CHAPTER 12

Pelecaniformes (Pelicans, Tropicbirds, Cormorants, Frigatebirds, Anhingas, Gannets)

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BIOLOGY

The Order Pelecaniformes was previously defined as comprising birds that have feet with all four toes webbed. Hence, they were formerly also known by such names as *totipalmates* or *steganopodes*. The group included frigatebirds, gannets, cormorants, anhingas, and tropicbirds.[2] The current International Ornithological Committee classification now groups pelicans with the Families Threskiornithidae (ibises and spoonbills), Ardeidae (herons, bitterns, egrets), Scopidae (hamerkop), Balaenicipitidae (shoebill), and Pelicanidae (pelicans). Previously included families are now classified in the Order Suliformes, that is, Fregatidae (frigates), Sulidae (gannets and boobies), and Phalacrocococidae (cormorants and shags).[3] However, for the purposes of consistency and for this chapter, the previous grouping of Pelecaniformes (pelicans, tropicbirds, cormorants, frigatebirds, anhingas, gannets) will be used with a focus on pelicans (Table 12-1). Most of the birds in this order have large beaks relative to their head size and a distensible pouch formed by the floor of the mouth, between the mandibles. The natural range of the species extends around the world, mainly in the tropical areas. The species most commonly maintained in captivity are the pelicans and cormorants but the others rarely so.

UNIQUE ANATOMY

The most obvious distinguishing feature of the pelican, besides being large birds, is the gular pouch. The floor of the mouth is greatly enlarged to form the pouch used for scooping up water and prey and then draining the water before swallowing the captured prey. The large beak ends in a pronounced downward facing hook. The tongue is significantly reduced in size. The pelicans are among the largest flying birds and yet are relatively light because of the extensive air sac diverticula between the skeletal muscles of the neck and the breast. These air pockets under the skin are readily palpated when the birds is restrained. The subcutaneous air sacs are known to anatomically connect with the respiratory system, and the bird maintains inflation by the closing of the glottis. The subcutaneous air pockets are presumed to act as a shock absorber when the bird hits the water at speed during a dive and also assist in floating. Males are generally larger than females and have longer bills. Several other species, for example boobies and gannets, as mentioned earlier, also have extensive subcutaneous air sacs. The external nares are not patent in some birds in this order, including brown pelicans, cormorants, boobies, and gannets, perhaps as an adaptation to diving. The rest of the Order Pelecaniformes comprises long-legged birds that hunt or scavenge prey near lakes or rivers and are relatively slender in body shape. The gular pouch is used for courtship displays in frigatebirds and absent in the tropicbirds. Birds of this order are typically carnivorous (primarily fish eating). The proventriculus and the ventriculus are both thin and extensible in the pelican and cormorant species and relatively indistinguishable. The pylorus is very well defined and well muscled, and this may be an adaptation to prevent foreign bodies and bones entering the small intestine.

SPECIAL HOUSING REQUIREMENTS

In common with many other marine species, Pelecaniformes typically have supraorbital salt glands that may atrophy in captivity if they are housed on fresh water. When birds are transferred between institutions, the salinity of the water should be noted, and it must be ensured that the birds are transferred between the same systems; in the case of transference from a freshwater environment to a saline environment, supplementation with dietary salt (if a pool of increasing salinity cannot be provided) should be carefully instigated to reactivate the salt glands without risking salt poisoning. The birds should be carefully monitored during this process. This process should also occur prior to release from a freshwater or a low-salt facility. Birds in this order are characteristically semi-aquatic birds that dive from a great height into water to capture prey. It may be challenging to replicate this behavior in captivity, but the birds should certainly be provided with pools that permit swimming and surface diving. Maintenance of adequate water hygiene, using appropriate surface skimmers and other measures, will be required to prevent the accumulation of fish oils damaging the feathers. Sufficient dry land area is required, especially for pelicans, cormorants, and anhingas, which have feathers that tend to get waterlogged. The substrate needs to be supportive and noninjurious, as all birds in this order, particularly the heavier species, are prone to pododermatitis.

FEEDING

The natural diet of pelicans is quite varied and related to their aquatic habitat, including fish (up to 30 centimeters [cm] long), crustaceans, amphibians, turtles, and occasionally other birds. The way different species of pelican feed varies. For example, the brown pelican feeds by diving into water, whereas the white pelican species feed cooperatively by herding fish and dipping their beaks into the water to scoop the fish out. Cormorants and anhingas are surface divers and capture their prey underwater. Tropicbirds, boobies, and gannets are plunge divers. Frigatebirds are renowned scavengers and steal food from other birds. Birds in captivity need to adapt to taking dead fish, and training may be required when presenting the fish in a manner dissimilar to their wild presentation. Throwing fish into the air is the least natural presentation of fish, but the movement may stimulate attack and feeding. If feeding fish that has been frozen, supplementation with vitamins is often required; further information on fish handling as food and supplementation will not be covered in this chapter.

RESTRAINT AND HANDLING

In general, restraint of these species is simple, with the birds being captured in a net or herded into a corner, the beak restrained in one hand initially, and then the body and wings restrained under the other arm. As the nares are not patent in some species (brown pelicans, cormorants, boobies, and gannets), the beaks should be held

TABLE 12-1

Biological Data for Selected Pelecaniformes

Scientific Name	Common Name	Weight (Adults, kg)	Distribution
Phaethon rubricauda	Red-tailed tropicbird	0.64–1.1	Tropical Indian and Pacific Oceans
Fregata magnificens	Magnificent frigatebird	1.2–1.6	Tropical Atlantic and Pacific Oceans
Sula sula	Red-footed booby	0.85–1.0	Tropical Indian, Pacific, and Atlantic Oceans
Morus bassanus	Northern gannet	2.2–3.6	Newfoundland, Iceland, and Great Britain
P. bougainvillii	Guanay cormorant	1.55–3.2	Western South America
Anhinga anhinga	Anhinga	1.23–1.27	Southern North America to Argentina
Pelecanus occidentalis	Brown pelican	2.05–4.1	Coastal southern North America and Central and South America
Pelecanus erythrorhynchos	American white pelican	6.18–8.0 (males); 4.21–8.0 (females)	Coastal and inland North and Central America
Pelecanus rufescens	Pink-backed pelican	3.86–5.55 (males); 3.42–4.57 (females)	Sub-Saharan Africa

Adapted from Weber M: *Zoo and wild animal medicine*, 5th ed, St. Louis, MO, 2003, Elsevier. Chapter 13: Pelecaniformes.

slightly open during restraint to prevent asphyxia. When stressed, some birds (gannets and pelicans) may inflate their subcutaneous air sac diverticulae that may easily be palpated by the handler as crepitus under the skin; this may be an alarming finding to the novice. Staff should consider wearing eye protection when handling birds such as the anhingas, which have long sharp beaks.

SURGERY AND ANESTHESIA

Inhalant anesthesia using isoflurane is a simple and easy way of anesthetizing Pelecaniformes. The long beak makes application of a mask difficult; a useful tip is to use a disposable rectal glove as a makeshift mask for induction. Pelecaniformes are easily intubated with an uncuffed endotracheal tube. Nitrous oxide should be avoided because it has been reported to cause significant expansion of the subcutaneous air sacs of a pelican.[9] Endotracheal intubation of some species may be challenging because of the crista ventralis, a septum or projection across the lumen of the trachea just inside the glottis. Intubation is readily achieved using a smaller tube, with the awareness that the inhalation anesthesia may be less efficient and the bird will also be breathing room air, that the airway is less protected, and that assisted ventilation will be less effective. As with other bird species, the addition of ketamine (3 milligrams per kilogram intramuscularly [mg/kg, IM]) and butorphanol (1 mg/kg, IM) provides more controlled anesthesia suitable for surgery and endoscopy (personal communication, author).

Surgery, particular to this group of birds, is performed for repair of the pouch.[12] Special considerations include establishing that subramal and ventral gular blood supply is intact, as no evidence of anastomoses between these vessels exists, so vascular damage to these areas may result in poor wound healing. Full thickness suture patterns should also be avoided when repairing laceration of the pouch to avoid compressing the vascular layer. The pouch should be repaired by separating the epithelial layers and suturing them separately using a simple interrupted pattern.

Flight is often restricted in the larger species such as pelicans, as their size necessitates very large (and relatively expensive) meshed aviaries to permit free flight; they are therefore often restrained in large, open-topped areas by such methods as feather clipping, feather follicle extirpation, or pinioning. Clinicians should note that in some countries, pinioning (amputation of the wing tips) is legally performed by nonprofessionals in very young birds. In other countries, pinioning is legally restricted; for example, it is considered "an act of veterinary surgery" in the United Kingdom and, as such, may only be performed by a veterinary surgeon (on a bird of any age) and must be performed with the bird under general anesthesia if the bird is over 10 days old.

Currently, few publications on pelican surgery exist in the literature, but a case of successful keratoplasty performed on the left cornea of a young adult female California brown pelican (*Pelecanus occidentalis*) for the treatment of vision-threatening corneal scarring has been reported.[5]

DIAGNOSTICS

Blood collection is similar to that in other birds, with the metatarsal veins being the most accessible. Blood collection via the jugular vein or the wing veins may be challenging in pelicans because the subcutaneous air pockets make visualization and palpation of the vessels difficult. Complete blood cell count and serum biochemistry values are comparable with those performed in other avian species (Table 12-2).

DISEASES

General

Pelecaniformes are susceptible to a wide range of diseases noted to affect other avian species. Diseases particularly noted in captivity include aspergillosis, pododermatitis, endoparasitism, and vitamin deficiencies and other conditions associated with the feeding of frozen fish. In general, diagnosis and treatments are similar to those in other avian species.

Infectious Disease

Bacterial enteritis has been reported in captive pelicans and cormorants. *Escherichia coli*, *Proteus* spp., *Salmonella* spp., and *Campylobacter* spp. have been cultured from affected animals. Fatal *Clostridium perfringens* enteritis has been diagnosed in a captive brown pelican, and contaminated fish was suspected to be the source of the infection.

Viral diseases reported in Pelecaniformes include infections with West Nile virus, Newcastle disease virus, and poxvirus. Avian influenza vaccination has a mixed result in the Pelecaniformes; a study reported that the commercially inactivated H5N2 vaccine (manufactured for domestic poultry) elicited only a partial response in cormorants and no immune response in pelicans.[7]

Parasitic Diseases

Pelecaniformes may harbor parasites typically infesting many bird species in captivity, typically ascarids, which are trematodes that are routinely treated with fenbendazole or albendazole (Table 12-3). External parasitism is common but rarely leads to clinical signs, and treatment is routine. A study of the parasites of the American white pelican found 75 different species of parasites, the majority of which

TABLE 12-2

Reference Ranges for Hematologic and Serum Biochemical Parameters of Selected Pelican Species*

		American white pelican, *Pelecanus erythrorhynchos*			Brown pelica, *Pelecanus occidentalis*			Pink-backed pelican, *Pelecanus rufescens*		
Test	**Units**	**Reference Interval**	**Mean**	**Median**	**Reference Interval**	**Mean**	**Median**	**Reference Interval**	**Mean**	**Median**
White Blood Cell Count	*10∧9 cells/L	4.56–32.02	14.02	12.93	3.85–25.40	11.25	10.32	0.00–41.07	19.23	16.37
Red Blood Cell Count					1.63–3.89	2.78	2.76	1.67–3.38	2.55	2.52
Hemoglobin	g/L	95–191	140	143	115–198	156	157	56–186	121	121
Hematocrit	L/L	0.314–0.560	0.436	0.434	0.330–0.559	0.457	0.458	0.289–0.564	0.43	0.435
MCV						171.4	167.3	116.7–222.8	168.6	169.8
MCH								25.5–70.4	48.6	47.9
MCHC	g/L	267–409	341	338	245–411	325	328	161–407	287	284
Heterophils	*10∧9 cells/L	2.41–20.02	8.14	6.9	1.71–14.76	6.25	5.54	0.00–25.13	12.23	10.34
Lymphocytes	*10∧9 cells/L	0.90–14.11	4.76	3.98	0.43–9.34	3.3	2.67	0.00–9.18	4.07	3.36
Monocytes	*10∧6 cells/L	68–2227	580	374	50–2049	639	472	0–1658	669	576
Eosinophils	*10∧6 cells/L	63–1310	420	289	50–1419	402	296	0–1637	653	512
Basophils	*10∧6 cells/L	0–789	335	282	47–1117	371	270		387	310
Glucose	mmol/L	7.51–17.35	11.87	11.56	5.46–17.86	12.41	12.39	5.47–16.88	10.79	11.18
Blood Urea Nitrogen	mmol/L	0.0–3.1	1.4	1.1	0.0–2.9	1.4	1.2			
Creatinine	µmol/L	0–66	29	24	0–80	40	35			
Uric Acid	µmol/L	97–870	376	330	162–1238	511	436	0–896	448	391
Calcium	mmol/L	2.01–2.76	2.35	2.36	1.85–3.15	2.41	2.38	1.79–2.92	2.37	2.36
Phosphorus	mmol/L	0.25–1.91	0.89	0.83	0.46–2.73	1.24	1.08	0.26–2.01	1.21	1.13
Ca/Phos ratio		1.7–8.4	3.9	3.6	0.9–6.6	3.2	3	0.8–4.5	2.8	2.7
Sodium	mmol/L	139–159	150	150	138–164	149	150		151	151
Potassium	mmol/L	1.5–6.4	3.1	2.8	1.4–6.2	2.9	2.8		4.2	3.9
Na/K ratio		23.0–101.7	55.1	52.5	23.2–113.3	56.5	51	16.4–60.1	37.8	38.2
Chloride	mmol/L	100–125	113	113	95–122	111	112			
Total Protein	g/L	31–59	43	42	28–63	45	44	20–60	43	40
Albumin	g/L	10–22	15	15	9–25	16	16	6–22	14	14
Globulin	g/L	16–42	27	27	11–47	28	27	9–44	28	26
Alkaline Phosphatase	U/L	362–2317	1281	1339	225–2161	1176	1193	0–1192	536	484
Lactate Dehydrogenase	U/L	0–1035	557	511	0–1750	893	684			
Aspartate Aminotransferase	U/L	60–466	181	155	104–840	301	247	0–770	352	311
Alanine Aminotransferase	U/L	0–71	34	33	0–132	56	40		64	57
Creatine Kinase	U/L	223–1405	609	531	290–3246	1138	920	0–1808	937	744
Gamma-glutamyltransferase	U/L	0–9	4	3	0–15	6	5		5	5
Amylase	U/L	0–3969	1737	1586	466–5728	3178	3097	472–2822	1631	1647
Total Bilirubin	µmol/L	0.0–9.6	4.2	3.8	0.0–12.8	5.1	3.7			
Cholesterol	mmol/L	2.57–6.73	4.7	4.73	2.98–9.89	5.54	5.41	0.32–5.83	3.4	3.07

*Values from ISIS, USA, downloaded at Twycross Zoo, U.K., January 2013.

ALK. PHOS., Alkaline phosphatase; *ALT (SGPT)*, alanine transaminase (serum glutamic pyruvic transaminase); *AST (SGOT)*, aspartate aminotransferase (serum glutamic-oxaloacetic transaminase); *BUN*, blood urea nitrogen; *CPK*, creatine phosphokinase; *fL*, fluid ounce; *g/L*, gram per liter; *GGT*, gamma-glutamyl transpeptidase; *HCT*, hematocrit; *HGB*, hemoglobin; *LDH*, lactate dehydrogenase; *MCH*, mean corpuscular hemoglobin; *MCHC*, mean corpuscular hemoglobin concentration; *MCV*, mean corpuscular volume; *mmol/L*, millimole per liter; *µmol/L*, micromole per liter; *RBC*, red blood cell; *SD*, standard deviation; *WBC*, white blood cell; *Units/L*, units per liter.

From Teare JA, ed: 2013, American White Pelican; Brown Pelica; Pink Backed Pelican_No_selection_by_gender__All_ages_combined_Standard_International_Units__2013_CD.html *in* ISIS Physiological Reference Intervals for Captive Wildlife: A CD-ROM Resource, International Species Information System, Bloomington, MN.

TABLE 12-3

Common Parasites of Pelecaniformes

Parasite (Type)	Site Typically Found	Clinical/Pathologic Findings
Contracaecum (ascarid)	Ventriculus, distal esophagus, gular pouch	Ulcerative gastritis, if present in large numbers
Phagicola longa, Mesostephanus appendiculatoides (trematodes)	Intestines	Mild histologic changes only
Piagetiella sp. (pouch lice)	Gular pouch	Severe hemorrhagic stomatitis in debilitated pelicans and cormorants

TABLE 12-4

Reproductive Characteristics of Pelecaniformes

Parameter	Pelicans	Cormorants	Gannets	Boobies	Tropicbirds
Maturity (approx.)	3–4 years	2–4 years	5 years	1–6 years	4 years
Eggs/clutch (approx.)	2–4	2–4	1	1–3 (facultative siblicide may occur)	1
Incubation period (approx.)	28–35 days	24–31 days	42–46 days	40–45 days	40–46 days
Incubation method	Under foot webs	On foot webs	Under foot webs	Under foot webs	Insulated in breast feathers

cause little or no clinical signs.[8] Fenbendazole is reported to be effective in brown pelicans at a relatively low dose of 22 mg/kg and effectively treated *Contracaecum multipapillatum*, *Mesostephanus appendiculatoides*, and *Phagicola longus*.[1] Fatal enteritis and bone marrow damage have been seen in pink-backed pelicans following administration of fenbendazole. Affected birds were found dead or exhibited respiratory distress and died shortly after presentation. In treatment with benzimidazoles, the recommendation is to medicate the birds individually or to hand-toss medicated fish to individuals, rather than treating an entire group with medicated fish placed in a pan.

Toxicities

Poisoning with marine toxins, including domoic acid and brevetoxin, has been reported in brown pelicans, Brandt's cormorants, and double-crested cormorants.[4] Pelicans affected by domoic acid poisoning exhibited slow, side-to-side head motion, fine motor tremors, scratching at the pouch, and vomiting, whereas affected cormorants were unusually docile when approached by humans.[13] Cormorants affected by brevetoxicosis showed ataxia, disorientation, and intention tremors.

Botulism, caused by ingestion of the toxin produced by *Clostridium botulinum*, has been reported in Pelecaniformes birds and has been associated with up to 20% of a population die-off in the western population of the American white pelican.[10]

Noninfectious Disease

Osteodystrophy caused by dietary calcium, vitamin D_3 deficiency, or both has been reported in captive raptors fed all-meat diets and in cormorants (*Phalacrocorax auritus*).[6] Reports of neoplasia are rare but include skin melanoma diagnosed in a pelican throat pouch in addition to a multicentric T-cell lymphoma. The pelican was found dead but a clinical history of T-cell lymphoma did not exist.[11]

REPRODUCTION

Reproduction has been low for most of the Pelecaniformes species maintained in captivity and may be caused, in part, by the small flock sizes that are maintained (Table 12-4). Mature white pelicans have a keratinized growth on the dorsal maxilla during the breeding season; this growth is shed at the end of the season. Both sexes incubate eggs and participate in rearing chicks.

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