Chapter 6

Health and Medicine

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Husbandry Issues That Affect the Health of Flamingos

Flight restraint methods

It is encouraged to keep flamingos full-winged when the appropriate facilities are available and, hopefully, more zoos will account for this when designing facilities for flamingos in the future. Pinioning is the most common de-flighting method performed on flamingos maintained in outdoor enclosures. Successful pinioning has been performed on chicks from 2-10 days of age. Refer to Reproduction, Chapter 4 for further details on animal husbandry issues related to pinioning. The procedure may be performed with simple crushing of the tissue with a hemostat and cutting with a scissors or scalpel. The incision may be closed with tissue glue. General anesthesia is needed if the procedure is performed on adult-sized flamingos. For traditional pinioning, the site of amputation is determined by finding the alula and cutting the bone just distal to the base of this structure. Remove the flight feathers at the amputation site. Other feathers should be plucked and the skin surgically prepared. A circumferential skin incision is made, leaving enough skin to close the wound. The major vessels in this area are between the metacarpal bones, which are fused at either end. A figure eight transfixation ligature is placed loosely around the proximal ends of the bone. The bones are amputated with a sharp chisel, a bone-cutting forceps or a giggly wire. Once the distal end of the metacarpal bones is freed, the ligature is tightened. The skin is pulled into place to cover the end of the bones and sutured closed. A light pressure bandage is applied to assist in controlling hemorrhage. The bird usually removes the bandage in a day or two. Amputating less bone (i.e. “long pinioning”) may improve reproductive success, but it is still unclear if some birds are completely inhibited from flight. Tendonectomy is not recommended because it is more invasive and in some countries is forbidden. Birds often develop droopy wings, and the procedure frequently does not prevent the flamingo from flying.

When designing a new facility, efforts should be made to allow chicks to be retrieved for pinioning and other procedures with minimal disturbance to the flock. Refer to the Management and Housing Chapters for details.

Sexing Methods

Males and females are sexually monomorphic, although males are usually larger than females.

A non-blood feather technique utilizing PCR technology is currently available in the US (Avian Biotech, 1-800-514-9672, Fax: 850-386-1146, e-mail: agt@nettally.com,

http://www.avianbiotech.com). This technique is the least invasive, easiest to perform, and the preferred method to be used for sexing flamingos by some institutions. A small amount of DNA is extracted from the shaft of a freshly plucked feather. It is then purified, and special primers are used to amplify a sex-specific DNA fragment. This technique still needs to be validated in flamingos.

European Laboratories that are able to sex flamingos by this methodology are as follows:

Austria

1) Pluma Osterreich
Lochauestrasse 2
6912 Hobranz
T: +43(0) 55 73 8 54 03
F: +43(0) 55 73 8 54 03

Czech Republic

1) Genservice, s. r. o.
Laborator molekulami genetiky
Palackeho 1-3
612 42 Brno
T: +420 5 41321229
F: +420 5 41562648
Email: genservice@volny.cz

2) Statni veterinarni ustav Brno
Palackeho 174
612 38 Brno
T: +420 5 41321229
F: +420 5 41211509, 41212383
Emai: svubrno@login.cz

Germany

1) Pluma GbR-Molekularbiologische Analytik
Postfach 70 03 59
70573 Stuttgart
T: +49(0) 711 990 59 23
F: +49(0) 711 990 59 24

2) Genedia GmbH
Burgstrasse 12
D-80331 Muenchen
T: +49 (0) 89 64289624
F: +49 (0) 89 64249666
Email: info@genedia.de

3) Loboklin
Prinzregentenstr. 3
D- 97688 Bad Kissingen
T: +49 (0) 971 72020
F: +49 (0) 971 68546
Email: laboklin@t-online.de

4) Tieraeztiches Institut
Georg-August-Universitaet Goettingen
Abt. Molekularbiologie
Groner Landstrasse 2
D-37073 Goettingen
F: +49(0) 531 393399
Email: ipfeiff@gwdg.de

The Netherlands

(1) Gendika
Industrieweg 1
9641 HM Veendam
T: +31 (0) 598 619343
F: +31 (0) 598 612194
Email: info@gendika.com

(2) Dr. van Haeringen Laboratorium BV
Agro Business Park 100
P.O. Box 408
6700 AK Wageningen
T: +31 (0) 317 416402
F: +31 (0) 317 426117
Email: vhl@bedrijf.diva.nl / info@vhlgenetics.com

United Kingdom

1) An-Gen
PO Box 60
Winchester
Hampshire S023 9XN
England
T: +44(0) 1962 882 986
F: +44(0) 1962 881 790
Email: parrots@an-gen.com

2) Avian Biotech International
PO Box 107
Truro
Cornwall TR1 2YR
T: +44 (0) 1872 262 737
F: +44 (0) 1872 262 737
Email: abluk@globlnet.co.uk

DNA testing from a blood sample for gender determination is a commonly used technique and is relatively non-invasive. Zoogen (PE AgGen, Inc) has validated the technique for most flamingo species. For ease of sampling from a chick, blood can be taken from the pinion site.

Surgical sexing via laparoscopy may be performed. The advantages of this method are that the gonad can be visualized directly (e.g. assessment of sexual maturity and activity can be made) and other body organs can be evaluated. The disadvantages are that the bird must be restrained,

preferably with anesthesia, and the procedure is somewhat invasive. It is recommended to perform this technique on birds two years of age or older so that the bird is sexually mature and out of the age range where traumatic injury is most common.

Proper Environment to Prevent Bumblefoot

The most satisfactory enclosures for flamingos have a substrate of grass and several shallow pools for feeding and bathing. Refer to Housing, Chapter 2 for details. Hospitalized flamingos should be housed on soft, thick rubberized or meshed mats (again, refer to the Housing Chapter for details).

Housing

Avoid isolating flamingos by themselves. Sick flamingos should be housed with at least one other bird. If this is inappropriate for the specific medical problem (e.g. infectious disease issues), then mirrors or a tape recording of vocalizations can be used as alternatives. Another flamingo should be placed with the ill flamingo as soon as is appropriate, e.g. no infectious disease issues. Refer to Housing, Chapter 2 for specifics on enclosure design and size.

Life Span

Flamingos are long-lived, some reaching over 50 years (Fowler and Cubas, 2001). They are capable of reproducing at this age as well (Shannon, pers. comm., 1999). Geriatric medical problems start at approximately 35 years of age (Shannon, pers. comm., 1999).

Physical Restraint

Flamingos may be slowly herded into a corner, allowing handlers to capture them. The base of the neck is lightly, but securely, grasped with one hand and the body with the other, lifting the bird off its feet and directing the legs slightly away from the handler. The body with the wings of the bird folded in the natural position should be held next to the hip of the handler. Care must be used in controlling the long legs to prevent them from flailing about. A cloth hood may help calm the bird down. Manual restraint is adequate for physical examination, blood collection, and minor medical treatments and procedures. Refer to Management, Chapter 3 for specific details on proper manual restraint.

Anesthesia

General anesthesia is commonly used to facilitate positioning during radiography as well as to provide immobilization and analgesia during laparoscopy and other surgical procedures. Isoflurane is currently the preferred inhalant gas. Initially, the animal is manually restrained as described in the Management Chapter (3). The anesthetic gas is administered via a facemask (a converted one-liter plastic bottle or a large bell-shaped mask may be used). Due to the peculiar conformation of the bill, the mouth can only be opened wide enough to introduce the endotracheal tube, thus making visualization of the glottis difficult especially in smaller flamingo species (e.g. lesser

flamingos). The glottis, however, may be visualized most of the time in larger species. Blind intubation may be attempted. Maintenance anesthesia may also be performed via facemask, if intubation is not possible. Surgical placement of an air sac tube is an option in critical situations where more controlled anesthesia is needed and intubation is not feasible. Attempts should be made to limit anesthetic episodes to two hours or less.

Ketamine at a dose of 20 mg/kg intramuscularly can be utilized if Isoflurane is unavailable (Fowler, 1986). However, recovery can be unpredictable and is more likely to lead to post-anesthetic problems. Monitoring the anesthetized bird is extremely important. Heart rate, respiratory rate, and body temperature should be monitored frequently throughout the procedure. An ultrasonic Doppler may be used to monitor the pulse. The most common site used is the ulnar (or basilic) artery. Pulse oximetry is also useful. A reflectance probe placed against the upper palate or a clamp on a digit works well. Careful attention must be given to maintenance of body temperature. Temperature probes may be placed in the esophagus or cloaca. The animal may be placed on a water-circulating heating pad, and hot packs may be placed along the body of the animal to help maintain the bird's position (like sand bags) and body temperature. Flamingos that become hypothermic while under anesthesia will have prolonged recoveries and fatalities may result. For longer procedures, warmed fluids should be administered intravenously at 20 ml/kg/hour. Subcutaneous fluids may be administered prior to recovering the flamingo if necessary.

Recovery from anesthesia may be dangerous because the bird may attempt to stand prematurely, which may traumatize the long legs. It is best to hold the bird until it has recovered. Alternatively, the bird may be placed in a 100% cotton, lightweight pillowcase, with the head extended through the opening. If the bird is held, the legs are usually extended and a finger is placed between the hocks to prevent abrasions.

Behavioral Signs of Disease in Adult Birds

It is important to observe the bird prior to going into the enclosure so that an accurate assessment can be made. Knowing individual bird behaviors may also be helpful. Clinical signs of disease may include lethargy, anorexia, one bird isolating itself from the flock or being picked on, "dull eyes", plumage deterioration, long-term pair bond breaks, leg trembling in combination with other signs, weakness, and lack of breeding behavior and egg production.

Physical Examination

Unusual anatomy

Flamingos have long, thin legs and can stand on one leg with the head tucked beneath a wing for a considerable period of time. The bill is uniquely adapted for filter feeding. The neck is proportionately the longest of any bird, containing 17 cervical vertebrae (Fowler, 2001). The feet are fully webbed with four digits in Caribbean and Chilean flamingos (Fowler, 2001). The hallux is absent in James and Andean flamingos (Fowler, 2001). Flamingo legs are very delicate and are more easily damaged than other long-legged bird species.

Physical examination

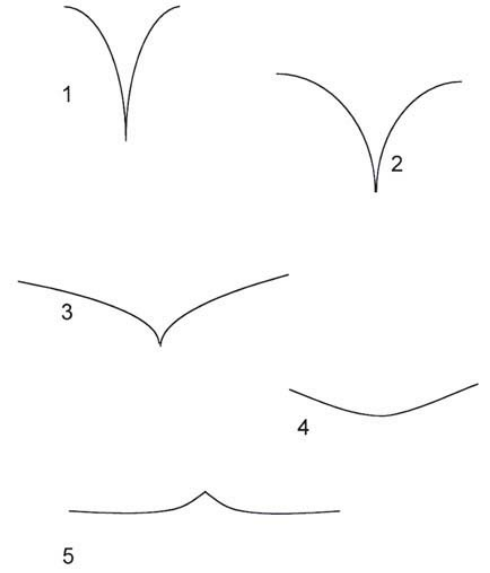
The physical examination is an important diagnostic tool in flamingos. A complete oral exam is difficult to perform due to the inability to open the beak wide enough. The feet should be examined carefully because pododermatitis and cracks in the feet are common. A pectoral musculature score assessment adapted from a model used for psittacines (Romagnono, 1999) has been utilized in flamingos at Sea World. It has been especially useful when the weight of the bird is normal but the actual muscle condition has changed. Normal flamingos are usually 2 to 2.5 on a scale 1 to 5 (Henry, pers. comm. 1999). A normal keel score rating will vary with the species of flamingo. It is a subjective determination to be evaluated in the context of the overall health and body weight of the bird.

Keel Score Rating Guide

Linda Henry, Sea World San Diego

The guide is designed to provide a means for a more consistent assessment of a bird's palpated weight. The keel score ratings are listed below with their description and a sketch example of the degree of flesh. Sometimes a bird may seem to be between two scoring possibilities. In this case, a score of 1.5 or 2.5 may be appropriate.

Where possible, always pair the assessed keel score with the gram weight of the bird. Keep in mind that what is a *normal* keel score rating will vary with the species. It is a subjective determination to be evaluated in the context of the overall health of the bird and the gram weight of the bird. If an increase in weight does not correspond with an increase in keel score, consider

KEEL SCORE	DESCRIPTION	EXAMPLES
1	Emaciated, keeling severely and sharply.	
2	Keeling, only small amount of muscle dipped to either side of keel.	
3	Keel palpable but muscle firm to either side.	
4	Muscle appears straight across over keel, keel palpable between muscles.	
5	Cleavage, keel not palpable, muscle mounded to either side of keel.	

behavioral observations to determine if there is a health problem. Generally, keel score and weight are in agreement.

Factors that figure into weight vs. keel score ratings include age of the bird, pinioning, amputation, degree of hydration, and, in flamingos, height, etc.

This technique was borrowed and adapted from a parrot center in Florida.

Supportive Care

Tube Feeding

Tube feeding is similar to other avian species, although it is difficult to visualize the glottis in the flamingo. In addition, lesser flamingos have unusual tracheal anatomy and are more prone to having the trachea accidentally intubated and aspirating the formula (Lung, pers. comm. 1999). Personnel performing this procedure should be appropriately trained. Two people should be involved in tube feeding (one person to hold the bird and the other to place the tube) and should communicate with each other throughout the procedure. A 14 French red rubber feeding tube or similar type of tubing works well for this purpose (a smaller tube may be needed for lesser flamingos) and is directed toward the right side of the oral cavity and esophagus. The tube should be well lubricated prior to placement. Prior to administering fluids or gruel, the neck should be palpated to assure that the tube and the trachea can be palpated. It may be helpful to actually feel the tip of the tube as it goes down the esophagus, especially in lesser flamingos. A small amount of saline can be placed prior to administering formula to assure tube placement. If the bird coughs, the tube should be pulled out and redirected. It is recommended to make a gruel out of the flamingo's regular diet. The bird should be well hydrated prior to administering a gruel diet. In very ill birds, it is a good idea to dilute the gruel initially.

An alternative to tube feeding is to feed with a catheter-tipped syringe placed in the beak. This method was utilized for supportive care of a flamingo at the Denver Zoo and seemed to be less stressful and caused less struggling than tube feeding (Baier pers. comm. 1999).

Fluid Therapy

Fluids are administered to flamingos in a similar fashion as with other avian species. Methods of administration will depend on the severity of illness in the bird being treated. Oral, subcutaneous, and intravenous (bolus, IV catheter) fluid therapy methods are most common. The medial metatarsal vein is the preferred site for indwelling catheters. Intraosseous fluid therapy may be an option in critically ill flamingos.

Sling Use and Construction

A very functional sling has been designed by Sea World (Henry, unpublished information, 2002). This sling design is suitable for long-term slinging of long-legged birds for recovery of leg injuries or for short-term slinging required during treatment of myopathy. Flamingos have been slung for up to

eight weeks continuously, with infrequent removal for routine weights or radiography. Ideally, flamingos should be in the sling for as short a time as is required for recovery.

Sea World Adventure Park San Diego has used this sling design for several years. Although the original sling consisted of nothing more than a foam pad, duct tape and cording, a few years ago several design elements were incorporated to make the sling more uniform, washable, adjustable and user friendly.

The Sea World sling now consists of fabric-covered foam pad with four webbing straps, which end in D-rings. The bird is suspended using additional straps that thread through the D-rings on the sling pad and are attached with hook and loop tape. The hook and loop segment at the D-rings allow for easy height adjustments to the sling without necessitating the removal of the bird. This is vital to finding a comfortable posture and height for the bird. The other end of the suspension straps is then affixed to the interior of the caging ceiling.

Once constructed, the sling can be machine-washed and dried, depending on the materials used. The Sea World sling is made using headliner fabric of 100% nylon fabric with polyester foam core. Velour may be substituted for the headliner fabric, but it is less durable. The foam insert is a medium density, one-inch polyurethane foam with a 1.9-pound resiliency. The hook and loop tape is nylon and is “sew-on” rather than adhesive. The webbing is polypropylene; cotton webbing is also available but not as sturdy. These supplies are readily available at upholstery suppliers or fabric stores.

To protect these long-necked birds from tangling and injuring themselves on the suspension webbing, it is recommended to cover the support straps with pipe insulation foam on all four straps, for approximately three feet of each strap.

Sling Set-up and Use

To place a bird in the sling, it is best to have two people, one to hold the body of the bird and a second person restraining and guiding the legs. Once in the sling, the flamingo must be wrapped into the sling around both the body and the sling. This is the portion of the slinging process that is the most difficult to standardize. Flamingos will often wriggle their way out of a sling if improperly secured. It often takes several attempts to find the wrapping method that works best for a particular bird. In general, the wrap should cover the body over the wings as well as secure the bird from forward and backward movement within the sling. Four-inch wide Vetwrap is the most effective bandage material for wrapping birds into the sling. Vetwrap is the product name for an elastic non-adhesive tape or bandage material that adheres to itself by the crimped nature of the product. Vetwrap comes in rolls and can be obtained through most veterinary or medical supply companies. It is important to monitor birds closely after slinging. Birds may loosen bandage material and come out of the sling; height and posture adjustments may be needed or bandaging may be too tight. Sometimes birds will appear limp and unresponsive. Such behavior may indicate further veterinary treatment. At other times, this behavior is the transition period where the bird is becoming familiar with the sling. It is recommended to wait 30-60 minutes, allowing time for the bird to acclimate to its new surroundings, before readjusting the sling. Once managers become more proficient at slinging and the bird becomes more accustomed to it, birds will not need to be watched as closely.

In slinging a bird, handlers must be mindful of the crop and vent locations. The vent should be unobstructed by either the sling pad or bandage material so that feces do not build up in this area.

The crop should not have undue pressure from the sling, which may interfere with proper feeding and natural processes of food digestion.

An additional consideration is the keel region. For most birds of adequate weight, the keel should be well protected by both the muscle/fat of the bird and the foam of the sling. However, for very thin birds or for birds in the sling for extended periods, the keel may need additional protection or cushioning. A small doughnut-shaped insert can be made of foam, with a cutout to accommodate the keel, and backed with hook and loop tape that can be attached to the sling pad for added protection for the keel.

Substrate for the bird to stand on while in the sling is another area of concern. Any soft matting are good substrates; even terry cloth toweling is sufficient. (See Housing, Chapter 2). Asphalt, bare concrete or other abrasive surfaces should be avoided.

Flamingos often will need to be tube fed during the slinging period. In the initial days, birds often refuse to eat. Even those eating may need supplemental tubing. We offer a food and water tray within easy reach of the bird, usually raised on an overturned crate to allow for easier access by the bird. The caution here is to prevent a struggling bird from inadvertently injuring itself by banging a leg into the food tray.

Adjustments to Height and Posture

If a bird is swinging too much, it may be unable to get its weight underneath enough to try to stand. If a bird fights too much, the front height may be too low. Generally, the front of the sling should be higher than the back. The goal is for the bird to be able to stand, even minimally, while in the sling. The sling functions to provide stability and safety.

Sling Construction

The following instructions work for both the large (Caribbean flamingo size) and the small (lesser flamingo size) slings. Full-size patterns are available from the AZA Ciconiiformes Taxon Advisory Group or the Aviculture Department of Sea World San Diego, California. Fabric yardages are available in standard widths of 60 inches. The half-yard specified might make more than one cover, but that is the smallest amount that you might be able to purchase for a single sling. Foam is available in bed sizes (i.e., full, queen, king). We recommend having more than one sling on hand.

Supplies list: yardages given are for one large sling

- 1/2 yard headliner fabric (e.g., Tempo)
- 1/2 yard of one-inch foam
- Up to 9 yards of one-inch nylon webbing
- Four one-inch D-rings
- Up to 4 yards of pipe insulation foam
- Hook and loop tape (e.g., Velcro)

Sling Pad Construction:

1. Cut two pad pieces (pattern A) from headliner fabric
2. Cut one foam insert (pattern B) from one-inch foam
3. Cut four eight-inch lengths from the one-inch webbing; melt the ends of the webbing

with a lighter flame to secure from ravels
4. Place fabric pieces A right sides together with webbing inserted between layers at each “X”
5. Sew seams around edges leaving V-shaped area between dots open as specified on pattern A
6. Reinforce stitching at each point where webbing is inserted
7. Clip corners and curves; turn right-sides-out
8. Insert foam at opening
9. Machine stitch opening closed
10. Sew D-rings to webbing straps

Support Straps: Cut four pieces of one-inch webbing at least 12 inches longer than needed. Sew six inches of male and six inches of female hook and loop tape to each end of these straps.

Sling completion: Put one end of each of the long webbing pieces through each D-ring, securing hook and loop tape. The other end of each long webbing piece should be secured to whatever is used to suspend the bird. Our indoor caging is seven feet high and the strap ends are secured to the caging ceiling (e.g. cable ties, bicycle rings).

Sling maintenance: Before using a sling, be sure to check each of the insert points of the webbing to be sure that each attachment is secure. The hook and loop tape may need replacement if the hook end becomes filled with lint/debris. This must also be very secure in its attachment. When using washable materials, the sling can be machine-washed and dried using warm water and gentle cycles.

Drug Therapy

Pharmacokinetic studies have not been performed on flamingos, thus drug dosages should be extrapolated from other avian species. Flunixin meglumine (Banamine) has been documented to cause renal toxicosis in flamingos and cranes, and thus should be avoided (Klein et al, 1994). Fenbendazole (Panacur), a commonly used anthelmintic, has recently been found to cause bone marrow suppression in several avian species (Howard et al, 1999). It should be used with caution in flamingos.

Diagnostic Evaluation

Blood drawing, hematology, and serum biochemistry

Blood can be collected from the jugular, medial metatarsal, or ulnar (or basilic) veins. The jugular is preferred if large volumes (>3.0 ml) are desired. The medial metatarsal vein is the preferred site for indwelling catheters. Blood is usually collected into a heparinized syringe or green-top tube. Lead poisoning is a concern for free-living birds (Aguirre et al, 1991), and whole blood collected to diagnose lead poisoning should be preserved in EDTA (purple-top tube). A complete blood count (CBC), chemistry panel, blood smear evaluation for hemoparasites, and plasma banking should be part of initial diagnostic evaluations. Normal CBC and chemistry values have been published for some flamingo species, and the results are consistent with other groups of birds (Tables 1 and 2, Norton, In Press; Merrit et al, 1996; Ball et al, 2000; Hawkey et al, 1984 and 1985). The plasma and serum from captive flamingos is orange and should not be confused with hemolysis.

Parameter	American (Merritt et al, 1996)	Chilean (Hawkey et al, 1984)	Greater (Hawkey et al, 1985)	Lesser (Hawkey et al, 1985)
RBC X 10^6/ul)	1.12-1.85	2.44-2.93	2.3-3.1	2.4-2.9
PCV (%)	37.95-57.83	41-51	43-57	46-54
Hemoglobin g/dl	9.22-17.65	14.1-18.1	16.6-20.9	15.2-19.5
MCV (fl)	234.31-419.06	161.7-182.4	168-210	179-195
MCH (pg)	57.82-125.35	57.3-64.8	62.9-73.9	55.4-70.5
MCHC (g/dl)	20.42-35.87	33.3-37.9	33.5-39.1	30.8-37.5
Leukocytes/ul	1,531-15,898	1,600-9,000	900-4,500	3,800-8,500
Heterophils/ul	589-12,445	410-4,740	570-2,620	1,700-6,870
Lymphocytes/ul	927-14,504	820-2,610	490-1,680	530-2,370
Eosinophils/ul	0-544	0-710	0-310	0
Monocytes/ul	3-1,418	0	0-130	0-340
Basophils/ul	0-4629	0-360	0-350	0-230
Thrombocytes	adequate	6000-33,000	1,400-35,000	3000-23,000
Plasma protein	5.29-8.08			
Fibrinogen (mg/dl)	40-600	130-360	140-330	140-290

Table 1. Reference range for hematologic parameters in flamingos (Norton 2002, Zoo and Wild Animal Medicine Fifth edition)

Parameter	American (captive) (Merrit et al, 1996)	American (captive) (mean and SD) (Ball and Port, 2000)	American (Semi-free-ranging) (mean and SD) (Ball and Port, 2000)	Chilean (captive) (mean and SD) (Norton, in press)
Total protein (g/dl)	3.18-4.94	4.5/0.4	4.3/0.6	4.9/0.5
Albumin (g/dl)		2/0.3	1.8/0.2	1.7/0.2
Globulin (g/dl)		2.5/0.4	2.5/0.4	
Calcium (mg/dl)	4.95-21.78	10.9/2	10.2/0.6	11.0/0.8
Phosphorous (mg/dl)	1.11-6.76	2.4/1	4.3/2.5	
Sodium (mEq/L)	139.5-160.2		157.5/2.7	153.1/3.0
Potassium (mEq/L)	1.86-6.76		3.2/1.3	2.2/0.3
Chloride (mEq/L)	110.55-123.30		117.0/4.5	116.4/2.8
Creatinine (mg/dl)				0.4/0.08
Urea nitrogen (mg/dl)				
Uric acid (mg/dl)	3.73-22.10		4.1/1.8	2.1/0.9
Cholesterol (mg/dl)			345/50.7	
Glucose (mg/dl)	107.22-288.32	238/52.9	162.4/40.8	270.7/55.7
LDH (IU/L)	47.74-696.94	175/115.5		151.0/72.6
ALP (IU/L)	18.26-737.55	17.9/6.4		
CK (IU/L)	157.15-3,521.44	460.3/228	1578.6/1692.4	
AST (IU/L)	70.42-475.72	221.9/36.8	233/140.2	255.3/94.9

Table 2. Reference ranges for plasma biochemical parameters in flamingos (Norton 2002, Zoo and Wild Animal Medicine, Fifth edition)

Fecal Evaluation (Parasites, Special Stains, Culture)

Fecal cytology (modified Wright's stain or Diff Quick stain), fecal gram stain, fecal acid fast stain, fecal flotation and direct smear, and fecal culture for Salmonella sp. may also be part of initial data collection. The presence of inflammatory cells in the feces is suggestive of an enteritis. Fecal gram stains may be used to approximate fecal flora and identify budding yeast. Fecal acid-fast stains are used to screen for the presence of acid-fast bacteria; however, shedding of these organisms is often intermittent and inconsistent. If fecal acid-fast bacteria are identified, fecal culture for *Mycobacterium spp*. should follow. Fecal flotation and a direct smear with saline are used to identify ova, parasites, and protozoa from feces.

Serology

After a review of the initial lab work is complete, banked plasma may be used to run additional tests such as protein electrophoresis and *Aspergillus spp.* and West Nile virus serology. Additional serology that may be useful but that has not been validated for flamingos includes titers for diseases such as equine encephalomyelitis virus, avian influenza, Paramyxovirus, and Mycoplasma spp.

Microbiology

Microbiology can be very useful in identifying specific etiologic agents. *Escherichia coli*, *Proteus spp., Pseudomonas spp*., *Enterobacter spp.*, and *Edwardsiella tarda* may be part of the normal flamingo intestinal flora but also may be pathogenic in some cases (Lamberski, 1998; Aguirre et al, 1991; Baylet et al, 1979; Glunder and Siegman, 1989; Shane et al, 1984). *Escherichia coli*, *Salmonella spp*., *Aeromonas hydrophila*, *Pasteurella multocida*, and *Streptococcus spp*. should be considered to be potential pathogens, as these organisms have been isolated from healthy as well as sick birds (Aguirre et al, 1991; Lamberski, 1998; Baylet et al, 1979; Glunder and Siegman, 1989; Shane et al, 1984).

Laparoscopy/Biopsy

Laparoscopy and biopsy of specific organs or lesions are often necessary to confirm a diagnosis. Laparoscopy is also used to surgically sex birds. These procedures are conducted similarly to other avian species.

Radiology

Radiography is a very useful diagnostic tool. Flamingos are positioned similar to other bird species (lateral and ventrodorsal views of the entire body). Due to their large size, it is not possible to include both the wings and legs on one cassette. Multiple cassettes are used. Animals that have lesions on the bottoms of their feet or have traumatized pinion sites should have these areas radiographed to rule out osteomyelitis.

Neonatal Medicine

(Refer to the Chick Management section of Chapter 2 for additional details)

Routine Physical Exam

A health assessment should take place when chicks are handled for other reasons. If feasible, a blood sample can be taken for CBC, plasma biochemical profile, sexing, and plasma banking. Normal clinical pathology for growing flamingo chicks has not been established.

Supportive Care and Medical Treatment

Medical and supportive care for flamingo chicks is similar to other avian species. If the chick is being parent-reared, the goal should be to get the chick back to the parents as quickly as possible. If aggressive therapy is needed, a commitment to hand-rearing may be necessary. Supportive care may include tube feeding (see Supportive Care section of Medical Chapter) fluids or formula, fluid therapy (subcutaneous, intravenous, or intraosseous depending on the severity of the problem), providing a warm dry environment, etc.

Rickets-like syndrome

A rickets-like condition was reported in young flamingos at WWT/Slimbridge, UK and has been noted at several other institutions (Humphreys et al, 1975). The birds exhibited bending of the tibiotarsus and thickening of the head of the bone. Affected birds became lame, appeared painful, and were stunted. The condition has been found in birds from four weeks to fully feathered. This syndrome has always been observed at the end of the breeding season. Radiographic examination reveals the upper third of the tibiotarsus to be bent medially with severe thinning of the bone. The medullary canal follows the curvature of the bone. On the lateral side of the tibiotarsus there is extensive soft replacement bone extending from below the bend to the epiphyseal junction. Remnants of the original shaft may be seen projecting downwards from the proximal epiphysis. There is an unusually large gap between the already ossified proximal epiphysis and the metaphysis due to thickening of the epiphysis growth line. There appears to be an interruption of normal ossification, which allows bending as the body weight increases. This condition differs from true rickets in that abnormalities in other long bones have not been demonstrated (Humphreys et al, 1975, Fowler, 2001). Similar conditions have been described in fast-growing broilers, which were fed a high protein diet and grew faster than normal (Humphreys et al, 1975). More research is needed in this area (refer to the necropsy protocol).

Metabolic Bone Disease

Metabolic bone disease is rare in captive flamingos, but it may occur if the parents are on a calcium-deficient diet, if chicks are not exposed to ultraviolet irradiation, or if birds are hand-reared on a calcium/vitamin D deficient diet (Fowler 1978; Fowler 1986). Many zoos have large indoor exhibits that do not have access to natural sunlight.

Fractures/trauma

Physeal fractures of the tibiotarsal-tarsometatarsal bones are not uncommon in chicks handled for pinioning and other procedures (eleven days to three months is the critical time for these fractures to occur). Fractures of any bone are possible. Physeal fractures are very difficult to repair (Fowler, 2001).

Tibiotarsal Rotation

Tibiotarsal rotation does occur in flamingos. However, it is not observed as commonly as in other long-legged birds such as cranes. Although there is not any published information on medical management of this problem, it should be handled in a manner similar to other species (i.e. decrease rate of growth by diet manipulation, increase exercise in hand-reared birds, surgical correction).

Omphalitis/Incomplete Closure of the Umbilicus

Omphalitis is most commonly caused by gram-negative bacteria in flamingos and other avian species (Griner, 1983). It may be prevented by providing a clean environment and swabbing the umbilicus at hatching with dilute povidine iodine. Antibiotics may be warranted in some situations. The umbilicus may require surgical removal.

Incomplete closure of the umbilicus may accompany a small yolk sac protuberance (Griner, 1983). If this protuberance starts to dry and turn black due to constriction, it is best to keep the area clean and place the chick on appropriate antibiotic therapy. It should not be forced into the abdomen and will usually fall off in a few days.

Noninfectious Diseases

Heat Stress

Captive flamingos are susceptible to heat stress, and care should be taken when handling or shipping birds in hot weather (refer to Management, Chapter 3 for details).

Capture or Exertional Myopathy

This condition may occur with prolonged restriction of limb movement, which may occur during shipping or recovery from anesthesia (Young, 1967). Vitamin E/selenium deficiency may predispose the bird to this condition (Dierenfeld, 1989). Lactic acid builds up in the muscles and causes necrosis of the muscle fibers. The flamingo may have difficulty standing or be unable to stand. A plasma biochemical profile will reveal elevations in muscle enzymes (creatinine

phosphokinase, AST). Prognosis is guarded, but treatment can be successful. Treatment may consist of placing the bird in a sling, vitamin E/selenium supplementation (IM or oral), hydrotherapy, supportive care, and anti-inflammatory (dexamethasone) and muscle relaxant (robaxin) drugs as needed. Handling should be minimized. Supplementation of the diet with vitamin E prior to and after handling or shipment may aid in prevention of this problem.

Some flamingos have died while being handled (Fowler, 1978, Humphreys, 1975) and based on clinical assessment, the cause of death was thought to be cardiac related (Henry, pers. comm., 1999). Postmortem evaluation did not reveal typical gross or histopathological lesions suggestive of capture myopathy (Henry pers.comm., 1999). Further clinical attention and research are needed in this area.

Trauma

Leg fractures are the most common cause of morbidity and mortality in captive flamingos and usually occur when they are startled or when physically restrained. Growth plate fractures of the tibiotarsal-tarsometatarsal bones may occur when chicks are physically restrained. Fractures of the tarsometatarsus and the proximal tibiotarsus are the most common in adult birds.

Avulsion of the ligament of the femoral head, producing coxofemoral dislocations, and medial collateral avulsions of the intertarsal joint occasionally occur. Wing and rib fractures may also occur secondary to trauma. Leg tendon injuries are not uncommon. The tarsometatarsal fractures are almost always compound, involve the diaphysis, and frequently include damage to metatarsal dorsalis and superficial arteries and veins and extensor and flexor tendons. Wounds are usually contaminated, and significant blood loss is common (Reiderson pers. comm., 1999). The flamingo should be treated for shock, and supportive care should be instituted prior to surgical repair. Once the bird is stable, the bird should be anesthetized (refer to Anesthesia section) with Isoflurane. A lateral approach to tarsometatarsal fractures is recommended. A type 1 Kirshner-Ehmer external fixation apparatus where four to five pins are driven through both cortices and skin surfaces with one connecting bar has been successful in repairing these fractures. Closure of the skin and scales over the fracture is usually impossible, owing to the extensive skin damage and surgical swelling. The defect should be covered with a protective water-resistant transparent dressing, which allows good oxygen and moisture vapor permeability such as Tegaderm (3M Health Care, St. Paul, MN 55144, USA), BioDres (DVM Pharmaceuticals, Inc., Miami, FL 33178), or Duoderm.

One Chilean flamingo drowned when its lower beak became wedged between a leg band and the leg. The leg band had been placed around the distal segment of the leg rather than above the tibia-metatarsal articulation (Griner, 1983).

Predation by various predators is another common cause of flamingo mortality in captivity and the wild. Predator control is recommended. See the Management Chapter for additional information.

Foot Problems

Frostbite

Frostbite of the interdigital webs and digits has been documented when flamingos are exposed to below freezing temperatures (Fowler, 2001). Clinical signs include lameness, darkening of the interdigital web and eventual necrosis of the affected tissue. Prevention should include limiting exposure to temperatures below freezing. Refer to the Housing Chapter for details.

Pododermatitis/Bumble Foot

Flamingos are susceptible to abrasions of the feet due to contact with hard or rough surfaces such as concrete, which may result in pododermatitis. The skin on the plantar surface of the foot becomes cracked and swollen. This may lead to bacterial invasion (Staphylococcus sp is most common), which eventually may lead to osteomyelitis, joint infections, renal disease (the kidney is the most common site for bacteria to lodge in a variety of avian species) (Phelan et al, 1990)), and/or septicemia.

Clinical signs range from inconspicuous to severe lameness. Foot lesions may start as cracks or fissures (Grade 1) which get infected and then become nodular (Grade 2 when nodules are small). The nodules increase in size (Grade 3 when nodules are large), and then other structures become involved such as tendons and bone (Grade 4). Proliferative wart-like lesions may be secondary to a papilloma virus (Heldstab and Studer-Thiersch, unpublished data, 2002).

The following are predisposing factors for pododermatitis:

a. The condition occurs slightly more often in zoo-hatched birds than in birds from the wild (Heldstab and Studer-Thiersch, pers. comm., 2002).
b. Males develop symptoms more frequently than females (Heldstab and Studer-Thiersch, pers. comm., 2002).
c. Cold weather and water causes cracks in feet.
d. Larger flamingo species may be more susceptible to the condition.

Treatment may consist of one or all of the following depending on the severity:

1. Local antiseptic cleaning and bandaging
2. Various lubricating or moisturizing ointments
3. Systemic antibiotics
4. Surgical debridement

Prevention may include:

1. Providing a substrate of grass or similar short, dense vegetation and a shallow pool.
2. Good sanitation of the exhibit and water.
3. Winter housing should be well designed and allow birds access to outdoors when possible.
4. Increase the activity of the birds by stimulating them to forage, providing a larger flock size to stimulate normal social behaviors, and artificially increasing day length.

5. Salt water around the feeding areas may decrease the incidence of the condition (Heldstab and Studer-Thiersch, pers. comm., 2002).
6. When flamingos are confined for medical reasons, rubber or mesh mats should be utilized (rubberized flooring, 3M matting-Nomad, Dri-Dek).
7. Regular examination of feet so treatment can be initiated early in the course of the disease.
8. Some institutions have had success with birds walking through moisturizing-type solutions on a regular basis.

Unusual Forms of Pododermatitis

An unusual form of pododermatitis occurred at one institution while birds were housed for the winter. The housing situation was sub optimal (e.g. concrete floors with Dri-Dek being provided sporadically). Two birds presented with similar lesions on two different occasions. A hemorrhagic fluid-filled bullae developed on one foot. Local and systemic antibiotics were used to treat the lesion. The bullae disappeared, however, the skin sloughed and the interdigital webbing became very dark and dry. Eventually the skin sloughed, leaving a healthy granulation bed. The lesion resolved in a month. Approximately 1.5 years later, the flamingo avulsed her nail and developed an osteomyelitis on the adjacent bone. The cellulitis and infection spread despite antibiotic treatment until the base of the foot and distal tendons of the leg were involved. The infection ruptured through the scales approximately two-thirds down the length of the leg, which allowed drainage to occur. The tendons in the area were necrotic. The flamingo developed similar bullae on the interdigital webbing during this episode. Approximately, 3-4 cm of necrotic deep and superficial digital flexor tendons were removed. Once the necrotic tendons had been removed, healing was quite rapid. Two years later, the bird was still walking well. A second bird developed a very similar problem and was handled the same way and is now walking with no obvious abnormalities (Wallace, pers. comm., 1999).

Nutritional Diseases (Refer to Nutrition, Chapter 5 for further details)

The following are examples of nutrition-related diseases:

a) **Metabolic bone disease**. Chicks fed a diet low in calcium, an improper calcium/phosphorous ratio, or a diet low in vitamin D, or lack of exposure to ultraviolet irradiation, are the most susceptible to metabolic bone disease (Humphreys, 1975; Fowler, 1978). Some zoos have their flamingos housed indoors without access to natural sunlight.
b) **Tibiotarsus rotation** (see Neonatal Medicine).
c) **Atherosclerosis** occurs sporadically in some zoological collections. The etiology of this condition remains unknown (Griner, 1983).
d) **Vitamin E/selenium deficiency**. This condition may predispose birds to capture myopathy (Dierenfeld, 1989). Currently captive diets appear to be low in vitamin E, thus supplementing the diet is recommended (see Nutrition, Chapter 5 for details).
e) **Vitamin D toxicosis**. A toxic nephropathy has been noted in captive flamingos from Europe. Vitamin D toxicosis leads to hypercalcemia, resulting in calcium deposition in renal tissue. It was suspected that there was a dietary excess in vitamin D (Phalen, Ambrus, and Graham, 1990).

Neoplasia

Neoplasia is relatively uncommon in flamingos. A few cases have been reported and are as follows:

a) Complex hepatocellular carcinoma was found in a lesser flamingo. The bird presented with bilateral pododermatitis and had a systemic trematode infestation (Campbell et al, 1993).
b) Cholangiocarcinoma was documented in a lesser flamingo (Wadsworth et al, 1985).
c) Cholangiocarcinoma and hepatic megalocytosis was reported in a Caribbean flamingo (Lopez and Marino-Moncada, 1986).
d) An ovarian adenocarcinoma was found in a Caribbean flamingo (Wadsworth et al, 1985).
e) A cholangioma was found in two Caribbean flamingos by one of the authors (JR).

Gout

Visceral gout has been observed with some frequency in flamingos housed at several North American zoological institutions. It is not clear if these are primary cases of gout or secondary to dehydration caused by other clinical diseases. A survey will be conducted on morbidity and mortality factors in the North American captive flamingo population, and elucidating the causes of this condition will be one of the primary goals.

Toxicities

Heavy metal toxicity is not common in captivity but possible. Zinc toxicosis has been suspected at a few institutions however, the source of zinc remains unknown. Lead poisoning has been reported in free-ranging greater flamingos and Caribbean flamingos secondary to ingestion of lead shot consumed while foraging (Aguirre et al., 1991). The clinical signs included emaciation and high mortality. At necropsy lead pellets were found in the gastrointestinal tract. There was evidence of enteritis, and the ventricular lining was stained an intense green. Therapy has not been reported but should be similar to that used in psittacine birds and waterfowl.

Flunixin meglumine has induced renal toxicosis in flamingos and cranes, thus is not recommended to use this drug in flamingos (Klein et al, 1994).

Vitamin D toxicosis is covered in Nutritional Diseases (see above).

Algal Toxicosis

Microcystins are hepatotoxic cyclopeptides produced by some types of cyanobacteria. Ten adult captive Chilean flamingos (*Phoenicopterus chilensis*) died acutely. Concurrently, an algal bloom was noted in the exhibit pond in which the flock of over 100 birds resided. The 10 affected flamingos presented dead or moribund with clinical signs of extreme weakness, lethargy, recumbency, and dyspnea. Bleeding from injection sites was noted in the five birds in which venipuncture and treatment were attempted. Blood abnormalities included severe hypoglycemia and marked elevations in AST, CK, LDH, and iron. Therapeutic efforts focused on controlling shock,

hypoglycemia, dehydration, and delayed hemostasis. Despite treatment attempts with fluids, dextrose, vitamin K, oxygen, vitamin E/Se, dexamethasone, and piperacillin, all birds died within eight hours of presentation. Initial differential diagnoses included toxicosis (e.g. anticoagulants, blue-green algae toxins), trauma, sepsis, or capture myopathy. Necropsies were performed on seven birds. Cultures from the liver, kidney, lung, and brain of three birds showed mixed bacterial growth but did not provide a causative etiologic agent for the epornitic. Consistent gross and histopathological lesions included multifocal areas of hemorrhage in the muscle, gastrointestinal, and respiratory tracts, severe hepatocellar dissociation and necrosis with hemorrhage and splenic congestion. High performance liquid chromatography (HPLC) was used to determine the presence of toxicological agents in pond water samples and internal organs of two birds. Liver tissues were negative for seven different anticoagulant rodenticides, while gastrointestinal contents and pond samples contained microcystins. Under light microscopy, pond water samples also contained non-filamentous granular clumps of cells surrounded by a clear calyx, consistent with the morphology of organisms of the genus *Microcystis*. It was determined that blue-green algae toxicosis caused the acute deaths seen in this flamingo flock. Further flamingo access to the exhibit pond was prohibited and no further mortalities occurred (Chitick et al, 2002).

Stress

Some flamingos fail to adjust to captivity (Humphreys et al, 1975). Malnutrition may develop. Occasionally captive flamingos collapse and die acutely. Acute deaths have been noted in physically restrained flamingos and are thought to be related to cardiac arrest. Chronic stress can cause immunosuppression and predispose to various infectious diseases (e.g. aspergillosis, malaria) (Humphreys et al, 1975).

Cardiovascular Diseases

Examples are as follows:

a) A lesser flamingo's heart contained a myocardial infarct as well as foci of myocarditis. The bird's liver contained a granuloma of undetermined etiology (Griner, 1983).
b) Atherosclerosis has been seen in the aorta, brachial, carotid, and internal iliac arteries of a Chilean flamingo (Griner, 1983). The intimal plaques in the left brachiocephalic trunk had almost occluded the vessels. The left pectoral muscles were ischemic, soft, and moist. Atheromatous plaques were also seen on the intimal surface of the aorta and brachiocephalic trunk of an American flamingo (Griner, 1983). Multiple renal granulomas, micro-calculi and glomerulosclerosis were also observed in this flamingo. A form of atherosclerosis characterized by intimal and medial fibromuscular hyperplasia and mineralization and sometimes with atheromas and cartilagenous metaplasia has been noted at necropsy in the aorta of several adult American flamingos by one of the authors (JR).
c) Cardiac arrest (see above for details).

Sand/Sand-like Impactions

Lesser flamingos appear to be predisposed to developing impactions with sand and material with similar consistency to sand (Henry, pers. comm., 1999). It is not clear in each case the source of material causing the impactions. Most birds have been found extremely debilitated or dead.

Parasitic Diseases

Parasites have only occasionally been reported to cause clinical disease in captive flamingos (Fowler, 2001) and are most commonly incidental in wild flamingos.

External Parasites

Lice belonging to the same genera as those found on waterfowl are seen in captive and free-living birds (Lamberski, 1998).

Internal Parasites

Tetrameres americana and *T. coccinea* are commonly found in ductal areas of the proventricular glands with no associated inflammation in wild *Phoenicopterus ruber ruber* (Aguirre et al, 1991; Griner, 1983; Rollin, 1981; Threlfall, 1981). *Tetrameres spp*. have been problematic in some captive flamingos at The Wildfowl and Wetlands Trust in Slimbridge (Humphries et al, 1976).

Cestodes in the genus *Amabilia*, *Cladogynia*, *Sobolevicanthus*, and *Gynandrotaenia*, have been found incidentally in free-ranging flamingos (Aguirre et al, 1991), however, cestodes were found to cause an intestinal diverticulosis in a captive lesser flamingo (Poynton et al, 2000). Artemia of saline lagoons have been recognized as intermediate hosts for the cysticercoides of cestodes parasitizing free-living flamingos in Camargue, France (Gabrion and MacDonald, 1980).

Trematodes are frequently found incidentally in wild flamingos (Aguirre et al, 1991). A disseminated trematode infection has been reported in a captive flamingo with concurrent hepatic neoplasia (Campbell et al, 1993). Schistosome ova were detected in histologic sections of six Chilean flamingos that died at the Calgary Zoo over a 10-year period. Death could be attributed in part to the presence of trematode ova in only one flamingo. Ova were most numerous and most consistently found in the pancreas, spleen, ventricular muscle, and proventricular submucosa. Other sites in which ova were found included the cerebellum, liver, kidneys, lungs, and skeletal muscle. Moderate inflammation was present around ova trapped in the hepatic parenchyma but was minimal or absent in all other sites. Examination of necropsy records suggested that infections occurred before the birds were caught in Chile in 1988. On the basis of ova found in the aorta and in arterioles, the trematode was tentatively identified as belonging to the genus *Dendritobilharzia* (Pare and Black, 1999).

Acanthocephalids have been reported in free-ranging flamingos (Aguirre et al, 1991). Besnotia-like sarcocyts were found in smooth muscle of small intestine in a wild Caribbean flamingo and Sarcocystis sp. merozoites were found in pectoral muscle tissue in free-living Caribbean and lesser flamingos (Agurirre et al, 1991; Fowler, 2001). *Sarcocystis phoeniconaii n sp*. Murata was identified as a new species of Sarcocystis in the lesser flamingo (*Phoeniconaias minor*). Tiny rice-like grains, measuring 3-5 x 1 mm were found in the skeletal muscle (Lamberski, 1998).

Flamingos may harbor hemoparasites asymptomatically and occasionally develop clinical disease. In one report, *Plasmodium spp*. (type of malaria) caused a flamingo to become anemic and weak (Fowler, 2001). A diagnosis was made by microscopic examination of a blood smear. Mosquitoes are the vector of this parasite.

Treatment

Antiparasitic drugs and dosages used in other avian species should be effective and safe in flamingos. Due to the possibility of causing bone marrow suppression, fenbendazole should be used with caution in all avian species (Howard et al, 1999).

Prevention

Routine fecal examinations should be performed on captive flamingos. The parasite load in the particular group of birds being examined should dictate the frequency of fecal examinations. A minimum of twice-yearly fecal examination is recommended. Preventive deworming is rarely needed but should be instituted if chronic parasite problems exist.

Infectious Diseases

Bacterial

Escherichia coli, Proteus spp., *Pseudomonas spp., Enterobacter spp.,* and *Edwardsiella tarda* may be part of the normal flamingo intestinal flora (Lamberski, 1998). *Escherichia coli*, *Salmonella spp*., *Aeromonas hydrophilia*, and *Pasteurella multocida* should be considered potential pathogens, as these organisms have been isolated from healthy as well as sick birds (Aguirre et al, 1991). Staphylococcal septicemia and synovitis have been reported (Griner, 1983). Septicemia occasionally arises from the infected lesions of bumblefoot, and pneumonia may occur in newly imported or stressed flamingos (Humphreys, 1975). *Salmonella spp*. can cause enteritis and septicemia in flamingos (Humphreys, 1975). Flamingos may also be asymptomatic carriers of *Salmonella spp*.

Mycobacterium

Mycobacterium avium complex is not a common problem in captive flamingos. It was found in six (1.9%) out of a sample of 306 flamingos examined over a 28-year period at The Wildfowl and Wetlands Trust in Slimbridge (Brown and Pickering, 1992). Some speculate that the low incidence of *Mycobacterium avium* in captive flamingos may suggest that they have some natural immunity (Cromie et al, 1991). However, *Mycobacterium avium* infections have also been reported in free-ranging flamingos (Cooper et al, 1975; Kock et al, 1999; Sileo et al, 1979). An epizootic in free-ranging lesser flamingos in Kenya resulted in more than 18,500 deaths over a few months in 1993. The disease was concentrated along the shores of Rift Valley Lakes Bogoria and Nakuru and did not involve any of the other avian or mammalian species frequenting the lakes. Discrete necrotic and granulomatous lesions were often noted in spleen and liver, and *Mycobacterium avium serovar* I was isolated from both organs. Furthermore, *Escherichia coli* and *Pseudomonas aeruginosa* were recovered in pure culture from the liver of a high percentage of the birds. Histopathology revealed lesions indicative of an acute septicemia. Algal toxicosis was initially suspected as the cause of the deaths due to a concurrent algal bloom; however, this was not confirmed (Kock et al, 1999).

Viral

Pox Virus

Cutaneous poxvirus lesions have been reported in captive flamingo chicks and adults. The lesions are usually on the legs in the adults and around the mouth and eyes in chicks. Surgical resection may be curative (McManamon et al, 1992), however, the condition can also be fatal in chicks (Arai et al, 1991). Sea World of Florida vaccinates their chicks with a commercially available avian pox vaccine (M. Walsh, pers. comm., 1999). Gross appearance of the lesion, histopathology and electron microscopy may be used to make a diagnosis.

Herpes Virus

Herpes viral infections are widespread in avian species and have been reported in Ciconiiformes (Ritchie, 1995; Kaleta, 1990; Gomex-Villamandos et al, 1998). Natural and experimental herpesviral infections have been previously reported in black and white storks and green herons (Gomex-Villamandos et al, 1998). A series of cases in three species of stork with hemorrhagic necrotic enteritis was recently reported (Gomex-Villamandos et al, 1998). Stork herpes viral infections are often fatal. Viral replication occurs in different cell populations resulting in tissue necrosis and organ failure. The stork herpes virus is currently unclassified.

A novel herpes virus has recently been identified as being responsible for mortalities in captive Caribbean flamingos in one zoological collection (Pers. comm. J. Raymond, 2002; Montali et al, 1998). Term embryo and neonatal flamingo chicks appear to be most susceptible to infection. Clinical signs are usually nonspecific and include weakness, lethargy, dyspnea, and diarrhea.

Gross necropsy lesions include an enlarged liver and spleen with pinpoint foci of necrosis, evidence of inflammation in the cloaca and intestinal tract, pale gritty kidneys, lesions indicative of pneumonia, and inanition. Histopathologic findings include bursal lymphoid depletion, necrotizing hepatitis, cloacitis, pneumonia, air sacculitis, enteritis, and eosinophilic intranuclear inclusion bodies in the liver, cloaca, and kidney. Syncytial cells have been observed in the liver and cloaca of infected chicks. Other less frequent histologic lesions are yolk peritonitis, renal gout, splenitis, and colitis. Electron microscopic examination of hepatocytes has been used to identify intranuclear viral particles with ultrastructural features compatible with herpes virus. Refer to the necropsy protocol for recommendations for collecting and processing tissues.

Treatment options are currently unknown. Some flamingo chicks infected with herpes virus may develop concurrent septicemia, and the use of antibiotics and supportive care are recommended. Acyclovir has been documented to reduce mortality in psittacine birds infected with herpes virus (Norton et al, 1991) but has not been evaluated in flamingos. Acyclovir pharmacokinetic data is available for psittacine birds (Norton et al, 1992) and could be extrapolated for use in flamingos.

Managerial changes that involve the reduction of stress (e.g. not pinioning chicks) and prevention of septicemia (e.g. prophylactic antibiotics) have decreased mortality from the virus at the National Zoological Park. The mode of transmission is currently unknown but appears to have a vertical component. Immunosuppression appears to play a role in the pathogenesis of this disease as evidence by the bursal lesions found in all flamingo chicks infected with herpes virus. The exact

source of the herpes virus is still undetermined but may be indigenous in flamingos. Presently, the virus has not been isolated, but molecular viral techniques have identified it as a novel alpha herpes virus.

Paramyxoviruses

Newcastle's disease virus has caused mortality in free-living Caribbean flamingos (Fowler, 2001). The central nervous system is primarily affected. Clinical signs include tremors, paresis and paralysis. Free-living birds have been shown to have elevated antibodies to arboviruses. Paramyxovirus serotype 3 was isolated from tissues of captive flamingos (*Phoenicopterus ruber*) in Israel. The virus caused a high mortality, with respiratory system pathology being most notable (Shihmanter et al, 1998).

West Nile Virus

West Nile virus is caused by a flavivirus and is usually transmitted by mosquitoes. This virus may affect numerous avian species including flamingos. It also can affect humans and other mammalian species. Clinical signs are usually nonspecific; however, birds may exhibit signs of neurological disease such as abnormal head or neck posture, ataxia, tremors, circling, disorientation, unilateral or bilateral posterior paresis, and impaired vision. A bird may be found dead with no premonitory signs. The course of clinical illness is usually less than one week but may range from 1-24 days (Calle et al, 2000). Treatment is limited to supportive care and prevention of secondary infectious diseases. Vaccine trials are currently being conducted on flamingos at several institutions. The virus has affected flamingos in several North American captive collections.

Fungal

Aspergillosis

Aspergillosis may result in emaciation, lethargy, dyspnea, and increased mucous production in captive flamingos. Other than traumatic injuries, aspergillosis was the most important cause of mortality (3.1%) in the captive flamingo collection at The Wildfowl and Wetlands Trust at Slimbridge. Various forms of stress and housing birds indoors on straw in humid conditions were predisposing factors. Diagnosis and treatment are similar to other avian species. Prophylactic treatment may be a consideration under stressful conditions.

Cladosporium herbarum (Sooty Mold)

Fungal infections of the plumage associated with *Cladosporium herbarum* ("sooty mold") have been reported in the UK (Beer and Kear, 1975) and in Florida (S. Clubb, pers. comm., 1999). The fungus appears to be associated with Osier willows. This saprophytic fungus forms a black sclerotia, which ruptures the feather cortex, weakening it so that the distal part of the barb breaks off. The plumage of the back becomes unkempt, frayed, and the birds look wet and lack waterproofing. A black dust

is often noted and is especially visible on birds with pale plumage. Birds may become wet through to the skin and chilled. Death by pneumonia or drowning (due to a loss of waterproofing and buoyancy) is a consequence. The condition has been described in Chilean, Andean, James' and Caribbean flamingos. The mold is slow growing at the optimal temperature of 24-25° C. Growth is reduced or inhibited at higher or lower temperatures. Because of this temperature requirement, only the outer feathers are affected. Badly affected feathers may be pulled out or cut off.

Prevention includes the following (N. Jarrett pers. comm., 2002):

a) Raising the environmental temperature to 30° C will inhibit growth of the fungus.
b) Good hygiene of enclosures and exhibits.
c) Removal of Osier willows or keeping birds away from the trees.
d) Provide winter quarters with ambient air temperatures of 15° C to prevent mold growth.
e) Provide clean water to encourage bathing after gross contamination has been removed or when lack of water for bathing has stopped the bird from preening.

Geotrichum candidum

Geotrichum candidum was isolated from skin lesions of three Caribbean flamingos that died showing necrotic inflammation of the skin of legs and the digital webbing of the feet (Spanoghe et al, 1976). Abundant mycelium and arthrospores were observed in the dermis and epidermis. This fungus was subsequently inoculated into chickens and mice where it produced granulomas or more purulent nodules with central growth of abundant mycelium. *Geotrichum candidum* was re-isolated from 20 of 28 experimental animals. The authors suggested that prolonged contact with pond water and the presence of small wounds, as well as the advanced age of the affected birds, were predisposing factors in development of this disease. *Geotrichum candidum* is a common saprophytic fungus frequently found associated with mucous membranes and skin of humans and animals but rarely associated with disease. In this case report, seven of 21 flamingos had lameness and the presence of whitish skin lesions on the legs and digital webs. The lesions were observed during the first warm period after a cold winter. Three birds died after the onset of the lesions. These birds had been kept at this zoo for 16 years. The remaining four birds were separated from the flock, placed in a dry environment, and treated with an acaricide and an antibacterial ointment. The lesions disappeared approximately three weeks after the onset of the disease, even though no antifungal therapy was used. As the lesions in the affected birds were only in areas with maximum exposure to the pond water, it was surmised that this was a predisposing factor.

Amyloidosis (J. Raymond, pers. comm., 1999)

Amyloidosis is a disease that involves pathologic proteinaceous substance deposited between cells, causing tissue and organ failure (Landman et al, 1998). There are a number of biochemically distinct forms of amyloid; however, the protein is always composed of nonbranching fibrils arranged in beta-pleated sheets. Ninety-five percent of amyloid is composed of fibril proteins and 5% is composed of the glycoprotein called P component. Amyloidosis occurs in most avian orders, however, Anseriformes, Gruiformes, and Ciconiiformes have the highest incidence. The disease is progressive, fatal and has a high incidence in older birds. Systemic amyloidosis can be associated with a variety of infectious and noninfectious chronic inflammatory conditions as well as stress (Landman et al, 1998).

There appears to be a high incidence of amyloidosis in some captive collections of Caribbean flamingos. Stress and concurrent inflammatory conditions play major roles in the development of the disease. Most cases of amyloidosis in flamingos have been associated with infectious and noninfectious inflammatory disease(s); however, some flamingos with amyloidosis have no evidence of concurrent disease.

The most common gross lesions associated with amyloidosis in flamingos are an enlarged, tan-brown spleen, light brown, swollen liver and enlarged tan kidneys. Histologically, amyloid deposits are found primarily in the spleen, kidney and liver. Blood vessels in the heart, pancreas, liver, spleen, thyroid glands, and kidneys frequently contain amyloid deposits. Other organs less frequently affected with amyloid include adrenal glands, ovaries, and testes.

In the kidneys, amyloid deposits are primarily found within glomerular tufts. In cases of glomerular amyloidosis, flamingos can present with clinical signs suggestive of renal failure, which includes dehydration, lethargy, weight loss, anorexia, and shock. Many of these flamingos have elevated plasma uric acid and phosphorous levels. Most of these flamingos have concurrent urate nephrosis.

Enteritis due to a variety of causes is a common concurrent inflammatory disease associated with amyloidosis in flamingos. Other common concurrent inflammatory diseases are pododermatitis, hepatitis, dermatitis, arthritis, and nephritis.

There is no treatment for amyloidosis. Supportive care, including fluids, is an option to use in flamingos with renal disease due to amyloidosis. Treatment and prevention of various inflammatory diseases may aid in decreasing the incidence of the disease in flamingos.

Preventive Medicine

A good preventive medicine program is the best way to ensure a healthy and long-lived captive flamingo population. Preventive medicine begins with quarantine. All new arrivals should be housed separately from the existing collection for a minimum of 30 days. During this time period, the following is recommended:

a) A thorough medical and husbandry history should be acquired from the sending institution. Dietary and methods of feeding changes should be avoided or at least very gradually changed. Flamingos may stop eating even with very subtle changes to their environments. It is preferred to move flamingos in groups.
b) Monitor fecal quality and quantity closely during quarantine.
c) Physical examination at the beginning and preferably end of the quarantine period including assessment of body condition, examination for ectoparasites, and examination of the plantar surface of the feet. If physical examination at the end of the quarantine period is not possible, a visual exam should suffice.
d) Body weight (refer to the Management Chapter for details on methods of weighing) should be obtained at the beginning and end of quarantine period and opportunistically (i.e. quarantine exam).
e) Feces should be collected at weekly intervals for a total of three samples for fecal flotation, direct smear, fecal cytology, and fecal gram stain.

f) Cloacal swab or fecal culture for *Salmonella spp*. should be done at least once and preferably 2-3 times during the quarantine period. Placing feces in enrichment media may increase the yield of enteric bacterial pathogens.
g) Blood collection for CBC, chemistry, sexing, and plasma banking.
h) Animals should be permanently identified using leg bands or microchips.
i) If animals are to be housed in open outdoor enclosure, provisions should be made to restrict flight such as wing clipping or pinioning.

Birds housed in the collection should be examined opportunistically (i.e. when bringing in for the winter or moving for other management purposes). The husbandry and veterinary staffs of the individual institution should dictate the frequency of examination. It is important to catch birds prior to the breeding season, as not to disturb the nests and/or eggs. Routine health assessments should include the following:

a) Physical examination, including assessment of body condition, examination for ectoparasites, and examination of the plantar surface of the feet.
b) Body weight determination (refer to Management, Chapter 3 for details on weighing methods).
c) Feces should be collected at regular intervals for fecal flotation, direct smear, fecal acid-fast stain, fecal cytology, and fecal gram stain.
d) Cloacal swab or fecal culture for *Salmonella spp*.
e) Blood collection for CBC, chemistry panel, and serum banking. *Aspergillus spp*. serology and protein electrophoresis can be evaluated in healthy birds in order to establish reference intervals for these individuals.

Postmortem Evaluation

A thorough necropsy should be performed on all flamingos that die. Institutions are encouraged to perform a cosmetic necropsy for museum specimens; however, this should not compromise obtaining a complete set of tissues.

A complete and detailed history should be included. The bird should be sexed at necropsy and, if it was sexed antemortem, methods of sexing should be included so that sexing techniques may be standardized.

a) Collect a small section of all major tissues (heart, lung, air sac (on a piece of paper towel), thymus, bursa, crop, proventriculus, multiple sections of intestine, pancreas, kidney, adrenal gland, gonad, oviduct, muscle, bone marrow, gizzard, eye, tongue, esophagus, trachea, aorta, spleen, skin, peripheral nerve, and brain in 10% buffered formalin. Collect bone from chicks with suspected boney abnormalities.
b) Include a description of the gross findings, body weight in grams at the time of death, and important clinical history (including current diet).
c) Anaerobic, aerobic, and fungal cultures of various lesions should be taken when indicated.
d) Liver, kidney, spleen, bursa and any abnormal tissue should be frozen (-70° C) pending histopathology findings.

North American zoos should send the pathology report (gross and histopathology) or glass slides and culture results to Dr. James Raymond. If you suspect herpes virus, please call or email Dr.

Raymond for instructions and send a complete set of slides or formalinized tissues in conjunction with frozen (-70° C) samples of liver, kidney, spleen, and bursa of fabricus mailed overnight in a cooler of dry ice to:

Dr. James Raymond
Zoo Path
PO Box 1398
Harpers Ferry, WV 25425
Phone and fax number: 304-725-9212
Email: Zoopath2@aol.com

References

Aguirre, A.A., Cook, R. S., McLean, R. G., Quan, T. J., and Spraker, T. R. 1991. Occurrence of potential pathogens in wild Caribbean flamingos (*Phoenicopterus ruber ruber*) during a lead poisoning die-off in Yucatan, Mexico. J Zoo Wildlife Med 22:470-475.

Arai, S., Arai, C., Fujimaki, M., Iwamoto, Y., Kawarada, M., Saito, Y., Nomura, Y., Suzuki, T. 1991. Cutaneous tumor-like lesions due to pox virus infection in Chilean flamingos. J Comp Path 104(4):439-442.

Ball, R. L. and Port, M. R. 2000. Translocation of a large flock of American flamingos (*Phoenicopterus ruber ruber*) and comparisons of hematology and plasma biochemical values with a semi-free ranging population. Proceedings of the Annual Meeting of the American Association of Zoo Veterinarians, New Orleans, LA. pp 313-316 .

Brown, M. J. and Pickering, S. P. C. 1993. The mortality of captive flamingos at Slimbridge 1975-89. Wildfowl 43:185-193.

Baylet, R. and Rollin, P. E. 1979. Edwardsiella tarda et sp, et Salmonella typhinurium chez des oiseaux en Camargue. Bull. Soc. Pathol. Exot. 72: 405-410.

Calle, P. P., Ludwig, G. V., Smith, J. F., et al. 2000. Clinical aspects of West Nile virus infection in a zoological collection. Proceedings of the Annual Meeting of the American Association of Zoo Veterinarians, New Orleans, LA. pp 92-96.

Campbell, T., and Johnson, L. K. 1993. Complex hepatocellular carcinoma in an African lesser flamingo (*Phoeniconaias minor*). Proceedings of the Annual Meeting of the American Association of Zoo Veterinarians, St. Louis, MO. pp 408-409.

Chitick, E., Puschner, B., Walsh, M., Gearhart, S., St. Leger, J., Skocelas, E., and Branch, S. 2002. Blue-green algae microscystin toxicosis in captive Chilean flamingos. Proceedings of the Annual Meeting of the American Association of Zoo Veterinarians, Milwaukee, WI. in press.

Cooper, J. E., Karstad, L., and Boughton, E. 1975. Tuberculosis in flamingos in Kenya. Journal of Wildlife Disease 11:32-36.

Cromie, R. H., Stanford, M. J., Brown, M. J., and Price, D. J. 1990. Epizootiology of avian tuberculosis at The Wildfowl and Wetlands Trust at Slimbridge. , In Proceedings of the Zoological Society of London. British Veterinary Autumn Meeting.

Dierenfeld, E.S. 1989. Vitamin E deficiency in zoo reptiles, birds, and ungulates. J Zoo and Wildlife Med 20(1): 3-11.

Fowler, M. E. 1978. Phoenicopteriformes. In Fowler, M. E. (ed). Zoo and Wild Animal Medicine, W. B. Saunders Company, Philadelphia, PA. pp 160-163.

Fowler, M. E. 1986. Storks and flamingos (Ciconiiformes and Phoenicopteriformes). In Fowler, M. E. (ed). Zoo and Wild Animal Medicine, W. B. Saunders Company, Philadelphia, PA. pp 327-331.

Fowler, M. E. 2001. Phoenicopteriformes. In Fowler, M. E. and Cubas, Z. S. (eds). Biology, Medicine and Surgery of South American Wild Animals. Iowa State Press.

Gabrion, C. and MacDonald, G. 1980. *Artemia sp*. (Crustace, Anostrace), hote intermediaire d Eurycestus avoceti Clark 1954 (Cestode Cyclophyllide) parasitede l'avocette en Camargue. Annales de Parasitologie (Paris) 55(3): 327-331.

Glunder, G. and Siegman, O. 1989. Occurrence of *Aeromonas hydrophila* in wild birds. Avian Pathol, 18:685-695.

Gobel, E., Erber, M., and Grimm, F. 1986. *Sarcocystis phoeniconaii n sp.* Murata, 1986 (Apicomplexa: Sarcocystidae) des lesser flamingo (*Phoeniconaias minor*: Ciconiiformes) {German}. [*Sarcocystis phoeniconaii n. sp*. Murata, 1986 (Apicomplexa: Sarcocystidae) from the lesser flamingo (*Phoeniconaias minor*: Ciconiiformes)]. Berliner Und Muenchener Tieraeztliche Wochenschrift 109(6-7): 239-244.

Gomex-Villamandos, J. C. et al. 1998. Hemorrhagic enteritis associated with herpes virus in storks. Avian Pathology. 27:229-236.
Greenwood, A. G. 1992. Laparoscopic salpingectomy in a hybrid flamingo. Veterinary Record 131:349.
Griner, L. A. 1983. Pathology of Zoo Animals, 1st ed. Zoological Society San Diego. pp 153-157.
Hawkey, C., Hart, M. G., and Samour, H. J. 1984. Age-related haematological changes and haematological responses in Chilean flamingos (*Phoenicopterus chilensis*). Avian Pathology 13:223-229.
Hawkey, C. M., Hart, M. G., and Samour, H. J. 1985. Normal and clinical haematology of greater and lesser flamingos (*Phoenicopterus roseus* and *Phoeniconaias minor*). Avian pathology 14:537-541.
Howard, L. L., Papendick, R., Stalis, I.H., Allen, J. L., Sutherland-Smith, M., Zuba, J. R., Ward, D., and Rideout, B. A. 1999. Benzimidazole Toxicity in Birds. Annual Meeting of the American Association of Zoo Veterinarians, Columbus, OH. p. 36.
Humphreys, P. N. 1975. Pathological conditions. In Flamingos. Kear, J. and Duplaix-Hall, N. (eds.). T. and A. D. Poysner, Berkhamsted, Hertfordshire, England.
Kaleta, E. F. 1990. Herpes viruses of birds. A review. Avian Pathology 19: 193-211.
Kear, J. and Duplaix-Hall, N., (eds.) 1975. Flamingos. T. and A. D. Poyser, Berkhamsted, Hertfordshire, England,. pp 162-182.
Klein, P. N., Charmatz, K., and Langenberg, J. 1994. The effect of flunixin meglumine (Banamine) on the renal function in northern bobwhite (Colinus virginianus): an avian model. Proceedings of the Annual Meeting of the American Association of Zoo Veterinarians. Pittsburgh, PA. pp 128-131.
Klein, P. N., Cranfield, M. R., and Wagner, R. A. 1997. The novel use of hinged braces as external support devices for soft tissue joint injuries in long-legged birds. Proceedings of the Annual Meeting of the American Association of Zoo Veterinarians, Houston, TX. pp 332-333.
Kock, N. D., Kock, R. A., Wambua, J., Kamau, G. J., and Mohan, K. 1999. Mycobacterium avium-related epizootic in free-ranging lesser flamingos in Kenya. J Wildlife Dis 35:297-300.
Lamberski, N. 1998. The medical management of flamingos. Proceedings of the North American Veterinary Conference, Orlando, FL. pp 880-882.
Landman, W. J. M. et al. 1998. Avian amyloidosis. Avian Pathology 27: 437-449.
Lopez, A. and Merino-Moncada, M. 1986. Cholangiocarcinoma and hepatic megalocytosis in a captive flamingo, *Phoenicopterus ruber*. J Zoo An Med 17:147-148.
Merritt, E. L., Fritz, C. L., and Ramsay, E. C. 1996. Hematologic and serum biochemical values in captive American flamingos (Phoenicopterus ruber ruber). J Avian Med and Surgery 10: 163-167.
Montali, R. J., Hallager, S., Tomassoni, P. E., Cooper, G., and Richman, L. 1998. Proceedings of 1998 Meeting of the Colonial Waterbird Society and the Flamingo Specialist Group. pp. 17-18.
MacMananomon, R., Powel-Johnson, G., Dubielzig, R. R., Rakich, P. L , and Latimer, K. S. 1992. Surgical management of a pox virus lesion in a Chilean flamingo (Phoenicopterus chilensis). Proceedings, Joint Meeting AAZV/AAWV, p 179.
Murata, K. 1986. A case report of sarcocystis infection in a lesser flamingo. Jpn. J. Parasitlol. 35; 555-557.
Norton, T. M. Phoenicopteriformes, In Fowler, M. E. and Miller, R. E. (eds). In press. Zoo and Wild Animal Medicine, Current Therapy 5. W.B. Saunders Company, Philadelphia, PA.
Norton, T. M., Kollias, G. V., Clark, C. H., Gaskin, J., Wilson, R. C., and Coniglario, J. 1992. Acyclovir (Zovirax) pharmacokinetics in Quaker parakeets, Myiopsitta monachus. J Vet Pharmacol Therap, 15: 252-258.

Norton, T. M., Gaskin, J., Kollias, G. V., Homer, B., Clark, C. H., and Wilson, R. 1991. Efficacy of acyclovir against herpes virus infection in Quaker parakeets. Am J Vet Res, 52(12): 2007-2009.

Pare, J. A., and Black, S. R. 1999. Schistosomiasis in a collection of captive Chilean flamingos (Phoenicopterus chilensis). J Zoo Wildlife Med 13: 187-191.

Poynton, S. L., Mukherjee, G., and Strandberg, J. D. 2000. Cestodiasis with intestinal diverticulosis in a lesser flamingo (*Phoeniconaias minor*). J Zoo Wildlife Med 31: 96-99.

Ritchie, B. W. 1995. Herpesviridae. In: Avian Viruses: Function and control. Harrison, L. R. (ed). Wingers Publishing Company, Inc., Lake Worth, FL. pp. 171-222.

Rollin, P. E. 1981. Index of disease of Phoenicopteriformes. Special Report No. 1. Flamingo Working Group-Old World, Paris, France.

Rollin, P. E., Baylet, R., and Johnson, A. R. .Intestinal microflora of young Greater flamingos (*Phoenicopterus ruber roseus*) in the Camargue. J of Wildlife Dis 19: 61-62.

Romagnano, A. 1999. Examination and preventive medicine protocols in psittacines. In: The Veterinary Clinics of North America, Exotic Animal Practice. May, p. 338.

Shane, S. M., Harrington, K. S., Montrose, M. S., and Roebuck, R. G. 1984. The occurrence of Aeromonas hydrophila in avian diagnostic submissions. Avian Dis 28: 804-807.

Shihmanter, E., Weisman, Y., Lublin, A., et al. 1998. Avian paramyxoviruses serotype 3 isolated from captive birds in Israel: clinical signs, pathology, and antigenic characterization. Avian Dis 42(2): 418-422.

Sileo, L., Grootenhuis, J. G., Tuite, G. H., and Holcraft, B. D. 1979. Mycobacteriosis in the lesser flamingo of Lake Nakuru, Kenya. Journal of Wildlife Disease 15:387-390.

Spanoghe, L., Devos, A., and Viaene, N. 1976. Cutaneous geotrichosis in the Red Flamingo (*Phoenicopterus ruber*). Sabouraudia 14:37-42.

Threlfall, W. 1981. Helminth parasites of an American flamingo from Newfoundland, Canada. Proceedings of the Helminthological Society of Washington 48(1): 89-90.

Wadesworth, P. F., Jones, D. M., and Pugsley, S. L. 1985. A survey of mammalian and avian neoplasms at the zoological society of London. J Zoo An Med 16:73-80.

Young, E. 1967. Leg paralysis in the greater flamingo and lesser flamingo following capture and transportation. International Zoo Yearbook, 7:226.

Bumble foot, Zoo Basel; text corr. Alphen 19.3.2001; A.St

Bumble foot: some experiences from the Basel zoo.

Andreas Heldstab, Adelheid Studer-Thiersch, Zoo Basel

Foot problems are normally inconspicuous and therefore often not detected. Only when a bird begins to limb, we realize that something might be wrong

Short description of the symptoms:

Two different and independent ways of infections occur: an infection with bacteriae and one with the papilloma virus. The bacterial infection leads to infected wounds as cuts, fissures -> nodes -> balls (extremely large nodes); the virus infection to warts.

Both probably start with small cracks, cuts or fissures in the skin and may occur together.

Adult birds:

In the Basel zoo foot problems in the flamingos were recognized since long and were regarded mainly as problem of reduced blood circulation in the feet. Therefore, when the new exhibit for the flamingos was built in 1991, we tried to improve the conditions for the feet by natural precautions:

- by increasing the general activity of the birds i.e. foraging, walking around, stimulating social behaviour,
- by including the winter quarter into the exhibit enabling a regular moving in and out of the birds whenever possible also in the cold seasons,
- by adding a saltwater circle (concentration between normal seawater to double seawater-concentration) around the feeding pan
- by providing the resting places with dense, short vegetation.

Before the birds were transferred to the new exhibit in May 1991 the symptoms at the feet of all birds were checked and noted. This was repeated a few years later in December.

The comparison of the two checks showed following results:

- At both places (old and new exhibit) foot infections occurred a little more often in the zoo hatched birds than in birds from the wild.
- At both places (old and new exhibit) the males had somewhat more symptoms than the females.
- The feet had clearly become better in the new exhibit, the amount of the symptoms and the degree of infections having decreased.
- Active infections had become very rare.
- The papilloma infection had decreased only slightly.

- In birds from the wild the decrease of symptoms was more pronounced than in the birds hatched in the zoo

Young birds:

The young birds of the year are caught for the first time in August/September for individual leg banding. In October-December they are separated from the group and, if they remain at Basel, spend the winter at a different quarter.

Between late summer (scarcely any symptoms) and early winter there is a clear increase in cracks or cuts and nodes, virus infections are very rare.

In the winter quarter:

1. Odd asphalt floor covered with straw:
    - dramatic increase of symptoms, concerning bacterial and virus infections. (These birds are still living in our group. We lost 2 males in the following months due to foot problems, but the feet of the others underwent a drastic change, most of symptoms having disappeared within the following months in the outdoor exhibit. If these birds retain a susceptibility to later infections is not known.)
2. Smooth concrete.
    - Increase of the virus infections, but only to a low degree.
    - Combined with very shallow saltwater (for resting): no increase or even slight decrease of bacterial infections
    - Combined with Encamat mats (for resting): slight increase of bacterial infections but compared to the asphalt floor only to a low degree.

Summary of the experiences in the Basel zoo:

1. Males generally seem to suffer to a somewhat higher degree from the infections than females, as do birds hatched in the zoo compared to birds from the wild.
2. The infections leading to bumble feet are a dynamic process, the feet can get worse in a short time but the contrary is also true. Especially in young birds symptoms may disappear without leaving clear traces. Old chronic infections may also be reduced, but leave scars.
3. A steady disinfection of the feet by saltwater seems to reduce the rate of infections.
4. Papilloma infection seems to be more difficult to reduce and the degree may perhaps also be influenced by stress and similar factors. Indirectly this infection may be reduced by reducing the rate of small wounds, a probable entrance of the virus.
5. The cold and dark seasons seem to favour foot problems.

The conditions in the outdoor exhibit during the warm seasons could be improved by the different preventive measures. But there remain problems during the cold and dark seasons: Due to the low temperatures blood circulation will be reduced in the legs causing the skin of the feet to become hard and brittle leading to cracks and cuts in the skin thus enabling infections. Additionally the decreasing day length and the lacking sun reduce the general activity of the birds.
Under different climatic conditions than those in Middle Europe the situation might be different.

Proposals to reduce foot problems in flamingos by general preventive measures (not by medical treatment):

1. Saltwater through which the birds have to pass regularly, in outdoor and indoor enclosures.
2. Soft and slightly humid floor at the resting places (outdoor: short and dense vegetation, indoor: we experienced with woodchips this winter.)
3. Prolongation of the period the birds stay indoor at night to avoid the low night-temperatures
4. Increasing the general activity:

Outdoor:

- by offering large areas of shallow water with plankton production for extended foraging behaviour,
- by offering different resting places for different day times according to the position of the sun,
- by stimulating social behaviour.

Indoor:

- by adding artificial light to extend the short day length in winter and compensate for the lacking sun.
- by large winter quarter allowing display behaviour.