CHAPTER 10

Sphenisciformes (Penguins)

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BIOLOGY

Penguins are flightless pelagic birds that are widely distributed along the coastal areas of the southern hemisphere, from cold tolerant species inhabiting Antarctica and the subantarctic areas, to temperate species found near the equator.[37] Currently, 6 genera and 18 recognized species (Table 10-1) exist, with the rockhopper penguin (*Eudyptes chrysocome*) recently being split into two distinct species on the basis of morphologic, vocal, and genetic distinctions: the northern rockhopper penguin (*Eudyptes moseleyi*) and the southern rockhopper penguin (*Eudyptes chrysocome*).[17] Penguins are long lived, with captive individuals frequently living to be 25 to 30 years of age. Age of sexual maturity varies among species but usually occurs around 3 to 5 years of age. Penguins are generally monogamous. Some species mate with one partner each season but change partners in successive breeding seasons, whereas other species form strong pair bonds that last for the life of the individuals. Occasionally, extra-mate pairing occurs. Males and females share the responsibility for incubation and chick rearing. Most species have a clutch of two eggs and use a variety of nest types: under rocks or bushes, in small cavities, or in shallow scrapes. Some build nests out of stones or dig deep burrows. Incubation generally lasts 37 to 45 days. Aptenodyptes is the exception, laying only one egg per clutch and incubating the egg on its feet for 62 to 67 days.[37]

UNIQUE ANATOMY AND CLINICAL RELEVANCE

Penguin species have a very similar body shape that allows for efficient swimming, diving, and porpoising but vary in height and weight. The little blue penguin is the smallest, standing 40 centimeters (cm) tall and weighing about 1 kilogram (kg), whereas the emperor penguin is the largest and may reach a height of 130 cm and weigh up to 38 kg. Despite the size differences among species, all penguins share several unique anatomic features.

1. The trachea bifurcates at different levels in most penguin species; the area of bifurcation may be seen radiographically. Use of an endotracheal tube may result in unilateral intubation, but with the efficiency of the avian pulmonary–air sac system, this usually does not lead to the problems of hypoventilation or hypooxygenation seen in mammals. The medial cartilaginous septum is easily traumatized, and if the tracheal size diminishes distal to the bifurcation, tracheal trauma may occur if an inappropriately sized tube is used.
2. Penguins lack a crop. The large stomach has two distinct chambers: the proventriculus and the ventriculus. The proventriculus stores food to feed chicks. Therefore, before administering oral medications, consideration must be given to penguins feeding small chicks, as toxic doses of medication may be regurgitated to the chick. Foreign objects often settle in the distal aspect of the ventriculus and radiographically appear to be in the distal intestine near the cloaca. This frequently leads clinicians to erroneously believe that the object is about to pass through on its own. Usually, endoscopy or surgery is needed for foreign body retrieval.
3. Feathers are short and dense in number and highly waterproof, providing a watertight and highly insulating layer. In preparation for surgery, it is easier and less traumatic to the underlying skin if the feathers are shaved rather than plucked. The feather shafts will fall out, and normal feathers will grow back during the next molt. Until that time, heat loss will occur in cold ambient temperatures and in water, but in captivity, the penguin may compensate for the loss. In the wild, successful rehabilitation of oiled birds requires complete waterproofing before the birds are released to prevent debilitating heat loss.

TABLE 10-1

Status of Wild Penguin Species Populations

Genus	Common Name	Scientific Name	Population Trend	2012 IUCN Status	Estimated Breeding Pairs in Wild
Aptenodytes	Emperor penguin	*A. forsteri*	Stable	Near threatened	238,000
Aptenodytes	King penguin	*A. patagonicus*	Increasing	Least concern	*2,000,000
Eudyptes	Southern rockhopper penguin	*E. chrysocome*	Decreasing	Vulnerable	1,230,000
Eudyptes	Macaroni penguin	*E. chrysolophus*	Decreasing	Vulnerable	9,000,000
Eudyptes	Northern rockhopper penguin	*E. moseleyi*	Decreasing	Endangered	265,000
Eudyptes	Fiordland penguin	*E. pachyrhynchus*	Decreasing	Vulnerable	5,000–6,000
Eudyptes	Snares penguin	*E. robustus*	Stable	Vulnerable	31,000
Eudyptes	Royal penguin	*E. schlegeli*	Stable	Vulnerable	850,000
Eudyptes	Erect-crested penguin	*E. sclateri*	Decreasing	Endangered	67,000
Eudyptula	Little penguin (Fairy or Blue penguin)	*E. minor*	Decreasing	Least concern	<1,000,000
Megadyptes	Yellow-eyed penguin	*M. antipodes*	Decreasing	Endangered	3500
Pygoscelis	Adélie penguin	*P. adeliae*	Increasing	Near threatened	2,370,000
Pygoscelis	Chinstrap penguin	*P. antarcticus*	Increasing	Least concern	9,000,000
Pygoscelis	Gentoo penguin	*P. papua*	Decreasing	Near threatened	387,000
Spheniscus	African penguin	*S. demersus*	Decreasing	Endangered	26,000
Spheniscus	Humboldt penguin	*S. humboldti*	Decreasing	Vulnerable	†45,000 (all ages)
Spheniscus	Magellanic penguin	*S. magellanicus*	Decreasing	Near threatened	1,300,000
Spheniscus	Galápagos penguin	*S. mendiculus*	Decreasing	Endangered	600

*International Penguin Conservation Working Group (www.penguins.cr).
†Wallace, unpublished data.
From International Union for Conservation of Nature, 2012: *Red List of Threatened Species Version 2012.2*: www.iucnredlist.org. Accessed December 24, 2012.

4. Penguin bones are not pneumatic and are much denser than in other species of birds; therefore, intraosseous catheterization for administration of fluids may be quite difficult.
5. Countercurrent heat exchange mechanisms are well developed in the feet and flippers to aid in thermoregulation. This, along with the insulation provided by feathers, may lead to hyperthermia during anesthetic procedures, especially in the Antarctic and subantarctic species. Ice packs placed on the feet and flippers will help prevent hyperthermia.
6. Daily activities of penguins have both aquatic and terrestrial components. The visual system has anatomic features that allow penguins to have normal sight in either environment. Although the corneal shape is flatter than in mammals, the ultrastructure is similar.[26] The nictitating membrane is transparent to allow normal vision while providing protection to the cornea when the penguin is under water. When performing ocular surgery, the nictitating membrane must be identified and retracted to avoid accidental incision.
7. Salt glands in the orbital region handle the excess salt in a marine environment. The glands will atrophy in captive penguins maintained in a fresh water environment unless supplemental salt is provided. However, studies have shown that atrophied glands will become functional rapidly if exposed to a saline environment.[20]

IDENTIFICATION METHODS

The use of flipper bands in the wild is controversial.[2,15] However, most institutions successfully use flipper bands on captive penguins. Color cable ties and metal or silicone flipper bands may be used. Bands should be tightened to the point where a finger may be slipped between the band and the flipper. As cable ties may continue to tighten after application, the fastener should be glued so that it does not slip and impede blood circulation to the flipper. During molt, flippers swell, potentially restricting circulation. Band tightness must be monitored and bands replaced with looser bands, if needed. Small metal rings may be placed in the interdigital webbing of the foot. Microchips may be placed subcutaneously in the loose skin of the back of the neck, on top of the head, or in the fleshy part of the foot in the front of the tarsus. Chicks weighing as little as 500 grams (g) may be microchipped. For smaller collections, identification of adults may be done on the basis of photographs of spot patterns of the breast feathers after molt into adult plumage.[24]

SEXING

Penguin species are only subtly dimorphic, males generally being slightly larger with bigger and thicker bills, but overlap in size exists between sexes. Although research on morphometrics has been published, it is unreliable for captive Humboldt penguins and thus might be expected to be unreliable for other penguin species. DNA (deoxyribonucleic acid) sexing from feather, blood, or egg membranes is highly reliable and is the recommended method for sexing penguins.[24]

SPECIAL HOUSING REQUIREMENTS

To successfully manage penguins in captivity, exhibits must be designed to meet the physical, behavioral, and psychological needs of the species. As colony birds, penguins should not be housed alone, and the AZA Penguin Taxonomic Advisory Group (TAG) recommends a minimum of 10 birds. Air and water quality, lighting, and type of substrate must be considered for optimal health as well as

protection from land and air predators. The various penguin species have widely differing environmental requirements, and it must be ensured that in a mixed species exhibit, penguins with similar requirements are housed together. Indoor exhibits are generally preferred to facilitate control of air and water temperatures for the various species, decrease exposure to disease vectors, and provide protection from predators. *Aptenodyptes*, *Pygoscelis*, *Eudyptes*, and *Megadyptes* species are best kept indoors under refrigerated conditions (<9°C). Temperate climate species are often exhibited outdoors and may tolerate temperature ranges from freezing to 30°C. In cold climates, pools should be prevented from freezing, and penguins should have access to shelters with supplemental heat. Misters may be used during warm weather to aid in cooling the birds. An indoor area with climate control capability should be available for protection from extreme heat and humidity and for nesting. Mosquitoes are the vectors for several diseases in penguins (see list below); therefore, mosquito control is paramount for penguins housed outdoors. This includes removing standing water on a weekly basis; applying larvicide to standing water that cannot be removed, including any drains in the penguins' indoor and outdoor enclosures; and minimizing foliage near animal exhibits. Exposure to mosquitoes may be reduced by bringing the penguins indoors during peak mosquito hours (dusk to dawn), ensuring that door sweeps and screens are in good condition, placing screens over intake fans, and providing fans, wherever possible, to keep the air moving to discourage mosquitoes.[24]

The AZA Penguin TAG recommends minimum land and water surface areas for exhibition and holding. Additional space should be provided to allow for a full range of species-appropriate behaviors, including nesting (species other than *Aptenodytes*). For king and emperor penguins, the minimum land and water surface areas for exhibit and holding are 18 square feet for the first six birds and 9 square feet for each additional bird, with a minimum pool depth of 4 feet. For all other species of penguins, the recommendations are 8 square feet for the first six birds, 4 square feet for each additional bird, and a minimum pool depth of 2 feet. Ideally, larger water areas should be provided to encourage swimming to help prevent obesity and pododermatitis. A separate holding area should be provided for birds with behavioral problems or noncontagious health problems that require separation from the flock. Quarantine facilities with separate air and water systems should be available for newly acquired birds or birds with infectious diseases. Water may be either fresh water or salt water, and recent studies show that salt supplementation is not needed for penguins in fresh water exhibits. Water cleanliness and clarity may be maintained with the use of sand and gravel filters, judicious addition of chlorine to keep coliform counts to a minimum, and surface skimmers to remove excess fish oil and debris from the surface of the water. Lighting indoor exhibits should mimic the natural light cycle with gradual increasing and decreasing of daylight hours. Inappropriate lighting may lead to poor molt cycles and decreased reproductive success.[24] Spheniscid species enjoy climbing, so exhibits designed to allow climbing provide enrichment.

FEEDING AND NUTRITION

In the wild, penguins feed on pelagic schooling fish species, squid, and crustaceans (mostly euphasid species). Food consumed varies with availability and season. In captivity, the type of prey items fed by a given institution is often limited and dictated by cost and availability from commercial fisheries. Feeding several different types of whole prey is recommended to provide a complete nutrient profile and so that the birds do not "imprint" on one item to the exclusion of others. In most cases, the prey items are frozen. Fish should be individually quick frozen (IQF) instead of in large blocks, stored at −18° to −30°C, and used within 4 to 6 months to ensure optimal nutritional quality. Institutions should consider whether the food items used are being harvested in an ecologically sustainable fashion.[10] If appropriate species of prey are unavailable or the condition of the fish is less than ideal, three types of a nutritionally complete powder (reconstituted into a gel) are commercially available as substitutes for low-fat fish, high-fat fish, or squid and crustacean diets.

The size of the fish must be appropriate for the species. If an item must be cut because it is too large, all portions should be fed to ensure ingestion of the entire nutrient supply of the item. To prevent bacterial growth, food should be thawed in a refrigerator in clean containers, then kept refrigerated or on ice until the time of feeding. Using running water for thawing may wash away many of the water-soluble nutrients, but in some institutions, the fish is quickly rinsed in cold water just prior to feeding to remove any surface contaminants. Extensive vitamin supplementation is not needed if penguins are fed good-quality whole-food items thawed appropriately. Recommendations are limited to vitamin E at 100 international units per kilogram (IU/kg) and thiamine at 25 to 30 milligrams per kilogram (mg/kg) of diet fed on a wet weight basis. Supplements should be added to the fish immediately before feeding to prevent breakdown by the enzymes and oxidants in the fish. Salt supplementation is not needed.[10]

Most institutions hand-feed individual penguins, especially if they are receiving medication or vitamin supplements. Complete hand-feeding may cause penguins to become lazy and develop poor swimming habits; therefore, some pool feeding is recommended, but feeding must be observed to ensure that all individuals are eating enough. Penguins may consume up to 20% of their body weight daily, with increased consumption during the few weeks prior to molt, and during chick rearing. Consumption usually decreases drastically during molt with frequent skipped feedings. Penguins may gain more than 25% of their body weight prior to molt and then rapidly return to premolt weight or slightly below by the end of molt.[37]

RESTRAINT AND ANESTHESIA

Penguins are sturdy and may tolerate handling for minimally invasive procedures. Several different methods exist for capturing the animal, with initial restraint often done by grabbing the back of the head or very high on the neck and then lifting and supporting the belly with the other hand. Grabbing penguins by the flippers should be avoided, since the flippers may dislocate or fracture. Two people should work together when capturing and restraining king and emperor penguins. People capturing the birds should wear eye protection, especially with king penguins. Once the bird has been secured, a black bag may be placed over its head with the beak and nares exposed. Noninvasive procedures may require only minimal restraint. Stronger restraint is needed for procedures that require the bird to be immobile. One method involves placing the penguin between the handler's legs such that the flippers are held secure. In this way, the handler's hands are free to restrain and position the head and neck to facilitate procedures such as blood collection or banding. With king and emperor penguins, a second person may be needed to avoid injury to the bird or handlers. Other methods of restraint include using large diameter PVC pipes or traffic cones to secure the bird. Air kennel or large tubs may be used for transport.

Animals should be fasted 18 to 24 hours prior to anesthesia to prevent regurgitation and aspiration of gastric contents. Isoflurane or sevoflurane are the most commonly used gas anesthetics. A facial cone is used for induction, with subsequent intubation, if desired. Shallow breathing or breath holding (dive reflex) may occur, resulting in a chronic excitement phase and swimming-like behavior. Assisted ventilation two to three times per minute may achieve a smoother plane of anesthesia. Midazolam given intramuscularly or intranasally may be used for sedation for minor procedures or to reduce the stress of handling. Sedation may then be reversed with flumazenil. Ketamine or diazepam given intramuscularly for induction has been recommended over isoflurane for Little (Fairy or Blue) penguins (*Eudyptula minor*) because of the fragile nature of this species and its tendency to traumatize itself during

anesthetic induction with isoflurane. However, recovery is prolonged compared with using isoflurane alone. If cold climate species are anesthetized for extended periods, ice, ice packs, or other ways to prevent hyperthermia should be used during the anesthetic procedure.

BLOOD SAMPLE COLLECTION

Blood may be collected from a variety of sites, including the jugular, medial metatarsal, interdigital, and brachial veins (the brachial vein is also a good site for intravenous [IV] catheterization). Blood may also be collected from a venous sinus located on the dorsal aspect of the vertebral column at the base of the tail. The amount of blood that may be removed follows normal avian standards of no more than 1% of body weight. Each institution should establish its own set of normal blood parameters for every species maintained. If no institutional norms exist, the International Species Information System has norms for most species. Otherwise, zoos that have the penguin species in question may be contacted. As Galápagos penguins are rarely kept in captivity, values for this species are not readily available, but values obtained from the wild population have been published.[33] Postprandial increases in uric acid occur; therefore, penguins should be fasted for accurate uric acid assessment.[9] Both egg-laying and molt may have a temporary effect on specific blood chemistry values.[38] As with other avian species, increases in cholesterol, calcium, phosphorus, and occasionally alkaline phosphatase are often seen in reproductively active females.[21]

SURGERY

Surgery has been successfully performed on a variety of penguin species. It is important to remember to keep Antarctic and subantarctic species cool during surgery. Standard surgical technique is employed. Intubation, standard patient monitoring, and fluid administration are generally easy to perform. Birds should be kept out of the water until the skin incision has healed.

BLOOD TRANSFUSIONS

Blood transfusions may be performed when birds are severely anemic from malaria, blood loss, or clotting disorders. Transfusions may stabilize a bird until a diagnosis is made and treatment initiated, and is indicated when the packed cell volume (PCV) drops rapidly into the teens or lower and does not stabilize. If the PCV stabilizes, penguins generally have a good bone marrow response, if not debilitated by concurrent disease or old age, and generally respond well to supportive care alone (fluids, oral or injectable iron supplementation, oxygen and B-vitamins). In malarial birds with a stable PCV in the teens, transfusion appears to shorten the convalescent time until the treatment with chloroquine or primaquine takes effect. Homologous transfusions are preferred, since the blood cells probably remain in the recipient's circulation longer. Instructions for transfusion may be found in the *Penguin Husbandry Manual*.[24]

BACTERIAL AND FUNGAL DISEASES

Penguins are susceptible to a variety of bacterial diseases, including outbreaks caused by *Erysipelothrix*,[4] mycobacteria,[13,22] *Edwardsiella*,[23] *Plesiomonas*,[23] and *Chlamydophila*.[14] Although few pharmacokinetic studies exist,[35] various antibiotics have been used successfully in penguins (Table 10-2). The diagnosis of *Chlamydophila* in live birds is complicated by confusion with regard to the testing methods of various laboratories and how to interpret test results to determine whether illness is caused by active infection. A thorough understanding of the latest diagnostic techniques, what each test result signifies, and its validity in penguins is needed. Doxycycline is the drug of choice for treatment. *C. psittaci* is a zoonotic disease, and risk of transmission to the public or to the animal care staff is real. Affected birds or flocks should be quarantined to protect other collection birds as well as the staff. Persons working with ill birds should wear protective clothing, including N-95 masks.

The primary fungal disease causing illness in penguins is aspergillosis. The causative agent is *Aspergillus* spp., typically *A. fumigatus*. The organism is ubiquitous in the outdoor environment and is often found in indoor exhibits. It may exist at low levels without causing problems in healthy and well-adapted penguins. Disease frequently occurs in stressed or debilitated animals. Stressors associated with aspergillosis include substandard air quality, poor ventilation, elevated ammonia levels, overcrowding, excessive environmental heat or cold, and social incompatibility. Historically, many severe outbreaks of aspergillosis have occurred after major environmental changes, especially those involved with social factors such as

TABLE 10-2

Antimicrobials and Parasiticides Commonly Used in Penguins

Generic Name	Route of Administration	Dosage	Comments
Itraconazole	PO	5–10 mg BID	Until signs resolve; manufacturer's product (not generic) must be used
Voriconazole	PO	10 mg/kg BID	Until signs resolve
Terbinafine	PO	15 mg/kg q24h	Can combine with itraconazole
Clotrimazole	Nebulize	1% solution 15 minutes BID	Until signs resolve
Amphotericin B	Nebulize	0.3–1 mg/mL of saline 15 minutes BID	Until signs resolve
Amphotericin B	IV	1.5 mg/kg BID–TID	3–5 days
Enrofloxacin	PO, IM	15 mg/kg BID	2–4 weeks
Trimethoprim sulfa	PO	50–100 mg/kg q12h	7–10 days
Cephalexin	PO	50–75 mg/kg BID	10–21 days
Clindamycin	PO	75 mg/kg BID	10–14 days
Ivermectin	PO, SQ	0.2–0.4 mg/kg	Repeat in 7–14 days, if needed
Praziquantel	PO, IM, SQ	15–20 mg/kg	Use the higher doses orally; repeat in 2 weeks
Fenbendazole	PO	20–50 mg/kg ×3 days	Repeat in 2 weeks

bid, Twice daily; *IM*, intramuscular; *IV*, intravenous; *mg/kg*, milligram per kilogram; *PO*, oral; *q12h*, every 12 hours; *q24h*, every 24 hours; *SQ*, subcutaneous; *TID*, three times daily.

Note: For antimalarial drug treatments, see individual disease writeup.

introduction to a new social group, or inappropriate, prolonged, or stressful relocation. Exposure to new *Aspergillus* species may occur via new substrate or change in location. Construction in the area of the exhibit may increase exposure to fungal spores.

Signs are often nonspecific, and early diagnosis is difficult. Signs include open-mouth breathing, coughing, altered vocalization, inappetence, weight loss, lethargy, weakness, and self-isolation. A complete blood cell count (CBC) may show a moderate to marked leukocytosis with monocytosis, and changes in the protein electrophoretic pattern compatible with chronic inflammation may be present. Serologic titers to *Aspergillus* may be useful, but it is difficult to differentiate an acute infection from previous exposure. Fungal cultures of the throat, trachea, or air sacs may grow the causative agent. Radiography, fluoroscopy, or computed tomography (CT) is helpful in identifying pulmonary or air sac granulomas or general cloudiness of air sac or lung fields.

Success of treatment depends on the stage and severity of disease when diagnosed. Antifungal drugs may be given systemically (orally or intravenously), by nebulization, or intratracheally. Treatment is typically long term, frustrating, and often unsuccessful if begun in the later stages of disease. Several drugs have been used (see Table 10-2), but, again, few pharmacokinetic studies in penguins have been done.[3,31] If itraconazole is used, the manufacturer product, not the generic form, must be used.[31] Supportive care may include fluids given by gavage, subcutaneously, or intravenously and fish gruel by gavage. For indoor exhibits, maintaining good air quality is crucial for disease prevention. If the air filtration system in a penguin exhibit is shut down, it is recommended that the system run for at least a week after it is restarted before putting penguins back into the exhibit. Air cultures and disinfection for *Aspergillus* sp. should be taken at this time. Regular fungal air cultures may be taken from the exhibit area to monitor levels of *Aspergillus*. Prophylactic antifungal drugs, typically 10 mg/kg itraconazole given orally once a day should be administered when shipping, relocating, or introducing new birds to an exhibit. It is crucial to avoid shipping or relocating penguins during molt (including the premolt and immediate postmolt periods).[24]

PARASITIC DISEASES

Malaria is the most significant parasitic disease in captive penguins housed outdoors. Malaria is caused by a blood parasite carried by mosquitoes, biting flies, or both. The causative agent is a *Plasmodium* organism, usually *P. relictum* or occasionally *P. elongatum*. Wild birds serve as reservoir hosts. Most cases of penguin malaria occur in animals that are currently or have historically been housed outside. Penguins of all ages may be clinically affected, but susceptibility is highest during first exposure; therefore, chicks and juvenile birds, naïve adults previously housed indoors, or those that have been transported from areas with low mosquito or malaria problems are at higher risk of disease. The mortality rate from novel malaria infection is high, and stressors such as molt, chick rearing, or poor husbandry may increase mortality. Blood samples may be collected every 2 weeks from birds considered at high risk and stained smears of the blood checked for the presence of malarial organisms. Unfortunately, this test is not very sensitive, as malarial organisms are often visible only after the onset of severe clinical signs or during necropsy when organisms may be seen in blood smears or splenic impressions.[8]

A serologic test has been validated for black-footed penguins (*Spheniscus demersus*) and may be useful for other Spheniscid species.[8] Research is underway to try to detect malarial organisms in blood using polymerase chain reaction (PCR) techniques, but accurate tests have yet to be developed.

Clinical signs for malaria may vary and range from acute death with or without dyspnea to lethargy, inappetence, pale mucous membranes (from anemia), and behavioral separation from the group.

Malarial infection has both tissue and blood phases, and treatment targets both phases. Standard treatment is with 5 mg/kg chloroquine every 12 hours for four doses, or four doses of mefloquine at 0, 12, 24, and 48 hours.[32,36] Concurrent treatment with primaquine for 10 to 14 days is needed to treat exo-erythrocytic forms. Prophylaxis during the mosquito season (potentially year round in some locations) may be attained using 1.25 mg/kg primaquine daily or mefloquine 30 mg/kg once a week if primaquine is not available. A compounded capsule containing 125 mg sulfadiazine, 4 mg pyrimethamine, and 0.4 mg folic acid administered every other day to penguins weighing 3 to 5 kg has also been used for prophylaxis. Pyrimethamine is a folic acid inhibitor and is teratogenic and may cause fetal malformations if given to laying females. Doxycycline is used in humans for both treatment and prevention of malaria, but to date, no studies have been published indicating dose or efficacy in birds. Administration of any prophylactic treatment is risky in adults that are feeding chicks, as the parent may regurgitate the medication to a small chick. Discontinuing treatment for a week or two while the chick is small should be considered. Then treatment may be restarted first in the parent that is less involved in feeding the chick. If using the every-other-day therapy, the parents should be treated on alternate days to minimize the chance that the chick might receive two doses in a day.

Deaths from toxoplasmosis have occurred in black-footed penguin chicks exposed to cat feces.[27] Signs were primarily neurologic, with death occurring within 24 hours. Aside from the direct threat of predation that cats may pose to penguins, *Toxoplasma* oocysts transmitted from infected cat feces pose a risk; therefore, penguin exhibits should be secured to prevent entry by domestic cats.

VIRAL DISEASES

A number of viruses may cause encephalitis in birds. Disease spread is usually through the bite of an infected mosquito, and wild birds may act as reservoirs for the virus. Some evidence suggests that bird-to-bird transmission occurs via semen and other infected bodily fluids. Diseases relevant to penguins include eastern equine encephalitis (EEE) and West Nile virus (WNV). Both EEE and WNV have been reported in Spheniscid penguins, and these penguins may have high rates of morbidity and mortality in response to these diseases.[11,34]

WNV is caused by a flavivirus. Species susceptibility to severe morbidity and mortality varies widely, with penguins being one of the more highly susceptible avian groups (see Chapter 77). Birds that survive infections are assumed to have some latent immunity to reinfection, but it is not known how long this immunity lasts. Acute death may occur with few premonitory signs, or death may occur within 3 to 4 days. Clinical signs, when present, include anorexia, weakness (lying down frequently), and vomiting, with inability to retain even small amounts of water or oral electrolyte solutions. Dyspnea from excessive mucoid tracheal or pulmonary secretion may occur. In Humboldt penguins, neurologic abnormalities are not common. No specific treatment exists for this disease; therapy is limited to supportive care. With supportive care, the course of the disease may be protracted, with death occurring after a couple of weeks. Recovery may be prolonged in those animals that survive, with weakness and decreased appetite lasting for several weeks. Antifungal or antibacterial therapy may be given, as needed, for secondary infections. Oral supplementation of fluids or gruel is not recommended until the penguin's condition has stabilized, as sick birds tend to vomit. Virus may be shed in the respiratory secretions, and horizontal transmission of the virus to humans from avian species has been documented.[7] Therefore, WNV should be considered a zoonotic disease, and appropriate protective clothing should be worn when working around infected birds.

Vaccination is recommended for susceptible species. At this time, no vaccines produced specifically for birds are commercially available. Two vaccines developed for horses have been used. Innovator (Pfizer) is a killed vaccine. Its efficacy, as measured by serologic titers, differs in different avian species. Recommendations are to vaccinate

susceptible birds three times at 3- to 4-week intervals and then annually 1 month prior to the mosquito season.[24] Recombitek (Merial) is a live recombinant canarypox vaccine. Anecdotal reports of this being used exist, but efficacy is currently unknown.

EEE is caused by an alphavirus. This disease was reported in a group of African penguins housed outdoors.[34] Common signs included acute anorexia, lethargy, intermittent vomiting, bile-stained diarrhea, and self-isolation. Ataxia developed after 3 to 4 days, progressing to recumbency and seizures in about 25% of affected penguins. Signs in less severely affected penguins began to resolve in 6 to 9 days but only after 14 days in more severely affected penguins. A hemagglutinin inhibition test for titers to the EEE virus may confirm exposure to the disease, and although no reference limits for penguins exist, a rising titer in samples taken 2 to 4 weeks apart suggests true infection. No specific treatment is available, and therapy is limited to supportive care, including anticonvulsants to control seizures. Antifungal or antibacterial therapy should be provided, as needed, for secondary infections. A killed vaccine against EEE is available for horses, and although the required dose and efficacy for penguins has not been determined, some institutions in EEE-endemic areas have opted to use this vaccine.

Avian pox has occurred in both captive and wild penguin populations.[18] Both diphtheritic and cutaneous forms may manifest. Currently no treatment exists, and supportive care must be provided while the disease runs its course, usually lasting 2 to 3 weeks. The virus may survive for prolonged periods in the scabs or other dried secretions, so meticulous disinfection of any areas where ill animals were housed is necessary to prevent transmission.

NONINFECTIOUS DISEASES

Pododermatitis (bumblefoot) continues to cause problems in captive penguins. Factors associated with pododermatitis include decreased swimming (sedentary behaviors) and prolonged standing on hard, abrasive surfaces or on surfaces with excessive moisture or fecal contamination. The original lesion may result from a puncture wound or soft tissue damage caused by pressure necrosis. Once the epithelium is compromised, secondary bacterial invasion may occur, resulting in deep soft tissue infections. If left untreated, severe complications, including mineralized soft tissue and osteomyelitis, may occur. Therapy should be aimed at protecting the foot from further damage, instituting local and systematic treatment of the lesion, and altering the environment to prevent future occurrences, for example, improving hygiene and changing to an appropriate substrate or flooring. Treatments that have been used include systemic antibiotics; local antibiotics with or without dimethyl sulfoxide (DMSO); topical ointment; surgical debridement; cryotherapy; and chronic bandaging in conjunction with various salves and ointments, accompanied by intermittent debridement of devitalized tissue. Often initial improvement is seen, but the condition tends to recur once therapy is discontinued. When bandaging, it is helpful to provide padding to minimize pressure on the wound site. Gauze, waterproof cast padding, and booties made from soft material have all been used. Healing efficiency may be improved with proper debridement and the use of hydroactive dressings. Booties may be made from neoprene dive suits or are commercially available in various sizes. Prevention is key, as treatment is typically long term and frustrating. Penguins should be encouraged to swim, and appropriate substrate free of standing contaminated water should be provided. Anecdotal evidence suggests that allowing birds with bandages to swim in salt water may promote healing.

Preen gland infections have been reported in penguins.[19] The specific etiology is unknown, but predisposing factors include sedentary birds with decreased swimming patterns, nonpreening birds that do not molt regularly, and nutritional deficiencies. Early diagnosis and treatment may prevent impaction. In birds that do not respond to symptomatic or antibiotic therapy, surgical removal may be needed to avoid rupture and secondary septicemia. Encouraging swimming, particularly with nesting birds, may be beneficial. If birds are temporarily housed without a pool, daily showers may stimulate preening.

Gastrointestinal foreign bodies may cause significant morbidity and death.[25] Young penguins and nesting females, in particular, will investigate small and novel items and may ingest them. Ingested items have included nesting material, bristles from cleaning brushes, coins, lead pellets, and molted tail feather shafts. When metal objects are ingested, zinc, lead, and other heavy metal toxicities are possible. Although penguins regurgitate easily, foreign objects usually remain in the stomach and tend not to pass into the intestinal tract. Treatment is usually by endoscopic or, less frequently, surgical removal.

Pathology of the reproductive system is uncommon in penguins, although salpingitis, egg binding, and cloacal prolapse occur. Treatment for egg binding is similar to that in other avian species. Birds may benefit from calcium supplementation. Manual extraction of the egg is preferable, but surgical removal of the egg may be required. Removal of the entire oviduct may be necessary if egg retention leads to oviductal rupture or necrosis. The toxic effects of lead and zinc on the smooth muscle of the uterus and oviduct may predispose to egg retention.

Various neoplasms have been reported in penguins including T-cell lymphoma,[30] melanoma,[28] carcinomas,[12,29] and adenocarcinomas.[39]

Nutritional disorders may occur with poor-quality or improperly handled fish. Thiamine deficiency occurs when fish quality is compromised. Incoordination and "stargazing" are occasionally reported as clinical symptoms. Differential diagnoses for nonspecific signs of central nervous system involvement include viral, parasitic, or bacterial encephalitis; fungal granuloma; sepsis; and tumors. Metabolic bone disease has been reported in several hand-raised penguin chicks.[1] Poisoning by domoic acid was reported to cause the total loss of a rockhopper penguin collection.[6] Exposure came from ingesting fish contaminated by the algal toxin. Consideration should be given to the source of the fish (caught in shallow versus deep water) fed to penguins.

CONSERVATION

The conservation status of the penguin species is given in Table 10-1. Many populations have declined rapidly in the last 70 years, although for a few species the numbers are stable or increasing, with expanding ranges.[16] Reclassification of the rockhopper penguin from one to two distinct species has conservation implications, since the northern population is smaller and more fragmented compared with the southern population. Many penguin species live in rather inaccessible areas without direct daily contact with humans, but nonetheless human activities affect these populations. Threats include climate change or El Niño, overfishing, entanglement in fishing nets, habitat loss and destruction, predation, and human disturbance. Oiling has caused significant deaths in some species.[5] Various conservation measures have been undertaken to protect specific penguin populations, and these include establishment of natural reserves, some of which include no-fishing areas in the water adjacent to these reserves, providing barriers to protect colonies from predators, observation and monitoring of guano harvesting to minimize poaching and disruption of nesting areas, temporary relocation of entire colonies to prevent oiling, and controlled access and viewing by ecotourists.

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