaquinoxaline	1 mg/mL drinking water × 14-21 days ^{2,90}	All species/coccidiosis
Thiabendazole	50-100 mg/kg PO q24h × 5 days ⁹⁰	Most species/ascaridiasis
	100-200 mg/kg PO q24h × 5 days ¹⁰	Guinea pigs
Tinidazole	50-100 mg/kg PO ⁶⁹	Prairie dogs/ <i>Giardia</i>
	2.5 g/L drinking water ^{10,99}	Rats, mice, gerbils
Toltrazuril (Baycox, Bayer)	10 mg/kg PO q24h × 3 days, off 3-5 days, on 3 days ^{30,103,113}	Most species/drug of choice for coccidiosis; 2.5% solution has very low pH; needs to be diluted with equal parts water and propylene glycol (1:1:1); ¹⁰⁶ 5% solution does not need to be diluted
	10-20 mg/kg PO q24h for 3 days, 5 days break, then give for 3 more days ¹¹³	Hamsters/coccidiosis
	25 mg/L drinking water ¹⁰	Most species

TABLE 9-3 Chemical Restraint/Anesthetic Agents Used in Rodents.

Agent	Dosage	Comments
Acepromazine	— 0.5-1 mg/kg IM ^{90,114} 0.5-2.5 mg/kg IM, SC, PO ⁸⁴ 0.5-5 mg/kg IM, SC, PO ⁸⁴	See ketamine for combinations Most species Rats Guinea pigs, hamsters, mice/higher doses should only be given PO
Alfaxalone	— 2-5 mg/kg IV ⁶⁵ 5-10 mg/kg SC, IM administration ⁹⁴ 20 mg/kg IP ⁶⁵ 40 mg/kg IM, IP ⁸⁴ 80 mg/kg IP ¹⁰⁸ 100 mg/kg SC, IP ⁴⁸	Licensed for IV administration; can be administered IM, SC, IP, but high doses needed, resulting in large volumes Rats/anesthesia; mean duration <15 min Chinchillas, not effective ⁹⁴ Rats/anesthesia, 20-60 min; no induction in 30% of animals Guinea pigs Mice/surgical anesthesia for ~60 min Mice/anesthesia
Alfaxalone (A)/butorphanol (B)	(A) 5 mg/kg + (B) 0.5 mg/kg IM ⁹⁴	Chinchillas/short-term inconsistent anesthesia (<20 min); significant postanesthetic reduction in food intake and fecal output ⁹⁴
Alfaxalone (A)/medetomidine (Me)/butorphanol (B)	(A) 40-80 mg/kg + (Me) 0.3 mg/kg + (B) 5 mg/kg SC ⁴³	Mice/anesthesia; surgical anesthesia for 35-85 min dependent on alfaxalone dose; not effective after IP administration
Alfaxalone (A)/xylazine (X)	(A) 80 mg/kg + (X) 10 mg/kg IP ¹⁰⁸	Mice/surgical anesthesia for 80 ± 18 min
Atipamezole (Antisedan, Pfizer) ^a	5 × the administered medetomidine dose, or 10 × the administered dexmedetomidine dose SC, IM ⁸⁴ 1 mg/kg SC ⁹⁰	Dexmedetomidine/medetomidine reversal All species
Atropine	0.04-0.4 mg/kg SC, IM ⁹⁰ 0.05-0.2 mg/kg SC, IM, IV ⁹⁰ 0.1-0.2 mg/kg SC, IM ⁸⁴	Gerbils, hamsters, mice, rats/rats possess serum atropinesterase Chinchillas, guinea pigs Chinchillas, guinea pigs
Bupivacaine	0.5 mg/kg ³ 1 mg/kg + 0.1 mg/kg morphine (preservative free) epidural ⁸⁴ 1-2 mg/kg local nerve block ⁸⁴ 1.6 mg/kg epidural ⁸⁴ 2.3 mg/kg epidural ⁸⁴	Guinea pigs/nerve blocks Limit volume to 0.33 mL/kg Guinea pig, rats Anesthesia to level of L4 Anesthesia to level of T11-13
Dexmedetomidine (Dexdomitor, Orion)	—	α ₂ -agonist similar to medetomidine; see ketamine for combination
Diazepam	— 0.5-5 mg/kg IM ⁸⁴ 2.5-5 mg/kg IM ⁸⁴	See fentanyl/fluanisone and ketamine for combinations Guinea pigs Chinchillas, hamsters, gerbils, rats, mice

Continued

TABLE 9-3 Chemical Restraint/Anesthetic Agents Used in Rodents. (cont'd)

Agent	Dosage	Comments
Fentanyl/fluanisone (Hypnorm, Janssen)	— 0.2-0.6 mL/kg IM, IP ⁷⁴ 0.5-1 mL/kg IM ⁸⁴	Anesthesia Mice, rats Guinea pigs
Flumazenil	0.1 mg/kg SC ⁴⁶	Chinchillas/midazolam reversal
Glycopyrrolate	0.01-0.02 mg/kg SC ⁵⁰	All species/excess oral or respiratory mucus
Isoflurane	2%-5% induction, then 0.25%-4% maintenance ^{74,84}	All species/inhalant anesthetic of choice
Ketamine	— 20-40 mg/kg IM ⁷⁴ 22 mg/kg IM ⁷⁴ 22-44 mg/kg IM ⁷⁴ 40-60 mg/kg IM ⁷⁴	Avoid use alone, due to high doses needed; ketamine combinations follow Chinchillas, hamsters/light sedation; heavy sedation at higher doses in hamsters Mice, rats/light sedation; heavy sedation at 44 mg/kg in mice and 25-40 mg/kg in rats Guinea pigs/light sedation; heavy sedation at higher doses Gerbils/light sedation; heavy sedation at higher doses (marked individual variation)
Ketamine (K)/acepromazine (A)	(K) 40 mg/kg + (A) 0.5 mg/kg IM ⁸⁹ (K) 50-150 mg/kg + (A) 2.5-5 mg/kg IM ⁸⁸	Chinchillas/anesthesia; prolonged recovery Mice, rats/lower end of doses preferred
Ketamine (K)/dexmedetomidine (De)	(K) 2-4 mg/kg + (Me) 0.025 mg/kg IM ⁸⁴ (K) 3-5 mg/kg + (De) 0.05 mg/kg SC, IM ⁸⁴ (K) 4 mg/kg + (De) 0.015 mg/kg ^{24,35} (K) 75 mg/kg + (De) 0.5 mg/kg IP ⁷⁴	Most species/sedation Guinea pigs/short anesthesia Chinchillas/surgical anesthesia; provide supplemental oxygen; reverse with atipamezole ³⁵ Mice, rats
Ketamine (K)/diazepam (D)	(K) 20-30 mg/kg + (D) 1-2 mg/kg IM ⁷⁴ (K) 20-40 mg/kg + (D) 1-2 mg/kg IM ⁴⁹	Guinea pigs/anesthesia Chinchillas/anesthesia
Ketamine (K)/medetomidine (Me)	(K) 2-4 mg/kg + (Me) 0.05 mg/kg IM ⁸⁴ (K) 3-5 mg/kg + (Me) 0.1 mg/kg SC, IM ⁸⁴ (K) 4-5 mg/kg + (Me) 0.03 mg/kg ⁶⁹ (K) 5 mg/kg + (Me) 0.06 mg/kg IM ⁴⁶ (K) 5-10 mg/kg + (Me) 0.02-0.04 mg/kg IM ⁵¹ (K) 20 mg/kg + (Me) 0.1 mg/kg + buprenorphine 0.03 mg/kg IM ³ (K) 40 mg/kg + (Me) 0.5 mg/kg IM, IP ^{31,74} (K) 40-75 mg/kg + (Me) 1 mg/kg IP ²²	Most species/sedation Guinea pigs/short anesthesia Chinchillas/anesthesia; provide supplemental oxygen; reverse with atipamezole Chinchillas/anesthesia Degus/anesthesia; supplement with isoflurane if needed Guinea pigs/premedication Guinea pigs/20-30 min duration of anesthesia Mice/anesthesia; minor procedures; use the higher dose of ketamine in females; (Me) reversal is atipamezole

TABLE 9-3 Chemical Restraint/Anesthetic Agents Used in Rodents. (cont'd)

Agent	Dosage	Comments
Ketamine (K)/medetomidine (Me) (cont'd)	(K) 75-90 mg/kg + (Me) 0.5 mg/kg IM, IP ^{74,90} (K) 100 or 200 mg/kg + (Me) 0.25 mg/kg IP, SC ^{25,58}	Rats, gerbils/surgical anesthesia 20-30 min duration Hamsters (Syrian)/anesthesia
Ketamine (K)/midazolam (M)	(K) 5-10 mg/kg + (M) 0.5-1 mg/kg IM ⁹⁰ (K) 40 mg/kg + (M) 1-2 mg/kg IM, SC, IP ³¹	Chinchillas, guinea pigs, prairie dogs Rats/anesthesia
Ketamine (K)/midazolam (M)/butorphanol (B)	(K) 5-10 mg/kg + (M) 0.2-0.4 mg/kg + (B) 0.3-0.5 mg/kg IM ⁵¹	Degus/anesthesia; supplement with isoflurane if needed
Ketamine (K)/xylazine (X)	(K) 20-40 mg/kg + (X) 2 mg/kg IM ⁴¹ (K) 40 mg/kg + (X) 2 mg/kg IM ⁴⁶ (K) 50 mg/kg + (X) 2 mg/kg IP ⁴¹ (K) 60 mg/kg + (X) 6 mg/kg IP ⁵⁶ (K) 80 mg/kg + (X) 5 mg/kg IM, IP ⁴¹ (K) 80 mg/kg + (X) 8 mg/kg IP ⁵⁶ (K) 100 mg/kg + (X) 5 mg/kg IM, IP ²⁹	Guinea pigs/light anesthesia Chinchillas/anesthesia Gerbils/anesthesia Mice/anesthesia; <40 min Hamsters/anesthesia Mice/anesthesia; <30 min Rats/anesthesia
Medetomidine	— 0.1 mg/kg SC ⁷⁴ 0.1-0.2 mg/kg SC ⁷⁴ 0.15 mg/kg IM ^{12,31} 0.15-0.25 mg/kg IM ⁴² 0.2-0.3 mg/kg SC ³¹	See ketamine for combinations Hamsters/light to moderate sedation Gerbils/light to moderate sedation Rats, guinea pigs/sedation Rats/sedation Hamsters/sedation
Medetomidine (Me)/butorphanol (B)	(Me) 0.1 mg/kg + (B) 2 mg/kg IM ¹²	Rats/sedation
Midazolam	— 0.4-2 mg/kg IM ¹¹⁴ 1-2 mg/kg IM ⁷⁴ 2-3 mg/kg IM ¹¹⁴	See ketamine for combination Guinea pigs, chinchillas All species/preanesthetic Rats, mice, gerbils
Midazolam (M)/butorphanol (B)	(M) 0.2-0.8 mg/kg + (B) 0.3-0.5 mg/kg IM ⁵¹	Degus/sedation
Midazolam (M)/medetomidine (Me)/butorphanol (B)	(M) 1 mg/kg + (Me) 0.05 mg/kg + (B) 2 mg/kg IP ¹² (M) 2 mg/kg + (Me) 0.15 mg/kg + (B) 2.5 mg/kg IP ⁵⁹ (M) 4 mg/kg + (Me) 0.3 mg/kg + (B) 5 mg/kg IP ^{48,56}	Rats/sedation; completely reversible Rats/anesthesia; completely reversible Mice/anesthesia; <60 min; completely reversible
Midazolam (M)/medetomidine (Me)/fentanyl (F)	(M) 1 mg/kg + (Me) 0.05 mg/kg + (F) 0.02 mg/kg IM ⁴⁶ (M) 2 mg/kg + (Me) 0.15 mg/kg + (F) 0.005 mg/kg IM ⁴	Chinchillas/anesthesia, completely reversible with flumazenil (0.1 mg/kg) + atipamezole (0.5 mg/kg) + naloxone (0.05 mg/kg) SC ⁴⁶ Rats/anesthesia, completely reversible with flumazenil (0.2 mg/kg) + atipamezole (0.75 mg/kg) + naloxone (0.12 mg/kg)

Continued

TABLE 9-3 Chemical Restraint/Anesthetic Agents Used in Rodents. (cont'd)

Agent	Dosage	Comments
Midazolam (M)/ medetomidine (Me)/ fentanyl (F) (cont'd)	(M) 2 mg/kg + (Me) 0.2 mg/kg + (F) 0.025-0.05 mg/kg IM ³¹ (M) 3.3 mg/kg + (Me) 0.33 mg/kg + (F) 0.033 mg/kg SC ³¹	Guinea pigs/anesthesia; completely reversible with flumazenil (0.1 mg/kg) + atipamezole (1 mg/kg) + naloxone (0.03 mg/kg) ³¹ Hamsters/anesthesia; completely reversible
Naloxone	0.01-0.1 mg/kg SC, IP ^{46,74,84} 0.02 mg/kg/h IV ⁸⁴	All species/opioid reversal Constant rate infusion (CRI)
Pentobarbital	— 30-45 mg/kg IP ⁴¹ 50 mg/kg IP ⁵⁶ 50-90 mg/kg IP ⁴¹	Anesthesia; not recommended; marginal analgesia; autonomic depression; euthanasia dose is 150 mg/kg ⁸⁴ Guinea pigs, chinchillas, rats Mice/anesthesia, <45 min; no surgical anesthesia achieved Gerbils, hamsters, mice
Propofol	— 3-5 mg/kg IV ⁹⁰ 7.5-10 mg/kg IV ^{74,84}	Anesthesia; induction Guinea pigs, chinchillas, prairie dogs Rats
Sevoflurane	To effect ⁹⁰	Most species
Tiletamine/ zolazepam (Telazol, Fort Dodge)	20-40 mg/kg IM ⁷⁴ 30 mg/kg IM IP ³¹ 50-80 mg/kg IM ⁸⁸	Chinchillas, rats/anesthesia Hamsters Mice, rats
Tiletamine/ zolazepam (T)/ xylazine (X)	(T) 20 mg/kg + (X) 10 mg/kg IP ⁷⁴ (T) 30 mg/kg + (X) 10 mg/kg IM, IP ⁴¹	Gerbils/anesthesia Hamsters/anesthesia
Xylazine	— 5-10 mg/kg SC, IM, IP ⁸⁸	See ketamine, tiletamine/zolazepam for combinations Most species/may cause muscle necrosis when given IM
Yohimbine	0.5-1 mg/kg IV, IP ⁴¹	All species/xylazine reversal

TABLE 9-4 Analgesic Agents Used in Rodents.

Agent	Dosage	Comments
Acetaminophen	100 mg/kg PO ⁸⁶ 200 mg/kg PO ³³ 1-2 mg/mL drinking water ⁵⁰	Rats/PD Mice, rats All species
Acetylsalicylic acid	50-150 mg/kg PO q4-8h ⁸⁴ 87 mg/kg PO ³³ 100 mg/kg PO ^{33,37} 120 mg/kg PO q4h ³³	All species Guinea pigs Rats Mice

TABLE 9-4 Analgesic Agents Used in Rodents. (cont'd)

Agent	Dosage	Comments
Buprenorphine	0.01-0.05 mg/kg IM, SC q6-12h ^{29,84}	Gerbils, hamsters
	0.01-0.05 mg/kg SC, IV q8-12h ³³	Rats
	0.05 mg/kg SC q8-12h ^{31,33}	Guinea pigs, chinchillas
	0.05 mg/kg q12h SC, IM ¹⁰⁷	Rats/PD; PK
	0.05-0.1 SC q12h ³³	Mice
	0.1 mg/kg SC q12h ⁵⁷	Mice/PD; not sufficient analgesia following laparotomy
	0.1-0.25 mg/kg PO q8-12h ³³	Rats
	0.1-0.4 mg/kg PO ^{87,100}	Rats
	0.2 mg/kg SC q4-6h ⁷¹	Chinchillas/PD
	0.2 mg/kg q5h oral transmucosal ¹⁰²	Guinea pigs/PK
	0.2 mg/kg IV q7h ¹⁰²	Guinea pigs/PK
0.5 mg/kg SC q8h ³¹	Hamsters	
Buprenorphine, extended release (Animalgesics for Mice and Rats, Animalgesic Labs)	0.65 mg/kg SC q48h ⁵⁴	Rats/PD
Buprenorphine, sustained release (Buprenorphine SR, Zoopharm)	—	Injections site lesions have been reported
	0.3-1.2 mg/kg SC q48-72h ²¹	Rats/PD
	0.6 mg/kg SC q72h ⁵⁷	Mice/PD; sufficient post-laparotomy analgesia
	1.2 mg/kg SC q72-96h ^{54,107}	Rats/PD; PK
	1.2 mg/kg SC q72h ¹⁶	Prairie dogs/PK
	1.5 mg/kg SC q48h ⁴⁴	Mice/PD
2.2 mg/kg SC q24-48h ⁵³	Mice/PD; PK	
Butorphanol	0.2-2 mg/kg q2-4h ^{6,90}	Most species
	1-2 mg/kg SC q4h ³³	Guinea pigs, rats, mice
	1-5 mg/kg SC q4h ^{29,84,90}	Gerbils, rats, mice, hamsters
Carprofen	—	Nonsteroidal antiinflammatory; high end of dosage reflects total daily dose; can be divided
	2-5 mg/kg PO, SC, IM, IV total daily dose give q12-24h ⁸⁴	All species
	4 mg/kg SC q12-24h ⁸⁷	Guinea pigs, chinchillas
	5 mg/kg SC ^{29,33}	Rats, mice, gerbils
	5-10 mg/kg PO ^{67,114}	Rats, mice, gerbils
	5-15 mg/kg SC ^{100,101}	Rats/PD
Celecoxib	10-20 mg/kg PO ⁸⁶	Rats/PD
Clonidine	0.25-0.5 mg/kg PO ³⁷	Mice
Codeine	40 mg/kg SC ⁸⁰	Rats/PD

Continued

TABLE 9-4 Analgesic Agents Used in Rodents. (cont'd)

Agent	Dosage	Comments
Diclofenac	2.1 mg/kg PO ³³ 8 mg/kg PO ³³ 10 mg/kg PO ³³	Guinea pigs Mice Rats
Dipyron	—	See metamizole
Duloxetine	10 mg/kg IP ⁵⁵ 30 mg/kg PO q24h ⁵⁵	Mice/PD Mice/PD
Fentanyl	0.025-0.6 mg/kg SC ³⁷ 0.16 mg/kg SC ⁸⁰	Mice Rats/PD
Flunixin meglumine	— 2.5 mg/kg SC ⁸⁷ 2.5-5 mg/kg SC q12-24h ³³	Nonsteroidal antiinflammatory; do not use in dehydrated animals Most species Most species
Gabapentin	10-30 mg/kg PO ⁵⁵ 30 mg/kg PO q8h ⁸⁴ 50 mg/kg PO q24h ⁸⁴	Mice/PD Rats Hamsters
Hydrocodone	10-40 mg/kg SC ⁸⁰	Rats/PD
Hydromorphone	0.4 mg/kg SC < q2h ¹¹⁰ 2 mg/kg SC < q4h ⁷⁰	Rats/PD Chinchillas/PD
Ibuprofen	10 mg/kg PO q4h ³³ 15 mg/kg PO ³³ 30 mg/kg IP ⁹¹ 30 mg/kg PO ³³ 40 mg/kg PO ⁴³	Guinea pigs Rats Rats/PD Mice Mice/PD study
Indomethacin	8 mg/kg PO ³³	Guinea pigs
Ketoprofen	1-3 mg/kg SC, IM q12-24h ^{84,90} 5 mg/kg SC ³³ 5-15 mg/kg SC ¹⁰¹	Chinchillas, guinea pigs, prairie dogs/in prairie dogs, doses of 3-5 mg/kg have been used Rats, mice Rats/PD
Meloxicam	0.1-0.3 mg/kg PO, SC q24h ^{33,87} ≥0.5 mg/kg PO, SC q24h ⁹⁰ 1 mg/kg PO, SC ^{33,87} 1-2 mg/kg PO q12-24h ^{6,84} 1-5 mg/kg PO, SC q24h ⁹⁰ 5 mg/kg PO, SC ³³	Guinea pigs Chinchillas, guinea pigs, hamsters, gerbils Rats Rats Mice Mice
Meloxicam, sustained release (Meloxicam SR, Zoopharm Fort Collins, CO)	4 mg/kg SC q72h ¹⁶ 4 mg/kg SC q96h ¹⁰⁷	Prairie dogs/PK Rats/PD
Meperidine	10-20 mg/kg SC, IM q2-3h ³³	Guinea pigs, mice, rats
Metamizole	20-50 mg/kg PO, SC q6-12h ^{29,30}	Most species

TABLE 9-4 Analgesic Agents Used in Rodents. (cont'd)

Agent	Dosage	Comments
Methadone	0.5-3 mg/kg SC ²⁶	Rats/PD
	1-2 mg/kg SC, IM ⁶	Mice
	1-4 mg/kg SC, IM ⁶	Rats
	5-10 mg/kg IP ¹	Rats/PD
Morphine	1-3 mg/kg SC ⁵⁵	Mice/PD
	2-5 mg/kg SC, IM q4h ^{6,33,90}	Most species, guinea pigs
	2.5 mg/kg SC q2-4h ^{33,84}	Rats, mice, hamsters
Nalbuphine	1-2 mg/kg IM q3h ³³	Guinea pigs, rats
	2-4 mg/kg IM q4h ³³	Mice
Oxycodone	10-40 mg/kg SC ⁸⁰	Rats/PD
Oxymorphone	0.2-0.5 mg/kg SC, IM q4h ^{33,87}	Guinea pigs, rats, mice
Pentazocine	5-10 mg/kg SC q2-4h ⁸⁴	Gerbils, guinea pigs, hamsters, mice, rats
	5-10 mg/kg SC q3-4h ³³	Rats, mice
Pethidine	10-20 mg/kg SC, IM q2-3h ^{33,84}	Most species
Piroxicam	3.4-20 mg/kg PO ⁸⁴	Mice
Tolfenamic acid	2 mg/kg SC q24h ⁸⁴	Guinea pigs
	4 mg/kg PO, SC q24h for 3 doses max ^{29,30}	Most species
Tramadol	—	Oral route unlikely to be effective
	5 mg/kg SC, IP ^{6,33}	Rats/mice
	10-20 mg/kg PO, SC q8-12h ⁸⁴	Rats
	10-40 mg/kg SC q12h ⁸⁴	Mice
	10-40 mg/kg SC ⁷⁰	Chinchillas/PD; no analgesic effects; side effects at >40 mg/kg; single-dose study

TABLE 9-5 Cardiovascular Agents Used in Rodents.

Agent	Dosage	Comments
Atenolol	0.2-2 mg/kg PO q24h ⁵²	Most species/beta-blocker; hypertension and tachyarrhythmias
	2-10 mg/kg IV, IP q24h ⁸⁴	Mice
Atropine	0.05-0.5 mg/kg SC, IM ^{2,52}	All species/preanesthetic, cardiac problems
	0.1-0.2 mg/kg SC IM ⁸⁴	Guinea pigs, chinchillas
	Up to 10 mg/kg IM, SC, IV q20min ^{41,84}	All species/organophosphate toxicity
Benazepril	0.05-0.1 mg/kg PO q24h ^{52,84}	Most species/ACE inhibitor; heart failure, hypertension, and chronic renal failure
	0.125-0.25 mg/kg PO q24h ^{29,30}	

Continued

TABLE 9-5 Cardiovascular Agents Used in Rodents. (cont'd)

Agent	Dosage	Comments
Carvedilol	1-11 mg/kg PO q24h ⁸⁴ 2-30 mg/kg PO q24h ⁸⁴	Hamsters/beta-blocker Rats/beta-blocker
Digoxin	0.005-0.01 mg/kg PO q12-24h ²⁹⁻³¹ 0.05-0.1 mg/kg PO q12-24h ^{74,84}	Most species Hamsters/dilated cardiomyopathy
Diltiazem	0.5-1 mg/kg PO q12-24h ^{31,52}	Most species/Ca channel blocker; hypertension and hypertrophic cardiomyopathy
Dopamine	0.08 mg/kg IV prn ⁶⁴	Guinea pigs/hypotension, especially anesthetic related
Enalapril	0.5-1 mg/kg PO q24h ^{30,31}	ACE inhibitor; heart failure
Epinephrine (adrenaline)	0.003-0.1 mg/kg IV prn ³¹ 0.01 mg/kg IV ⁸⁴ 0.1 mg/kg IV ⁹⁰	Guinea pigs/cardiac arrest Most species Most species
Etilefrine	0.5-1 mg/kg PO q6-8h ³⁰	Sympathomimetic
Furosemide	1-4 mg/kg SC, IM q4-6h, or 5-10 mg/kg SC, IM q12h ⁸⁴ 1-5 mg/kg PO, SC, IM q12-24h ^{29,30}	Most species Most species/congestive heart failure
Glyceryl trinitrate ointment (2%)	3 mm strip applied to inner pinna q6-12h ^{52,84}	Most species/congestive heart failure
Glycopyrrolate	0.01-0.02 mg/kg SC, IM, IV ⁸⁴	Most species/anticholinergic agent used for bradycardia; premedication
Imidapril hydrochloride	0.125-0.25 mg/kg PO q24h ³⁰	ACE inhibitor
Lidocaine	1-2 mg/kg IV, or 2-4 mg/kg IT ⁵²	Most species/arrhythmias
Metildigoxin	0.005-0.01 mg/kg PO q24h ³⁰	Dilative cardiomyopathy, tachycardic arrhythmia
Pimobendan	0.2-0.4 mg/kg PO q12h ⁷⁴ 0.25 mg/kg PO q12h ^{29,30}	Most species/inodilator for treating heart failure Most species
Propentofyllin	10-25 mg/kg PO q12-24h ^{29,30}	Ischemia; phosphodiesterase inhibitor
Taurine	100 mg/kg PO q12h × 8 wk ⁵²	Most species/cardiomyopathy
Verapamil	0.25-0.5 mg/kg SC q12h ⁸⁴	Hamsters/calcium channel blocker

TABLE 9-6 Emergency Drugs Used in Rodents.

Agent	Dosage	Comments
Atropine	0.05-0.1 mg/kg SC ^{29,30} 0.1-0.2 mg/kg SC, IM ⁸⁴ Up to 10 mg/kg IM, SC, IV q20min ^{41,84}	All species/bradycardia; some rats possess serum atropinase Chinchillas, guinea pigs All species/organophosphate toxicity

TABLE 9-6 Emergency Drugs Used in Rodents. (cont'd)

Agent	Dosage	Comments
Calcium gluconate	100 mg/kg IM, IP once ^{31,74}	Guinea pigs/dystocia; follow with 1 U oxytocin (see Table 8.7)
	100 mg/kg IM, IP once ⁸⁴	Chinchillas/hypocalcemic tetany; eclampsia
Charcoal (activated)	0.5-5 g/kg PO prn ⁸⁴	Acute poisoning with organophosphates and other pesticides
Dexamethasone	—	All species/antiinflammatory
	0.5-2 mg/kg SC, IM, IV ⁹⁰	
	0.6 mg/kg IM, IV ^{2,84}	Guinea pigs/pregnancy toxemia
	4-5 mg/kg SC, IM, IP, IV ⁷⁴	Shock
Diazepam	0.5-5 mg/kg IM, IV, IP ⁸⁴	All/treatment of seizures, sedation
Diphenhydramine	—	Antihistamine; anaphylaxis
	1-2 mg/kg PO, SC q12h ⁹⁰	All species
	1-5 mg/kg SC prn ^{84,90}	Guinea pigs
Dopamine	0.08 mg/kg IV ⁶⁴	Guinea pigs/hypotension
Doxapram	—	Respiratory stimulant
	2-5 mg/kg IV, IP, SC ^{31,84}	Guinea pigs
	5-10 mg/kg IV, IP ^{30,84}	Most species
Ephedrine	1 mg/kg IV ⁸⁴	Guinea pigs/antihistamine; stimulant
Epinephrine (adrenalin)	0.003-0.1 mg/kg IV prn ³¹	Guinea pigs/cardiac arrest
	0.01 mg/kg IV ⁸⁴	Most species
	0.1 mg/kg IV ⁹⁰	Most species
Furosemide	—	Diuretic for edema, pulmonary congestion, ascites
	1-4 mg/kg SC, IM q4-6h, or 5-10 mg/kg SC, IM q12h ⁸⁴	Most species
	1-5 mg/kg PO, SC, IM q12-24h ^{29,30}	Most species/congestive heart failure
Glycopyrrolate	0.01-0.02 mg/kg SC, IM, IV ⁸⁴	Most species/anticholinergic agent used for bradycardia; premedication
Hetastarch	1-10 mL/kg IV ⁸⁴	Rats/hypotension, shock
	3 mL/kg IV, IO ⁶⁶	Shock; administer with hypertonic saline (3 mL/kg) over 10 min
Lactated Ringer's solution	10-25 mL/kg IV, IO ⁹⁶	Most species/give slowly over 5-10 min (if unsuccessful, administer IP)
Mannitol	0.3 g/kg/h IV ³⁰	Reduction of intracranial pressure, acute glaucoma, oliguric renal failure
Prednisolone	10-20 mg/kg IV, IM, IP once ³⁰	Most species/shock
Saline, hypertonic (7.2%-7.5%)	3 mL/kg IV, IO slow over 10 min ⁶⁶	Shock; administer with hetastarch (3 mL/kg) over 10 min

TABLE 9-7 Miscellaneous Agents Used in Rodents.

Agent	Dosage	Comments
Acetylcysteine	3 mg/kg PO, SC q12h ^{29,30} 2% solution nebulization over 30-60 min prn ⁸⁴	Mucolytic Injectable form can be used for nebulization; dilute in 0.9% NaCl
Aglepristone	10 mg/kg IM, SC on days 1, 2, and 8 ⁸⁴ 10 mg/kg SC q24h for 2 doses ²⁹ 10-20 mg/kg SC q12h for 2 doses, repeat after 8 days ³¹	Guinea pigs/progesterone antagonist for treatment of pyometra/metritis, pregnancy termination Rats, hamsters, gerbils/pyometra Hamsters/pyometra
Aluminum hydroxide	20-40 mg/animal PO prn ⁸⁴	Guinea pigs/hyperphosphatemia caused by renal failure
Aminophylline	10 mg/kg PO q12-24h ⁹³ 50 mg/kg PO, SC ^{84,90}	Rats Guinea pigs
Aminotriptyline	5-20 mg/kg PO q24h ⁸⁴	Rats/antidepressant; chronic antianxiety treatment
Asparaginase (L-asparaginase)	400 IU/kg SC q7d ³¹ 10,000 IU/m ² SC, IM q21d ⁸⁴	Guinea pigs/lymphoma Guinea pigs/lymphoma
Atropine (1%)/phenylephrine (10%)	Topical to eyes ⁴¹	All species/mydriasis for non-albino eyes
Barium sulfate (1000 mg/mL)	5-10 mL/kg PO ^{29,30}	Most species/contrast studies; might need to be diluted with water (1:1)
Bromhexine	0.5 mg/kg PO q12-24h ^{29,30} 0.5-1 mg/kg PO q12-24h ³¹	Bronchial secretolytic Guinea pigs
Cabergoline	10-50 µg/kg PO q12-24h ⁸⁴ 0.6 mg/kg PO q72h ⁷⁶ 12.5-15 µg/kg PO q24h × 4-6 days ^{29,30}	Rats/pituitary adenoma Most species/pseudopregnancy
Calcium EDTA	25-30 mg/kg SC q6-12h, 5 days on, 5 day off cycle ⁸⁴ 30 mg/kg SC q12h ^{49,90}	Lead or zinc intoxication; treat until blood levels within normal range at end of off period All species/lead chelation
Carbimazole	1-2 mg/kg PO q24h ^{30,78}	Guinea pigs/hyperthyroidism
Charcoal (activated)	1 g/kg PO ²⁹	Most species/use only in cases of toxicity (not with general diarrhea)
Chlorpheniramine maleate	0.6 mg/kg PO q24h ^{2,84}	Guinea pigs/antihistamine
Cholestyramine	1 g/animal mixed with water PO q24h ⁸⁴	Guinea pigs/gastrointestinal clostridial overgrowth; decreases toxin absorption
Cimetidine	5-10 mg/kg PO, SC, IM, IV q6-12h ⁸⁴	All species/H ₂ -blocker; gastric, duodenal ulceration; esophagitis, gastroesophageal reflux
Cisapride	0.1-0.5 mg/kg PO q8-12h ³¹ 0.1-1 mg/kg PO q8-12h ⁸⁴	All species/may enhance gastrointestinal motility; not commercially available in the United States; must be compounded Chinchillas, guinea pigs

TABLE 9-7 Miscellaneous Agents Used in Rodents. (cont'd)

Agent	Dosage	Comments
Clomipramine	16-32 mg/kg PO q12h ⁸⁴	Rats
Cyclophosphamide	300 mg/kg IP q24h ⁶⁴ 300 mg/m ² IP q24h ⁸⁴	Guinea pigs/antineoplastic
Cyclosporine	10 mg/kg PO q24h ⁸⁴	Rats
Cyproheptadine	0.5 mg/kg PO q12h ⁸⁴	Guinea pigs, chinchillas/appetite stimulation
Deslorelin acetate	4.7 mg implant/animal SC ^{62,105} 4.7 mg implant/animal SC ^{5,19,40,109}	Guinea pigs/suppression of estrus; ovarian cysts (not effective against serous cysts) Rats/anti-gonadal effects, for at least 12 mo ^{5,19}
Dexamethasone	— 0.5-2 mg/kg PO, SC, then decreasing dose q12h × 3-14 days ⁴¹ 0.6 mg/kg IV, IM, SC q24h ⁸⁴	Antiinflammatory All species Guinea pigs/pregnancy toxemia
Diazoxide	25 mg/kg PO q12h ⁴⁷	Guinea pigs/insulinoma
Diphenhydramine	— 1-2 mg/kg PO, SC q12h ⁹⁰ 1-5 mg/kg SC pm ⁸⁴	Antihistamine; anaphylaxis Chinchillas, hamsters, mice, rats Guinea pigs
Diphenylhydantoin	25-50 mg/kg q12h ⁵²	Most species/seizures
Dorzolamide	1 drop of 1% solution q12h ⁸⁴	Rats/glaucoma
Ephedrine	1 mg/kg PO, IV pm ^{64,84}	Guinea pigs/antihistamine; anaphylaxis
Famotidine	0.4-0.5 mg/kg PO, SC, q24h ⁸⁴	Guinea pigs, chinchillas
Fluoxetine	1-1.5 mg/kg PO q24h ⁸⁴ 5-10 mg/kg PO q24h ⁵²	Rats Most species/for behavioral problems (i.e., fur chewing)
Furosemide	1-4 mg/kg SC, IM q4-6h, or 5-10 mg/kg SC, IM q12h ⁸⁴ 1-5 mg/kg PO, SC, IM q12-24h ^{29,30}	Most species Most species/congestive heart failure
GnRH (e.g., gonadorelin)	20 µg/animal IM once ³⁹ 25 µg/animal q14d × 2 treatments ⁷⁵	Guinea pigs/follicular ovarian cysts, short-acting formulations Guinea pigs/follicular ovarian cysts
Heparin	5 mg/kg IV pm ⁶⁴	Guinea pigs/disseminated intravascular coagulation
Human chorionic gonadotropin (hCG)	100 U/kg SC q10-14d × 3 injections ³⁰ 100 U/kg SC q7d for 3 injections ⁸⁴	Guinea pigs/follicular ovarian cysts Guinea pigs/follicular ovarian cysts
Insulin	1 U/kg SC q12h ⁸⁴ 1-3 U/kg q12-24h SC ³⁰ 1-2 U/animal SC q12h ⁸⁴	Chinchillas Guinea pigs, chinchillas, degus/starting dose is 1 U/kg ³⁰ Guinea pigs

Continued

TABLE 9-7 Miscellaneous Agents Used in Rodents. (cont'd)

Agent	Dosage	Comments
Insulin (cont'd)	1-3 U/animal SC q12h ⁸⁴ 2 U/animal SC ⁸⁴	Rats Hamsters, gerbils
Iodine, I-131 (radioactive)	1 mCi/animal SC once ⁷⁸	Guinea pigs/hyperthyroidism
Kaolin pectin	0.2 mL PO q6-8h ² 1-2 mL/kg PO q2-6h ⁸⁴	Guinea pigs/antidiarrheal
Lactulose	0.5 mL/kg PO q12h ⁸⁴ 2 mL/kg PO prn ^{29,30}	Most species/constipation, hepatic disorders Most species/constipation
Leuprolide acetate depot (Lupron Depot, TAP Pharmaceuticals)	0.2-0.3 mg/kg IM q28d ⁹²	Guinea pigs/follicular ovarian cysts
Levetiracetam	20 mg/kg PO q8h ⁸⁴	Prairie dogs/seizures
Levothyroxine	5 µg/kg PO q12h ⁸⁴ 10-20 µg/kg PO q24h ³⁰	Most species/hypothyroidism Guinea pigs/hypothyroidism
Loperamide	0.1 mg/kg PO q8h ^{41,84}	All species/diarrhea; limit use to avoid gastrointestinal stasis
Magnesium hydroxide	4 mg/kg PO ⁵² prn	Prevention of calcium oxalate uroliths
Methimazole	0.5-2 mg/kg PO q24h ⁷⁸ 1-3 mg/kg PO q8-24h ⁶³	Guinea pigs/hyperthyroidism Guinea pigs/hyperthyroidism
Metoclopramide	0.2-1 mg/kg PO, SC, IM q12h ⁹⁰ 0.5-1 mg/kg PO, SC q6-12h ⁸⁴ 1-5 mg/kg q8-12h SC, PO ^{29,30}	Most species Guinea pigs/antiemetic and upper gastrointestinal prokinetic
Metryprone	8 mg/animal PO q24h × 4 wk ^{31,52}	Hamsters/hyperadrenocorticism
Milk thistle (<i>Silybum marianum</i>)	4-15 mg/kg PO q8-12h ⁵²	Most species/hepatic disorders
Mitotane	5 mg/animal PO q24h × 4 wk ⁵²	Hamsters/hyperadrenocorticism
Oxytocin	0.2-3 U/kg SC, IM, IV ⁸⁴ 1 U/kg SC, IM ^{29,30} 1-2 U/animal IM ² 6.25 U/kg SC ²	All species/delayed parturition if unobstructed All species Guinea pigs/uterine contraction; milk letdown Mice/milk letdown
Pentosan polysulphate	3 mg/kg SC q5-7d for 4 doses ⁸⁴	Guinea pigs/osteoarthritis, idiopathic cystitis
Phenobarbital	5-20 mg/kg PO, IV, IP ⁹⁰ 5-25 mg/kg IV, IP q12-24h ⁸⁴	Guinea pigs/antiseizure medication; sedative Guinea pigs, gerbils/seizures
Phenoxybenzamine	0.25 mg/kg PO q12h ⁶⁹	Guinea pigs/urolithiasis
Potassium citrate	10-30 mg/kg PO q12h ⁹⁰	Guinea pigs

TABLE 9-7 Miscellaneous Agents Used in Rodents. (cont'd)

Agent	Dosage	Comments
Prednisolone	1-2 mg/kg PO, SC q12-24h ^{30,31}	Guinea pigs
Prednisone	0.5-2.2 mg/kg PO, SC, IM ⁹⁰	All species
Pseudoephedrine	1.2 mg/animal PO q12h ⁹⁸	Chinchillas/nasal and sinus decongestant
Ranitidine	5 mg/kg PO q12h ⁸⁴	Guinea pigs, chinchillas
S-Adenosylmethionine (SAME)	20-100 mg/kg PO q24h ⁸⁴	Most species
Sildenafil citrate	5 mg/kg PO q24h ⁶¹	Rats
Silymarin	50-200 mg/kg/day PO ¹⁷	Rats
Sucralfate	25-50 mg/kg PO q6-8h ⁸⁴ 25-100 mg/kg PO q8-12h ⁹⁰	Most species/oral, esophageal, gastric, and duodenal ulcers Most species/oral, esophageal, gastric, and duodenal ulcers
Terbutaline	5 mg/kg every PO q12h ^{84,95}	Most species
Theophylline	2-3 mg/kg PO q8-12h ^{29,30} 4-10 mg/kg PO q8-12h ³¹ 10-20 mg/kg PO q8-12h ⁸⁴	Most species Guinea pigs Rats, prairie dogs
Thiamazol	102 mg/kg PO q24h ³⁰	Most species/hyperthyroidism
Thiamine	1 mg/kg feed ⁵²	Most species/thiamine deficiency
Thyroid stimulating hormone (TSH); human recombinant	100 µg/animal IM ⁷⁷	Guinea pigs/thyroid function testing
Toremifene	12 mg/kg PO q24h ⁵²	Rats/pituitary hyperplasia/adenoma
Trilostane	2-4 mg/kg PO q24h ⁸⁴	Hyperadrenocorticism
Vitamin A	50-500 U/kg IM ⁸⁴ 2000 U/animal ⁵² 2 µg vitamin A palmitate/g feed ⁸⁴ 10 mg β-carotene/kg of feed ⁸⁴	Guinea pigs, hamsters Chinchillas/hypovitaminosis A Hamsters Guinea pigs
Vitamin B complex (small animal)	0.02-0.2 mL/kg SC, IM ⁸⁴	All species/B ₁ (100 mg/mL), B ₂ (2 mg/mL), B ₁₂ (0.1 mg/mL)
Vitamin C (ascorbic acid)	10-30 mg/kg PO, SC, IM ⁸⁴ 50-100 mg/kg SC, PO ³¹ 100-200 mg/kg PO q24h ⁸⁴ 0.2-0.4 mg/mL drinking water ⁸⁴	Guinea pigs/maintenance Guinea pigs/treatment of deficiency Guinea pigs/hypovitaminosis C Guinea pigs/prevents deficiency; change daily water
Vitamin D	200-400 U/kg SC, IM ⁷⁴	All species
Vitamin E	50 mg/kg PO q24h ³¹	Guinea pigs
Vitamin K ₁	1-5 mg/kg SC q12-24h ^{29,30} 1-10 mg/kg IM q24h × 4-6 days ⁴¹	Most species All species/warfarin poisoning; menadiols not used in acute cases

TABLE 9-8 Common and Scientific Names of Pet Rodents.³¹

Common Name	Other Common Names	Scientific Name
Chinchilla	Long-tailed chinchilla	<i>Chinchilla lanigera</i>
Chipmunk	Siberian chipmunk; Korean chipmunk	<i>Eutamias sibiricus</i>
Degu	Common degu	<i>Octodon degus</i>
Gerbil	Mongolian gerbil; Mongolian jird, clawed jird	<i>Meriones unguiculatus</i>
Guinea pig	Cavy, cuy	<i>Cavia porcellus</i>
Hamster, Chinese	Striped hamster	<i>Cricetulus griseus</i>
Hamster, dwarf	Russian dwarf hamster, Siberian dwarf hamster, Djungarian hamster	<i>Phodopus sungorus</i>
	Campbell dwarf hamster	<i>Phodopus campbelli</i>
	Roborowski dwarf hamster	<i>Phodopus roborovskii</i>
Hamster, golden	Syrian hamster	<i>Mesocricetus auratus</i>
Mouse	Common mouse	<i>Mus musculus</i>
Prairie dog	Black-tailed prairie dog	<i>Cynomys ludovicianus</i>
Rat	Brown rat, Norway rat	<i>Rattus norvegicus</i>

TABLE 9-9 Hematologic and Serum Biochemical Values of Rodents.⁷⁴

Measurement	Mouse	Rat	Gerbil	Hamster	Guinea Pig	Chinchilla	Prairie Dog
PCV (%)	35-40	35-45	35-45	45-50	35-45	27-54	36-54
RBC ($10^6/\mu\text{L}$)	7-11	7-10	7-8	7-8	4-7	5.6-8.4	5.9-9.4
Hgb (g/dL)	10-20	12-18	14-16	16.6-18.6	11-17	11.8-14.6	12.7-19.6
WBC ($10^3/\mu\text{L}$)	4-12	5-23	7.5-10.9	7-10	7-14	5.4-15.6	1.9-10.1
Neutrophils (%)	5-40	10-50	22	18-40	20-60	39-54	43-87
Lymphocytes (%)	30-90	50-70	75	56-80	30-80	45-60	8-54
Monocytes (%)	0-10	0-10	0-4	2	2-20	0-5	0-12
Eosinophils (%)	0-5	0-5	0-3	0-1	0-5	0-5	0-10
Basophils (%)	0-1	0-1	0-1	0-1	0-1	0-1	0-2
ALT (U/L)	26-77	20-92	—	22-128	10-25	10-35	26-91
ALP (U/L)	45-222	16-96	—	99-186	—	6-72	25-64
AST (U/L)	54-269	—	—	28-122	—	96	16-53
Bilirubin, total (mg/dL)	0.1-0.9	0.2-0.6	0.2-0.6	0.1-0.9	0.3-0.9	0.6-1.3	0.1-0.3
BUN (mg/dL)	17-28	15-21	17-27	12-26	9-32	17-45	21-44
Calcium (mg/dL)	3.2-8	5.3-13	3.7-6.2	5.3-12	7.8-10.5	5.6-12.1	8.3-10.8
Chloride (mEq/L)	82-114	—	—	—	98-115	108-129	—
Cholesterol (mg/dL)	26-82	40-130	90-150	55-181	20-43	50-302	—
Creatinine (mg/dL)	0.3-1	0.2-0.8	0.6-1.4	0.4-1	0.6-2.2	0.4-1.3	0.8-2.3
Glucose (mg/dL)	62-175	50-135	50-135	37-198	60-125	109-193	120-209
Phosphorus (mg/dL)	6-10.4	5.8-8.2	3.7-7	3-9.9	5.3	4-8	3.6-10
Potassium (mEq/L)	5.1-10.4	5.9	3.3-6.3	3.9-5.5	6.8-8.9	3.3-5.7	4-5.7
Protein, total (g/dL)	3.5-7.2	5.6-7.6	4.3-12.5	5.2-7	4.6-6.2	3.8-5.6	5.8-8.1
Albumin (g/dL)	2.5-4.8	3.8-4.8	1.8-5.5	3.5-4.9	2.1-3.9	2.3-4.1	2.4-3.9
Globulin (g/dL)	0.6	1.8-3	1.2-6	2.7-4.2	1.7-2.6	0.9-2.2	3.4-4.2
Sodium (mEq/L)	112-193	135-155	141-172	128-144	146-152	142-166	144-175
Triglycerides (mg/dL)	—	26-145	—	72-227	0-145	—	—

TABLE 9-10 Biologic and Physiologic Data of Rodents.^{30,31,74}

Species	Life Span	Avg wt (g) (male/female)	Temperature °C (°F)	Heart Rate (beats/min)	Respiratory (breaths/min)
Chinchilla	10-20	450-600/550-800	34.9-37.9 (94.8-100.2)	200-240	40-80
Degu	5-7	170-350	37-39 (98.6-102.2)	240-390	80-150
Gerbil	3-4	65-130/70-100	37-39 (98.6-102.2)	260-450	70-130
Guinea pig	4-6	900-1500/700-1000	37.5-39.5 (99.5-103.1)	230-380	40-120
Hamster, Chinese	1.5-3	30-45/30-45	—	—	—
Hamster, golden	2-3	80-150/90-160	37-39 (98.6-102.2)	250-500	50-135
Hamster, Russian dwarf and Campbell	2-3	19-45/19-36	37-39 (98.6-102.2)	200-560	90-120
Hamster, Roborowski dwarf	1.5-2	20-28/18-23	37-39 (98.6-102.2)	200-560	90-120
Mouse	1.5-3	20-40/18-35	36-38 (96.8-100.4)	300-800	70-220
Prairie dog	8-10	1000-2200/500-1500	35.4-39.1 (95.7-102.3)	150-320	30-60
Rat	1.5-3	350-500/250-350	37.5-39.5 (98.6-103.1)	250-450	70-120

TABLE 9-11 Blood Volumes of Rodents with Safe-Bleeding Volume Recommendations.⁹²

Species	Blood Volume (Average)	Safe Venipuncture Volume
Gerbil	67 mL/kg	0.3 mL/animal
Guinea pig	75 mL/kg	7.7 mL/kg
Hamster	78 mL/kg	5.5 mL/kg
Mouse	79 mL/kg	7.7 mL/kg
Rat	64 mL/kg	5.5 mL/kg

TABLE 9-12 Urinalysis Reference Values of Rodents.^{a,23,28,29,32,52,74}

Measurement	Chinchilla	Gerbil	Guinea Pig	Hamster	Mouse	Prairie Dog	Rat
Specific gravity	1.014- >1.060	1.006- 1.080	1.005- 1.050	1.014- 1.060	1.034- 1.058	1.005- 1.059	1.022-1.050
pH	≥8.5	6.2-8.2	8.4 ± 0.3	6.9-9	7.3-8.5	8-8.5	7.3-8.5
Protein ^b (mg/dL)	Present ^b (6-87)	Present ^b	Present ^b	Present ^b	Present ^b	Present ^b (6-124)	Present ^b
Crystals	Common, amorphous crystals predominant		Amorphous crystals predominant			Rare, amorphous	
Parasites	—	—	Cysts of <i>Klossiella</i> <i>cobaye</i> might be seen	—	—	—	<i>Trichosomoides</i> <i>crassicauda</i> (bladder threadworm), larvated ova in urine

^aValues should be considered as guides; values are likely to vary between groups of animals according to such variables as strain, age, sex, fasting, and methodology.

^bProteinuria is a normal feature in most rodent species, and dip stick protein levels do not correlate with actual urinary protein levels in most species, in particular in the presence of alkaline urine.

TABLE 9-13 Reproductive Data for Rodents.^{13,31,41,74}

Species	Estrus Cycle Length (days)	Gestation (days)	Litter Size	Birth Weight (g)	Age Eyes Open (days)	Weaning Age (days)	Breeding Life	Separate Adults Before Birth
Chinchilla	30-50	105-115	1-4	30-50	birth	36-48	—	—
Degu	18-21	87-93	1-10	10-20	2-3	35-42	—	—
Gerbil	4-6	24-26	1-12	2.5-3.5	16-20	21-28	15-20 months	No (mate for life)
Guinea pig	15-19	59-72	2-5	60-100	birth	21-28	3-4 years	No
Hamster	4-5	15-22	4-12	2	14-16	20-28	11-18 months	Yes
Mouse	4-5	19-21	10-12	0.5-1.5	10-14	21-28	12-18 months	No
Prairie dog	14-21	33-38	1-10	15	14	37-51	—	—
Rat	4-5	19-23	6-12	5-6	12-17	17-21	14 months	No

TABLE 9-14 Determining the Sex of Mature Rodents.⁷⁴

Male	Female
<ul style="list-style-type: none"> • Anogenital distance is longer in the male • Manipulate prepuce to protrude penis • Palpate for testicles either in a scrotal sac (if present) or subcutaneous in inguinal region • Males have only two external openings in the inguinal area: <ul style="list-style-type: none"> ◦ Anus ◦ Urethral orifice at tip of penis • In very fat males, there may be a depression between the penis and anus; this depression can be obliterated by manipulating the skin in that area 	<ul style="list-style-type: none"> • Anogenital distance is shorter in the female • Look for three external openings in the inguinal area: <ul style="list-style-type: none"> ◦ Anus (most caudal opening) ◦ Vaginal orifice (middle opening)—look carefully ◦ Urethral orifice at tip of urethral papilla (most cranial opening) • The urethral papilla is located outside the vagina (unlike most other mammals) • In very fat females or young females, the vaginal orifice may be either hidden by folds of skin (the former) or sealed (latter); gentle manipulation of the skin in this area will divulge the orifice

TABLE 9-15 Nutritional Data for Rodents.^{31,74}

Species	Consumption (per 100 g BW/day)		Nutritional Recommendations			
	Food (g)	Water (mL)	Minimum Fiber (%)	Carbo- hydrates (%)	Fat (%)	Protein (%)
Chinchilla	3-6	—	16-18	—	2-4	14-16
Gerbil	5-8	4-7	—	—	2-4	16-22
Guinea pig	6	10	16-18	16	—	18-30
Hamster	8-12	8-10	—	8	3-5	15-25
Mouse	12-18	15	—	45-55	5-25	16-20
Prairie dog	2.3-4.1	—	—	—	—	—
Rat	5-6	≥10-12	—	—	5-25	12-27

TABLE 9-16 Zoonotic Diseases in Rodents.⁷⁴

Species	Potential Zoonotic Disease
Chinchilla	<i>Giardia duodenalis</i> ; <i>Listeria monocytogenes</i> Lymphocytic choriomeningitis (LCM); rare Dermatophytes (<i>Trichophyton mentagrophytes</i> , <i>Microsporum canis</i> , <i>M. gypseum</i>)
Gerbil	Salmonellosis; rare <i>Hymenolepis nana</i> ; rare
Guinea pig	Allergies (cutaneous and respiratory) to dander and urinary proteins <i>Bordetella</i> , salmonellosis, <i>Yersinia pseudotuberculosis</i> , <i>Streptococcus</i> ; rare Dermatophyte (<i>Trichophyton mentagrophytes</i>) Sarcoptic mites (<i>Trixacarus caviae</i> , <i>Sarcoptes scabiei</i>)

Continued

TABLE 9-16 Zoonotic Diseases in Rodents. (cont'd)

Species	Potential Zoonotic Disease
Hamster	Salmonellosis, <i>Acinetobacter</i> Lymphocytic choriomeningitis (LCM); rare Dermatophytes (<i>Trichophyton mentagrophytes</i> , <i>Microsporum</i> spp.) <i>Hymenolepis nana</i>
Mouse	Allergies (cutaneous and respiratory) to dander and urinary proteins Salmonellosis; rare Lymphocytic choriomeningitis (LCM); rare
Prairie dog	<i>Clostridium piliforme</i> , <i>Pasteurella multocida</i> , salmonellosis, <i>Yersinia pseudotuberculosis</i> , <i>Y. pestis</i> , <i>Y. enterocolitica</i> Hantavirus (wild-caught), rabies virus (wild-caught) Dermatophytes (<i>Trichophyton mentagrophytes</i> , <i>Microsporum gypseum</i>) Various ectoparasites (mites, fleas, lice)
Rat	Allergies (cutaneous and respiratory) to dander and urinary proteins Leptospirosis, salmonellosis, cestodiasis, streptococcal infection Seoul virus (hantavirus; hemorrhagic fever with renal syndrome), sylvatic plague (vector: rat fleas), St. Louis encephalitis (vector: <i>Liponyssus sylviarum</i>), rat bite fever (<i>Streptobacillus moniliformis</i>)

TABLE 9-17 Disease Testing in Rodents.²¹

Laboratory	Test
Animal Health Diagnostic Center College of Veterinary Medicine Cornell University, 240 Farrier Rd, Ithaca, NY 14853, USA 607-253-3900 www.diagcenter.vet.cornell.edu Email: diagcenter@cornell.edu	Serum neutralization and direct fluorescence for canine distemper virus, <i>Giardia</i> and <i>Cryptosporidium</i> antigen ELISA, fungal serology
Avian Biotech International 1336 Timberlane Road Tallahassee, FL 32312, USA 800-514-9672 Email: contact@avianbiotech.com www.avianbiotech.com	PCR for <i>Mycobacterium</i> , <i>Candida</i> , <i>Cryptosporidium</i> , <i>Giardia</i> , <i>Salmonella</i>
Avian Biotech International UK PO Box 107 Truro Cornwall, TR1 2YR, England 011-44-1872-262737 Email: contact@avianbiotech.co.uk www.avianbiotech.co.uk	PCR for <i>Mycobacterium</i> , <i>Candida</i> , <i>Cryptosporidium</i> , <i>Giardia</i> , <i>Salmonella</i>
BioReliance Ltd. Todd Campus Glasgow, G20 0XA, Scotland 44 (0)141 946 9999	Rodent and rabbit serology, rodent PCR
Charles River Laboratories International, Inc. 251 Ballardvale Street Wilmington, MA 01887, USA 877-274-8371 (US and Canada) 800 3195 3430 (International) www.criver.com/products-services/basic-research/health-monitoring-diagnostic-services	Serology and PCR for rodents

TABLE 9-17 Disease Testing in Rodents. (cont'd)

Laboratory	Test
IDEXX BioResearch 4011 Discovery Drive Columbia, MO 65201, USA 573-499-5700 800-669-0825 www.idexxbioresearch.com.animal-health-monitoring	PCR testing for rodents and serology for rodents and rabbits
Laboratory Animal Diagnostic Services (LADS) BioReliance Corporation 14920 Broschart Road Rockville, MD 20850, USA 301-738-1000 800-533-5372	Rodent and rabbit serology, rodent PCR
Taconic Anmed One Hudson City Centre, Hudson, NY 12534, USA 888-822-6642 www.taconic.com Email: custserv@taconic.com European Customer Services Email: TaconicEurope@taconic.com	Serology for rodents and rabbits
University of Georgia 110 Riverbend Rd, Riverbend North Athens, GA 30602, USA 706-542-5812 www.vet.uga.edu/IDL/	PCR for <i>Salmonella</i> and <i>Pasteurella</i> , serology for <i>Pasteurella</i> , Aleutian disease virus ELISA
University of Miami—Comparative Pathology 1120 NW 14th Street CRB Building Miami, FL 33136, USA 800-596-7390 www.cpl.med.miami.edu Email: compathlab@med.miami.edu	Serology for rodents, <i>Giardia</i> and <i>Cryptosporidium</i> antigen ELISA
Zoologix Inc 9811 Owensmouth Avenue, Suite 4 Chatsworth, CA 91311, USA 818-717-8880 www.zoologix.com Email: info@zoologix.com	Extensive list of avian, primate, wildlife, and rodent PCR tests

TABLE 9-18 Endocrine Values in Rodents.^{36,52}

Test	Syrian			
	Guinea Pig	Hamster	Mouse	Rat
Free plasma cortisol (µg/dL)	0.6-5.8	0.5-1	—	—
Salivary cortisol ^a (ng/mL)	Baseline: 6.6 ± 3.4	—	—	—
	Post-ACTH stim: 157 ± 53	—	—	—
Total serum T ₄ (µg/dL)	2.26-5.82 ³⁶	3.6	3.08-4.74	3.4-6.22
Free T ₄ (ng/dL)	1.26-2.03	—	—	1.17-2.8
Total T ₃ (ng/dL)	39-44	45.45	84.42-110.39	—
Free T ₃ (ng/dL)	0.221-0.26	—	52-77.9	110-1038 (pg/dL)

^aFor ACTH stimulation test, inject 20 U ACTH IM; repeat sample 4 hr postinjection.

TABLE 9-19 Echocardiographic Measurements in Rodents.^{18,45,68,74,116}

Parameters	Guinea				
	Chinchilla	Pig ^a	Hamster ^a	Mouse ^a	Rat ^a
Left ventricular internal diameter in diastole (mm)	4.3-7.5	6.49-7.21	3.7-4.5	3.48-3.66	5.93-6.43
Left ventricular internal diameter in systole (mm)	1.8-4.0	4.18-4.52	1.9-2.7	2.26-2.42	4.08-4.42
Thickness of left ventricular free wall in diastole (mm)	1.8-3.1	1.44-2.06	0.9-1.1	0.41-0.43	1.12-1.7
Thickness of left ventricular free wall in systole (mm)	—	1.91-2.61	—	0.86-0.92	2.02-2.7
Thickness of interventricular septum in diastole (mm)	1.6-2.5	1.88-2.68	0.9-1.1	0.42-0.44	1.06-1.36
Thickness of interventricular septum in systole (mm)	—	2.22-3.38	—	0.89-0.93	1.4-1.9
Left atrial diameter (mm)	4.3-5.9	4.61-5.29	—	—	—
Aortic diameter (mm)	3.6-4.9	4.4-4.9	—	—	—

^aMeasurements obtained in anesthetized animals.

TABLE 9-20 Electrocardiographic Measurements in Rodents.^{45,112}

Parameters	Guinea Pig	Prairie Dog, Black-Tailed
P-wave duration (sec)	0.015-0.035	0.02-0.03
P-wave amplitude (mV)	0.01	0.01-0.06
PR interval (sec)	0.048-0.06	0.04-0.06
QRS duration (sec)	0.008-0.046	0.02
QRS wave amplitude (mV)	1.1-1.9	0.1-1.15
QT interval (sec)	0.106-0.144	0.1-0.14
T-wave amplitude (mV)	0.062	
Mean electrical axis (degrees)	120 to 180	-15 to +120

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Chapter 10 **Rabbits**

Peter Fisher | Jennifer Graham

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TABLE 10-1 Antimicrobial Agents Used in Rabbits.^a

Agent	Dosage	Comments
Amikacin	5-10 mg/kg SC, IM, IV divided q8-24h ⁴¹ 8-16 mg/kg SC, IM, IV q24h ¹¹² 1.25 g/20 g methylmethacrylate ⁴¹	Increased efficacy and decreased toxicity when given once daily; for IV use, dilute in 4 mL/kg saline and give over 20 min Place in bone after surgical debridement of jaw abscess
Azithromycin	4-5 mg/kg IM q48h × 7 days ¹⁹ 15-30 mg/kg PO q24h × 15 days ⁴¹	Effective against syphilis PD; pulmonary infections
Cefazolin	2 g/20 g methylmethacrylate ⁴¹	Place in bone after surgical debridement of jaw abscess
Cefotaxime	50 mg/kg IM q8h ⁴¹	Pneumococcal endocarditis
Ceftazidime	50 mg/kg IM, IV q3h ¹ 100 mg/kg IM q12h ⁴¹	PK
Ceftiofur	2 g/20 g methylmethacrylate ⁴¹	Place in bone after surgical debridement of jaw abscess
Ceftriaxone	40 mg/kg IM q12h × 2-3 days ⁴¹ 71 mg/kg IV q24h ²⁸	Effective against syphilis, pneumococcal endocarditis Pneumococcal pneumonia
Cephalexin	— 15 mg/kg SC q12h ⁴¹	Oral cephalosporins are not recommended ⁴¹ Parenteral form not available in the United States; not generally recommended
Cephalothin	12.5 mg/kg IM q6h × 6 days ⁴¹ 2 g/20 g methylmethacrylate ⁴¹	Cephalosporins are generally not recommended; ¹¹² not available in the United States Place in bone after surgical debridement of jaw abscess
Chloramphenicol	— 25 mg/kg PO q8-12h ⁴¹ 30-50 mg/kg SC, IM, IV q8-24h ^{41,112} 55 mg/kg PO q12h × 4 wk ⁴¹	The use of chloramphenicol in food-producing animals is prohibited in the United States Effective against syphilis
Chlortetracycline	50 mg/kg PO q24h ⁴¹	
Ciprofloxacin ^b	— 5-20 mg/kg PO q12h ⁴¹ 1 drop topical q8-12h ⁵³	May cause arthropathies in young animals ¹²⁶ Suspension in water is stable for 14 days Nasal pasteurellosis; maintains therapeutic levels in tear film for at least 6hr after application (tears drain into nasal sinus)
Difloxacin ^b (Dicural, Fort Dodge)	5 mg/kg IM, IV q24h ³	PK; dose appropriate for <i>E. coli</i> infections
Doxycycline	2.5 mg/kg PO q12h ²⁰ 4 mg/kg PO q24h ⁴¹	

Continued

TABLE 10-1 Antimicrobial Agents Used in Rabbits. (cont'd)

Agent	Dosage	Comments
Enrofloxacin ^b	— 5 mg/kg IM, IV q12-24h ³⁶ 5 mg/kg PO, SC, IM, IV q12h ^{15,16,41} 5-20 mg/kg PO, IM q12h × 14-30 days ⁴¹ 200 mg/L drinking water × 14 days ⁴¹	May cause arthropathies in young dogs, but similar effects using standard dosages in rabbits have not been reported; SC and IM injections may cause muscle necrosis or sterile abscesses; dilute before giving parenterally ⁴¹ Angora rabbits/PK PK; ^{15,16} clinical trial for pasteurellosis, × 14 days ⁴¹ Pasteurellosis
Florfenicol	— 25 mg/kg IM, IV q6h ⁷⁴ 30 mg/kg PO, IV q8h ²	In the United States, use of related drug chloramphenicol is prohibited in food-producing animals PK PK
Furazolidone	5 mg/kg PO q24h × 14 days ⁴¹ 5.5 g/L drinking water ⁴¹ 50 mg/kg feed ⁴¹	The FDA has prohibited extra-label use in food animals
Gentamicin	— 4 mg/kg SC, IM q24h ⁴¹ 5-8 mg/kg SC, IM, IV q8-24h ⁴¹ 1 g/20 g methylmethacrylate ⁴¹	Seldom indicated; use with caution Decreased toxicity when given once daily; for IV use, dilute in 4 mL/kg saline and give over 20 min Place in bone after surgical debridement of jaw abscess
Marbofloxacin ^b	— 2 mg/kg SC, IM, IV q24h ^{4,92} 5 mg/kg PO q24h × 10 days ²²	Lowest MIC of nine antibiotics tested against bacteria responsible for upper respiratory infections ¹²⁰ PK; study during <i>Pasteurella</i> infection ⁴ PK
Metronidazole	5 mg/kg IV q12h ¹¹² 20 mg/kg PO q12h × 3-5 days ¹¹² 40 mg/kg PO q24h × 3 days ⁴¹	Administer slowly
Minocycline	6 mg/kg IV q8h ¹⁰⁰	PK
Moxifloxacin ^b	5 mg/kg PO, IM q24h × 10 days ³⁹ 40 mg/kg IV q12h × 2 doses, then q24h ¹⁰⁴	PK; susceptible infections (some bacteria may require higher doses) Bacterial meningitis
Netilmicin (Netromycin, Schering)	6-8 mg/kg SC, IM, IV q24h ⁴¹ 7 mg/kg IV q12h ¹²²	For IV use, dilute and give over 20 min PK; induced renal tubular necrosis in 50% of animals

TABLE 10-1 Antimicrobial Agents Used in Rabbits. (cont'd)

Agent	Dosage	Comments
Ofloxacinb (Ocuflox, Allergan)	20 mg/kg SC q8h ⁹¹	Urogenital, skin, respiratory infections
Orbifloxacin ^b	20 mg/kg PO q24h × 7-21 days ¹³⁸	PK
Oxytetracycline	15 mg/kg IM q8h ⁹⁴ 25 mg/kg SC q24h ⁴¹ 50 mg/kg PO q12h ⁴¹ 1 mg/mL drinking water ⁴¹	PK; anorexia and diarrhea at 30 mg/kg IM q8h; tissue irritation can occur
Penicillin G	—	Do not give any form of penicillin orally to rabbits
Benzathine form	42,000-60,000 U/kg IM q48h ⁴¹ 42,000-84,000 U/kg SC q7d × 3 wk ⁴¹	Benzathine penicillin achieves lower serum levels than other forms and is effective against only highly susceptible organisms
Procaine form	40,000 U/kg IM q24h × 5-7 days ⁴¹ 42,000-84,000 U/kg SC, IM q24h ⁴¹ 60,000 U/kg IM q8h ¹³⁹	Rabbit syphilis PK
Benzylpenicillin	60,000 U/kg IM q12h ⁶⁴	PK
Rifampin (R)/azithromycin (A)	(R) 40 mg/kg PO q12h + (A) 50 mg/kg PO q24h ⁴¹	<i>Staphylococcus</i> osteomyelitis
Rifampin (R)/clarithromycin (C)	(R) 40 mg/kg + (C) 80 mg/kg PO q12h ⁴¹	<i>Staphylococcus</i> osteomyelitis
Silver sulfadiazine cream (Silvadene, Marion)	Topical q24h ⁴¹	Does not cause diarrhea if ingested
Spectinomycin	1 g/L drinking water × 7 days ¹¹²	May cause diarrhea in weanling rabbits
Sulfadimethoxine	10-15 mg/kg PO q12h ¹¹²	
Sulfamethazine	1 mg/mL drinking water ⁴¹ 5-10 g/kg feed ⁴¹	
Sulfaquinoxaline	1 mg/mL drinking water ⁴¹ 0.6 g/kg feed ⁴¹	
Tetracycline	50-100 mg/kg PO q8-12h ¹¹² 250-1000 mg/L drinking water ⁴¹	Therapeutic levels not achieved even at 800-1600 mg/L; ¹⁰⁸ 250 mg/L not effective in clinical trial for pasteurellosis ⁴¹
Tilmicosin (Micotil, Elanco)	12.5 mg/kg PO q24h × 7 days ⁴⁸ 25 mg/kg SC once ⁴¹	PK Pasteurellosis; use cautiously: at least one rabbit death and several human deaths have been reported; ²⁰ has been associated with anemia and leukopenia

Continued

TABLE 10-1 Antimicrobial Agents Used in Rabbits. (cont'd)

Agent	Dosage	Comments
Tobramycin	1 g/20 g methylmethacrylate ⁴¹ 10% in calcium sulfate pellets ⁹⁹	Place in bone after surgical debridement of jaw abscess Biodegradable implants for treatment of osteomyelitis
Trimethoprim/sulfa	15 mg/kg PO q12h ⁴¹ 30 mg/kg PO, SC, IM q12h ^{41,112} 15-30 mg/kg PO q12-24h ¹¹² 30-48 mg/kg SC q12h ¹¹²	May cause tissue necrosis when given SC ¹¹²
Tylosin	10 mg/kg PO, SC, IM q12-24h ¹²	
Vancomycin	50 mg/kg IV q8h ¹⁰⁰ 10 mg vancomycin and 50 mg DL-lactide-co-glycolide copolymer ⁴¹	PD Osteomyelitis; effective locally for 56 days

^aThere is a potential for antibiotic-induced enterotoxemia following administration of some antimicrobial agents (see Table 10.15). Appetite and fecal character must be monitored closely during and following therapy.

^bThe use of fluoroquinolones in food-producing animals is strictly prohibited in the United States. Do not use these drugs in rabbits that may be consumed by humans.

TABLE 10-2 Antifungal Agents Used in Rabbits.^a

Agent	Dosage	Comments
Albaconazole	5 mg/kg PO q24h ⁹⁸ 50 mg/kg PO q24h ¹⁸	Cryptococcal meningitis Disseminated <i>Scedosporium prolificans</i>
Amphotericin B	—	Severe fungal infections; use in combination with fluconazole; ⁴¹ potentially nephrotoxic and hepatotoxic
Desoxycholate form	1 mg/kg IV q24h ^{41,112,121}	
Liposomal form	5 mg/kg IV q24h ¹¹⁰	Invasive aspergillosis
Clotrimazole (Lotrimin, Bayer)	Topical ⁴¹	Localized dermatophytosis
Fluconazole	5 mg/kg PO q24h ⁹⁸ 25-43 mg/kg IV (slow) q12h ^{87,112} 38 mg/kg PO q12h ³ 80 mg/kg PO q24h × 21 days ⁴¹	Cryptococcal meningitis Systemic fungal disease <i>Aspergillus</i> keratitis Coccidioidal meningitis; controlled but did not cure

TABLE 10-2 Antifungal Agents Used in Rabbits. (cont'd)

Agent	Dosage	Comments
Griseofulvin	12.5-25 mg/kg PO q12h-24h × 30-45 days ⁴¹	Advanced cases of dermatophytosis; decrease dose by 50% if using ultra-microsize form (Gris-PEG, Allergan Herbert), which has better absorption
	15-25 mg/kg PO q24h, or divided q12h × 30 days ⁵⁸	At high doses may cause bone marrow suppression and panleukopenia
Itraconazole	5-10 mg/kg PO q24h × 30 days ^{38,58}	Dermatophytosis
	20-40 mg/kg PO q24h ⁴¹	<i>Aspergillus</i> pneumonia
	40 mg/kg PO q24h ¹⁰⁷	Invasive aspergillosis
Ketoconazole	10-40 mg/kg PO q24h × 14 days ^{38,41}	Dermatophytosis
Lime sulfur (2%-3%)	Topical q5-7d × 4 wk ⁴¹	Dermatophytosis; use with caution
	Topical 1:32 dilution with water 2 × /wk ⁵⁸	
Micafungin	0.25-2 mg/kg IV q24h ¹¹⁰	Systemic candidiasis
Miconazole (Conofite, Merck)	Topical q24h × 14-28 days ⁴¹	Localized dermatophytosis
Miconazole/chlorhexidine shampoo	Bathe once daily ⁶⁵	Dermatophytosis
Nystatin	20 mg/kg PO q12h × 10 days ⁴¹	<i>Cyniclomyces guttulatus</i> yeast overgrowth
Posaconazole	6 mg/kg PO q24h ¹⁰⁹	<i>Aspergillus</i> pneumonia
	20 mg/kg PO q24h ⁴¹	<i>Aspergillus</i> pneumonia
Terbinafine	—	Best used as part of combination therapy; little activity when used as a single agent ^{41,73}
	10 mg/kg PO q24h ⁵⁸	Dermatophytosis
	100 mg/kg PO q12h × 21 days ⁴¹	Less effective than fluconazole for coccidioidal meningitis
	100 mg/kg PO q12-24h ⁴¹ 100 mg/kg PO q24h in combination with amphotericin B 0.4 mg/kg IV q24h ⁷³	Invasive aspergillosis
Voriconazole	—	The short terminal elimination half-life of less than 1 hr in the rabbit indicates that the efficacy of voriconazole is less than optimal in this species; ¹¹⁷ however, voriconazole is effective as a topical antifungal ophthalmic preparation in the rabbit (see Table 10.6)

^aAntifungal protocols using amphotericin B administered intravenously or itraconazole, fluconazole, or ketoconazole administered orally alone or in combination for deep mycotic infections have been based on those used successfully in the dog and may be adequate treatment options in the rabbit; however, this hypothesis requires confirmation and validation.¹⁴ Certain antifungal protocols have not caused death in rabbit models, even when given for extended periods.^{18,41,107,109,110,121}

TABLE 10-3 Antiparasitic Agents Used in Rabbits.

Agent	Dosage	Comments
Albendazole	7.5-20 mg/kg PO q24h ⁴¹ × 3-14 days ^{41,112}	Potential treatment for encephalitozoonosis; use cautiously, deaths have been reported ⁵²
Amprolium (9.6%)	0.5 mL/pint drinking water × 10 days ¹¹² 0.625 mL/pint drinking water × 21 days ⁴¹	Coccidiosis
Carbaryl powder 5%	Topically q7d ⁴¹	Ectoparasites; use sparingly
Cyromazine 6% (Rearguard, Novartis)	Topically q6-10wk ⁴¹	Preventative for myiasis
Decoquinatate (Deccox, Rhone-Poulenc)	62.5 ppm in feed ⁴¹	Coccidiosis
Diclazuril	4 mg/kg SC ¹⁰⁶ 1 ppm in feed ^{41,135}	PD; intestinal and hepatic coccidiosis
Doramectin	0.2 mg/kg IM once ^{68,112} 0.3 mg/kg SC ⁵⁰	<i>Psoroptes</i> mites PD
Emodepside 2.1%/ praziquantel 8.6% (Profender, Bayer)	0.14 mL/kg topically once ⁴¹	<i>Trichostrongylus colubriformis</i>
Eprinomectin	0.2-0.3 mg/kg SC once ¹⁰⁵ 2 mg/kg topically once ¹⁴⁰	<i>Psoroptes</i> mites <i>Psoroptes</i> mites
Febantel/pyrantel pamoate/ praziquantel (Drontal Plus, Bayer)	½ tablet/5 kg PO once ⁴¹	Use tablet for puppies and small dogs (2-25 lb); effective against nematodes and cestodes
Fenbendazole	— 5 mg/kg PO ⁴¹ 5-20 mg/kg PO q24h × 5 days; repeat in 14 days ⁴¹ 20 mg/kg PO q24h × 7 days before and 2 days after mixing rabbits ¹³⁰ 20 mg/kg PO q24h × 28 days ^{112,130} 50 ppm in feed × 2-6 wk ⁴¹	On rare occasions, anemia and arteritis have been reported ⁵² Nematodes; use 20 mg/kg for <i>Passalurus ambiguus</i> Preventive against encephalitozoonosis Treatment for encephalitozoonosis; failed to clear all parasites
Fipronil (Frontline, Merial)	Contraindicated ⁴¹	Can cause neurologic disease and death
Imidacloprid (Advantage, Bayer)	10-16 mg/kg topically once ^{41,61}	Flea adulticide; use single 0.4 mL dose, 10% solution
Imidacloprid (I) 10%/ moxidectin (M) 1% (Advantage Multi for Cats, Bayer)	10 mg/kg (I) + 1 mg/kg (M) topically q4wk × 3 treatments ⁴¹	<i>Psoroptes</i> mites
Imidacloprid 8.8%/ permethrin 44% (Advantix, Bayer)	11-16.6 mg/kg topically once ¹²	<i>Leporacarus gibbus</i> (rabbit fur mite)

TABLE 10-3 Antiparasitic Agents Used in Rabbits. (cont'd)

Agent	Dosage	Comments
Ivermectin	—	Ectoparasites
	0.1-0.2 mg/kg SC, repeat in 14 days ⁴¹	Ear mites, clinical trial
	0.2-0.44 mg/kg PO, SC q8-14d ¹¹²	<i>Psoroptes</i> (ear mites)
	0.3-0.4 mg/kg SC, repeat in 14 days ¹¹²	<i>Sarcoptes scabiei</i> (sarcoptic mange); <i>Notoedres cati</i>
	0.4 mg/kg SC q80h × 3 doses ⁵⁹	Sarcoptic mange
Lasalocid	120 ppm in feed ⁴¹	Coccidiosis
Lime sulfur (2%-3%)	1-2 dips/wk × 28 days ⁴¹	Ectoparasites; young animals
	Dip q7d × 4-6 wk ^{41,112}	
Lufenuron (Program, Novartis)	30 mg/kg PO q30d ¹¹²	Flea larvicide
Metronidazole	20 mg/kg PO q12h ⁴¹	Antiprotozoal agent
Monensin (CoBan 60, Elanco)	0.002%-0.004% in feed ⁴¹	Coccidiosis
Moxidectin	0.2 mg/kg PO, repeat in 10 days ^{112,136}	Psoroptic mange
	0.3 mg/kg SC ⁵⁰	PD
Oxibendazole	30 mg/kg PO q24h × 7-14 days, then 15 mg/kg PO q24h for 30-60 days ¹¹²	Encephalitozoonosis; no highly effective treatment has been identified; bone marrow suppression has been reported with the use of benzimidazoles, so an intratreatment CBC is recommended ⁵²
Piperazine	100 mg/kg PO q24h × 2 days ⁴¹	Use with citrate formulation
	200 mg/kg PO, repeat in 14-21 days ¹¹²	Use with citrate formulation
	200-500 mg/kg PO × 2 days ¹¹²	Adults; use with adipate formulation
	750 mg/kg PO × 2 days ⁴¹	Juveniles; wash perianal area
	2-5 mg/mL drinking water × 7 days ⁴¹	
Praziquantel	5-10 mg/kg PO, SC, IM, repeat in 10 days ¹¹²	Cestodes, trematodes
Pyrantel pamoate	5-10 mg/kg PO, SC, IM, repeat in 10 days ⁴¹	
	5-10 mg/kg PO, repeat in 14-21 days ¹¹²	
Pyrethrins	Topically as directed for puppies/kittens q7d ⁴¹	Flea control
Selamectin (Revolution, Zoetis)	12 mg/kg topically at base of neck once ⁷²	Cheyletiellosis
	20 mg/kg topically q7d ²¹	PK/flea infestation; further studies are needed to assess long-term safety in rabbits at this dose following repeated application ²¹

Continued

TABLE 10-3 Antiparasitic Agents Used in Rabbits. (cont'd)

Agent	Dosage	Comments
Selamectin (Revolution, Zoetis) (cont'd)	30 mg (8-14 mg/kg) topically q30 days × 2 doses ^{37,76} 30 mg (6-18 mg/kg) topically once ^{76,96}	Sarcoptic mange <i>Psoroptes</i>
Sulfadimethoxine	50 mg/kg PO once, then 25 mg/kg q24h × 10-20 days ⁴¹	Coccidiosis
Sulfadimethoxine/ormetoprim (Rofenaïd 40, Roche)	62.5-250 ppm in feed ⁴¹	Coccidiosis
Sulfadimidene	100-233 mg/L drinking water ⁴¹	Coccidiosis
Sulfamerazine	100 mg/kg PO ⁴¹ 0.05%-0.15% in drinking water ⁴¹	Coccidiosis
Sulfamethazine	100 mg/kg PO q24h ⁴¹ 0.77 g/L drinking water ⁴¹ 0.5%-1% in feed ⁴¹	Coccidiosis
Sulfamethoxine	50 mg/kg PO once, then 25 mg/kg PO q24h × 10-20 days ⁴¹	Coccidiosis
Sulfaquinoxaline	0.02%-0.05% in drinking water ⁴¹ 0.025%-0.1% in drinking water ¹¹² 0.1%-0.15% in drinking water ⁴¹ 1 mg/mL in drinking water ⁴¹ 0.025%-0.03% in feed × 4-6 wk ¹¹² 125-250 ppm in feed ⁴¹	Coccidiosis; prevention Alternating 2 wk periods for 4-8 wk during weaning Coccidiosis; treatment During weaning
Thiabendazole	25-50 mg/kg PO ⁴¹ 50-100 mg/kg PO q24h × 5 days ¹¹² 0.1% in feed × 3 mo ⁴¹	
Toltrazuril	2.5-5 mg/kg PO ¹¹⁵ 10 mg/kg PO ^{60,71} 25 ppm in drinking water (or 25 mg/kg PO) q24h × 2 days, repeat after 5 days ⁴¹ 50 ppm in drinking water ¹⁷	Intestinal coccidiosis PK, ⁴¹ coccidiosis due to <i>Eimeria tenella</i> ⁴¹ Coccidiosis Hepatic coccidiosis due to <i>Eimeria stiedae</i>

TABLE 10-4 Chemical Restraint/Sedative/Anesthetic/Analgesic Agents Used in Rabbits.^{a,b}

Agent	Dosage	Comments
Acepromazine	— 0.25-1 mg/kg IM ⁴¹ 1-5 mg/kg SC, IM ⁴¹	See butorphanol, ketamine, ketamine/xylazine for combinations Preanesthetic; sedative; tranquilizer Preanesthetic; lower end of dose range is preferred
Acetaminophen (Tylenol, McNeil)	— 200-500 mg/kg PO ⁴¹ 1-2 mg/mL drinking water ⁴¹	Short-term use only; use with caution as associated with liver failure ⁸⁸ Analgesia
Acetaminophen/codeine (120 mg/12 mg per 5 mL)	1 mL elixir/100 mL drinking water ⁴¹	Analgesia
Acetylsalicylic acid (aspirin)	5-20 mg/kg PO q24h ¹¹² 10-100 mg/kg PO q8-12h ⁴¹ 100 mg/kg PO q8-24h ^{25,41} 100 mg/kg PO q48h ⁴¹	Antiinflammatory; for low grade analgesia
Alfaxalone (Alfaxan, Jurox)	— 0.5-1 mg/kg IM ⁸⁵ 1 mg/kg IV slowly to effect ⁸⁵ 2-3 mg/kg IV ⁵⁵ 4 mg/kg IV ¹¹¹ 4-6 mg/kg IM ⁶²	Neurosteroid anesthetic; IV dose dependent respiratory depression; no analgesic properties For additional sedation when combined with midazolam, an opioid, and ketamine ⁸⁵ Anesthetic induction when used in conjunction with preanesthetic sedatives (i.e., midazolam 0.5 mg/kg, hydromorphone 0.1 mg/kg, ketamine 7 mg/kg, and dexmedetomidine 0.005 mg/kg combined in single syringe and given IM) ⁸⁵ Anesthetic induction; give slow to effect Dilute with 5% dextrose and give over 1 min for smooth induction that allows intubation Deep sedation; longer duration of action with higher dose
Atipamezole (Antisedan, Orion)	Give same volume SC, IV, IP as medetomidine or dexmedetomidine (5 × medetomidine or 10 × dexmedetomidine dose in mg) ⁴¹ 0.25 mg/kg IV ¹¹² 0.5 mg/kg SC, IM ¹¹² 1 mg/kg SC, IM, IV ⁴¹	Dexmedetomidine and medetomidine ^c reversal ⁴¹
Atracurium	0.1 mg/kg IV ⁴¹	Paralysis for intraophthalmic surgery; requires assisted ventilation

Continued

TABLE 10-4 Chemical Restraint/Sedative/Anesthetic/Analgesic Agents Used in Rabbits. (cont'd)

Agent	Dosage	Comments
Atropine	— 0.1-0.5 mg/kg SC, IM ⁴¹ 0.1-3 mg/kg SC ⁴¹ 0.8-1 mg/kg IM ⁴¹ 10 mg/kg SC q20min ^{41,112}	Many rabbits possess serum atropinase, hence very high doses are often administered; glycopyrrolate often preferred To treat organophosphate toxicity
Bupivacaine 0.125%, 0.5%	— 1 mg/kg ²⁰ 2 mg/kg ⁸⁴	Local and regional anesthetic techniques; concentrations of 0.125% or less produce a good sensory block with least motor effect; epidural anesthesia; dilute with preservative-free saline only; total volume should not exceed 0.33 mL/kg ⁵⁶ Injectable epidural; use 0.125% preparation ⁵⁶
Buprenorphine	— 0.01-0.05 mg/kg SC, IM, IV q6-12h ^{25,41} 0.012 mg/kg ^{20,56} 0.02-0.1 mg/kg SC, IM, IV ^{41,83} 0.06 mg/kg IV q8h ¹²⁵	Partial agonist that exerts significant actions at the mu opioid receptor; duration of analgesia may be dose dependent; may cause respiratory depression; ¹⁰ see midazolam for combination Analgesia Epidural anesthesia; dilute with preservative-free saline only; total volume should not exceed 0.33 mL/kg ⁵⁶ Preanesthetic Analgesia
Buprenorphine SR-LAB (1 mg/mL, ZooPharm)	0.12 mg/kg SC ³²	Compounded formulation of sustained-release buprenorphine
Butorphanol	— 0.1-0.5 mg/kg SC, IM, IV q4h ^{25,41} 0.3-0.5 mg/kg SC, IM, IV q2-4h ¹²³ 0.1-1 mg/kg SC, IM, IV q4-6h ⁴¹	See ketamine/xylazine and midazolam for combinations; mixed agonist/antagonist with low intrinsic activity at the mu receptor and strong agonist activity at kappa and sigma receptors; duration of analgesia may be dose dependent; use lower doses IV Analgesia
Butorphanol (B)/acepromazine (A)	(A) 0.5 mg/kg + (B) 0.5 mg/kg SC, IM ⁴³	

TABLE 10-4 Chemical Restraint/Sedative/Anesthetic/Analgesic Agents Used in Rabbits. (cont'd)

Agent	Dosage	Comments
Carprofen	— 1-2.2 mg/kg PO q12h ²⁵ 1-5 mg/kg PO q12-24h ⁴¹ 2-4 mg/kg PO q12-24h ¹⁰ 2-4 mg/kg SC q24h ^{25,41} 4 mg/kg SC, IM q24h ^{10,41}	Nonsteroidal antiinflammatory; chronic osteoarthritis or degenerative joint disease
Dexmedetomidine (Dexdomitor, Orion)	— 0.005 mg/kg IM ⁷⁹ 0.035-0.05 mg/kg IM ⁷⁹	See ketamine/fentanyl and midazolam/hydromorphone/ketamine for combinations; α_2 agonist similar to medetomidine; reverse with atipamezole Preanesthetic when combined with ketamine Induction/maintenance when combined with ketamine
Diazepam	— 0.5-2 mg/kg IM, IV ^{41,67,112} 1 mg/kg intracavernous ³³ 1-3 mg/kg IM ⁴¹ 1-5 mg/kg IM, IV ^{25,41}	Benzodiazepine sedative; IV route preferred; see ketamine for combination For sedation Seizures; alternative to IV route Preanesthetic; tranquilizer Preanesthetic; tranquilizer
Etomidate	1-2 mg/kg ^{79,80,83}	Give slow to effect for anesthetic induction; short-acting induction agent; good choice with cardiac patients
Fentanyl	— 0.0074 mg/kg IV ^{25,41}	Mu opioid agonist; analgesia; see ketamine/dexmedetomidine and medetomidine/midazolam for combinations
Fentanyl patch	½ patch/medium-sized rabbit (3 kg) × 3 days ⁴¹ 25 µg/h patch/3 kg rabbit × 3 days ⁴⁵ 12.5 µg/h patch/3/ kg rabbit × 3 days ²⁵	Postoperative analgesia; do not cut patch; cover portion not in use Note: rapid hair regrowth decreases plasma concentrations Do not cut patches; may cause drowsiness when initially applied
Fentanyl/fluanisone (Hypnorm, Janssen)	0.2-0.3 mL/kg ⁴¹ 0.25 mL/kg SC ⁴¹	Premedication; analgesia; sedation
Flumazenil	0.01-0.1 mg/kg IM, IV ⁴¹	Reversal for benzodiazepines
Flunixin meglumine	— 0.3-2 mg/kg PO, IM, IV q12-24h ⁴¹	Analgesia; nonsteroidal antiinflammatory ⁴¹ Use for no more than 3 days

Continued

TABLE 10-4 Chemical Restraint/Sedative/Anesthetic/Analgesic Agents Used in Rabbits. (cont'd)

Agent	Dosage	Comments
Flunixin meglumine (cont'd)	1.1 mg/kg SC, IM q12h ⁴¹ 1-2 mg/kg SC q12-24h ⁴¹	
Gabapentin	— 3-5 mg/kg PO q12-24h ⁴¹ 25 mg/kg SC ⁷⁵	Neuropathic pain analgesic; indicated for adjunctive treatment of chronic or neurogenic pain in dogs and cats at 3 mg/kg PO q24h and for ancillary therapy of refractory seizures in dogs at 10-30 mg/kg PO q8h ¹¹² Dose used to approximate plasma concentrations in humans
Glycopyrrolate	— 0.01-0.02 mg/kg SC ⁴¹ 0.01-0.1 mg/kg SC, IM ⁴¹ 0.02 mg/kg IV, IO, intratracheally ⁵⁷	Anticholinergic; premedication to prevent salivation and bradycardia
Hydromorphone	— 0.05-0.2 mg/kg SC, IM q6-8h ²⁰ 0.1-0.2 mg/kg SC, IM, IV q6-8h ⁶⁶	Opioid analgesic; mainly a mu agonist with less affinity for delta receptors
Ibuprofen	— 2-7.5 mg/kg PO q4h ⁴¹ 7.5 mg/kg PO q6-8 h ⁴¹	Analgesia; nonsteroidal antiinflammatory; may have gastrointestinal side effects
Isoflurane	3%-5% induction, 1.5%-1.75% maintenance ⁴¹ 3%-5% induction, 2%-3% maintenance ⁴¹	MAC = 2.05%; ⁴¹ prior use of a sedative or injectable induction agent (s) is recommended, as use of preanesthetic agent or combinations will lower the MAC of inhalants
Ketamine	— 1-10 mg/kg IM ⁸⁰ 5-50 mg/kg SC, IM ⁴¹ 7-10 mg/kg IM ^{79,81} 15 mg/kg IV ⁴¹ 15-20 mg/kg IV ⁴¹ 20-50 mg/kg IM ⁴¹ 20 mg/kg IM ⁷⁹	NMDA receptor antagonist; should be administered in combination with other agents; combinations to follow Preanesthetic; add to midazolam/opioid combination if additional sedation required ⁸¹ 60 min of sedation Anesthetic induction, maintenance

TABLE 10-4 Chemical Restraint/Sedative/Anesthetic/Analgesic Agents Used in Rabbits. (cont'd)

Agent	Dosage	Comments
Ketamine (K)/acepromazine (A)	(K) 25-40 mg/kg + (A) 0.25-1 mg/kg IM, IV ⁴¹	Anesthesia
	(K) 40 mg/kg + (A) 0.5-1 mg/kg IM ⁴¹	Anesthesia
Ketamine (K)/dexmedetomidine (D)/fentanyl (F)	(D) 0.02 mg/kg + (K) 5 mg/kg + (F) 0.01 mg/kg IM ¹⁹	May result in mild respiratory depression, respiratory acidosis and hypoxemia; supplemental oxygen recommended
Ketamine (K)/diazepam (D)	(K) 10 mg/kg + (D) 0.5 mg/kg IV ⁴¹	Anesthesia; follow with isoflurane
	(K) 15 mg/kg + (D) 0.3 mg/kg IM ⁴¹	Anesthesia; follow with isoflurane
	(K) 20-40 mg/kg + (D) 1-5 mg/kg IM ⁴¹	Anesthesia; follow with inhalant as needed
	(K) 30-40 mg/kg + (D) 2-5 mg/kg IM ⁴¹	Surgical anesthesia; lower end of dose range for (D) is preferred; less preferable than aforementioned (K)/(D) combinations
Ketamine (K)/medetomidine (Me) ^c	(K) 5 mg/kg + (Me) 0.35 mg/kg IM, IV ⁴¹	Surgical anesthesia
	(K) 15 mg/kg + (Me) 0.25 mg/kg SC, ⁴¹ IM ⁵⁴	Anesthetic induction; laryngospasm common
Ketamine (K)/midazolam (Mi)	(K) 15 mg/kg IM + (Mi) 3 mg/kg IM ⁵⁴	Anesthetic induction
	(K) 25 mg/kg + (Mi) 2-5 mg/kg IM ⁴¹	May be preferable to use (Mi) at <2 mg/kg
Ketamine (K)/xylazine (X)	—	Anesthesia; may result in bradycardia; less preferable than (K)/(D) with isoflurane combinations; seldom indicated
	(K) 10 mg/kg + (X) 3 mg/kg IV ⁴¹ (K) 30-40 mg/kg + (X) 3-5 mg/kg IM ⁴¹	
Ketamine (K)/xylazine (X)/acepromazine (A)	(K) 35 mg/kg + (X) 5 mg/kg + (A) 0.75 mg/kg IM ⁴¹	Anesthesia; may result in bradycardia; less preferable than (K)/(D) with isoflurane combinations; seldom indicated
Ketamine (K)/xylazine (X)/butorphanol (B)	(K) 35 mg/kg + (X) 5 mg/kg + (B) 0.1 mg/kg IM ⁴¹	Anesthesia; may result in bradycardia; less preferable than (K)/(D) with isoflurane combinations; seldom indicated
Ketamine (K)/midazolam (Mi)/hydromorphone (H)/dexmedetomidine (D)	(K) 7 mg/kg + (Mi) 0.5 mg/kg + (H) 0.1 mg/kg + (D) 0.005 mg/kg IM ⁸⁵	Preanesthetic
Ketoprofen	—	Nonsteroidal antiinflammatory
	1 mg/kg IM q12-24h ⁴¹	Musculoskeletal pain; nonsteroidal antiinflammatory
	1-3 mg/kg IM q12-24h ⁴¹ 3 mg/kg SC, IM q24h ^{25,41}	Estimated duration of action 12-24 hr ⁴⁴

Continued

TABLE 10-4 Chemical Restraint/Sedative/Anesthetic/Analgesic Agents Used in Rabbits. (cont'd)

Agent	Dosage	Comments
Ketoprofen 2.5% topical gel (Menarini, France)	Apply topically (visceral) q6-12 h ⁷	Musculoskeletal pain
Lidocaine (2% injectable)	— 1 mg/kg ⁷⁸ 2-3 mg/kg ⁸³	Amide local anesthetic; local, regional, topical, and epidural anesthesia; also see Table 5
1.5%	0.4 mL/kg epidural ⁴¹	Epidural anesthesia
10%	Topical to glottis ⁴¹	Facilitates intubation
Lidocaine 2.5%/prilocaine 2.5% (Emla cream)	Topical to skin	Facilitates IV catheter placement
Maropitant citrate (Cerenia, Zoetis)	2 mg/kg SC q24h × 3-5 days ²⁴	Neurokinin (NK1) receptor antagonist; gastrointestinal (visceral) and arthritic pain; can be administered long term q48h or 3 × weekly as needed ²⁴
Medetomidine	— 0.1-0.25 mg/kg IM ⁴¹	Medetomidine is no longer commercially available in the United States, although it may be obtained from select compounding services
Medetomidine (Me) ^c /fentanyl (F)/midazolam (Mi)	(Me) 0.2 mg/kg + (F) 0.02 mg/kg + (Mi) 1 mg/kg IM ⁴¹	Anesthesia; endotracheal intubation and supplemental oxygen are required
Medetomidine (Me) ^c /propofol (P)	(Me) 0.35 mg/kg IM + (P) 3 mg/kg IV ⁴¹	Surgical anesthesia; note high medetomidine dose ⁴¹
Meloxicam	— 0.2 mg/kg SC, IM q24h ⁴¹ 0.2-0.5 mg/kg PO, SC, IM q24h ²⁵ 0.3 mg/kg PO q24h × 10 days ²³ 0.3 mg/kg PO q24h ⁴¹ 0.3-1.5 mg/kg PO q24h × 5 days ¹³³ 1 mg/kg PO q24h ⁴⁶	Nonsteroidal antiinflammatory; analgesia; antipyretic; used for osteoarthritis and postoperative pain; palatable PO form PK; a higher dose (≥0.5 mg/kg) ²⁰ may be required, but efficacy and safety studies have not been performed ²² PK; the higher dose was based on a limited sample size, but efficacy and safety studies have not been performed PK; dose required to achieve plasma levels associated with analgesia in other species; clinical efficacy was not evaluated

TABLE 10-4 Chemical Restraint/Sedative/Anesthetic/Analgesic Agents Used in Rabbits. (cont'd)

Agent	Dosage	Comments
Meloxicam (cont'd)	1 mg/kg PO q24h × 29 days ³⁰	PK; safety studies indicated may be safe for long-term use in rabbits
Midazolam	— 0.25-0.5 mg/kg IM ⁵⁷ 0.5-2 mg/kg IM, IV, IP ^{25,41,57} 1-2 mg/kg IM, IV, IP ⁴¹	Benzodiazepine sedative; may reverse with flumazenil; more potent, shorter action than diazepam; water soluble; rapidly absorbed and less painful than diazepam when given IM; combinations to follow When combined with an opioid Preanesthetic; tranquilizer Preanesthetic; tranquilizer
Midazolam (Mi)/buprenorphine (Bpr)	(Mi) 0.5 mg/kg + (Bpr) 0.01-0.05 mg/kg SC, IM ⁵⁷	Add ketamine (1-10 mg/kg) for additional sedation
Midazolam (Mi)/butorphanol (B)	(Mi) 0.5 mg/kg + (B) 0.2-0.4 mg/kg SC, IM ⁵⁷ (Mi) 0.5-1 mg/kg + (B) 0.25-0.5 mg/kg IM ⁹⁰	Add ketamine (1-10 mg/kg) for additional sedation and analgesia Add ketamine 5-10 mg/kg IM for additional sedation and analgesia
Midazolam (Mi)/oxymorphone (O)	(Mi) 0.5 mg/kg + (O) 0.05-0.2 mg/kg SC, IM ⁵⁷	Add ketamine (1-10 mg/kg) for additional sedation
Morphine	— 0.1 mg/kg ^{20,56} 0.5-2.0 mg/kg SC, IM q2-4h ²⁰ 2-5 mg/kg SC, IM q2-4h ^{25,41} 10 mg/kg IM ²⁹	Analgesic; mu receptor agonist; decreases GI transit time ²⁹ Epidural anesthesia; dilute with preservative-free saline only; total volume should not exceed 0.33 mL/kg ⁵⁶ Analgesia Decreased GI transit time and affected stomach and cecum motility ²⁹
Naloxone	0.01-0.1 mg/kg IM, IV ^{25,41}	Narcotic reversal; note that analgesic effects are also reversed; avoid use following painful procedure as sudden awareness of pain may predispose to breath-holding, increased catecholamine release, and fatal arrhythmias; ⁴¹ mu opioid agonist
Oxymorphone	0.05-0.2 mg/kg SC, IM q8-12h ⁴¹ 0.1-0.3 mg/kg SC, IM, IV q3-4h ^{10,112}	Analgesia
Pentazocine (Talwin-V, Upjohn)	5-10 mg/kg IM, IV q2-4h ⁴¹	Analgesia
Pentobarbital	20-45 mg/kg IV, IP ⁴¹	Marginal analgesia; autonomic depression; not recommended

Continued

TABLE 10-4 Chemical Restraint/Sedative/Anesthetic/Analgesic Agents Used in Rabbits. (cont'd)

Agent	Dosage	Comments
Piroxicam	0.2 mg/kg PO q8h ⁴¹	Analgesia; nonsteroidal antiinflammatory
Propofol	— 2-3 mg/kg IV ⁴¹ 3-6 mg/kg IV ⁴¹ 5-14 mg/kg slow IV (20 mg/kg/min) ^{41,112} 6-8 mg/kg IV induction, followed by 0.8-1 mg/kg/min CRI ¹¹⁸ 7.5-15 mg/kg IV ²⁶ 12.5 mg/kg IV, IO followed by 1 mg/kg/min CRI ⁹³ 16 ± 5 mg/kg IV ⁶	Intravenous nonbarbituate anesthetic; slow IV; lower dose after pre-med, higher dose when used alone; see medetomidine for combination Induction after premedication; maintain with approximately 1 mg/kg IV q15min To effect Anesthetic induction and maintenance; premedicated with dexmedetomidine (20 µg/kg IM), ketamine (5 mg/kg IM), fentanyl (10 µg/kg IM) ¹¹⁸ Anesthetic induction and maintenance Anesthetic induction
Sevoflurane	To effect ⁶ 6%-8% induction, 1%-3% maintenance	Anesthesia; MAC = 3.7% ⁴¹ Prior use of a sedative or injectable induction agent is recommended, as use of preanesthetic combinations will lower the MAC of inhalants
Thiamylal	15-25 mg/kg IV to effect ⁴¹	
Thiopental	15-30 mg/kg IV to effect ⁴¹	
Tiletamine/zolazepam (Telazol, Zoetis, Fort Dodge)	3 mg/kg IM ⁴¹	Sedation prior to gas anesthetic; tiletamine causes severe renal tubular necrosis at 32 mg/kg and mild nephrosis at 7.5 mg/kg; ⁴¹ not generally recommended for use in rabbits
Tramadol	— 4.4 mg/kg IV ³⁴ 5 mg/kg SC, IV q8h ²⁵ 5-15 mg/kg PO q8-12h ²⁵ 10 mg/kg PO q12-24h ¹⁰ 11 mg/kg PO ¹²⁷	Pharmacokinetic data reported to be variable, data on clinical efficacy lacking ¹⁰ Did not result in isoflurane-sparing effects ³⁴ Recommendation based on personal experience and anecdotal reports PK; did not achieve adequate plasma concentrations for analgesia based on human levels

TABLE 10-4 Chemical Restraint/Sedative/Anesthetic/Analgesic Agents Used in Rabbits. (cont'd)

Agent	Dosage	Comments
Xylazine	— 1-5 mg/kg SC, IM ⁴¹	See ketamine for combinations Preanesthetic; tranquilizer; lower end of dose range preferred; seldom indicated
Yohimbine	0.2-1 mg/kg IM, IV ⁴¹	Alpha ₂ -adrenergic antagonist; xylazine reversal

^aSee Table 10-5 for Constant Rate Infusion (CRI) protocols.

^bDrugs and doses chosen dependent on individual patient requirements and health status, procedure planned, and level of sedation desired. Combination of drugs mixed in one syringe unless otherwise indicated. Atipamezole may be used to reverse dexmedetomidine or medetomidine, flumazenil may be used to reverse midazolam, and naloxone may be used to reverse opioids.

^cMedetomidine is no longer commercially available in the United States although it may be obtained from select compounding services.

TABLE 10-5 Constant Rate Infusion (CRI) Protocols Used in Rabbits.^a

Agent(s)	Loading Dose IV	CRI Rate IV Per Hour Unless Noted
Butorphanol	0.2-0.4 mg/kg ⁵⁶	0.1-0.2 mg/kg ¹¹² 0.2-0.4 mg/kg ⁵⁶
Fentanyl	5-10 µg/kg ⁵⁶	10-30 µg/kg ⁵⁶ 30-100 µg/kg/min ⁴¹
Ketamine	2-5 mg/kg ⁵⁶	0.3-1.2 mg/kg ⁵⁶
Ketamine (K)/ butorphanol (B)	(K) 0.4-0.5 mg/kg + (B) 0.02-0.06 mg/kg ⁸¹	(K) 0.6 mg/kg (0.4-1) + (B) 0.1-0.2 mg/kg ⁸¹
Ketamine (K)/ butorphanol (B)	(K) 0.4-0.5 mg/kg + (B) 0.02-0.06 mg/kg ⁸²	(K) 0.4-1 mg/kg + (B) 0.1-0.2 mg/kg ⁸²
Ketamine (K)/ fentanyl (F)	(K) 0.4-0.5 mg/kg + (F) 0.005 mg/kg ⁸¹	(K) 0.6 mg/kg (0.4-1) + (F) 0.005-0.02 mg/kg ⁸¹
Ketamine (K)/ hydromorphone (H)	(K) 0.4-0.5 mg/kg + (H) 0.05 mg/kg ⁸¹	(K) 0.6 mg/kg (0.4-1) + (H) 0.025-0.05 mg/kg ⁸¹
Ketamine (K)/ hydromorphone (H)	(K) 0.4-0.5 mg/kg + (H) 0.05 mg/kg ⁸²	(K) 0.4-1 mg/kg + (H) 0.025-0.05 mg/kg ⁸²
Lidocaine	2 mg/kg ¹²⁴	50 or 100 µg/kg/min; ¹²⁴ both CRI doses decreased the isoflurane MAC ¹²⁴

^aSurgical fluid rate is 10 mL/kg/h IV.⁸¹

TABLE 10-6 Ophthalmologic Agents Used in Rabbits.

Agent	Dosage	Comments
Amphotericin B (liposomal form) (A)/moxifloxacin (Mo)	(A) 10 µg in 0.05 mL + (Mo) 100 µg in 0.05 mL intravitreally ³¹	(Mo) strongly augments efficacy of (A)
Atropine 1%	Topical to eyes q12h prn ⁴¹	Mydriasis; systemic effects are possible; may be ineffective in rabbits with pigmented irides or those that produce atropinase ¹⁴¹

Continued

TABLE 10-6 Ophthalmologic Agents Used in Rabbits. (cont'd)

Agent	Dosage	Comments
Atropine 1%/phenylephrine 10%	Topical to eyes ⁴¹	Mydriasis for non-albino eyes
Azithromycin 1% (Azasite, Akorn)	Topical to eyes q12h × 2 days, then q24h × 5 days ⁵	Bacterial conjunctivitis
Besifloxacin 0.6% (Besivance, Bausch & Lomb)	Topical to eyes q12h ¹¹³	Fluoroquinolone; bacterial conjunctivitis/ endophthalmitis; ¹⁰² minimal systemic absorption
Betaxolol 0.5% (Betoptic, Alcon)	Topical to eyes q12h ⁷⁰	Glaucoma; effectively decreases intraocular pressure in rabbits
Ciprofloxacin 0.3% (Ciloxan, Alcon)	Topical to eyes q8-12h ⁴¹ 2 drops topical q1h for 7-14 hr ⁴¹	Susceptible infections Ocular penetration injuries; good penetration into aqueous and vitreous humor
Cyclosporine A 0.05% (Restasis, Allergan)	Topical to eyes q12h ¹³¹	Dry eye due to autoimmune dacryoadenitis
Cyclosporine A 0.2% (Optimmune, Schering-Plough)	Topical to eyes q12h ¹³²	Shown to increase tear production in rabbits; may inhibit recurrence of precorneal membranous occlusion postoperatively ⁴⁹
Dichlorophenamide (Daranide, Merck)	1-2 mg/kg PO q24h ⁴¹	Glaucoma
Diclofenac sodium 0.1%	Topical to eyes ¹³⁷ Topical to eyes q12h ⁸⁹	Nonsteroidal antiinflammatory Blepharitis ¹⁴¹
Dorzolamide 2% (Trusopt, Merck)	Topical to eyes q8-12h ^{41,89}	Glaucoma
Doxycycline monohydrate	2.5 mg/kg PO q12h ⁸⁹	<i>Encephalitozoon cuniculi</i> -induced glaucoma
Fluconazole	37.5 mg/kg PO q12h ⁸	<i>Aspergillus</i> keratitis
Flurbiprofen sodium 0.03%	Topical to eyes ⁴¹	Nonsteroidal antiinflammatory; blepharitis ¹⁴¹
Fusidic acid (Fucithalmic, Leo)	Topical to eyes q12-24h ⁴¹	Bacterial conjunctivitis
Gatifloxacin 0.3% (Zymar, Allergan)	Topical to eyes q8h ¹¹³	Bacterial conjunctivitis
Gentamicin (Tiacil, Virbac)	Topical to eyes q8h ⁴¹	Bacterial conjunctivitis
Ketorolac tromethamine 0.1%	Topical to eyes ¹³⁷	Nonsteroidal antiinflammatory; blepharitis ¹⁴¹
Marbofloxacin (Marbocyl FD, Vetoquinol)	4 mg/kg IV ¹¹⁶	Penetration of marbofloxacin into the aqueous and vitreous humor after IV administration was significantly enhanced by intraocular inflammation
Methylsulfonylmethane (MSM) ophthalmic 15% (Alcon)	Topical to eyes q12h ⁸⁹	<i>Encephalitozoon cuniculi</i> -induced glaucoma
Metipranolol 0.1%/ pilocarpine 2%	Topical to eyes q8-12h ⁴¹	Glaucoma

TABLE 10-6 Ophthalmologic Agents Used in Rabbits. (cont'd)

Agent	Dosage	Comments
Moxifloxacin 0.5% (Vigamox, Alcon)	Topical to eyes q6h ^{95,102}	Bacterial conjunctivitis; good aqueous concentration with both oral and ophthalmic administration; oral better for vitreous concentration ⁴⁷
Micafungin 0.1%	0.5 mL subconjunctivally q24h × 3 wk ⁵⁹	<i>Candida</i> keratitis
Neomycin/bacitracin/polymyxin B	Topical to eyes q6h ⁴¹	Susceptible infections; corneal ulceration
Penicillin G	40,000 U/kg SC q7d × 3 treatments ⁴⁹	<i>Treponema cuniculi</i> -induced blepharitis
Phenylephrine 10%	— Topical to eyes ⁴¹	See atropine for combination Mydriasis
Prednisolone acetate 1%	Topical to eyes q6-12h ⁴¹ Topical to eyes q12h ⁸⁹	Inflammation of eyes; rabbits are a corticosteroid-sensitive species; use with extreme caution <i>Encephalitozoon cuniculi</i> -induced glaucoma
Terbinafine 1% ointment	Topical q6h × 8 wk ^{13,112}	Keratomycosis; compounded
Timolol 0.5% (Timoptic, Merck)	Topical to eyes q12h ⁷⁰	Glaucoma
Tobramycin 0.3%	Topical to eyes q6h ¹³	Bacterial ulcerative keratitis
Tropicamide 1%	Topical to eyes ⁴¹	Mydriasis
Trovafloxacin 0.5%	Topical to eyes ⁹	Broad-spectrum; safe for intravitreal injection up to 25 µg
Vancomycin 0.3%, 1%	Topical to eyes q2h for 10 hr each day × 5 days ³⁵	Commercially available product not available in the United States; compounded from injectable form of vancomycin; used to treat methicillin-resistant <i>Staphylococcus aureus</i>
Voriconazole	Topical to eyes q12h ¹²⁸	Fungal keratitis; compounded to a 1% voriconazole solution ¹¹²

TABLE 10-7 Miscellaneous Agents Used in Rabbits.

Agent	Dosage	Comments
Activated charcoal (1 g/5 mL water)	1 g/kg PO q4-6h ^{63,103}	May reduce intestinal absorption of toxins
Aluminum hydroxide	30-60 mg/kg PO q8-12h ⁴¹	Phosphorus-binder; hyperphosphatemia due to renal failure
Barium	10-14 mL/kg PO ⁴¹	Gastrointestinal contrast studies
Benazepril	0.25-0.5 mg/kg PO q24h ⁴¹	Vasodilator; potentially less nephrotoxic than enalapril
Blood transfusion (whole blood)	10-20 mL/kg given no faster than 22 mL/kg/h ⁴¹	Cross-matching advised, especially for repeated transfusions

Continued

TABLE 10-7 Miscellaneous Agents Used in Rabbits. (cont'd)

Agent	Dosage	Comments
Calcium EDTA (edetate calcium disodium) (Calcium Disodium Versenate, 3 M)	13-27 mg/kg SC, IV ⁴¹ 27 mg/kg SC q6-12h prn ⁴¹	Chelation therapy Lead toxicosis; diluted to <10 mg/mL with 0.45% NaCl/2.5% dextrose
Cellulose powder (Unifiber, Niche)	½-1 tsp/feeding ⁴¹	Nonsoluble fiber source for rabbits on liquid enteral diets; will pass through small diameter feeding tubes
Chlorpheniramine maleate	0.2-0.4 mg/kg PO q12h ⁴¹	Antihistamine
Cholestyramine (Questran Light, Squibb)	2 g/animal PO q24h × 18-21 days ⁴¹	Ion exchange resin for toxin absorption following inappropriate antibiotic administration; use for treating enterotoxemia; gavage with 20 mL water; may result in constipation
Chondroitin sulfate (Cosequin, Nutramax)	Used empirically at feline dose ¹³⁴	Arthritis; nutraceutical
Cimetidine	5-10 mg/kg PO, SC, IM, IV q6-12h ^{65,112}	Gastric and duodenal ulcers
Cisapride	0.5 mg/kg PO q8-12h ¹¹²	Enhances gastrointestinal motility; must be compounded in United States
Cyclizine	8 mg/rabbit PO q12h ⁴¹	Vertigo associated with torticollis
Cyproheptadine	1-4 mg/rabbit PO q12-24h ⁵¹	Possible appetite stimulant
Dexamethasone	— 0.2-0.6 mg/kg SC, IM, IV ⁴¹ 0.5-2 mg/kg PO, SC, then taper dose q12h × 3-14 days ⁴¹ 2 mg/kg IM, IV ⁴¹	Corticosteroids are seldom indicated in rabbits; rabbits are a corticosteroid-sensitive species; ⁴¹ use with extreme caution and consider concurrent administration of a gastroprotective agent Antiinflammatory Shock; effectiveness is controversial
Digoxin	0.005-0.01 mg/kg PO q12-24h ⁴¹	Congestive heart failure; atrial fibrillation
Diltiazem	0.5-1 mg/kg PO q12-24h ⁴¹	Calcium channel blocker for hypertrophic cardiomyopathy
Diphenhydramine	2 mg/kg PO, SC q8-12h ^{41,112}	Torticollis, antihistamine
Doxapram	2-5 mg/kg SC, IV q15min ⁴¹	Respiratory stimulant
Enalapril	0.1-0.5 mg/kg PO q24-48h ⁶⁵	Beware of hypotensive side effects
Epinephrine	0.2-0.4 mg/kg IM, IV, intratracheally ¹¹²	Cardiac arrest
Epoetin alpha, recombinant (Epoen, Amgen)	50-150 U/kg SC q2-3d ¹¹²	Biosynthetic form of erythropoietin; treatment of anemia; use until PCV is normal, then q7d for at least 4 wk
Famotidine	0.5-1 mg/kg PO, SC, IV q12-24h ^{40,112}	H ₂ -receptor antagonist used to reduce GI acid production
Fecal transfaunation	Mix fresh cecotrophs with warm saline, strain through gauze, and administer by gavage ⁴¹	Dysbiosis; placement of E-collar on donor facilitates collection of sample
Ferrous sulfate	4-6 mg/kg PO q24h ⁴¹	Iron deficiency anemia

TABLE 10-7 Miscellaneous Agents Used in Rabbits. (cont'd)

Agent	Dosage	Comments
Furosemide	— 0.3-2 mg/kg SC, IM, IV ⁴¹ prn 1-4 mg/kg SC, IM, IV q4-6h ¹¹² 2-5 mg/kg PO, SC, IM, IV q12h ¹¹² prn	Loop diuretic Pulmonary edema Congestive heart failure
Hetastarch (Hespan, DuPont)	5 mL/kg IV given over 5-10 min; repeat if necessary ⁴¹ 20 mL/kg IV ¹⁰¹	Volume expansion in hypoproteinemic patients; may be of benefit in endotoxemia
Human chorionic gonadotropin (hCG)	20-25 U/animal IV ⁴¹	Ovulation
Hydroxyzine	2 mg/kg PO q8-12h ⁴¹	Antihistamine; antipruritic
Iron dextran	4-6 mg/kg IM once ⁴¹	Iron deficiency anemia (treatment or prevention)
Lactated Ringer's solution or other appropriate fluid of choice	60-90 mL/kg \times 1 hr ⁴¹ 100-150 mL/kg/day CRI or divided SC q6-12h ⁴¹	Treatment for shock Maintenance fluid support
Lactobacilli	— Administer PO during antibiotic treatment period, then 5-7 days beyond cessation ⁴¹	May aid in treatment of enteritis; ⁴¹ efficacy not determined Give 2 hr before or 2 hr after antibiotic treatment
Levetiracetam (Keppra, UCB)	20 mg/kg PO q8h ¹¹	Anticonvulsant; dosage not established in rabbits, but PD are similar to those in dogs
Lidocaine	1-2 mg/kg IV (bolus) ⁴¹ 2-4 mg/kg intratracheally ⁴¹	Cardiac arrhythmia Cardiac arrhythmia
Loperamide	0.1 mg/kg PO q8h \times 3 days, then q24h \times 2 days ¹¹²	Enteropathies (nonspecific diarrhea); give in 1 mL water
Maropitant citrate (Cerenia, Zoetis)	2 mg/kg SC q24h \times 3-5 days, then q48h or 3 \times weekly if needed ²⁴	May be helpful in arthritis or inflammatory conditions; reduces visceral pain
Meclizine	2-12 mg/kg PO q24h ¹¹² 12.5-25 mg/kg PO q8-12h ⁴¹	Reduces disorientation and rolling with torticollis (for prevention of motion sickness in small animals)
Metoclopramide	0.2-0.5 mg/kg PO, SC q6-8 h ⁴¹ 0.2-1 mg/kg PO, IM, SC q6-24h ¹¹² 0.5 mg/kg PO, SC q4-12 h ⁴¹	Stimulates gastrointestinal motility
Mirtazapine	0.3-0.5 mg/kg PO q24h ¹¹⁴	Appetite stimulant; dosage not established in rabbits; cat dose given here
Nandrolone (Deca-Durabolin, Organon)	2 mg/kg SC, IM ⁴¹	Anabolic steroid; appetite stimulant; adjunct to treatment for anemia, especially in chronic renal failure

Continued

TABLE 10-7 Miscellaneous Agents Used in Rabbits. (cont'd)

Agent	Dosage	Comments
Omeprazole	20 mg/kg SC q12h ⁷⁷	Proton pump inhibitor used as a gastroprotective agent
Oxytocin	0.1-3 U/kg SC, IM ⁴¹	Use in delayed, but unobstructed, parturition;agalactia
Pimobendan	0.1-0.3 mg/kg PO q12-24h ⁴¹	Phosphodiesterase inhibitor; increases cardiac contractility with dilated cardiomyopathy or mitral valve disease
Polysulfated glycosaminoglycan (Adequan, Luitpold)	2.2 mg/kg SC, IM q3d × 21-28 days, then q14d ¹¹²	Noninfectious, traumatic, or degenerative joint disease
Potassium citrate	33 mg/kg q8h ⁴¹	Urinary calculi; may decrease calcium-based stone formation
Prednisolone	— 0.25-0.5 mg/kg PO q12h × 3 days, then q24h × 3 days, then q48h ⁴¹ 0.5-2 mg/kg PO q12h ¹¹²	See dexamethasone; rarely indicated Treatment of nonresponsive torticollis, when negative for pasteurellosis; give antibiotics concurrently
Prednisone	— 0.5-2 mg/kg PO ^{41,112}	See dexamethasone; rarely indicated Antiinflammatory
Prochlorperazine	0.2-0.5 mg/kg PO q8h ⁴¹	Torticollis; doses as high as 30 mg/kg q8h are used to treat labyrinthine disorders in humans
Ranitidine	2 mg/kg IV q24h ⁴¹ 2-5 mg/kg PO q12h ¹¹²	Gastric ulceration (often in inappetent rabbits)
Sevelamer	Dosage not established in animals	Human dosage is 2-4 capsules PO q8h; ¹¹² phosphorus binder for hyperphosphatemia associated with chronic renal failure; consider monitoring coagulation parameters, as vitamin K absorption may be affected; drug is not absorbed systemically so toxicity is unlikely
Silymarin (milk thistle)	4-15 mg/kg PO q8-12h ⁶⁵ 20-50 mg/kg PO q24h ¹¹²	Nutraceutical used as an adjunctive treatment for liver disease; hepatoprotectant; dosage not established for rabbits; suggested dose for small animals
Simethicone	65-130 mg/animal PO q1h × 2-3 treatments ⁴¹	May reduce abdominal discomfort associated with excess gas
Sodium bicarbonate	2 mEq/kg IV, IP ⁴¹	Ketoacidosis (pregnancy toxemia); dose is approximate
Stanozolol	0.5-2 mg PO once ¹¹²	Stimulates appetite following surgery or illness; may be available from compounding pharmacy
Succimer (DMSA)	1050 mg/m ² PO × 1 wk, then 700 mg/m ² × 2 wk ¹⁴²	Lead toxicity
Sucralfate	25 mg/kg PO q8-12h ⁴¹	Gastrointestinal ulcers; may interfere with other orally administered drugs

TABLE 10-7 Miscellaneous Agents Used in Rabbits. (cont'd)

Agent	Dosage	Comments
Sulfasalazine	$\frac{1}{8}$ - $\frac{1}{4}$ crushed 500 mg tablet/animal q8-24 h ⁴¹	May reduce inflammation of intestinal mucosa
Verapamil	2.5-25 μ g/kg/h IP ¹²⁹ 8-16 mg/kg PO plus 0.5-2 mg/kg SC q24h ¹¹²	Postoperative administration decreases adhesion formation Slow-channel calcium blocking agent
Vitamin A	500-1000 U/kg IM ⁴¹	
Vitamin B complex	0.02-0.4 mL/rabbit SC, IM q24h ⁵¹	Possible appetite stimulant; vitamin B deficiency
Vitamin C (ascorbic acid)	100 mg/kg PO q12h ¹¹²	Nutritional supplement
Vitamin K	1-10 mg/kg IM prn ⁴¹	Select bleeding disorders and toxicities

TABLE 10-8 Hematologic and Serum Biochemical Values of Rabbits.⁴¹

Measurement	Normal Values
Hematology	
PCV (%)	30-50
Hgb (g/dL)	8-17.5
RBC ($10^6/\mu$ L)	4-8
MCV (fL)	58-75
MCH (pg)	17.5-23.5
MCHC (g/dL)	29-37
Reticulocytes (%)	2-4
Platelets ($10^3/\mu$ L)	290-650
WBC ($10^3/\mu$ L)	5-12
Heterophils (neutrophils) (%)	35-55
Lymphocytes (%)	25-60
Monocytes (%)	2-10
Eosinophils (%)	0-5
Basophils (%)	2-8
Chemistries	
ALP (U/L)	4-70
ALT (U/L)	14-80
Amylase (U/L)	200-500
AST (U/L)	14-113
Bicarbonate (mEq/L)	16.2-31.8
Bile acids (μ mol/L)	<40
Bilirubin, total (mg/dL)	0-0.75

Continued

TABLE 10-8 Hematologic and Serum Biochemical Values of Rabbits. (cont'd)

Measurement	Normal Values
Calcium (mg/dL)	8-14.8
Chloride (mEq/L)	92-112
Cholesterol (mg/dL)	12-116
Creatinine (mg/dL)	0.5-2.6
Glucose (mg/dL)	75-150
LDH (U/L)	34-129
Lipids, total (mg/dL)	280-350
Phosphorus (mg/dL)	2.3-6.9
Potassium (mEq/L)	3.5-7
Protein, total (g/dL)	5.4-7.5
Albumin (g/dL)	2.5-5
Globulin (g/dL)	1.5-3.5
Sodium (mEq/L)	138-155
Triglycerides (mg/dL)	124-156
T ₃ (ng/dL)	130-430
T ₄ (µg/dL)	1.7-2.4
Urea nitrogen (mg/dL)	15-50
Vitamin A, plasma (µg/mL)	30-80
Vitamin E, plasma (µg/mL)	>1
Vitamin D ₃ (pmol/L)	20-45 (free-range, outdoors)

TABLE 10-9 Rabbit Blood Glucose and Sodium Levels as Prognostic Indicators.⁶⁵

Physiologic State	Blood Glucose (mg/dL)	Sodium (mEq/L)	Osmolarity ^a (mOsm/L)	Tonicity ^a (mOsm/L)
Normal	76-148	136-147	284-312	278-302
Stress (e.g., handling)	144-180	—	—	—
Severe disease (e.g., enterotoxemia, mucoid enteropathy, GI obstruction)	360-540	<129 carries a 2.3 times mortality risk	—	—
Diabetes mellitus	540-601	—	—	—

^aOsmolarity and tonicity may be used to differentiate true hyponatremia from pseudohyponatremia (may occur with hyperlipidemia, severe liver disease, or congestive heart failure).

Calculated tonicity:

$$\text{Ton (mOsm/L)} = 2 \times \text{Na (mEq/L)} + \text{glucose (mg/dL)/18}$$

Calculated osmolarity:

$$\text{P}_{\text{osm}} \text{ (mOsm/L)} = 2 \times \text{Na (mEq/L)} + \text{glucose (mg/dL)/18} + \text{BUN (mg/dL)/2.8}$$

TABLE 10-10 Biologic and Physiologic Data of Rabbits.⁴¹

Parameter	Normal Values
Adult body weight, male (buck)	1.5-5 kg
Adult body weight, female (doe)	1.5-6 kg
Birth weight	30-80 g
Respiratory rate	30-60 breaths/min
Tidal volume	4-6 mL/kg
Heart rate	130-325 beats/min
Rectal temperature	38.5-40°C (101.3-104°F)
Life span	5-6 years (up to 15 years)
Food consumption	50 g/kg/day
Water consumption	100 mL/kg/day
Gastrointestinal transit time	4-5 hours
Breeding onset, male	6-10 months
Breeding onset, female	4-9 months
Breeding life of female	4 months to 3.75 years
Reproductive cycle	Induced ovulation
Gestation period	29-35 days
Litter size	4-10
Weaning age	4-6 weeks
Dental formula	I2/1 C0/0 P3/2 M3/3

TABLE 10-11 Urinalysis Values in Rabbits.⁴¹

Measurement	Normal Values
Urine volume	
Large breeds	20-350 mL/kg/day
Average breeds	130 mL/kg/day
Specific gravity	1.003-1.051
pH	7.7-9.6
Crystals	Ammonium magnesium phosphate, calcium carbonate monohydrate, anhydrous calcium carbonate
Casts, epithelial cells, or bacteria	Absent to rare
Leukocytes or erythrocytes	Occasional
Albumin	Occasional in young rabbits
Protein:creatinine ratio	0.11-0.47
Protein (g/L, reference assay)	0.57-10.66
Protein (Multistix dipsticks)	Negative to +++

TABLE 10-12 Cerebrospinal Fluid Values in Rabbits.⁴¹

Measurement	Normal Values
Leukocyte count	≤4 cells/μL (1-97 cells/μL in <i>E. cuniculi</i> positive rabbits)
Alkaline phosphatase	5 U/dL
Calcium	5.4 mEq/L
Carbon dioxide	41.2-48.5 mL%
Chloride	127 mEq/L
Cholesterol	33 mg/dL
Creatinine	17 mg/dL
Glucose	75 mg/dL
Lactic acid	1.4-4 mg/dL
Magnesium	2.2 mEq/L
Nitrogen, nonprotein	5.6-16.8 mg/dL
Phosphate	2.3 mEq/L
Potassium	3 mEq/L
Protein, total	13-59 mg/dL (31-154 mg/dL in <i>E. cuniculi</i> positive rabbits)
Sodium	149 mEq/L
Urea nitrogen	20 mg/dL

TABLE 10-13 Electrocardiographic (ECG) and Echocardiographic Values in Rabbits.⁴¹

ECG Parameter	Normal Values
Heart rate	198-330 beats/min ^a
Measurements (lead II)	
P wave	
Duration (width)	0.01-0.05 sec
Amplitude (height)	0.04-0.12 mv
P-R interval	
Duration	0.04-0.08 sec
QRS complex	
Duration	0.02-0.06 sec
R-wave amplitude	0.03-0.039 mv
Q-T interval	
Duration	0.08-0.16 sec
T wave	
Amplitude	0.05-0.17 mv
Electrical axis (frontal plane)	-43 to +80 degrees
Thickness of interventricular septum in diastole	0.143-0.310 cm
Thickness of interventricular septum in systole	0.217-0.403 cm
Left ventricular internal diameter in diastole	1.187-1.906 cm

TABLE 10-13 Electrocardiographic (ECG) and Echocardiographic Values in Rabbits. (cont'd)

ECG Parameter	Normal Values
Left ventricular internal diameter in systole	0.783-1.353 cm
Thickness of left ventricular free wall in diastole	0.16-0.28 cm
Thickness of left ventricular free wall in systole	0.243-0.455 cm
Fractional shortening	22.6%-36.83%
Ejection fraction	49.07%-70%
Aortic diameter	0.673-0.980 cm
Left atrial appendage diameter	0.753-1.200 cm
Left atrial appendage diameter:aortic diameter	0.94-1.54
Mitral valve E-point-to-septal separation interval	0.120-0.233 cm
Doppler heart rate	115-234 beats/min
Maximal aortic outflow velocity	0.56-1.06 m/sec
Maximal pulmonary artery outflow velocity	0.34-0.84 m/sec
Maximal mitral E-wave velocity	0.41-0.83 m/sec
Maximal mitral A-wave velocity	0.19-0.44 m/sec
Maximal mitral E-wave velocity:A-wave velocity	1.34-3.55

^aLower values may be expected in acclimated rabbits.

TABLE 10-14 Determining the Sex of Mature Rabbits.⁴¹

Male	Female
<ul style="list-style-type: none"> • Protrude penis by manipulating skin of prepuce • Palpate for testicles • Anogenital distance is longer 	<ul style="list-style-type: none"> • There is a common orifice for both the vagina and urethra (like dogs and cats) • No structure like a "penis" can be protruded from the urogenital orifice • Anogenital distance is shorter

TABLE 10-15 Drugs Reported to Be Toxic in Rabbits.^a

Drug	Comments
Amoxicillin ⁴¹	Enteritis; enterotoxemia
Amoxicillin/clavulanic acid ⁴¹	Enteritis; enterotoxemia
Ampicillin ⁴¹	Enteritis; enterotoxemia, high risk especially if given orally
Benzimidazoles (fenbendazole, oxi-bendazole, albendazole) ⁵²	Bone marrow suppression reported; recommend intratreatment CBC to r/o anemia, leukopenia, thrombocytopenia
Cephalosporins ⁴¹	Enteritis; enterotoxemia if given orally
Clindamycin ⁴¹	Enteritis; enterotoxemia, high risk
Erythromycin ⁴¹	Enteritis; enterotoxemia
Fipronil ⁴¹	Can cause neurologic disease and death

Continued

TABLE 10-15 Drugs Reported to Be Toxic in Rabbits. (cont'd)

Drug	Comments
Lincomycin ⁴¹	Enteritis; enterotoxemia, high risk
Penicillin ¹¹²	Enteritis; enterotoxemia if given orally
Procaine ⁴¹	May be fatal at doses of 0.4 mg/kg
Tiletamine ⁴¹	Nephrotoxic

^aThere have also been some reports of antibiotic-related colitis in rabbits given penicillin/streptomycin, trimethoprim/sulfamethoxazole, tetracycline, and gentamicin.

TABLE 10-16 Treatments Used in the Management of Rabbit Gastrointestinal Syndrome (RGIS).^a

Agent	Dosage	Comments
Buprenorphine	0.01-0.05 mg/kg SC, IV, IP q6-12h ⁴¹	Analgesia
Butorphanol	0.1-0.5 mg/kg SC, IM, IV q4h ⁴¹	Analgesia
Cisapride	0.5 mg/kg PO q8-12h ¹¹²	Enhances gastrointestinal motility; compounded in United States
Cyproheptadine HCl	1-4 mg/rabbit PO q12-24h ⁵¹	Possible appetite stimulant
Enrofloxacin	5 mg/kg PO, SC, IM, IV q12h ^{15,16,41}	Suspected primary bacterial enteritis (rare in rabbits)
Famotidine	0.5-1 mg/kg PO, SC, IV q12-24h ^{40,111}	H2-receptor antagonist used to reduce GI acid production
Fluid therapy	Weight (kg) × % dehydration × 1000 mL = fluid deficit divided into SC boluses or divided IV per hr over 12-24 hr ⁵¹ 60-90 mL/kg × 1 hr 100-150 mL/kg/day constant rate infusion or divided SC q6-12h	Add deficit to maintenance requirement of 3-4 mL/kg/h Shock therapy Maintenance fluid support
Herbivore critical care diet	Follow manufacturer's instructions	Syringe feeding; use fine grind for nasogastric tubes
Hydromorphone	0.05-0.2 mg/kg SC, IM, IV q6-8h ²⁰	Analgesia
Lidocaine	2 mg/kg IV loading dose given over 5 minutes followed by 60-100 µg/kg/min ¹²⁴ 100 µg/kg/min × 2 days ¹²⁵	CRI for severe, refractory cases of RGIS Better surgical and postoperative outcome than buprenorphine
Maropitant citrate (Cerenia, Zoetis)	2 mg/kg SC q24h × 3-5 days; then q48h or 3 × weekly if needed ²⁴	May be helpful in inflammatory conditions; reduces visceral pain
Meloxicam	0.3-1 mg/kg PO q24h ^{23,133}	NSAID; use only if well hydrated with normal renal parameters
Metoclopramide	0.2-0.5 mg/kg PO, SC q6-8h ⁴¹ 0.01-0.09 mg/kg/h IV ¹¹²	Stimulates gastrointestinal motility CRI
Metronidazole	20 mg/kg PO q12h for 3-5 days ¹¹² 5 mg/kg slow IV q12h ¹¹²	For suspected clostridial overgrowth and enterotoxemia

TABLE 10-16 Treatments Used in the Management of Rabbit Gastrointestinal Syndrome (RGIS). (cont'd)

Agent	Dosage	Comments
Midazolam	0.25-0.5 mg/kg IM, IV ⁵⁷	Antianxiety; may also stimulate appetite
Ranitidine	2 mg/kg IV q24h ⁴¹ 2-5 mg/kg PO q12h ¹¹²	Gastric ulceration (often in inappetent rabbits)
Simethicone	65-130 mg/animal PO q1h × 2-3 treatments ⁴¹	May reduce abdominal discomfort associated with excess gas
Thermal support	Provide thermal support if body temperature <99°F ⁵¹	Avoid overheating
Trimebutine	1.5 mg/kg PO, IV ⁸⁶	Enhance GI motility; not available in the United States; oral available in Canada
Vitamin B Complex	0.02-0.4 mL/rabbit SC, IM q24h ⁵¹	Possible appetite stimulant

^aConcurrent to treatment, it is important to correct the cause (e.g., boredom, stress, excessive shedding, inadequate dietary roughage, nutritional deficiency or imbalance, disease, toxin, obesity). Surgical intervention is no longer considered the primary treatment option and is rarely indicated except in cases of complete obstruction.

TABLE 10-17 Bronchoalveolar Lavage (BAL) in Rabbits.^{a,41}

BAL Parameter	Results and Comments
Volume	40%-76% recovery = 1.2-2.3 mL
Leukocyte count	200-700 cells/μL, predominantly macrophages
Heterophils	0-28 cells/μL (0%-5%)
Lymphocytes	15-98 cells/μL (4%-30%)
Macrophages	180-602 cells/μL (69%-94%)
Eosinophils	0-60 cells/μL (0%-12%)

^aBronchoscopic bronchoalveolar lavage in New Zealand white rabbits was performed with 3 mL of sterile saline into both left bronchus and right bronchus.

TABLE 10-18 Clinical Signs and Behavioral Changes Used in the Assessment of Pain in Rabbits.^a

Clinical Signs	Behavioral Changes
Change of body posture; tensing of abdominal muscles, pressing abdomen onto ground	Decreased grooming activity; piloerection; unkempt and ruffled fur coat
Change of body posture; tucking of abdomen, hunched body; abdominal splinting on palpation	Decreased interest in food or cessation of food intake
Eyelids squinted; lack of focus; orbit may be retracted or bulging	Decreased frequency and duration of exploring/searching
Muzzle and nares contracture; increased intensity associated with level of pain	Decreased frequency and duration of movement or response to stimuli
Increased teeth grinding (bruxism)	Decreased conspecific interaction
Ears pinned back, held close to head	Irritable or aggressive temperament

Continued

TABLE 10-18 Clinical Signs and Behavioral Changes Used in the Assessment of Pain in Rabbits. (cont'd)

Clinical Signs	Behavioral Changes
Increased heart rate; increased frequency and depth of respirations	Stiff gait, lameness, staggering; difficulty finding comfortable resting position
Decreased body weight over time	Decreased fecal output or decreased size of fecal pellets

^aModified from Fisher (2010).⁴²

TABLE 10-19 Percentage of Antibiotic Susceptibility Results for the Most Common Bacteria Isolated From Nasal Cultures of 121 Rabbits With Signs of Upper Respiratory Disease.¹²⁰

Antibiotic	Bacteria ^a											
	<i>Pateurella multocida</i> (N=106)			<i>Bordetella bronchiseptica</i> (N=99)			<i>Pseudomonas</i> spp. (N=41)			<i>Staphylococcus</i> spp. (N=27)		
	S	I	R	S	I	R	S	I	R	S	I	R
Cephalexin	100	0	0	2.0	0	98.0	2.4	2.4	95.2	88.9	0	11.1
Danofloxacin	100	0	0	43.4	40.4	16.2	65.9	22.0	12.1	77.8	18.5	3.7
Doxycycline	97.2	2.8	0	88.9	2.0	9.1	56.1	7.3	36.6	74.1	3.7	22.2
Enrofloxacin	100	0	0	71.7	15.2	13.1	58.5	22.0	19.5	81.5	14.8	3.7
Gentamicin	99.1	0.9	0	96	1.0	3.0	75.6	4.9	19.5	85.2	0	14.8
Marbofloxacin	100	0	0	88.9	6.1	5.0	87.8	4.9	7.3	96.3	0	3.7
Oxytetracycline	97.2	0	2.8	86.9	2.0	11.1	63.4	9.8	26.8	74.1	0	25.9
Trimethoprim-sulfamethoxazole	93.4	5.7	0.9	81.8	1.0	17.2	24.4	19.5	56.1	92.6	3.7	3.7

^aS, sensitivity; I, intermediate; R, resistant.

TABLE 10-20 Sensitivity and Specificity Calculators for IgM and IgG Titers and CRP Levels Relative to the Diagnosis of Suspected *Encephalitozoon cuniculi* Infections in Pet Rabbits.^{a,27}

IgM ≥ 1:64	IgG ≥ 1:512	CRP > 38 mg/L	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)
+	ND	ND	69	75	88	48
ND	+	ND	62	78	88	44
ND	ND	+	40	89	90	38
+	+	ND	58	89	92	41
+	ND	+	27	100	100	34
ND	+	+	22	97	95	32
+	+	+	20	100	100	32

^aCRP, C-Reactive Protein; ND, results of analyte not included in analysis.

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Chapter 11 Ferrets

James K. Morrisey | Matthew S. Johnston



TABLE 11-1 Antimicrobial and Antifungal Agents Used in Ferrets.

Agent	Dosage	Comments
Amikacin	8-16 mg/kg SC, IM, IV divided q8-24h ⁵³ 10-15 mg/kg SC, IM q12h ⁵²	Potentially ototoxic and nephrotoxic
Amoxicillin	20 mg/kg PO, SC q12h ⁵² 30 mg/kg PO q8h × 21 days ¹⁶	<i>Helicobacter</i> ; can use with metronidazole and bismuth subsalicylate
Amoxicillin/clavulanic acid (Clavamox, Zoetis)	13-25 mg/kg PO q8-12h ⁵² 18.75 mg per jill PO q12h ¹⁵	For treatment of <i>E. coli</i> induced mastitis
Amphotericin B	0.15 mg/kg IV 3×/wk × 2-4 mon ²⁵ 0.25-1 mg/kg IV q24h or q48h until total dose of 7-25 mg has been given ²⁵ 0.4-0.8 mg/kg IV q7d ⁵²	Treatment of cryptococcosis Blastomycosis; monitor for azotemia; total dose 7-25 mg
Ampicillin	5-30 mg/kg SC, IM, IV q8-12h ^{51,52}	
Azithromycin	5 mg/kg PO q24h ⁶⁰	
Cefadroxil	15-20 mg/kg PO q12h ⁵²	
Cefovecin (Convenia, Zoetis)	8 mg/kg SC q2-3d ⁴⁹	Second generation parenteral cephalosporin; long-acting antibiotic
Cephalexin	15-30 mg/kg PO q8-12h ⁵³	
Cephaloridine	10-25 mg/kg SC, IM q24h × 5-7 days ⁵³	Dermatitis
Chloramphenicol	25-50 mg/kg PO, SC, IM, IV q12h ⁵³ 50 mg/kg SC, IM q12h ¹⁵	14-day minimum for proliferative bowel disease For treatment of mastitis
Ciprofloxacin	10-30 mg/kg PO q24h ⁵³	Mix 500 mg tablet in 10 mL water (50 mg/mL); flavor for improved acceptance
Clarithromycin	12.5 mg/kg PO q8-12h × 14 days ⁴⁴ 50 mg/kg PO q24h or divided q12h × 14 days ⁵¹	<i>Helicobacter</i> ; use with ranitidine bismuth citrate <i>Helicobacter</i> ; use with omeprazole (or ranitidine) and metronidazole
Clindamycin	5.5-10 mg/kg PO q12h ⁵³ 12.5 mg/kg PO q12h ⁵³	Anaerobic infections; bone and dental disease Toxoplasmosis
Cloxacillin	10 mg/kg PO, IM, IV q6h ⁶⁵	
Doxycycline	10 mg/kg PO q12h ³⁷	May help with ferret systemic coronavirus infection
Enrofloxacin (Baytril, Bayer)	5 mg/kg PO, IM q12h ¹⁵ 5-10 mg/kg PO, SC, IM q12h ⁵³ 10-20 mg/kg PO, SC, IM q12-24h ⁵²	For treatment of mastitis IM for short term (generally 1 injection); injectable form can be given PO in palatable liquid; liquid for PO can also be compounded
Erythromycin	10 mg/kg PO q6h ⁵² 220 g/ton feed ⁵³	Controlling <i>Campylobacter</i> diarrhea in large groups

Continued

TABLE 11-1 Antimicrobial and Antifungal Agents Used in Ferrets. (cont'd)

Agent	Dosage	Comments
Fluconazole	50 mg/kg PO q12h ⁵³	
Gentamicin	2 mg/kg PO q12h × 10-14 days ²¹ 2-5 mg/kg SC, IM, IV q12-24h ⁵²	Parenteral form can be given PO; proliferative colitis that is nonresponsive to chloramphenicol ^{12,21} If given IV, dilute with saline and administer over 20 min
Griseofulvin	25 mg/kg PO q12-24h ⁵³	Refractory dermatomycosis; use with lime-sulfur dips q7d
Itraconazole	1.5 mg/kg PO q24h ⁴¹ 10 mg/kg PO q12h ²⁰ 10-20 mg/kg PO q24h ⁶⁷ 25-33 mg/kg PO q24h ^{25,72}	Invasive nasal cryptococcosis Histoplasmosis Cryptococcosis
Ketoconazole	10-50 mg/kg PO q12-24h ³⁹	
Lime sulfur	Dip q7d ⁵²	Dermatomycosis; see griseofulvin
Lincomycin	11 mg/kg PO q8h ⁵³	
Metronidazole	15-20 mg/kg PO q12h ⁵²	Anaerobic infections; can use with amoxicillin and bismuth subsalicylate for <i>Helicobacter</i>
Neomycin	10-20 mg/kg PO q6h ⁵²	Potential nephrotoxicity and neuromuscular blockage
Netilmicin (Netromycin, Schering)	6-8 mg/kg SC, IM, IV q24h ⁵³	Severe staphylococcal infections
Nitazoxanide (Alinia, Romark Laboratories)	5 mg/kg PO q12h ²⁵	Treatment of cryptosporidiosis
Oxytetracycline	20 mg/kg PO q8h ⁵²	
Penicillin G (sodium or potassium)	20,000 U/kg IM q12h ³⁹ 40,000 U/kg SC, IM q24h ⁵²	
Pentamidine isethionate	3-4 mg/kg SC q48h ²⁵	<i>Pneumocystis pneumonia</i>
Pyremethamine	0.5 mg/kg PO q12h ²⁵	Combine with trimethoprim sulfa (30 mg/kg PO q12h) and folic acid (3-5 mg/kg PO q24h) for treatment of toxoplasmosis
Sulfadimethoxine	25 mg/kg PO, SC, IM q24h ⁵³ 30-50 mg/kg PO q12-24h ⁵²	
Sulfamethazine	1-5 mg/mL drinking water ⁵²	
Sulfasoxazole	50 mg/kg PO q8h ⁵³	
Sulfathalidine	Mix in food at dose of 1 g/day/kg body weight ¹²	Opioid useful for management of <i>Salmonella</i> and to reduce shedding in colonies
Tetracycline	20-25 mg/kg PO q8-12h ⁵²	
Trimethoprim/sulfa	5 mg/kg PO q24h ¹⁵ 15 mg/kg IV q12h ⁸ 15-30 mg/kg PO, SC q12h ⁵²	Pyelonephritis Dosage amount of combined drugs
Tylosin (Tylan, Elanco)	5-10 mg/kg PO, SC, IM, IV q12h ^{51,52}	

TABLE 11-2 Antiparasitic Agents Used in Ferrets.

Agent	Dosage	Comments
Amitraz (Mitaban, Upjohn)	0.0125% topical solution q7d × 3 treatments, then 0.0375% q7d × 3 treatments ⁵²	Demodectosis secondary to other illness
	0.03% topical solution to affected area q7d × 3-6 treatments ⁵³	Demodectosis; use full concentration
Amprolium	19 mg/kg PO q24h ⁵²	Coccidiosis
	100 mg/kg PO in food or water for 7 days ²⁵	<i>Isospora</i>
Carbaryl powder (5%)	Topical q7d × 3-6 treatments ⁵²	Ectoparasites
Decoquinatate	0.5 mg/kg PO for at least 2 wk ⁶⁰	Coccidiosis; larger groups of ferrets
Fenbendazole	20 mg/kg PO q24h × 5 days ⁵²	<i>Mesocestoides</i> infection
	50 mg/kg PO q24h × 30 days ⁵²	
Fipronil (Frontline, Merial)	1 pump of spray or 1/5-1/2 of cat pipette topical q60d ⁵²	Flea adulticide
	0.2-0.4 mL topically q30d ⁵²	
Imidacloprid (Advantage, Bayer)	10 mg/kg topically ³⁶	Flea treatment; PD
	0.1-0.4 mL topically q30d ^{39,52}	Flea adulticide; use small cat/kitten vial
Imidacloprid/moxidectin (Advantage Multi, Bayer)	1.9-3.3 µg/kg topically q30d ⁶⁰	Heartworm prevention
Ivermectin	0.02 mg/kg PO, SC q30d ⁶⁹	Heartworm prevention
	0.05 mg/kg PO q30d until negative testing ⁶⁹	Recommended treatment for heartworms; give prednisolone (1 mg/kg/day) concurrently
	0.05-0.3 mg/kg PO q24h for 1 mo after negative skin scraping ⁶	Demodectosis
	0.2-0.5 mg/kg SC q14d × 3 treatments ⁵²	Sarcoptic mange
	0.4 mg/kg PO, SC, repeat in 14-28 days ⁵²	Ear mites, ticks
Lime sulfur	0.5-1 mg/kg in ears, repeat in 14 days ⁵²	Ear mites; half dose in each ear; treat cats and dogs in house concurrently
	Dip 1:40 dilution q7d × 6 wk ²¹	Demodectic mange
Lufenuron (Program, Novartis)	10 mg/kg SC ²⁵	Flea larvicide
	30 mg/kg PO in food ²⁵	
	30-45 mg/kg PO q30d ⁵²	
Mebendazole	50 mg/kg PO q12h × 2 days ²⁵	Nematodes
Melarsomine dihydrochloride (Immiticide, Merial)	2.5 mg/kg IM once, repeat in 30 days with 2 treatments 24 hr apart ⁵²	Heartworm adulticide; less commonly used; use prednisone (1 mg/kg q24h × 4 mo) following treatment
Metronidazole	15-20 mg/kg PO q12h × 14 days ⁵²	Gastrointestinal protozoa
Milbemycin oxime (Interceptor, Novartis)	1.15-2.33 mg/kg PO q30d ⁵²	Heartworm preventive
Moxidectin	0.17 mg SC once ⁶⁰	Heartworm adulticide
Paromomycin	165 mg/kg PO q12h × 5 days ⁶⁰	Cryptosporidiosis; possible treatment; use with caution, severe renal disease possible

Continued

TABLE 11-2 Antiparasitic Agents Used in Ferrets. (cont'd)

Agent	Dosage	Comments
Piperazine citrate	50-100 mg/kg PO q14d ⁵³	Intestinal nematodes
Praziquantel (Droncit, Bayer)	5-10 mg/kg PO, SC, repeat in 10 ⁵³ -14d ⁵² 25 mg/kg PO × 3 days ⁶⁰	Cestodes Trematodes
Pyrantel pamoate	4.4 mg/kg PO, repeat in 14 days ⁵²	
Pyrethrins	Topical q7d prn ⁵²	Fleas; use products safe for puppies and kittens
Pyrimethamine	0.5 mg/kg PO q12h ²⁵	Toxoplasmosis; antiprotozoal
Selamectin (Revolution, Zoetis)	6-18 mg/kg topically ^{51-53,60} 15 mg topically q30d ¹⁴ 45 mg/ferret topically ⁵⁰	Ectoparasites (fleas, lice, most mites except <i>Demodex</i>) Ear mites, fleas; PD Ear mites; although this dose has been reported in a PD study, it appears that lower (safer?) doses (see previous) are also quite effective
Sulfadimethoxine	20-50 mg/kg PO q24h ⁷ 50 mg/kg PO, then 25 mg/kg q24h × 9 days ⁵² 0.5 mL/kg of a 12.5% solution mixed into drinking water ⁵⁶	Coccidia For treatment of enteric coccidiosis in a large group of ferrets
Thiabendazole/ dex-amethasone/ neomycin (Tresaderm, Merial)	2 drops in each ear q24h × 7 days, off 7 days, on 7 days ⁵⁵	Ear mites

TABLE 11-3 Chemical Restraint/Anesthetic Agents Used in Ferrets.

Agent	Dosage	Comments
Acepromazine	— 0.1-0.25 mg/kg SC, IM ⁵² 0.1-0.5 mg/kg SC, IM ³³ 0.2-0.5 mg/kg SC, IM ⁵²	See ketamine for combination Preanesthetic; light sedation Rapid onset of sedation if given IM; doses above 0.2 mg/kg are associated with prolonged recovery times and hypothermia Tranquilization
Alfaxalone (Alfaxan, Jurox)	5 mg/kg IV ¹⁸ 5-15 mg/kg IM ²⁸	Anesthetic induction; PD Sedative
Atipamezole (Antisedan, Zoetis)	0.4 mg/kg IM ⁵³ 1 mg/kg SC, IV, IP ⁵²	Dexmedetomidine and medetomidine reversal; give same volume SC, IV, IP as medetomidine or dexmedetomidine (5 × medetomidine or 10 × dexmedetomidine dose in mg)
Atropine	0.04-0.05 mg/kg SC, IM, IV ⁵²	Preanesthetic; bradycardia; hypersalivation
Bupivacaine	1 mg/kg epidurally ⁵² 1-1.5 mg/kg SC infiltrate ²⁷	Epidural anesthesia; analgesia Local anesthesia; lasts several hours

TABLE 11-3 Chemical Restraint/Anesthetic Agents Used in Ferrets. (cont'd)

Agent	Dosage	Comments
Butorphanol	Loading dose 0.05-0.2 mg/kg; maintenance 0.1-0.4 mg/ kg/hr ²¹	Constant-rate infusion (CRI) for perioperative analgesia; see ketamine, midazolam, and tiletamine/zolazepam for combinations
Dexmedetomidine (Dexdomitor, Zoetis)	0.04-0.1 mg/kg IM ⁴⁹	α_2 agonist similar to medetomidine; not commonly used because of bradycardia and other side effects
Diazepam	— 0.5 mg/kg PO, IM, IV q6-8 h ⁵⁹ 0.5-1.5 mg/kg/h constant- rate infusion ³ 1 mg/animal IV ⁵² 2 mg/kg SC, IM ²⁵	See ketamine for combinations; drug is slowly and incompletely absorbed following IM administration Smooth muscle relaxation in urethral obstruction cases Seizure control Seizure control; 1-2 boluses Tranquilization; seizure control
Enflurane	2% maintenance ⁵²	Anesthesia
Etomidate	1 mg/kg IV ²⁷	Induction and intubation of critically ill animal
Fentanyl citrate/fluanisone (Hypnorm, Janssen)	0.3 mg/kg IM ⁵²	Anesthesia; not available in the United States
Fentanyl/droperidol (Innovar-Vet, Schering Plough)	0.15 mL/kg IM ⁵²	Minor surgical procedures; deep sedation
Glycopyrrolate	0.01 mg/kg IM ⁵²	Preanesthetic; bradycardia; hypersalivation
Isoflurane	To effect ³²	Inhalant anesthesia
Ketamine	— 10-20 mg/kg IM ⁵² 30-60 mg/kg IM ⁵²	Ketamine combinations follow Tranquilization; induction Anesthesia; when used alone, high doses cause poor muscle relaxation, rough recoveries, and convulsions; not recommended as a sole agent
Ketamine (K)/acepromazine (A)	(K) 20-35 mg/kg + (A) 0.2-0.35 mg/kg SC, IM ⁵²	Anesthesia
Ketamine (K)/diazepam (D)	(K) 10-20 mg/kg + (D) 1-2 mg/kg IM ⁵² 0.1 mL/kg IV ⁵²	Anesthesia; poor analgesia ⁶¹ Induction; will allow intubation with premedication; use equal volumes of (K) at 100 mg/mL and (D) at 5 mg/mL
Ketamine (K)/dexmedetomidine (D)	(K) 5 mg/kg IM + (D) 0.03 mg/kg IM ⁵²	Medetomidine no longer commercially available; dexmedetomidine at half the dose of medetomidine may be effective
Ketamine (K)/medetomidine (M) or dexmedetomidine (D)/butorphanol (B)	(K) 5 mg/kg + (M) 0.08 mg/kg or (D)	Medetomidine no longer commercially available; induction or total injectable

Continued

TABLE 11-3 Chemical Restraint/Anesthetic Agents Used in Ferrets. (cont'd)

Agent	Dosage	Comments
	0.04 mg/kg + (B) 0.2 mg/kg IM ³²	anesthesia; allows for intubation; 60-80 min of surgical plane of anesthesia
Ketamine (K)/midazolam (M)	(K) 5-10 mg/kg + (M) 0.25-0.5 mg/kg IV ⁵¹ 0.1 mL/kg IV ⁵²	Induction; use equal volumes of (K) at 100 mg/mL and (M) at 5 mg/mL
Ketamine (K)/xylazine (X)	(K) 10-25 mg/kg + (X) 1-2 mg/kg IM ⁵²	Anesthesia; avoid in sick animals; ³⁹ may result in cardiac arrhythmias ⁶¹
Lidocaine	1-2 mg/kg total SC ²⁷ 0.5-1.0 mg/kg IV q12h ⁵²	Local anesthesia; use 1%-2% solution; lasts 15-30 min
Midazolam (Versed, Roche)	— 0.25-0.3 mg/kg SC, IM ²⁵ 0.25-0.5 mg/kg SC, IM, IV ⁵³	See ketamine for combination; can be reversed with flumazenil at same volume Mild sedation; premedication
Midazolam (M)/butorphanol (B)	(M) 0.2 mg/kg + (B) 0.2 mg/kg IM ^{10,58}	Good sedation; premedication for minor procedures (i.e., ultrasonography, endoscopy, etc.); if needed, can follow with gas anesthesia or IV propofol; can reverse midazolam with flumazenil
Naloxone (Narcan, Dupont)	0.01-0.03 mg/kg IM, IV ⁵² 0.04 mg/kg SC, IM, IV ⁵²	Reversal of opioids; up to 1 mg/kg may be used
Propofol	1-3 mg/kg IV ³² 2-10 mg/kg IV ²⁵	Induction when premedicants are used; bradypnea or apnea and hypoxia common; intubation and oxygen insufflation is recommended Induction
Sevoflurane	To effect ⁵¹	Inhalant anesthesia
Tiletamine/zolazepam (Telazol, Fort Dodge)	— 12-22 mg/kg IM ⁵²	Tiletamine/zolazepam combinations follow Minor surgical procedures at 22 mg/kg; recovery may be prolonged at higher doses; poor muscle relaxation; rarely indicated
Tiletamine/zolazepam (T)/xylazine (X)	3 mg/kg (T) + 3 mg/kg (X) IM ³⁴	Small injection volume; rapid and smooth induction; allows for endotracheal intubation
Tiletamine/zolazepam (T)/xylazine (X)/butorphanol (B)	1.5 mg/kg (T) + 1.5 mg/kg (X) + 0.2 mg/kg (B) ³⁴	Small injection volume; rapid and smooth induction; allows for endotracheal intubation; analgesia; profound cardiorespiratory depression necessitates oxygen insufflation
Tiletamine/zolazepam (T)/dexmedetomidine (D)/butorphanol (B)	0.03 mL/kg IM of prepared solution (see comment) ³²	Telazol powder is reconstituted with 2.5 mL of dexmedetomidine and 2.5 mL of butorphanol (10 mg/mL) to form final volume of 5 mL

TABLE 11-3 Chemical Restraint/Anesthetic Agents Used in Ferrets. (cont'd)

Agent	Dosage	Comments
Xylazine	—	See ketamine and tiletamine/zolazepam for combinations
	0.1-0.5 mg/kg SC, IM ⁵³	Tranquilization; may cause hypotension, bradycardia, and arrhythmias; use with care in sick animals
	2 mg/kg IM ³³	Rapid immobilization within 3-5 minutes; associated with arrhythmias, hypotension, bradycardia
Yohimbine (Yobine, Lloyd)	0.2-0.5 mg/kg IV ⁵²	Xylazine reversal
	0.5-1 mg/kg IM ^{52,53}	

TABLE 11-4 Analgesic Agents Used in Ferrets.

Agent	Dosage	Comments
Acetylsalicylic acid (aspirin)	0.5-22 mg/kg PO q8-24h ⁵²	Analgesia; antiinflammatory; antipyretic; cannot be compounded as molecule is unstable in aqueous solution
Amantadine	3-5 mg/kg PO ⁴⁹	May potentiate other analgesics via NMDA antagonist action
Bupivacaine	1-2 mg/kg SC ³²	
Buprenorphine	12 µg/kg epidurally ²¹	Epidural analgesia/anesthesia
	0.04 mg/kg IM q4-6h ²⁹	PK
	0.01-0.05 mg/kg oral transmucosal, SC, IM, IV q6-12h ^{32,52}	Analgesia
Butorphanol	—	See ketamine, midazolam, and tiletamine/zolazepam (see Table 11-3) for anesthetic combinations
	0.05-0.5 mg/kg SC, IM q8-12h ^{32,52}	Analgesia; lower end of dose may be too low for clinical effect; higher end of dose range may cause profound sedation
	0.3 mg/kg SC q2-4h ²⁹	PK
Carprofen (Rimadyl, Zoetis)	1-5 mg/kg PO q12-24h ^{21,52}	Nonsteroidal antiinflammatory; use caution in animals with gastritis or enteritis
	4 mg/kg SC ³²	
Fentanyl citrate	1.25-5 µg/kg/h IV via constant-rate infusion ^{21,49}	Postoperative analgesia
	10-30 µg/kg/h IV via constant-rate infusion ^{21,49}	Perioperative analgesia; administer after loading dose of 5-10 µg/kg IV

Continued

TABLE 11-4 Analgesic Agents Used in Ferrets. (cont'd)

Agent	Dosage	Comments
Flunixin meglumine (Banamine, Schering)	0.3-2 mg/kg IV, PO, SC q12-24h ^{52,53} 2.5 mg IM q12h ¹⁴	Nonsteroidal antiinflammatory; use caution in animals with gastritis or enteritis; use caution in using drug more than 5 days continuously; mix injectable form with palatable syrup for PO
Gabapentin	3-5 mg/kg PO q8-24h ⁵²	Neurotropic pain; may cause sedation at higher doses
Hydromorphone	0.1 mg/kg SC q1-2h ²⁹ 0.1-0.2 mg/kg SC, IM, IV ³⁹	Opioid; PK
Ibuprofen	1 mg/kg PO q12-24h ⁵¹	Nonsteroidal antiinflammatory
Ketamine	0.1-0.4 mg/kg/h IV via constant-rate infusion ²¹ 0.3-1.2 mg/kg/h IV via constant-rate infusion ²¹	Postoperative analgesia Perioperative analgesia; administer after 2-5 mg/kg IV loading dose
Ketoprofen (Ketofen, Fort Dodge)	1-3 mg/kg PO, SC, IM q24h ⁵³	Nonsteroidal antiinflammatory; use caution with gastritis or enteritis or if using >5 days
Meloxicam	0.1-0.3 mg/kg PO, SC, IM q24h ^{24,25,27}	Nonsteroidal antiinflammatory; monitor liver and kidney values
Meperidine (Demerol, Winthrop-Breon)	5-10 mg/kg SC, IM, IV q2-4h ²⁵	Analgesia
Morphine	0.1 mg/kg epidurally ²¹ 0.2-5 mg/kg SC, IM q2-6h ⁵²	Analgesia SC administration of 1 mg/kg associated with emesis, excitability, and ptialism ³⁹
Nalbuphine (Nubain, Endo Labs)	0.5-1.5 mg/kg IM, IV q2-3h ²⁵	Analgesia
Oxymorphone	0.05-0.2 mg/kg SC, IM, IV q8-12 h ^{27,52}	Analgesia
Pentazocine (Talwin, Sanofi Winthrop)	5-10 mg/kg IM q4h ⁵²	Analgesia
Tramadol	5-10 mg/kg PO q12-24 ²⁵	Analgesia; synergistic with NSAIDs

TABLE 11-5 Cardiopulmonary Agents Used in Ferrets.

Agent	Dosage	Comments
Aminophylline	4-6.6 mg/kg PO, IM, IV q12h ⁵²	Bronchodilator
Amlodipine (Norvasc, Pfizer)	0.2-0.4 mg/kg PO q12h ²⁸	Vasodilator
Atenolol (Tenormin, ICI)	3.125-6.25 mg/kg PO q24h ^{35,52} 6.25 mg/animal PO q24h ⁵²	β -adrenergic blocker for hypertrophic cardiomyopathy
Atropine	0.02-0.04 mg/kg SC, IM ⁵² 0.1 mg/kg intratracheal ⁵²	Bradycardia

TABLE 11-5 Cardiopulmonary Agents Used in Ferrets. (cont'd)

Agent	Dosage	Comments
Benazepril	0.25-0.5 mg/kg PO q24h ^{35,68}	Vasodilator; less nephrotoxic than enalapril
Captopril (Capoten, Squibb)	1/8 of 12.5 mg tablet/animal PO q48h ⁵²	Vasodilator; starting dose, gradually increase to q12-24h; can cause lethargy
Digoxin (Cardoxin, Evsco)	0.005-0.01 mg/kg PO q12-24h ⁵²	Positive inotrope for dilated cardiomyopathy; monitor serum levels
Diltiazem (Cardizem, Marion Merrill Dow)	1.5-7.5 mg/kg PO q12h ^{35,52}	Calcium channel blocker for hypertrophic cardiomyopathy
Dobutamine	0.01 mL/animal IV prn ²⁸	Hypotension
Doxapram	1-2 mg/kg IV ⁵² 5-11 mg/kg IV ⁵²	Respiratory stimulant
Enalapril (Enacard, Merck)	0.25-0.5 mg/kg PO q24-48h ^{35,52}	Vasodilator for dilated cardiomyopathy; do not use with concurrent renal disease
Epinephrine	0.02 mg/kg SC, IM, IV, intratracheal ⁴³ 0.2 mg/kg IV, intracardiac, IO ²⁵ 0.2-0.4 mg/kg diluted in 0.9% NaCl ²⁵ intratracheal	Cardiac arrest; anaphylactic reactions (including vaccine reactions) Administer during cardiopulmonary arrest
Furosemide	1-4 mg/kg PO, SC, IM, IV q8-12h ⁵² 2-3 mg/kg IM, IV q8-12h followed by 1-2 mg/kg PO q12h for long-term management ⁶⁹	Diuretic; use high dose in fulminant heart failure Emergency management of fulminant heart failure
Hyperimmune serum	1 mL/animal IV once ⁵⁷	Use serum from a healthy, appropriately vaccinated ferret for treatment of canine distemper virus infection
Isoproterenol	20-25 µg/animal SC, IM q4-6h ⁶⁹ 40-50 µg/animal PO q4-6h ⁶⁹	Positive chronotrope to increase ventricular rate in third-degree AV block
Metaproterenol	0.25-1 mg/kg PO q12h ⁶⁹	Positive chronotrope to increase ventricular rate in third-degree AV block
Nitroglycerin (2%) ointment (Nitrol, Savage)	1/8-1/4 inch/animal q12-24h ⁵²	Vasodilator for cardiomyopathy; apply to shaved inner thigh or pinna
Pimobendan	0.25-1.25 mg/kg PO q12h ²⁵ 0.5 mg/kg PO q12h ⁶⁹ 0.625-1.25 mg/kg q12h ³⁹	Phosphodiesterase inhibitor; increases cardiac contractility with dilated cardiomyopathy or mitral valve disease
Propranolol (Inderal, Wyeth-Ayerst)	0.2-1 mg/kg PO q8-12h ⁵² 2 mg/kg PO, SC q12h ⁵²	β-blocker for hypertrophic cardiomyopathy; may cause lethargy, loss of appetite
Pseudophedrine	5 mg/kg PO q8h ⁶⁹	Positive chronotrope to increase ventricular rate in third-degree AV block
Terbutaline	2.5-5 mg/kg PO q12-24h ²⁷	Bronchodilator
Theophylline	4.25 mg/kg PO q8-12h ¹²	Bronchodilator; use elixir

TABLE 11-6 Adrenal Gland Disease Agents Used in Ferrets.

Agent	Dosage	Comments
Anastrozole (Arimidex, Astrazeneca Pharmaceuticals)	0.1 mg/kg PO q24h ⁵²	Estrogen inhibitor; precursor hormones blocked by inhibition of aromatase enzyme; use until signs resolve, then 7 days on, 7 days off, etc.; pregnant owners should avoid handling agent
Bicalutamide (Casodex, Astrazeneca Pharmaceuticals)	5 mg/kg PO q24h ⁵²	Testosterone inhibitor; competitively inhibits androgen by binding to receptors in target tissues; use until clinical signs resolve, then 7 days on, 7 days off, etc.; pregnant owners should avoid handling agent
Deoxycorticosterone pivalate (DOCP)	2 mg/kg IM q21d ⁵²	Treatment of adrenal insufficiency following bilateral adrenalectomy
Deslorelin (Suprelorin, Virbac Animal Health)	—	Long-acting GnRH analog that may suppress LH and FSH; used to control signs of adrenal disease; given as a subcutaneous implant approximately once yearly; now available in the United States
	2.7 mg implant SC ³⁸	Alternative to spay/neuter; the 2.7 mg implant is not available in the United States
	3 mg or 4.7 mg SC ^{38,71}	The 3 mg implant is not available in the United States
	4.7 mg implant SC ²⁵	Treatment of adrenal disease; lasts 10-18 months
	9.4 mg implant SC ²⁵	Treatment of adrenal disease; lasts 16-48 months; not available in the United States
Finasteride (Proscar, Merck)	5 mg/kg PO q24h ⁵²	Inhibits conversion of testosterone to active form of dihydrotestosterone; also used in treatment of prostatic enlargement
Flutamide (Eulexin, Schering)	5-10 mg/kg PO q12-24h ^{11,52,63}	Androgen inhibitor; reduces enlarged periurethral prostate tissue; lifetime treatment; associated with mammary tumors
Leuprolide acetate (Lupron, AbbVie)	—	Long-acting GnRH analog that may cause an initial stimulation, then suppression of LH and FSH; palliative treatment of adrenal disease (will not resolve tumor); administer q28d until clinical signs regress, then treatment interval can be up to 6-8 wk; lifetime treatment; higher dosage may shrink prostate within 12-48 hr which may improve urine flow in cases of urethral obstruction; must be prepared in aliquots and frozen (although the effects of freezing on drug efficacy are questionable) until used; very expensive
	1 mg IM q60-75d ¹¹ 3 month depot	Adrenal disease
Lupron, Depot 30 day (TAP)	100-150 µg/kg IM q4-8wk ^{1,70}	
	250 µg/kg IM q4-8wk ²⁶	
Lupron, Depot 4 month (TAP)	250 µg/kg IM ⁵⁹	
	2 mg/kg SC, IM q16wk ⁵²	
Melatonin	0.5-1 mg/animal PO q24h ⁵¹ prn	Symptomatic treatment of hyperadrenocorticism; may not affect tumor growth
	5.4 mg implant SC ⁵²	Should last 6-12 mo

TABLE 11-6 Adrenal Gland Disease Agents Used in Ferrets. (cont'd)

Agent	Dosage	Comments
Mitotane (o,p'-DDD) (Lysodren, Bristol-Myers)	—	Hyperadrenocorticism; variable results and not a reliable alternative to adrenalectomy or other drugs mentioned above; results have been largely unsatisfactory and, therefore, use is not recommended
Trilostane (Vetoryl, Dechra)	2 mg/kg PO q12h ⁵²	May be useful for treating pituitary-dependent hyperadrenocorticism or adrenal dependent hyperadrenocorticism; reduces synthesis of adrenal androgens

TABLE 11-7 Miscellaneous Agents Used in Ferrets.^a

Agent	Dosage	Comments
Activated charcoal	1-3 g/kg PO ⁵²	Orally administered adsorbent for gastrointestinal tract toxins/drug overdoses
Amantadine (Symmetrel, Endo Labs)	6 mg/kg as aerosol q12h ^{5,25,52}	Influenza; experimental antiviral
Apomorphine	0.7 mg/kg SC ⁵² 5 mg/kg SC ⁵²	Emetic Emetic; may cause excitation
Atropine	5-10 mg/kg SC, IM ⁵²	Organophosphate toxicity
Azathioprine (Imuran, GlaxoSmithKline)	0.9 mg/kg PO q24-72h ⁹	Immunosuppressive agent; may use in chronic hepatitis
Barium (30%)	8-13 mL/kg PO ⁵²	Gastrointestinal contrast study
Barium (60%)	17 mL/kg PO ⁶⁶	Followed 30 minutes later by 42 mL/kg of air for a double contrast gastrointestinal study
Bismuth subcitrate, colloidal	6 mg/kg PO q12h ⁵²	In combination with enrofloxacin at 4.25 mg/kg q12h for <i>Helicobacter</i>
Bismuth subsalicylate (Pepto-Bismol, Procter & Gamble)	0.25-1 mL/kg PO q4-8h ⁵² 17.5 mg/kg PO q8-12h ⁵²	Gastrointestinal ulcers; may help prevent <i>Helicobacter</i> colonization
Bleomycin (Blenoxane, BristolMyersSquibb)	10 U/m ² SC ⁵²	Treatment of squamous cell carcinoma
Budesonide (Entocort, AstraZenca)	Up to 1 mg/ferret PO q24h ⁴⁹	Novel steroid may have use as single agent treatment for inflammatory bowel disease
Cabergoline	5 µg/kg PO q24h × 5 days ²⁷	Pseudopregnancy
Calcium EDTA	20-30 mg/kg SC q12h ⁶²	Treatment of heavy metal toxicosis
Chitosan	0.5 mg/kg on food q12h ⁴⁹	Intestinal phosphorus and uremic toxin absorbent; cellulose-like biopolymer from exoskeletons of marine invertebrates
Chlorambucil (Leukeran, Glaxo)	1 mg/kg PO ⁴ 20 mg/m ² PO ⁵²	Antineoplastic; in chemotherapy protocols for lymphoma ³

Continued

TABLE 11-7 Miscellaneous Agents Used in Ferrets. (cont'd)

Agent	Dosage	Comments
Chlorpheniramine (Chlor-Trimeton, Squibb)	1-2 mg/kg PO q8-12h ⁵²	Antihistamine; control sneezing and coughing when they interfere with eating or sleeping
Cimetidine (Tagamet, SmithKline)	5-10 mg/kg PO, SC, IM q8h ⁵² 10 mg/kg PO, IV q8h ²⁵	H ₂ blocker; inhibits acid secretion; gastrointestinal ulcers; unpalatable; give IV (slow)
Ciproheptadine (Periactin, Merck)	0.5 mg/kg PO q12h ⁴⁹	Appetite stimulation
Cisapride (Propulsid, Janssen)	0.5 mg/kg PO q8-12h ⁵²	Antiemetic; motility enhancer; not currently available in the United States; must be compounded
Cobalamin	25 µg/kg SC q7d × 6 wk, then q14d × 6 wk, then q30d ²⁴	Chronic diarrhea; with cobalamin malabsorption
Cyclophosphamide	10 mg/kg PO, SC ⁵² 200 mg/m ² PO, SC ⁴ 250 mg/m ² PO q4-5wk ⁴⁷	Antineoplastic; use at higher dose for salvage treatment of lymphoma ^a Part of a noninvasive protocol for treatment of lymphoma ^a
Cyclosporine	4-6 mg/kg PO q12h ⁴²	Pure red cell aplasia
Cytarabine (Cytosar-U, Zoetis)	300 mg/m ² q8wk ⁴⁷	Part of a noninvasive protocol for treatment of lymphoma ^a
Dexamethasone	0.5 mg/kg SC, IM, IV ⁵² 1 mg/kg IM ⁵²	Post-adrenalectomy; follow with prednisone
Dexamethasone sodium phosphate	1-2 mg/kg IV ³ 2 mg/kg IM, IV ¹⁹ 4-8 mg/kg IM, IV ⁵²	Cerebral edema therapy Anaphylactic reaction to vaccine Shock therapy
Dextrose 50%	0.25-2 mL IV ⁴⁰ 1.25%-5% IV ⁴⁰	Bolus for hypoglycemia; give to effect Infusion for hypoglycemic or inappetent animal
Diazoxide (Proglycem, Medical Market Specialties)	5-30 mg/kg PO q12h ^{45,52} 10 mg/kg PO q24h or divided q8-12h ⁵²	Insulinoma; insulin-blocker; can cause hypertension, lethargy, depression, nausea
Diphenhydramine	0.5-2 mg/kg PO, IM, IV q8-12h ^{43,52}	Antihistamine; controls sneezing and coughing when they interfere with eating or sleeping; give at high dose IM prevaccination when previous reaction occurred or for treatment of vaccine reaction
Doxapram	1-2 mg/kg IV ⁵² 2-5 mg/kg IV ⁵³	Respiratory stimulant
Doxorubicin	1 mg/kg IV q21d × 4 treatments ⁴	Antineoplastic agent; lymphoma; ^a salvage treatment
Epinephrine	0.02 mg/kg SC, IM, IV, IT ⁵²	Severe vaccine reaction; cardiac arrest
Epoetin alfa (Epoen, Amgen)	50-150 U/kg PO, IM q48h ⁵²	Stimulates erythropoiesis; after desired PCV is reached, administer q7d for maintenance

TABLE 11-7 Miscellaneous Agents Used in Ferrets. (cont'd)

Agent	Dosage	Comments
Famotidine (Pepcid, Merck)	0.25-0.5 mg/kg PO, SC, IV q24h ⁵² 2.5 mg PO, SC, IV q24h ²⁵	Inhibits acid secretion; gastrointestinal ulcers
Fludrocortisone (Florinef, SquibbMark)	0.05-0.1 mg/kg PO q24h or divided q12h ⁵²	Mineralocorticoid replacement after adrenal gland removal
Flunixin meglumine (Banamine, Schering)	1 mg/kg SC, IM ⁵² 2.5 mg/animal SC, IM q12h prn ¹⁴	Prevention of prostaglandin-mediated hypotension of endotoxemia Reduce inflammation in mastitis
Flurbiprofen sodium	1-2 drops q12-24h ²⁵	Ophthalmic inflammation
Gadolinium-diethylenetriamine pentaacetic acid (Gd-DPTA) (Omniscan, GE Healthcare)	0.2 mL/kg ³	MRI contrast agent for neurological studies
Glucagon	15 ng/kg/min IV constant-rate infusion ⁸	Emergency management of hypoglycemia secondary to insulinoma
Glutamine	— 0.5 g/kg PO divided daily ⁴⁹	Amino acid; L form available OTC as a nutritional supplement; improves immune system, digestive health, and enhances muscle production Enterocyte supplementation with starvation
Gonadotropin-releasing hormone (GnRH) (Cystorelin, Sanofi)	20 µg/animal IM ¹⁴	Termination of estrus after day 10 of estrus; repeat in 2 wk prn
Hairball laxative, feline	1-2 mL/animal PO q48h ⁵²	Trichobezoar prophylaxis
Heparin	100 U/animal (0.45-1.35 kg) SC q24h × 21 days ³⁵ 200 U/kg SC, IM q12h × 5 days ⁵²	May be used in some heartworm treatments Decreases thromboembolism; start day prior to some heartworm adulticide treatments
Human chorionic gonadotropin (hCG) (Pregnyl, Organon)	— 50-100 U/animal IM ¹⁴ 200-1000 U/animal IM ⁵²	Use 10 or more days after onset of estrus to induce ovulation and prevent hyperestrogenemia; repeat in 1-2 wk prn
Hydrocortisone sodium succinate	25-40 mg/kg IV ⁵²	Shock
Hydrogen peroxide (3%)	2.2 mL/kg PO ⁵²	Emetic
Hydroxyzine (Atarax, Roerig)	2 mg/kg PO q8h ⁵²	Antihistamine; pruritus; may cause drowsiness
Insulin, glargine	0.5 U SC q12h ²³	
Insulin, NPH	0.1 U/animal SC q12h ⁵² 0.5-1 U/kg (or to effect) SC ⁴⁹	Diabetes mellitus; diabetic ketoacidosis; monitor blood glucose

Continued

TABLE 11-7 Miscellaneous Agents Used in Ferrets. (cont'd)

Agent	Dosage	Comments
Insulin, ultralente	0.1 U/animal SC q24h ⁵²	Diabetes mellitus; monitor blood glucose
Interferon- α	107 units IV or intranasal q24h for several days ³¹	Adjunctive therapy for influenza
Iohexol	0.25-0.5 mL injected epidurally at the L5-L6 intervertebral disc space/kg ³ 10 mL/kg PO ⁵² 2.3 mL/kg IV ⁶⁶	Myelography Gastrointestinal contrast study; can dilute 1:1 with water Excretory urography
Ipecac (7%)	2.2-6.6 mL/animal PO ⁵²	Emetic
Iron dextran	10 mg/animal IM once ⁴⁹	Iron deficiency anemia; hemorrhage
Isotretinoin	2 mg/kg PO q24h ⁴	Cutaneous epitheliotropic lymphoma
Kaolin/pectin	1-2 mL/kg PO q2-6h prn ⁵²	Gastrointestinal protectant
Lactulose syrup (Cephulac, Merrill Dow)	0.15-0.75 mL/kg PO q12h ⁵² 150-175 mg/kg PO q8-12h ²⁵	Absorption of blood ammonia in hepatic disease; may cause soft stools at higher dose
L-asparaginase	400 U/kg SC, IM ⁴ 10,000 U/m ² SC q7d \times 3 treatments ⁴⁷	Antineoplastic Part of a noninvasive chemotherapy protocol
Levothyroxine	50-100 μ g/animal q12h ⁷²	Hypothyroidism
Loperamide	0.2 mg/kg PO q12h ⁵²	Antidiarrheal
Mannitol	0.5-1 g/kg IV ³	Give over 20 min
Methotrexate	0.5 mg/kg IV ⁴ 0.8 mg/kg IM ⁴⁷	Antineoplastic Part of noninvasive protocol for treatment of lymphoma ⁴
Metoclopramide	0.2-1 mg/kg PO, SC, IM q6-8h ⁵³	Antiemetic; motility enhancer
Milk thistle (<i>Silybum marianum</i>)	4-15 mg/kg PO q8-12h ²⁵	Hepatoprotective
Misoprostol (Cytotech, Searle)	1-5 μ g/kg PO q8h ⁵²	Gastric ulcers
Nandrolone decanoate	1-5 mg/kg IM q7d ⁵²	Anabolic steroid
Nutri-Cal (EVSCO)	1-3 mL/animal PO q6-8h ⁵²	Nutritional supplement
Octreotide (Sandostatin, Novartis)	1-2 μ g/kg SC q8-12h ⁴⁹	Somatostatin analogue; potential treatment for insulinomas
Omeprazole (Prilosec, Astra Merck)	0.7 mg/kg PO q24h ¹⁷ 4 mg/kg PO q24h ²⁵	Proton-pump inhibitor; decreases gastric secretion of HCl <i>Helicobacter</i> ; use with clarithromycin and metronidazole
Ondansetron	1 mg/kg PO q12-24h ⁴⁹	Antiemetic
Oseltamivir phosphate (Tamiflu, Genentech)	5-10 mg/kg PO q12h \times 10 days ³¹	Antiviral for influenza treatment
Oxytocin	0.2-3 U/kg SC, IM ⁵²	Expels retained fetuses; stimulates lactation
Penicillamine	10 mg/kg PO q24h ²⁵	Copper toxicity

TABLE 11-7 Miscellaneous Agents Used in Ferrets. (cont'd)

Agent	Dosage	Comments
Pentoxifylline (Pentoxil, Upsher-Smith)	20 mg/kg PO q12h ³⁷	Improves perfusion to hypoperfused tissue by increasing deformability of erythrocytes; supportive treatment for ferret systemic coronavirus
Pet-Tinic (SmithKline)	0.2 mL/kg PO q24h ⁵²	Nutritional/iron supplement for anemia
Phenobarbital	1-2 mg/kg PO q8-12h ^{39,52} 2-10 mg/kg/h IV constant-rate infusion ³	Seizure control Seizure control if diazepam is not effective
Phenoxybenzamine (Dibenzylamine, SmithKline Beecham)	3.75-7.5 mg/animal PO q24-72h ⁵⁹	α -Adrenergic antagonist; smooth muscle relaxation for urethral obstruction; potential gastrointestinal or cardiovascular side effects
Polyprenol (Vetimmune, Sasse & Sasse)	3 mg/kg PO 3 \times /wk ³⁷	Antioxidant and immunostimulant; supportive treatment for ferret systemic coronavirus
Potassium bromide	— 22-30 mg/kg q24h PO ³ 70-80 mg/kg q24h PO ³	Seizure control Dose if used with phenobarbital Dose if used alone
Prazosin (Minipress, Zoetis)	0.05-0.1 mg/kg PO q8h ⁵⁹	α -Adrenergic antagonist; smooth muscle relaxation for urethral obstruction; potential for gastrointestinal and cardiovascular side effects
Prednisone	0.25 mg/kg PO q12h \times 5 days, then 0.1 mg/kg q12h \times 10 days ⁵² 0.25-1 mg/kg PO divided q12h ⁵² 0.5 mg/kg PO q12h \times 7-10 days, then q24h \times 7-10 days, then q48h \times 7-10 days ⁵² 1 mg/kg PO q24h \times 7-14 days ⁵² 1.25-2.5 mg/kg PO q24h ⁵² 1.5 mg/kg PO q24h \times 7 days, then taper to 0.8 mg/kg PO q24h ⁴⁶ 2 mg/kg PO q24h ⁵²	Postoperative adrenalectomy; after initial dose of dexamethasone Insulinoma; gradually increase to 4 mg/kg/day prn; up to 2 mg/kg/day when given with diazoxide Postoperative adrenalectomy Use following heartworm adulticide treatment; thromboembolism Eosinophilic gastroenteritis; treat until clinical signs abate; gradually decrease to q48h Management of eosinophilic gastroenteritis Palliative therapy for lymphosarcoma ^a or chronic inflammatory bowel disease; taper dose as able
Procarbazine	50 mg/m ² PO q24h \times 14 days ⁴	Part of a noninvasive protocol for treatment of lymphoma ^a
Proligestone	50 mg SC ⁵⁹	Induce ovulation when jill has been in estrus for 10 days; not available in the United States

Continued

TABLE 11-7 Miscellaneous Agents Used in Ferrets. (cont'd)

Agent	Dosage	Comments
Prostaglandin F ₂ -α (Lutalyse, Upjohn)	0.1-0.5 mg/animal IM prn ⁷ 0.5 mg/animal IM ⁷	Metritis; expels necrotic debris Can induce delivery on day 41 if only one kit; follow with 6 U oxytocin 1-4 hr later
Pyridostigmine (Mestinon, Valeant)	1 mg/kg PO q8h ¹³ 1 mg/kg PO q8-12h ²	Oral cholinesterase inhibitor for potential treatment of myasthenia gravis Myasthenia gravis; overdose possible with long-term use
Ranitidine bismuth citrate (Pylorid, Glaxo Wellcome)	24 mg/kg PO q8h ⁴⁴	<i>Helicobacter</i> ; use in combination with clarithromycin; not available in the United States
Ranitidine HCl (Zantac, Glaxo Wellcome)	3.5 mg/kg PO q12h ^{25,66}	Inhibits acid secretion; gastrointestinal ulcers
S-adenosylmethionine (SAME) (Vetri-SAME, Vetriscience Labs)	20-100 mg/kg PO q24h ⁴⁹	Adjunctive treatment for liver disease; hepatoprotectant; improves synthesis of glutathione and other compounds important for liver function
Saw palmetto	0.15 mL/animal PO q12h ⁵²	Homeopathic remedy used for dysuria associated with prostatic enlargement
Stanozolol (Winstrol, Upjohn)	0.5 mg/kg PO, SC q12h ⁵²	Anemia; anabolic steroid; use with caution in hepatic disease
Sucralfate (Carafate, Hoechst Marion Roussel)	25-125 mg/kg PO q8-12h ⁵²	Gastrointestinal ulcers; give before meals; requires acidic pH
Sulfasalazine	62.5-125 mg PO q8-24h ⁴⁹	Management of colitis
Theophylline elixir	4.25 mg/kg PO q8-12h ⁵²	Bronchodilator
Thyroid-stimulating hormone (TSH)	1 U IV ³⁰	Blood for T ₄ measurement taken 120 min later
Thyroxine	0.2-0.4 mg/kg q12h ⁵²	Hypothyroidism; adjust and taper as needed
Trientine (Syprine, Valeant)	10 mg/kg PO q12h ²⁵	Chelating agent used for copper toxicosis
Ursodiol (Actigall, Ciba)	15 mg/kg PO q12h ⁹	Treatment of chronic hepatopathies
Vincristine	0.12-0.2 mg/kg IV ⁴ 0.75 mg/m ² IV ⁴	Minimal myelosuppression
Vitamin A (retinol palmitate)	50,000 U IM q24h × 2 treatments ⁶²	Reduced mortality secondary to canine distemper virus infection
Vitamin B complex	1-2 mg/kg IM prn ⁵²	Dose based on thiamine content
Vitamin C	50-100 mg/kg PO q12h ²⁵	Adjunct therapy for lymphoma
Vitamin K	2.5 mg/kg SC, then 1-2.5 mg/kg PO divided q8-12h × 5-7 days ⁴⁹ 5 mg/kg SC, then 2.5 mg/kg PO divided q8-12h × 3 wk ⁴⁹ 2.5-5 mg/kg SC, then 2.5 mg/kg PO divided q8-12h × 3-4 wk ⁴⁹	First generation rodenticide toxicity (e.g., warfarin class) Second generation rodenticide toxicity (e.g., brodifacoum class) Inandione or unknown anticoagulant toxicity

TABLE 11-7 Miscellaneous Agents Used in Ferrets. (cont'd)

Agent	Dosage	Comments
Yeast, brewer's	1/6-1/4 tsp PO q12h ⁵²	Source of chromium to stabilize glucose and insulin for animals with insulinomas
Zanamivir (Relenza, GlaxoSmithKline)	12.5 mg/kg intranasal only ⁵ 0.3-1 mg/kg via inhalation q12h ³¹	Antiviral for influenza treatment; greater effect if used with amantadine

^aSee Table 11-13 for chemotherapy protocols for lymphoma.

TABLE 11-8 Hematologic and Biochemical Values of Ferrets.^{22,43,52}

Measurements	Female	Male
Hematology^a		
PCV (%)	34.6-55	33.6-61
RBC (10 ⁶ /μL)	6.77-9.76	7.1-13.2
Hgb (g/dL)	11.9-17.4	12-18.5
MCV (fL)	44.4-53.7	42.6-52.5
MCH (pg)	16.4-19.4	13.7-19.7
MCHC (g/dL)	33.2-42.2	30.3-34.9
WBC (10 ³ /μL)	2.5-18.2	4.4-19.1
Neutrophils (%)	12-84	11-82
Band cells (%)	0-4.2	0-2.2
Lymphocytes (%)	12-95	12-73
Monocytes (%)	1-8	0-9
Eosinophils (%)	0-9	0-8.5
Basophils (%)	0-2.9	0-2.7
Platelets (10 ³ /μL)	264-910	297-730
Reticulocytes (%)	2-14	1-12
Biochemistries		
ALP (U/L)	3-62	11-120
ALT (U/L)	54-280	54-289
AST (U/L)	40-120	28-248
Bilirubin, total (mg/dL)	0-1	0-0.1
Bile acids (μmol/L)	0.0-28.9	0.0-28.9
BUN (mg/dL)	10-45	11-42
Calcium (mg/dL)	8-10.2	8.3-11.8
Carbon dioxide (mEq/L)	16.5-27.8	12.2-28
Chloride (mEq/L)	112-124	102-126
Cholesterol (mg/dL)	122-296	64-221
Creatinine (mg/dL)	0.2-1	0.2-1
GGT (U/L)	0-5	0-5

Continued

TABLE 11-8 Hematologic and Biochemical Values of Ferrets. (cont'd)

Measurements	Female	Male
Glucose (mg/dL)	85-207	62.5-198
LDH (U/L)	—	241-752
Lipase (U/L)	—	0-200
Phosphorus (mg/dL)	4.2-10.1	4-8.7
Potassium (mEq/L)	4.2-7.7	4.1-7.3
Protein, total (g/dL)	5.1-7.2	5.3-7.4
Albumin (g/dL)	3.2-4.1	2.8-4.2
Globulin (g/dL)	2.2-3.2	2-4
Albumin:globulin	1-1.6	0.8-2.1
Sodium (mEq/L)	142-156	137-162
Triglycerides (mg/dL)	—	10-32

^aSeveral of these hematology values were obtained from ferrets under isoflurane anesthesia. This can artificially lower red cell indices and may be responsible for the wide ranges in some values.

TABLE 11-9 Protein Electrophoresis Values for Ferrets.⁴⁸

Parameter	Normal Values
Total protein (g/dL)	5.6-7.2
Albumin (g/dL)	3.3-4.1
Alpha ₁ globulins (g/dL)	0.33-0.56
Alpha ₂ globulins (g/dL)	0.36-0.60
Beta globulins (g/dL)	0.83-1.2
Gamma globulins (g/dL)	0.3-0.8
A/G	1.3-2.1

TABLE 11-10 Biologic and Physiologic Data of Ferrets.^{43,52,64}

Parameter	Normal Values
Adult body weight, male	1-2 kg
Adult body weight, female	0.65-0.95 kg
Birth weight	6-12 g
Weight at 7 days	30 g average
Weight at 14 days	60-70 g
Sexual maturity	6-12 mo (usually 1st spring after birth)
Reproductive cycle	Induced ovulator
Gestation period	42 ± 2 days
Litter size	1-18 (average 8, primiparous jill 10)
Weaning age	6-8 wk
Eyes open	34 days

TABLE 11-10 Biologic and Physiologic Data of Ferrets. (cont'd)

Parameter	Normal Values
Hearing	32 days
Life span	5-9 yr (average in United States)
Food consumption	43 g/kg/day
Water consumption	75-100 mL/day
Gastrointestinal transit time	3-4 hr
Enteral feeding requirements	2000-3000 kcal/kg/day
Dental formula	2(I 3/3 C 1/1 P 3/3 M 1/2) = 34
Deciduous teeth erupt	20-28 days
Permanent teeth erupt	50-74 days
Canines erupt	50 days
Molars erupt (first to fourth)	53-74 days
Heart rate	200-400 beats/min
Mean systolic blood pressure	133-161 mmHg
Respiratory rate	33-36 breaths/min
Rectal temperature	37.8-40°C (100-104°F)
Blood volume	60-80 mL (5%-7% body weight)
Intraocular pressure	22.8 ± 5.5 mmHg
Endotracheal tube size	2-4 mm ID
Prothrombin time (PT)	8-16.5 sec
Partial thromboplastin time (PTT)	16-25 sec

TABLE 11-11 Urinalysis Values of Ferrets.⁵²

Parameter	Male	Female
Volume (mL/24 hr)	26 (8-48)	28 (8-140)
Sodium (mmol/24 hr)	1.9 (0.4-6.7)	1.5 (0.2-5.6)
Potassium (mmol/24 hr)	2.9 (1-9.6)	2.1 (0.9-5.4)
Chloride (mmol/24 hr)	2.4 (0.7-8.5)	1.9 (0.3-7.8)
pH	6.5-7.5 ^a	6.5-7.5 ^a
Protein (mg/dL)	7-33	0-32
Exogenous creatinine clearance (mL/min/kg) ^b	—	3.32 ± 2.16
Insulin clearance (mL/min/kg)	—	3.02 ± 1.78
Specific gravity	1.040-1.052	—

^aUrine pH can vary according to diet; normal urine pH in ferrets on a high-quality, meat-based diet is approximately 6.^bEndogenous creatinine clearance (mL/min/kg) = 2.5 ± 0.93.

TABLE 11-12 Proposed Schedule of Vaccinations and Routine Prophylactic Care for Ferrets.^{43,52}

Age	Recommendation
4-6 wk	CDV ^a vaccination if dam is unvaccinated
6-8 wk	CDV ^{a,b} vaccination if dam was vaccinated; physical examination; fecal examination
10-11 wk	CDV ^{a,c} vaccination; physical examination; fecal examination
12-14 wk	CDV ^{a,c} vaccination; rabies vaccination; ^d physical examination; fecal examination (optional)
4-8 mo	Spay/castrate; fecal examination; remove musk glands (optional); start heartworm and flea prevention (endemic areas)
1 yr	CDV ^{a,e} booster; rabies booster; ^d physical examination; dental prophylaxis and fecal examination if indicated; CBC; heartworm and flea prevention
2 yr	CDV ^{a,e,f} booster; rabies booster; ^d physical examination; dental prophylaxis and fecal examination if indicated; CBC; heartworm and flea prevention
3 yr and older (every 6 mo)	CDV ^{a,e,f} booster (annual); rabies booster ^d (annual); physical examination; dental prophylaxis and fecal examination if indicated; CBC; serum chemistries, including fasting blood glucose; heartworm and flea prevention

^aCDV, canine distemper vaccine; Purevax (Merial) is the only CDV approved for use in ferrets; if Purevax is unavailable, other vaccines which have been used include Novibac DPv (Merck) and Recombitek (Merial).

^bPurevax is recommended to be administered at 8 wk, then every 3 wk for 3 doses.

^cVaccinations are generally administered at 2-3 wk intervals until the ferret is 12-14 wk of age.

^dOnly a killed virus vaccine (Imrab 3, Rhône Merieux) should be used. Vaccines should be separated by several days to reduce vaccine reactions.

^eIn previously unvaccinated adults, an initial series of two vaccinations given 14-28 days apart should be given.

^fRabies and distemper titers are under evaluation and may alter the revaccination schedule of older animals.

TABLE 11-13 Chemotherapy Protocols for Lymphoma in Ferrets.^a

Protocol I ^{47,52}			
Week	Day	Agent	Dosage
1	1	Prednisone	1-2 mg/kg PO q12h and continued throughout therapy
	1	Vincristine	0.025 mg/kg IV
	3	Cyclophosphamide	10 mg/kg PO, SC
2	8	Vincristine	0.025 mg/kg IV
3	15	Vincristine	0.025 mg/kg IV
4	22	Vincristine	0.025 mg/kg IV
	24	Cyclophosphamide	10 mg/kg PO, SC
7	46	Cyclophosphamide	10 mg/kg PO, SC
9	63	Prednisone	Gradually decrease dose to 0 over the next 4 wk

TABLE 11-13 Chemotherapy Protocols for Lymphoma in Ferrets. (cont'd)

Protocol II ^{b,52}		
Week	Agent	Dosage
1	Vincristine	0.025 mg/kg IV
	L-asparaginase	400 U/kg IP
	Prednisone	1 mg/kg PO q24h and continued throughout therapy
2	Cyclophosphamide	10 mg/kg SC
3	Doxorubicin	1 mg/kg IV
4-6	As weeks 1-3 above, but discontinue L-asparaginase	—
8	Vincristine	0.025 mg/kg IV
10	Cyclophosphamide	10 mg/kg SC
12	Vincristine	0.025 mg/kg IV
14	Methotrexate	0.5 mg/kg IV

Protocol III ⁴⁷		
Week	Agent	Dosage
1	L-asparaginase	10,000 U/m ² SC
	Cytosin	250 mg/m ² PO, SC (in 50 mL/kg of NaCl SC)
	Prednisone	2 mg/kg PO daily for 7 days, then q48h throughout therapy
2	L-asparaginase	10,000 U/m ² SC
	Perform CBC ^c	
3	L-asparaginase	10,000 U/m ² SC
	Cytosar	300 mg/m ² SC × 2 days (dilute 100 mg with 1 mL H ₂ O)
4	Perform CBC ^c	
5	Cytosin	250 mg/m ² PO, SC (in 50 mL/kg of NaCl SC)
7	Methotrexate Perform CBC ^c	0.8 mg/kg IM
8	Perform CBC ^c	
9	Cytosin	250 mg/m ² PO, SC (in 50 mL/kg of NaCl SC)
11	Cytosar	300 mg/m ² SC × 2 days (dilute 100 mg with 1 mL H ₂ O)
	Leukeran	1 tablet/animal PO or ½ tablet/animal PO × 2 days
12	Perform CBC ^c	
13	Cytosin	250 mg/m ² PO, SC (in 50 mL/kg of NaCl SC)
15	Procarbazine	50 mg/m ² PO q24h × 14 days
16	Perform CBC ^c	
17	Perform CBC ^c	
18	Cytosin	250 mg/m ² PO, SC (in 50 mL/kg of NaCl SC)
20	Cytosar	300 mg/m ² SC × 2 days (dilute 100 mg with 1 mL H ₂ O)
	Leukeran	1 tablet/animal PO or ½ tablet/animal PO × 2 days
23	Cytosin	250 mg/m ² PO, SC (in 50 mL/kg of NaCl SC)
26	Procarbazine	50 mg/m ² PO q24h × 14 days
27	Perform CBC ^c and chemistry panel	If not in remission, continue weeks 20-26 for 3 cycles

Continued

TABLE 11-13 Chemotherapy Protocols for Lymphoma in Ferrets. (cont'd)

Protocol IV ^a		
Week	Agent	Dosage
3 days	L-asparaginase	400 U/kg SC (premedicate with diphenhydramine)
1	Vincristine	0.12 mg/kg IV
	Prednisone	1 mg/kg PO q24h continue throughout therapy
	Cyclophosphamide	10 mg/kg PO
2	Vincristine	0.12 mg/kg IV
3	Vincristine	0.12 mg/kg IV
4	Vincristine	0.12 mg/kg IV
	Cyclophosphamide	10 mg/kg PO
7, 10, 13, etc.	Vincristine	0.12 mg/kg IV
	Cyclophosphamide	10 mg/kg PO
		Continue therapy every 3 wk for 1 yr, then decrease to every 4-6 wk
Rescue treatment	Doxorubicin	1-2 mg/kg IV (over 20 min)

^aCBC should be checked weekly during therapy; after therapy is discontinued, continue to monitor CBC and do physical examination at 3-mo intervals.

^bProtocol is continued in sequence biweekly after week 14, making the therapy protocol less intensive.

^cIf CBC shows severe myelosuppression, reduce dosage by 25% for all subsequent treatments of the previously used myelosuppressive drug.

TABLE 11-14 Conversion of Body Weight (kg) to Body Surface Area (m²).⁴⁷

Body Weight (kg)	Body Surface Area (m ²)
0.5	0.063
0.6	0.071
0.7	0.079
0.8	0.086
0.9	0.093
1.0	0.100
1.1	0.107
1.2	0.113
1.3	0.119
1.4	0.125
1.5	0.131
1.6	0.137
1.7	0.142
1.8	0.148
1.9	0.153
2.0	0.159
2.1	0.164
2.2	0.169
2.3	0.174
2.4	0.179
2.5	0.184

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Chapter 12 **Miniature Pigs**

Valarie V. Tynes | Kristie Mozzachio



TABLE 12-1 Antimicrobial Agents Used in Miniature Pigs.^a

Agent	Dosage	Comments
Amoxicillin	10-22 mg/kg PO q12-24h ¹⁴ 11-13 mg/kg PO q24h ³	
Amoxicillin/clavulanate (Clavamox, Pfizer)	11-13 mg/kg PO q12 ²¹ -24h ¹⁰ 12.5-25 mg/kg PO q12h ^{25,b}	
Ampicillin	20 mg/kg SC, IM q8h ³ 6.5 mg/kg IM q24h ¹⁰	
• Sodium	10-20 mg/kg SC, IM, IV q6-8h ^{14,25,b}	
• Trihydrate	20-40 mg/kg PO q8h ^{25,b} 4.4-22 mg/kg IM q8-24h ¹⁴ 10-50 mg/kg SC, IM q12-24h ^{25,b}	
Apramycin (Apralan, Elanco)	10-20 mg/kg PO q12-24h ¹⁰	
Ceftiofur	3-10 mg/kg IM q24h ¹⁰	No more than 2 mL/injection site ^c
• Hydrochloride (Excenel, Zoetis)	3-5 mg/kg IM q24h ¹⁴ × 3 days ²⁵	
• Sodium (Naxcel, Zoetis)	3-5 mg/kg IM q24h ¹⁴ × 3 days ²⁵	
• Long acting (Excede, Zoetis)	5 mg/kg IM ^c q3-5d ²¹	
Ceftriaxone	50-75 mg/kg IM, IV q24h ²⁸	
Cephalexin	10-30 mg/kg PO q6-12h ^{21,25,b}	
Cephadrine (Velocef, Bristol-Myers Squibb)	25-50 mg/kg PO q12h ²⁸	
Clindamycin	11-33 mg/kg q12h PO ^{21,25,b}	Tusk abscesses
Doxycycline	3-5 mg/kg PO q12h ^{21,25,b} 10 mg/kg PO q24h ^{25,b}	Tick-associated illness
Enrofloxacin (Baytril, Bayer)	2.5-5 mg/kg IM q24h ^{25,30} 7.5 mg/kg SC, IM ^c	Extra-label use prohibited in food-producing animals; oral form extremely unpalatable to pigs making PO administration nearly impossible, even with compounded flavoring ²¹
Florfenicol (Nuflor, Intervet)	15 mg/kg IM q48h ²⁵ 20 mg/kg IM q48h ¹⁴ 20 mg/kg PO, IM, IV q48h ¹⁷	
Nuflor 2.3% concentrate solution	400 mg/gal drinking water × 5 days ²⁵	

Continued

TABLE 12-1 Antimicrobial Agents Used in Miniature Pigs. (cont'd)

Agent	Dosage	Comments
Gentamicin	5 mg/kg PO q24h ¹⁰ 10-15 mg/kg SC, IM q24h ²⁵ 1.1-2.2 mg/kg × 3 days in drinking water ²⁵	Colibacillosis and swine dysentery
Lincomycin	10 mg/kg IM q24h ¹⁰ 11 mg/kg IM q24h ^{14,25} 8.4 mg/kg q24h in drinking water ¹⁴ × 5-10 days ²⁵	<i>Mycoplasma</i> Swine dysentery
Metronidazole	Anaerobes: 15 mg/kg PO q12h ^{25,b} <i>Giardia</i> : 12-15 mg/kg PO q12h for 8 days ^{25,b} 15-20 mg/kg PO q12h ¹⁵	Prohibited in food-producing animals
Neomycin	10 mg/kg PO q6h ¹⁰ 11 mg/kg PO q24h ²	
Oxytetracycline	44-55 mg/kg PO q24h ³ 7-11 mg/kg IM q24h ³ 1.4-2.3 mg/kg q24h IM × maximum 4 days ^c	
Penicillin G, procaine	15,000-25,000 U/kg IM q24h ²⁵ 20,000-45,000 U/kg IM q24h ¹⁰ 20,000-60,000 U/kg IM q24h ¹⁴	
Spectinomycin (Spectam, Merial)	6.6-22 mg/kg IM q12-24h ²⁵ 50-100 mg/pig PO ²⁵	
Tetracycline	10-20 mg/kg IM q24h ¹⁰ 11 mg/kg q12h in water or as a bolus ²⁵ 20 mg/kg IM q48h ¹⁰	Enteritis and pneumonia
Trimethoprim/sulfadiazine	15 mg/kg PO q12h ^{25,b} 30 mg/kg PO q12-24h ^{25,b} 30 mg/kg PO q24h ¹⁴	
Tulathromycin (Draxxin, Zoetis)	2.5 mg/kg IM as a single injection ²⁵	Draxxin 25 formulation available for small pigs
Tylosin (Tylan, Elanco)	9 mg/kg IM q12-24h ¹⁰	

^aNot to be used in animals for human consumption.

^bAuthors note: In the past, in the absence of published dosages specific to swine, the authors have often found it necessary to rely upon canine dosages published by Papich (2016) when treating pet pigs. This has generally been found to be safe and effective.

^cFrom product insert.

TABLE 12-2 Antiparasitic Agents Used in Miniature Pigs.^a

Agent	Dosage	Comments
Dichlorvos	11.2-21.6 mg/kg PO once ²⁵ 20 mg/kg PO ²	
Doramectin (Dectomax, Zoetis)	0.3 mg/kg IM ^{16,25}	Use same as ivermectin; may cause less discomfort than ivermectin when injected ²¹
Fenbendazole (Safe-Guard, Intervet)	3 mg/kg PO q24h × 3 days ¹⁶ 9 mg/kg PO in divided doses × 3-12 days ^b	Whipworms
Ivermectin	0.3 mg/kg PO, SC, IM ^{4,5,25}	Repeat in 10-14 days for sarcoptic mange; PO dosing ineffective for treating sarcoptic mange; may cause pain on injection ²¹
Levamisole	10 mg/kg PO ² 8 mg/kg in drinking water ²⁵	
Piperazine	200 mg/kg PO ² 110 mg/kg in drinking water ²⁵	
Pyrantel pamoate	6.6 mg/kg PO, repeat prn ^{4,5} 22 mg/kg in feed, once ^{21,25}	Can give ½ of this dose initially if suspect high parasite burden; in 7-10 days, repeat with full dose ²¹
Sulfadimethoxine (Albon, Zoetis)	25 mg/kg PO ² 55 mg/kg PO as loading dose followed by 27.5 mg/kg PO q12h ^{25,c}	Coccidia

^aNot to be used in animals for human consumption.

^bFrom product insert.

^cAuthors note: In the past, in the absence of published dosages specific to swine, the authors have often found it necessary to rely upon canine dosages published by Papich (2016) when treating pet pigs. This has generally been found to be safe and effective.

TABLE 12-3 Chemical Restraint/Anesthetic Agents Used in Miniature Pigs.^a

Agent	Dosage	Comments
Acepromazine	0.1-0.45 mg/kg IM ³ 0.2-1.1 mg/kg IM ⁵	Tranquilization; slow onset of action; inconsistent results Higher doses reportedly produce more profound tranquilization
Acepromazine (A)/ketamine (K)	(A) 0.5-1.1 mg/kg IM, followed in 15 min by (K) 15-33 mg/kg IM ³ (A) 1.1 mg/kg + (K) 33 mg/kg IM, SC ²⁹	
Atipamezole	For IM dose, see comments	Reverses detomidine and dexmedetomidine, and potentially other α_2 -adrenergic agonists; actual volume is same as volume used for detomidine (1 mg/mL) or dexmedetomidine (0.5 mg/mL)

Continued

TABLE 12-3 Chemical Restraint/Anesthetic Agents Used in Miniature Pigs. (cont'd)

Agent	Dosage	Comments
Atropine	0.02-0.05 mg/kg SC, IM, IV ²⁹	Anesthesia adjunct; increases heart rate, decreases GI and respiratory secretions
Azaperone (Stresnil, Schering-Plough)	— 0.25-0.5 mg/kg IM ⁴ 0.25-2 mg/kg IM ²⁴ 2 mg/kg IM ⁴ 2-8 mg/kg IM, SC ^{9,24,29} 5-8 mg/kg IM ³	See also ketamine for combinations Relaxation, sedation, without ataxia up to 0.5 mg/kg dose Moderate sedation; doses exceeding 2 mg/kg likely to produce negative side effects such as hypotension, bradycardia, and decreased cardiac output and contractility ²⁴
Azaperone (Az)/midazolam (Mi)/± atropine (At)	(Az) 4 mg/kg + (Mi) 0.5 mg/kg ± (At) 0.04 mg/kg IM ³	Moderate to deep sedation; no analgesia
Butorphanol	—	See detomidine, dexmedetomidine, ketamine, tiletamine/zolazepam, xylazine for combinations; see Table 12-4 for analgesic doses
Detomidine (Dormosedan, Zoetis)	—	Detomidine combinations follow
Detomidine (De)/butorphanol (B)/Midazolam (Mz)	(De) 0.06-0.125 mg/kg + (B) 0.3-0.4 mg/kg + 0.3-0.4 (Mz) IM ²⁴	Rapid, smooth induction with excellent relaxation
Dexmedetomidine (Dexdomitor, Zoetis)	—	See dexmedetomidine/midazolam/butorphanol for combination
Dexmedetomidine (De)/midazolam (Mi)/butorphanol (B)	(De) 0.01-0.04 mg/kg + (Mi) 0.1-0.3 mg/kg + (B) 0.2-0.4 mg/kg IM ^{20,21}	Can substitute xylazine 1 mg/kg (for dexmedetomidine)
Diazepam	— 0.1-0.5 mg/kg PO ^{24,33} 0.5-1.5 mg/kg IV ³⁰ 0.5-2 mg/kg IM ³ 5.5-8.5 mg/kg IM ⁷	See ketamine for combination Calming for car trip or veterinary examination Sedation; rarely used in conscious pigs since venous access is extremely difficult Effective muscle relaxation Sedation
Fentanyl	0.02-0.04 mg/kg SC, IM, IV q2h ^{25,b} 0.02-0.05 mg/kg, IM, IV ¹⁸	
Fentanyl/droperidol (Innovar-Vet, Schering-Plough)	1 mL/10-14 kg IM ³⁵ 1 mL/9-25 kg IM ^{5,18}	Sedation; maximum effect in 20 min; analgesia with some mild sedation Tranquilization; minor procedures

TABLE 12-3 Chemical Restraint/Anesthetic Agents Used in Miniature Pigs. (cont'd)

Agent	Dosage	Comments
Flumazenil	0.02 mg/kg IV ²⁵ 1 mg/10-15 mg midazolam IM ⁷	Benzodiazepine (midazolam, diazepam) reversal; use with caution if ketamine is only other agent being used
Glycopyrrolate	0.004-0.01 mg/kg SC, IM, IV ²⁹	Anesthesia adjunct; increases heart rate, decreases GI and respiratory secretions; use with caution as heart may be overtaxed; atropine preferred ²⁰
Guaifenesin(G)/ketamine (K)/xylazine (X)	0.5-1 mg/kg IV to induce unpremedicated pig; decrease dose by 50% if sedative or tranquilizer given prior to induction ³⁵	Administer atropine IM prior to induction. Combination prepared using (G) (50 mg/mL), (K) (2 mg/mL), and (X) (1 mg/mL); induction; maintain at 2 mL/kg/h; rarely used since IV access is impractical in conscious pigs
Isoflurane (or sevoflurane)	4%-5% induction or to effect ^{21,33} 1%-3% maintenance ^{20,21,33}	Especially recommended for sick or debilitated pigs and for those <8 weeks of age
Ketamine	Use only in combination	Ketamine combinations follow; see guaifenesin, tiletamine/zolazepam for additional combinations Used alone results in poor muscle relaxation, poor visceral analgesia, and rough recovery (hyperkinesia, severe and prolonged ataxia, distress vocalizations), ²⁴ especially IM; use with other agents
Ketamine (K)/azaperone (Az)	(K) 15 mg/kg + (Az) 2 mg/kg IM, SC ^{9,29}	
Ketamine (K)/diazepam (D)	(K) 8-10 mg/kg + (D) 1-2 mg/kg IM ³ (K) 15-20 mg/kg + (D) 2 mg/kg IM, SC ^{9,29} (D) 1-2 mg/kg IM, followed by (K) 12-20 mg/kg IM ⁵	Short-term anesthesia; prolong with (K) 2-4 mg/kg IV prn; minimal analgesia; smoother recovery than ketamine alone ⁵
Ketamine(K)/midazolam (Mi)	(K) 10 mg/kg + (Mi) 1 mg/kg IM ³	This drug combination can cause profound hypothermia ²⁹
Ketamine (K)/xylazine (X)	(K) 15-20 mg/kg + (X) 2 mg/kg IM, SC ^{9,29} (K) 10 mg/kg + (X) 1 mg/kg IM ²⁰ (X) 2.2 mg/kg IM, followed by (K) 12-20 mg/kg IM ⁵	Anesthesia; rough recovery Short-term anesthesia; prolong with (K) 2-4 mg/kg IV prn

Continued

TABLE 12-3 Chemical Restraint/Anesthetic Agents Used in Miniature Pigs. (cont'd)

Agent	Dosage	Comments
Ketamine (K)/xylazine (X)/butorphanol (B)	(K) 5 mg/kg + (X) 2 mg/kg + (B) 0.22 mg/kg IM ³ (K) 11 mg/kg + (X) 2 mg/kg + (B) 0.22 mg/kg IM ⁷	Anesthesia; butorphanol enhances analgesia
Ketamine (K)/xylazine (X)/midazolam (Mi)	(K) 5-10 mg/kg + (X) 1 mg/kg + (Mi) 0.2 mg/kg IM ²⁰	Can substitute dexmedetomidine (for xylazine) at 10-40 mcg/kg
Ketamine (K)/xylazine (X)/oxymorphone (O)	(K) 2 mg/kg + (X) 2 mg/kg + (O) 0.075 mg/kg IV ²⁹	
Lidocaine 2%	Topical ¹⁸	Spray onto larynx 2 min before intubation to prevent laryngospasm
Lidocaine/prilocaine (EMLA cream, AstraZeneca)	Topical ¹⁸	Apply to skin at time of premedication to ease intravenous access; may take 20-30 min to take effect
Midazolam	— 0.1-0.5 mg/kg IM, IV ^{9,29}	See azaperone, dexmedetomidine, ketamine, xylazine for combinations Sedation
Naloxone (P/M Naloxone, Schering-Plough)	0.5-2 mg/kg IV ²⁹	Narcotic reversal; given to effect prn
Nitrous oxide	—	Nitrous oxide and oxygen at equal levels (1-2 L/min) before isoflurane induction; may help calm animal during mask induction ³³
Pentobarbital	20-40 mg/kg IV ^{9,29}	Anesthesia with some analgesia
Promazine hydrochloride	0.4-1 mg/kg IV ¹³ 0.5-2 mg/kg IM ¹³	Tranquillization Tranquillization
Sevoflurane	—	See isoflurane
Thiamylal	6.6-30 mg/kg IV ^{9,29}	Induction
Tiletamine/zolazepam (Telazol, Fort Dodge)	—	Tiletamine/zolazepam combinations follow Poor muscle relaxation; may cause rough recovery; ^{24,33} avoid using as sole agent Anesthesia with good analgesia
Tiletamine/zolazepam (T)/ketamine (K)/xylazine (X)	— 2.2-4.4 mg/kg IM ⁵ 0.03 mL/kg IM ²¹	Reconstitute (T) (500 mg) with 2.5 mL (K) (100 mg/mL) and 2.5 mL (X) (100 mg/mL), instead of sterile water; mixture has 50 mg/mL each of tiletamine, zolazepam, ketamine, xylazine; rough recovery Induction; maintain with 2.2 mg/kg IV prn Heavy sedation; useful prior to euthanasia

TABLE 12-3 Chemical Restraint/Anesthetic Agents Used in Miniature Pigs. (cont'd)

Agent	Dosage	Comments
Tiletamine/zolazepam (T)/xylazine (X)	(T) 2 mg/kg + (X) 2 mg/kg IV ⁴ (T) 4-6 mg/kg + (X) 2.2 mg/kg IM ^{4,9} (T) 4.4 mg/kg + (X) 4.4 mg/kg IM, SC ²⁹ (T) 4.4 mg/kg + (X) 2.2-4.4 mg/kg IM ³ (T) 4.4-6 mg/kg + (X) 1.1-4.4 mg/kg IM ⁷ (X) 2.2 mg/kg, then (T) 2-4 mg/kg IM ¹³	Not routinely recommended; difficult venous access in a conscious pig makes this impractical Anesthesia; rapid induction; poor muscle relaxation; may have rough recovery Anesthesia duration of 30-40 min; the use of two separate injections makes this an impractical choice
Tiletamine/zolazepam (T)/xylazine (X)/butorphanol (B)	(T) 0.6 mg/kg + (X) 2-3 mg/kg + (B) 0.3-0.4 mg/kg IM ²⁴ (T) 4.4 mg/kg + (X) 2.2 mg/kg + (B) 0.22 mg/kg IM, SC ²⁹	
Xylazine	— 0.5-3 mg/kg IM ⁵	See also guaifenesin, ketamine, tiletamine/zolazepam for combinations Sedation; tranquilization; some analgesia; deep sedation seldom encountered
Xylazine (X)/butorphanol (B)/midazolam (Mi)	(X) 2-3 mg/kg + (B) 0.3-0.4 mg/kg + (Mi) 0.3-0.4 mg/kg IM ²⁴	Antagonize xylazine with atipamezole or yohimbine and butorphanol with naltrexone; xylazine or midazolam can be administered as a premedicant or concurrently ²⁴
Yohimbine	0.25-0.5 mg/kg SC, IM ^{25,b} 0.11 mg/kg IV ^{25,b} 0.3 mg/kg SC, IM, IV ⁷	α_2 -antagonist (xylazine, dexmedetomidine, detomidine reversal)

⁴Not to be used in animals for human consumption.

^bAuthors note: In the past, in the absence of published dosages specific to swine, the authors have often found it necessary to rely upon canine dosages published by Papich (2016) when treating pet pigs. This has generally been found to be safe and effective.

TABLE 12-4 Analgesic Agents Used in Miniature Pigs.^a

Agent	Dosage	Comments
Aspirin	10-20 mg/kg PO q6-8h ^{22,25,29}	Also antiinflammatory and antipyretic; use enteric coated tablets
Bupivacaine (multi-vesicular liposomal)	Infiltrate surgical site with 100-200 mg/site ^{25,b}	Local anesthetic
Buprenorphine	0.005-0.01 mg/kg IM q12h ¹¹ 0.005-0.01 mg/kg IM, IV q8-12h ¹⁸ 0.005-0.02 mg/kg IM q6-12h ³ 0.01-0.05 mg/kg SC, IM, IV q6-12h ²² 0.01-0.05 mg/kg SC, IM q8-12h ²⁹ 0.05-0.1 mg/kg IM q8-12h ⁹	
Butorphanol	0.05-0.2 mg/kg SC, IV q3-4h ¹¹ 0.1-0.3 mg/kg SC, IM q8-12h ²⁹ 0.1-0.3 mg/kg SC, IM q4-6h ^{3,9} 0.2-0.4 mg/kg SC, IM, IV q2-6h ²²	
Carprofen ^c	1-4 mg/kg SC q24h ³ 2 mg/kg SC q24h ²⁹ 2.2 mg/kg SC q12h ²² 2-3 mg/kg PO q12h ^{9,29} 2-4 mg/kg SC, IV q24h ¹⁷ 4.4 mg/kg SC q24h ²²	
Dexamethasone	0.01-0.04 mg/kg IM ²¹	Antiinflammatory used in treating arthritis; administer once then switch to oral medications
Etodolac ^c	10-15 mg/kg PO q24h ²²	
Fentanyl	0.03-0.1 mg/kg/h IV (CRI) ³ 0.005-0.01 mg/kg SC, IM, IV q2h ^{25,b} 0.02-0.05 mg/kg IM, IV prn ²² 0.02-0.05 mg/kg IM q2h ⁹ 0.02-0.1 mg/kg/h IV CRI ²²	Analgesia
Fentanyl, transdermal patch	12.5 or 25 µg/h/27-82 kg ²²	Intense or prolonged pain or when oral or injectable analgesics are not an option; apply 12 h before surgery ²² ; may last up to 72 h
Flunixin meglumine (Banamine, Schering Plough)	0.5-1 mg/kg SC, IV q12-24h ¹¹ 1.1 mg/kg SC, IM, IV q12-24h ²² 1-2 mg/kg SC q24h ³ 2.2 mg/kg IM once ²⁵	
Gabapentin	5-15 mg/kg PO q12h, then increase gradually to as high as 40 mg/kg PO q8-12h prn ^{21,25,b}	

TABLE 12-4 Analgesic Agents Used in Miniature Pigs. (cont'd)

Agent	Dosage	Comments
Hydromorphone	0.1-0.2 mg/kg IV q2h ²² 0.2 mg/kg SC, IM q4-6h ²²	
Ibuprofen ^c	10 mg/kg PO q6-8h ²²	
Ketoprofen ^c	1 mg/kg PO q24h up to 5 d ^{22,25,b} 1-3 mg/kg PO, SC, IM q24h ²⁹ 3 mg/kg PO, SC, IM, IV q24h ^{3,22,25}	
Meloxicam ^c	0.1-0.4 mg/kg PO q24h ^{21,22} 0.4 mg/kg SC, IM q24h ^{22,29}	
Meperidine (Demerol, Winthrop Breon)	2-10 mg/kg IM q4h ^{9,11} 10 mg/kg SC q8h ²⁹	
Morphine	0.2 mg/kg (max total dose 20 mg) IM q4h or pm ¹¹ 0.2 mg/kg SC, IM q4h ²² 0.2-0.5 mg/kg IM q4h ²⁰ 0.2-1 mg/kg IM q4h ³	
Oxymorphone	0.1-0.2 mg/kg SC, IM, IV, re-dose at 0.05-0.1 mg/kg q1-2h ²² 0.15 mg/kg IM, SC q8-12h ²⁹ 0.15 mg/kg IM q4h ⁹	
Pentazocine (Talwin-V, Pharmacia & Upjohn)	1.5-3 mg/kg IM, SC q4h ^{9,29} 2-5 mg/kg SC, IM, IV q4h ²²	
Phenylbutazone	4 mg/kg IV q24h ^{22,25} 4-8 mg/kg PO q12h ²² 5-20 mg/kg PO q12h ²⁹ 10-20 mg/kg PO q12h ⁹	Also antiinflammatory and antipyretic
Prednisone	0.5-1 mg/kg PO q12-24h initially, then taper to q48h ²²	Antiinflammatory used in treating arthritis
Tramadol	2-4 mg/kg PO q6h-24h ²²	

^aNot to be used in animals for human consumption.

^bAuthors note: In the past, in the absence of published dosages specific to swine, the authors have often found it necessary to rely upon canine dosages published by Papich (2016) when treating pet pigs. This has generally been found to be safe and effective.

^cPotential exists for gastrointestinal upset and gastric ulcers, although these are uncommon in the pet pig; should be given with food and gastrointestinal protectants.

TABLE 12-5 Miscellaneous Agents Used in Miniature Pigs.^a

Agent	Dosage	Comments
Dantrolene sodium (Dantrium, Procter & Gamble)	1-3 mg/kg IV ²⁵	Malignant hyperthermia
	5 mg/kg PO (\pm) 8h ⁸	For treatment
	2-5 mg/kg IV q8h ⁸	For treatment and prevention
	3.5-5 mg/kg IV ³	
	5 mg/kg PO, ^{8,25} IV ⁹	Malignant hyperthermia; treatment and prevention
Dexamethasone	0.1 mg/kg IM, IV ²³	Shock; laryngeal edema
Dextrose	10 mL/kg of 10% solution IP ⁴	Hypoglycemic neonate
	20 mL/kg of 5% solution IP ⁴	
Famotidine	0.1-0.2 mg/kg PO, SC, IM, IV q12h ^{21,24,b}	Reduce gastric acid secretion
Glucosamine (G)/chondroitin sulfate (C)	(G) 12 mg/kg + (C) 3.8 mg/kg PO q12h \times 4 wk ²²	Loading dose
	(G) 4 mg/kg + (C) 1.3 mg/kg q12h ²²	Maintenance dose
Hydrogen peroxide	1 mL/5 kg PO ³⁰	Induces vomiting; some animals may require larger dose
Ipecac syrup	7-15 mL/animal PO ³⁰	Induces vomiting
Iron dextran	25 mg/animal IM in first few days of life; may repeat in 2-3 wk ²⁶	Iron deficiency in baby pigs; uncommon in miniature pigs so rarely used as a part of routine management practices
Kaolin/pectin	1-2 mL/kg PO q2-6h ^{25,b}	Antidiarrheal
Metoclopramide	0.2-0.5 mg/kg q6-8h PO, IM, IV ^{21,25,b}	Prevent postoperative ileus; start with the lower end of the dose to prevent cramping
Oxytocin	5-10 U/animal IM ²⁵	Dystocia, if not obstructed
	10-20 U/animal IM ⁴	Dystocia, if not obstructed
Pentobarbital	1 mL/4.5 kg (1 mL/10 lb) IV ^{21,25,b}	Euthanasia
	>150 mg/kg IV ^{9,29}	
	100-150 mg/kg IV ³	
Polysulfated glycosaminoglycan (Adequan, Novartis)	4.4 mg/kg IM once, then 3.3 mg/kg q4d \times 7 treatments ¹⁵	May not see results until after 3-4 treatments; if good clinical results after first 8 treatments, then decrease frequency to weekly for 1 month, then 2 \times /month, then monthly as needed for maintenance
Prostaglandin F ₂ - α (Lutalyse, Pharmacia & Upjohn)	5 mg/animal IM ⁴	Induces parturition in 24-30 h when given within 3 days of expected parturition; causes abortion after 12 days of gestation
	8 mg and 5 mg (in a 25-kg pig) 12 h apart ¹⁶	For inducing estrus; estrus should occur 3-7 days later

^aNot to be used in animals for human consumption.^bAuthors note: In the past, in the absence of published dosages specific to swine, the authors have often found it necessary to rely upon canine dosages published by Papich (2016) when treating pet pigs. This has generally been found to be safe and effective.

TABLE 12-6 Hematologic and Serum Biochemical Values of Miniature Pigs.

Measurement	Mean (Reference Range) ^{6,a}	Mean (Reference Range) ^{3,b}	Mean (Reference Range) ^{12,c}
Hematology			
PCV (%)	36 (22-50)	—	—
Hematocrit (%)	—	32-61	35-56
RBC (10 ⁶ /μL)	5.7 (3.6-7.8)	5.30-9.25	5.6-9.3
Hgb (g/dL)	12 (7.8-16.2)	9-17	10.9-17.0
MCV (fL)	63 (55-71)	40-73	46.0-72.5
MCH (pg)	21 (18-24)	15.2-26.4	13.7-24.3
MCHC (g/dL)	33.5 (31-36)	29.4-37.9	29.6-34.5
Platelets (10 ³ /μL)	310 (204-518)	148-898	152-845
WBC (10 ³ /μL)	11.5 (5.2-17.9)	4.4-26.4	6.9-32.4
Neutrophils (10 ³ /μL)	5.7 (0-11.4)	—	1.8-6.4
Band cells (10 ³ /μL)	0.03 (0-0.19)	—	0.0-24.6
Lymphocytes (10 ³ /μL)	5.3 (0.8-9.8)	—	2.1-17.3
Monocytes (10 ³ /μL)	0.2 (0-0.67)	—	0.2-1.3
Eosinophils (10 ³ /μL)	0.14 (0-0.73)	—	0-1.5
Basophils (10 ³ /μL)	0.15 (0-0.61)	—	0-0.5
Fibrinogen (g/L)	2 (1-4)	—	—
Chemistries			
ALP (U/L)	65 (27-160)	—	166-576
ALT (U/L)	53 (11-95)	20-106	—
AST (U/L)	32 (16-64)	13-53	15-90
Bilirubin, total (mg/dL)	0.25 (0.2-0.45)	0.0-0.3	0.1-0.41
BUN (mg/dL)	9.7 (4.2-15.1)	—	5.7-29
Chloride (mEq/L)	110 (106-113)	94-140	95-114
Creatine kinase (U/L)	701 (213-2852)	37-6000	—
Creatinine (mg/dL)	1.7 (1-2.3)	0.5-2.0	0.5-1.1
GGT (U/L)	35 (15-56)	25-86	20.4-96.4
Glucose (mg/dL)	105 (60-175)	43-153	56-123
Potassium (mEq/L)	4.3 (3.7-5)	3.5-7.4	3.9-7.7
Protein, total (g/dL)	7.7 (6.6-8.9)	6.0-9.4	4.9-9.4
Albumin (g/dL)	4.3 (3.6-5)	2.9-5.6	2.9-5.6
Globulin (g/dL)	—	1.4-5.2	1.4-3.7
Sodium (mEq/L)	144 (139-149)	132-153	139-153
TCO ₂ (mEq/L)	24 (8-31)	—	20-29
Calcium (mg/dL)	—	8.6-12.6	9.3-11.7
Phosphorus (mg/dL)	—	4.9-9.8	5.0-10.7

^an=100, 2- to 10-year-old healthy, Vietnamese potbellied pigs.

^bCombined ranges for adult Yucatan micropig, Gottingen, Sinclair, Yucatan, and Hanford minipigs weighing 35-70 kg and 70-90 kg.

^cCombined ranges for male and female Hanford, Yucatan micropig, and male and female Gottingen minipigs.

TABLE 12-7 Urinalysis Reference Values for Miniature Pigs.^{1,16,21,34}

Parameter	Reference Value
Specific gravity	1.010-1.050
pH	6.9 (range 5-8)
Color	Yellow-dark amber; may be slightly cloudy
Protein	Negative to trace
Red blood cells (per HPF)	0-5
White blood cells (per HPF)	0-5
Crystals	Common, occasionally pathologic; ²¹ calcium oxalate or triple phosphate crystals
Bacteria	Numerous in voided samples; only significant if numerous WBCs also present

TABLE 12-8 Biological and Physiological Data of Miniature Pigs.^{3,5,12,16,19,22}

Parameter	Value
Life expectancy	14-21 yr (avg 15-18)
Respiratory rate (breaths/min)	
Newborn	50-60
Weaned pigs	25-40
10-15 wk	30-40
15-26 wk	25-35
Adult	12-18
Heart rate (beats/min)	
Newborn	200-250
Weaned pigs	90-100
10-15 wk	80-90
15-26 wk	75-85
Adult	70-80
Rectal temperature	37.6-39°C (99.7-102.2°F); diurnal variation in body temperature exists; temperature decreases as age increases
Weight	
Birth	250-450 g
Adult	34-91 kg (avg 55)
Reproduction	
Puberty	
• Boars	3 mo of age
• Gilts	3.5-4 mo of age
Estrous cycle	17-25 days (avg 21)
Standing heat duration	1-3 days
Ovulation	
• Gilts	24-36 h after onset of estrus
• Sows	30-44 h after onset of estrus
Gestation length	112-116 days (avg 114)
Litter size	2-15 piglets (avg 6-8)

TABLE 12-9 Preventive Medicine Recommendations for Miniature Pigs.^{5,12,16,21,32}

Recommended Vaccinations	
<p>Pet pigs</p> <ul style="list-style-type: none"> • Erysipelas • Leptospirosis • Pneumonia (<i>Actinobacillus pleuropneumoniae</i>) • Rabies <p>Breeder pigs</p> <ul style="list-style-type: none"> • Erysipelas • Leptospirosis • Parvovirus • Pneumonia (<i>Actinobacillus pleuropneumoniae</i>) 	<p>8-12 wk of age; repeat in 3-4 wk; revaccinate semiannually or annually</p> <p>8-12 wk of age; repeat in 3-4 wk; revaccinate semiannually or annually; substantial risk of high fever after use¹⁶</p> <p>8-12 wk of age; repeat in 3-4 wk; revaccinate semiannually or annually</p> <p>Off-label use but recommended if at risk of exposure; 14-16 wk of age; revaccinate annually</p> <p>8-12 wk of age; repeat in 3-4 wk; revaccinate 3 wk before breeding</p> <p>8-12 wk of age; repeat in 3-4 wk; revaccinate 3 wk before breeding; substantial risk of high fever after use¹⁶</p> <p>5-6 mo of age; repeat in 3-4 wk; revaccinate 3-8 wk before breeding; boars should be revaccinated semiannually</p> <p>Sows: 5 and 2 wk before farrowing Piglets: 3-8 wk of age; repeat in 3 wk</p>
Selected Disease Vaccinations for Higher Risk Pigs	
<p>Colibacillosis (baby pig scours) (<i>E. coli</i>)</p> <p>Other enteritides (rotavirus, TGE virus, <i>Clostridium</i>, <i>Salmonella</i>)</p> <p>Atrophic rhinitis (<i>Bordetella bronchiseptica</i>, <i>Pasteurella multocida</i> [types A and D])</p> <p>Pneumonia (<i>Mycoplasma hyopneumoniae</i>)</p> <p>Tetanus toxoid</p> <p>Tetanus antitoxin</p>	<p>Sows: 5 and 2 wk before first farrowing, and 2 wk before each subsequent farrowing</p> <p>Sows: 5 and 2 wk before farrowing</p> <p>Sows: 7 and 3 wk before first farrowing, and 3 wk before each subsequent farrowing</p> <p>Piglets: 1 wk of age; repeat in 3 wk</p> <p>Boars: semiannually or annually</p> <p>Sows: 5 and 2 wk before first farrowing, and 2 wk before each subsequent farrowing</p> <p>Piglets: 1 wk of age; repeat in 2-3 wk</p> <p>Boars: semiannually or annually</p> <p>Vaccinate after surgery or trauma or annually when exposure is likely</p> <p>Administer 500-1500 U (depending on body weight) after surgery, dental procedure, or trauma; if not current on tetanus vaccine and where exposure is likely</p>

Continued

TABLE 12-9 Preventive Medicine Recommendations for Miniature Pigs. (cont'd)

Neonatal Care

Preferred environmental temperature at 1-7 days of age	33-35°C (91-95°F); may be lowered 1.7-2.8°C (3-5°F) each wk for 4-6 wk until weaned
Colostrum	15-20 mL in 2-3 feedings within first 12 h of life
Castration	<3 mo of age and older
Ovariohysterectomy or ovariectomy	3-4 mo of age and older, but may be performed as early as 6 wk of age
Tusk (canine) removal	Not recommended
Tusk (canine) trimming	As needed

Fecal Examination

Young (6 wk to 6 mo of age)	Bimonthly
Adults	Semiannually if potential for exposure

TABLE 12-10 Blood Collection Sites in Miniature Pigs. ^{21,24,27,30,34}

Venipuncture Site	Comments
Cranial vena cava/right brachiocephalic vein	Anesthesia required for safety
Right external jugular vein	Short, fat neck of most pet pigs makes this challenging; best if pig is anesthetized; advance a ≥1.5-inch needle cranially in the jugular furrow, angled slightly medially while applying slight negative pressure
Cephalic vein	Thick skin makes this difficult; cut down may be required; reasonable choice for catheterization for fluid or medication administration if pig is sedated or moribund
Radial vein	Can be easily sampled in a properly restrained, awake patient; vein runs along medial aspect of front leg and landmarks are readily palpable
Lateral auricular vein	Easiest in debilitated or very cooperative pigs; good for obtaining very small blood samples; recommended for most routine catheterization
Subcutaneous abdominal vein	Easy to visualize and access in most large, cooperative pigs

TABLE 12-11 Recommendations for Feeding Miniature Pigs. ^{21,31}

- Miniature pet pigs should be offered feeds made specifically for the miniature pig.
- A rate of 1%-2% of the pig's body weight daily, depending upon life stage, is usually appropriate, or
 - Piglet: ½ cup per 15-20 lb per day
 - Adult: 1 cup per 50-80 lb per day
- The pig's current body condition should be the most important consideration when determining how much to feed.
- Divide daily ration into 2-3 meals daily when possible; ideally broadcast food on a grassy area, or place in food-dispensing toys or in rooting boxes.
- Some manufacturers of feeds for miniature pigs:

Heartland Animal Health, Inc;
www.healthypigs.com

Mazuri Exotic Animal Nutrition;
www.mazuri.com

Ross Mill Farm's
 Champion Pet Pig Feed;
www.rossmillfarm.com

TABLE 12-12 Tips for Oral Dosing of Miniature Pigs.^{21,33}

- Choose flavored pediatric liquid formulations whenever possible.
- Mix medications with food items known to be favored by the individual; most pigs prefer sweets, including:
 - Jams or jelly, placed on a small piece of bread
 - Fruit flavored gelatin
 - Peanut butter
 - Bread, cookies, pastry, etc.
 - Fruit juice
- If a medication is known to be bitter, a few spoonfuls of peanut butter and jelly smeared on a piece of bread is recommended; if the pig tastes the medication, it will likely refuse this offering on the second dose; be prepared to change the food item for each dose.
- Small tablets can be placed inside a grape and will be consumed readily by most individuals.
- Medications can be mixed with fruit juice and frozen into cubes.

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Chapter 13 **Primates**

Kathryn C. Gamble



TABLE 13-1 Antimicrobial and Antifungal Agents Used in Primates.

Agent	Dosage	Species/Comments
Amikacin	2-3 mg/kg IM q24h ⁵⁹ 2.3 mg/kg IM q24h ³ 5 mg/kg IM q8h ³	Chimpanzees Monkeys
Amoxicillin	6.7-13.3 mg/kg PO, IM q8h ³ 7 mg/kg PO q8h ⁸⁶ 10-15 mg/kg PO q12h ⁷ 10-20 mg/kg PO q12h ⁹⁰ 11 mg/kg PO q12h or SC, IM q24h ^{44,59} 500 mg/animal PO, IM, IV q8h ³	Monkeys Macaques/quadruple treatment for <i>Helicobacter pylori</i> with clarithromycin, omeprazole, bismuth subsalicylate Eulemurs Prosimians Chimpanzees
Amoxicillin trihydrate, clavulanic potassium	6.7-13.3 mg/kg PO q8h ³ 13.75 mg/kg PO q12h ³ 15 mg/kg PO q12h ⁵⁹	Monkeys Chimpanzees
Amphotericin B	0.5 mg/kg IV 3 ×/wk suspended in 30 mL of 5% dextrose, increased to 1.7 mg/kg ⁸⁶ 150 µg/kg IV 3 ×/wk × 2-4 mo ⁴¹	Swamp monkey (<i>n</i> = 1)/ <i>Cryptococcus</i> ; discontinued due to nephrotoxicity Common marmosets
Ampicillin	10-30 mg/kg SC, IM, IV q6-8h ^{7,90} 20 mg/kg PO, IM, IV q8h ³ 25-50 mg/kg/day IM, IV divided q6-8h ³ 150-200 mg/kg/day IM, IV divided q3-4h ³	Prosimians, <i>Eulemur</i> Chimpanzees Monkeys Monkeys/meningitis, septicemia
Azithromycin	— 5-10 mg/kg PO q24h ^{3,7,90} 25 mg/kg PO q24h × 7 days, or 40 mg/kg PO q24h × 7 days, or 70 mg/kg PO q24h × 4 days ⁷³ 30-50 mg/kg IM q12h × 7-14 days ⁴¹ 40 mg/kg PO q24h ⁴⁴ 40 mg/kg PO once, then 20 mg/kg PO q24h × 4 days ³	In humans, associated with increased cardiac arrhythmogenicity; ⁷⁵ use with caution in older great apes Chimpanzees, ³ prosimians ^{7,90} Macaques/antimalarial <i>Campylobacter</i> -associated diarrhea Monkeys
Cefadroxil	20 mg/kg PO q12h ⁸⁶	Prosimians
Cefazolin sodium	8-16 mg/kg IM q8h ⁵ 10-30 mg/kg IM, IV q8h ⁹⁰ 20 mg/kg IM, IV q8h ³ 25 mg/kg IM, IV q12h ^{3,44} × 7 days ⁸¹	<i>Eulemur</i> Prosimians Monkeys Chimpanzees, ³ rhesus macaques ⁸¹

TABLE 13-1 Antimicrobial and Antifungal Agents Used in Primates. (cont'd)

Agent	Dosage	Species/Comments
Cefovecin (Convenia, Zoetis)	8 mg/kg SC ^{9,68,74}	In studies of both New World primates ⁶⁸ and Old World primates, ^{9,68,74} pharmacokinetics were not consistent with those of dogs and cats; not considered effective in nonhuman primates ^{9,68,74}
Ceftazidime	1 g IM, IV q6-12h ³ 50 mg/kg IM, IV q8h ^{3,59}	Chimpanzees Monkeys
Ceftiofur	1.1-2.2 mg/kg IM q24h ^{7,90} 2 mg/kg IM q24h ³ 2.2 mg/kg IM q24h ⁴⁴	Prosimians, <i>Eulemur</i> Chimpanzees Monkeys
Ceftiofur CFA (Excede, Zoetis)	5 mg/kg SC once ⁸¹ 20 mg/kg SC once ⁵³ 20 mg/kg SC once ⁸¹	Rhesus macaques/PK; with plasma concentrations >0.2 µg/mL for at least 2 days Lion-tailed macaques; <i>Streptococcus</i> toxic shock Rhesus macaques/PK; with plasma concentrations >0.2 µg/mL for at least 7 days
Ceftriaxone	10 mg/kg IV ⁸⁵ 25 mg/kg IM, IV q24h ⁴⁴ 50 mg/kg IM q24h ³ 50-100 mg/kg IM q12-24h ³	Macaques, chimpanzees/PK Monkeys Chimpanzees
Cephalexin	1-4 g q8-12h ³ 10 mg/kg IM q12h ²⁹ 20 mg/kg PO q12h ^{7,59} 30 mg/kg PO q12h ³	Chimpanzees <i>Eulemur</i> ⁷ Monkeys
Cephalothin	25 mg/kg IM q12h ⁸⁶	Macaques
Chloramphenicol palmitate	20 mg/kg IM q12h ²⁹ 25 mg/kg PO q8h ³	Monkeys (infants)
Chloramphenicol sodium succinate	20 mg/kg IM q12h ³ 33.3 mg/kg IM q8h ³ 50 mg/kg SC q8h ³	Chimpanzees Monkeys Chimpanzees
Ciprofloxacin	10 mg/kg PO q12h ³ 16-20 mg/kg PO q12h ³ 20 mg/kg PO q12h ⁵⁹	Monkeys Chimpanzees
Clarithromycin	10 mg/kg PO q12h × 10 days ⁸⁶ 20 mg/kg PO q24h ⁸ 250-500 mg/animal PO q12h × 7-14 days ³	Macaques/quadruple treatment of <i>Helicobacter pylori</i> ; see amoxicillin Macaques/PK Chimpanzees

Continued

TABLE 13-1 Antimicrobial and Antifungal Agents Used in Primates. (cont'd)

Agent	Dosage	Species/Comments
Clindamycin	10 mg/kg PO q12h ⁵⁹	Monkeys Chimpanzees Chimpanzees
	12.5 mg/kg IM q8h ³	
	150-300 mg/animal PO q6h ³	
	300-600 mg/animal IM q8-12h ³	
Doxycycline	2-5 mg/kg PO q12h ³	Chimpanzees
	2.5 mg/kg PO q12h × 1 day, then 2.5 mg/kg PO q24h ³	Monkeys
	3-4 mg/kg PO q12h ⁵⁹	Prosimians
	5-10 mg/kg PO q12h ⁹⁰	
Enrofloxacin	5 mg/kg SC q12h ²⁹	Prosimians ⁹⁰ /hallucinations in humans ⁵⁹ Rhesus macaques/PK; <i>Shigella flexneri</i> Chimpanzees, monkeys
	5 mg/kg IM q24h ⁴⁴	
	5 mg/kg PO, SC, IM q24h ^{59,90}	
	5 mg/kg PO, IM q24h ⁷ × 6 days ⁵⁰	
	5 mg/kg PO, IM q12-24h ³	
Erythromycin	15-20 mg/kg/day IM q12h ³	Monkeys
	30-50 mg/kg IM q12h ⁴⁴	Monkeys <i>Campylobacter</i> -associated diarrhea
	35 mg/kg PO q8h ³	
	75 mg/kg PO q12h × 10 days ⁵⁹	
Ethambutol	Start 15 mg/kg, then 25 mg/kg PO q24h ³	Chimpanzees/antituberculosis drug
Florfenicol	50 mg/kg IM q48h ²¹	
Fluconazole	2-3 mg/kg PO q24h × 30 days ⁸⁶	Macaques/coccidioidomycosis; prolonged treatment; relapses may occur
	18 mg/kg PO q12-24h ^{59,86}	Swamp monkey (<i>n</i> = 1)/ <i>Cryptococcus</i> ; treated concurrently with flucytosine
Flucytosine	50-150 mg/kg/day PO divided q6h ³	Chimpanzees
	143 mg/kg PO q24h ⁸⁶	Swamp monkey (<i>n</i> = 1)/see fluconazole
Fluorofamide	25 mg/animal PO q12h × 3 doses ⁴¹	Common marmosets/ <i>Ureaplasma</i> ; bacterial urease inhibitor
Furazolidone	10 mg/kg PO q12h ³	Monkeys
	10-15 mg/kg PO q24h ⁸⁶	Chimpanzees
	100 mg/animal PO q6h ³	
Gentamicin	2-4 mg/kg IM, IV q12h ³	Monkeys, chimpanzees
	3 mg/kg IM q6-8h ⁸⁹	Baboons/PK
	3-5 mg/kg SC, IM q24h ⁴⁴	
Griseofulvin	20 mg/kg PO q24h ^{3,59}	Monkeys
	25 mg/kg PO q24h for 30-60 days ⁶⁹	Common marmosets/dermatophytosis
	200 mg/kg PO once every 10 days ^{3,59}	Monkeys ³
	500 mg/day PO divided q6-24h ³	Chimpanzees

TABLE 13-1 Antimicrobial and Antifungal Agents Used in Primates. (cont'd)

Agent	Dosage	Species/Comments
Isoniazid	5 mg/kg PO q24h ³ 30-50 mg/kg PO q24h × 9 mo ³ 300 mg PO q24h ³	Monkeys Chimpanzees/active tuberculosis Chimpanzee/prophylaxis; treat concurrently with rifampin
Itraconazole	5-10 mg/kg PO q12h ⁴¹ 10 mg/kg PO q24h ⁵⁹	Common marmosets/dermatophytosis Fungal (yeast) gastroenteritis
Ketoconazole	5-10 mg/kg PO q12h ³ × 30 days ⁶⁹ 10-30 mg/kg PO q24h × 60 days ⁴¹ 200-400 mg/day PO ³	Monkeys Common marmosets Chimpanzees
Levofloxacin	— 500 mg PO q24h ³	In humans, associated with increased cardiac arrhythmogenicity; ⁷⁵ use with caution in older great apes Chimpanzees
Metronidazole	25 mg/kg PO q24h ⁹⁰ 25 mg/kg PO q12h ^{3,59} 25-30 mg/kg PO divided q12h ⁸⁶ 50 mg/kg PO q12h ³	Prosimians Chimpanzees <i>Clostridium</i> ; treat concurrently with tylosin Monkeys
Minocycline	4 mg/kg PO ³ 200 mg, then 100 mg, IV (slow) ³ 200 mg PO q12h ³	Monkeys Chimpanzees Chimpanzees
Neomycin	10 mg/kg PO q12h ²⁹ 50 mg/kg PO q12h ³	Monkeys
Nystatin	100,000 U/animal PO q8h ³ 100,000 U/kg PO q24h × 10 days ⁴¹ 200,000 U/animal PO q6h ^{44,59} 500,000-1,000,000 U/animal PO q8h ³	Monkeys Common marmosets/ <i>Candida</i> Gastrointestinal candidiasis; continue 48 hr after clinical recovery Chimpanzees
Ofloxacin	200-400 mg PO, IV constant rate infusion ³	Chimpanzees
Oxacillin	16.7 mg/kg IM q8h ³	Monkeys
Oxytetracycline	10 mg/kg SC, IM q24h ^{3,59} 25-50 mg/kg PO ³ 250-300 mg/day PO, IM divided q8-24h ³	Monkeys Monkeys Chimpanzees
Penicillin G, benzathine	20,000-60,000 U/kg IM q12-24h ^{3,44}	Monkeys ³
Penicillin G, procaine	20,000 U/kg IM q12h ⁵⁹ 20,000-40,000 U/kg SC, IM q12h ³ 22,000 U/kg IM q24h ³	Monkeys Chimpanzees
Penicillin VK	11 mg/kg PO q6h ³	Chimpanzees

Continued

TABLE 13-1 Antimicrobial and Antifungal Agents Used in Primates. (cont'd)

Agent	Dosage	Species/Comments
Pentamidine isethionate	4 mg/kg IM, IV q24h × 14 days ⁸⁶	Great apes/ <i>Pneumocystis</i> ; slow IV infusion; associated with profound hypotension, cardiac arrhythmias
Rifampin	600 mg PO, IV q24h ³	Chimpanzees/tuberculosis; treat concurrently with or without isoniazid
Streptomycin	1-2 g/day divided q6-24h ³ 2.5-5 mg/kg IM q12h ³	Chimpanzees Monkeys
Sulfadimethoxine	50 mg/kg first day, then 25 mg/kg IM q24h ³	Monkeys
Tetracycline	20 mg/kg PO q8h ³ 20-25 mg/kg PO q8-12h ³	Monkeys Chimpanzees
Ticarcillin/clavulanate	65-100 mg/kg IV q8h ³ 200-300 mg/kg/day divided evenly q4-6h ³	Monkeys Chimpanzees
Tilmicosin	—	Shown to be fatal in humans and nonhuman primates when injected ⁷¹
Trimethoprim/sulfa	30 mg/kg PO, IM q24h ⁷	Prosimians
Trimethoprim/sulfadiazine	15 mg/kg PO q12h ⁵⁹ 30 mg/kg SC, IM q24h ⁵⁹	
Trimethoprim (T)/sulfamethoxazole (S)	4 mg/kg PO, SC q8h ³ (T) 4 mg/kg + (S) 20 mg/kg PO q12h ⁴⁴ (T) 5 mg/kg + (S) 25 mg/kg PO q6h ⁸⁶ 15-20 mg/kg/day IV divided q6-12h ² or 800 mg/animal PO q12h ³ 25 mg/kg PO, IM q12h ⁹⁰	Monkeys Useful to treat shigellosis ⁶⁹ Great apes/ <i>Pneumocystis carini</i> Chimpanzees Prosimians
Tylosin	2 mg/kg IM q24h ³ 5 mg/kg PO q12h ⁸⁶ 20 mg/kg IM q24h × 10 days ¹³	Monkeys <i>Clostridium</i> ; treat concurrently with metronidazole Rhesus macaques/chronic diarrhea
Vancomycin	20 mg/kg IM, IV q12h ³ 500 mg/animal PO q6h × 7-10 days; can give IV slow ³	Monkeys Chimpanzees

TABLE 13-2 Antiparasitic Agents Used in Primates.

Agent	Dosage	Species/Comments
Albendazole	10 mg/kg PO ⁷ 10 mg/kg PO q24h × 6 wk ⁴¹ 20 mg/kg PO q12h × 5 days ⁵¹	<i>Eulemur</i> ⁷ Common marmosets/ <i>Encephalitozoon cuniculi</i> Geoffroy's tamarins ($n=3$)/ <i>Angiostrongylus</i> ; treat concurrently with prednisolone

TABLE 13-2 Antiparasitic Agents Used in Primates. (cont'd)

Agent	Dosage	Species/Comments
Albendazole (cont'd)	25 mg/kg PO q12h × 5 days ^{19,59}	New World primates, Old World primates/ <i>Filaroides</i> , <i>Giardia</i> , ¹⁹ gastrointestinal nematodes ⁵⁹
	28.5 mg/animal PO q12h × 10 days × 3 at 10 day intervals ³⁴	Red ruffed lemur (<i>n</i> =1)/cysticercosis; administer with praziquantel (SC)
	50 mg/kg PO q12h × 16 days ^{33,41}	Common marmosets, cotton-topped tamarins/ <i>Acanthocephalus</i> sp.
	100 mg/kg PO q12h × 3 days, then repeat 2 × weekly × 4 treatments ^{33,41}	Common marmosets, cotton-topped tamarins/ <i>Acanthocephalus</i> sp.
Amitraz	250 ppm dip for 2-5 min duration q14d × 4 treatments or until resolution of skin lesions ^{19,40,59}	Red-handed tamarins (<i>n</i> =2)/demodectic mange; no hair clipping or bathing; not rinsed after treatment; dried by hot-air; ataxia (transient)
Bunamidine	25-100 mg/kg PO once ¹⁹	New World primates, Old World primates/cestodes
Chloroquine	2.5-5 mg/kg IM q24h × 4-7 days ¹⁹	New World primates, Old World primates/ <i>Plasmodium</i> ; follow with primaquine; give drugs separately to prevent toxicity
	5 mg/kg PO, IM q24h × 14 days ¹⁹	New World primates, Old World primates/ <i>Entamoeba histolytica</i>
	10 mg/kg IM q24h × 2 days, then 5 mg/kg IM q24h on day 3 ⁸⁶	<i>Plasmodium</i> sp.; treat concurrently with primaquine
	10 mg/kg via nasogastric tube day 1 AM; 5 mg/kg via nasogastric tube day 1 PM, days 2 and 3 q24h ³	Monkeys
	10 mg/kg PO, IM once, then 5 mg/kg 6 hr later, then 5 mg/kg q24h × 2 days ^{19,86}	New World primates, Old World primates/ <i>Plasmodium</i> sp.; treat concurrently with primaquine
Clindamycin	12.5 mg/kg PO, IM q12h × 28 days ¹⁹	New World primates, Old World primates/toxoplasmosis
	12.5-25 mg/kg PO q12h × 28 days ⁵⁹	<i>Toxoplasma</i> infection
Diethylcarbamazine	50 mg/kg PO q24h × 10 days ⁸⁶	Squirrel monkeys/filariasis; effective against microfilaria and adults
Diiodohydroxyquinoline (iodoquinol)	12 mg/kg PO q8h × 10-20 days ³	Monkeys
	12-16 mg/kg PO q8h ⁸⁶	Great apes (infants, juveniles)/ <i>Balantidium coli</i>
	30-40 mg/kg PO q24h × 3-21 days; 14-21 days for <i>Balantidium coli</i> ; 21 days for <i>Entamoeba histolytica</i> ⁸⁶	Great apes/minimal absorption; use with other agents for invasive disease
	35-50 mg/kg PO q24h × 21 days ⁸⁶	Great apes (juvenile)
Dithiazanine	630 mg PO q8h × 20 days ³	Chimpanzees
	10-20 mg/kg PO q24h × 3-10 days ¹⁹	New World primates, Old World primates/ <i>Strongyloides</i> ; low margin of safety

Continued

TABLE 13-2 Antiparasitic Agents Used in Primates. (cont'd)

Agent	Dosage	Species/Comments
Doxycycline	2.5 mg/kg PO q12h × 1 day, q24h × 10 days ¹⁹	New World primates, Old World primates/ <i>Balantidium</i>
Fenbendazole	10-20 mg/kg PO q24h × 30 days ⁴¹	Common marmosets/ <i>Encephalitozoon cuniculi</i>
	10-25 mg/kg PO q24h × 3-10 days ¹⁹	New World primates, Old World primates/ <i>Anatrichosoma cynomolgi</i>
	20 mg/kg PO q24h × 7 days ¹⁹	New World primates, Old World primates/ <i>Prosthenorhynchus</i>
	20 mg/kg PO q24h × 14 days ^{19,59}	New World primates, Old World primates/ <i>Strongyloides</i> , <i>Filaroides</i> , ¹⁹ gastrointestinal nematodes ⁵⁹
	25 mg/kg PO once, repeat in 7 days ¹⁹	New World primates, Old World primates/ <i>Ancylostoma</i>
	50 mg/kg PO q24h × 3 days, repeat in 2 wk ⁴⁴	Baboons/ ⁷⁷ gastrointestinal nematodes, <i>Filaroides</i> , ⁵⁹ <i>Trichuris trichura</i> , ⁷⁷ New World primates/ <i>Capillaria hepatica</i> ²²
	50 mg/kg PO q24h × 3-14 days ¹⁹	New World primates, Old World primates
	50 mg/kg PO q24h × 5 days ⁴¹	Common marmosets/ <i>Baylisascaris</i>
	50 mg/kg PO q24h × 14 days ^{19,41}	Common marmosets/ <i>Filaroides</i> sp., <i>Trichospira leptostoma</i>
	50 mg/kg PO q24h × 3 days, repeat in 3 wk ³	Chimpanzees/for monkeys repeat in 3 mo
50 mg/kg PO every 2 wk until infection resolved ⁴¹	Common marmosets/ <i>Capillaria hepatica</i>	
Fipronil (9.8% soln)	0.2 mL/kg topically every 6 wk ¹⁹	Prosimians/ <i>Cuterebra</i> sp., ticks
Furazolidone	5 mg/kg PO q6h × 7 days ⁸⁶	Great apes (juveniles)/ <i>Giardia</i> sp.
	100 mg/animal PO q6h × 7 days ⁸⁶	Great apes (adults)/ <i>Giardia</i> sp.; more palatable, but less effective than other agents
Ivermectin	0.2 mg/kg PO ²⁷	Lemurs
	0.2 mg/kg PO, ^{3,7} SC, ^{3,12,44} IM ^{7,44}	Chimpanzees, monkeys, <i>Eulemur</i> ⁷
	0.2 mg/kg PO, SC, IM, repeat in 10-14 days ^{19,59}	
	0.2 mg/kg SC or topically, repeat after 4 wk ⁴¹	Common marmosets/ <i>Anatrichosoma</i> , <i>Sarcoptes</i> , <i>Demodex</i> , <i>Dipetalonema</i> , pentastomids
	0.3 mg/kg PO every 7 days × 4 treatments ⁴²	Callitrichids/ <i>Gongylonema</i> sp.
Levamisole	2.5 mg/kg PO q24h × 14 days ⁸⁶	Prosimians/ <i>Physaloptera</i>
	5 mg/kg PO, repeat in 21 days ^{19,59}	<i>Strongyloides</i> , <i>Trichuris</i> , <i>Spiruroides</i> ⁵⁹
	7.5 mg/kg SC, repeat in 14 days ¹⁹	New World primates, Old World primates/ <i>Trichuris</i> , <i>Ancylostoma</i>

TABLE 13-2 Antiparasitic Agents Used in Primates. (cont'd)

Agent	Dosage	Species/Comments
Mebendazole	3 mg/kg PO q24h × 10 days ¹⁹	New World primates, Old World primates/ <i>Ancylostoma</i>
	10-20 mg/kg PO ⁷ q12h × 3 days, repeat in 14 days ⁸⁶	<i>Eulemur</i> , ⁷ prosimians/gastrointestinal nematodes
	15 mg/kg PO q24h × 3 days ¹⁹	<i>Strongyloides</i> , <i>Necator</i> , <i>Pterygo dermatites</i> , <i>Trichuris</i>
	22 mg/kg PO q24h × 3 days, repeat in 14 days ^{19,44} or repeat in 3 wk ⁴¹	Common marmosets ⁴¹ / <i>Giardia</i> sp. ⁴⁴
	22 mg/kg PO q24h × 3 days, repeat in 10-14 days ⁸⁶	Gastrointestinal nematodes
	40 mg/kg PO q24h × 3 days, repeat 3-4 times per year for prevention ¹⁹	New World primates, Old World primates/ <i>Pterygo dermatites</i>
	40 mg/kg PO q24h × 30 days ⁵⁹	<i>Strongyloides</i> , <i>Trichuris</i> , <i>Pterygo dermatites</i>
	50 mg/kg PO q12h × 3 days ³	Monkeys
	70 mg/kg PO q24h × 3 days ¹⁹	New World primates/oral spiruridiasis
	100 mg/animal PO q12h × 3 days ³	Chimpanzees, monkeys
100 mg/kg PO q12h × 3 days, repeat in 3 wk ³	Monkeys/ <i>Trichuris</i>	
Mefloquine	25 mg/kg PO once via nasogastric tube ³	Monkeys
	Active infection: 1250 mg PO once; preventive: 250 mg PO q7d ¹⁹	Chimpanzees
Metronidazole	10-16.7 mg/kg PO q8h × 5-10 days ¹⁹	New World primates, Old World primates/ <i>Giardia</i>
	17.5-25 mg/kg PO q12h × 10 days ¹⁹	Enteric flagellates and amoebas
	20 mg/kg PO q12h ⁴¹	Common marmosets/ <i>Entamoeba</i>
	25 mg/kg PO q12h × 5 days ¹⁹	New World primates, Old World primates/ <i>Giardia</i>
	25 mg/kg PO q12h × 10 days ⁵⁹	Enteric protozoans
	25 mg/kg PO q24h ⁹⁰	Prosimians
	30-50 mg/kg q24h × 5-10 days ⁴¹	Common marmosets/ <i>Giardia</i>
	30-50 mg/kg PO q12h × 5-10 days ⁸⁶	<i>Balantidium coli</i>
	30-50 mg/kg PO q24h × 5-10 days ^{19,41,44}	Common marmosets/ <i>Giardia</i> ⁴¹
35 mg/kg PO q24h × 3 days ⁷⁰	Macaques/ <i>Trichomonas vaginalis</i>	
Milbemycin oxime	1 mg/kg PO q24h every 30 days for 3 mo ⁷⁷	Baboons/ <i>Trichuris trichiura</i>
Moxidectin	0.5 mg/kg PO, IM once ¹⁹	New World primates, Old World primates/ <i>Strongyloides</i>
Niclosamide	37.5 mg PO q24h × 5 days ³	Monkeys
	100 mg/kg once ¹⁹	New World primates, Old World primates/intestinal cestodiasis
Nifurtimox	15-20 mg/kg PO q8h × 90 days ⁴¹	Common marmosets/ <i>Trypanosoma cruzi</i>

Continued

TABLE 13-2 Antiparasitic Agents Used in Primates. (cont'd)

Agent	Dosage	Species/Comments
Nitazoxanide	5 mg/kg PO q24h ⁴¹ 25 mg/kg PO q24h × 5-7 days ⁹⁰	Common marmosets/ <i>Cryptosporidium</i> Prosimians/protozoa
Oxytetracycline	1500 mg/animal q24h IV constant rate infusion ⁸⁶	Gorillas ($n=2$)/ <i>Balantidium coli</i>
Paromomycin	10 mg/kg PO q8h × 5-10 days ⁹⁶ 10-20 mg/kg PO q12h × 5-10 days ¹⁹ 12.5-15 mg/kg PO q12h × 5-10 days ¹⁹ 15 mg/kg PO q12h × 28 days ^{34,41} 100 mg/kg PO q24h × 10 days ¹⁹	Great apes/ <i>Entamoeba</i> New World primates, Old World primates/ <i>Balantidium coli</i> New World primates/amoebae; minimal enteric absorption Common marmosets ($n=2$)/ <i>Cryptosporidium</i> Cercopithecids
Praziquantel	5 mg/kg IM ⁴⁴ 5 mg/kg PO, SC, IM once ^{3,44} 15-20 mg/kg PO, IM ^{19,44,86} 20 mg/kg PO, IM once ⁵⁹ 20 mg/kg PO q8h × 1 day ³ 23 mg/animal PO at 10 day intervals × 3 treatments ⁹⁴ 40 mg/kg PO, IM ^{19,59}	Cestodes Monkeys New World primates, Old World primates/trematodes ⁸⁶ Cestodes Chimpanzees Red ruffed lemur ($n=1$)/subcutaneous cysticercosis; treat concurrently with albendazole Trematodes, ^{19,59} cestodes ¹⁹
Primaquine	0.3 mg/kg PO via nasogastric tube q24h × 14 days ^{3,86} 0.3 mg/kg PO q24h × 14 days ¹⁹	Monkeys/ ³ <i>Plasmodium</i> ; treat concurrently with chloroquine ⁸⁶ New World primates, Old World primates/treat with chloroquine; give drugs separately to prevent toxicity
Pyrantel pamoate	5-10 mg/kg PO, ⁷ repeat in 2 wk ⁹⁰ 6 mg/kg PO ²⁷ 10 mg/kg PO, repeat in 3 wk ³	<i>Eulemur</i> , ⁷ prosimians/nematodes ⁹⁰ Lemurs Chimpanzees
Pyrimethamine	0.5 mg/kg PO q12h ⁴¹ 2 mg/kg PO q24h × 3 days, then 1 mg/kg PO q24h × 28 days ⁸⁶ 10 mg/kg PO q24h ¹⁹	Common marmosets/ <i>Encephalitozoon cuniculi</i> ; treat concurrently with trimethoprim/sulfamethoxazole and folic acid for encephalitozoonosis or toxoplasmosis Great apes/ <i>toxoplasmosis</i> ; maximum dose of 100 mg/animal q24h for days 1-3 and 25 mg/animal q24h for 28 days; treat concurrently with sulfadiazine <i>Plasmodium</i> ; folic acid antagonist so monitor for deficiency
Pyvium	5 mg/kg PO once, repeat every 6 mo ¹⁹	New World primates, Old World primates/pinworms

TABLE 13-2 Antiparasitic Agents Used in Primates. (cont'd)

Agent	Dosage	Species/Comments
Quinacrine	2 mg/kg PO q8h × 7 days ^{19,86} 10 mg/kg PO q8h × 5 days ¹⁹	New World primates, Old World primates/may cause gastrointestinal upset in squirrel monkeys; ¹⁹ great apes/ <i>Giardia</i> ; maximum dose of 300 mg/day ⁸⁶ New World primates, Old World primates/ <i>Giardia</i>
Ronnel	55 mg/kg PO or topically q72h × 4 treatments, then every 7 days for 3 mo ¹⁹	Lung mites
Sulfadiazine	25-50 mg/kg PO q6h ⁸⁶ 100 mg/kg PO q24h ¹⁹	Great apes/toxoplasmosis, maximum dose of 6 g/animal/day; treat concurrently with pyrimethamine Toxoplasmosis; treat concurrently with pyrimethamine
Sulfadimethoxine	50 mg/kg PO once, then 25 mg/kg q24h ¹⁹	Coccidiosis
Tetracycline	15 mg/kg PO q8h × 10-14 days ⁸⁶ 25-50 mg/kg PO q24h × 5-10 days ⁸⁶ 500-1000 mg/animal PO q8h × 10-14 days ⁸⁶	Great apes (infants, juveniles)/ <i>Balantidium coli</i> Great apes/ <i>Entamoeba</i> , <i>Balantidium</i> Great apes (adults)/ <i>Balantidium coli</i>
Thiabendazole	50 mg/kg PO ⁷ q24h × 2 days ^{3,19} 50 mg/kg PO × 3-5 days ⁹⁰ 75-100 mg/kg PO q24h once, repeat in 21 days ¹⁹ 100 mg/kg PO q24h ³ 100 mg/kg PO once, repeat in 3 wk ⁴⁴ 750-1500 mg/animal PO q24h × 2 days or 7 days ^{3,19}	<i>Eulemur</i> , ⁷ infant monkeys ³ / <i>Necator</i> ¹⁹ Prosimians/nematodes New World primates, Old World primates Monkeys (adult) <i>Strongyloides</i> Chimpanzees/visceral larval migrans
Tinidazole	40-45 mg/kg PO q24h × 6 days ⁹⁰ 150 mg/kg PO q24h once, then 77 mg/kg PO q24h on day 4 ^{19,41,52}	Prosimians/protozoa Marmosets/ <i>Giardia</i>
Toltrazuril	7 mg/kg PO q24h × 2 days ⁴¹	Common marmosets/toxoplasmosis; treat concurrently with trimethoprim/sulfamethoxazole
Trimethoprim/sulfa	15 mg/kg PO q12h ⁵⁹	Toxoplasmosis
Trimethoprim/sulfamethoxazole	30 mg/kg PO q12h for at least 3 wk ⁴¹	Common marmosets/ <i>Encephalitozoon cuniculi</i> ; treat concurrently with folic acid and pyrimethamine for encephalitozoonosis or toxoplasmosis

TABLE 13-3 Chemical Restraint/Anesthetic/Analgesic Agents Used in Primates.

Agent	Dosage	Species/Comments
Acepromazine	— 0.1-0.5 mg/kg IM, IV ³ 0.5-1 mg/kg PO, ⁵⁹ SC, IM ³	See butorphanol and ketamine for combinations Monkeys Chimpanzees
Acetaminophen	5-10 mg/kg PO q6h ^{41,59,72} 6 mg/kg PO q8h ³ 10-15 mg/kg PO q8-12h ⁹¹ 15-20 mg/kg rectal ⁷² 500-1000 mg/animal PO q8h ³	New World primates, juvenile macaques, common marmosets/pyrexia, mild pain Monkeys Prosimians Chimpanzees
Acetaminophen/codeine suspension (120 mg/12 mg per 5 mL)	10-15 mL PO q6h ³	Chimpanzees
Acetylsalicylic acid (aspirin)	— 5-10 mg/kg PO q4-6h ^{3,41,59,86} 10-20 mg/kg PO q8-12h ⁹¹ 20 mg/kg PO q8-12h ³ 20 mg/kg PO q12h ²	NSAID; analgesic; antipyretic, ⁵⁹ avoid aspirin based products during viral infections due to concerns of Reyes syndrome ⁶⁵ Monkeys, common marmosets, chimpanzees use q6h Prosimians Monkeys Rhesus macaques/platelet aggregation was significantly decreased
Alphaxalone	— 18 mg/kg IM, IV ⁸⁶	Injectable steroid anesthetic; available in the United States as Alfaxan but not yet reported as sole agent for doses Marmosets, small primates/Saffan (9 mg/mL alphaxalone in 12 mg/mL); therefore 13.5 mg of reported dose was calculated as alphaxalone
Atipamezole (Antisedan, Zoetis)	IM use only per label 0.15-0.3 mg/kg IM, IV ^{3,72} 0.2 mg/kg IV ⁷² 0.25 mg/kg IM, IV ⁷²	Specific α_2 -adrenergic antagonist; more specific for medetomidine and dexmedetomidine than for xylazine; as a general rule, atipamezole is dosed at the same volume of medetomidine or dexmedetomidine; ³⁸ atipamezole dose is $5 \times$ dose of medetomidine or $10 \times$ dose of dexmedetomidine on mg basis ²⁰ Chimpanzees; ³ use lower dose in monkeys ³ and baboons ⁷² Squirrel monkeys Macaques
Bupivacaine (0.5%)	1.2 mg/kg epidural as two 0.6 mg/kg doses at 2 min, then 20 min ⁸⁶ 2 mg/kg maximum perineurally ²⁵	Rhesus macaques/epidural analgesia Macaques/local anesthetic

TABLE 13-3 Chemical Restraint/Anesthetic/Analgesic Agents Used in Primates. (cont'd)

Agent	Dosage	Species/Comments
Buprenorphine	—	Opioid agonist-antagonist; analgesia ³⁵
	0.005-0.01 mg/kg SC, ³⁸ IM, IV q6-12h ²⁹	Rhesus macaques, marmosets
	0.005-0.01 mg/kg SC, IM, IV q6-12h ³⁵	
	0.005-0.03 mg/kg IM, IV q6-12h ⁴¹	Common marmosets
	0.01 mg/kg IM, IV q6-8h ^{66,72}	Macaques/PK; not to exceed 0.3 mg/animal IM q8h in chimpanzees ⁷²
	0.01 mg/kg IM q12h ¹⁶	Rhesus macaques/postoperative analgesia
	0.01-0.02 mg/kg SC, IM, IV q8-12h ⁹¹	Prosimians
	0.01-0.02 mg/kg IM q12h ⁵⁹	
	0.01-0.05 mg/kg IM, SC q8-12h ⁴⁴	
Butorphanol	—	In primates, butorphanol behaves more as an agonist with intermediate efficacy; may cause profound respiratory depression—reverse with naloxone ^{41,59,67}
	0.01-0.02 mg/kg SC, IM, IV q6-12h ⁴¹	Common marmosets
	0.013 mg/kg IM q8h ¹⁶	Rhesus macaques
	0.02 mg/kg IM q3-4h ⁵⁹	
	0.02 mg/kg SC, IV q8h ^{3,72}	New World primates
	0.05 mg/kg IM q8h ^{3,72}	Monkeys, ³ macaques ⁷²
	0.1-0.15 mg/kg SC q6h ⁴⁴	
	0.1-0.2 mg/kg IM q12-48h ⁹⁶	
	0.1-0.4 mg/kg IM ⁷	Eulemurs
Butorphanol (B)/acepromazine (A)	0.1-0.4 mg/kg SC, IM, IV q3-4h ⁹¹	Prosimians
	(B) 0.013 mg/kg + (A) 0.02 mg/kg IM ⁸⁶	Macaques/premedication for general anesthesia; butorphanol could be substituted with buprenorphine (0.01 mg/kg) and ketamine (10 mg/kg)
Butorphanol (B)/dexmedetomidine (D)/ketamine (K)	(B) 0.3-0.4 mg/kg + (D) 0.02 mg/kg + (K) 3-5 mg/kg IM ^{90,91}	Prosimians/can exchange ketamine with 0.2-0.3 mg/kg IM midazolam
Carfentanil	—	This product is no longer available commercially in the United States; prior publications suggest substantial concern with use of this product, both alone and in combinations, for use in nonhuman primates ^{20,45,86}
Carprofen	2 mg/kg PO q12h ³	Chimpanzees, monkeys
	2-4 mg/kg PO, SC, IV q12-24h ^{38,41,59,72,86}	NSAID; analgesia; antipyretic; half-life varies with species; COX-1 selectivity ⁵⁹
	3-4 mg/kg IV, SC once ²⁸	Macaques/preoperatively

Continued

TABLE 13-3 Chemical Restraint/Anesthetic/Analgesic Agents Used in Primates. (cont'd)

Agent	Dosage	Species/Comments
Celecoxib	200 mg/animal PO q12-24h ³	Chimpanzees/COX-2 NSAID
Deracoxib (Deramaxx, Eli Lilly)	2 mg/kg PO q24h ³	Chimpanzees/COX-2 NSAID; chronic use
	4 mg/kg PO q24h ³	Chimpanzees
Diazepam	—	Used often as an adjuvant with ketamine
	0.25-0.5 mg/kg PO, IV ^{7,90}	Prosimians, lemurs
	0.25-0.5 mg/kg IM, IV ³	Chimpanzees
	0.5-1 mg/kg PO ^{3,59,86}	Chimpanzees ³
	0.5-1 mg/kg IM, IV ³	Monkeys/seizures
	0.5-2.5 mg/kg IV ⁹¹	Prosimians
	1 mg/kg IM ²⁹ 5 mg/animal PO ²⁰	Marmosets Gorillas (juvenile)
Droperidol	2.5-10 mg/animal IM ³	Chimpanzees/given 30-60 min prior to procedure
Etomidate	0.1 mg/kg/min IV constant rate infusion ²⁶	Rhesus macaques/maintenance
	1 mg/kg IV ²⁶	Rhesus macaques/induction
Fentanyl	—	Produced respiratory depression and analgesia at dosages as low as 2 µg/kg IV, and apnea was seen consistently at 60 µg/kg ⁶⁷
	0.001-0.03 mg/kg/h IV constant rate infusion ^{90,91}	Prosimians
	0.05-0.15 µg/kg IM as needed ³	Monkeys
	1-2 µg/kg as an adjunct to general anesthesia; 50-150 µg/kg as sole anesthetic ¹⁸	Great apes
	5-10 µg/kg IV bolus ⁷² or IV constant rate infusion ^{3,25} or 10-25 µg/kg/h IV constant rate infusion ⁷²	Rhesus macaques, baboons, ⁷² chimpanzees ³
	8 µg/kg IV ⁸⁷ 10-15 µg/kg PO as lollipops ²⁰	Rhesus macaques (<i>n</i> =6)/PK; published with error in dose Orangutans, gorillas/adequate sedation in 30-45 min; chimpanzees suboptimal effects
	25 µg/kg/h (5-10 kg); 50 µg/kg/h (10 kg) q48-72h ³	Monkeys/transdermal patch
Fentanyl/droperidol (Innovar-Vet, Janssen)	0.05 mL/kg IM ³	New World primates
	0.1-0.3 mL/kg IM ³	Chimpanzees, monkeys
Flumazenil	0.02 mg/kg IV ^{72,91}	Patas monkeys, prosimians
	0.025 mg/kg IV ^{20,86}	Chimpanzees, gorillas/did not significantly enhance speed or quality of recovery

TABLE 13-3 Chemical Restraint/Anesthetic/Analgesic Agents Used in Primates. (cont'd)

Agent	Dosage	Species/Comments
Flunixin meglumine	0.25-0.5 mg/kg SC, IM, IV q24h ⁹¹ 0.3-1 mg/kg SC, IV q12-24h ^{59,86} 1 mg/kg IM q12h ²⁵ 2 mg/kg IM q12h ³	Prosimians NSAID; analgesia; antipyretic Rhesus macaques Monkeys
Hydrocodone bitartrate	5 mg/animal PO q4-6h pm ³	Chimpanzees
Hydromorphone	0.2 mg/kg IM, IV bolus q4h ⁴⁷	Rhesus macaques/PK; whole-body pruritus, sedation, and decreased appetite
Ibuprofen	7 mg/kg PO q12h ^{3,72} 10 mg/kg PO q8-12h ⁹¹ 20 mg/kg PO q24h ^{41,59} 200-400 mg/animal PO q8h ³	Old World primates, New World primates/NSAID; mild analgesia ⁷² Prosimians Common marmosets Chimpanzees
Isoflurane	1%-3% maintenance ^{59,72}	Marmosets, chimpanzees
Ketamine	— 5 mg/kg IM ⁸⁶ 5 mg/kg IV ³ 5-12 mg/kg IM ⁶⁷ 5-15 mg/kg IM, IV ^{59,91} 5-15 mg/kg PO, IM, IV or rectally ¹⁸ 5-40 mg/kg IM ³ 10 mg/kg IM ³ 10-15 mg/kg IM ³	Tranquillization; anesthesia; mg/kg dose increases as size of animal decreases; causes seizures in lemurs when used as sole agent so not recommended for use alone in prosimians ⁹⁰ Great apes/follow with inhalant anesthetic; ketamine provides a shorter recovery time than tiletamine-zolazepam Monkeys Monkeys Prosimians ⁹¹ Great apes/in general 6-10 mg/kg should allow safe initial immobilization Chimpanzees Monkeys New World primates
Ketamine (K)/acepromazine (A)	(K) 4 mg/kg + (A) 0.4 mg/kg IM ²⁷	Lemurs
Ketamine (K)/detomidine (Det)	(K) 9.6 mg/kg + (Det) 0.32 mg/kg PO ²⁰ (K) 10 mg/kg + (Det) 0.5 mg/kg PO ⁶⁰	Gorillas Gorillas ($n=6$), mandrill baboons ($n=7$)/reduced the reaction to darting
Ketamine (K)/dexmedetomidine (De)	(K) 2-4 mg/kg + (De) 0.02-0.03 mg/kg IM ¹⁹	Medium to large primates
Ketamine (K)/medetomidine ^a (Me)	—	Medetomidine is no longer commercially available; can be compounded; ^a replaced with dexmedetomidine; recoveries can be quite sudden even without reversal ²⁰

Continued

TABLE 13-3 Chemical Restraint/Anesthetic/Analgesic Agents Used in Primates. (cont'd)

Agent	Dosage	Species/Comments
Ketamine (K)/medetomidine (Me) (cont'd)	(K) 2 mg/kg + (Me) 0.03-0.04 mg/kg ¹⁸	Chimpanzees
	(K) 2-4 mg/kg + (Me) 0.04-0.06 mg/kg IM ¹⁹	Medium to large primates
	(K) 2-6 mg/kg + (Me) 0.03-0.06 mg/kg IM ^{3,86}	Chimpanzees
	(K) 3 mg/kg + (Me) 0.02-0.03 mg/kg IM ²⁰	Orangutans
	(K) 3-4 mg/kg + (Me) 0.15 mg/kg IM ^{56,67,72,84}	Macaques, capuchins
	(K) 5 mg/kg + (Me) 0.01 mg/kg IM ⁴¹	Common marmosets
	(K) 5 mg/kg + (Me) 0.05 mg/kg IM ⁶⁷	Japanese macaques
	(K) 5-7.5 mg/kg IM + (Me) 0.05-0.1 mg/kg IM, IV ^{69,67}	Use higher dosages for smaller primates
Ketamine (K)/medetomidine ^a (Me)/butorphanol (B)	—	Medetomidine is no longer commercially available; can be compounded; ^a replaced with dexmedetomidine
	(K) 2-3 mg/kg + (Me) 0.02-0.03 mg/kg + (B) 0.2-0.4 mg/kg ²⁰	Great apes
	(K) 3 mg/kg + (Me) 0.04 mg/kg + (B) 0.4 mg/kg IM ^{86,92}	Ring-tailed lemurs/anesthesia; long duration of action
Ketamine (K)/midazolam (Mi)	(K) 1-2 mg/kg + (Mi) 0.03 mg/kg IM ²⁰	Orangutans
	(K) 2.5 mg/kg + (Mi) 0.25 mg/kg IM ²⁰	Chimpanzees
	(K) 4-20 mg/kg IM + (Mi) 0.05-0.2 mg SC, IM ³⁸	
	(K) 5 mg/kg + (Mi) 0.1 mg/kg IM ⁷²	Baboons
	(K) 8 mg/kg + (Mi) 0.2 mg/kg IM ^{6,72}	Macaques/up to 1 mg/kg IM of midazolam ^{44,56}
	(K) 9 mg/kg + (Mi) 0.05 mg/kg IM ²⁰	Gorillas
	(K) 10 mg/kg + (Mi) 1 mg/kg IM ^{32,67}	Marmosets
	(K) 15 mg/kg + (Mi) 0.05-0.09 mg (lower body weight) ³⁵ or 0.05-0.15 mg (higher body weight) IV ⁷²	
Ketamine (K)/tiletamine-zolazepam (T)	(K) 1-3 mg/kg + (T) 2-4 mg/kg IM ¹⁸	Great apes/combination reduces amount of ketamine needed for induction
Ketamine (K)/xylazine (X)	(K) 5 mg/kg + (X) 0.5-1 mg/kg ⁶⁷	Monkeys
	(K) 5-7 mg/kg + (X) 1-1.4 mg/kg IM ²⁰	Orangutans
	(K) 5-10 mg/kg + (X) 0.25-0.3 mg/kg SC, IM ³⁸	
	(K) 7 mg/kg + (X) 0.6 mg/kg IM ^{3,72}	Monkeys, macaques
	(K) 10 mg/kg + (X) 0.25 mg/kg for 45 min, or (X) 2 mg/kg for 138 min sedation ⁷²	Macaques
	(K) 10-20 mg/kg IM + (X) 3 mg/kg IM ³	New World primates
	(K) 15-20 mg/kg IM + (X) 1 mg/kg IM ^{2,20,72}	Chimpanzees ²⁰

TABLE 13-3 Chemical Restraint/Anesthetic/Analgesic Agents Used in Primates. (cont'd)

Agent	Dosage	Species/Comments
Ketoprofen	2 mg/kg IM q24h ²⁰	Gorilla (<i>n</i> = 1)
	2 mg/kg IM, IV q24h ^{3,44}	Chimpanzees, monkeys ³
	2 mg/kg PO, SC, IM, IV ⁹¹	Prosimians/NSAID; reduce prosimians to 1 mg/kg q24h after first dose
	5 mg/kg IM q6-8h ⁸⁶	Macaques
	5 mg/kg IM q24h ²⁵	
Ketorolac	0.5-1 mg/kg ⁶⁷ SC, IM q8-12h × 4 days ³⁸	NSAID
	15-30 mg/animal IM ⁷²	Baboons
	30 mg/animal PO q6h ^{3,72}	Chimpanzees
	60 mg/animal PO once ³	Chimpanzees
Lidocaine	2-4 mg/kg ¹⁸	Great apes/preferred to bupivacaine for dental procedures
	6 mg/kg maximum perineurally ²⁵	Macaques/local anesthetic
Medetomidine ^a	—	Medetomidine is a more selective, potent and specific α_2 -agonist than xylazine; can be compounded; replaced with dexmedetomidine
	0.01-0.035 mg/kg IM ^{3,44}	Monkeys ³
	0.1 mg/kg PO ²⁰	Great apes
	0.1 mg/kg SC, IM ⁷²	Squirrel monkeys, baboons
	0.15 mg/kg ⁷²	Macaques
Medetomidine (Me) ^a / midazolam (Mi)	(Me) 0.03-0.06 mg/kg + (Mi) 0.3 mg/kg IM ⁶⁷	Japanese macaques
Meloxicam	0.1 mg/kg PO q24h ¹¹	Cynomolgus macaques/PK; sustained-release formation (0.6 mg/kg SC) achieved adequate steady-state plasma concentration for 2-3 days; PO formulation limited use
	0.1-0.2 mg/kg SC q24h ²⁹ up to 3 days ⁷²	Marmosets, rhesus macaques/NSAID
	0.2 mg/kg IM q24h ¹¹	Cynomolgus macaques/PK; see above dose for cynomolgus macaques; IM provided adequate plasma concentrations for 12-24 hr
	0.2-0.3 mg/kg PO, SC, IM q24h × 4 days ³⁸	Lower dose—common marmosets, ⁴¹ macaques ⁷²
	0.3 mg/kg PO, SC q24h ²	Rhesus macaques/platelet aggregation was not affected
Meperidine	2 mg/kg IM ⁷²	Macaques
	2-4 mg/kg IM, ⁷² IV q30-60 min ³	Baboons, monkeys/analgesia
	50-150 mg/animal PO ⁷² q3-4h prn ³	Chimpanzees

Continued

TABLE 13-3 Chemical Restraint/Anesthetic/Analgesic Agents Used in Primates. (cont'd)

Agent	Dosage	Species/Comments
Midazolam	—	See ketamine and medetomidine for combinations
	0.05-0.1 mg/kg IM, slow IV ^{3,44}	Monkeys ³
	0.1-0.3 mg/kg IM, ^{7,91} IV ⁹¹	Eulemurs, prosimians
	0.5 mg/kg PO ⁵⁹	More applicable in larger species
	0.7-1.2 mg/kg PO ²⁰	Gorillas, chimpanzees, orangutans
	1-2.5 mg/animal IV, or 5 mg/animal IV ³	Chimpanzees
Morphine	—	Opioid analgesia; dose dependent respiratory depression ⁵⁹
	0.01-0.1 mg/kg IV ^{3,72}	Chimpanzees
	0.15 mg/kg epidurally ⁷²	Baboons
	1 mg/kg PO, SC, IM, IV q4h ⁵⁹	Monkeys, macaques, baboons, squirrel monkeys
	1-2 mg/kg SC, ^{72,86} IM, IV q4h ^{3,72}	Common marmosets
	1-2 mg/kg SC, IM q6h ⁴¹	
Nalbuphine	0.5 mg/kg IM, IV q3-4h ⁸⁶	Agonist-antagonist opioid
	2.5-5 mg/kg IM q3-4h ³	Monkeys
	10 mg SC, IM, IV q3-6h as needed ³	Chimpanzees
Naloxone	—	Opioid antagonist/reversal, ⁵⁹ short acting; a second dose may be necessary to avoid the return of respiratory depression ⁷²
	0.015 mg/kg SC, IM, IV ^{3,72}	Chimpanzees
	0.01-0.05 mg/kg IM, IV ^{41,59}	Common marmosets ⁴¹
	0.02 mg/kg IM ⁹¹	Prosimians
	0.1 mg/kg SC, IM, IV as needed ³	Monkeys
	0.1-0.2 mg as needed ⁷²	Macaques, baboons, squirrel monkeys, common marmosets
Naproxen	5 mg/kg PO q24h ³	Chimpanzees
	10 mg/kg PO q12h ⁸⁶	Lemurs
Nitrous oxide (N ₂ O)	Up to 60% with O ₂ ³⁸	Not acceptable as sole agent
Oxymorphone	—	Opioid analgesia
	0.025 mg/kg SC, IM, IV q4-6h ³	New World primates
	0.075 mg/kg IV bolus ⁴⁹	New World primates, rhesus macaques (<i>n</i> =4), titi monkeys (<i>n</i> =4)/PK
	0.075 mg/kg IM, IV q4-6h ⁷²	Squirrel monkeys, marmosets
	0.15 mg/kg SC, IM, IV q4-6h ^{3,44,49,72}	Old World primates, ⁴⁹ macaques, baboons, ⁷² monkeys ³
	1-1.5 mg/animal SC, IM q4-6h ^{3,72}	Chimpanzees
Pentobarbital (pentobarbitone sodium)	—	The product has considerable variation between species; severe respiratory depression; inability to modulate depth of anesthesia; ³⁸ should be used for euthanasia only, not for sedation

TABLE 13-3 Chemical Restraint/Anesthetic/Analgesic Agents Used in Primates. (cont'd)

Agent	Dosage	Species/Comments
Propofol	— 0.3-0.5 mg/kg/min constant rate infusion ⁴⁴ 1 mg/kg IV ⁴⁴ 1-2 mg/kg IV bolus, followed by constant rate infusion to effect ^{3,72} 2 mg/kg IV bolus ⁵⁸ 2-4 mg/kg/min IV constant rate infusion ⁷² 2-5 mg/kg IV bolus; ⁴¹ maintenance with 0.3-0.4 mg/kg/min IV constant rate infusion ⁷² 2.5-5 mg/kg IV bolus; maintenance with 0.3-0.4 mg/kg/min constant rate infusion ³ 3-6 mg/kg IV ⁹¹ 5 mg/kg IV bolus at 0.6 mg/kg/min ⁶¹ 5-10 mg/kg IV, then 0.3-0.6 mg/kg IV constant rate infusion ²⁹	Dose to maintain anesthesia in great apes 5-10 × less than human dose; ¹⁸ use sterile technique due to vehicle Induction Chimpanzees Neonatal rhesus macaques (<i>n</i> =4)/ induction Baboons Common marmosets, macaques Monkeys Prosimians Japanese macaques (<i>n</i> =5)/step down started at 0.6 mg/kg/min, then 0.3 mg/kg/min for 10 min, then 0.2 mg/kg/min for 100 min Marmosets
Sevoflurane	1 MAC = 2% ⁷²	Macaques
Thiamylal sodium	15-25 mg/kg IV to effect ³	Monkeys/barbiturate anesthesia
Thiopental	— 5-7 mg/kg IV if combined with ketamine ⁷² 15-17 mg/kg/h IV constant rate infusion ⁷² 25 mg/kg IV to effect ³	Barbiturate anesthesia Macaques Baboons Monkeys
Tiletamine-zolazepam (Telazol, Fort Dodge; Zoletil, Virbac)	— 1-2.5 mg/kg IM ³ 1.5-3 mg/kg IM ⁸⁶ 2-5 mg/kg IM ¹⁹ 2-6 mg/kg IM ^{20,72} 3-5 mg/kg IM ^{3,44,72,91} 4-6 mg/kg IM ^{72,86} 5-8 mg/kg IM ³ 10 mg/kg ^{67,72,78}	Can concentrate in vial; see ketamine for combination New World primates New World primates, Old World primates Chimpanzees, gorillas, orangutans (up to 6.9 mg/kg) Prosimians/for restraint only ⁴⁴ Macaques, baboons Chimpanzees, monkeys Squirrel monkeys, ⁷² chimpanzees ⁷⁸

Continued

TABLE 13-3 Chemical Restraint/Anesthetic/Analgesic Agents Used in Primates. (cont'd)

Agent	Dosage	Species/Comments
Tiletamine-zolazepam (T)/medetomidine (Me) ^a	(T) 0.8-2.3 mg/kg + (Me) 0.02-0.06 mg/kg IM ^{20,67}	Orangutans, monkeys, gibbons, macaques
	(T) 1-3 mg/kg + (Me) 0.02-0.06 mg/kg ⁶⁷	Monkeys, macaques, gibbons
	(T) 1.25 mg/kg + (Me) 0.03 mg/kg IM ⁷²	Chimpanzees
	(T) 2 mg/kg + (Me) 0.03 mg/kg IM ⁷⁸	Chimpanzees
	(T) 3 mg/kg + (Me) 0.05 mg/kg IM ⁶³	Chimpanzees
Tramadol	(T) 3 mg/kg IM + (Me) 0.1 mg/kg PO ⁶³	Chimpanzees
	1-4 mg/kg PO q12h ⁹¹	Prosimians
	1.5 mg/kg IV q24h ⁴⁸ 3 mg/kg PO ⁴⁸	Rhesus macaques/PK; sedation, pruritus Rhesus macaques/PK; PO bioavailability poor; oral dosages of 4-20 × this dose may be required for analgesia
Xylazine	—	See ketamine for combination
	0.5-6 mg/kg IM ³	Monkeys
	1.1 mg/kg IV ³ 2.2 mg/kg IM ³	Chimpanzees Chimpanzees
Yohimbine	0.1 mg/kg IM, IV ³	Monkeys, chimpanzees (0.11 mg/kg)
	0.125-0.25 mg/kg IM ²⁰	Chimpanzees
	0.5 mg/kg IV or 1 mg/kg IM ^{72,86}	Macaques/xylazine reversal
Zuclopenthixol (Clopixol, Lundbeck)	0.1-0.36 mg/kg PO q12h ²⁰	Gorillas/antipsychotic drug; not approved for use in the United States

^aMedetomidine is no longer commercially available although it can be obtained from select compounding services (i.e., Wildlife Pharmaceuticals, www.zoopharm.net); limited data on the efficacy and safety of dexmedetomidine in primates; the effects of the v/v use of the two drugs may not be equivalent, so the dose of dexmedetomidine may need to be adjusted based on clinical response.

TABLE 13-4 Miscellaneous Agents Used in Primates.

Agent	Dosage	Species/Comments
Allopurinol	200-600 mg PO q24h ³	Chimpanzees
Aminophylline	10 mg/kg IV ^{3,27}	Chimpanzees, ³ lemurs
	25-100 mg/animal PO q24h ³	Monkeys
Amlodipine	0.1 mg/kg PO q24h ³	Chimpanzees/antihypertensive agent
Atropine	0.02-0.04 mg/kg SC, IM, IV ⁷²	Chimpanzees; for marmosets use higher dose
	0.02-0.05 mg/kg SC, ⁴¹ IM ⁷²	Macaques, baboons, common marmosets

TABLE 13-4 Miscellaneous Agents Used in Primates. (cont'd)

Agent	Dosage	Species/Comments
Atropine sulfate	0.01 mg/kg IM ²⁰	Orangutan (<i>n</i> = 1)
	0.02-0.04 mg/kg SC, IM, IV ³	Monkeys
	0.02-0.05 mg/kg SC, IM, IV ³	Chimpanzees
	0.04 mg/kg IM ²⁰	Gorillas
	2-5 mg/animal IM ²⁰	Chimpanzees (juvenile)
Azathioprine	1-2 mg/kg PO q24h ³	Monkeys/immunosuppressive agent; purine antagonist
	1-2.5 mg/kg PO q24h ³	Chimpanzees
Benazepril	0.25-0.5 mg/kg PO q24h ⁴¹	Common marmosets/less nephrotoxicity than enalapril
Bisacodyl	10-15 mg PO as needed ³	Chimpanzees
Bismuth subsalicylate	10 mg/kg PO q12h ⁸⁶	Macaques/quadruple treatment for <i>Helicobacter pylori</i> ; see amoxicillin (Table 13.1)
	30 mL PO as needed ³	Chimpanzees
	40 mg/kg PO q8-12h ³	Monkeys
Budesonide	0.5 mg/animal PO q24h × 8 wk, then 0.75 mg PO q24h × 8 wk ⁴¹	Common marmosets/marmoset wasting syndrome
Calcitonin	10 U/kg q48h × 3 wk ⁴¹	Common marmosets/must be normocalcemic
Calcitriol	0.03 mg/kg PO q24h ³	Chimpanzees
Calcium gluconate	1 mL/kg PO q12h ⁴¹	Common marmosets/metabolic bone disease
Calcium gluconate	200 mg/kg SC, IM, IV ^{3,86}	Chimpanzees/hypocalcemia; hyperkalemia; prophylaxis and therapy of nutritional secondary hyperparathyroidism
Captopril	1 mg/kg PO ⁸⁶	ACE inhibitor and vasodilator
Carvedilol	3.125 mg PO q12h × 2 wk, then 6.25 mg PO q12h, increase as needed ³	Chimpanzees
Cimetidine	5-10 mg/kg PO ⁴¹	Common marmosets/ <i>Helicobacter</i>
	10 mg/kg PO, IM q8h ³	Monkeys/gastrointestinal ulceration
	300 mg/animal PO, IM, slow IV q6-8h ³	Chimpanzees
Cisapride	0.2 mg/kg PO q12h × 3 wk ⁸⁶	Macaques/promotes gastrointestinal motility; compounded in United States
Dapsone	50 mg/animal PO q24h; 100 mg/animal PO q24h ³	Chimpanzees/use higher dose with leprosy
Depoprovera	2.5-5 mg/kg IM ⁸⁰	Old World primates/contraception for 45-90 days; higher doses for smaller species
	5 mg/kg IM ^{7,80}	Prosimians/contraception for 30-45 days, during breeding season (Nov-March)
	20 mg/kg IM ⁸⁰	New World primates/contraception for 30 days

Continued

TABLE 13-4 Miscellaneous Agents Used in Primates. (cont'd)

Agent	Dosage	Species/Comments
Deslorelin (Suprelorin, Virbac)	4.7 mg SC implant effective for 6 mo; 9.4 mg SC implant effective for 12 mo ^{41,59,80}	GnRH antagonist implant; need secondary contraception of megestrol acetate (not depoprovera) for 7 days prior to and postimplantation
Dexamethasone	0.25-1 mg/kg PO, IM q24h ³	Monkeys
Digoxin	0.005-0.01 mg/kg PO q12h or IV as needed ³ 0.01 mg/kg PO q24h ⁴¹ 2-12 µg/kg PO, IM, IV divided q12-24h ³	Chimpanzees Common marmosets/congestive heart failure Monkeys/maintenance dose
Diphenhydramine	5 mg/kg/day PO, IM, ²⁷ IV, daily total may be divided q6-8h ³ 25-50 mg/animal PO, IM, IV q6-8h ³	Monkeys, ³ lemurs ²⁷ Chimpanzees
Dobutamine	2.5-10 µg/kg/min IV constant rate infusion ³	Chimpanzees, monkeys/adrenergic β ₁ agonist; increases cardiac output
Docusate sodium (DSS)	10-40 mg/animal PO ³ 50-200 mg/animal PO ³	Monkeys Chimpanzees
Dopamine	2-5 µg/kg/min IV constant rate infusion ³ 2-10 µg/kg/min IV constant rate infusion ¹⁸ 5-15 µg/kg/min IV constant rate infusion ³	Chimpanzees, monkeys/low to moderate doses; positive inotropic effects and renal vasodilation Great apes/stimulates dopaminergic, α and β adrenergic receptors; positive inotrope which significantly can improve blood pressures intraoperatively Monkeys
Doxapram	2 mg/kg IV ³	Chimpanzees/respiratory stimulant
Duloxetine	30-60 mg/kg PO q12h ⁵⁴	Drill (<i>n</i> = 1)/serotonin-norepinephrine reuptake inhibitor
Enalapril	0.015-0.125 mg/kg PO q12-24h ⁸⁶ 0.3 mg/kg PO, IV ³ 0.5 mg/kg PO q48h ⁴¹	Gorillas/antihypertensive Chimpanzees/ACE inhibitor; balanced vasodilator Common marmosets
Enoxaparin sodium	20 mg SC q24h × 10 days, repeat in 2 mo ⁸⁸	Rhesus macaque (<i>n</i> = 1)/deep vein thrombosis; low-molecular weight heparin
Ephedrine	0.1-0.5 mg/animal SC, IM, IV, IC ³ 1.25-2.5 mg/kg IV ⁷² 2.5 mg/kg IV bolus ⁷²	Monkeys Macaques, baboons/vasopressor; safest during maternal hypotension Use when hypotension is accompanied by bradycardia
Epinephrine	0.1-0.5 mg/animal SC, IV, IM, IC ³ 0.2-0.4 mg/kg diluted in 5 mL sterile water, ⁴¹ IT if ≥3 kg or 1:10,000 dilution ³¹ 0.2-1 mg/animal SC, IM; 0.5-10 mg IV, IC ³	Monkeys Common marmosets/cardiac arrest Chimpanzees

TABLE 13-4 Miscellaneous Agents Used in Primates. (cont'd)

Agent	Dosage	Species/Comments
Fluoxetine	0.45 mg/kg PO q24h ⁸⁶ 0.5-1 mg/kg PO q24h ³ 2 mg/kg PO q24h ⁵⁵ × 1-4 wk ³⁰	Bonobo (<i>n</i> = 1) ⁸⁶ /antianxiety; serotonin reuptake inhibitor; antidepressant used to moderate abnormal behaviors ⁷⁶ Chimpanzees Rhesus macaques (<i>n</i> = 6)/reduction of self-biting behavior, but not self-directed stereotypes; venlafaxine ineffective
Folic acid	15 µg/kg PO q24h ³ 500 µg/kg PO ³	Monkeys Chimpanzees
Furosemide	1-2 mg/kg PO, IM, IV ³ 1-4 mg/kg PO, SC q12h ⁴¹ 1-4 mg/kg IV ³ 2-4 mg/kg IM q8h ³	Chimpanzees/diuresis; congestive heart failure; pulmonary edema Common marmosets/congestive heart failure Monkeys Monkeys
Glipizide	1.25 mg/kg PO q24h ⁸⁶	Titi monkey (<i>n</i> = 1)/sulfonylurea; gestational diabetes
Glycopyrrolate	0.004 mg/kg IM, IV ³ 0.004-0.008 mg/kg IM ³ 0.005-0.01 mg/kg IM ^{20,72} 0.01 mg/kg IM ^{16,20} 1 mg/animal PO q8h ³	Chimpanzees Monkeys Macaques, baboons, chimpanzees ⁷² Rhesus macaques, ¹⁶ orangutan ²⁰ Chimpanzees
GnRH immunocontraceptive vaccine (GonaCon, USDA Wildlife Services)	500 µg dose IM ²⁴	Vervet monkeys/1 of 3 monkeys (adjuvant 1) cycled at 33 wk; 3 of 3 monkeys (adjuvant 2) cycled 25 wk; both had localized swelling at injection site
Guaifenesin	10-20 mL PO q4-6h ³	Chimpanzees
Guanfacine	— 0.3 mg/kg PO, IM q12h × 5-10 days, followed by gradual reduction to 0.15 mg/kg q24h over 30 days ⁵⁷ 0.5 mg/kg PO, IM q12h × 5-10 days, followed by gradual reduction to 0.25 mg/kg q24h over 30 days ⁵⁷	Self-injurious behavior; decreased agitation without profound sedation Baboon (<i>n</i> = 1)/recurrence controlled by returning to 0.3 mg/kg q12h Macaques (<i>n</i> = 2)/recurrence controlled by returning to 0.5 mg/kg q12h
Haloperidol	0.03-0.05 mg/kg IM q12h ³ 0.5-5 mg PO q8-12h ³ 60 mg PO q24h ⁷⁶	Monkeys Chimpanzees Gorilla (<i>n</i> = 1)/antipsychotic; treat concurrently with sulpiride; extrapyramidal symptoms; neuroleptic malignant syndrome is a rare but potential side effect

Continued

TABLE 13-4 Miscellaneous Agents Used in Primates. (cont'd)

Agent	Dosage	Species/Comments
Heparin	5000-10,000 units IV q6h; 10,000-20,000 units SC q12h ³	Chimpanzees
Human chorionic gonadotropin (hCG)	5000-10,000 U IM ³	Chimpanzees
Hydrochlorothiazide	1 mg/kg PO q24h ³	Chimpanzees
Hydrocortisone sodium succinate	5 mg/kg IM, IV q12h ³	Chimpanzees
Insulin, NPH	0.1 U/animal SC q12h ⁴¹ 0.25-0.5 U/kg SC q24h ³ 0.5 U/kg q24h ⁸⁶ 2.5 U/kg divided into 2 doses IM ⁸⁶	Common marmosets/glucose monitoring Chimpanzees/starting dose; diabetes mellitus; diabetic ketoacidosis Advisable to start with this dose and reevaluate with blood glucose Cynomolgus macaques/use combination of short-acting and longer-acting insulin (70:30); dose is highly variable
Iron dextran	10 mg/kg IM q7d ³ 11-22 mg/kg IM ³	Monkeys Chimpanzees
Isoproterenol	0.05-2 µg/kg/min IV constant rate infusion ³ 0.1-1 µg/kg/min IV constant rate infusion or 0.02-0.06 mg IV bolus ³	Monkeys/nonselective β-adrenergic agonist Chimpanzees
Lactulose	0.25-1.1 mL/kg PO q8-12h ⁴¹	Common marmosets
Leuprolide acetate (Lupron)	Effective contraception for 1-6 mo 0.3 mg/kg IM every 4 wk ³ 3.75 mg suspension once/mo for 6 mo ³⁹	New World primates/GnRH antagonist implant; need secondary contraception of megestrol acetate (<i>not</i> depoprovera) for 7 days prior to and postimplant placement ⁸⁰ Allen's swamp monkey (<i>n</i> =1)/uterine fibroids and ovarian cysts
Levothyroxine	0.05 mg/animal PO q24h; incremental changes of 0.025 mg q24h at 30 day intervals up to 0.1 mg q24h ⁸⁶	Gorilla (<i>n</i> =1)/hypothyroidism; monitor TSH and T ₄ q6-8wk
Lidocaine	0.7-1.4 mg/kg IV as needed ³ 1-2 mg/kg IV bolus ^{41,72} 20-50 µg/kg/min IV constant rate infusion ⁷²	Monkeys, chimpanzees at 1-1.5 mg/kg IV and max of 3 mg/kg Common marmosets ⁴¹ Ventricular arrhythmia
Lisinopril	0.25-0.5 mg/kg PO q24h ³	Chimpanzees
Loperamide	0.04 mg/kg PO q8h ³ 4 mg/animal PO prn ³	Monkeys Chimpanzees
Mannitol (25%)	0.25-0.5 g/kg IV over 5-10 min ³ 0.5-1 g/kg IV constant rate infusion ³ 1.65-2.2 g/kg IV over 20 min ³	Monkeys/diuretic Chimpanzees Monkeys/cerebral edema

TABLE 13-4 Miscellaneous Agents Used in Primates. (cont'd)

Agent	Dosage	Species/Comments
Medroxyprogesterone acetate	5 mg/kg IM q6wk ⁵⁹ 5-10 mg/animal PO q24h × 5-10 days ³ 150 mg/animal IM once q3mo ³ or q30d ²³	Lemurs/seasonal contraceptive Monkeys/contraceptive Chimpanzees, monkeys/ contraceptive; ³ rhesus macaques/ endometriosis ²³
Megestrol acetate	800 mg/animal PO q24h ³	Chimpanzees
Melengestrol acetate implant (MGA, WildPharm)	— 0.06 g/kg ⁸⁰ 0.1 g/kg ⁸⁰ 0.25 g/kg ⁸⁰ 0.4 g/kg ⁸⁰ 0.5 g/kg ⁸⁰ 0.7 g/kg ⁸⁰ 1 g/kg ⁸⁰	Implant must be ethylene oxide sterilized then degassed for 2 wk before surgical placement; available only in United States Great apes, gibbons Old World primates, except colobinae (0.15 g/kg) Lemurs Howler monkeys Spider monkeys, saki monkeys, cebids New World primates other than howler, spider, saki, capuchin, and squirrel monkeys; not recommended in <i>Callimico</i> ^{41,80} Squirrel monkeys
Metformin	5-10 mg/kg PO q12h ⁴¹	Common marmosets/oral hypoglycemic
Metoclopramide	0.2-0.5 mg/kg IM q8-24h ³ 0.4 mg/kg PO, ²⁰ IM, slow IV q8-24h ³	Monkeys/antiemetic; stimulates motility of upper gastrointestinal tract Chimpanzees
Milk thistle (silymarin)	4-15 mg/kg PO q8-12h ⁴¹	Common marmosets
Mirtazapine	15 mg PO q24h ¹⁵	Mandrill (<i>n</i> = 1)/antianxiety
Misoprostol	5 µg/kg PO q6h; 1-3 µg/kg intravaginal ³	Chimpanzees
Nitroglycerin (2% ointment)	3 mm topically q12-24h ⁴¹ 7.5 mg topically q8h ³	Common marmosets/congestive heart failure Chimpanzees
Nitroprusside	0.3-10 µg/kg/min IV constant rate infusion ³	Chimpanzees
Norepinephrine	0.05-0.1 µg/kg/min IV constant rate infusion ⁷² 0.2-0.4 µg/kg/min IV constant rate infusion ³	Hypotension Chimpanzees
Omeprazole	0.4 mg/kg PO q12h × 10 days ⁸⁶	Macaques/quadruple treatment of <i>Helicobacter pylori</i> ; see amoxicillin (Table 13.1)
Ondansetron	1-2 mg/kg PO × 2 doses ⁸⁶	Macaques/antiemetic
Oxytocin	0.5-1 U/min IV constant rate infusion ³ 1-2 U IM every 20 min × 4 doses ⁴¹ 2 U/dose as needed ³ 5-30 U/animal SC, IV as needed ³	Chimpanzees Common marmosets Monkeys Chimpanzees

Continued

TABLE 13-4 Miscellaneous Agents Used in Primates. (cont'd)

Agent	Dosage	Species/Comments
Paroxetine	0.3 mg/kg PO q12-24h ⁸⁶	Bonobo (<i>n</i> = 1)/antianxiety
PGF ₂ alpha	1 mg/kg IM q24h ³	Monkeys
Phenobarbital	1-6 mg/kg PO, or 2 mg/kg IV ³	Monkeys/seizures
Phentolamine mesylate	5-10 mg SC, IV ³	Chimpanzees/antihypertensive
Phenylephrine	1-2 µg/kg IV bolus, followed by 0.5-1 µg/kg/min IV constant rate infusion ⁷²	Drug of choice to treat isoflurane-induced hypotension
Phenytoin	2.5 mg/kg PO q12h, increase as needed ³ 125 mg PO q8h, increase as needed ³	Monkeys Chimpanzees
Pimobendan	0.2 mg/kg PO q24h ⁴¹	Common marmosets/congestive heart failure
Polysulfated glycosaminoglycan (Adequan, Luitpold Pharmaceuticals)	2 mg/kg IM q3-5d × 2-3 mo ³ 2-3 mg/kg IM q4d × 2 mo ³	Monkeys Chimpanzees
Potassium chloride	0.5-1 mEq/kg/h IV ³ 20-100 mEq PO q24h ³	Chimpanzees, monkeys Chimpanzees, monkeys
Prednisolone sodium succinate	1 mg/kg PO q24h ⁴¹ 10 mg/kg IM, IV ^{3,27}	Common marmosets/myelofibrosis Chimpanzees, monkeys, ³ lemurs/shock ²⁷
Prednisone	0.5-2 mg/kg PO ³ 0.5-2.2 mg/kg PO ³	Monkeys Chimpanzees
Probencid	1 g/animal PO q12h × 7 days ³	Chimpanzees
Procainamide	50 mg/kg/day PO divided q6h ³	Chimpanzees
Prochlorperazine	0.12 mg/kg IM, IV ³ 5-10 mg PO, IM, IV q8-24h ³	Monkeys/antiemetic Chimpanzees
Propranolol	0.25-1 mg/kg PO q8-12h ³	Chimpanzees
Quinidine	100-200 mg/animal PO q8-12h ³	Chimpanzees
Ranitidine	0.5 mg/kg PO q12h ³ 150 mg/animal PO q8-12h ³	Monkeys Chimpanzees
Ribavirin	150 mg/kg IM q24h × 6 days ³³	Callitrichid hepatitis virus
S-Adenosylmethionine (SAM-e) (Denosyl, Nutramax)	18 mg/kg PO q24h ³	Chimpanzees
Spironolactone	20-300 mg/day divided q8-24h ³	Chimpanzees
Stanozolol	2 mg/animal PO q6-8h ³ 5-10 mg/kg IM q4-7d ³	Chimpanzees Monkeys
Sucralfate	0.5 g/animal PO; maintenance q12h, active ulcer q6h × 4-6 wk ³ 1 g/animal PO q12h ³	Monkeys/prevent or treat gastric ulcers Chimpanzees
Sulpiride	400-800 mg/animal PO q24h ⁷⁶	Gorilla (<i>n</i> = 1)/antipsychotic; treat concurrently with haloperidol; extrapyramidal symptoms; neuroleptic malignant syndrome is rare but potential side effect

TABLE 13-4 Miscellaneous Agents Used in Primates. (cont'd)

Agent	Dosage	Species/Comments
Telmisartan	1 mg/kg PO ⁴¹	Common marmosets/protein losing nephropathy
Terbutaline	0.05 mg/kg IM, IV ¹⁸ 5 mg/animal PO q24h ³	Great apes/bronchodilator Chimpanzees
Theophylline	5 mg/kg, then 2-4 mg/kg PO q6-8h ³	Chimpanzees
Tolbutamine	250 mg/animal PO q24h, then 100 mg/animal PO q48h ⁸⁶	Capuchin monkey (<i>n</i> =1)/ non-insulin-dependent diabetes mellitus
Triamcinolone	0.2-2 mg/kg IM prn ³ or q3d ⁸⁶	Monkeys
Vitamin B ₁₂	3-5 mL PO, IM, IV ³	Chimpanzees
Vitamin C (ascorbic acid)	— 1-4 mg/kg PO q24h ⁴¹ 3-6 mg/kg PO q24h to prevent scurvy ⁶⁹ 4-25 mg/kg PO q24h ³ 25 mg/kg PO, IM ⁸⁶ q12h × 5 days ⁴¹ 30 mg/kg IM q24h ³	Vitamin C is an essential nutrient for nonhuman primates ^{59,64,71} Common marmosets/maintenance; up to 25 mg/kg/day ⁵⁹ Chimpanzees Macaques, ⁸⁶ common marmosets ⁴¹ /deficiency situation Monkeys
Vitamin D ₃	— 20 U/kg PO q24h ³ 110 U/100 g ⁵⁹ 2000 U/kg ⁴¹ 5000 U ergocalciferol depot (sesame oil) IM once at age 4 mo and ergocalciferol 400 U PO q24h from age 4 mo until weaning ⁴³	Vitamin D is an essential nutrient for nonhuman primates; ¹⁰ elevated concentration that is not D ₂ is required for New World primates ⁶⁴ Chimpanzees New World primates/UVB light Common marmosets Infant chimpanzees/prevention of rickets
Vitamin E	3.75 U/kg PO q24h ³	Chimpanzees
Vitamin K ₁	1 mg/kg PO, IM q8h ³ 1-5 mg/animal IM q24h ³	Chimpanzees Monkeys
Winstrol	2-4 mg PO q24h ³	Chimpanzees
Zinc	2.5 µg/animal PO q24h × 3 days ³ 75 mg PO q12h as needed ³	Monkeys Chimpanzees
Zuclopenthixol	10-25 mg PO q8h ⁷⁶	Gorilla (<i>n</i> =1)/aggression; tapered with a decrease of 5 mg/wk; antipsychotic; extrapyramidal symptoms; neuroleptic malignant syndrome is a rare but potentially side effect

TABLE 13-5 Hematologic and Serum Biochemical Values of Primates. ^{19,37,41,59,62,90,93}

Measurement	Baboon (<i>Papio</i> spp.)	Capuchin Monkey (<i>Cebus</i> sp.)	Chimpanzee (<i>Pan</i> <i>troglydotes</i>)	Common Marmoset (<i>Callithrix</i> <i>jacchus</i>) ^b	Ring- Tailed Lemur (<i>Lemur</i> <i>catta</i>)
Hematology					
PCV (%)	45	45-53	38-51	45-48	44-57
RBC (10 ⁶ /μL)	4.5-4.8	6	4.7-6.4	2.5-10.4	6.7-8.6
Hgb (g/dL)	13	14-17	7.6-10.7	15.1-15.5	13.8-17.2
WBC (10 ³ /μL)	14.1	5-24	7.3-15.7	3-15	4.8-12.5
Neutrophils (%)	60.5	55	3.0-10.7 ^a	28-55	1.2-7.5 ^a
Lymphocytes (%)	36	41	2.0-7.3 ^a	43-67	1.7-5.7 ^a
Monocytes (%)	1.5	1.8	64.8-572.2 ^a	0.4-2.1	0-0.8 ^a
Eosinophils (%)	1.5	1.6	68.8-629.6 ^a	0.5-0.6	0-0.7 ^a
Basophils (%)	0.4	<1	0-23.6 ^a	0.3-1.3	0-0.1 ^a
Platelets (10 ³ /μL)	406	108-187	130-379	390-490	161-379
Chemistries					
ALT (U/L)	12-20	13-43	20.5-62.1	9.5-10.2	36-154
AST (U/L)	22-28	21-57	12.1-56.6	160-182	12-80
Bilirubin (mg/dL)	0.3-0.4	0-4	0.2-0.6	0.5-0.6	0.2-1
BUN (mg/dL)	8-14	24-44	8.3-17.8	13.0-38.5	13-29
Calcium (mg/dL)	8-10	10	7.8-10.5	9.5-10.2	8.8-10.4
Cholesterol (mg/dL)	60-134	170-254	166.8-295.8	89-292	1.6-3.0
Glucose (mg/dL)	80-95	44-94	66-118	95-257	66-222
Phosphorus (mg/dL)	5.5-8.5	7	1.5-4.9	1.6-10.4	3.3-6.7
Protein, total (g/dL)	6-7	7.5-8.7	6.7-8.4	4.1-8.9	6.5-8.1
Measurement	Rhesus Macaque (<i>Macaca mulatta</i>)	Spider Monkey (<i>Ateles</i> spp.)	Squirrel Monkey (<i>Saimiri</i> <i>sciureus</i>)	Tamarin (<i>Saguinus</i> spp.)	
Hematology					
PCV (%)	39-43	35-40	43-56	45	
RBC (10 ⁶ /μL)	4.5-6	5.5	7.1-10.9	6.6	
Hgb (g/dL)	12.7	16	12.9-17	15.5	
WBC (10 ³ /μL)	11.5-12.4	10-12	5.1-10.9	12.6-14.4	
Neutrophils (%)	20-56	52	36-66	43-64	
Lymphocytes (%)	40-76	40	27-55	34-49	
Monocytes (%)	0-2	3	0-6	2-5	
Eosinophils (%)	1-3	5	0-11	1-1.2	
Basophils (%)	0-1	0-1	<1	0.1	
Platelets (10 ³ /μL)	130-144	239-343	112	331-650	

TABLE 13-5 Hematologic and Serum Biochemical Values of Primates. (cont'd)

Measurement	Rhesus Macaque (<i>Macaca mulatta</i>)	Spider Monkey (<i>Ateles</i> spp.)	Squirrel Monkey (<i>Saimiri sciureus</i>)	Tamarin (<i>Saguinus spp.</i>)
Chemistries				
ALT (U/L)	145-171	8-78	59-99	7-14
AST (U/L)	20-34	42-210	56-118	49-59
Bilirubin (mg/dL)	0.10-0.66	0.1-1.0	0.1-0.53	0.14-0.26
BUN (mg/dL)	14.2-19.6	25.9	23-39	6-12
Calcium (mg/dL)	8.1-11.3	12.8	8.3-9.7	10
Cholesterol (mg/dL)	94-162	76-278	127-207	69
Glucose (mg/dL)	53-87	82.3	52-108	125-189
LDH (U/L)	201-665	—	271-490	0-1578
Phosphorus (mg/dL)	4-6	2.1-8.5	3.3-7.7	3-6
Protein, total (g/dL)	6.1-7.1	10.2	6.9-8.1	6.2-8.6

^aThese values are reported as absolute differential as $10^3/\mu\text{L}$ for more accuracy when they were available.

^bChemistry values for this species were not obtained from standard deviation but direct high and low values for $n=21$ animals as reported in the cited study.⁹³

TABLE 13-6 Biologic and Physiologic Data of Primates. ^{4,19,20,31,59,62,79,90}

Species	Temperature °C (°F)	Respiratory (breaths/min)	Heart Rate (beats/min)	Avg Adult Wt (kg) M/F	Estrus Length (days)	Gestation (days)	Weaning Age (days)	Median Life Expectancy (yrs)
Baboon (<i>Papio</i> sp.)	37-39 (98.6-103.1)	22-35	85-90	14-41; males 50% larger	32-36	154-193	180-450	30-45
Capuchin monkey (<i>Cebus</i> sp.)	37-38.5 (98.6-101.3)	30-50	165-225	3.5-3.9/2.5-3	18-23	180	270	50
Chimpanzee (<i>Pan troglodytes</i>)	34.6-38.7 (94.3-101.7)	20-60	60-200	45-90/40-80	28-53	215-239	1440	31.7-37.4
Common marmoset (<i>Callithrix jacchus</i>)	38.4-39.1 (101.1-102.4)	36-44	204-399	0.34-0.35	16-30	141-145	40-120	8-12
Ring-tailed lemur (<i>Lemur catta</i>)	37.9-38.1 (100.2-100.6)	30-60	168-210	2-3	39	130-136	90-120	16.5
Rhesus macaque (<i>Macaca mulatta</i>)	37-39 (98.6-103.1)	35-50	98-122	6-11/4-9	24-40	144-210	210-420	18-23.8
Spider monkey (<i>Ateles</i> sp.)	—	—	—	6-10/6-8	26	225-232	365	24.4
Squirrel monkey (<i>Saimiri sciureus</i>)	37-38.5 (98.6-101.3)	20-50	200-350	0.75-1.1	7-16	140-180	180	14.6
Tamarin (<i>Saguinus</i> sp.)	—	—	—	0.225-0.9	15	140	60-90	11.5

TABLE 13-7 Identifying Characteristics of Small Nonhuman Primates by their Taxonomic Classification.^{19,31,79,90}

Characteristic	Prosimians	New World Monkeys (Platyrrhini)	Old World Monkeys (Catarrhini)
Tapetum	Yes	—	—
Moist rhinarium	Yes	—	—
Specialized scent glands	Yes	—	—
Uterus	Bicornuate	Simplex	Simplex
Placenta	Epitheliochorial	Hemochorial	Hemochorial
Closed orbits	—	Yes	Yes
Incisor comb	Yes	—	—
Dental formula	2.1.3.3./2.1.3.3. (36)	2.1.3.3./2.1.3.3. (36)	2.1.2.3./2.1.2.3. (32)
Grooming claw	Yes	—	—
Prehensile tail	—	Yes	—
Nostrils	At end of rhinarium	Round, directed laterally	Narrowed, directed ventrally
Claws or nails	Claws	Claws	Nails
Ischial callosities	—	—	Yes

TABLE 13-8 ECG Intervals and Durations.^{5,41,82}

Species	P Wave duration (sec)	PR Interval (sec)	QT Interval (sec)	QRS Duration (sec)
Baboon (<i>Papio</i> sp.)	0.02-0.06	0.05-0.09	0.13-0.19	0.01-0.05
Capuchin monkey (<i>Cebus</i> sp.)	0.02-0.04	0.07-0.09	0.14-0.16	0.01-0.03
Chimpanzee (<i>Pan troglodytes</i>)	<0.12	0.104-0.242	0.327-0.445	0.059-0.103
Common marmoset (<i>Callithrix jacchus</i>)	0.021-0.029	0.052-0.062	0.088-0.156	—
Rhesus macaque (<i>Macaca mulatta</i>)	0.03-0.05	0.08-0.1	0.18-0.22	0.02-0.04
Squirrel monkey (<i>Saimiri sciureus</i>)	0.02-0.04	0.05-0.07	0.14-0.16	0.01-0.03

TABLE 13-9 Preventive Medicine Recommendations for Primates. ^{19,35,36,41,59,62}

Procedure	Schedule	Comments
Routine examination	Annually for small or medium nonhuman primates; q2-3yr great apes	Routine: physical examination, hemogram, serum biochemical analysis, serum banking, rectal culture, mycobacterial screening, radiographs, ultrasound By institution history: viral serology, vaccination
Tuberculin skin testing (Intradermal Mammalian Old Tuberculin, Synbiotics)	0.1 mL ID via 27 g needle; test at routine examination intervals	Typically, the test is placed intrapalpebrally so test site can be examined without restraint; an alternative site, or used for subsequent screening, is the areolar area; following test placement, test is evaluated visually at 24, 48, and 72 hr; a positive reaction is erythema, edema, induration, or combination of these signs persisting for >48 hr; false positives (especially in orangutans) and false negatives (anergic animals) can occur; comparative testing with evaluation of hemogram, comparative antigens (e.g., avian purified protein derivative), thoracic radiographs, mycobacterial culture of tracheal or gastric lavage assists interpretation; imported primates to the United States have testing dictated by Centers for Disease Control and Prevention with three negative intradermal tests required over a 30-day interval; for all caretakers, tuberculin screening for in-contact staff is recommended annually; comparative testing could include serologic testing for gamma interferon, but often this methodology is not available reliably as a commercial test for nonhuman primates; although it is available for humans, these products were not validated for nonhuman primates.
	0.05 mL ID via 27 g needle; test annually ³⁷	Commonly used dose reduction for callitrichids and similar sized New World primates; see previous comments
Fecal parasite examination	q3-12mo based on collection history or when abnormal fecal quality is present	Direct wet mount of fresh feces for protozoa; flotation and/or sedimentation procedures for parasite ova; trichrome stains can be used to identify protozoal cysts; direct staining of fecal smears for cell populations
Fecal culture	At collection entry; at routine examination schedule; based on collection history or when abnormal fecal quality is present	Culture for <i>Salmonella</i> , <i>Shigella</i> , <i>Campylobacter</i> , <i>Yersinia</i> ; may take multiple samples to identify asymptomatic carriers of <i>Salmonella</i> or <i>Shigella</i>

TABLE 13-10 Immunization Recommendations for Primates.^a

Species	Immunization	Dose/Schedule	Comments
Prosimians	Rabies		There are no specific recommendations for prosimians ⁹¹
	Tetanus	Tetanus toxoid	Killed vaccine only; consider with elevated exposure risk situations ⁹¹
New World primates	Measles		Used in some institutions; ⁹¹ of note, current preparations are combined with <i>Diphtheria</i> prophylaxis
	Rabies	Volume of vaccine adjusted by body size: ¹⁹ callitrichids, 0.05-0.1 mL; medium-sized primates, 0.25 mL; ⁶⁹ larger primates, 0.5 mL	Measles in New World primates is a severe disease that may be associated with epizootics of high morbidity and mortality; in callitrichids, the virus targets the gastrointestinal tract; ⁵⁹ in the United States, only an attenuated measles/mumps/rubella vaccine is available; however, it is rarely recommended due to declined human incidence of this disease and extensive vaccination of humans ^{19,59}
	Tetanus	1 mL dose of killed vaccine IM (quadriceps muscle) days 2,7,12,19,33 postexposure and single dose of human rabies immunoglobulin IM 5 days postexposure ³⁶	Used by some institutions in rabies-endemic areas; use only killed virus preparation ⁶⁹
Old World primates	Tetanus	Volume of tetanus toxoid adjusted by body size: ¹⁹ callitrichids, 0.05-0.1 mL; medium-sized primates, 0.25 mL; larger primates, 0.5 mL	Capuchin monkeys/postexposure prophylaxis in monkeys that had direct contact with rabid bats; animals developed and maintained levels of rabies virus neutralizing antibody >0.05 U/mL by 67 days postexposure ³⁶
	Measles		New World monkeys are susceptible to <i>Clostridium tetani</i> ; ¹⁹ of note, current preparations are combined with <i>Diphtheria</i> prophylaxis
	Rabies	Volume of vaccine adjusted by body size: ¹⁹ medium-sized primates, 0.25 mL; larger primates, 0.5 mL	In the United States, only an attenuated measles/mumps/rubella vaccine is available; however, it is rarely recommended due to declined human incidence of this disease and extensive vaccination of humans ¹⁹
	Tetanus	Volume of tetanus toxoid adjusted by body size: ¹⁹ medium-sized primates, 0.25 mL; larger primates, 0.5 mL	Used by some institutions in rabies-endemic areas; use only killed virus preparation
			Old World monkeys are susceptible to tetanus; ^{19,83} of note, current preparations are combined with <i>Diphtheria</i> prophylaxis

Continued

TABLE 13-10 Immunization Recommendations for Primates. (cont'd)

Species	Immunization	Dose/Schedule	Comments
Great apes	Measles	MMR II (live-attenuated product; Merck) – 12-15 mo; 4-6 yr of age ⁶²	Optional; ⁶² risk of shedding live virus and susceptibility of pregnant females and fetus is unquantified but rubella component has fetal concerns labeled in pregnant humans; from Attenuvax (Merck) product vaccine, seroconversion occurred in Western lowland gorillas and persisted for at least 11 yr following 1, 2, or 3 vaccinations on 12 mo, 15 mo, and 10 yr of age or 2 doses separated by 2-4 wk for unvaccinated, seronegative adults ¹⁴
	Polio	Inactivated poliovirus – 2, 4, 6-18 mo; 4-6 yr ⁶²	Although human adult vaccination in the United States is no longer considered necessary, catch-up protocols exist for pediatric patients
	Rabies		Used by some institutions in rabies-endemic areas; use only killed virus preparation ⁶²
	Tetanus	<i>Diphtheria</i> , tetanus, pertussis (DTaP) – 2, 4, 6, 15-18 mo; 11-12 yr; q10yr ⁶²	Based on human schedule; of note, current products are combined with <i>Diphtheria</i> prophylaxis

^aVaccination protocols are highly individualized to institutional risk with considerations of potential exposure, age of animals, outdoor housing, access to humans, and community health profiles of the in-access human population.⁶² Additionally, killed vaccine products are strongly encouraged whenever possible with caution of live or attenuated products for monitoring for vaccine-induced disease. It also should be noted that immunoprophylaxis products vary with availability to the medical community and human health issues and, therefore, absolute recommendations are not possible. Sources to consider for planning a program-specific approach include: www.cdc.gov, American Academy of Pediatrics publications,¹ *Conn's Current Therapy* (published annually),¹⁷ AAZV's *Infectious Diseases of Concern to Captive and Free-Ranging Animals in North America*,³³ and species care guidelines available on www.aza.org.

TABLE 13-11 Nonhuman Primate Laboratories.

Antech Diagnostics
17672-B Cowan Avenue, Irvine, CA 92614, USA
ANTECH West: 1-800-745-4725; ANTECH East: 1-800-872-1001; ANTECH Test Express: 1-888-397-8378
<http://www.antechdiagnostics.com/Main/TestGuide.aspx>

Arbovirus Diagnostic Laboratory
3156 Rampart Road, Fort Collins, CO 80521, USA
970-221-6400
<http://www.cdc.gov/ncezid/dvbd/specimensub/arboviral-shipping.html>

B Virus Research and Resource Laboratory
Dr. Julia Hilliard
Georgia State University, Viral Immunology Center, 161 Jesse Hill Jr Dr., Atlanta, GA 30303, USA
For emergency: 404-358-8168
<http://www2.gsu.edu/~wwwvir/>

BioReliance, Serology/PCR Laboratories
14920 Broschart Rd., Rockville, MD 20850, USA
301-610-2227
<http://www.bioreliance.com/us/services>

Centers for Disease Control and Prevention
1600 Clifton Rd. Atlanta, GA 30329, USA
800-232-4636
<http://www.cdc.gov/>

Clinical Parasitology Diagnostic Service Laboratory
University of Tennessee College of Veterinary Medicine, 2407 River Drive, Knoxville, TN 37996, USA
865-974-5645
<https://vetmed.tennessee.edu/vmc/dls/Pages/default.aspx>

Colorado State University Veterinary Diagnostic Laboratory
300 West Drake Road, Ft. Collins, CO 80526
970-297-1281
<http://csu-cvmb.colostate.edu/vdl/Pages/default.aspx>

Comparative Pathology Laboratory
University of Miami, Clinical Research Building, 1120 NW 14th Street, 14th Floor, Suite 1409, Miami, FL 33136, USA
305-243-7284
<http://www.pathology.med.miami.edu/clinical-pathology>

Diagnostic Center for Population and Animal Health (DCPAH)
Clinical Pathology Laboratory, A215 Veterinary Medical Center, Michigan State University, East Lansing, MI 48824, USA
517-355-1774
<https://www.dcpah.msu.edu/Sections/>

IDEXX Laboratories, Inc.
One IDEXX Drive, Westbrook, ME 04092, USA
1-207-556-0300
1-800-548-6733
<https://www.idexx.com/small-animal-health/products-and-services/products-and-services.html>

Infectious Diseases Laboratory
University of Georgia College of Veterinary Medicine
110 Riverbend Rd., Riverbend North, Room 150, University of Georgia, Athens, GA 30602, USA
Lab: 706-542-5812
<http://www.vet.uga.edu/idl/>

Infectious Disease Pathology Activity
CDC (MS-G32), 1600 Clifton Rd, NE, Atlanta, GA 30333, USA
1-800-232-4636

Continued

TABLE 13-11 Nonhuman Primate Laboratories. (cont'd)

<p>Kansas State University Diagnostic Laboratory Kansas State University, 1800 Denison Avenue, Manhattan, KS 66506, USA 785-532-5650 http://www.ksvdl.org/</p>
<p>Louisiana Animal Disease Diagnostic Laboratory School of Veterinary Medicine, 1909 Skip Bertman Drive, Room 1519, Baton Rouge, LA 70803, USA 225-578-9777 http://www.lsu.edu/vetmed/laddl/index.php</p>
<p>MiraVista Diagnostics 4705 Decatur Blvd., Indianapolis, IN 46241, USA 317-856-2681 http://miravistalabs.com/veterinary-fungal-infections/</p>
<p>New York State Veterinary Diagnostic Laboratory Cornell University, 240 Farrier Rd, Ithaca, NY 14852, USA 607-253-3900 https://ahdc.vet.cornell.edu/test/list.aspx?Species=16&Test_Name=&TstTyp=&WebDisc=</p>
<p>North Carolina State University College of Veterinary Medicine Vector Borne Disease Diagnostic Laboratory 1060 William Moore Drive, Room 462A Raleigh, NC 27607, USA 919-513-8279 https://cvm.ncsu.edu/research/labs/diagnostic-testing-labs/</p>
<p>Northwest ZooPath 654 W Main St., Monroe, WA 98272, USA 360-794-0630 http://www.zoopath.com/</p>
<p>Pathogen Detection Laboratory California National Primate Research Center, University of California, Road 98 & Hutchison Davis, CA 95616, USA 530-752-8242 http://www.cnprc.ucdavis.edu/our-services/core-services/pathogen-detection-laboratory-core-2/services/</p>
<p>Primate Diagnostic Services Laboratory (PDSL) Washington National Primate Research Center University of Washington, 3000 Western Ave, B-411, Seattle, WA 98195, USA 206-543-0440 https://www.wanprc.org/</p>
<p>Texas A&M Veterinary Medical Diagnostic Laboratory PO Box Drawer 3040, College Station, TX 77841, USA 979-845-3414 888-646-5623 https://tvmdl.tamu.edu/</p>
<p>The Fungus Testing Laboratory Department of Pathology, Room 329E, Mail Code 7750, The University of Texas Health Science Center at San Antonio, San Antonio, TX 78229, USA 210-567-4131 http://pathology.uthscsa.edu/strl/fungus/index.shtml</p>
<p>UC Davis Coccidioidomycosis Serology Laboratory, 3416 One Shields Avenue, Davis, CA 95616, USA 530-752-9402 http://www.ucdmc.ucdavis.edu/medmicro/cocci-lab.html</p>
<p>USDA-APHIS-VS-NVSL 1920 Dayton Ave. (packages), Ames, IA 50010, USA 515-337-7266 https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/lab-info-services/ct_laboratory_information_services</p>

TABLE 13-11 Nonhuman Primate Laboratories. (cont'd)

Veterinary Molecular Diagnostics, Inc. 5989 Meijer Dr., Suite 5, Milford, OH 45150, USA 513-576-1808 http://www.vmdlabs.com/
Virus Reference Laboratories, Inc. (VRL) P.O. Box 40100, 7540 Louis Pasteur Road, San Antonio, TX 78229, USA 877-615-7275 http://www.vrlsat.com/nhp
Zoological Pathology Program 3300 Golf Road, Brookfield, IL 60513, USA 312-585-9050 http://vetmed.illinois.edu/vet-resources/veterinary-diagnostic-laboratory/zoological-pathology-program/
Zoologix Inc. 9811 Owensmouth Avenue, Suite 4, Chatsworth, CA 91311, USA 818-717-8880 http://zoologix.com/primate/index.htm

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Chapter 14 **Wildlife**

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TABLE 14-1 Checklist for the Care of Sick, Injured, or Orphaned Wildlife.^{a-c}

The information contained within this section is designed to help a veterinarian triage and provide basic stabilizing care to injured or orphaned wildlife. The veterinarian is strongly encouraged to transfer these animals to or consult with experienced wildlife veterinarians or wildlife rehabilitators as soon as possible. In addition, any individual working with wildlife should check with state and federal officials on permit requirements. In the event of bites inflicted by rabies vector species or wild mammals showing neurologic signs to persons or domestic pets, the local health department should be contacted regarding appropriate rabies prevention procedures.

A. Regulations and reporting

- a. Permits: check with state and federal officials on laws and permit requirements for hospitalizing wildlife; if you do not have permits, stabilize the animal and transport it to a permitted facility as soon as possible.
- b. Species reporting: check with state wildlife officials for a list of reportable endangered, threatened, or listed species; these may vary from state to state.
- c. Illegal activity: report injuries caused by illegal activities such as gunshot wounds to nongame species to local, state, or federal wildlife authorities.
- d. Reportable diseases: reportable or foreign animal diseases diagnosed in wildlife should be reported to the USDA-APHIS Area veterinarian-in-charge (<https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/contact-us>).
- e. Banded birds: band numbers on federally banded birds should be reported to the US Geological Survey Bird Banding Laboratory (<http://www.pwrc.usgs.gov/bbl/>).
- f. Advise the public not to approach rabies vector species and to contact local authorities instead. In addition, bats should never be handled bare handed. If a rescuer has handled a rabies vector species, report any potential rabies exposure (bite or contact with saliva through broken skin or mucous membranes) to the local health department.

B. Patient background

- a. Is the “orphan” truly an orphan? If not, return to nest or site found because natural parents provide the best care. Human scent will not cause rejection of the young by the mother.
 - i. Fledgling birds normally spend time on the ground before gaining full flight ability. The parents will continue to feed and guard the fledgling.
 - ii. Adult rabbits and deer normally leave their young unattended for much of the day. Parents will return to the site where offspring were left to reunite, often hours later. Check for a “milk line” in young rabbits to determine if they were recently fed.
- b. Get precise information. When was animal found? Exact location? Circumstances? Has any medical or supportive care been provided?
- c. The rescue location of many turtle species is particularly important as they have high site fidelity.
- d. Obtain rescuer’s name, address, and phone number in case further details are required.

C. Initial patient triage

- a. What is medically wrong with the animal? Can it be treated, survive the rehabilitation period (sometimes months), and be released or placed into an education program? Check with experienced wildlife veterinarians if unsure. Unfortunately, euthanasia is often required.
- b. Address life-threatening problems first. ABC: Check that the *airway* is clear, the animal is *breathing*, and *cardiac beat and pulse* are present. Provide cardiopulmonary resuscitation if needed.
- c. Control hemorrhage. Total blood loss of more than 1% of body weight is considered an emergency. Remove broken blood feathers by pulling the feather shaft out of the follicle with straight, steady pressure. Apply direct pressure to hemorrhage sites. Use topical epinephrine, cautery, and ligation if needed.
- d. Assess for shock. Evaluate neonates for hypoglycemia and hypothermia. Clinical signs include cold extremities, pale and tacky mucous membranes, and rapid heart rate. Treat with fluids and supplemental heat if needed, and treat hypoglycemia with intravenous or oral dextrose. Treat hyperthermia with fluids, placing the patient in a cool place and spraying limbs with cool water.
- e. Perform full examination once the patient is stable. Examination may need to be delayed, limited to a cursory exam, or done in stages to minimize patient stress.
 - i. If possible, determine the species, gender, life stage, body condition, and weight.
 - ii. Is zoonotic disease or infectious disease a concern? Isolate the patient if necessary.

Continued

TABLE 14-1 Checklist for the Care of Sick, Injured, or Orphaned Wildlife. (cont'd)

D. Develop treatment and supportive care plan

- a. Assume most wildlife patients are 10% dehydrated on admission. Provide hydrating solutions and electrolyte support for the first 24 to 48 hours parenterally (Normasol, 2.5% dextrose, LRS, 0.9% saline) or orally with a multispecies electrolyte solution (e.g., Pedialyte [Abbott], Gatorade [Gatorade], or Bounce Back [Manna Pro]). Continue to treat if ongoing fluid losses occur. Most birds, reptiles, and mammals can be triaged with fluids based on an assumed maintenance rate of 40-60 mL/kg/day, 10-25 mL/kg/day, and 60 mL/kg/day, respectively.
- b. Provide supplemental heat to neonates at 80-90°F (27-32°C). Keep heating pads on low to prevent thermal burns. Use wrapped hot water bottles and warmed air.
- c. Treat and prevent infection. Most open wounds will require antimicrobial therapy.
- d. Provide analgesia and antiinflammatory medications if needed. Nonsteroidal antiinflammatory drugs are useful for soft-tissue injury, head trauma, and spinal trauma. Although steroids are used by some clinicians to treat acute spinal trauma and shock, their use in shock, especially in birds, may be controversial and is generally not recommended. Opioids are useful for severe soft-tissue injury and fractures.
- e. Develop a nutritional plan. Attempt to calculate the calories needed for each day's feeding. Except for neonates, do not provide food for the first 24 hours while the animal is being rehydrated. Emaciated animals may need special diets (Emeraid Nutritional Care System [Lafeber]; Carnivore and Critical Care [Oxbow]) to avoid refeeding syndrome.
- f. Neonatal mammals must be stimulated to urinate and defecate by gently brushing anal and genital areas with moist cotton or clean tissue after each feeding.
- g. Determine appropriate housing. The main goals are safety and to reduce stress on the animal by preventing noise and visual stimulation. In general, minimize contact to people and domestic animals. Wildlife should not be kept in close proximity to domestic animals while being housed for veterinary care.

E. Rehabilitation

- a. Contact the International Wildlife Rehabilitation Council (866-871-1869; <https://theiwrc.org/>), the National Wildlife Rehabilitators Association (320-230-9920; www.nwrwildlife.org/), or State Rehabilitation Associations to find a rehabilitator near you.
- b. Transfer the animal to a qualified rehabilitator for continued therapy and to prepare the animal for release.
- c. Rehabilitators are often familiar with animal nutrition and natural history and can provide initial supportive care recommendations as well.

F. Release criteria

- a. Animals must meet the following criteria in order to be released to the wild:
 - i. Initial illness or injury is resolved with no risk of recurrence. Animals must have normal laboratory values if tested.
 - ii. All secondary problems have been resolved.
 - iii. The animal does not pose an unnatural risk to the wild population, humans, or the environment. It is not likely to spread pathogens or contribute to disease processes in other ways. The animal does not pose a zoonotic risk.
 - iv. The animal can effectively avoid predators.
 - v. The animal is able to find food by foraging or hunting in the wild. This requires adequate vision and locomotive skills.
 - vi. The animal can function reasonably within the population and can reproduce.
 - vii. The animal displays proper species behavior (not improperly imprinted) and the fight or flight behavioral response.
 - viii. The animal must be the correct age and weight for independent survival.
 - ix. The animal must possess pelage or plumage that is adequate for that species to survive. The animal must exhibit waterproof pelage/plumage sufficient for that species.

TABLE 14-1 Checklist for the Care of Sick, Injured, or Orphaned Wildlife. (cont'd)

- b. Animals should be released at the original site of capture unless conservation efforts or safety considerations dictate otherwise. Animals should be released in their natural environment and habitat suitable for species survival but in areas away from traffic, people, and pets. The habitat must be within carrying capacity for the species. Release diurnal species in the morning and nocturnal species at dusk. Check local and state laws regarding release of rabies vector species and deer.
- c. Animals that cannot be returned to the wild for any reason should be euthanized unless they can be legally placed in educational, breeding, or research programs.

^aSee references in appendices.

^bFor information on nutritional management of captive wildlife, see Carpenter JW, ed. *Exotic Animal Formulary*. 3rd ed. St. Louis: Saunders/Elsevier; 2005.

^cWeb resources:

- National Wildlife Rehabilitation Association—<http://www.nrawildlife.org>
- International Wildlife Rehabilitation Council—<http://theiwrc.org/>
- Wildlife Center of Virginia—www.wildlifecenter.org
- USGS National Wildlife Health Center—<http://www.nwhc.usgs.gov/>
- U.S. Fish and Wildlife Service—<http://www.fws.gov/>
- Southeastern Cooperative Wildlife Disease Study—<http://vet.uga.edu/scwds>
- Birds of North America Online—<https://birdsna.org/Species-Account/bna/home>
- World Organization for Animal Health—<http://www.oie.int/>
- National Association of State Public Health Veterinarians—<http://www.nasphv.org/>

TABLE 14-2 Considerations for Developing a Wildlife Policy in Private Practice. ^{2,4,15,34,56,76,78,79,83,84}

Topic	Notes
General Considerations	
Treating injured and orphaned wildlife	Whether your practice admits wildlife or not, all veterinary clinics should have a wildlife policy to ensure injured and orphaned wildlife receive timely care, regulatory and public health guidelines are followed, and a consistent message is presented to the public regarding the practice's willingness to see wildlife. Wildlife policies do not need to be complicated and are often built on lessons learned from prior wildlife patients and experiences. Although practitioners should not feel obligated to treat wildlife, referral information should be on-hand to expedite appropriate treatment and/or supportive care. The referral list should contain contact information for veterinarians that treat wildlife, permitted wildlife rehabilitators, referral wildlife hospitals, game wardens, wildlife biologists, animal control officers, and state and federal wildlife agencies. It may be advantageous to build a network of volunteer transporters able to quickly move the wild animal to an appropriate location for initial or additional treatment. Depending on the comfort level and expertise of the veterinarians and staff, the clinic may decide to see only certain types of wildlife, may treat to stabilize and transfer, or admit only severely injured animals for humane euthanasia.
Legalities	Practitioners need to be aware of local, state, and federal laws pertaining to wildlife. Endangered, threatened, and listed species need to be reported immediately to the appropriate authorities. Practitioners should also check with local wildlife agencies and veterinary licensing boards for guidance on how long wildlife may be in a practitioner's possession without rehabilitation permits. The state veterinarian and local APHIS Veterinary Services need to be contacted if you suspect or confirm a notifiable animal disease. The state public health agency needs to be contacted if you suspect or confirm a notifiable disease of public health concern.

Continued

TABLE 14-2 Considerations for Developing a Wildlife Policy in Private Practice. (cont'd)

Topic	Notes
Preparedness and safety	<p>Does the practice have the necessary restraint devices, enclosures, food, and experienced veterinarians and staff to provide treatment and supportive care to wildlife? Is there a space to house wildlife away from domestic animals? Are biosecurity measurements in place to prevent the spread of potential infectious diseases or parasites?</p> <p>Appropriate personal protective equipment should be onsite and appropriate for the species. Additional considerations include reservoir or vector status of the animal, rabies immunization and titers of staff, and general safety for staff, clients, domestic patients, and the public.</p>
Euthanasia	<p>Injured wildlife may require humane euthanasia to alleviate pain and suffering due to injuries that are either severe or nonconductive to release or placement in an education program. Euthanasia of wild animals should be conducted according to the AVMA Guidelines on Euthanasia or the AAZV Guidelines for the Euthanasia of Nondomestic Animals. Wildlife authorities should be contacted if a wild animal is fitted with a band, transmitter, tag, or other identification device. Consideration of carcass disposal is necessary, the usual means being incineration, burial/landfill, composting, or newer evolving technologies. Animals euthanized with pentobarbital should never be disposed in a manner that makes the carcass accessible to scavenging and subsequent secondary pentobarbital toxicosis. All carcasses, parts, and feathers from bald eagles and golden eagles must be sent to the National Eagle Repository. According to the Migratory Bird Treaty Act, it is illegal to keep carcasses, parts and feathers from any migratory bird without an appropriate federal permit.</p>

TABLE 14-3 Recommendations for Safe Restraint of Native Wildlife. [5,9,11,12,19,28,47,49,54,57,58,70,72,75](#)

Topic	Notes ^a
	<p>Wild animals may carry a variety of infectious and parasitic diseases that may present a health risk to veterinary staff, clients, the public, and domestic patients. It is strongly advised to wear a primary barrier (latex gloves) when handling wild animals.</p>
Badgers, coyotes, foxes, bobcats, and lynx	<p>Young kits/cubs weighing less than 1 kg can be handled by wearing latex gloves under long leather gloves and caught up by wrapping in a thick towel or blanket. For long procedures or fractious adults, anesthetize by injectable/inhalant combinations. Inject larger animals (over 3 kg) using squeeze cage, netting, or syringe pole. Do not scruff animals for restraint because they can still turn and bite. Restrain by grasping the head around the back of the neck and holding the dorsal pelvis with the legs aimed away from your abdomen to avoid personal injury. Use muzzles to prevent biting.</p>
Raccoons	<p>Infants/juveniles may be restrained by the scruff of the neck or by holding the shoulder area of the forelegs with one leg in each hand. Animals tend to scream, grasp, or bite at the gloves and may urinate with handling. Restrain older juveniles and adults with chemical or a combination of chemical and gas anesthesia.</p>
Skunk	<p>Limit handling in this species to avoid being sprayed from the musk glands. Wear eye protection when handling. For young animals, attempt to drape a towel or plastic sheet and tuck the tail between the hind legs to decrease the possibility of being sprayed. Restrain older juveniles and adults with chemical and/or gas anesthesia.</p>

TABLE 14-3 Recommendations for Safe Restraint of Native Wildlife. (cont'd)

Topic	Notes
River otters	Natural defense is to bite, grasp, and twist which may cause significant tissue trauma. Appropriate protective gear includes elbow-length leather gloves for protection against teeth and nails. Adult animals may need to be anesthetized for restraint.
Opossums	Appropriate protective gear includes elbow-length leather gloves for protection against teeth and nails. Anesthesia may be required for examination of adults.
Rabbits and hares	Appropriate protective gear includes a towel or light gloves for adults. Cover with a towel before picking up to reduce stress. Restrain so that the patient cannot kick its hind legs and injure its back. Avoid overhandling and anesthetize for prolonged restraint.
Wild rodents	Adults of these species can deliver hard bites. Appropriate protective wear includes leather gloves to the elbow. Use nets for initial restraint of larger rodents. A noose-style catch pole may be appropriate for initial restraint of large beavers.
Birds of prey	Appropriate protective gear includes leather gloves (garden gloves for small species and up to the elbows or higher for larger hawks and eagles) and protective eyewear. A leather welder's jacket may be used for large raptors such as eagles. Raptors will use talons for primary defense but may also use their beak. Restrain feet first and head second. A body grab should be used if the bird has a known leg injury. A towel may be placed over the body before restraint to reduce wing flapping. Vulture defense includes regurgitation. Keeping the patient's neck extended will reduce regurgitation efforts. Keep the patient's eyes covered with a hood or light cloth during handling to reduce patient stress.
Passerines, woodpeckers, doves, etc.	Appropriate protective gear includes light leather gloves. Patients may become stressed or overheat with handling. Watch the patient closely and perform procedures in stages if needed. Secure smaller birds using fore and middle fingers around the base of the head and the bird's back pressed against your palm. Do not compress the body by grasping too tightly as this may compromise breathing. Cup doves, pigeons, and similar species in a light towel.
Waterfowl, pelagic, and wading birds	Appropriate protective gear includes vinyl or light leather gloves. Powdered latex gloves and bare hands are inappropriate for waterfowl, pelagic birds, and other species that require waterproofing of the feathers. Handle passerine-sized precocial birds the same as altricial birds. Waterfowl and large wading birds should be restrained by securing the legs with one hand, tucking the bird's body between your side and the arm restraining the legs, and securing the head and neck with the opposite hand. Long-billed birds such as herons and loons require the handler to wear goggles and/or face shields to protect the eyes.
Insectivorous bats	Appropriate protective gear includes latex gloves under leather garden gloves. Place the bat gently in a soft cloth and cover. Expose portions of the bat to perform a physical exam. Cotton tip applicators are useful to examine wing membranes, head and oral cavity, integument, etc.
Snakes	Nonvenomous snakes may be restrained by grasping the head just behind the mandibles and securing the body with the other hand. An additional handler is needed for every 3-4 feet of snake to support the spine. Venomous snakes should be restrained only by experts using snake hooks and tongs to handle and clear plastic tubes for restraint.

Continued

TABLE 14-3 Recommendations for Safe Restraint of Native Wildlife. (cont'd)

Topic	Notes
Chelonians	Chelonians may scratch with claws or bite. Appropriate handling gear includes latex gloves. Nonaggressive species may be restrained by grasping the sides of the shell between the front and back legs. Larger turtles, especially snapping turtles, require a hand under the caudal third of the plastron and the other hand grasping the tail or the caudal carapace. Snapping turtles can extend the head and neck two-thirds their body length caudally. Consider using a toilet plunger over a snapping turtle's head to reduce the risk of biting.
Lizards	Place the index finger and thumb around the base of the mandibles to secure the head and prevent biting. Use the free hand to restrain the hind legs and tail. Never grab lizards by the tail, especially in species with tail autonomy. To calm lizards, a vagal response can be created by placing cotton balls over the eyes and securing with bandage material.

^aAlthough this outline is intended to provide general guidelines for the care of injured wildlife, the veterinarian is strongly encouraged to transfer these animals to experienced rehabilitators as soon as possible and/or to contact rehabilitators if questions arise. In addition, any individual working with wildlife should check with state and federal officials on permit requirements.

TABLE 14-4 Recommendations for Venipuncture Sites in Native Wildlife. ^{19,22,28,31,35,57,62,65,68,72,75}

Topic	Notes
Badgers, river otters, skunks, coyotes, foxes, raccoons, bobcats, lynx	Medial saphenous vein, lateral saphenous vein, jugular vein, cephalic vein, ventral coccygeal vein, femoral vein, cranial vena cava (in otters)
Opossums	Lateral coccygeal and ventral tail vein/artery, cephalic vein, saphenous vein, pouch vein in females
Rabbits and hares	Jugular vein, cephalic vein, femoral vein, lateral saphenous vein
Wild rodents	Small rodents often require cranial vena cava venipuncture under anesthesia; larger species have accessible jugular veins, cephalic veins, and medial and lateral saphenous veins; beavers have accessible tail vein
Birds of prey	Jugular vein (right is larger), basilic vein in either wing, medial metatarsal vein (use caution when working near talons)
Passerines, woodpeckers, doves, etc.	Right jugular vein; basilic vein in larger birds is an alternative site
Waterfowl, pelagic, and wading birds	Medial metatarsal vein is preferred; jugular vein and basilic veins are secondary sources
Insectivorous bats	Need 24 μ L for a manual complete blood cell count; venipuncture sites include heart, infraorbital sinus, jugular, peripheral vessels (median vein, cephalic vein, uropatagial vein)
Snakes	Heart (snakes >200 g; dorsal recumbency; insertion of needle under central abdominal scale at 45° angle caudal to heart; pericardial fluid contamination can occur), jugular vein (needle is inserted parallel or perpendicular to the ribs and 9 ventral scales cranial to the heart), or ventral coccygeal vein; venomous snakes should only be handled by professionals using appropriate equipment (tongs, hooks, clear snake-handling tubes)
Chelonians	Jugular, dorsal venous sinus/dorsal coccygeal vein, subcarapacial venous sinus; less commonly used vessels include brachial venous plexus, femoral venous plexus, and femoral vein; all sites except the jugular vein may be subject to lymph contamination
Lizards	Ventral coccygeal vein (accessed laterally or ventrally), jugular, ventral abdominal/coelomic vein

TABLE 14-5 Recommendations for Meat Withdrawal Times in Game Species for Select Medications.^{3,14,27,82,89}

Drug use in wild animals is considered extra-label and as such is regulated by the Food and Drug Administration (FDA) through the Animal Medicinal Drug Use Clarification Act (AMDUCA). This act is divided into food-producing animals and non-food-producing animals. Drug residues in game animals are a potential public health risk to those who consume the meat. Game animals are defined by the FDA as “an animal, the products of which are food, that is not classified as livestock, sheep, swine, goat, horse, mule or other equine, or as poultry or fish.” Game animals include mammals such as deer, antelope, rabbit, squirrel, opossum, raccoon, nutria, or muskrat, and nonaquatic reptiles such as land snakes. The FDA classifies wild game birds as “poultry” and includes “migratory waterfowl or game birds, pheasant, partridge, quail, grouse, or pigeon.”

Practitioners need to be aware of potential meat withdrawal times (defined as the time between drug administration and when the meat can safely be consumed by a human) when administering drugs to game species during or just before established hunting and trapping seasons. There are very few established withdrawal times for wildlife, and practitioners should check the Food Animal Residue Avoidance Database (FARAD) for guidance on drug administration in game species that could be consumed. If a game animal cannot be held until the meat withdrawal time has passed, it should be identified with a unique number and warning that the meat should not be consumed. Permission to tag wildlife may also require permission from state or federal authorities.

Some drugs may never be used in food-producing animals throughout the year. These include: chloramphenicol, clenbuterol, diethylstilbestrol, dimetridazole, ipronidazole, metronidazole, other nitroimidazoles, furazolidone, nitrofurazone, glycopeptides, and fluoroquinolones. Adamantane and neuraminidase inhibitors are prohibited in wild game birds. The following is a list of recommended withdrawal times for select drugs used in wildlife.

Agent	Meat Withdrawal Time (days)	Agent	Meat Withdrawal Time (days)
Acepromazine	14	Naloxone	30
Atipamezole	14	Naltrexone	30
Diazepam	14	Penicillin (long-acting)	21
Diprenorphine	30	Tolazoline	30
Etorphine	30	Xylazine	30
Ivermectin	49	Yohimbine	30
Ketamine	3	Zolazepam and tiletamine (1:1)	14
Medetomidine	14		

TABLE 14-6 Antimicrobial Agents Used in Wild Mammals.^{a-c}

Agent	Dosage	Species/Comments
Amikacin	10-15 mg/kg SC, IM, IV q12h ³⁰	Rodents
	20 mg/kg SC q24h ⁷	Bats
	1.25 g/20 g methylmethacrylate ⁸⁵	To make antibiotic impregnated polymethylmethacrylate beads
Amoxicillin	10-20 mg/kg PO q8h ⁶⁷	Rats, mice, squirrels, bats, raccoons, opossums, wild felids, canids; do not use in rabbits and certain species of rodents
Amoxicillin/ clavulanic acid (Clavamox, Zoetis)	—	Do not use in rabbits and certain species of rodents
	13-22 mg/kg PO q8-12h ^{67,74}	Rats, mice, squirrels, bats, raccoons, opossums, wild felids, canids

Continued

TABLE 14-6 Antimicrobial Agents Used in Wild Mammals. (cont'd)

Agent	Dosage	Species/Comments
Ampicillin sodium/sulbactam (Unasyn, Pfizer)	— 10-20 mg/kg IM, IV q8h ⁶⁷	Stable for 3 days refrigerated and 3 mo frozen For infections susceptible to amoxicillin/clavulanate in patients unable to receive oral doses
Ampicillin trihydrate	— 6.6 mg/kg SC, IM q12h ⁶⁷	Do not use in rabbits and certain species of rodents Canids, felids
	20-30 mg/kg SC, IM, IV q8h ^{67,74}	Rats, mice, squirrels, raccoons, opossums
Azithromycin (Zithromax, Pfizer)	5-10 mg/kg PO q24h × 3-5 days ⁶⁷ 20 mg/kg PO q24h ⁷	Carnivores Bats
Cefazolin sodium	— 10-30 mg/kg SC, IM, IV q8h ⁶⁷	Do not use in rabbits and rodents Carnivores
	2 g/20 g methylmethacrylate ⁸⁵	To make antibiotic impregnated polymethylmethacrylate beads
Cefovecin (Convenia, Zoetis)	8 mg/kg SC once, repeat in 10 days if indicated	Carnivores; based on authors' experience in raccoons, foxes, otters ^{3,54}
Ceftazidime	25-30 mg/kg IM, IV q8-12h ⁶⁷	Carnivores
Ceftiofur crystalline-free acid (Excede, Zoetis)	7 mg/kg SC ^{45,81}	Carnivores
Cephalexin	— 22-60 mg/kg PO q6-12h ^{7,67}	Do not use in rabbits and certain species of rodents Rats, mice, bats, squirrels, raccoons, opossums, wild felids, canids
Clindamycin	— 11-33 mg/kg PO q24h ⁶⁷ 15-30 mg/kg PO q12h ⁶⁷	Do not use in rabbits, rodents, and ruminants ^{58,69} Felids Carnivores
Doxycycline	2.5-5 mg/kg PO q12h ⁶⁸ 5-10 mg/kg PO q12h ⁶⁷	Rabbits, rodents Carnivores
Enrofloxacin	— 5 mg/kg PO q24h ⁶⁷ 5-10 mg/kg PO, IM q12h ²¹ 5-20 mg/kg PO, IM, IV q24h ⁶⁷	Injectable may cause tissue necrosis; in general, more than one IM injection not advised; appears stable when compounded; dilute 1:10 to reduce irritation Felids/contraindicated in young, growing animals Rabbits, rodents Canids/contraindicated in young, growing animals
Metronidazole	10-15 mg/kg PO q12h ⁶⁷	Felids
Penicillin G procaine	— 20,000-40,000 IU/kg IV q6h or SC, IM q12h ⁶⁷	Do not use in rabbits or rodents Carnivores
Piperacillin/tazobactam (Zosyn, Wyeth)	50 mg/kg IV q8h ⁶⁷	Canids

TABLE 14-6 Antimicrobial Agents Used in Wild Mammals. (cont'd)

Agent	Dosage	Species/Comments
Trimethoprim/ sulfadiazine (Tribrissen, Schering- Plough)	15 mg/kg PO q12h ⁶⁷	Felids
	15-30 mg/kg PO q12h ^{7,67}	Canids, bats
Tylosin (Tylan, Elanco)	—	Not recommended for use in rodents; injectable may cause tissue necrosis
	10-40 mg/kg PO q12h ⁶⁷	Carnivores

^aAdditional drug doses for other classes of wild animals may be found in other chapters of this formulary.

^b"Carnivores" may include wild North American felids, canids, procyonids, ursids, and mustelids.

^cMany species of wildlife are hunted for human consumption. Drugs prohibited for use in food animals should not be administered to these species if they will be released to the wild and/or consumed by humans. See www.farad.org for list of drugs.

TABLE 14-7 Antiparasitic Agents Used in Wild Mammals.^{a-c}

Agent	Dosage	Species/Comments
Fenbendazole (Panacur, Intervet)	—	Toxicosis reported in porcupines and rabbits ^{32,88}
	10-25 mg/kg PO q24h × 5 days ⁵¹	Prairie dogs, other rodents
	25 mg/kg PO q24h × 5 days ⁶	Marsupials/ <i>Capillaria</i>
	25-50 mg/kg PO q12h × 10-14 days ⁶⁷	Canids, felids/ <i>Paragonimus</i>
	50 mg/kg PO q24h × 3-5 days ⁶⁷	Canids, felids/ascarids, hookworms, whipworms, <i>Taenia</i>
Fipronil	—	Canids, felids/ <i>Giardia</i>
	Mix 1 mL fipronil with 4 mL 70% isopropyl alcohol; apply 0.5 mL to 15 g bat; 0.7 mL to 20 g bat; 1 mL to 25 g bat ⁷	Most species/do <i>not</i> use in rabbits ⁶⁸ Bats
Imidacloprid/ moxidectin (Advantage Multi, Bayer)	0.2 mg/kg topically prn ⁸⁷	Most species
	Mix 0.1 mL imidacloprid with 0.9 mL water ⁷	Bats/imidacloprid only; apply 1 drop of solution to back of head
Ivermectin	—	Intravenous lipid emulsion has been successfully used to treat ivermectin toxicosis in mammals ⁴⁹
	0.2-0.4 mg/kg PO, SC q7d ^{1,68}	Most species/many endoparasites and ectoparasites; continue 2 wk past negative skin scrape for mites
Metronidazole	100 µg/kg PO once ⁷	Bats/toxicosis possible; higher doses not recommended ¹⁸
	15-25 mg/kg PO q12h × 5-7 days ⁶⁷	Carnivores/ <i>Giardia</i>
	10-40 mg/kg PO q24h ¹⁰	Rodents
Moxidectin	0.2-0.4 mg/kg PO q7-10d × 3-6 doses ⁸⁷	Carnivores, rabbits

Continued

TABLE 14-7 Antiparasitic Agents Used in Wild Mammals. (cont'd)

Agent	Dosage	Species/Comments
Nitenpyram (Capstar, Novartis)	— 11.4 mg (1 tablet) PO for animals weighing 0.9-11.36 kg ⁶⁷	Capstar wound flush: one 11.4 mg tablet crushed and mixed with 30 mL sterile 0.9% NaCl or water ⁵⁵ Carnivores/fleas, myiasis
Praziquantel (Droncit, Bayer)	5-10 mg/kg PO, SC ⁶⁷ 20-25 mg/kg PO q24h × 3-10 days ⁶⁷	Carnivores/cestodes Carnivores/trematodes
Pyrantel pamoate	5-10 mg/kg PO after meal q2-3wk ^{44,67}	Carnivores
Sulfadimethoxine (Albon, Zoetis)	25-50 mg/kg PO q24h ^{1,51,71}	Most species

^aAdditional drug doses for other classes of wild animals may be found in other chapters of this formulary.

^b"Carnivores" may include wild North American felids, canids, procyonids, ursids, and mustelids.

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TABLE 14-8 Antifungal Agents Used in Wild Mammals.^{a-c}

Agent	Dosage	Species/Comments
Amphotericin B	0.25 mg/kg IV 3 ×/wk; maximum dose 8 mg/kg; 4 mg/kg if used with an azole ⁶⁰	Carnivores/efficacy against aspergillosis may be low; MIC indicated ⁷⁷
Griseofulvin	1 mg/kg IV q24h ⁷³ — 25 mg/kg PO q12h or 50 mg/kg PO q24h ⁶⁰ 25 mg/kg PO q24h × 28 days ^{1,39}	Rabbits, rodents Administer with fatty meal; may cause bone marrow depression; monitor CBC during treatment Carnivores/dermatophytosis; continue therapy 2 wk beyond clinical resolution Rabbits, rodents, Virginia opossums, eastern grey squirrels/dermatophytosis
Itraconazole (Itrafungol, Elanco)	— 5-10 mg/kg PO q24h ^{38,67}	Give with meal for most effective absorption; monitor liver function Carnivores, rabbits
Nystatin 100,000 IU/mL suspension	— 5,000 IU/kg PO q8-12h ⁵⁹ 50,000-150,000 IU topically q6-8h ⁶⁷	Apply topically to oral lesions Opossums Carnivores/oral candidiasis
Terbinafine	8-20 mg/kg PO q24h ³⁸ 10-20 mg/kg PO q24h ⁶⁷	Rabbits Carnivores/dermatophytosis; can do pulse therapy (7 days on, 21 days off)
Voriconazole	— 4 mg/kg PO q12h ⁶⁷	Not recommended in felids due to significant side effects Canids

^aAdditional drug doses for other classes of wild animals may be found in other chapters of this formulary.

^b"Carnivores" may include wild North American felids, canids, procyonids, ursids, and mustelids.

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TABLE 14-9 Chemical Restraint/Anesthetic Agents Used in Wild Mammals.^{a-c}

Agent	Dosage	Species/Comments
Acepromazine	0.5-2.5 mg/kg IM ³⁷ 0.1 mg/kg IM ³⁷	Prairie dogs Beavers, porcupines
Alfaxalone (Alfaxan, Jurox)	5-10 mg/kg IM or 1.5 mg/kg IV ⁷⁴	Most species
Atipamezole (Antisedan, Zoetis)	—	Dexmedetomidine and medetomidine reversal; give same volume SC, IV, IP as medetomidine and dexmedetomidine (dexmedetomidine is used at one-half the dose of medetomidine but the same volume due to higher concentration); medetomidine is no longer commercially available, but can be compounded
Atropine sulfate	0.03-0.05 mg/kg SC ⁶⁷	Most species/preanesthetic dose; may not be effective in lagomorphs and some rodents
Dexmedetomidine (Dexdomitor, Zoetis)	0.05-1 µg/kg IM, IV (use lower end of range if giving IV) ³⁶	Most species/generally insufficient alone to produce sedation in most wild mammals; combine with opioids and/or benzodiazepines; see ketamine for combinations
Diazepam (available as a 1 mg/mL oral solution)	0.1-1 mg/kg IM, PO ³⁷ 0.5-2 mg/kg IM, SC, PO ⁷ 1-2.5 mg/kg PO, IM, IP ³⁷	Beavers, porcupines Bats Prairie dogs
Flumazenil	0.01-0.05 mg/kg IM, IV, IO; repeat q1h prn ⁶⁷	If using 5 mg/mL midazolam and 0.1 mg/mL flumazenil, use 2 × the volume of midazolam given
Glycopyrolate	0.01 mg/kg SC, IM ³⁷ 0.01-0.02 mg/kg SC, IM ³⁷	Beavers, porcupines Prairie dogs
Ketamine	— 30-100 mg/kg SC ⁷	Combinations frequently used by the authors; most can be followed by intubation and inhalant anesthetic drugs if general anesthesia is required; concentrated formulations of ketamine (200 mg/mL), butorphanol (30-50 mg/mL), and medetomidine (10 or 20 mg/mL) are available from compounding pharmacies and are advised for larger mammals; sustained release (SR) products available from compounding pharmacies; can also be combined with benzodiazepines Bats
Ketamine (K)/ medetomidine (M)	(K) 2-5 mg/kg + (M) 0.04-0.1 mg/kg IM ²⁶	Carnivores
Ketamine (K)/medetomidine (M)/dexmedetomidine (D)/butorphanol (B)	(K) 2-4 mg/kg + (M) 0.02 mg/kg + (B) 0.04-0.2 mg/kg or 0.01 mL/lb IM each of (K) 100 mg/mL, (D) 0.5 mg/mL, and (B) 10 mg/mL ²⁶	Carnivores/deepen anesthesia with isoflurane for invasive procedures; reverse dexmedetomidine with equal volume of atipamezole IM (wait at least 30 min after ketamine is administered)

Continued

TABLE 14-9 Chemical Restraint/Anesthetic Agents Used in Wild Mammals. (cont'd)

Agent	Dosage	Species/Comments
Midazolam	0.1-0.5 mg/kg IM ³⁷	Beavers, porcupines
	0.2-0.5 mg/kg IM, IV ²⁶	Carnivores/preanesthetic or sedative
	1-2 mg/kg IM, IP ³⁷	Prairie dogs
Propofol	—	Reduce dose with hypoproteinemia; supplemental oxygen recommended; induces profound respiratory depression; be prepared to ventilate
	3-7 mg/kg IV slowly to effect ⁶⁷	Carnivores
	0.1-0.6 mg/kg/min constant rate infusion ³⁶	Carnivores/sedation at lower doses; light anesthesia at higher doses

^aAdditional drug doses for other classes of wild animals may be found in other chapters of this formulary.

^b"Carnivores" may include wild North American felids, canids, procyonids, ursids, and mustelids.

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TABLE 14-10 Analgesic and Nonsteroidal Antiinflammatory Agents Used in Wild Mammals.^{a-c}

Agent	Dosage	Species/Comments
Buprenorphine	0.01-0.02 mg/kg SC, IM q12h; may be administered via transmucosal route at higher dosage of 0.02-0.03 mg/kg q12h ⁶⁸	Felids
	0.01-0.05 mg/kg SC, IM, IV, IP, oral transmucosal q6-12h ^{23,29}	Most species
	0.1 mg/kg SC q24h ⁷	Bats
Buprenorphine-SR (Buprenorphine SR-LAB, ZooPharm)	—	Acquired from compounding pharmacy; sustained release; shelf life 1 yr; refrigerate
	0.06-0.12 mg/kg SC q72h ¹³	Carnivores
Butorphanol	1-2 mg/kg SC q48-72h ^{25,46}	Rodents
	—	Can be compounded at 30-50 mg/mL by compounding pharmacy
	0.1-0.5 mg/kg SC, IM, IV q2-4h ⁶⁷	Carnivores
Carprofen	2 mg/kg SC, IM q4h ⁹⁰	Prairie dogs
	2-5 mg/kg SC, PO q12h ²⁴	Rodents
Fentanyl	2.2 mg/kg PO q12h ⁶⁷	Canids/not recommended for felids
	Transdermal patch 1-5 µg/kg/h ⁶⁷	Most species/dysphoria more prevalent at higher end of dose range
Gabapentin	5-10 mg/kg PO q12h ⁶⁷	Carnivores/anecdotal dosage
	100 mg/kg PO q24h ³³	Rodents
Ketoprofen	2-5 mg/kg SC q24h ⁷	Bats

TABLE 14-10 Analgesic and Nonsteroidal Antiinflammatory Agents Used in Wild Mammals. (cont'd)

Agent	Dosage	Species/Comments
Meloxicam	0.1 mg/kg PO q24h ⁷ 0.2 mg/kg PO, SC, IV, then 0.1 mg/kg PO q24h ⁶⁷ Label dosage: 0.3 mg/kg SC once for 3-4-day effect; ⁶⁷ Extra-label dosage: 0.2 mg/kg PO once, then 0.1 mg/kg PO q24h in food for 3-4 days ⁸	Bats Canids Felids, raccoons, Virginia opossums, skunks
Morphine	1 mg/kg PO q24h × 29 days ¹⁷ 1-2 mg/kg PO, SC q24 ⁸ 0.1-0.5 mg/kg SC, IM q4-6h ⁶⁷ 0.5-2 mg/kg SC, IM q4-6h ⁶⁷	Rabbits Rodents Felids/not recommended to use alone Canids
Tramadol	— 0.5-2 mg/kg PO q12h ⁶⁷ 3-5 mg/kg PO q8-12h ⁶⁷	Compounded suspension has a shelf life of 90 days at 5°C/41°F ⁸⁶ Felids Canids
Lidocaine	— <3 mg/kg ⁹⁰ <4 mg/kg ⁹⁰	Toxic dose varies with species; use lowest dose possible Felids Canids
Bupivacaine	— 2 mg/kg ⁹⁰	Toxic dose varies with species; use lowest dose possible Carnivores

^aAdditional drug doses for other classes of wild animals may be found in other chapters of this formulary.

^b"Carnivores" may include wild North American felids, canids, procyonids, ursids, and mustelids.

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TABLE 14-11 Agents Used in Wild Mammal Emergencies.^{a-c}

Agent	Dosage	Species/Comments
Activated charcoal	1-4 g/kg with 5-10 mL of water per g of charcoal PO q4-6h ⁶⁷	Carnivores
Atropine (0.54 mg/mL)	2-3 g/kg PO ⁴³ 0.02-0.04 mg/kg IM, IV ⁶⁷ 0.04 mg/kg IV, IO; repeat q3-5min prn for maximum of 3 doses or 0.08-0.1 mg/kg intra-tracheal; dilute with 5-10 mL sterile water before administration ⁶⁷ 0.04-0.05 mg/kg SC, IM ^{36,37} 0.2-0.5 mg/kg; give ¼ dose IV and remainder SC, IM ⁶⁷	Rabbits, rodents Carnivores; bradycardia Carnivores; cardiopulmonary resuscitation Most species/preanesthetic Organophosphate toxicity

Continued

TABLE 14-11 Agents Used in Wild Mammal Emergencies. (cont'd)

Agent	Dosage	Species/Comments
Crystalloid fluids (isotonic) bolus volume for shock	0.8-1 mg/kg SC, IM ⁶¹ 90 mL/kg 1st hr ⁴⁰	Rabbits/many have serum atropinase and need higher doses Most species/administer one quarter of total dose over 15 min, then reassess heart rate, blood pressure, mucous membranes
Crystalloid fluids (maintenance)	40-60 mL/kg/day ⁸⁰	Carnivores
Diazepam	0.5-1 mg/kg IV, intranasally, rectally; repeat 2 × prn ⁶⁷	Carnivores/status epilepticus or cluster seizures
Dexamethasone sodium phosphate; methylprednisolone sodium succinate	—	High dose (e.g., 30 mg/kg IV), fast-acting corticosteroids are no longer recommended for use in shock or CNS trauma (still controversial); recent studies have not demonstrated significant benefit and it actually may cause increased deleterious effects ⁶⁷
Dextrose 50%	0.5 mL/kg IV bolus (dilute by half to make a 25% solution), follow up with constant rate infusion of 5% dextrose in a balanced electrolyte solution ⁶⁷ 0.25 mL/kg of 50% dextrose diluted 50% w/saline ⁵⁰	Most species/hypoglycemia Small mammal CPR
Edetate calcium disodium (CaEDTA)	— 25 mg/kg SC q6-12h × 5 days ^{16,51,67}	Nephrotoxic; consider administration of fluids during treatment to maintain hydration Most species/recheck lead levels after 5 days of treatment; if still elevated, allow 5-7 day rest period before restarting treatment
Epinephrine 1:1000 (1 mg/mL)	— 0.01 mg/kg IV/IO epinephrine administered every 3-5 min ^{50,67,69} 0.1 mg/kg IV, IO ^{50,67,69} 0.1-0.2 mg/kg IV, IO, intratracheal ^{50,67,69}	Most species Low-dose; early in CPR is recommended High-dose; consider after prolonged CPR Dilute in 5-10 mL sterile water or saline for intratracheal administration
Furosemide	1-4 mg/kg IM, IV q4-12h ⁴² 2-4 mg/kg IM, IV q1-2h until respiration improves ⁶⁷	Rabbits/pulmonary edema Carnivores/pulmonary edema, ascites
Hetastarch	1-2 mL/kg/h IV constant rate infusion ⁶⁷ 1-2 mL/kg/h IV constant rate infusion ⁶⁷ 5-10 mL/kg IV bolus over 15-30 min ⁴⁰ 10-20 mL/kg IV bolus 15-30 min ⁴⁰	Canids/do not exceed 25 mL/kg/day Felids/do not exceed 10 mL/kg/day Felids Carnivores
Mannitol	0.5-1.5 g/kg IV over 10-20 min ⁶⁷	Most species/traumatic brain injury; repeat q6-8h prn for maximum of 3 boluses and only if patient is showing response

TABLE 14-11 Agents Used in Wild Mammal Emergencies. (cont'd)

Agent	Dosage	Species/Comments
Pralidoxime (2-PAM)	20 mg/kg SC, IM, IV (slowly) q6-12h until nicotinic signs are present ⁶⁷	Carnivores
Saline (NaCl; hypertonic; 7.5%)	4-6 mL/kg slow bolus ⁶⁷	Most species/head trauma, pulmonary contusions; consider using with a colloid to prolong effect

^aAdditional drug doses for other classes of wild animals may be found in other chapters of this formulary.

^b"Carnivores" may include wild North American felids, canids, procyonids, ursids, and mustelids.

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TABLE 14-12 Miscellaneous Agents Used in Wild Mammals.^{a-c}

Agent	Dosage	Species/Comments
Acetylcysteine	Nebulize 50 mg as a 2% solution diluted with saline ^{60,67}	Most species/can be stored in refrigerator for 6 mo; do not freeze
Calcium gluconate	— 50-100 mg/kg IV for 10-20 min ⁶⁷ 94-140 mg/kg IV slowly to effect ⁶⁷	Dilute the 23% solution 1:1 with saline or sterile water for IM or IV administration Most species/hyperkalemic cardiotoxicity (serum K >8 mEq/L); monitor ECG Most species/hypocalcemia; monitor respiration and cardiac rhythm during administration; halt administration if arrhythmias occur
Cimetidine	5-10 mg/kg PO, SC, IM, IV q6-12h ^{44,67,71}	Most species
Diphenhydramine	2 mg/kg PO, SC ^{7,67}	Most species
Famotidine	0.5 mg/kg PO, SC, IM, IV q6-12h ^{60,67}	Most species
Iron dextran	10-20 mg/kg IM followed by oral therapy ⁶⁷	Carnivores
Isoxuprine	1 mg/kg PO q24h ⁶⁷	Canids
Lactulose	0.25-0.5 mL/kg PO q6-8h until stools are loose ⁶⁷	Carnivores
Loperamide	0.1 mg/kg PO q8h × 3 days, then q24h × 2 days (give in 1 mL water) ^{44,60}	Most species
Maropitant (Cerenia, Zoetis)	0.5-1 mg/kg SC, IV slow q24h 2-4 mg/kg PO q24h up to 5 consecutive days ^{60,67}	Carnivores Carnivores
Meclizine	2-12 mg/kg PO q12-24h ^{44,60,67}	Most species
Metoclopramide	0.2-0.5 mg/kg PO, SC q6-8h ^{51,60,67}	Carnivores, rodents, rabbits
Omeprazole	0.5-1 mg/kg PO q24h ⁶⁷	Carnivores
Oxytocin	0.2-3 IU/kg SC, IM, IV ^{53,64}	Most species
Simethicone (66 mg/mL)	60 mg/kg PO q8-12h or at every feeding for infants ⁶⁰	Most species (adult or infant)/also consider burping nursing neonates after every feeding

Continued

TABLE 14-12 Miscellaneous Agents Used in Wild Mammals. (cont'd)

Agent	Dosage	Species/Comments
Sucralfate	25-125 mg/kg PO q8h ^{41,71}	Most species/give 30-60 min after histamine-2 blockers
Vitamin B complex	10-20 mg/kg SC, IM q8-12h pm ⁶⁷	Carnivores/dose based on thiamine (B ₁)

^aAdditional drug doses for other classes of wild animals may be found in other chapters of this formulary.

^b"Carnivores" may include wild North American felids, canids, procyonids, ursids, and mustelids.

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Chapter 15 **Select Topics for the Exotic Animal Veterinarian**

Julie Swenson | James W. Carpenter



TABLE 15-1 Classification of Select Antimicrobials Used in Exotic Animal Medicine.

Class	Antimicrobial Agent
Benzyl penicillins ^a	Benzathine penicillin G Procaine penicillin G
Extended-spectrum penicillins ^a	
Aminopenicillins	Amoxicillin Ampicillin
Antipseudomonal penicillins	
Carboxypenicillins	Carbenicillin Ticarcillin
Piperazine penicillins	Piperacillin
Carbapenems ^b	Imipenem Meropenem
β -lactamase inhibitors	Ampicillin ^a /sulbactam Piperacillin ^a /tazobactam
Clavulanic acid	Amoxicillin ^a /clavulanate Ticarcillin ^a /clavulanate
First-generation cephalosporins ^a	Cefadroxil Cefazolin Cefovecin Cefpodoxime Cephalexin
Third-generation cephalosporins ^a	Cefixime Cefotaxime Ceftazidime Ceftiofur
Fourth-generation cephalosporins ^a	Cefepime Cefpirome
Macrolides ^b	Clarithromycin Erythromycin Tilmicosin Tylosin
Azalides ^b	Azithromycin
Ketolides ^b	Telithromycin
Tetracyclines ^b	Chlortetracycline Doxycycline Oxytetracycline Tetracycline
Chloramphenicol (or its derivative) ^b	Chloramphenicol Florfenicol
Lincosamides ^c	Clindamycin Lincomycin Pirlimycin

Continued

TABLE 15-1 Classification of Select Antimicrobials Used in Exotic Animal Medicine. (cont'd)

Class	Antimicrobial Agent
Aminoglycosides ^a	Amikacin
	Gentamicin
	Kanamycin
	Neomycin
	Streptomycin
	Tobramycin
	Spectinomycin
Aminocyclitols ^b	Metronidazole
Nitroimidazole ^d	Ronidazole
	Sulfachlorpyridazine
	Sulfadiazine
	Sulfadimethoxine
	Sulfamethazine
	Sulfamethoxazole
	Sulfaquinoxaline
	Sulfathiazole
	Sulfisoxazole
	Trimethoprim ^a
Trimethoprim/sulfas ^a	Trimethoprim/sulfadiazine
	Trimethoprim/sulfamethoxazole
Quinolones ^b	Nalidixic acid
Fluoroquinolones ^a	Ciprofloxacin
	Danofloxacin
	Diffloxacin
	Enrofloxacin
	Marbofloxacin
	Orbifloxacin

^aBactericidal.^bBacteriostatic.^cBacteriostatic or bactericidal.^dCidal vs. amoebae, *Giardia*, *Trichomonas*, and most obligate anaerobes; inactive vs. most aerobic bacteria or facultative anaerobes.

TABLE 15-2 General Efficacy of Select Antimicrobial Agents Used in Exotic Animals.

Infectious Agent	Antimicrobial Agent
Gram-positive bacteria	
Gram-positive bacteria (in general)	<ul style="list-style-type: none"> • Aminoglycosides (select) (amikacin, gentamicin) • Azalides (i.e., azithromycin) • Cephalosporins • Chloramphenicol • Erythromycin • Florfenicol • Fluoroquinolones • Lincosamides • Macrolides • Penicillins • Tetracyclines
<i>Staphylococcus</i> spp.	<ul style="list-style-type: none"> • Aminoglycosides (select) (amikacin, gentamicin) • Azithromycin • β-lactams (early-generation) • Cephalosporins (cefovecin, cefpodoxime) • Chloramphenicol • Clindamycin • Fluoroquinolones • Lincosamides • Macrolides • Penicillin/β-lactamase inhibitor (amoxicillin/clavulanate, ampicillin/sulbactam, piperacillin/tazobactam, ticarcillin/clavulanate) • Trimethoprim/sulfas
<i>Streptococcus</i> spp.	<ul style="list-style-type: none"> • Azithromycin • β-lactams (early-generation) • Cephalosporins • Chloramphenicol • Clindamycin • Lincosamides • Macrolides • Penicillins • Tetracyclines • Trimethoprim/sulfas
<i>Clostridium</i> spp. and other anaerobes	<ul style="list-style-type: none"> • Azithromycin • Cephalosporins (cefotetan, ceftioxin) • Chloramphenicol • Clindamycin • Erythromycin • Florfenicol • Lincomycin • Metronidazole^a • Penicillins (amoxicillin/clavulanate) • Tetracyclines
Gram-negative bacteria	
Enterobacteriaceae (in general)	<ul style="list-style-type: none"> • Aminoglycosides (amikacin, gentamicin) • Azalides • Carbapenems • Cephalosporins (third/fourth-generation) • Fluoroquinolones • Penicillins (extended-spectrum) • Trimethoprim/sulfas

Continued

TABLE 15-2 General Efficacy of Select Antimicrobial Agents Used in Exotic Animals. (cont'd)

Infectious Agent	Antimicrobial Agent
<i>Campylobacter</i> spp.	<ul style="list-style-type: none"> • Amoxicillin • Azithromycin • Ceftriazone • Chloramphenicol • Clindamycin • Doxycycline • Erythromycin • Fluoroquinolones • Furazolidone • Gentamicin • Neomycin
<i>Pasteurella</i> spp. (resistance may occur)	<ul style="list-style-type: none"> • Aminoglycosides (amikacin, gentamicin) • Chloramphenicols (chloramphenicol, florfenicol) • Erythromycin • Fluoroquinolones • Penicillins • Sulfonamides • Tetracyclines • Trimethoprim/sulfas
<i>Pseudomonas</i> spp. (often resistant)	<ul style="list-style-type: none"> • Aminoglycosides (frequently in combination with an advanced-generation β-lactam) • Carbapenems • Ceftazidime and fourth-generation cephalosporins (frequently in combination with an aminoglycoside) • Chloramphenicol • Fluoroquinolones • Penicillins (advanced-generation) (carbenicillin, ticarcillin; frequently in combination with an aminoglycoside)
<i>Salmonella</i> spp.	<ul style="list-style-type: none"> • Aminoglycosides • Chloramphenicol • Fluoroquinolones • Penicillins (advanced-generation) • Trimethoprim/sulfas
<i>Chlamydia</i>	<ul style="list-style-type: none"> • Azithromycin • Enrofloxacin (vs. some species) • Erythromycin • Tetracyclines (doxycycline)
<i>Mycoplasma</i> spp.	<ul style="list-style-type: none"> • Azithromycin • Chloramphenicol • Clindamycin • Enrofloxacin • Lincosamides • Macrolides • Tetracyclines

^aEffective vs. most obligate anaerobes; inactive vs. most aerobic bacteria or facultative anaerobes.

TABLE 15-3 Antimicrobial Therapy Used in Exotic Animals According to Site of Infection.^{a,b}

Site of Infection	Antimicrobial Agent
Bacteremia, septicemia	Aerobic bacteria
	Anaerobic bacteria
Soft-tissue infection	Respiratory tract
	Alimentary tract

Continued

TABLE 15-3 Antimicrobial Therapy Used in Exotic Animals According to Site of Infection. (cont'd)

Site of Infection	Antimicrobial Agent	
Skin	Amoxicillin/clavulanate	
	Azithromycin	
	Cephalosporins	
	Clindamycin	
	Erythromycin	
	Fluoroquinolones	
	Lincomycin	
	Trimethoprim/sulfas	
	Bone and/or joint	Aminoglycosides
		Azithromycin
Cephalosporins		
Cephalosporins (third-generation) with clindamycin (vs. anaerobes)		
Clindamycin		
Fluoroquinolones		
Lincosamides		
Penicillins (extended-spectrum)		
Penicillins with clindamycin (vs. anaerobes)		
Urinary tract		Cephalosporins (cefadroxil, cefazolin, cephalexin)
	Fluoroquinolones	
	Penicillins (amoxicillin, amoxicillin/clavulanate, ampicillin)	
	Sulfisoxazole	
	Tetracyclines	
	Trimethoprim/sulfas	
	Central nervous system	Azithromycin
Cephalosporins (third-generation) (excluding cefovecin, cefpodoxime)		
Chloramphenicol (encephalitis)		
Florfenicol		
Fluoroquinolones (meningitis)		
Metronidazole (vs. anaerobes)		
Penicillins (in cases of inflammation)		
Reproductive tract	Trimethoprim/sulfas	
	Amoxicillin/clavulanate	
	Chloramphenicol	
	Clindamycin (vs. anaerobes)	
	Fluoroquinolones	
	Florfenicol	
Trimethoprim/sulfas		

^aDefinitive therapy should be based on bacterial culture and sensitivity and host species involved.

^bModified from: Carpenter JW, ed. *Exotic Animal Formulary*. 4th ed. St. Louis: Elsevier-Saunders; 2013; Papich MG. *Saunders Handbook of Veterinary Drugs. Small and Large Animal*. 4th ed. St. Louis: Elsevier; 2016; Plumb DC, ed. *Plumb's Veterinary Drug Handbook*. 8th ed. Ames: Wiley Blackwell; 2015.

TABLE 15-4 Antimicrobial Combination Therapies Commonly Used in Exotic Animals.^a

Antimicrobial Agent	Synergistic or Combination Agent
Aminoglycosides ^b (amikacin, gentamicin)	Cephalosporins, clindamycin, fluoroquinolones, lincomycin, metronidazole, penicillins (amoxicillin, ampicillin, carbenicillin, piperacillin, ticarcillin), trimethoprim/sulfas
Amoxicillin	Clavulanate
Ampicillin	Sulbactam
Cephalosporin	Aminoglycosides, ^b clindamycin, fluoroquinolones, metronidazole, semi-synthetic penicillins
Clindamycin	Aminoglycosides, cephalosporins (third-generation), enrofloxacin, penicillins
Fluoroquinolones (enrofloxacin, ciprofloxacin, marbofloxacin)	Aminoglycosides, ^b cephalosporins (third-generation), clindamycin, metronidazole, penicillins (extended-spectrum)
Lincomycin	Aminoglycosides, ^b spectinomycin
Metronidazole	Amikacin, azithromycin, carbenicillin, cefazolin, cefotaxime, chloramphenicol, enrofloxacin, gentamicin, marbofloxacin, others as indicated
Ormetoprim	Sulfadimethoxine
Penicillins (ampicillin, carbenicillin, piperacillin)	Aminoglycosides, ^b fluoroquinolones
Penicillins, early generation	Aminoglycosides, ^b third-generation cephalosporins, fluoroquinolones
Ticarcillin	Clavulanate
Trimethoprim	Sulfadiazine, sulfamethoxazole
Tylosin	Oxytetracycline

^aIndicated when synergy is advantageous in definitive therapy, to treat polymicrobial infections, to broaden empiric coverage, or to attempt to prevent the development of antimicrobial resistance.

^bGenerally amikacin, occasionally gentamicin.

TABLE 15-5 Select Laboratories Conducting Exotic Animal Diagnostic Procedures.

Laboratory	Select Tests/Procedures
Animal Health Diagnostic Center College of Veterinary Medicine Cornell University PO Box 5786 Ithaca, NY 14852 USA (607) 253-3900 ahdc.vet.cornell.edu	General: Chemistry, hematology, clotting panels, histopathology, microbiology, necropsy, parasitology, virology Avian: <i>Chlamydia</i> , <i>Cryptosporidium</i> , <i>Giardia</i> , <i>Mycobacterium</i> , <i>Mycoplasma</i> , infectious bronchitis virus, infectious bursal disease, influenza virus, paramyxovirus, West Nile virus, viral isolation, blood lead/zinc Mammal: Ferret enteric coronavirus, ferret influenza virus, mink enteric coronavirus, ferret adrenal testing Reptile: <i>Cryptosporidium</i> , <i>Salmonella</i>
Antech Diagnostics 10 Executive Boulevard Farmingdale, NY 11735 USA (800) 745-4725 (West) (800) 872-1001 (East)	General: Chemistry, electrophoresis, hematology, microbiology, virology Avian: <i>Mycoplasma</i> , <i>Chlamydia</i> , <i>Aspergillus</i> , polyomavirus, psittacine beak and feather disease virus, West Nile virus, sex determination, blood lead/zinc

Continued

TABLE 15-5 Select Laboratories Conducting Exotic Animal Diagnostic Procedures. (cont'd)

Laboratory	Select Tests/Procedures
<p>(800) 341-3440 (Canada) antechdiagnostics.com</p>	<p>Mammal: <i>Pasteurella</i>, <i>Encephalitozoon</i>, <i>Treponema</i>, <i>Toxoplasma</i>, ferret adrenal panel, distemper virus, Aleutian disease virus Reptile: <i>Mycoplasma</i></p>
<p>Avian Biotech International Animal Genetics, Inc. 1336 Timberlane Road Tallahassee, FL 32312 USA (800) 514-9672 (850) 386-1145 avianbiotech.com</p>	<p>Avian: <i>Bordetella</i>, <i>Chlamydia</i>, <i>Mycobacterium</i>, <i>Salmonella</i>, <i>Aspergillus</i>, <i>Candida</i>, <i>Cryptosporidium</i>, <i>Giardia</i>, paramyxovirus, pigeon circovirus, polyomavirus, psittacine beak and feather disease virus, herpes virus, influenza virus, West Nile virus, Pacheco's disease, sex determination</p>
<p>Avian & Exotic Animal Clin Path Labs 2712 North Highway 68 Wilmington, OH 45177 USA (937) 383-3347 (800) 350-1122 avianexoticlab.com</p>	<p>General: Chemistry, electrophoresis, hematology, histopathology, microbiology, parasitology, toxicology, virology Avian: <i>Chlamydia</i>, <i>Salmonella</i>, <i>Aspergillus</i>, <i>Histoplasma</i>, <i>Cryptosporidium</i>, <i>Giardia</i>, <i>Sarcocystis</i>, adenovirus, influenza virus, Pacheco's disease, paramyxovirus, polyomavirus, West Nile virus, blood iron/lead/zinc Mammal: Heartworm testing, <i>Toxoplasma</i>, distemper virus Herps: <i>Cryptosporidium</i>, <i>Giardia</i>, chytrid, inclusion body disease, ophidian paramyxovirus</p>
<p>Avian and Wildlife Laboratory Division of Comparative Pathology University of Miami School of Medicine 1611 NW 12th Avenue Miami, FL 33136 USA (305) 585-6303 cpl.med.miami.edu</p>	<p>General: Chemistry, electrophoresis, hematology Avian: <i>Aspergillus</i>, <i>Chlamydia</i>, <i>Cryptosporidium</i>, Pacheco's virus, polyomavirus, psittacine beak and feather disease virus, sex determination Mammal: CAR bacillus, <i>Clostridium piliforme</i>, <i>Mycoplasma</i>, <i>Pasteurella</i>, <i>E. cuniculi</i>, guinea pig adenovirus, coronavirus, Kilham's rat virus, lymphocytic choriomeningitis virus, mouse hepatitis virus, minute virus of mice, pneumonia virus of mice, parainfluenza virus 3, parvovirus, rotavirus, Sendai virus, Theiler's murine encephalomyelitis virus</p>
<p>Diagnostic Center for Population and Animal Health Michigan State University 4125 Beaumont Road Lansing, MI 48910 USA (517) 353-1683 animalhealth.msu.edu</p>	<p>General: Chemistry, hematology, histopathology, microbiology, necropsy, protein electrophoresis, toxicology, virology Avian: <i>Chlamydia</i>, <i>Mycobacterium</i>, <i>Mycoplasma</i>, <i>Aspergillus</i>, <i>Cryptosporidium</i>, <i>Salmonella</i>, Newcastle disease virus, infectious bronchitis virus, infectious laryngotracheitis virus, influenza virus, West Nile virus, blood lead Mammal: <i>Cryptosporidium</i>, <i>Giardia</i>, <i>Salmonella</i>, Aleutian disease virus, ferret enteric coronavirus, ferret rotavirus Herps: <i>Mycoplasma</i>, <i>Salmonella</i>, <i>Cryptosporidium</i></p>
<p>Diagnostic Laboratory Service College of Veterinary Medicine University of Tennessee 2407 River Drive Knoxville, TN 37996 USA (865) 974-8387 vetmed.tennessee.edu/vmc/dls</p>	<p>General: Chemistry, endocrinology, hematology, histopathology, microbiology, necropsy, parasitology, toxicology, virology Avian: <i>Chlamydia</i>, <i>Mycobacterium</i>, <i>Mycoplasma</i>, <i>Aspergillus</i>, <i>Cryptosporidium</i>, sex determination Mammal: <i>Giardia</i>, influenza A virus, ferret adrenal panel, rabbit adrenal panel Herps: <i>Mycoplasma</i>, <i>Cryptosporidium</i>, herpesvirus, ophidian paramyxovirus, ranavirus</p>

TABLE 15-5 Select Laboratories Conducting Exotic Animal Diagnostic Procedures. (cont'd)

Laboratory	Select Tests/Procedures
<p>Georgia Veterinary Diagnostic Laboratories College of Veterinary Medicine University of Georgia 501 DW Brooks Drive Athens, GA 30602 USA (706) 542-5568 vet.uga.edu/dlab/</p>	<p>General: Chemistry, hematology, histopathology, microbiology, necropsy, parasitology, toxicology, virology Avian: <i>Chlamydia</i>, <i>Mycobacterium</i>, <i>Mycoplasma</i>, <i>Salmonella</i>, <i>Aspergillus</i>, <i>Cryptosporidium</i>, <i>Plasmodium</i>, herpesvirus, influenza virus, Newcastle disease virus, West Nile virus, Pacheco's disease Mammal: <i>Bordetella</i>, <i>Clostridium</i> (toxin panel), <i>Francisella tularensis</i>, <i>Helicobacter</i>, <i>Lawsonia</i>, <i>Mycobacteria</i>, <i>Mycoplasma</i>, <i>Pasteurella</i>, <i>Salmonella</i>, <i>Treponema</i>, <i>Encephalitozoon</i>, herpesvirus, influenza A virus, lymphocytic choriomeningitis virus, morbilliviruses, mouse hepatitis virus, mouse reoviruses, murine norovirus, paramyxovirus, pneumonia virus of mice, rabies virus, rodent parvoviruses, Sendai virus, simian virus 5, Tyzzer's disease Herps: <i>Cryptosporidium</i>, <i>Mycoplasma</i>, <i>Salmonella</i>, adenovirus, herpesvirus, ranavirus Aquatic: Aquatic bacterial and fungal cultures (including <i>Mycobacterium</i> and <i>Mycoplasma</i>)</p>
<p>Kansas State Veterinary Diagnostic Laboratory College of Veterinary Medicine Kansas State University 1800 Denison Avenue Manhattan, KS 66506 USA (866) 512-5650 vet.k-state.edu/depts/dmp/service</p>	<p>General: Chemistry, hematology, histopathology, microbiology, necropsy, parasitology, protein electrophoresis, toxicology, virology Avian: <i>Bordetella</i>, <i>Chlamydia</i>, <i>Salmonella</i>, <i>Aspergillus</i>, <i>Cryptosporidium</i>, influenza virus, Newcastle disease virus, West Nile virus, blood lead Mammal: <i>Francisella tularensis</i>, <i>Lawsonia</i>, <i>Giardia</i>, <i>Cryptosporidium</i>, influenza virus, rabies virus Herps: <i>Salmonella</i></p>
<p>National Veterinary Services Laboratory USDA-APHIS-VS-NVSL PO Box 844 Ames, IA 50010 USA (515) 337-7266 aphis.usda.gov/aphis/ourfocus/animalhealth/lab-info-services</p>	<p>General: Microbiology, virology Avian: <i>Avibacterium paragallinarum</i>, <i>Bordetella</i>, <i>Chlamydia</i>, <i>Mycobacterium</i>, <i>Mycoplasma</i>, <i>Ornithobacterium rhinotracheale</i>, <i>Pasteurella</i>, <i>Salmonella</i>, adenoviruses, avian pox virus, chicken anemia virus, duck viral enteritis virus, encephalomyelitis virus, goose parvovirus, herpesviruses, infectious bronchitis virus, infectious bursal disease, infectious laryngotracheitis, influenza virus, Marek's disease, metapneumovirus, nephritis virus, paramyxoviruses, reovirus, rotavirus, West Nile virus Mammal: <i>Francisella tularensis</i> Aquatic: Various bacterial and viral testing options for aquaculture (contact lab for arrangements)</p>
<p>Northwest ZooPath 654 West Main Street Monroe, WA 98272 USA (360) 794-0630 zoopath.com</p>	<p>General: Pathology</p>
<p>Research Associates Laboratory 14556 Midway Road Dallas, TX 75224 USA (972) 960-2221 veta.com</p>	<p>General: Microbiology, virology Avian: <i>Bartonella</i>, <i>Bordetella</i>, <i>Chlamydia</i>, <i>Cryptosporidium</i>, <i>Helicobacter</i>, <i>Mycobacterium</i>, <i>Mycoplasma</i>, <i>Salmonella</i>, <i>Aspergillus</i>, <i>Candida</i>, avian gastric yeast, <i>Giardia</i>, plasmodium, adenoviruses, circoviruses, duck enteritis virus, herpesviruses, Marek's disease, polyomavirus, poxvirus, psittacine beak and feather disease virus, sex determination</p>

Continued

TABLE 15-5 Select Laboratories Conducting Exotic Animal Diagnostic Procedures. (cont'd)

Laboratory	Select Tests/Procedures
<p>Texas Veterinary Medical Diagnostic Laboratory Texas A&M University 1 Sippel Road College Station, TX 77843 USA (979) 845-3414 (888) 646-5623 tvmld.tamu.edu</p>	<p>Mammal: <i>Anaplasma</i>, <i>Babesia</i>, <i>Bartonella</i>, <i>Bordetella</i>, <i>Brucella</i>, <i>Campylobacter</i>, <i>Chlamydia</i>, <i>Clostridium</i>, <i>Coxiella</i>, <i>E. coli</i>, <i>Ehrlichia</i>, <i>Francisella tularensis</i>, <i>Helicobacter</i>, <i>Lawsonia intracellularis</i>, <i>Pasteurella</i>, <i>Mycobacterium</i>, <i>Mycoplasma</i>, <i>Candida</i>, <i>Cryptosporidium</i>, <i>Encephalitozoon</i>, <i>Entamoeba</i>, <i>Enterocytozoon</i>, <i>Giardia</i>, <i>Hepatozoon</i>, <i>Plasmodium</i>, <i>Sarcocystis</i>, <i>Spironucleus</i>, <i>Toxoplasma</i>, Aleutian disease, astrovirus, distemper virus, ferret epizootic catarrhal enteritis, hantavirus, hepatitis E virus, lymphocytic choriomeningitis virus, myxomavirus, orthopoxvirus, rabies virus, West Nile virus</p> <p>Herps: <i>Campylobacter</i>, <i>Clostridium</i>, <i>Mycobacterium</i>, <i>Mycoplasma</i>, <i>Pasteurella</i>, <i>Salmonella</i>, <i>Aspergillus</i>, <i>Candida</i>, CANV, chytrid, <i>Cryptosporidium</i>, <i>Entamoeba</i>, <i>Giardia</i>, <i>Plasmodium</i>, <i>Spironucleus</i>, arenavirus, atadenovirus, herpesviruses, iridovirus, fibropapillomatosis, ophidian paramyxovirus, ranavirus, sunshine virus, West Nile virus</p> <p>Aquatic: Bacterial, viral, and parasitic testing (see Web site for extensive list)</p>
<p>Veterinary Medical Diagnostic Lab College of Veterinary Medicine University of Missouri PO Box 6023 Columbia, MO 65205 USA (573) 882-6811 vmdl.missouri.edu</p>	<p>General: Chemistry, hematology, histopathology, microbiology, necropsy, protein electrophoresis, toxicology, virology</p> <p>Avian: <i>Chlamydia</i>, <i>Mycobacterium</i>, <i>Mycoplasma</i>, <i>Salmonella</i>, <i>Aspergillus</i>, <i>Cryptosporidium</i>, avian encephalomyelitis virus, duck enteritis virus, infectious bronchitis virus, infectious bursal disease virus, infectious laryngotracheitis virus, influenza virus, paramyxoviruses, reovirus, reticuloendotheliosis virus, West Nile virus, blood lead/zinc/iron</p> <p>Mammal: <i>Bordetella</i>, <i>E. coli</i>, <i>Mycoplasma</i>, <i>Salmonella</i>, <i>Cryptosporidium</i>, <i>Giardia</i>, distemper virus, rabies virus</p> <p>Herps: <i>Mycoplasma</i>, <i>Salmonella</i>, <i>Cryptosporidium</i></p> <p>General: Histopathology, microbiology, necropsy, toxicology, virology</p> <p>Avian: <i>Bordetella</i>, <i>Chlamydia</i>, <i>Mycoplasma</i>, <i>Ornithobacterium rhinotracheale</i>, <i>Salmonella</i>, <i>Cryptosporidium</i>, avian encephalitis virus, hemorrhagic enteritis virus, infectious bronchitis virus, influenza virus, Newcastle disease virus, rotavirus, blood lead/zinc</p>
<p>Veterinary Molecular Diagnostics, Inc. 5989 Meijer Drive, Suite 5 Milford, OH 45150 USA (513) 576-1808 vmdlabs.com</p>	<p>General: Molecular diagnostics</p> <p>Avian: <i>Bordetella</i>, <i>Chlamydia</i>, <i>Mycobacterium</i>, <i>Mycoplasma</i>, <i>Aspergillus</i>, avian gastric yeast, adenovirus, bornavirus, circoviruses, coronavirus, polyomavirus, psittacine beak and feather disease virus, psittacine herpes virus, West Nile virus, sex determination</p> <p>Mammal: <i>Campylobacter</i>, <i>Helicobacter</i>, <i>Lawsonia</i>, <i>Encephalitozoon</i>, Aleutian disease virus, epizootic catarrhal enteritis virus</p> <p>Herps: <i>Cryptosporidium</i>, <i>Mycoplasma</i>, bearded dragon atadenovirus</p>
<p>Wisconsin Veterinary Diagnostic Laboratory University of Wisconsin 455 Easterday Lane</p>	<p>General: Histopathology, microbiology, necropsy, virology</p> <p>Avian: <i>Bordetella</i>, <i>Chlamydia</i>, <i>Mycoplasma</i>, <i>Salmonella</i>, <i>Cryptosporidium</i>, avian encephalitis virus, duck viral enteritis virus, infectious bronchitis virus, infectious bursal disease virus,</p>

TABLE 15-5 Select Laboratories Conducting Exotic Animal Diagnostic Procedures. (cont'd)

Laboratory	Select Tests/Procedures
Madison, WI 53706 USA (608) 262-5432 (800) 608-8387 wvdl.wisc.edu	infectious laryngotracheitis virus, influenza virus, paramyxovirus, pneumovirus, polyomavirus, poxvirus, psittacine herpes virus, turkey hemorrhagic enteritis virus, West Nile virus Herps: <i>Mycoplasma</i> , <i>Salmonella</i>
Zoo/Exotic Pathology Service 2825 Kovr Drive West Sacramento, CA 95605 USA (916) 725-5100 zooexotic.com	General: Pathology
Zoologix, Inc 9811 Owensmouth Avenue Suite 4 Chatsworth, CA 91311 USA (818) 717-8880 zoologix.com	General: Molecular diagnostics Avian: <i>Avibacterium paragallinarum</i> , <i>Bordetella</i> , <i>Chlamydia</i> , <i>Mycobacterium</i> , <i>Mycoplasma</i> , <i>Ornithobacterium rhinotracheale</i> , <i>Salmonella</i> , <i>Aspergillus</i> , <i>Candida</i> , <i>Atoxoplasma</i> , <i>Cryptosporidium</i> , <i>Plasmodium</i> , adenovirus, bornavirus, circovirus, herpesvirus, infectious bronchitis virus, infectious bursal disease virus, infectious laryngotracheitis virus, influenza virus, Newcastle disease virus, Pacheco's disease, polyomavirus, poxvirus, psittacine beak and feather disease virus, reovirus, West Nile virus
	Mammal: <i>Bordetella</i> , <i>Campylobacter</i> , <i>E. coli</i> , <i>Francisella tularensis</i> , <i>Helicobacter</i> , <i>Lawsonia intracellularis</i> , <i>Mycobacterium</i> , <i>Mycoplasma</i> , <i>Pasteurella</i> , <i>Salmonella</i> , <i>Giardia</i> , <i>Treponema</i> , Aleutian disease virus, hantavirus, lymphocytic choriomeningitis virus, mink enteritis virus, monkeypox, mouse adenovirus, mouse cytomegaloviruses, mouse hepatitis virus, mouse minute virus, mouse norovirus, mouse parvovirus, mouse polyoma virus, mouse pox virus, mouse rotavirus, pneumonia virus of mice, rabbit fibroma virus, rabies virus, rat coronavirus, reovirus, rotavirus, Sendai virus, sialodacryoadenitis virus, Tyzzer's disease Herps: <i>Mycobacterium</i> , <i>Mycoplasma</i> , <i>Salmonella</i> , chytrid fungus, <i>Cryptosporidium</i> , ranavirus
Zoo Medicine Service College of Veterinary Medicine University of Florida PO Box 100126 Gainesville, FL 32610 USA (352) 392-4700 (ext. 5700) http://labs.vetmed.ufl.edu/sample-requirements/zoo-med-infections/	General: Consensus polymerase chain reaction (PCR) and sequencing Herps: <i>Chlamydiales</i> , <i>Mycobacterium</i> , <i>Mycoplasma</i> , coccidia, <i>Cryptosporidium</i> , microsporidians, pentastomids, adenoviruses, arenaviruses, astroviruses, erythrocytic iridoviruses, ferliruses, herpesviruses, orthoreoviruses, papillomaviruses, paramyxoviruses, poxviruses, ranaviruses, rhabdoviruses

TABLE 15-6 Professional Associations for Veterinarians Interested in Exotics.^a

Organization	Web Site
American Association of Wildlife Veterinarians	aawv.net
American Association of Zoo Veterinarians	aazv.org
American Board of Veterinary Practitioners	abvp.com
American College of Zoological Medicine	aczm.org
American Society of Laboratory Animal Practitioners	aslap.org
Association of Amphibian and Reptilian Veterinarians	arav.org
Association of Avian Veterinarians	aav.org
Association of Exotic Mammal Veterinarians	aemv.org
Association of Primate Veterinarians	primatevets.org
Association of Sugar Glider Veterinarians	asgv.org
Association of Zoo Veterinary Technicians	azvt.org
British Veterinary Zoological Society	bvzs.org
Canadian Association of Zoo and Wildlife Veterinarians	cazww.org
European Association of Zoo and Wildlife Veterinarians	eazww.org
International Association for Aquatic Animal Medicine	iaaam.org
National Wildlife Rehabilitators Association	nrawildlife.org

^aWeb sites accessed on August 2, 2016.

TABLE 15-7 Exotic Animal Online Resources for Practitioners.^a

Site Name	Web Site	Description
American Society for the Prevention of Cruelty to Animals	aspc.org	Contains an Animal Poison Control Center and general pet care guidelines
Amphibian Diseases Home Page	arwh.org/amphibian-dz-homepage	Australian page focusing on current information on amphibian diseases
Animal Diversity Web	animaldiversity.org	Taxonomic site from the University of Michigan Museum of Zoology
Avibase	avibase.bsc-eoc.org	Searchable database with taxonomic information and photographs of the world's bird species
Biodidac	biodidac.bio.uottawa.ca	Bank of digital resources for teaching biology; includes anatomy line drawings
BioOne	bioone.org	Resource database collection of bioscience research journals; contains multiple peer-reviewed exotic journals

TABLE 15-7 Exotic Animal Online Resources for Practitioners. (cont'd)

Site Name	Web Site	Description
Center for Agricultural Bioscience International	cabi.org	Resource database collection of agricultural and bioscience journals; contains multiple peer-reviewed exotic journals
Convention on International Trade in Endangered Species	cites.org	International agreement between governments concerning the international trade of wild animals and plants
The Colyer Institute	colyerinstitute.org	Center for the study of oral disease and nutrition in exotic animals
Dental Anatomy	arbl.cvms.colostate.edu/hbooks/pathphys/digestion/pregastric/dentalanat.html	Includes information and images of dental anatomy of rabbits and rodents (from Colorado State University)
Diseases of Research Animals (DORA)	dora.missouri.edu	Teaching resources from the University of Missouri regarding diseases seen in species commonly kept for research purposes
Exotic DVM	exoticdvm.com	Web site for the <i>Exotic DVM</i> magazine
Exotic Pet Vet Net	exoticpetvet.net	Web site of veterinary articles from exotic veterinarians
The Humane Society	humanesociety.org	Includes care sheets for many exotic species
International Species Information System (recently renamed: Species 360)	species360.org (previous Web site: isis.org)	Global network of animal management professionals
International Union for the Conservation of Nature	iucn.org	Organization dedicated to finding pragmatic solutions to environment and development challenges; produces the IUCN Red List of Threatened Species
International Veterinary Information System	ivis.org	Online veterinary book publisher with free access to multiple online books
An Introduction to Ratite Rearing and Medicine	instruction.cvhs.okstate.edu/kocan/ostrich/ostbk2a1.htm	Online book of ratite medicine from Oklahoma State University
Medirabbit	medirabbit.com	Rabbit medicine articles and video demonstrations
The Merck Veterinary Manual	merckvetmanual.com	<i>Merck Veterinary Manual</i> online including exotic animals with normal physiological parameters
PubMed	ncbi.nlm.nih.gov/pubmed	Digital Archive of the US National Library of Medicine; contains multiple peer-reviewed exotic journals
Species 360 (formerly International Species Information System)	species360.org	Global network of animal management professionals
Tufts University Open Courseware, Zoological Medicine Course	ocw.tufts.edu/Course/60	Open access course notes from the Tufts University College of Veterinary Medicine Zoological Medicine Course

Continued

TABLE 15-7 Exotic Animal Online Resources for Practitioners. (cont'd)

Site Name	Web Site	Description
University of Pennsylvania Computer Aided Learning	research.vet.upenn.edu/Home/tabid/5849/Default.aspx	Computer Aided Learning Program from the University of Pennsylvania School of Veterinary Medicine; includes Special Species Clinical Pathology and Special Species Radiology Sections
USDA APHIS	aphis.usda.gov	United States Department of Agriculture, Animal Plant Health Inspection Service
Veterinary Information Network	vin.com	Member-based network of veterinary consultants; large bank of information on zoo and exotic animals
Veterinary Partner	veterinarypartner.com	Partner to the Veterinary Information Network, contains information and handouts for clients concerning medical diseases
World Organization for Animal Health (OIE)	oie.int	Intergovernmental organization responsible for improving animal health worldwide

^aWeb sites accessed on August 1, 2016. Please note that Elsevier Inc. and the editor of the *Exotic Animal Formulary*, 5th ed. have not reviewed all of the content of these sites and, therefore, cannot confirm the accuracy of the information presented.

TABLE 15-8 Captive Husbandry Web Sites for Owners of Exotic Animals.^a

Category	Site Name	Web Site	Description
Aquatics	Fish Channel	fishchannel.com	Web site with information on tropical and saltwater aquariums including a large variety of species-specific information
	Fish Lore	fishlore.com	Tropical fish, freshwater aquarium, and saltwater aquarium information Web site
	Fish Tank Guide	fish-tank-guide.com	Web site including information on basic tank care, fish care, and medical information. Also contains some species-specific information on common aquarium fish
	Goldfish Society of America	goldfishsociety.org	Association for goldfish enthusiasts; includes husbandry and care information
	International Fancy Guppy Association	ifga.org	Association dedicated to the Fancy Show Guppy; contains general starter information and medical information on guppies
Herptile	Bearded Dragon Care	beardeddragoncare.net	Web site dedicated to provide bearded dragon care information to pet lizard owners
	Boa Tips	boatips.com	Web site for pet snakes; includes husbandry and care articles as well as species-specific information and photographs

TABLE 15-8 Captive Husbandry Web Sites for Owners of Exotic Animals. (cont'd)

Category	Site Name	Web Site	Description
	Box Turtle Care and Conservation	boxturtlesite.info	Web site for natural history and captive care of North American box turtles
	Chameleon Care and Information Center	chameleoninfo.com	Web site devoted to chameleons; includes husbandry and care articles
	Frog World	frogworld.net	Web site concerning natural history, husbandry, and care of multiple frog species
	Green Iguana Society	greenigsociety.org	Society dedicated to providing quality information on iguana care; contains husbandry and care articles as well as some medical information
	Lizard Landscapes	lizard-landscapes.com	Web site with husbandry and care information for multiple species of reptiles; also contains information on building cage landscapes
	The Lizard Lounge	the-lizard-lounge.com	Web site containing husbandry and care information as well as taxonomy, photographs, natural history, and medical information on multiple species of lizards
	Melissa Kaplan's Herp Care Collection	anapsid.org	Web site containing husbandry and care articles on amphibians, reptiles, and invertebrates
	Pet Snakes	pet-snakes.com	Web site containing husbandry and care information as well as listings of some exotic animal vet clinics by states
	Poison Dart Frogs	poisondartfrog.co.uk	Web site containing husbandry and care information on <i>Dendrobates</i> species
	Reptile Web	reptilesweb.com	A world reptile amphibian information center; contains husbandry and care information for reptiles, amphibians, and invertebrates
	Tortoise Trust	tortoisetrust.org	Web site with information on turtles and tortoises including species care sheets and husbandry articles
	World Chelonian Trust	cheloniasociety.org	Web site with information on turtles and tortoises including species care sheets and chelonian taxonomy.
Avian	African Love Bird Society	africanlovebirdsociety.org	Association dedicated to keeping, breeding, and showing of love birds; contains husbandry and care information along with information on the nine species
	American Budgerigar Society	abs1.org	Society for information about keeping, breeding, and exhibiting budgerigars

Continued

TABLE 15-8 Captive Husbandry Web Sites for Owners of Exotic Animals. (cont'd)

Category	Site Name	Web Site	Description
	American Dove Association	americandoveassociation.com	Association for dove enthusiasts; contains husbandry and care information along with information on the different species
	American Federation of Aviculture	afabirds.org	Nonprofit organization whose purpose is to represent all aspects of aviculture and to educate the public about keeping and breeding birds in captivity
	American Ostrich Association	ostrich.org	Association to establish the standards for the highest quality American ostrich products to ensure the long-term viability of the industry
	Foraging For Parrots	foragingforparrots.com	Web site on how to make foraging toys for psittacine birds
	International Cockatiel Society	cockatiels.org	Society dedicated to providing information on the proper care, handling, maintenance, and breeding of cockatiels
	National Finch and Softbill Society	nfss.org	Society dedicated to promoting the enjoyment of keeping and breeding finches and softbills
	Parrot A.L.E.R.T.	parrotalert.org	Web site for reporting lost and found parrots; also includes husbandry articles
	Parrot Outreach Society	parrotoutreachsociety.org	Society dedicated to helping birds find homes; includes basic bird care articles
	World Parrot Trust	parrots.org	Organization to promote survival of all parrot species in the wild and to advocate for the welfare of individual birds in our homes
Mammal	American Fancy Rat and Mouse Association	afma.org	Association to promote and encourage the breeding and exhibition of fancy rats and mice for show and pets
	American Ferret Association	ferret.org	Association to promote the domestic ferret as a companion animal through public education via shows, newsletters, legislative education, and other venues
	American Gerbil Society	agsgerbils.org	Society providing support and education to breeders, caregivers, and gerbil enthusiasts
	American Rabbit Breeders Association	arba.net	Association dedicated to the promotion, development, and improvement of the domestic rabbit and cavy
	Cheeky Chinchilla	cheekychinchillas.com	Husbandry and care information for chinchillas
	Ferret Universe	ferretuniverse.com	Husbandry and care information for ferrets

TABLE 15-8 Captive Husbandry Web Sites for Owners of Exotic Animals. (cont'd)

Category	Site Name	Web Site	Description
	Ferret Village	ferretvillage.org	Message boards concerning ferrets
	Gerbil Care	gerbilcare.org	Husbandry and care information for gerbils
	Guinea Lynx	guinealynx.info	Husbandry and care information for guinea pigs
	Hamster Hideout	hamsterhideout.com	Husbandry and care information for hamsters
	Hamsterific	hamsterific.com	Husbandry and care information for hamsters
	House Rabbit Society	rabbit.org	Society that rescues rabbits from animal shelters and educates the public on rabbit care and behavior
	International Ferret Congress	ferretcongress.org	Organization to enhance the welfare of the domestic ferret as a companion animal
	International Hedgehog Association	hedgehogclub.com	Association to educate the public in the care and betterment of hedgehogs
	My House Rabbit	myhouserabbit.com	Web site celebrating house rabbits and educating the public about rabbit care and behavior
	North American Sugar Glider Association	mynasga.org	Association to provide information to persons considering getting a sugar glider for a family pet
	Pet Hamster Care	pethamstercare.com	Husbandry and care information for hamsters
	Rat Guide	ratguide.com	A layman's guide to health, medication use, breeding, and responsible care of pet rats
	Sugarglider	sugarglider.com	Husbandry and care information for sugar gliders
	Weasel Words	weaselwords.com	Husbandry and care information for ferrets

^aWeb sites accessed on August 1, 2016. Please note that Elsevier Inc. and the editor of the *Exotic Animal Formulary*, 5th ed. have not reviewed all of the content of these sites and therefore cannot confirm the accuracy of the information presented.

TABLE 15-9 Emergency Drug Doses (in mL) Commonly Used in Exotic Animals.^a

Emergency Drug			Gerbils, Hamsters, Mice, Rats								Guinea Pigs, Chinchillas		
Drug	Conc	Route	25 g	50 g	75 g	100 g	125 g	150 g	250 g	500 g	0.5 kg	1 kg	1.5 kg
Epinephrine	0.01 mg/mL	IV, IM, IO	0.01	0.02	0.02	0.03	0.04	0.05	0.08	0.15	0.15	0.3	0.45
Atropine	0.54 mg/mL	IM, SC	0.03	0.04	0.06	0.07	0.09	0.11	0.19	0.37	0.37	0.74	1.11
Glycopyrrolate	0.2 mg/mL	IM, SC	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.05	0.05	0.1	0.15
Dex SP	4 mg/mL	IV, IM	0.03	0.06	0.09	0.13	0.16	0.19	0.32	0.63	0.63	1.25	1.87
Doxapram	20 mg/mL	IV, SC	0.02	0.03	0.04	0.05	0.07	0.08	0.13	0.25	0.25	0.5	0.75
Diazepam	5 mg/mL	IV, IM, IO	0.01	0.03	0.05	0.06	0.08	0.09	0.15	0.3	0.3	0.6	0.9
Furosemide	5 mg/mL	IV, IM, SC	0.02	0.04	0.06	0.08	0.1	0.12	0.2	0.4	0.4	0.8	1.12

Emergency Drug			Rabbits							Ferrets			
Drug	Conc	Route	0.5 kg	1 kg	1.5 kg	2 kg	3 kg	4 kg	5 kg	0.5 kg	1 kg	1.5 kg	2 kg
Epinephrine	1 mg/mL	IV, IM, IO	0.5	1.0	1.5	2.0	3.0	4.0	5.0	0.1	0.2	0.3	0.4
Atropine	0.54 mg/mL	IM, SC	0.5	0.9	1.4	1.9	2.8	3.7	4.6	0.05	0.1	0.15	0.2
Glycopyrrolate	0.2 mg/mL	IM, SC	0.05	0.1	0.15	0.2	0.3	0.4	0.5	0.03	0.05	0.08	0.1
Dex SP	4 mg/mL	IV, IM	0.25	0.5	0.75	1.0	1.5	2.0	2.5	1.0	2.0	3.0	4.0
Doxapram	20 mg/mL	IV, SC	0.13	0.25	0.38	0.5	0.75	1.0	1.3	0.05	0.1	0.15	0.2
Diazepam	55 mg/mL	IV, IM, IO	0.3	0.6	0.9	1.2	1.8	2.4	3.0	0.2	0.4	0.6	0.8
Furosemide	50 mg/mL	IV, IM, SC	0.04	0.08	0.12	0.16	0.24	0.32	0.4	0.04	0.08	0.12	0.16
Diphenhydramine	50 mg/mL	IV, IM	—	—	—	—	—	—	—	0.02	0.04	0.06	0.08

TABLE 15-9 Emergency Drug Doses (in mL) Commonly Used in Exotic Animals. (cont'd)

Emergency Drug			Avian (Psittacine Birds)										
Drug	Conc	Route	0.05 kg	0.1 kg	0.2 kg	0.3 kg	0.4 kg	0.5 kg	0.6 kg	0.7 kg	0.8 kg	0.9 kg	1.0 kg
Epinephrine	1 mg/mL	IV, IM, IO	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
Atropine	0.54 mg/mL	IM, SC	0.05	0.09	0.19	0.28	0.37	0.46	0.56	0.65	0.74	0.83	0.93
Doxapram	20 mg/mL	IV, IM, IO	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
Dex SP	4 mg/mL	IV, IM	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
Ca gluconate	100 mg/mL	IV, IM	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
Diazepam	5 mg/mL	IV, IM, IO	0.01	0.02	0.04	0.06	0.08	0.1	0.12	0.14	0.16	0.18	0.2

Emergency Drug			Reptiles										
Drug	Conc	Route	0.1 kg	0.25 kg	0.5 kg	0.75 kg	1 kg	2 kg	3 kg	4 kg	5 kg	6 kg	7 kg
Atropine	0.54 mg/mL	IV, IM, SC	0.01	0.02	0.04	0.06	0.07	0.15	0.22	0.3	0.37	0.44	0.52
Glycopyrrolate	0.2 mg/mL	IV, IM	0.01	0.02	0.03	0.04	0.05	0.1	0.15	0.2	0.25	0.3	0.35
Dex SP	4 mg/mL	IV, IM	0.01	0.02	0.03	0.05	0.06	0.13	0.19	0.25	0.31	0.38	0.44
Diazepam	5 mg/mL	IV, IM, ICe	0.05	0.12	0.25	0.38	0.5	1.0	1.5	2.0	2.5	3.0	3.5
Ca gluconate	100 mg/mL	IV, IO, SC	0.1	0.3	0.5	0.75	1.0	2.0	3.0	4.0	5.0	6.0	7.0

^aModified from Kottwitz J, Kelleher S. Emergency drugs: Quick reference chart for exotic animals. *Exotic DVM* 2003;5:5:23-25.

TABLE 15-10 Fluid Solutions Used in Exotic Animal Medicine.

Solution Type	Solution	Na ⁺ (mEq/L)	K ⁺ (mEq/L)	Cl ⁻ (mEq/L)	Ca ⁺⁺ (mEq/L)	Mg ⁺⁺ (mEq/L)	Buffer (mEq/L)	Osmolality (mOsm/L)	pH
Crystalloids	Ringer's solution	147	4	156	4	0	0	310	5-7.5
	Lactated Ringer's solution	130	4	109	3	0	28 (lactate)	275	6-7.5
	0.9% NaCl	154	0	154	0	0	0	308	4.5
	5% Dextrose	0	0	0	0	0	0	252	4-6.5
	2.5% Dextrose/0.45% NaCl	77	0	77	0	0	0	280	4.5
	Plasma-Lyte	140	5	98	0	3	27 (acetate) 23 (gluconate)	294	4-6.5
	Normosol-R	140	5	98	0	3	27 (acetate) 23 (gluconate)	294	6.6
Colloids	Dextran 6% and 0.9% NaCl	154	0	154	0	0	0	310	3-7.0
	Hetastarch	154	0	154	0	0	0	309	5.5
	Pentastarch	154	0	154	0	0	0	326	5.0

TABLE 15-11 Common Abbreviations Used in Prescription Writing.

a.c.	before meals	o.d.	right eye
a.d.	right ear	o.s.	left eye
ad lib	at pleasure	o.u.	both eyes
adm	administer	oz	ounce
aq	water	p.c.	after meals
a.s.	left ear	PO (p.o.)	per os
a.u.	both ears	prn (p.r.n.)	as needed
b.i.d.	twice a day	q. (q)	every
c.	with	q.d.	every day
cap(s)	capsule(s)	q4h	every 4 hours, etc.
cc	cubic centimeter	q24h	once a day
disp	dispense	q.i.d.	four times a day
fl oz	fluid ounce	q.o.d.	every other day
g (gm)	gram	q.s.	a sufficient quantity
gr	grain	®	trademarked name
gtt(s)	drop(s)	SC (SQ)	subcutaneously
h (hr)	hour	Sig:	instructions to patient
h.s.	at bedtime	sol'n	solution
IM	intramuscularly	stat	immediately
inj	inject	susp	suspension
IP	intraperitoneally	tab(s)	tablet(s)
IV	intravenously	Tbs	tablespoon
kg	kilogram	t.i.d.	three times a day
lb	pound	tsp	teaspoon
mg	milligram	ut dict.	as directed
mL	milliliter		

TABLE 15-12 Common Weight, Liquid Measure, Length, Percentage, and Milliequivalent Conversions.
Weights

- 1 milligram (mg) = 1000 micrograms (mcg orig) = 0.015 grain
 1 grain (gr) = 64.8 mg (\approx 65 mg)
 1 gram (g) = 15.43 grains (\approx 15 grains) = 1000 mg
 1 kilogram (kg) = 1000 g = 2.2 lb
 1 ounce (oz) = 28.35 g
 1 pound (lb) = 454 g = 16 oz = 0.45 kg
 2.2 pound = 1 kg

Liquid Measures

- 1 drop = 0.05 (1/20) milliliter (mL)
 1 cubic centimeter (cc) = 1 mL
 1 liter (L) = 1000 mL
 1 teaspoon (tsp) = 5 mL
 1 tablespoon (Tbs) = 15 mL
 1 fluid ounce (fl oz) = 29.57 mL (\approx 30 mL)
 1 pint = 473.2 mL (\approx 473 mL)
 1 quart = 2 pints = 32 fl oz = 0.946 L
 1 gallon = 4 quarts = 3.785 L
 1 cup = 8 fl oz = 237 mL = 16 Tbs

Linear Measures

- 1 millimeter (mm) = 0.039 inches (in)
 1 centimeter (cm) = 0.39 in
 1 meter (m) = 39.37 in
 1 inch (in) = 2.54 cm
 1 foot (ft) = 30.48 cm
 1 yard (yd) = 91.44 cm

Percentage Equivalents

- 0.1% solution = 1 mg per mL
 1% solution = 10 mg per mL
 10% solution = 100 mg per mL

Milliequivalents

- 1 mEq Na = 23 mg Na = 58.5 mg NaCl
 1 g Na = 2.54 g NaCl = 43 mEq Na
 1 g NaCl = 0.39 g Na = 17 mEq Na
 1 mEq K = 39 mg K = 74.5 mg KCl
 1 g K = 1.91 g KCl = 26 mEq K
 1 g KCl = 0.52 g K = 13 mEq K
 1 mEq Ca = 20 mg Ca
 1 g Ca = 50 mEq Ca
 1 mEq Mg = 0.12 g $\text{MgSO}_4 \times 7\text{H}_2\text{O}$
 1 g Mg = 10.2 g $\text{MgSO}_4 \times 7\text{H}_2\text{O}$ = 82 mEq Mg

TABLE 15-13 Equivalents of Celsius (Centigrade) and Fahrenheit Temperature Scales.^a

°C	°F	°C	°F	°C	°F
0	32.0	17	62.6	34	93.2
1	33.8	18	64.4	35	95.0
2	35.6	19	66.2	36	96.8
3	37.4	20	68.0	37	98.6
4	39.2	21	69.8	38	100.4
5	41.0	22	71.6	39	102.2
6	42.8	23	73.4	40	104.0
7	44.6	24	75.2	41	105.8
8	46.4	25	77.0	42	107.6
9	48.2	26	78.8	43	109.4
10	50.0	27	80.6	44	111.2
11	51.8	28	82.4	45	113.0
12	53.6	29	84.2	46	114.8
13	55.4	30	86.0	47	116.6
14	57.2	31	87.8	48	118.4
15	59.0	32	89.6	49	120.2
16	60.8	33	91.4	50	122.0

^aConversions: °C = % × (°F - 32); °F = % × (°C) + 32.

TABLE 15-14 System of International (SI) Units Conversion Factors of Hematology Commonly Used in Exotic Animal Medicine.^a

Component	Conventional (USA) Units	SI Unit
Hemoglobin (Hgb)	g/dL	g/L
Red blood cells (RBC)	× 10 ⁶ /μL	× 10 ¹² /L
Reticulocytes	%	%
Mean corpuscular volume (MCV)	fL	fL
Mean corpuscular Hgb (MCH)	pg	pg
Mean corpuscular Hgb concentration (MCHC)	g/dL	g/L
Platelets	× 10 ³ /μL	× 10 ⁹ /L
White blood cells (WBC)	× 10 ³ /μL	× 10 ⁹ /L
Neutrophils (segmented)	× 10 ³ /μL	× 10 ⁹ /L
Neutrophils (bands)	× 10 ³ /μL	× 10 ⁹ /L
Lymphocytes	× 10 ³ /μL	× 10 ⁹ /L
Monocytes	× 10 ³ /μL	× 10 ⁹ /L
Eosinophils	× 10 ³ /μL	× 10 ⁹ /L
Basophils	× 10 ³ /μL	× 10 ⁹ /L

^aAdapted from *Veterinary Laboratory Medicine: Interpretation and Diagnosis*, Meyer DH, Harvey JW, 3rd ed., Copyright, 2004, with permission from Elsevier.

TABLE 15-15 System of International (SI) Units Conversion Factors of Clinical Chemistries Commonly Used in Exotic Animal Medicine.^a

Component	Conventional (USA) Units	Conversion Factor (x)	SI Unit
Albumin	g/dL	10	g/L
Alkaline phosphatase	U/L	1.0	IU/L
ALT (SGPT)	U/L	1.0	IU/L
Ammonia (NH ₃)	μg/dL	0.5871	μmol/L
Amylase	U/L	1.0	IU/L
AST (SGOT)	U/L	1.0	IU/L
Bilirubin	mg/dL	17.10	μmol/L
Calcium	mg/dL	0.2495	mmol/L
Carbon dioxide	mEq/L	1.0	mmol/L
Chloride	mEq/L	1.0	mmol/L
Cholesterol	mg/dL	0.02586	mmol/L
Copper	μg/dL	0.16	μmol/L
Cortisol	μg/dL	27.59	nmol/L
Creatine kinase	U/L	1.0	IU/L
Creatinine	mg/dL	88.40	μmol/L
Fibrinogen	mg/dL	0.01	g/L
Glucose	mg/dL	0.05551	mmol/L
Iron	μg/dL	0.1791	μmol/L
Lipase			
Sigma Tietz	U/dL	280	IU/L
Cherry-Crandall	U/L	1.0	IU/L
Lipid, total	mg/dL	0.01	g/L
Magnesium	mEq/L	0.5	mmol/L
Osmolality	mOsm/kg	1.0	mmol/kg
Phosphate (as inorganic P)	mg/dL	0.3229	mmol/L
Potassium	mEq/L	1.0	mmol/L
Protein (total)	g/dL	10	g/L
Sodium	mEq/L	1.0	mmol/L
Thyroxine (T ₄)	μg/dL	12.87	nmol/L
Triglycerides	mg/dL	0.011	mmol/L
Tri-iodothyronine (T ₃)	μg/dL	15.6	nmol/L
Urea nitrogen	mg/dL	0.3570	mmol/L ^b
Uric acid	mg/dL	59.48	umol/L

^aAdapted from *Veterinary Laboratory Medicine: Interpretation and Diagnosis*, Meyer DH, Harvey JW, 3rd ed., Copyright, 2004, with permission from Elsevier.

^bUrea.

TABLE 15-16 Select Compounding Pharmacies.^{a,b}

State	City	Name	Web Site	Phone
AR	Conway	US Compounding Pharmacy ^b	uscompounding.com	800-718-3588
AZ	Scottsdale	Diamondback Drugs	diamondbackdrugs.com	866-646-2223
AZ	Phoenix	Roadrunner Pharmacy	roadrunnerpharmacy.com	877-518-4589
CA	Bakersfield	Precision Pharmacy	myprecisionpharmacy.com/vet	877-734-3338
	Bellflower	B&B Pharmacy and Health Care Center ^b	bbpharmacy.com	800-231-8905
	Encino	Valley Drug and Compounding	valleydrug.net	818-788-0635
	La Habra	Central Drugs Compounding Pharmacy	centraldrugsrx.com	877-447-7077
	Los Angeles	American Health Solutions Pharmacy	ahsrx.com	800-337-2844
	Merced	Valley Prescription and Compounding Pharmacy ^b	valleyrxandcompounding.com	209-722-5765
	North Hollywood	E-Compounding Pharmacy	ecompounding.com/pharmacy	800-366-4961
	Placerville	Grandpa's Compounding Pharmacy	grandpas-rx.com	530-622-2323
	Rancho Cucamonga	Parkview Compounding Pharmacy ^b	parkviewrx.com	800-605-0166
	San Jose	Leiter's Pharmacy	leiters.com	800-292-6773
	San Rafael	Golden Gate Veterinary Pharmacy ^b	ggvetrx.com	415-455-5590
CO	Monument	Monument Pharmacy	monumentpharmacy.com	800-595-7565
CT	Southington	Beacon Compounding Pharmacy	beaconcompounding.com	860-628-3972
DE	Newark	Save Way Pharmacy	savewaypharmacy.com	302-369-5520
FL	Gainesville	Westlab Pharmacy ^b	westlabpharmacy.com	352-373-8111
IL	Chicago	Braun PharmaCare	braunrx.com	773-549-0634
	Naperville	Martin Avenue Pharmacy ^b	martinavenue.com	630-355-6400
IN	Fort Wayne	Fort Wayne Custom Rx ^b	fwcustomrx.com	260-490-3447
KS	Arkansas City	Taylor Drug	taylordrug.net	800-567-3733
	Lenexa	Midwest Compounders Pharmacy	mwcparmacy.com	888-245-3012
	Overland Park	Stark Pharmacy ^b	starkpharmacy.com	913-345-3800
MA	Scituate	Animal Pharm, LLC	animalpharmllc.com	866-544-3010
MI	Imlay	Creative Compounding Center	ccc-rx.com	800-672-2177
	Saginaw	Healthway Compounding Pharmacy ^b	healthwayrx.com	866-883-8868
MN	Saint Peter	Soderlund Village Drug	villagedrug.com	800-603-8196
MO	Jackson	Horst Pharmacy	horstpharmacy.com	800-640-5940
NE	Ord	Good Life Pharmacy	goodliferx.com	800-752-5694

Continued

TABLE 15-16 Select Compounding Pharmacies. (cont'd)

State	City	Name	Web Site	Phone
NH	Littleton	Eastern States Compounding Pharmacy ^b	easternstatescompounding.com	603-444-0094
NJ	Swedesboro	Wedgewood Pharmacy	wedgewoodpharmacy.com	800-331-8272
NY	Canandaigua	Animal Pharmacy	animalpharmacy.net	800-663-5261
	Cross River	Cross River Pharmacy and Compounding Center	crossriverpharmacy.com	914-763-3152
OH	Jamestown	Pharmacy Innovations	pharmacyinnovations.net	716-720-5121
	Cincinnati	Tri-State Compounding Pharmacy ^b	tristatex.com	513-624-7333
	Fairview Park	Nature's Pharmacy	naturescompound.com	440-331-8509
OR	Tualatin	Northwest Compounders	northwestcompounders.com	800-968-0742
PA	Hatboro	Philadelphia Professional Compounding Agency	ppcpharmacy.com	215-672-8552
	Pitcairn	Yakim's Compounding Pharmacy	yakims.com	800-368-3112
RI	South Kingstown	Bayview Pharmacy	bayviewrx.com	401-284-4505
TN	Cordova	Regel PharmaLab	regelpharmalab.com	866-907-3435
TX	Houston	BCP Veterinary Pharmacy	bcpvetpharm.com	800-481-1729
UT	Sandy	Meds for Vets	medsforvets.com	866-633-4838
VA	Alexandria	Alexandria Medical Arts Pharmacy & Compounding Lab ^b	amapharmacy.com	703-549-4350
WA	Bellevue	Custom Prescriptions ^b	custom-prescriptions.com	425-289-0347
	Puyallup	Bealls Compounding Pharmacy	beallspharmacy.com	253-858-8444
	Seattle	Ballard Plaza Pharmacy	ballardplazapharmacy.com	888-782-6354
WI	Milwaukee	Pet Apothecary	petapothecary.com	414-247-8633

^aWeb sites accessed on September 1, 2016.

^bAccredited by the Pharmacy Compounding Accreditation Board (PCAB). Accessed November 15, 2016.

TABLE 15-17 Additional Compounding Resources.^a

Name	Contact	Description
AVMA Compounding FAQs	Web site: Avma.org/KB/Resources/FAQs/Pages/Compounding-FAQs.aspx	FAQ regarding veterinary compounding
Compounding Today	Web site: compoundingtoday.com	Several databases including flavoring recommendations by species, requires a login but does offer a 14-day free trial
Fagron	Web site: us.fagron.com	Compounding bases and flavorings
FDA Compounding Resources	Web site: fda.gov/AnimalVeterinary/ResourcesforYou/ucm268128.htm#Compounding_of_Animal_Drugs	Information regarding legal requirements for compounding
Flavorx	Web site: flavorx.com	In house compounding kits
Humco	Web site: humcocompounding.com	Compounding bases and flavorings
Medisca	Web site: medisca.com	Compounding flavors and recipes
Perrigo	Web site: perrigo.com	Compounding bases and flavorings
<i>Trissel's Stability of Compounded Formulations</i> , 5th ed ^b	Publisher: American Pharmacists Association	Monographs on various commonly compounded drugs
U.S. Pharmacopeial Convention	Web site: usp.org/usp-healthcare-professionals/compounding	Compounding standards and resources

^aWeb sites accessed on September 1, 2016.

^bTrissel LA, American Pharmacists Association. *Trissel's Stability of Compounded Formulations/Lawrence A Trissel*. 3rd ed. Washington, DC: American Pharmacists Association, 2005.

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- Chloroquine
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- Chloroquine diphosphate, for fish, 25–30t
- Chloroquine phosphate
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- Chlorpheniramine, for ferrets, 543–549t
- Chlorpheniramine maleate
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for rodents, 476–479t
- Chlorpromazine, for birds, 253–257t
- Chlortetracycline
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for rabbits, 495–498t
for reptiles, 82–86t
for rodents, 460–463t
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- Cholestyramine
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- Chondroitin sulfate, for rabbits, 513–517t
- CHOP therapy, for reptiles, 113–116t
- Cimetidine
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- Clazuril
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- Ketamine/xylazine
 for birds, 218–236*t*
 for ferrets, 536–539*t*
 for miniature pigs, 561–565*t*
 for primates, 586–594*t*
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- Ketamine/xylazine/acepromazine, for birds, 218–236*t*
- Ketamine/xylazine/butorphanol, for miniature pigs, 561–565*t*
- Ketamine/xylazine/midazolam, for miniature pigs, 561–565*t*
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- Ketoconazole
 for amphibians, 56–57*t*
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 for ferrets, 533–534*t*
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 for primates, 576–580*t*
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- Ketolides, 637–638t
 Ketoprofen
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 for rabbits, 503–511t
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 Ketorolac, for primates, 586–594t
 Ketorolac tromethamine, for rabbits, 511–513t
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- Laboratories, non-human primate, 609–611t
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 Lactated Ringer's solution (LRS)
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 for backyard poultry and waterfowl, 391–398t
 for birds, 197–217t
 for fish, 25–30t
 for hedgehogs, 446t
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 Levamisole (*Continued*)
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 for miniature pigs, 559–560t
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- Lugol's iodine, for birds, 258–263*t*
- Lupron, for ferrets, 542–543*t*
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 for primates, 580–585*t*
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- Meds for Vets, 661–662*t*
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for ferrets, 539–540*t*
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- Metaproterenol, for ferrets, 540–541*t*
- Metformin, for primates, 594–601*t*
- Methadone
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- Methimazole
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- Metildigoxin, for rodents, 470–474*t*
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for primates, 576–585*t*
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- Winter savory extract (*Satureja montana*), for invertebrates, 2–4*t*
- Wisconsin Veterinary Diagnostic Laboratory, 643–647*t*
- Wood turtle (*Glyptemys insculpta*), hematologic and serum biochemical values of, 117–136*t*
- World Chelonian Trust, websites for owners of exotic animals, 650–653*t*
- World Organization for Animal Health (OIE), 648–650*t*
- World Parrot Trust, websites for owners of exotic animals, 650–653*t*
- X**
- Xylazine
 for backyard poultry and waterfowl, 399–403*t*
 for birds, 218–236*t*
 for ferrets, 536–539*t*
 for hedgehogs, 447–448*t*
 for invertebrates, 6–9*t*
 for miniature pigs, 561–565*t*
 for primates, 586–594*t*
 for rabbits, 503–511*t*
 for reptiles, 93–103*t*
 for rodents, 467–470*t*
 for sugar gliders, 434–435*t*
- Xylazine/butorphanol, for birds, 218–236*t*
- Xylazine/butorphanol/midazolam, for miniature pigs, 561–565*t*
- Y**
- Yakim's Compounding Pharmacy, 661–662*t*
- Yeast, for ferrets, 543–549*t*
- Yeast cell derivatives, for birds, 275–283*t*
- Yohimbine
 for ferrets, 536–539*t*
 for hedgehogs, 447–448*t*
 for miniature pigs, 561–565*t*
 for primates, 586–594*t*
 for rabbits, 503–511*t*
 for reptiles, 93–103*t*
 for rodents, 467–470*t*
 for sugar gliders, 434–435*t*
- Yohimbine HCl
 for backyard poultry and waterfowl, 399–403*t*
 for birds, 218–236*t*
- Z**
- Zanamivir, for ferrets, 543–549*t*
- Zeolite
 for fish, 34–36*t*
 for invertebrates, 9–10*t*
- Zinc, for primates, 594–601*t*
- Zolazepam
 for backyard poultry and waterfowl, 399–403*t*
 for rabbits, 503–511*t*
 for rodents, 467–470*t*
 for sugar gliders, 434–435*t*
- Zonisamide, for birds, 253–257*t*
- Zoo/Exotic Pathology Service, 643–647*t*
- Zoo Medicine Service, 643–647*t*
- Zoologix, Inc, 643–647*t*
- Zoonotic diseases
 carried by hedgehogs, 454*t*
 in rodents, 485–486*t*
- Zuclopenthixol, for primates, 586–601*t*