Penguin Taxon Advisory Group

PENGUIN HUSBANDRY MANUAL
THIRD EDITION

2005

American Zoo and Aquarium Association

CHAPTER 4
REPRODUCTION

CHAPTER 1

HOUSING AND ENCLOSURE REQUIREMENTS

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HOUSING AND ENCLOSURE REQUIREMENTS

Penguins are gregarious and best kept in groups, therefore, exhibits should be designed to accommodate a minimum of six birds. This conforms to the 1976 AAZPA resolution (Sladen, 1978) which recommended that penguins be kept in groups of no less than six birds of a single species.

A penguin exhibit is a complex and labor-intensive facility, requiring rigorous preventative and regular supportive maintenance programs. Polar, or Antarctic-dwelling, penguins require a constant, cool temperature with sophisticated air and water filtering systems. Failure of the cooling system compromises penguins' survival; it is advisable to install a back-up cooling system, especially for polar species. Upon completion of a new or renovated exhibit, it is prudent to test all systems for a period of five to seven days prior to the introduction of any birds. Keepers should test surfaces for abrasiveness and remove all ingestible material left by construction crews, such as bolts, brush bristles, wire, etc.

A penguin exhibit should include the following components:

1) Land space - enough land mass to accommodate the number of birds housed in the exhibit which allows for territorial disputes and provides areas for nesting during the breeding season;
2) Pool for swimming and bathing;
3) Isolation area - separate area to house birds that need to be isolated for forced pairing, behavioral, both parent and hand rearing of chicks, and non-contagious health problems.
4) Quarantine area - separate facility to accommodate newly-acquired birds or birds that must be separated from the group for health-related reasons. This area should provide separate air and water systems from the main exhibit.

   [Note: A quarantine area can serve as an isolation area if not in use for its intended purpose, or if one commits and treats the isolated birds as quarantine birds whenever quarantine is active. An isolation area without separate air and water systems should not be considered as an appropriate quarantine area.]

Attempts at defining a standardized formula to calculate optimal housing dimensions for penguins, taking into account all parameters, has been difficult at best. Therefore, the Penguin TAG, for now, adopts a minimum standard approach to housing dimensions. The guidelines that follow provide enough space for every penguin within the facility to be able to lay down and turn in a complete circle. The same criteria apply to the pool surface area and allows sufficient space should all birds be present in the pool at the same time.

The following guidelines are recommended as minimum and only minimum criteria for exhibit and holding standards. The Penguin TAG encourages those designing or renovating penguin exhibits to consider providing additional square footage and pool depth.

Recommendation for Exhibit Size:

	Pool Surface Area	Pool Depth	Land Surface Area
KINGS/EMPERORS			
Per bird for 1st 6 birds	1.67 sq m (18 sq ft)	1.22 m (4 ft) for any number of birds	1.67 sq m (18 sq ft)
Each additional bird	.84 sq m (9 sq ft)		.84 sq m (9 sq ft)

	Pool Surface Area	Pool Depth	Land Surface Area
OTHER SPECIES			
Per bird for 1st 6 birds	.74 sq m (8 sq ft)	.61 m (4 ft) for any number of birds	74 sq m (8 sq ft)
Each additional bird	.37 sq m (4 sq ft)		.37 sq m (4 sq ft)

Isolation/Quarantine Facilities:

Recommendation for short-term holding areas (six months or less):

	Pool Surface Area	Pool Depth	Land Surface Area
KINGS/ EMPERORS			
Per bird	0.84 sq m (9 sq ft)	1.0 m (3 ft)	0.84 sq m (9 sq ft)
OTHER SPECIES			
Per bird	0.37 sq m (4 sq ft)	.61 m(2 ft)	0.37 sq m (4 sq ft)

Temperature and light parameters in a short-term facility should be compatible with the main exhibit.

Excluding the *Aptenodytes*, the above recommendations do not include land area for nesting sites. Refer to Chapter 4, Reproduction, for details.

Additionally, facilities should be strongly encouraged to build or renovate exhibits that will allow offspring to be held for up to two years.

Species Isolation

Hybridization among several penguin genera, in particular *Spheniscus* and *Eudyptes*, has been documented. Managers contemplating mixed-species exhibits should carefully select desired species. It is recommended that *Spheniscus* be housed as single-species populations.

Air Temperature

The following optimum air temperature ranges are recommended for indoor exhibits. These same parameters can be used seasonally by northern facilities to exhibit these species outside.

Species	Indoor Air Temperature range
King, Gentoo, Chinstrap, Macaroni, Rockhopper	0° C to 11° C (22° F to 52° F)
Adelie, Emperor	-7° C to -1° C (19° F to 30° F)
Spheniscus	3° C to 22° C (37° F to 72° F)

For Emperor and Adelie penguins, -1° C or 30° F is the absolute recommended upper temperature limit. *Spheniscus* penguins can be successfully housed indoors or outdoors, or in exhibits using a combination of both. The success of an outside exhibit depends chiefly on the ambient temperature and the relative humidity of the area. *Spheniscus* penguins have been housed successfully in warmer climates where the exhibit is directly on the coast and the air is breezy. As a rule, penguins do not thrive in humid climates. They are highly susceptible to malarial infection; outside exhibits in areas with heavy mosquito populations should not be considered. Additionally, warm, humid climates may be conducive to *Aspergillus* infection in birds.

When housing *Spheniscus* penguins outside in areas where the temperature rises above 29.4° C (85° F), provisions should be made to allow the birds a means of heat relief. Sprinklers, misters, shaded areas, and forced-air movement are methods to be considered. Outside exhibits should be constructed so that the birds have shelter from freezing winds in the winter months. When the temperature falls below freezing all birds should have access to shelter. Open water must be available all winter and pools should not be allowed to freeze. Some institutions have reported mortalities among penguins that became entrapped under a pool's frozen surface. Larger colonies may benefit from a "beach" area to facilitate individual feeding of supplemented fish.

Drainage
Drainage systems for land areas and pool areas should be separate, to avoid pool contamination from run-off of exhibit maintenance. Drains, intake valves, and skimmers should be covered so that direct contact by birds is not possible. In filtered systems, care should be taken to provide a large enough bottom drain cover to prevent the possibility of a bird being sucked onto the drain.

Surface drainage should be adequate to allow for quick drying, and all **floors should slope to the drain**. Low spots that puddle should be avoided because a constantly wet substrate will eventually cause foot problems in penguins, not to mention the added staff hours needed for servicing the facility.

Substrate
Adequate substrate has been a topic of concern since zoos and aquariums first began exhibiting penguins. Although there are a number of products available that are used successfully, all have limitations. At this time, there is no one product that meets all of the requirements necessary for optimum penguin substrate. Many institutions use a combination of the following products to provide effective substrate for their birds:

- Astroturf
- Concrete
- Dirt
- Dri-Dek[1]
- Fiberglass
- Grass
- Gunite
- Ice
- Kitty litter
- Nomad[2] matting
- Peanut shells
- Polyurethane[3]
- Rocks (river, pea gravel)
- Sand
- Sport track surfacing

Kitty litter has been widely used to help reduce foot problems. Because of its desiccating nature, kitty litter has also been reported to decrease respiratory problems. However, caution should be used as kitty litter labels now include an OSHA warning because of the percent of silica dust contained in the product. Kitty litter will also find its way into the pool drains, as well as the water and filtering systems, where it will clog mechanical equipment, thereby creating additional keeper and maintenance work. Care must also be taken when using ground peanut shell litter products. Although peanut shells do not fall under OSHA regulations, they can serve as a natural media for *Aspergillus* growth. Therefore, if this product is used, it is recommended that a fungal retardant be added at the manufacturers' level. As a precaution, it is recommended that the product be cultured for fungi before use.

Historically, concrete has been used as a substrate; it is easy to clean and readily available. Over a period of time, the abrasive nature of concrete takes its toll on a penguin's foot and the result can be pododermatitis or bumblefoot. For this reason concrete, or any substrate, that remains wet for long periods of time should be avoided altogether. Many zoos have found it advantageous to use matting over concrete in selected areas of the exhibit. Some facilities place a protective coating of lacquer over concrete surfaces to reduce abrasiveness and to fill in the small pores where bacterial colonies can become established. Fiberglass and polyurethane have been reported to cause fewer foot problems than plain concrete.

In addition to kitty litter, ice has been used successfully over concrete floors to provide a less abrasive surface for the penguins to stand and walk on. Ice substrate should be used only in exhibits where the temperature is near freezing. Wet ice can also, over a period of time, contribute to foot problems.

In designing or renovating an exhibit, the Penguin TAG recommends that a variety of materials and textures be provided for the birds to stand on. Plain, concrete surfaces should be kept to a minimum and some sort of covering such as ice, matting, or kitty litter should be provided.

Nests and Nest Substrates

Nests for penguin species that burrow can be built as permanent or seasonal structures in exhibits. These can be in the form of boxes, caves, or air kennels (models #200 or #300). Nest boxes should be well-ventilated, have provision for drainage, and be positioned in the exhibit so that chicks cannot wander out of the nest and fall into the pool or become traumatized by others. In designing naturalistic exhibits for species that burrow in soil, it is crucial to provide soil with at least 20% clay to prevent nest cave-in.

Other species require a designated rookery/nursery area, which can either be a part of or separate from the main exhibit. Some institutions have found it advantageous to provide a four-inch berm around the nest site to effectively contain the nesting rocks. Adequate drainage is critical in the rookery area. Some institutions provide a separate room without rocks for temperate penguins; a door may provide selective access.

Provisions for land space for nesting should be in addition to the recommended land space parameters described in the Housing section of this chapter. (See also Chapter 4, Reproduction.)

Water Quality

Captive penguins historically have been exposed to a variety of water sources; both fresh water and salt water are used in exhibits. Water quality ranges anywhere from chlorinated tap water to sophisticated, state-of-the-art filtration systems. Areas with hard water may experience mineral deposits on exhibit viewing glass; use of a water softener may alleviate this problem.

The water in a penguin exhibit pool should be clear and of good color with low bacterial count. There are several ways of controlling coliform levels. Water treatment filtration systems include sand, diatomaceous earth, ozone, biological, and ultraviolet light (UV). The addition of a chlorine or Bromine system in conjunction with the filtering system aids in controlling coliform levels. Older exhibits without filtration should maintain a clean supply of constantly running water, with adequate surface water skimming. Skimming capacity is essential for birds' health. Oils that build up on the water need to be removed in order to maintain healthy feather condition. The number of skimmers should correspond to pool size and configuration.

Turbidity can be reduced by proper placement of water jets directed toward the pool bottom. A rotating fish-eye adapter at the end of the jet provides the flexibility of directing the water current so that debris is moved towards the bottom drains. Underwater vacuum systems are also effective in keeping the pool bottom clean. Exhibit pool floors should be smooth to facilitate the movement of feces and bottom debris to drains and filters.

Acceptable water temperature ranges for:

Adelie and Emperor	4 - 7^0 C (39 - 45^0 F)
Other Polar Species	4 - 13^0 C (39 - 55^0 F)
Spheniscus and Little Blue	0 - 29^0 C (32 - 85^0 F)

[NOTE: some outside exhibits may have an ambient temperature that could rise above 85^0 during the summer months without causing adverse effects to the birds. Care must be taken to assist birds in thermoregulation during the hot summer months. Methods to consider in accomplishing this could include cool-down of pool water through the addition of fresh water, a cool misting system, or a water chiller.]

Air Quality

Penguins as a group are highly susceptible to air-borne fungal infections. For this reason the air quality in an indoor penguin exhibit must be optimal. Air flow, fresh air exchange, and filter capacity should be researched to provide the cleanest air possible.

Aspergillus fumigatus spores range in size from 2.5 - 3 microns with other *Aspergillus* species spores as large as 10 microns; therefore, in order to remove them from the air, a filter must remove particles in that size range or smaller (See Chapter 6, Health). If possible sources of *Aspergillus* are external to the exhibit, then consideration should be given to reducing fresh air intake and providing a high-quality filter on the incoming air line as well as in the recirculation line. If the possible sources of *Aspergillus* are internal to the exhibit, then a high-quality filter in the recirculating system, a high volume air change per hour, and perhaps increased fresh air exchange (as well as identifying and removing the *Aspergillus* source within the exhibit) should be considered.

Air turnovers in the range of 15 air changes per hour have been recommended for laboratory animals (Lane-Petter, 1976). These parameters may be acceptable for penguins, however, the specific design of an air system needs to balance the tradeoffs between:

a) filter efficiency and air flow or ventilation; and b) fresh air exchange and temperature regulation capacity. Exhibits of some 1993 Penguin TAG Survey (1993 PTS) respondent institutions are under positive pressure, which allows air to be forced out instead of into the exhibit when a door is open. Doors should be well sealed to prevent air exchanges with outside areas.

Collection of regular air cultures in the exhibit as well as the air-handling system is a good practice in preventative maintenance. To aid in control of malaria in outdoor exhibits, consideration should be given to installing fans, since mosquitoes avoid persistent air movement.

Lighting
Penguins are maintained successfully in both northern and austral lighting cycles. Birds that are transferred from one cycle to another will usually adapt biologically within three years. Types of lighting that have been used are: skylights, mercury vapor, metal halide, quartz halogen, fluorescent (normal and full-spectrum), and incandescent. Although penguins have reproduced on a simple turn on/turn off lighting system, some zoos report enhanced reproductive success by varying the day length and light intensity. Several zoos and aquariums use lighting schedules that approximate that of the latitudes in which the species exhibited are found.

Variations in molt patterns have been correlated with lighting schedules. (Refer to Chapter 6, Health, for further details.) Artificial lighting in relation to captive penguins is an area that bears further research.

Special Features
Several types of special features should be considered for penguin exhibits. These include:
1) Video cameras - are an excellent tool to assist in recording events such as breeding, nesting, and chick rearing behavior.
2) Ice machines - are used in some facilities to create a constant supply of ice, which can be used effectively as substrate.
3) High velocity fans, though relatively new, appropriately placed to create an environment undesirable to mosquitos, warrants consideration and testing.

EXHIBIT MAINTENANCE
A broad-spectrum disinfectant and fungicide should be used daily to clean penguin exhibits. Some veterinarians recommend periodic rotation of these products. Care should be taken not to use products that produce strong or toxic fumes.

A heavy-duty garden or fire hose is the best tool for removing penguin guano from exhibit surfaces. Nylon scrub brushes that easily lose their bristles should be avoided as penguins have been known to ingest fallen bristles.

It is recommended that disinfectant foot baths be used entering and exiting the exhibit. Again, regular rotation of disinfectant products is recommended.

SUMMARY

Penguins require a multi-faceted exhibit that encompasses enough space for exhibitry, breeding, a pool for swimming, and areas for holding, isolating, and quarantining birds. Exhibits for penguins are complex structures that often involve a substantial financial investment not only to build but also to maintain. The specialized needs of polar birds mandate specific temperature requirements and high air quality standards whether the exhibit is indoors or outside. Other important components include proper substrate and drainage to provide a non-abrasive, dry area on which the birds can stand. Lighting schedules should reflect definitive photoperiods to encourage natural molting and breeding cycles. In multi-species exhibits, exhibitors are encouraged to choose one species of *Spheniscus* to preclude any chance of hybridization.

Product Information:

1 Dri-Dek, Kendall Products, 2706 South Horseshoe Drive, Maples, FL 33942 USA
2 Nomad matting, 3-M Corporation, 6043 Hudson Road, Woodbury, MN 55125 USA
3 Intracor, International Trading Company, PO Box 1948, Lake Oswego, OR 97035-0038 USA

CHAPTER 2

MANAGEMENT

Tom Schneider

INDIVIDUAL IDENTIFICATION METHODS

Accurate individual record keeping is essential to proper long-term management of any animal population. In order to maintain individual records it is essential to have animals banded or marked so individual identification is possible at a distance. In birds, a system of permanent identification is also recommended in case the band is lost, and also to track birds from one institution to another if banding techniques should change.

Cheney (1989) reported that most institutions use flipper-bands with good success. This is consistent with the 1993 Penguin TAG Survey (PTS) which reports that more than half of the institutions use flipper-bands. Several different bands are used - the most popular is the plastic cable tie because of its ease of use and durability. Metal and plastic bird bands are also used by some institutions.

Cable-ties are sold at electrical supply stores for use in securing or holding groups of wire together. Cable-ties are narrow plastic strips with a fastener on one side that the other end slides into; the band is securely held in place. They come in a variety of widths and lengths; 6 to 12 mm widths are commonly used.

There are two methods used to color-code cable-ties (flipper-band). One involves the use of colored tape, either plastic or cloth, on the flipper, using a unique color combination for each bird. A similar method uses smaller, colored cable-ties that are looped around the band with the fastener facing outside and the excess tie cut off (Figure 1). A variety of cable-tie colors are available and each color can signify a number, for example, blue/blue/green can stand for 7/7/6, or bird #776. When using this method, the band should be tightened to the point where a finger can be slipped between the band and the bird's flipper. Also, because the bands can continue to tighten after applied, they should be either glued when in place or monitored to ensure that they do not tighten further and impede circulation to the flipper. The band must be placed in such a manner that the fastener does not rub against the penguin's flipper and so it won't get hooked on protruding objects.

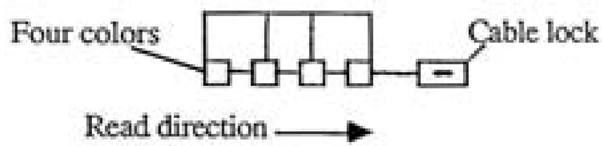

Figure 1. Use of a colored cable-tie identification system. The color code, as read from left to right, can be used to identify individual birds. Some institutions use the first color to identify species and the last three colors to indicate the birds' identification number.

Flipper-bands should be monitored closely during molt, when the penguins' flippers swell, thus restricting circulation. Many institutions report that molt necessitates replacing the flipper band with a larger size to accommodate swelling.

Flipper-bands can occasionally fall off. Several institutions, particularly those with large collections, use bands on both flippers. Therefore, if one band is lost, the bird can be identified by the remaining band. Another advantage of using two bands is that identification is possible from different angles of view. Flipper-bands can also be glued at the end to prevent falling off and accidental ingestion by penguins.

Other methods of individual identification include leg bands and physical characteristics. Leg bands are often difficult to see when the bird is resting in a sitting position. Physical characteristics are difficult to describe, and identification problems can occur if there is a turnover in keeper or management staff.

Regardless of the method of visible individual identification used, the Penguin TAG recommends that transponders also be used with penguins. This is particularly true for birds that are part of a cooperative management plan. The IUCN/SSC Captive Breeding Specialist Group's recommendations (CBSG, 1991) concerning product choice (TROVAN) and use should be followed when using a transponder system. The Penguin TAG recommends subcutaneous placement of the transponder in the loose skin of the back of the neck.

METHODS OF CAPTURE, HANDLING, AND RESTRAINT
Penguins are hardy animals and can normally tolerate routine handling for nail trimming and beak trimming, banding, or weighing. The individual to be captured should be separated from the colony and lifted from behind. There are several different methods for capturing the animal with initial restraint often done by grabbing the neck. Caution must be used when grabbing a bird by the flippers - several institutions have reported broken flippers during handling. When capturing and restraining King and Emperor penguins, two people should work together. It is also important that the people capturing the birds, especially with King penguins, wear eye protection for safety from the bird's beak.

There are a variety of restraint techniques for penguins. Non-invasive procedures may necessitate only minimal restraint. However, medical procedures, such as drawing blood, which require the bird to be immobile, dictate stronger restraint. One method used successfully involves placing the penguin between the handler's legs such that the flippers are held secure (Figure 2). In this way the handler's hands are free to restrain and position the head and neck to facilitate blood removal, rebanding, or the dictated procedure. With king and emperor penguins a second person may be needed to avoid injury to the bird and/or handler. Other methods of restraint include using large diameter PVC pipe or traffic cones to hold the bird secure (Figure 3).

If a penguin needs to be moved a short distance, it is recommended that the handler carry the bird close to his/her body with the head at their side facing their back (Figure 4).
If the bird needs to be moved to a different location, such as the hospital or a different holding area, it can be placed in an appropriate container such as an air kennel or large tub.

Depending on the distance and season, it may be necessary to provide ice to prevent polar penguins from overheating.

Figure 2. A penguin can be placed between the handler's legs with the flippers held secure. This allows the handler's hands to be free to restrain and position the head and neck to facilitate the designated procedure. With king and emperor penguins a second person may be needed to avoid injury to the bird and/or handler.

Figure 3. A large diameter PVC pipe or traffic cone can be used to hold a bird secure.

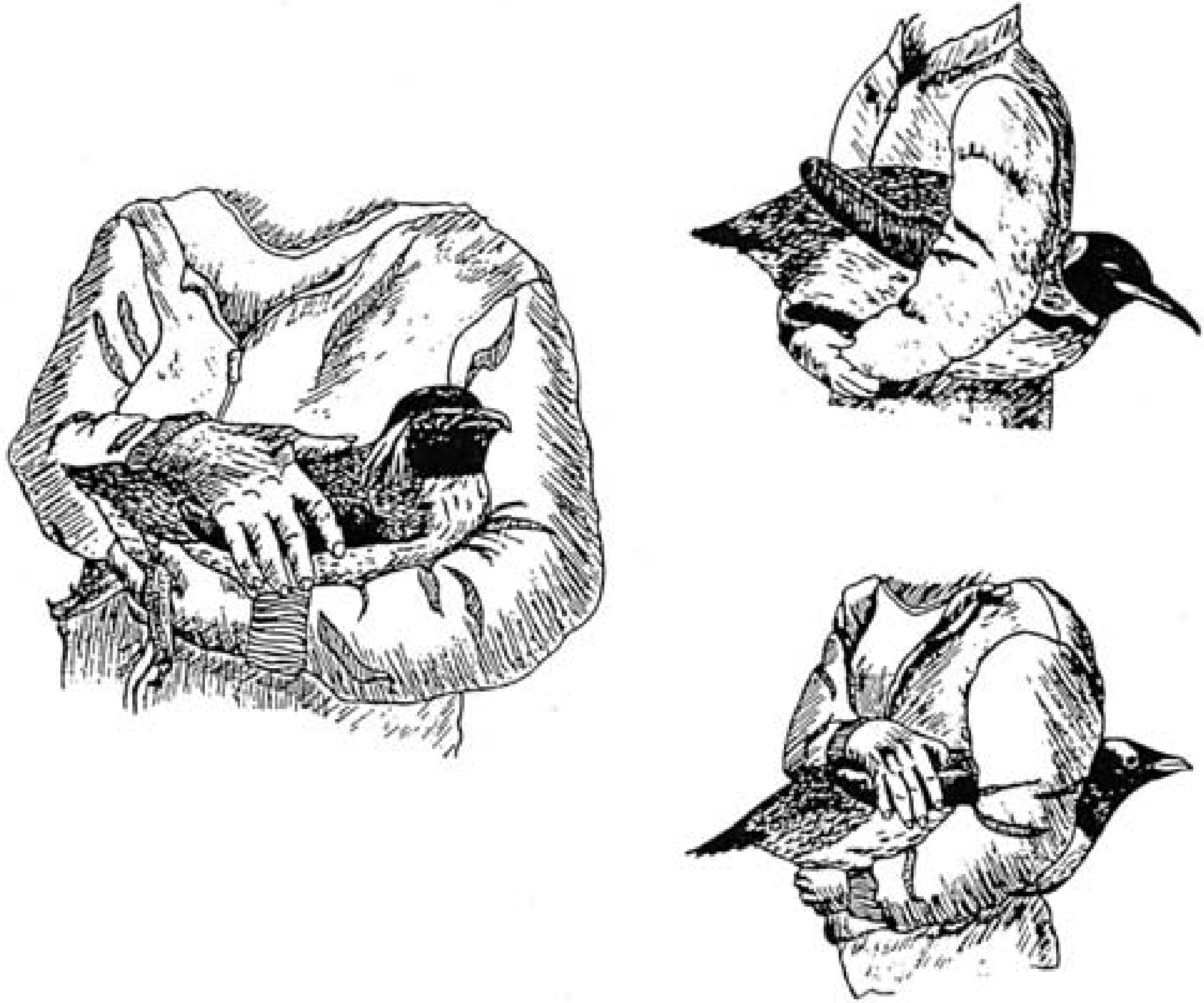

Figure 4 illustrates techniques for carrying birds for short-distance moves. Penguins should be carried close to the side of the handler's body with the bird facing their back.

METHODS OF CRATING AND TRANSPORT

Depending on the species (polar vs. *Spheniscus)* and the distance the penguin needs to be transported, different methods of transportation can be utilized. An alternative to transporting live adult birds is to transport eggs and then complete incubation and hand-rearing of the animals at the final destination.

Because of physiological stress associated with molting, it is necessary to avoid transporting the animals during this time. Timing of molt varies by species. The Penguin TAG recommends that birds should <u>not</u> be transported within the period commencing one month before and ending one month after molt. Because of previous experience with high mortality of Humboldt penguins during shipping, the Humboldt SSP recommends that Humboldt penguins not be shipped for one month before and two months after molt.

Consideration should be given to treating transported birds with Fluconazol or Itroconazole prior to and after shipping as a prophylactic treatment for Aspergillosis. This is discussed in more detail in the Chapter 6, Health.

It is also important to be certain the environmental conditions in quarantine be similar between the sending and receiving institutions. It is recommended that staff at the sending and receiving institutions consult with each other regarding light cycles, temperatures, and diet. It is also important, if possible, to have two or more birds quarantined together because of the social needs of the animals (See Chapter 4, Behavior and Social Organization). If this is not possible, efforts should be made for quarantined birds to have visual or auditory contact with other penguins.

Transport of Polar Penguins

Because of their susceptibility to overheating, special consideration must be taken when transporting polar species of penguins. If the temperature is above 4° C (40° F), it is recommended that the penguins be moved in a refrigerated truck. Sea World parks have developed protocols for the use of refrigerated trucks and have successfully transported many penguins between their facilities in California, Texas, Florida, and Ohio.

There are several key requirements when using refrigerated trucks. First, a suitable substrate is necessary for adequate footing for the animals. Smaller rocks (5 - 10 cm or 2 to 4 inches in diameter) covered with ice provide good footing while allowing drainage of melting ice and fecal materials. It is important to ensure that drains are clear to avoid backup. The interior of the truck should be carefully examined for sharp edges and organic debris. The truck should be cleaned, aired out, and disinfected several times over several days prior to transporting birds.

The animal area in the back of the refrigerated truck should be separated from the door with a wood or plastic barrier. This will ensure that the animals will not be able to exit when the door is opened. It also provides an area for storage of equipment and luggage. A skid or tarp should be used to prevent equipment and luggage from getting wet.

It is necessary that light be provided at all times in the animal transport area. The light source can be the truck light in the refrigerated compartment or a low wattage bulb that is powered with a 12-volt to110-volt converter. If accompanying staff will be spending the night in transit, it will be necessary to run an extension cord with a light so there is lighting throughout the night for the birds.

A temperature monitor should be installed in the animal area that has a readout in the truck's cabin. This allows the staff traveling with the penguins to constantly monitor temperature. Finally, a video camera should be installed in the animal area with a monitor in the cabin so the animals can be observed while they are in transport.

If the transport is more than a one-day drive, it is recommended that the drivers stop and rest during the evening. This not only gives the drivers needed rest but allows the penguins time to recover from transport. If the trip lasts more than 48 hours, it is recommended that the birds be fed after the day's trip. It is important that the birds have access to fresh water or clean ice at all times.

If transportation is taking place during the winter and the temperatures are below 4° C (30° F), the animals can be transported in an unheated passenger van. The birds should be placed in containers and proper substrate (e.g., kitty litter, rubber matting, Astroturf) should be provided.

Spheniscus species

Because *Spheniscus* species are more heat-tolerant, commercial air transportation can be used. It is recommended that shipping occur during cooler weather 0 - 21° C (32 - 70° F) and/or during the cooler parts of the day.

Adequate communication with the airlines is essential. Staff should communicate the need to move the birds in a timely fashion so that the time interval, which may be as long as two hours, to and from the air freight office to the plane can be minimized. Every effort should be made to accompany the birds to the plane so it is certain that they are placed on the proper flight. This can be done with perseverance when making flight arrangements (it may be necessary to speak to several airline personnel). If possible, the animals should be transported through the VIP or DASH systems of freight transportation that many airlines have available. The most direct flight should always be used. Accompanying staff should ask the airline if the birds can be loaded onto the plane last, so that they can be the first off-loaded.

Penguins can be transported in air kennels. Each bird should have at least enough room to stand up and turn around. It is recommended that the air kennels be divided so that each animal has their own compartment. Bonded pairs, however, can be kept together. The number of animals per kennel varies, but a #300 size kennel can hold six birds. The kennels should be bedded with kitty litter or rubber matting. Blue ice can be placed below the rubber matting to cool the container. Air-kennel doors should be secured with cable ties to prevent escapes.

If the distance is not too great (i.e., not more than a 10-hour drive), the birds can be transported by a passenger car or van. They should transported in containers as described above.

Transport of Eggs
If prior arrangements have been made, it may be possible to ship fertile eggs from one location to another. Sea World has developed techniques for transporting eggs from the wild to their incubation and rearing facilities (Todd, 1987). Eggs have also recently been transported between facilities.

If traveling time exceeds five hours, it is necessary to have a portable incubator that maintains a constant temperature. However, for shorter intra-continental flights, a well-insulated cooler with a mounted temperature probe can carry the eggs. A hot water bottle can be used as the heat source.

Timing of transport is important. Eggs should be transported either during the last one-third of their incubation period or before incubation begins (C. Kuehler, pers. comm.). The temperature in the cooler or incubator should be maintained at approximately 35.6° C (96° F). When the temperature drops below this, additional water should be added to the hot water bottle from a thermos carried for this purpose. If necessary, the airline can usually supply hot water.

Upon arrival at the destination, eggs are placed in an incubator and the procedures for artificial incubation in Chapter 6, Reproduction, should be followed.

PEST MANAGEMENT
Pests can cause problems in some outdoor *Spheniscus* exhibits. Rats can destroy eggs; raccoons or other predators can prey on eggs and/or adults. Fish should not be left outside overnight to avoid attracting rats. Also, if there are other exhibits nearby which attract rats, efforts should be made to keep these areas rodent-free. It is critical not to place any poison or traps in areas to which the birds have access.

If predators are a problem at an institution, then efforts should be made to protect the colony. These efforts can include trapping or making the exhibit area predator-proof through the use of predator-proof barriers such as fences or electrical barriers. Trapping should be used to remove potential predators from the area. Local laws concerning trapping or depredation of native wildlife should be checked prior to predator removal in this manner.

Native gulls (*Larus spp.*) often will raid penguin exhibits for fish, sometimes even taking fish from the beaks of the penguins. Several methods can be employed to discourage gulls including placement of fake predators in the area, playing recorded gull distress calls, placement of gull taxidermy specimens, and placing monofilament line over the exhibit. It is important that these methods be varied because gulls are likely to habituate quickly. Modifying the penguins' feeding times as well as the method of feeding may reduce the competition from the gulls. It is important to remember that gulls are protected by the U.S. Migratory Bird Treaty Act, and federal permits are required for culling or capture.

As with any animal facility, food preparation and storage areas should be kept clean to avoid attracting mice, roaches, and other insects.

RECORD KEEPING

Accurate records are essential for long-term management of penguin populations. It is recommended that all institutions participate in the International Species Information System (ISIS) and comply with data requests by species coordinators and/or studbook keepers.

Minimum records should include ISIS Accession number, whether the bird is wild-caught or captive-hatched, parentage, date of birth or capture, capture location if known, individual identification method, studbook data (if applicable), breeding history, molting, and weights. If in-house record keeping systems are used, essential data should be also entered into ARKS. Valuable reproductive data include egg weights, chick growth rates, and incubation and brooding information. Other records that may be kept include behavioral observations, environmental parameters, molting data, and food consumption. Thorough, accurate medical records should be maintained on all animals in the collection. Medical information should also be recorded and entered into MedARKS if possible.

WEIGHING OF PENGUINS

Weights are important for monitoring the health of individual animals. Weighing of individuals should be carried out whenever possible. This can be done on a routine basis if exhibit design and bird behavior allows it. The birds should always be weighed when they are handled for other reasons. Individual weight records should be maintained over time and utilized for comparison when a bird appears sick.

Average weights for the penguin species kept in captivity are presented in Table 1.

Table 1. Average weights of penguin species maintained in North American collections.

SPECIES	AVERAGE WEIGHT (± 10%)
Emperor	26 kg (57.2 lb)
King	15 kg (33 lb)
Gentoo	5.4 kg (11.8 lb)
Adelie	4.2 kg (9.2 lb)
Chinstrap	3.7 kg (8.1 lb)
Little Blue	1.1 kg (2.5 lb)
Macaroni	4.5 kg (9.9 lb)
Rockhopper	2.7 kg (5.9 lb)
Magellanic	3.9 kg (8.5 lb)
African	3.2 kg (7 lb)
Humboldt	4.2 kg (9.2 lb)

MOLT MANAGEMENT

Molting is a physiologically stressful time for penguins. A great deal of energy is expended for the regeneration of new feathers. Penguins usually molt once a year after breeding. The onset of molt occurs as the day begins to shorten and is thought to be initiated by a decrease in daylight, especially in the polar species. Some species, such as the African penguins, molt over a longer period of time. African penguins at Baltimore Zoo have molted in every month of the year but the majority of molts occur between March and August (Bennett, 1991).

Prior to molt there is a significant increase in appetite that corresponds with a visible gain in weight. Once the birds begin molt, their appetite decreases dramatically. Some birds refuse food altogether; others may only eat one or two fish a day. This corresponds to behavior in the wild, where molting occurs on land and birds do not have access to food. For wild African penguins, Cooper (1978) reported a 31% weight gain in pre-molt birds, with a subsequent loss of 41% of their peak body mass during molt.

Sometimes birds will either not go into or not complete their molt. In captivity, this condition appears to occur most frequently in Chinstrap penguins. The Sea World parks have tried several different methods to stimulate molt including hormonal treatments, increased day length, and natural sunlight. Problems with molt are discussed further in Chapter 6, Health.

During molt the birds lose all their feathers in a short period of time. Bennett (1991) reported that the average molt length is 16.75 days in African penguins. Other penguins have similar molting periods. In captive environments, this large loss of feathers can cause problems for some filtration systems, and it may be necessary to remove birds from the exhibit during this time. If birds are to be moved off-exhibit it is recommended that they are moved before they drop their feathers. Shed tail shafts have been reported ingested by some penguins (see section on Ingestion of Foreign Objects, this chapter).

As mentioned earlier, another consideration during molt is the potential need to change flipper-bands. The swelling that occurs during molt can cause the bands to constrict around the flippers. Bands may need to be removed and replaced with looser bands during molt; birds can then be re-banded after molt is completed. If the band is not removed it is important that the birds are closely observed to insure that the bands do not impede circulation.

It is recommended that birds are not shipped before, during, or immediately after molt. See the section on Methods of Crating and Transport earlier in this chapter for additional details.

INGESTION OF FOREIGN OBJECTS

Some institutions reported penguins eating foreign objects that can cause medical problems and even death (1993 PTS). Some of the items that have been reported being ingested include nesting material (sticks and stones), bristles from brushes used for cleaning, coins, and even molted tail feather shafts. Care should be taken to keep exhibits clean of such material. If it is suspected that a bird has swallowed a foreign object, consult Chapter 6, Health, for diagnosis and treatment.

SEX DETERMINATION

Determination of the sex of individual penguins is necessary for proper long-term population management. It is important not only to maintain equal sex ratios within colonies, but the sex of all individuals must be determined for genetic management. The sex of the majority of penguins in North America is unknown.

Because penguins are monomorphic, methods need to be developed and efforts made to determine the sex of individuals. A variety of different methods have been used for sex determination to date including behavioral observations, chromosomal analysis of blood or blood feathers, morphological differences, surgical sexing, and cloacal sexing.

The most reliable method of sex determination is karyotype analysis using blood. The techniques for this method have been developed for Humboldt penguins by Dr. Robert Lacy[1] of the Chicago Zoological Society. Dr. Peter van Tuinen[2] is also working on the development of these techniques with other species (E. Diebold, pers. comm.). The AAZPA Penguin TAG is developing a relationship with a commercial laboratory and, hopefully, this service will be available to zoos in the near future. Institutions wishing further information are advised to contact the Penguin TAG Chairperson for additional information.

Behavioral observation of individuals is the most common method of sex determination that has been used to date. Behaviors can include mate aggression, copulation, and timing of incubation (Edgington, 1989). However, atypical behaviors such as homosexual pairing and male on bottom/female on top copulation can make this method unreliable.

Acoustical differences exist between sexes in some species, and these have been documented by Bowles (pers. comm.) and Jouventin (1981). However, this technique requires extensive sampling with specialized equipment for accurate sex determination. This may not be a practical method for sex determination for most captive penguins.

Edgington (1981) reported that morphological differences occur between male and female Humboldt penguins; W. Turner (pers. comm.) reports morphological differences in Rockhopper penguins (males have larger bills and are slightly heavier). However, there is some overlap in the characteristics described and sex determination using this technique is not widely considered reliable at this time.

Penguins may also be sexed by cloacal examination; most reliable use of this technique is constrained to a two-week period following egg laying (Boersma and Davies, 1987). Sladen (1978) indicated that cloacascope method for sexing Adelie penguins at the Cape Crozier rookery has been used with some success with Humboldt and African penguins at the National and Baltimore Zoos. The differences between male and female physical characteristics are slight, and extensive training would be needed for this method to be used. It is felt that the latter technique is not developed to the point where it can be reliably used for captive animals.

Two other potential methods for sex determination include surgical sexing and blood feather chromosomal analysis. Surgical sexing is not commonly used for penguins. The ability to obtain adequate blood feathers is limited in penguins and can only be applied to those species with long tail feathers.

SUMMARY

Penguins are a highly specialized taxon of birds, and many management techniques that have been developed for other avian species cannot be applied to penguins. Because of their adaptation to an aquatic life-style, some physiological characteristics are unique to this taxon. The sex of the majority of penguins in North American collections has not been determined. Several techniques for determining sex are promising, especially karyotype analysis. Surgical sexing, a procedure often applied to sexually monomorphic birds, is not recommended because of penguins' specialized respiratory system. Likewise, penguin feathers are adapted for swimming and because of associated characteristics are not suited for blood feather analysis. As a result, sex determination is challenging.

Similarly, penguins' adaptation to cold weather conditions, especially the polar species, makes transportation challenging. Most avian management techniques used with other species can be modified for penguin management.

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CHAPTER 3

BEHAVIOR AND SOCIAL ORGANIZATION

Susie Ellis

GENERAL LIFE HISTORY PATTERNS

Penguins are highly specialized birds whose behavior and physical adaptations have been molded by the harsh climates of the Antarctic and surrounding areas. Each of the penguin species differs with regard to specific behavioral patterns and physical features, however, certain characteristics are shared by all taxa.

All penguins are flightless but use their flippers to "fly" in water; their webbed feet serve as rudders. Torpedo-shaped bodies facilitate penguins' movement through water. On land or ice, penguins walk upright with a waddling posture. Anatomically, penguins' waddle can be attributed to a tarsometatarsus bone that is shorter and wider than in other birds. Like most birds, penguins have good vision and hearing, with poor senses of smell and taste. Penguins recognize one another by vocalizations. All penguins feed exclusively on marine animals.

Penguins deal with excess salt by excreting it through a pair of salt glands that lie on top of the skull behind the beak. Aquatic predators in the wild include killer whales, leopard seals, and sharks. On land, depending on location, eggs and chicks may be lost to skuas (*Catharacta maccormicki*), Wekas (*Gallirallus australis*), domestic dogs and cats, rats (*Rattus spp.*), or small Mustelids.

Penguins are warm-blooded, with average body temperatures ranging from 37.8 - 38.9° C (100 - 102° F). Penguin species range from the equator to the Antarctic Circle but generally are found in waters that are relatively cool for the latitude. Temperature regulation is accommodated by both behavioral and physiological adaptations. Apart from behavior and weight, overlapping feathers with downy shafts and a thick layer of blubber provide very effective insulation against cold. Penguins found in warmer latitudes may face problems with excess heat. These birds generally have thinner layers of blubber than polar species, and also have less dense feathers on the head and flippers. Heat can be lost by ruffling feathers to expose the skin, holding the flippers away from the body, or by remaining in sheltered burrows. Feathers are replaced yearly in a "catastrophic" molt, which generally follows the breeding season.

Following a period of ritualized courtship, penguins normally lay one or two eggs, depending on the species. Both parents take part in incubation (except Emperor penguins) and chick rearing. As with many species, the breeding season tends to coincide with the time of year when food is most abundant.

SOCIAL GROUPINGS

Penguins are highly social, colonially-nesting birds. There is good evidence that reproduction in penguins, as in other colonial waterbirds, is socially facilitated (e.g., Berger, 1981) and that adequate stimulation by conspecifics is essential to successful reproduction under captive conditions. Boersma (1991) suggested that small colony sizes in captive populations of penguins may show decreased productivity. A minimal social grouping of three pairs of a single species were suggested by Gailey-Phipps (1978); this recommendation for social groupings was adopted as a resolution by the AAZPA as part of the 1976 Regional Conference (Sladen, 1978). This recommendation is endorsed by the Penguin TAG.

Considerations in development of social groupings include: number of birds able to be accommodated by the exhibit (see Chapter 2, Housing and Enclosure Requirements); availability of sufficient numbers of birds to encourage assortative mating and facilitation of successful reproduction; intra-specific aggression; and compatibility of individual birds.

MIXED SPECIES EXHIBITS

Many facilities successfully house and breed several species of penguins in one enclosure and in some cases mix penguins with other species such as Inca terns (*Larosterna inca*) or blue-eyed cormorants (*Phalacrocorax atriceps spp*). In addition to the considerations mentioned in the previous section, concerns for mixed species exhibits include: inter-specific compatibility and aggression; differential life support requirements; differential habitat use and habitat requirements; and avoidance of hybridization.

Avoidance of hybridization is a key factor in the conceptual development and subsequent management of mixed-species exhibits. In general, it is inadvisable to house *Spheniscus* species together, as it would also be inadvisable to house together *Eudyptes* subspecies that have been reported to hybridize in the wild, such as Rockhopper subspecies (*Eudyptes chrysocome spp.*). Aside from a few cases where multi-species exhibition may be problematic, housing several species together can work well if seasonality is maintained. At Sea World of Florida, King and Gentoo penguins are housed together and utilize the same nesting area. Gentoos nest first and as chicks are fledging, Kings begin to occupy the rookery and breed.

INTRODUCTIONS AND REMOVALS

In general, introduction of novel stimuli, including new birds, to a social group of penguins is met with curiosity and investigation. As with all animal introductions, staff should closely monitor both the introduced bird as well as the social group for signs of stress and aggression. The introduction of a new bird or introduction of a group of birds to an exhibit has been approached in several ways:

1) Gradual introduction. Use of this technique will depend on exhibit design as well as temperament of the birds. In gradual introduction, birds are introduced to an exhibit for a few hours at a time, with close monitoring over a several-day period. The time the birds are left in the exhibit is gradually increased until the birds appear to be acclimated. This technique is the most conservative and most likely to result in successful integration of new birds into an existing social group.
2) Group introduction. Most penguin managers feel that it is inadvisable to introduce a single bird into a colony. New birds can be isolated with one or more conspecifics removed from the social group for a period of time. Birds can then be introduced into an exhibit together and monitored by staff.
3) "Howdy" cage introduction. Birds are placed in a small enclosure within the exhibit for several hours daily and slowly acclimated to the exhibit and other penguins. Generally, a gradual introduction procedure, as described above, follows.
4) Immersion introduction. Birds are placed in the exhibit and regularly monitored by staff.

Introduction of hand-reared chicks into exhibits requires close monitoring (see Chapter 5, Reproduction) and is likely to be most successful if a gradual introduction procedure is followed. Especially if chicks have not yet lost all their down, adult birds may attempt to brood fledglings. Captive Emperor penguins, for example, have been observed to aggressively compete to brood newly-introduced hand-reared Pygoscelid chicks.

In large colonies, removal of individual birds does not seem to have a well-defined effect on social dynamics, except for individuals whose mates have been removed. In these cases, birds may show some signs of lethargy or may repeatedly visit the nest site, if it is the breeding season, as if searching for the bird that has been removed. Adelie penguins that have lost a mate have re-paired within a few days and have also been observed to lay a second clutch with the new mate (Ellis, unpublished data). In smaller colonies, removal of a dominant individual may cause a shift in the dominance hierarchy and may lead to a short-term increase in aggressive behavior as equilibrium in the social group is re-established.

BEHAVIORAL MANAGEMENT

Behavioral Enrichment

Behavioral enrichment programs for penguins are a relatively new concept and merit consideration. Beyond normal stimuli in a captive environment, such as snow, water, and conspecifics, penguins generally tend to respond with curiosity to novel objects. Enrichment does not require elaborate or costly apparatus. Sea World of Florida reports good success with brightly-colored rubber balls, sprinklers, and also with blocks of frozen fish placed into pools. Other items that penguins appear to find stimulating include varying water currents and sawhorses with securely affixed strips of fabric under which the birds can run. Underwater visual barriers may also provide enrichment. Some facilities report good success with the use of different feeding strategies, e.g., multiple feedings, extended feedings, scatter feedings.

Behavioral Management of Imprinted Birds

Occasionally, when birds are hand-reared, they develop preference for human companionship over that of conspecifics. Depending on the species, highly imprinted birds may or may not eventually reproduce. Imprinted hand-reared Pygoscelid penguins, for example, generally will not breed. Highly imprinted *Spheniscus* penguins, however, have been reported to breed and may make very good parents.

Imprinted birds can be disruptive in penguin colonies, wandering over other birds' nesting territories. Social dysfunction sometimes can be overcome in imprinted birds, especially if they pair with a non-imprinted bird. In general, it is advisable to discourage staff from reinforcing attention from imprinted birds. As with most species, the best strategy is the avoidance of imprinting during rearing.

Management of Aggressive Behavior
Aggressive behavior in penguins is most pronounced during courtship and pairing and again once chicks are hatched. Although it is a natural part of the reproductive cycle, aggression should be monitored closely by staff during the breeding season to ensure that reproduction is not deterred because of excess aggression or competition. Some institutions report mate "stealing" in exhibits with skewed sex ratios. For Emperor penguins, for example, removable barriers may need to be constructed to allow isolation of pairs or individuals because unpaired birds may attempt to "steal" eggs or chicks from conspecifics that may be incubating or brooding (See Chapter 4, Reproduction). Some institutions report that penguins attack and may kill birds that are weak or ill; there is also need to closely monitor birds that have been isolated and subsequently returned to the group. Harassment by groups is not common in penguins. Most aggressive exchanges take place between individual birds or pairs.

BEHAVIOR, REPRODUCTION, AND PARENTAL CARE
General Behavioral Descriptions
Throughout most of the year, the behavior of captive penguins is fairly predictable, primarily consisting of eating, swimming, and generalized social interaction. The onset of the breeding season, which varies between species, may create a flurry of activity much like that which is reported for wild penguins (e.g., Ainley et al., 1983; Penney, 1968; Sladen 1958). In the wild, the onset of the breeding season takes place when birds return to the colony (*Pygoscelis, Eudyptes, Aptenodytes*) or to the nesting territory (*Spheniscus*).

The breeding season can be defined in terms of four major phases: courtship; incubation; chick rearing; and fledging. Under captive conditions, some behaviors, such as mutual displays, observed during the early phases of the breeding season may be seen year-round, albeit less intensely. In one study, Adelie penguin pairs were observed to habitually occupy their nest sites year-round, even during periods when nesting materials were not available (Ellis-Joseph, 1988). In general, behaviors associated with pairing are observed more intensively three to four weeks prior to egg laying. Depending on the species and exhibit, initiation of courtship can be enhanced by manipulation of artificial lighting or introduction of nesting materials.

Penguins are generally considered to be perennially monogamous, except Kings and Emperors, which are serially monogamous. Mate fidelity in one colony of captive Adelie penguins has been reported to be 75% over a 13-year period (Ellis-Joseph, 1992), which is markedly higher than the 51% reported for wild Adelie penguins (Ainley et al., 1983). Mate fidelity in captivity may be affected by transfer, separation because of illness, or mortality. No differences are reported in reproductive success between Adelie penguins paired with a former or a new mate (Bowles et al., 1988; Ellis-Joseph, 1988). In Emperor and King penguins, however, pair bond formation and egg fertility are often positively correlated with competition for new mates (A. Bowles, pers. comm.).

Penguins are basically monomorphic. In some species, subtle differences in flipper length, bill size, and body weight can be used to determine sex (See Chapter 2, Management). Most institutions housing penguins have used behavioral observations in combination with morphological measures to achieve a "best guess" of gender. (Early collection expeditions distinguished females from males by muddy footprints on the backs of females.) In some genera such as *Pygoscelis*, presence or absence of the Ecstatic display, which is typically performed by males, may assist in making best guesses of gender. Techniques for sexing birds are discussed in Chapter 2, Management.

Penguins usually are housed in colonies large enough that birds can select their own mates. Occasionally, it may be necessary to selectively pair adults when undesirable pair bonding takes place (e.g., sibling, polygynous, polyandrous, or same-sex bonds). In *Spheniscus*, a successful pair bond may be encouraged by isolating the desired pair through egg laying and incubation. It is desirable to use the male's territory for this isolation.

Courtship displays occur at the nest site. Nest building or excavation (*Spheniscus*) begins along with courtship and increased territoriality in all genera except *Aptenodytes* (see Behavior in *Aptenodytes*, below). For Adelie penguins, initial nest site choice in a new exhibit appeared to be influenced primarily by salient physical characteristics of the rookery area, such as proximity to vertical structures (e.g., walls, rocks, large whale bones), rather than by social factors (Ellis-Joseph, 1988). Nesting accommodations are discussed in Chapter 4, Reproduction.

Agonistic displays increase during the breeding season as birds begin to reclaim and defend nest territory or compete for prime nest locations. Overall rates of vocalization and display may increase throughout the exhibit. It is important to note that injuries from disputes (such as jab wounds in King penguins and corneal abrasions in *Spheniscus* and *Pygoscelis* species) may occur more frequently, particularly in multi-species exhibits with high density.
For Adelie penguins, aggression is lowest during incubation and at highest levels once chicks are hatched (Ellis-Joseph, 1988).

Approximately three to four weeks from onset, courtship and nest building are complete. Copulations, which usually occur at the nest site, may be observed within one week of the onset of the breeding cycle. In *Spheniscus*, copulations may be noted frequently during courtship and nest building. Copulations for *Eudyptes* and *Pygoscelis* are generally observed within days of occupation of the rookery. In *Aptenodytes*, particularly Emperor penguins, copulation is rarely observed. It is important to note that captive Emperor penguins appear to be much heavier than their wild counterparts, which may hamper copulation and thus adversely affect reproduction. Management of *Aptenodytes* species during the breeding season is discussed in Chapter 4, Reproduction.

Atypical pairing behaviors have been noted in captivity. For example, same-sex pairing has been reported for Emperor, Humboldt, and African penguins. The Baltimore Zoo reported a male/male pair to which eggs were successfully cross-fostered for two breeding seasons. Other unusual behaviors include: copulations in which the traditionally effective male on top/female on the bottom position is switched; extra-pair copulations; or polyandrous or polygynous trios. In wild Adelie penguins, Muller-Schwarze (1984) described two types of pairing: trial pairing, which is temporary, and true pairing, which results in a clutch and a season-long bond. Such pairings have not been observed in captive Adelie penguins, possibly because there is no seasonal emigration from the colony and subsequently no advantage to trial pairing.

There are few data available concerning the time interval between copulation and egg laying. It has been suggested that there is a five to seven-day interval between copulation and egg laying in wild Emperor penguins (A. Bowles, pers.comm.). Captive Adelie penguins that pair and lay their eggs earlier in the season have been reported to be significantly more likely to fledge chicks (Ellis-Joseph, 1988; 1992).

For many species housed in captivity, copulations are frequent and egg laying occurs rather predictably after the onset of breeding behaviors. Extra-pair copulations after pairing are commonly observed in captive penguins. Paternity should not be assumed based on pair bonds.

Table 2 shows the most commonly reported timing of laying of first clutches for various penguin species in North American facilities. In conjunction with breeding and egg laying, appetite often increases and distinctive food preferences may be exhibited. Females may increase their weight by as much as 20-25 percent, and in some cases females may become inappetant one to two days before laying. In *Aptenodytes* species, incubation of rocks or ice may indicate that laying is imminent.

Table 2. Shaded areas indicate timing of laying of first clutches of eggs for captive penguin species*.

SPECIES	MONTH											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Emperor							A					A
King					N A	A				A	A	A
Gentoo				N					A	A		
Adelie										A	A	
Chinstrap				N	N					A		
Macaroni			N					A	A			
Rockhopper				N					A	A	A	
Magellanic			N	N								
Humboldt	N	N,A	N	N	N	N	N	N	N	N	N	N
African	N	N	N	N	N	N	N	N	N	N	N	N

A - Austral lighting schedule (30° S Latitude - 77° S Latitude)
N - Northern hemisphere or natural lighting conditions
* - as reported by respondents to the 1993 PTS.

Both sexes participate in incubation and in rearing of offspring. Species-specific differences in these behaviors are discussed in the following section as well as in Chapter 4, Reproduction. As with most species, whenever feasible, parental rearing is always preferred to hand-rearing. Options for rearing are discussed in greater detail in Chapter 4, Reproduction.

Genus-specific behavioral descriptions
Aptenodytes. The Emperor penguin is the largest of the penguin species, with an average weight in the wild of 66 pounds (range 42-100 pounds). Wild Emperor penguins breed in the austral winter, arriving at the breeding grounds in March. Sexual activity peaks in April and early May; eggs are laid throughout May and incubated for 65-67 days.

Emperor penguins do not occupy a nest site. Rather, as soon as the egg is laid, the female passes it to the male and he incubates it on the top of his feet under a ventral flap of highly vascularized skin. This offers some mobility and in the wild allows male Emperor penguins to gather in large huddles for social thermoregulation during the long, harsh Antarctic winter. This behavior seems to preclude the "usual" nest territoriality, although huddling for thermoregulation is not generally observed in captivity because of constant environmental conditions. After egg laying in the wild, Emperor females return to sea to feed for the entire incubation period, relieving the male approximately at the time of hatching.

In contrast to their wild counterparts, captive Emperor penguin pairs may stay in fairly close association during incubation. In captivity, Emperor penguins generally occupy one area of the exhibit, usually the darkest, and stand in pairs within groups until the egg is hatched. Like wild Emperors, females do not incubate. In the wild, food requirements of the chicks after approximately 40 days of age require both parents to forage simultaneously, leaving chicks alone on the ice to congregate with other chicks in creches. Creching is not observed in captive birds, presumably because of constant food sources and environmental conditions. Captive Emperor penguins continuously brood chicks for approximately four to six weeks. Captive, parent-reared chicks fledge at approximately four to six months. Fledging information is discussed in more detail in Chapter 4, Reproduction.

Like Emperor penguins, King penguins build no nest but defend a small nest "territory." For facilities housing King penguins, it is advisable to provide one area suitable for a nesting territory. Although Gentoo penguins housed in the same exhibit may attempt to utilize this area for off-season nest-building, King penguins dominate the site during their breeding cycle (S. Branch, pers. comm.).

In the wild, King penguins may lay eggs any time from November to March but generally exhibit two well-defined peaks - one in December and one in February. This time frame differs slightly in captivity (Table 2). Incubation lasts approximately 56 days. Pairs of King penguins tend to be less tolerant of conspecifics during the breeding season and generally decrease interactions outside the pair bond.

Instead of a short fledging period like most penguins, wild King penguin chicks winter over at the breeding colony and are fed every three to four weeks by their parents. At 12-15 months, they molt into juvenile plumage and depart for sea. Age at fledging is reported to differ in captivity, but generally ranges between four and eight months. Both in the wild and in captivity, once chicks fledge, parents then molt, court, and begin the breeding cycle again.

The King penguin reproductive cycle in the wild is not synchronized within each year. The time between eggs for a successful breeder in the wild ranges from 14-16 months. Therefore, in the wild an early breeder in Year 1 could be a late breeder in Year 2 but could not breed in Year 3 because its chick would not be fledged. These constraints do not appear to be as severe in captivity.

Pygoscelis. The three species of *Pygoscelis* - Gentoo, Adelie, and Chinstrap - exhibit similar characteristics. Gentoo penguins are slightly larger, weighing approximately 12-13 pounds;

Adelie and Chinstrap penguins weigh approximately 8-11 pounds. Wild Pygoscelid penguins return to rookeries in October, quickly establishing territories and pairing with mates. Pygoscelid penguins tend to be monogamous and return to natal rookeries year after year. Prior to pairing, males construct a perfunctory nest, using small rocks, within their territories (Ainley et al., 1983). Unpaired males perform Ecstatic displays to attract a mate; females assist in completion of the nest after pairing. Captive Adelie penguins nesting on the periphery of the rookery have been reported to take significantly longer to pair than birds nesting centrally (Ellis-Joseph, 1988), presumably because of increased disturbance from other birds wandering on the edge of the rookery.

Wild birds exhibiting mate fidelity are reported to exhibit higher reproductive success (i.e., more chicks fledged) than those which do not (e.g., Coulson, 1966; Mills, 1973; Richdale, 1957). Under captive conditions, however, mate fidelity does not appear to confer a reproductive advantage, however, the rates of affiliative behaviors within a pair is correlated with reproductive success (Ellis-Joseph, 1988).

Captive Pygoscelids tend to be fairly aggressive prior to incubation; upon egg laying, aggression falls to low levels. Eggs are incubated for approximately 34 days (Ellis-Joseph, 1988), with a range of from 34-42 days. In the wild, males generally incubate for approximately 14 days, followed by the female for approximately 10 days, followed by several shorter bouts by both the male and female. Patterns of incubation bouts for captive Adelie penguins range from 5 hr 35 min to 32 hr, with females performing a little more than half of incubation (Ellis-Joseph, 1988, 1990). These studies also reported that birds with shorter incubation bouts were significantly more successful at fledging chicks than those with longer incubation bouts. Non-incubating mates generally spend a great deal of time at the nest site in captivity.

Just prior to pipping, eggs become an object of great interest to parent birds. Much time is spent rising up and gazing at the egg(s), and most parents appear to become "restless" in their incubation behavior, shifting and resettling on the nest much more often than in earlier phases of incubation. The hatching process is described in Chapter 4, Reproduction.

After hatching, chicks are brooded for a period of approximately 15 days. Down color is species-specific, although Adelie penguin chicks can exhibit either a silvery grey or a sooty grey down. Most Pygoscelid chicks weigh less than 100 gms and cannot hold their heads up until one or two days following hatching. In the wild, some chicks are not fed until three days of age (Spurr, 1975). Food begging by chicks has been observed on the day of hatching but is apparently not essential to initiate feeding. When feeding a hatchling, a parent bird bends over and places its bill beneath that of the chick. Subsequent begging by the chick then stimulates regurgitation of food by the parent into the chick's open bill.

At about the time chicks begin to move away from the nest on their own, they enter the phase of most rapid growth (Taylor & Roberts, 1962). To keep up with chick food needs (approximately day 20), both parents forage simultaneously, leaving offspring alone at the nest site. Unattended chicks gather in creches. As with *Aptenodytes*, creching behavior is not observed in captive *Pygoscelis* species. Upon returning from sea, parents and chicks recognize each other via vocalizations. After absence from the nest, captive parents may bow to their chicks or perform mutual displays, which presumably serves to strengthen the filial bond.

Wild *Pygoscelis* chicks fledge between 41 and 56 days of age (Ainley et al., 1983; Ainley & Schlatter, 1972; Taylor, 1962). Captive, parent-reared Adelie penguin chicks become independent of their parents at approximately 60 days with a range of 56-64 days (Ellis-Joseph, 1988). Prolonged parental care in captivity may be facilitated by constant provisioning as well as inherent emigration limitations. Fledging is discussed in more detail in Chapter 4, Reproduction. Following fledging of chicks in the wild, adult birds fatten, molt, and subsequently return to sea (Croxall, 1984). Captive adults also fatten and molt following breeding.

Eudyptes. Crested penguin species of the genus *Eudyptes* are colonial, with some rookeries having enormous populations. Most Eudyptid penguins build nests with rocks, sometimes interspersed with grass. The first (A) and second (B) eggs are greatly different in size, although both are viable. The second egg is much larger; the first egg is often lost or not incubated. Rockhopper penguins often retain both eggs until the end of incubation, but Macaroni penguins normally retain only the B-eggs (Williams, 1980).

Both male and female Eudyptids take turns incubating the egg(s) and assist in chick-rearing. The period of incubation is species-specific but generally ranges between 33-39 days (See Table 3, Chapter 4). All crested penguins leave their breeding area in the late summer or fall and spend three to five months at sea. The more northern species breed in later winter or early spring, enabling their offspring to go to sea in mid-summer. The more southern species breed in the spring and offspring move to warmer waters in the fall.

Captive crested penguins tend to become fairly aggressive during the early stages of the breeding season, especially as they compete for territories and nesting materials. This may be ameliorated by providing adequate nesting sites and materials.

Eudyptula. Little Blue penguins are the smallest penguin species, weighing as little as 1.5 pounds. Unlike other penguins, they are somewhat reticent and are most active at night. Little Blue penguins are burrow-nesters, generally hiding their nests under rocks and plants or in small caves. They come ashore only after sunset, spending the night there and then returning to the sea at dawn.
During the breeding season, Little Blue penguins remain in their burrows during the day. Egg laying begins in February; two eggs are laid and incubated for approximately 36 days. Both males and females take part in incubation and chick rearing. Young fledge at approximately 8-9 weeks. Little Blue penguins are not widely kept in captivity and do not commonly reproduce in North American institutions.

Spheniscus. *Spheniscus* penguins - African, Humboldt, Magellanic, and Galapagos - are small to medium-sized birds (5-5.4 kg/11-12 lbs.), with smooth plumage. These species have shorter, less dense plumage and less body fat than the polar species, and often have bare patches on their faces. *Spheniscus* penguins nest in holes dug in firm sand or clay. Generally, two eggs are laid and incubated for approximately 40 days. As with other penguin species, both parents take part in incubation and chick rearing. Chicks fledge between 75-90 days. African (Cooper, 1980) and Humboldt penguins (Boersma, 1976) have been reported to breed year-round while Magellanic penguins have been reported to be highly seasonal breeders (Boersma, 1988).

In captivity, Magellanic penguins pair and become territorial in late spring and early summer. Coinciding with pairing, birds become generally more aggressive. Data concerning timing of laying and reproduction in captive *Spheniscus* species are presented in Table 2. Duffy (1991) suggested that breeding of *Spheniscus* is fairly similar across species. For all *Spheniscus*, the normal clutch size is two eggs, laid two to four days apart. Incubation ranges between 38 and 42 days; depending on the species, young fledge between 50 and 80 days of age (Duffy, 1991).

SUMMARY

This chapter represents a highly condensed overview of behavior and social organization in penguins. An attempt has been made to describe both wild and captive patterns of behavior, and when available, to provide information concerning specific phenomena observed in captive settings. This synopsis is by no means meant to be comprehensive. A great deal is known about the behavior of penguins in the wild. For further detail and insight, managers of penguins are advised to consult the wide array of literature for particular species and topics of interest (Refer to Additional References at the end of this Manual, for a partial list). It is essential that captive managers be knowledgeable concerning all aspects of penguin behavior and biology, including the effects of human management on behavior, genetics, and biology. This goal can be best served by the development of active exchange and cooperation within and between researchers in the field and managers in zoological facilities.

CHAPTER 4

REPRODUCTION

Linda Henry and Gayle Sirpenski

INTRODUCTION
The development of successful reproductive programs in captive populations of penguins is of increasing importance for several reasons. Most notably, two of the 11 penguin taxa now present in captivity are considered threatened in the wild. Environmental parameters, primarily temperature, humidity, photoperiod, substrate, and diet, along with group dynamics interrelate to impact eventual reproductive success. The following chapter is intended to provide information on the captive breeding biology of penguins and help penguin managers develop protocols which are conducive to successful breeding programs. Each facility must strive to develop a program that best suits its needs. Please refer to the other appropriate chapters in this manual for specific information concerning these topics.

NESTS
Burrows
Spheniscus species and *Eudyptula minor* are burrow nesters. In the wild, the typical burrow is fairly wide at the entrance (58 cm), then narrows slightly but widens again in the chamber where the eggs are laid (Boersma, 1991b). The height may range from 14 to 40 cm and may be 60 cm in length. In captive settings, burrow types range from natural, self-excavated holes, which are artificially covered, to naturalistic human-made caves, to air kennels.

Spheniscus penguins will utilize almost any nesting option provided. In designing nesting accommodations, managers should consider both the birds' needs and those of the keepers who manage the nest. Key components to consider are:

* a proper size burrow opening
* adequate number of nesting sites
* adequate air circulation
* drainage
* accommodation for cleaning and disinfecting, when needed

A large opening may make it difficult for a bird to defend its nest, resulting in a nesting failure. It is important to provide more nesting sites than will be needed to alleviate competition. Ideally, nests should be positioned to minimize traffic at the entrance of the burrow.

Adequate air circulation and drainage are important from the standpoint of humidity and disease control. Proper air circulation is essential in a humid environment; this is especially true if birds are coming from the water and going directly into the nest. Holes or vents can be placed along the sides of the nest box. In exhibits where burrow flooding may occur (due to rain or an overflowing pool) a small drain inside the nest can expedite recovery of the burrow.

A variety of designs have been developed which provide adequate nesting for *Spheniscus*. One popular, ready-made burrow used by many facilities is the plastic air kennel used for airline shipping. The optimal size for this purpose seems to be models #200 and #300. Using just the top portion of a kennel (with a handle on top) as the burrow is another option that works well. Approximate dimensions are 64 cm L x 43 cm W x 24 cm H with an opening of 20 x 23 cm. This facilitates monitoring and management of the nest because the cover can be lifted slightly to provide easy access. For example, Mystic Aquarium has found that African penguins are likely to move with the hut if it is moved forward. In this way, they can be induced into briefly moving off the nest so eggs and chicks can be handled without aggression from the parents.

Artificial burrows may be constructed from wood, providing they are painted in order to seal out moisture. A burrow of this material should be refurbished or replaced at the conclusion of the breeding season. All nest boxes should allow the keepers access without unnecessary disruption of the nest. One type of artificial burrow, used by Sea Life Park in Hawaii, uses 36-inch sections of cement pipe, open at both ends. Mystic uses a similar design made from expanded PVC pipe (18 inches long and an 18-inch opening). At Sea World in California, Humboldt penguins are housed in an outdoor exhibit where birds excavate burrows into the natural substrate. Excavation is augmented with a painted plywood tent or box or fiberglass cover (see illustration). In exhibits where birds are allowed to burrow, the soil mixture should be at least 20% clay to prevent nest cave-ins.

Nesting Substrate

The substrate beneath the nesting material should be absorbent to keep the nest dry. Good drainage and ventilation is essential. Many facilities use kitty litter as an absorbent base. It is important to choose a non-clumping clay litter. Other materials, which have been safely used in nest boxes include sand, pea gravel, rocks, wood shavings, and Aspen chips. Materials, which are reported to have caused problems (and which should be avoided) include: crushed corn cob (likelihood of fungal spores); peanut shell (fungal spores and possible fly infestation); and sterile potting soil (fungal spores). In exhibits where birds dig into the natural substrate, water may collect at the bottom of the nest. In this instance, the burrow should be drained and removed from access by birds.

Nest Box/Burrow Maintenance

The degree of daily maintenance of nest boxes or burrows seems to vary among facilities. 1993 PTS results indicate that some institutions clean nests daily while others do not clean the nest until it is abandoned by the parents following chick removal; other institutions remove nest boxes from the exhibit completely until the next breeding cycle. Daily cleaning of nest boxes does not appear to be necessary and may be disruptive. It is recommended that nest boxes are removed for annual disinfection, painting, or replacement.

NEST MATERIALS

Spheniscus

Nest materials should be offered at the onset of breeding season. While nest materials are not necessary for the comfort of the chicks, the collection of nesting material seems to be a strong component in pair bonding. Some recommended nest materials might include:

- rounded stones, too large to swallow
- grasses (e.g., pampas grass, outdoors only)

Pencil-sized, dry sticks are an example of a nesting material, which should be avoided; mortality has been reported in adults from eating sticks. Additionally, sticks could be dangerous for young chicks that may be impaled or become trapped under them. Although used successfully by some institutions, managers should be aware of the danger of introducing fungal spores through the use of fresh vegetation as nesting material.

Antarctic and Sub-antarctic Penguins

Wild *Pygoscelis* and *Eudyptes* penguins nest above ground, in the open or among vegetation, most commonly utilizing small rocks as the primary nest material. Feathers or even vegetation may also be incorporated depending on locale.

Nests are built to varying degrees among the species. It is important to provide adequate amounts of suitable rocks for nesting. Sea World of California reports that they add beach pebble and river rock to a depth of 4 to 5 inches on the rookery area to provide adequate base and a good rock source. Care should be taken to provide rocks large enough to preclude ingestion by chicks. It is unknown whether rock eating is dangerous since wild penguins are known to eat rocks as well. However, given the need to optimize success in the captive environment, managers would be well advised to avoid smaller sized rocks. Timing of the addition of nest materials should correlate with other reproductive stimuli that should be approximated to the natural cycle, e.g., artificial lighting. *Eudyptes* can be very aggressive when nesting and caution should be used in disturbing even an experienced pair during the hatching of the egg; to do so could result in injury to the chick or cause the parents to abandon the chicks.

Aptenodytes do not require addition of nest materials. In the King penguin, a small territory is defended but not associated with nest building. (See Chapter 3, Behavior and Social Organization)

EGG PRODUCTION AND INCUBATION

The degree of seasonality varies among species (see Chapter 3, Behavior and Social Organization). The egg-laying interval and incubation period also varies among species (Table 3). Incubation data from field studies are available. Factors influencing incubation period include exhibit temperature and humidity, "tight" incubation vs. constant up and down movements during incubation, and whether the egg is incubated by the pair or in combination with artificial incubation.

Table 3. Egg-laying intervals and incubation data for penguin species commonly maintained in captivity.

Species	Egg Lay Interval	Mean Incub Period	Incub Period Range	Pip-to-Hatch
Emperor	---	67 days	64-73 days	48-72 hrs
King	---	56 days	53-62 days	48-72 hrs
Adelie	3-4 days		34-42 days	24-48 hrs
Gentoo	3-5 days	38 days	36-41 days	36-48 hrs
Chinstrap	3-4 days	37 days	35-39 days	36-48 hrs
Macaroni	4-6 days	36 days	33-39 days	24-48 hrs
Rockhopper	3-5 days	36 days	32-36 days	24-48 hrs
Humboldt	2-4 days	42 days	40-46 days	24-48 hrs
Little Blue	2-3 days	35 days	32-35 days	48-56 hrs.
African	3-4 days	38 days	36-42 days	24-48 hrs
Magellanic	3-4 days	42 days	38-48 days	24-48 hrs

Spheniscus Penguins

The normal clutch size for this genus is two eggs. Reports of single and triple-egg clutches have been reported but are unusual. Onset of incubation varies among species. In African penguins, females incubate the first egg immediately (Gailey-Phipps, 1978). Humboldts partially incubate the first egg but are still willing to come off the nest until the second egg is laid. Magellanic penguins do not incubate until completion of the clutch (Boersma et al., 1990).

Depending on the egg management practices for a given group, Humboldt and African penguins may produce up to three clutches on an annual cycle, with peak laying periods as described in Chapter 4, Behavior and Social Organization (see also Egg Management, this chapter).

Antarctic and Sub-Antarctic Penguins
Clutch size varies among these genera: *Aptenodytes* lay a single egg, *Eudyptes* and *Pygoscelis* most commonly lay a two-egg clutch, although three-egg clutches have been reported. Onset of incubation also varies: Female King penguins begin incubation as soon as the egg is laid; for Emperors, the female merely shelters the egg for a few hours before transfer to the male, when incubation begins in earnest; Adelies, Chinstraps and Macaronis only partially incubate before laying the second egg; and Rockhoppers partially incubate the first egg (but it is often lost or ejected) before the second egg is laid.

Egg Size
Table 4 shows expected measurements of eggs for various species. Size differences noted between first (A) eggs and second (B) eggs for several species influence eventual reproductive success. Eudyptids, in particular, show preferential interest in B eggs, often resulting in differential egg mortality (Williams, 1980). For other species, size differences combined with hatching asynchrony may be correlated to a loss of chicks within a nest (Williams and Cooper, 1984). (Refer to Egg Management, this chapter).

Table 4. Sample egg measurements from captive-laid (*) or wild-collected eggs (Sea World of California, unpublished data).

Sample	Sample Size	Mean Length X Width (mm)	Range Length (mm)	Range Width (mm)	Range Weight (g)
Emperor*	10	121 X 82	100 - 130	78 - 86	
King	301	106 X 76	90 - 122	65 - 82	100 - 391
Adelie*	72	69 X 53	60 - 79	42 - 60	64 - 119
Chinstrap	52	66 X 52	61 - 71	48 - 56	72 - 113
Gentoo	111	70 X 58	61 - 78	53 - 61	93 - 145
Macaroni	157	80 X 60	63 - 90	44 - 68	63 - 184
Rockhopper A	50	63 X 49	56 - 67	41 - 52	47 - 88
Rockhopper B	84	70 X 54	64 - 80	50 - 57	83 - 123
Humboldt*	30	73 X 52	62 - 85	46 - 56	not avail.
Magellanic	101	73 X 55	68 - 82	50 - 60	94 - 134
African*	7	65 X 49	62 - 72	44 - 60	72 - 98
Little Blue	10		37 - 40	53 - 58	36 - 42

HATCHING

Hatching success can be affected by parental behavior during incubation. First-time parents do not always adequately cover the eggs. In the *Spheniscus*, they also tend to exhibit a higher degree of aggression, which may adversely affect fertility or lead to egg breakage. According to Cheney (1990) there is an apparent correlation between young, inexperienced parents and infertile or inadequately incubated eggs. This is true for first-time breeders of other species as well.

Another factor influencing hatching success is humidity. Generally, the microclimate of the brood patch is sufficient for hatching under parent birds.

Penguin chicks hatch without assistance from the parents, except by fortuitous movements of the egg on the nest or feet. It usually takes a chick 12 to 48 hours to completely emerge from the shell (slightly longer in *Aptenodytes*). Table 3 shows pip-to-hatch interval for several captive species.

Occasionally a chick will become malpositioned within the egg, preventing the chick from rotating properly. Such chicks may need assistance in hatching (see Hatching Problems, this chapter).

Parental Care

The normal weight for newly hatched, dry chicks of various genera and species can be found in Appendix I (these data were provided by Sea World Parks). Chicks below the lowest range for hatch weight for their species should be monitored carefully and hand-reared if necessary, especially if there is a sibling in the nest. There is considerable competition between nest mates, and weaker chicks frequently fail to thrive.

Chicks remaining with the parents should be monitored closely. If a problem is suspected, parent-reared chicks may be carefully removed from the nest, examined, and weighed. The weight gain within the first 5 to 7 days should be substantial. Upon examination, chicks should be checked for adequate hydration by lightly pinching the skin (usually on the back of the neck) and assessing resilience. If the skin stays in the pinched position, the chick is dehydrated. The lungs should sound clear, the eyes should be moist and the feet plump.

Several parameters can be used to determine the status of a chick in the nest.
A healthy chick can be heard vocalizing as it solicits food from the parents. It should be noted, however, that at least one institution has reported hearing no vocalizations from some chicks. In the case of first-time parents it is helpful, as well as reassuring, to know that they are indeed providing food for the chick. This can be determined not only by physical examination of the chick and weight gain, but by checking for the presence of regurgitated fish in the nest, or the institution of keeper-watches to monitor feeding behavior. Video cameras are also used successfully for this purpose.

Occasionally the amount of nutrition provided by the parents is inadequate to support proper growth. Keepers should be prepared to provide assistance to small or malnourished chicks. If the chick is being fed by the parents but still appears dehydrated, a 2cc – 4cc supplement feeding of Pedialyte can be helpful in sustaining very young chicks until the parents are providing an adequate diet. The veterinarian should monitor small chicks closely for other complications.

Penguin chicks grow quickly on the diet of regurgitated food from the parents. Parent-reared chicks can double their hatching weight in less than five days. Parent-raised chicks gain weight at a faster rate than chicks that are fed an artificial diet (Schofield, 1991). An example of comparative growth rate between hand-reared and parent-reared chicks is shown for African penguins in Table 5.

Table 5. Comparison of Average Weight Ranges for Developing *Spheniscus demersus* chicks.

Age in Days	Parent-reared	Hand-reared
5	130-170 grams	90-120 grams
15	500-800 grams	300-400 grams
25	1.0-1.2 kg	700-900 grams
30	1.6-1.8 kg	1.0-1.4 kg
40	2.0-2.3 kg	1.5-2.3 kg
60	2.8-3.3 kg	2.8-3.3 kg

The food regurgitated to newly hatched chicks is very watery. As the chicks age, the regurgitated food becomes less moist. Older chicks are better able to digest solid food.

As the chicks grow, the demand for food from the parents should increase. Therefore, the needs of parents may be met through increased frequency of feeding or by increasing the volume fed per feeding. Adults may increase their food consumption by three or four times their normal amount during this time (see Chapter 6, Nutrition).

By three weeks of age, chicks of smaller species are able to swallow whole fish of moderate size. At this time, some institutions begin feeding their *Spheniscus* on the nest to encourage acclimation to hand feeding. However, for other species, this is not recommended because of the disruption that it may cause on the rookery. For larger species, supplemental hand feeding of pre-fledgling chicks on the nest is not recommended because of the often-extreme aggression of the parents.

Age of Fledging and Sexual Maturity
Age of fledging, or independence from parents, varies among penguin species (Table 6). Penguins usually achieve their peak weight just prior to fledging. Smaller species of penguins

can be given access to water when their abdomen and back are completely molted. Larger species may not venture near the water until near completion of the molt. Chicks inexperienced with exiting the pool should be monitored at all times while swimming.

At onset of fledging, *Spheniscus* chicks often go through a timid stage and may even act aggressively towards keepers. This change in behavior may be accompanied by an apparent disinterest in food. A weight loss of as much as 1 kg is not unusual at this time (Bocxstaele, 1978); appetite improves over time. Some facilities report higher mortality among birds molting into their juvenile plumage; thus staff should continue to monitor fledglings closely.

Table 6. Average age at fledging and peak weight at fledging for several species of penguin. (Sea World of California, unpublished data).

Species	Age at fledging	Approx. Peak Weight (kg)
Emperor	4-6 months	varies
King	4-8 months	varies
Adelie	40-60 days	2.5-3.0
Chinstrap	55-60 days	3.1-4.2
Gentoo	70-75 days	6.5-7.5
Little Blue	33-34 days	.831 - .891
Macaroni	60-65 days	3.0-4.1
Rockhopper Chile	50-60 days	1.4-1.8
Humboldt	70-90 days	3.0-3.6
African	70-84 days	3.0-3.3
Magellanic	65-70 days	3.2-4.2

The exact age of sexual maturity is difficult to determine for some captive species. The sex ratio and age distribution of the colony will have an impact on the sexual behavior of the younger penguins. Young males generally will not compete with older males for mates. They will, however, engage in courtship behavior at an early age (1-2 years). The approximate age of sexual maturity are shown for wild penguins in Table 7.

Table 7. Average age of sexual maturity for wild penguins (from del Hoyo et al., 1992).

Species	Age at sexual maturity Female/Male (if available)
Emperor	5 years/6 years
King	5-7 years
Adelie	3-8 years
Chinstrap	3 years
Gentoo	2-3 years
Little Blue	2-3 years
Macaroni	6 years (captivity)
Rockhopper (Chile)	unknown
Humboldt	data not available
African	4 years
Magellanic	4-5 years/5-6 years

ARTIFICIAL INCUBATION

Preparation of the Incubator

1993 PTS results indicate that most institutions fumigate with formalin/potassium permanganate to disinfect the incubator. Some institutions combine the use of a disinfectant solution to wash the inside of the incubator with fumigation. Nolvasan can be used as a disinfectant. There are stringent regulations governing the use of potassium permanganate; in California, special training is required and proper personal protective gear must be worn.

Fumigation or Disinfection of the Eggs

Because many penguin eggs can become quite soiled in the nest before being removed to the incubator, there may be concern regarding cleaning and/or disinfecting eggs. However, the majority of the 1993 PTS reported that they do not fumigate the incubator with eggs present.

Types of Incubators

There are a variety of incubators available that are suitable for incubating penguin eggs. Incubators that have been used successfully include:

- Petersime Models 1 & 4
- Humidaire model 20, 50 & 120
- Grumbach
- Roll-X

Considerations in choosing an incubator to hold penguin eggs include:

- incubator room/ambient conditions
- size of eggs to be incubated
- number of eggs to be incubated at one time
- turning requirements

Temperature and Humidity

Artificial incubation temperatures reported by 23 institutions vary from 35.2°C (95.5°F) to 37.5°C (99.5°F) on the dry bulb and 26.6°C (80°F) to 30°C (86°F) on the wet bulb. The most commonly used dry bulb temperature is 35.8°C (96.5°F).

The Cincinnati Zoo reported poor hatchability of Magellanic eggs at 35.8°C (96.5°F) which improved when they increased the dry bulb temperature to 36.6°C (98°F).

The wet bulb temperature should range from 27.7° C -28.8° C (81-84° F). Depending on geographic locale and rainfall, this may necessitate more or less frequent additions of water to the incubator reservoir. Type of incubator and the number of eggs being held at one time will affect overall humidity. Monitoring eggs through egg weight loss measurements is well described in the literature and can assist managers in establishing humidity requirements for their care.

Egg Setting, Egg Turning Technique, and Frequency
Eggs should be set flat, not on end, in the incubator. The majority of institutions that have attempted artificial incubation report mechanical turning of the eggs every one to two hours. In addition to mechanical turning, some institutions also perform a 180° manual turn of the egg. This practice facilitates a more even development of vascularization in the egg (Jordan, 1989).

For incubators without automatic turning capability, manual turning can be done five or seven times (an uneven number of turns) in a 12-hour day. Eggs should be turned slowly to avoid rupture of developing blood vessels in the egg.

Managing the pip-to-hatch interval
Eggs may need to be candled more frequently in the week prior to expected hatch. Some institutions report daily candling of eggs in the incubator at this time. A penguin egg is ready to move to the hatcher following external pip. Turning of the egg is no longer necessary at this time. For rockhoppers and macaronis, the egg should be moved to the hatcher when the chick pips into the air cell because an often-shorter pip-to-hatch interval has been observed. Problems have been reported when moving *Pygoscelis* eggs to the hatcher prior to the chipping of the shell by the chick.

At the time of pip, humidity should be increased by 1-2° C (2-3° F) on the wet bulb. This can best be accomplished in a hatcher separate from the incubator. This is important for several reasons, including the ability to increase humidity without adversely affecting other earlier stage eggs and preventing contamination of the incubator by hatching eggs. However, this may not be feasible for those with one incubator. Hatching eggs should be checked four to five times per day, and the area surrounding the pip misted with distilled water. Water for misting should be kept in the hatcher so that the temperature is the same as the hatcher. Average pip-to-hatch interval for several species is noted in Table 3.

Hatching Problems
Generally, penguin chicks experience relatively few problems in hatching. However, when a questionable situation arises, it is helpful for managers to be familiar with the normal hatch sequence (pip-to-hatch interval, appearance of a newly hatched chick, etc.) which will help in determining when a problem arises.

Some general indicators of improper hatching (whether in the incubator or observed under the parent) are:

* if a chick has made internal pip but has failed to progress for over 12-15 hours or is well beyond expected incubation period.

* if a chick has chipped through shell, but has failed to progress after 12-15 hours.

* if a chick has rotated inside the egg without further chipping such that the bill is no longer visible at the pip hole.

* in *Aptenodytes* and *Pygoscelis* parental behavior can be indicative of a problem with hatching progress, as these birds will lift the brood pouch and bow more frequently.

The most common hatching difficulty for penguin chicks is malpositioning of the chick inside the egg. This may or may not be accompanied by unabsorbed yolk and/or residual albumen. Once a chick is determined to be having hatching difficulty, the egg should be removed for assistance (from the hatcher or from under the parent). When performing an assisted hatch, care should be taken not to introduce bacteria to the chick. Hands should be washed and gloved and all instruments cleaned. The pip should be examined and an evaluation of the problem should be made before beginning to assist the chick to hatch. The egg should be candled to assess vascularization (is the chick ready to hatch) and pip location (above or below the air cell), and a small flashlight can be used to look inside the pip hole to look for unabsorbed yolk, residual albumen or other problems. Once these steps are completed, carefully peel away small portions of the shell from the pip site with forceps.

After the pip area has been further exposed, the membrane should be moistened with warm water on a swab to check for active vessels. If no vessels are present, the membrane can be peeled back to expose the chick. Be sure the membrane does not stick to the nares and occlude breathing. Efforts should be made to expose the head first. In extreme cases, it may be necessary to manipulate the head out from under the wing. (For a more detailed description of hatching assistance, see Jordan, 1989.)

If the chick is to be parent-reared, it should be returned to the nest as soon as possible, following a careful examination for other problems. Sticky chicks (those with residual albumen) or chicks with protruding yolk sacs should be considered for hand rearing.

REPRODUCTIVE MANAGEMENT

General Record Keeping

The necessity of maintaining good records cannot be over-emphasized. Staff can learn from previous attempts at chick rearing if complete records are available to them. By reviewing past records, changes can be made to improve protocols for the future.

Egg production and reproductive history records

As mentioned in Chapter 2 (Management), individual identification is essential if accurate records are to be kept. It is imperative that pedigree information from birds that were transferred from other institutions be obtained if available. This information can easily be acquired for studbook species and is important in maintaining the genetic history of each individual.

Record keeping relating to reproductive management should begin at the time of egg laying. Marking the first egg laid is important if the expected incubation dates are to be calculated. Egg logs should be used to record data such as lay date, number of days incubated, sire and dam, sibling identification, and method of rearing. Further, the fertility results should be noted for each egg as well as survivability of chicks. By tracking a pair's reproductive history, trends in success and/or failure can be identified. One simple method for recording of reproductive data for penguins, using large rookery maps, was described by Ellis-Joseph (1990).

Chick records. Hatch weights and subsequent daily or weekly weights are important in determining the overall growth rate. Many institutions develop records which include first morning weight, weight before and after each feeding, amount of food offered and consumed at each feeding, types of food consumed, comment on behavior, and vitamins and medication. It is useful to record ambient temperature and brooder temperature (if applicable). Chick records should be maintained through fledging.

Egg Management

Managers and staff should be familiar with how husbandry, nutrition, genetics, disease, and incubation impact egg fertility and chick production (Kuehler, 1990).

Candling. This can be a useful tool in determining the fertility and development of an egg. Candling techniques require practice, and a person with experience should be consulted prior to handling the eggs. Some managers are of the opinion that the eggs should not be handled before the tenth day following onset of incubation due to the potential damage to the embryo. If staff is experienced at candling, this should not be a concern (C. Kuehler, pers. comm.). Care should always be taken to avoid jarring the egg during handling or burning the embryo with the light source. Cooling should be kept to a minimum; slight cooling of the egg during candling does not appear to have deleterious effects (Jordan, 1989; C. Kuehler, pers. comm.).

During the majority of incubation, the air cell will be clearly visible. The shape of the air cell will usually change during the 24-48 hours prior to external pip or chipping of the shell by the chick. This is described as drawdown and is immediately followed by internal pip (where the chick penetrates through the membrane into the air cell).

General discussion of individual incubation techniques, including causes of embryonic mortality or abnormalities in development, are well described the literature (e.g., Kuehler, 1983; Osborn and Kuehler, 1989; Jordan, 1989; Kuehler and Good, 1990).

Removing eggs. Age of the pair, reproductive experience, environmental and social conditions, as well as the goals of the reproductive program, factor into any decision to remove eggs from the nest. Other considerations that might necessitate the removal of an egg include:

* overdue hatching
* improper incubation
* replacement with dummy egg to avoid recycling

* fostering to another pair
* transportation to another facility
* contraception
* egg damage

If eggs are to be removed for the purpose of contraception, it is advisable that it be done soon after the eggs are laid to avoid any development. A dummy egg can be placed with the parents to prevent double-clutching. Dummy eggs should weigh approximately the same as an actual egg for that species. Eggs removed for fostering to another pair can be taken at any point during incubation. Options at this time include placing the egg in an incubator until the target (foster) pair is ready to receive the egg or transferring the egg immediately to the target pair. If this is the case, the target pair should be incubating a dummy egg prior to replacement with the fostered egg.

Institutions should be familiar with expected incubation behavior for a given species, in order to properly manage eggs on the nest. Many times eggs are removed from a pair based on an assumption of inadequate incubation when, in fact, incubation had not yet begun. Eggs removed from the parents because of improper incubation may be returned to the nest at or before pip for parent rearing if the pair has continued to adequately incubate a dummy egg during the period the egg was in the incubator.

Several methods may be employed to successfully and uneventfully remove eggs from the nest. For burrow nesters, boxes with peep holes or rear access can allow for easy monitoring and removal. Burrows with access solely through the burrow opening may necessitate removal of the incubating parent before the nest can be inspected.

For aboveground nesters, Sea World of California employs a creative distraction technique whereby a fishing pole-type apparatus is used to dangle an object (usually a plastic egg) above the incubating bird causing the bird to raise up, striking at the object in defense of the nest. At this time, eggs can be visually inspected (e.g., to determine presence of a second egg, look for pips, examine chicks, etc.). For egg removal, it works well to place one foot in front of the incubating bird as a distraction, while the bird is lifted from behind by the tail and the eggs(s) or chick(s) removed.

Aptenodytes may require more than one handler to effect egg or chick removal. The incubating bird should be held from behind (using minimal restraint) as a second person lifts the brood patch to remove the egg or chick.

Egg Size Differences. When a size difference exits between eggs in the same clutch, combined with hatch asynchrony, there can be a large weight differential between chicks in a brood. In Gentoos and Adelies, the A egg is noticeably larger than the B egg and hatches first, which can result in a less competitive second chick. Even with the unlimited food supply associated with captivity, a second Gentoo chick may fail to thrive in competition with a large sibling. At least one institution has been successful with Gentoo parents rearing both chicks.

Egg size difference is further exemplified by Eudyptid penguins which have an A egg considerably smaller than the B egg. During the course of incubation only two to four percent of A eggs survive to late incubation or hatching (Williams & Croxall, 1991). *Eudyptes* chicks hatched from A eggs usually fail to thrive in competition with the larger B egg sibling. However, if the B egg is lost, A eggs are viable. This is an important point for those managing *Eudyptes* in general. If maximum productivity is desired, one egg can be removed from pairs and either fostered or artificially incubated.

Parent/Chick Management
Although egg size difference is not significant for other species of penguins, hatch asychrony resulting in disparate size between first and second chicks can lead to trouble for a second chick under parental care. However, some Humboldt and African penguins have been reported to easily rear two-chick broods.

Fostering Eggs. The fostering of eggs to a “surrogate pair” for chick rearing is an option used by many facilities to maximize chick survivability. In cases where two chicks could be produced from a pair, this arrangement allows the parents to rear only one chick while the second chick is cared for by a pair that is known to be successful at rearing chicks. The timing of egg laying for both pairs should be within two weeks of each other. The eggs of the surrogate pair should be replaced with dummy eggs immediately. The egg(s) to be fostered can be placed under the surrogate pair a few days prior to the expected hatch date or at the time of pipping. Some facilities allow the first egg to hatch successfully before fostering the other egg. Fostering eggs can also be used to give younger or less experienced pairs an opportunity to rear a chick. One egg from a fertile clutch can also be given to a pair with infertile eggs.

Managing conspecific behavior. *Aptenodytes* require little intervention during incubation and chick rearing. Occasionally, other individuals or pairs will attempt to steal an egg. This occurs most commonly in Emperor penguins. The resultant dispute over the egg could result in loss through breakage. Therefore, it is recommended that Emperor pairs with eggs be separated from the main colony as soon as an egg is detected. Sea World of California utilizes a plexiglass barrier that physically separates incubating birds within the exhibit without adversely affecting visual and vocal stimuli from the group. Emperors with eggs are slowly walked to the barrier entrance. Initially, pairs are moved inside the barrier together. The female can be released back into the colony as soon as she transfers the egg to the male and begins to pace the enclosed area.

Feeding during incubation. Emperors generally eat from keepers' hands without difficulty during incubation. *Pygoscelis, Eudyptes* and *Spheniscus* penguins can be offered food on the nest as long as it does not cause unnecessary stress for the birds. These species may be aggressive and reluctant to accept food. King penguins may show inappetence at the time of incubation; more commonly, they are too aggressive to eat while on the egg. But keepers familiar with incubation exchanges can locate the bird for feeding when it is off the egg. Some facilities continue to feed the chick-rearing parent the normal morning vitamin fish, and some others prefer to wait until the chick is old enough to take vitamins in their own diet.

It is extremely important to remove all dropped fish if parents of smaller species are fed on the nest. The ease with which fish can be removed should be considered when the decision is made to offer food at the nest. If feeding or removal of fish elicits excessive aggression from the parents, perhaps an alternative to feeding on the nest should be considered.

If nesting birds are in an off-exhibit area or do not have access to water, it is a good idea to give the non-incubating partner the opportunity to swim sometime during the day. Most penguins quickly catch on to this routine and are willing to leave the nesting area for short periods.

Introduction of Chicks to the Colony

Hand-reared *Spheniscus* chicks can be introduced into the colony when they are nearly fledged (approximately 80 days). It is best to introduce chicks in a group or in pairs if possible. It is advisable to supervise the interactions of the newly introduced birds during the initial visit to the colony (See Chapter 3, Behavior and Social Organization). Chicks can be left unattended after a few days provided they are able to emerge from the water without trouble and are not being harassed by other birds. Juveniles tend to congregate together and will fight to establish a hierarchy of their own (Gailey-Phipps, 1978). Chicks should be encouraged to join the other birds at the feeding station rather than be provided with special treatment. It may be a few weeks before they are regularly feeding with the others. Some institutions find it advantageous to use an off-site area to introduce the chicks to members of the colony. A plexiglass barrier can also be used at first introduction within the exhibit.

HAND REARING

General Comments

It is advisable for all institutions managing penguins to gain experience in hand rearing. It may be necessary to remove an egg or chick for hand rearing in the event of the death of a parent or the failure of a chick to thrive in the nest. Success with hand-rearing chicks can be as high as 90% once a well-defined protocol has been established (Cheney, 1990). Hand rearing may be used to maximize founder representation within a colony, particularly if unrepresented birds do not exhibit successful parental behavior. Hand rearing can also be used to increase productivity; parents will often breed again within one season if chicks or eggs are removed.

Hand-reared chicks seem to be more tolerant of handling than parent-reared chicks. Depending on the routine husbandry practices of the facility, this may or may not be important. It should also be stressed that penguins are social animals and need to be in the company of conspecifics or congeners, even at a very young age, if they are to develop socially and not imprint (See Chapter 3, Behavior and Social Organization). Therefore, if possible, chicks of similar age should be reared together.

Prior to undertaking hand-rearing of penguin chicks, managers should consider the time and cost involved in hand-rearing penguins because this is a labor-intensive undertaking. Staff hours required to tend to the chicks along with the cost of the necessary equipment (brooder, formula, etc.) may have an impact on the decision whether or not to hand-rear chicks.

Early Chick Handling and Brooder Requirements - Days 1-14

Once chicks hatch, they should be allowed to dry in the hatcher for at least 12 to 24 hours. Immediately following hatching, the umbilical area should be swabbed with dilute iodine-based disinfectant such as Betadine, and the yolk sac size should be evaluated. It is important to continue to monitor the absorption of the yolk; slow absorption or a tight distention of the abdomen might be an indicator of a yolk sac infection. A normal abdomen will feel soft and yield easily to gentle palpation.

Once dry, chicks can be moved to an open brooder affixed with a heat source. Some types of brooders used (in order of prevalence) include:

* human infant incubator/modified Isolette with the top kept open
* painted plywood box
* plexiglass box
* ice chest type plastic cooler
* plastic box
* plastic wash basin

Primary concerns when choosing a brooder include:

1) adequate air circulation: penguin chicks require a dry rearing environment and should never be reared in an enclosed area where humidity is high.

2) ease of maintenance and disinfection: brooders should be cleaned at least twice daily.   If wood is used, it should be sealed; however, be sure that the sealer is compatible with the heat source that will be used, to prevent combustion.

3) size and temperature gradient: there should be an approximate 5° C (10° F) temperature difference from one side of the brooder to the other to allow the chick to adjust its behavior to meet its own thermoregulatory needs (after 5-7 days of age). If the brooder is too large, chicks may venture too far from the heat source and suffer serious cooling.

4) number of chicks to be reared together: it is recommended that no more than 2-5 chicks be reared in a single brooder. Overcrowding can lead to overheating of the chicks and increase the likelihood of transferring disease.

Typical early brooder dimensions might be 40 cm W x 83 cm L x 38 cm H to accommodate one to four chicks of smaller species or one to two chicks of larger species.

The most common heat source provided is a forced-air heater; heat lamps, heating pads and electric heaters were also reported as heat sources used (1993 PTS). To prevent burns, heat lamps should not be situated closer than three feet of the brooder. Heat sources should be adjusted to maintain 26.6 - 32.2° C (80 - 90° F) in the brooder for the first 14 days post-hatch. Dependent on ambient brooder room conditions, the temperature may need to be lowered as the chick approaches 14 days of age. Severely overheated chicks often lay flat with flippers and feet outstretched and may be panting; other subtle indicators of overheating are slight dehydration and unexplained inappetence.

Cloth toweling is the most commonly used substrate in the brooder for the first two weeks of rearing. Towels are readily available and can be easily laundered, using bleach, for adequate cleanliness. Roughly textured or frayed towels should not be used because of reports of leg injuries resulting from snagged toenails. Other early brooder substrates include:

- matting
- paper toweling
- surgical drape material

It is important that the substrate not be so smooth that the chick's feet slide out from under it. Temporary or permanent damage to muscles, tendons, and joints can result from improper footing.

Brooders should be cleaned at least twice daily. It is advantageous to correspond cleaning with feeding to reduce overall handling of the chick. Special care should be used when handling chicks that have just been fed as they may regurgitate. Additionally, toweling can be replaced as needed between scheduled cleanings.

Disinfectants should be thoroughly rinsed and allowed to dry before the chick(s) are returned to the brooder. Betadine sprayed directly on toweling and allowed to dry before adding the chick may reduce fungal spores.

Older Chick Handling and Brooder Requirements - Day 15 through Fledging
As chicks grow, larger brooder accommodations will be required. Most institutions utilize an in-house design plywood box. Wood should be painted or sealed with a suitable product. Some designs incorporate a 1/4-inch wire or mesh flooring and are elevated from ground level on legs or casters. Typical dimensions might be 2.4 m L x 1.2 m W x 0.6 m D with wooden dividers, which allow partitioning based on chick requirements. This size can accommodate eight chicks in four sections or four chicks in two sections. Brooders should never house more than four chicks together.

As chicks grow older and more timid, it may be useful to supply some type of shelter or cover. One method is to provide half of an air-kennel or a sheltered area can be built right into the brooder design. To expedite habituation to handling and desensitization to external stimuli, the shelter should be removed for portions of the day.

Generally, dependent on the chick's response and ambient temperature conditions, a heat source may not be required at this stage. For high latitude species, further cooling may be required. For *Spheniscus* penguins, addition of a fan or air conditioner to the brooder area can improve thermoregulatory conditions and air quality. Previously described symptoms of overheating are the best indicator of a chick's thermoregulatory needs.

At this stage, the brooder substrate most commonly used is indoor/outdoor carpeting. It is easily hosed for cleaning and can be soaked in a disinfectant and rinsed before drying. Other substrates used include rubberized matting and cloth toweling. Surfaces that are too smooth should be avoided to allow chick proper traction.

Brooders may require more frequent cleaning but should be done a minimum of twice daily.

HAND-REARING PROTOCOL FOR *SPHENISCUS, PYGOSCELIS,* AND *EUDYPTES*
The most commonly used diet for rearing penguins was developed by Sea World of California. This formula, commonly referred to as the "Penguin Milkshake," is discussed in Chapter 5, Nutrition. It is included in Appendix III at the end of this manual.

It is best to wait at least 12 hours after hatching before offering a penguin chick its first feeding. It is recommended that the first feeding be only water in order to assess the chick's feeding response and ability to swallow. Chicks with a large, unabsorbed yolk sac should only be given water for the first two or three feedings to allow time for yolk absorption. Once feeding begins, check the consistency and color of the stool. A black grainy or foul smelling stool may be indicative of improper digestion.

Feeding apparatus. Most institutions begin by using a 3-cc syringe affixed with a feeding tube (145 fr) as a feeding apparatus. As the chick grows, the syringe can be increased to 6, 12, 20 and finally 60 cc. Some institutions prefer a syringe alone, without the tube. If a tube is used, it should be securely glued to the syringe or longer than the chick's throat to prevent accidental ingestion of the tube by the chick. It is helpful to thoroughly blend the formula to facilitate the passage of formula out of the syringe and feeding tube.

Feeding Responses and Methods of Feeding
A feeding response can be initiated in a penguin chick by forming a "V" with the middle and index fingers, then placing the "V" upside-down on the top of the chick's bill and wiggling the fingers. The chick should respond by pushing up into the crook of the fingers. At this time, the formula can be delivered either by inserting the tube into the throat (at least 2 inches) or directing a tubeless syringe to the back of the throat. The fingers should be simultaneously wiggling to stimulate chick response and lifted very slightly to encourage the chick to stretch up. As the formula is delivered, it is important that the feeder watch the back of the throat for formula to back up; this can be a signal that the chick is no longer swallowing or that the formula is being delivered too quickly. If the chick tires and stops swallowing, remove the tube or syringe and wait. This process can be repeated until the feeding is completed. Chicks 1 to 5 days of age tire easily, therefore, it is important to be ready to give formula immediately after initiating the feeding responses.

Feeding and Weighing Protocol
Chicks generally begin with a schedule of five feedings per day, delivered every three hours; e.g., 0600, 0900, 1200, 1500, 1800. A chick's total intake per feeding can be determined

either by the gram differences in weight before and after feeding or by measuring the total amount delivered in the syringe.

Some facilities weigh chicks only once in the morning prior to feeding. However, it may be advisable to weigh a chick at the start of each feeding for the first 1-10 days as problems are common to this age group. When a chick reaches 1,000 grams, a single morning weight will suffice. Growth data for hand-reared chicks of penguin species commonly maintained in captivity are presented in Figures 6-20 in Appendix I. These data should be consulted frequently during hand rearing to determine if chicks are within the acceptable weight ranges for their species.

Hydration should be monitored carefully throughout a chick's development and particularly as a chick begins to eat fish. Check for signs of dehydration by assessing skin turgor and monitoring weight loss between feedings. Water may be injected into the fish to provide additional fluid.

Feeding protocol. Day 1 is defined as the first day of feeding; this may differ from the chick's age where day 1 equals day of hatch. When determining the amount to be fed per feeding, it is important that the chick does not receive a volume of formula greater than 10% of its first morning weight. For example, if a chick weighs 100 grams, it should not be given more than 10 grams in volume at any feeding. Overfeeding is a common rearing problem (see Age-specific rearing problems below). Chicks at 1 to 3 days of age should receive a volume slightly less than 10% of the daily weight. Older chicks already eating fish in addition to formula should receive a total volume per feeding (from all food sources) of 10% of the first morning weight. This is the "10% rule."

> There has been some discussion regarding the amount of water needed in the diet in addition to the formula. When fish is added to the diet, there is sometimes a concomitant need for water in addition to the formula. Those managing chick rearing should evaluate a chick's needs and give water accordingly. In the following protocol, water is mentioned frequently, but may or may not be required.

HAND-REARING PROTOCOL FOR NEONATE PENGUINS (EXCLUDING *APTENODYTES*)

Day 1: Following one or two 1 cc water feedings, give formula that is diluted by 50% (1 cc formula to 1 cc water) at each feeding. As discussed, the total amount fed per feeding will be dependent on the size of the chick (a Rockhopper, will get less than a Gentoo). As discussed, chicks at this stage will do better with an amount per feeding less than 10% of the first daily weight. Start with a 1cc syringe and work up.

Day 2: Give formula diluted by 25% (1.5 cc formula to 0.5 cc water) at each feeding in an amount slightly less than 10% of the first daily weight.

Day 3: Give full strength formula at each feeding in an amount slightly less than 10% of the first daily weight.

Day 4: Beginning at this age, full strength formula should be given at each feeding, hereafter referred to as formula. Try giving a volume equal to 10% of the first morning weight per feeding, a 120-gram chick could receive, but not exceed, 12 grams of formula.

Day 5: Use the "10% rule" as a guide for total intake per feeding.

Chicks should be weighed each morning prior to feeding. This weight is used in calculating the amount of food given at each feeding.

When a chick reaches 100 grams first morning weight, it can begin to receive solid fish in addition to formula. Humboldt and Chinstraps may need to reach 200g before they are fed solid fish. Introduce fish slowly using fish filets cut into 2.5 - 3.8 cm (1-1.5 inch) x 0.6 cm (0.25 inch) pieces. As the chick matures, whole small herring, capelin, or smelt may be used when the chick is able to swallow whole fish of varying sizes. Introducing fish can be done on the following schedule:

First day on fish: Three grams of fish given once during the first day at a.m. feeding. Fish given in proportion to formula and water following the 10% rule.

Second day on fish: 3-5 grams of fish given twice a day, fed in proportion to formula and water as stated above.

Third day on fish: 3-5 grams of fish every other feeding with formula to equal the 10% morning weight.

300 grams first morning weight: Gradually increase fish to 10-15 grams of fish every feeding (maximum) following the 10% rule.

400 grams first morning weight: Fish is 50% of the total intake every feeding maximum in proportion with formula, not to exceed 10% per feeding. Begin vitamin supplements at this time (25 mg B-1 BID)

NOTE ** heating formula to 95º F becomes less critical as the chick is consuming a higher percentage of cold fish.

When a chick reaches 500 grams or more at the first morning weight, the temperature should be lowered in the brooder area. Overheated chicks will display behaviors such as panting, flippers and feet extended, decreased appetite, etc. It is important to watch for dehydration. (See Age-Specific Rearing Problems below.) Additionally, the number of feedings per day can be decreased to four, e.g., 0600, 1000, 1400, 1800. Regardless of how much a chick solicits feeding, continue the "10% rule" as a guide for food intake. It is common for chicks at this stage to take less than 10%; this is often no cause for alarm, and the chick will likely eat well at subsequent feedings. At this stage vitamin supplementation may begin (See chapter Five, Nutrition).

After the chick reaches 600 grams at the morning weight and has been doing well on a diet of half fish and half formula, the proportion of fish in the diet can be gradually increased to two-thirds of the total intake. It is increasingly important to follow the "10% rule". In fact, some chicks may require less than 10% of their first daily weight at each feeding.

When a chick achieves 1000 grams at the morning weight, transition to a fish-only diet may begin. One method is to give only fish at two feedings and fish in combination with formula and water at two feedings. Additionally, feedings might be reduced to three per day with fish-only given at two of the three feedings. It is important to emphasize that chicks at this stage will not always eat all food offered. Additionally, chicks may begin refusing the formula completely. This is normal if the chick appears healthy; formula can be discontinued at this time, and the chick can be fed *ad libitum.*

At the time of fledging, the chicks may safely be given access to a pool. Penguin chicks should be weaned at this point.

Feeding Protocol for Aptenodytes

The feeding protocol for *Aptenodytes* is similar to that of the smaller species. The "10% rule" still applies. As with the smaller chicks, they should be fed only water for the first 1 to 2 feedings. Formula should be gradually introduced as outlined in Days 1 through 3 for smaller species. Again, chicks in this age group require a volume per feeding of less than 10% of their morning weight. For *Aptenodytes*, expect a daily weight loss for the first 1 to 4 days (See Appendix I, Figure 6 - King Penguin Growth Rate).

The chick should not be fed over 40cc's of formula because they regurgitate so easily.

Start chick on herring fillets at 7 days if age. You can add fillets sooner if the bird is regurgitating at all. Use capelin and herring fillets working up to feeding whole capelin and large herring fillets. Increase the size of the fist as the chick can handle it.

Feed only 10 % of the morning body weight. Water should be counted in the 10% and not in addition to it.

Do not feed more than 5 times per day.

No more than 3cc's of water should be given

King penguin chicks are weaned off formula sooner than the smaller species. Kings should be completely weaned off the formula by 21 days of age.

FEEDING GUIDELINES FOR KING PENGUINS

Day 1: 50:50 formula:water 5 x day, not to exceed 10% of morning weight. The first few feedings should be less than the 10%
Day 2: In crease to 75:25 formula:water
Day 3: Introduce straight formula
Day 4: First vitamin supplement
Day 7: Start on herring and capelin fillets. Give 5 grams every feeding plus formula to make up the 10%. Chicks should always be fed the formula first. Continue to increase the fillets by 5 grams daily provided the chick is progressing and processing them well.

Day 10 or 400 grams (whichever comes first)
1/8 of a children's multi-vitamin and
25 mg of B-1, twice a day

Day 11 (if not before) The chick should be getting 50:50 formula:fish
Day 14 Begin feeding four times a day

AT 600 GRAMS – increase vitamins to
¼ of a Children's multi-vitamin
160 mg of calcium gluconate
100 i.u vit. E
25mg B-1 a.m
25 mg B-Complex in p.m.

Day 20: Begin feeding 3 x daily
Day 21: Discontinue feeding formula
Day 25: Start on whole fish (capelin) combined with herring fillets

2000 GRAMS
½ children's multi
160 mg calcium
100 i.u. Vit. E SID, every other day

Day 112: Begin feeding two times per day, BID, whole large herring

3000 GRAMS
¾ of a Children's multi-vitamin, BID
320 gm calcium, BID
100 I.U. Vit. E every other day, SID
125 mg B-1 a.m.
50 mg B-complex p.m.

4000 GRAMS
1 whole Children's multi-vitamin
320 gm calcium, BID

125 mg B-1
75 mg B-complex

5000 GRAMS
Two ½-pound Mazuri multi-vitamins BID
640 mg calcium gluconate BID
100 I.U. Vit E every other day, SID
250 mg B-1 a.m.
100 mg B-Complex p.m.

6000 GRAMS
Same as above but increase Mazuri multi to 2.5-pound tablet BID

8000 GRAMS
Same as above but increase Mazuri multi to 5-pound tablet SID

Chicks remain on this vitamin regiment until they fledge. At that time they begin the adult protocol of one 5-pound Mazuri tablet SID.

NOTE: It is extremely important to monitor all chicks for possible anemia. Lethargy and/or labored breathing may be possible signs. If anemia is suspected, a vet check and blood sample will be necessary to determine whether an iron supplement is required.

AGE-SPECIFIC RE `ARING PROBLEMS

Overheating / Underheating
The brooder temperature should always be carefully monitored. Chicks should be observed closely for signs of heat or cold stress. The symptoms most frequently observed in overheated chicks include: lethargy, inappetence, panting, and extension of feet and flippers. Overheating can be problematic for chicks at any age but may quickly become life threatening in very young chicks unless corrective measures are taken. Underheated chicks may be observed shivering, huddled against the side of the brooder and feet will be cold to the touch. Chicks in this state will be slow to respond to a feeding stimulus.

Overfeeding
This problem can be avoided by carefully evaluating each chick's weight gains. Even when strictly following feeding protocols, problems from overfeeding can arise. It is always in the best interest of the chicks to address their needs individually. What may be an appropriate amount for one chick may be excessive for another. Generally, a 10-15% daily weight gain is expected during the first few weeks. Behavior associated with overfeeding include lethargy, spitting-up, and disinterest in food. Food should be withheld until the chick appears hungry. A dark, grainy stool may be an indicator of improper digestion and medical advice should be sought.

Hydration
Throughout development, hydration should be carefully monitored. This is particularly essential when solid fish is introduced into the diet. Symptoms of dehydration include: dry-looking eyes,

shriveled appearance of the skin on the feet, or thick, pasty feces. The skin along the back will remain "molded" up if the chick is inadequately hydrated (skin-tent test). Water feedings of appropriate amounts will improve this condition.

Splayed Leg Condition

Aptly named, this condition describes the outward turned position of the chick's legs. Although not often seen in penguins, this condition can result in serious and long-term complications. Therefore, early detection is important. The brooder or nest substrate should be textured enough so the chick's feet do not slip out from underneath it. Some facilities have had good results treating this condition by tying the legs together with a soft material. If using this treatment it is important to maintain a normal spacing between the legs. Another successful method used is to place the chick into a bowl approximately the same size as the chick's body so that the legs cannot splay. In very young chicks this often corrects the situation in 5-7 days.

Eye Irritation

Penguin chicks at any age can develop eye irritations attributable to a variety of factors, e.g., bacteria, injury, foreign matter. Keepers should take note if the chick's eyes tear excessively, appear red, swollen or become cloudy. If eye irritation is noticed, the eyes should be examined carefully for foreign materials. Chicks that are actively losing downy feathers also release tiny flecks of skin or dander that can adhere to the surface of the eye and cause damage to the cornea. In some cases simply flushing the eyes with water or saline solution can provide relief. If necessary, ophthalmic drops can be prescribed by the veterinarian.

SUMMARY

It is important for penguin managers to draw not only on the guidelines outlined in this chapter, but also to review the literature as well as other applicable chapters, particularly since reproduction in penguin groups is influenced by many interacting factors. These include allowing for proper group size, adequate nesting space, furnishing adequate nesting materials and, at appropriate times, proper nutrition and sometimes manipulation of artificial lighting to approximate a species' latitude of origin. Reproduction can be maximized for a group of penguins through fostering of eggs and hand rearing. Additionally, accurate record-keeping provides the basis for proper reproductive management of a penguin colony through knowledge of blood lines and genetic representation, adequacy of parenting skills, and viability of offspring. These and other factors interrelate to influence eventual reproductive success.

With reproductive success, however, institutions assume a certain responsibility. It is vital that penguin species are managed wisely with consideration for existing and potential captive spaces. Institutions should be wary of unmanaged reproduction, which could result in overcrowding and its associated problems. Through proper reproductive management, facilities housing penguins can enrich the captive environment and reinforce the overall health and well being of their penguin groups.

CHAPTER 5

DIET AND NUTRITION

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Provision of nutritional, behavioral, and environmental requirements is basic to the successful maintenance and reproduction of captive penguins. The following guidelines for nutrient intake and dietary husbandry were developed from studies of natural feeding ecology, published nutrient requirements of related species, information on potential penguin foods and their nutrient composition, and evidence of food preferences. Penguin foods are perishable and particularly susceptible to loss of thiamin and vitamin E. Therefore, suggestions for storage, handling, and supplementation are provided. Feeding methods are discussed, and calculated energy and nutrient concentrations in an example diet are presented.

FEEDING ECOLOGY

Natural diets

Knowledge of the feeding ecology of free-ranging penguins is relatively recent and very limited.[3,5,10,11,21,24,34-36,38-41] Although qualitative information on feeding habits is available for most penguin species, information on consumed quantities of specific foods is exceedingly rare. Some food intake data are available for little blue (*Eudyptula minor*) and African (Cape, jackass) penguins (*Spheniscus demersus*) for both non-breeding and breeding seasons.[21,35] More recent ecological research has focused on the seasonality of fasting and the physiology of molt[6,7] and on feeding as it relates to incubation energetics.[28]

A summary of the food items consumed by free-ranging penguins is presented in Table 1. All species consume more than one type of food in the wild, generally fish, krill, and/or squid. High-latitude species tend to consume krill as well as fish, with some species also taking squid.[10] The exception to this generalization is the chinstrap penguin (*Pygoscelis antarctica*), which has been reported to consume only krill and amphipods.[10] Macaroni (*Eudyptes chrysolophus*) and Adelie (*Pygoscelis adeliae*) penguins rely heavily on krill, but fish consumption has been reported in some locations.[24] Penguins that live at lower latitudes, such as little blue penguins and the *Spheniscus* species, tend to rely much more heavily on fish than do the high-latitude species.[10] The prey fish used most often are small-bodied, surface-schooling forms.

Intraspecific variation

Among penguin species that have been studied at more than one site or during more than one season, there are suggestions of within species diet variations.[10,11] Much of the variation may relate to differences in prey availability,[10],[11] but not all feeding patterns are clear. Both seasonal and site-based differences in quantities of specific prey items have been reported for little blue[27] and African penguins,[35] but African penguins sometimes exhibit seasonal variations in food selection that appear unrelated to prey supply.

Broadly similar patterns in diet composition persist from year to year with little annual variation, particularly in diets of high-latitude species. However, historical changes in diet composition have been reported for African penguins in relation to prey abundance.[35] For species such as Humboldt penguins (*Spheniscus humboldti*), supplies of prey fish may shift with major oceanographic events, such as El Niño.[19,20] For both of these penguin species and for others, the competition of human fisheries also may influence the prey species that are available.

One might anticipate that the larger average body size and bill dimensions of male penguins would result in consumption of somewhat larger prey than consumed by females. This sex-related difference has been documented in Gentoo penguins (*Pygoscelis papua*), but such differences have not been seen in Macaroni, chinstrap, and Adelie penguins.[40]

Nutrient Requirements and Related Concerns

The following information on nutrient requirements and nutrient content of food items is presented on a dry matter basis (DMB). Dry matter (DM) concentrations in whole fish and marine invertebrates range from about 14-37%.[2]

Published nutrient data

There are insufficient data from research with penguins to set nutrient requirements with certainty. Despite consumption of a variety of prey in the wild, it is likely that all penguin species have similar qualitative nutrient needs. It also is likely that the nutrient requirements of penguins are qualitatively similar to the nutrient requirements of most birds and mammals. The National Research Council (NRC) has published estimated nutrient requirements of domestic birds[31] and the carnivorous domestic cat.[29] Using these NRC estimates as guidelines, plus data on nutrient composition of free-ranging penguin foods and foods available in captivity, minimum nutrient

concentrations in diets for captive penguins are proposed in Table 2. These levels should be considered tentative until more specific nutrient requirements for penguins are defined.
Water. Penguins obtain water from food as well as in liquid form.[23,33,37] Because of their nasal salt glands, penguins are able to consume salt water.[33] However, in captivity, fresh water is commonly provided to meet possible needs beyond the water from food. If penguins have access only to fresh water, extra salt has sometimes been added to the diet to ensure development and maintenance of nasal salt gland function.[12] Whether this is a necessary practice has not been established.

Energy. It is presumed that penguins eat to meet their energy needs and will consume a greater mass of less energy-dense foods than of energy-rich foods. Gut-fill limits should not be a problem, given the relatively high energy density of most fish and the penguin's considerable stomach capacity. Penguins have been reported to carry up to 20-30% of their body mass in their stomachs as they bring food to their chicks.[10] Free-ranging Adelie penguins brooding chicks were noted to have metabolizable energy (ME) needs 3.8 times their basal metabolic rate (studied by doubly labeled water). When foraging and off the nest, the ME required was 5.4 times higher than basal metabolic rate.[28]

Alterations in energy intake are associated with molt.[17] There are several cues that induce this process, including changes in ambient temperature, day length, food resource availability (and possibly food nutrient content), and associated hormonal changes.[17] It appears that if fed an adequate diet ad libitum and the environment accurately mimics seasonal light and temperature changes, most captive penguins will exhibit a normal annual cycle of food intake and will molt and reproduce normally.[26,41]

Energy requirements are considerable for growth of chicks. King penguin (*Aptenodytes patagonicus*) chicks were estimated, by mass and energy density of stomach contents, to consume an average of 3,646 kJ (871 kcal) of gross energy (GE) per chick per day during a 3-month growth period.[5] The fish consumed contained 22-26 kJ (5.26-6.21 kcal) GE/g, DMB.

Vitamins and minerals. Dietary vitamin A requirements for studied avian species are between 1,700 and 5,600 IU/kg of diet on a DM basis.[31] Based on limited data, the vitamin A requirement for cats is 6,000 IU/kg of dietary DM.[29] It is possible that penguins, as fish-eating birds, have a high tolerance for vitamin A because comparatively high levels occur in their natural diet.[9] Whether this infers a high dietary vitamin A requirement has not been established. Studies with free-ranging macaroni penguins showed that vitamin A was mobilized from body stores during molt and reproduction.[16,17] Serum levels of vitamin A in captive Humboldt penguins[9] and plasma levels of vitamin A in captive Gentoo and rockhopper (*Eudyptes crestatus*) penguins[26] vary with diet fed and physiologic conditions, such as molt.

Vitamin D_3 requirements for most adequately studied bird species are between 220 and 1,000 IU/kg of diet on a DM basis.[31] Cats have a vitamin D_3 requirement of about 500 IU/kg of dietary DM.[29] Data on vitamin D_3 concentrations are available for very few penguin foods, but two species of smelt and one species of krill were found to have $\leq$633 IU/kg DM.[2] Atlantic mackerel, capelin, herring, and whitebait had vitamin D_3 concentrations that were much higher, ranging from 2,500 IU/kg DM in the latter to 16,800 IU/kg DM in the former.

Vitamin E is destroyed over time in stored marine foods.[2] It has been proposed that foods for marine animals should be supplemented with 100 IU of vitamin E/kg of diet on a wet basis or approximately 400 IU/kg DM.[15] Serum levels of vitamin E in captive Humboldt penguins[9] and plasma levels of vitamin E in captive Gentoo and rockhopper penguins[26] vary with diet and physiologic conditions, just as do serum and plasma vitamin A levels.

Thiaminases have been identified in mackerel, herring, smelt, and clams with activity sufficient to destroy much of the tissue thiamin during frozen storage.[2] It has been proposed that thiamin supplements should be added to marine animal diets, providing 25-30 mg/kg diet on a wet weight basis or approximately 100-120 mg/kg DM.[15]

Calcium concentrations in whole fish and krill (0.9-6.4% of DM)[2] seem adequate, even for breeding and laying penguins, and calcium supplements should not be required. Squid, however, are relatively low in calcium (0.1-0.2% of DM) and have an inverse calcium:phosphorus ratio. Some institutions have reported problems (without dietary details) in captive penguins that were ascribed to calcium deficiency during production of multiple clutches, and calcium supplements were used with no apparent ill effect.[12] However, consideration should be given to the concentrations of calcium, phosphorus, and vitamin D in dietary items (using analyses, if necessary), and to calcium:phosphorus ratio, since a disproportionate supply of one of these nutrients can adversely influence metabolism of the others.

Sodium is an essential nutrient for all animals. It is thought by some that the requirement for sodium is a special consideration for functional development of the nasal glands of marine birds with access only to fresh water.[12] Some institutions, with both fresh and saltwater environments, supplement penguin diets with salt at approximately 250 mg of NaCl/bird/day, without apparent harm.[12] The necessity for this practice has not been established, and it is noteworthy that the fish and invertebrates that have been analyzed, whether of marine or freshwater origin, contain sodium concentrations (0.2-5.5% of DM)[2] that are higher than the minimum need of any species for which a requirement has been established.

Based on analytical values for other nutrients in fish and marine invertebrates, it seems unlikely that other deficiencies would appear unless unwise food choices have been made or storage and handling of these foods has been below standards.[8]

Vitamin excesses. Fat-soluble vitamins A, D, and E accumulate in the body when intakes exceed need, and excessive amounts over extended periods will produce signs of toxicity.[25] It should be noted, however, that there are seasonal differences in the availability of these vitamins for some animal species in the wild, and the accumulation of body stores during comparatively short natural periods of plenty may be critical for health during periods of short supply. Chronic vitamin A toxicity typically results from long-term intakes that are 100 to 1,000 times dietary requirements, although toxic signs have been reported from dietary levels as low as 10 times the requirement.[30] The most characteristic signs of chronic vitamin A toxicity include skeletal malformations associated with excessive bone remodeling, spontaneous fractures, and internal hemorrhage. Other signs include anorexia, slow growth, weight loss, impaired liver and kidney function, enteritis, conjunctivitis, suppression of keratinization, and thickened skin.

Elevated serum levels of vitamin A have been observed in captive Humboldt penguins fed diets containing 59,800 IU of vitamin A/kg (DMB) for 12 months, but no toxicity signs were seen. [9]

Birds and many mammals appear to utilize vitamin D_3 more efficiently than vitamin D_2, and vitamin D_3 is about 10 to 20 times more toxic.[30] Vitamin D_3 is the primary form in animal tissues and in many vitamin supplements. Although most species appear to tolerate vitamin D_3 intakes up to 100 times the minimum requirement for less than 60 days, recommended maximum tolerable limits for long-term consumption by species that have been studied are about 4 to 10 times the requirement.[30] Signs associated with chronic vitamin D toxicity include anorexia, hypercalcemia, hypercalciuria, and calcification of soft tissues, especially kidneys, aorta, and lungs. There have been no reports of vitamin D toxicity in penguins.

Maximum tolerable levels of dietary vitamin E are quite high, but interference with blood clotting has been reported in pelicans with supplements of vitamin E adding 1,000 to 2,000 IU/kg of dietary DM.[32] Elevated serum levels of vitamin E have been observed in captive Humboldt penguins fed diets containing 58,600 IU of vitamin E/kg (DMB) for 12 months, but there were no signs of toxicity. [9]

Vitamin K has a relatively short metabolic half-life, and toxicity has not been demonstrated when large quantities of vitamin K were provided in a natural form such as phylloquinone. Furthermore, toxic dietary levels of menadione and its derivatives are at least 1,000 times the vitamin K requirement.[30]

POTENTIAL PENGUIN FOODS AND THEIR NUTRIENT COMPOSITION

Potential penguin foods

Several diets currently fed to penguins are presented in Table 5. Appendix 1 provides information on the supplements utilized. Frozen fish and marine invertebrates are available from a number of commercial suppliers. Some are purveyors of human food but also sell to zoos and aquariums. Others serve the zoo and aquarium market exclusively. Regardless, the quality of products purchased for feeding to penguins should meet human food standards.[8] The supplier should use a Hazard Analysis Critical Control Point (HACCP) program to help ensure that fish and marine invertebrates have been handled appropriately.[8] Given the current status/depletion of wild fish stock, suppliers should be encouraged to practice sustainable-use fishing. A list of potential foods is given in Table 3 with an indication of their size and usual locale and season of harvest.

Successful captive penguin husbandry depends upon a consistent source of high quality food that the penguins will eat. Because certain prey species are not available year-round, it may be necessary to purchase quantities sufficient for several months to ensure an uninterrupted supply. This necessitates that penguin foods be properly frozen and stored until used. Given the perishable nature of seafood, appropriate storage and handling procedures are crucial. These include freezing as soon as possible after catching and frozen storage that maintains an average product temperature of -18 to -30 C. Stock rotation should be practiced to ensure that foods are not stored for more than 4-6 months. Frozen foods should be thawed under refrigeration at temperatures of 2-3.5 C, as close in time as possible to feeding. See NAG Fact Sheet 005 "Feeding Captive Piscivorous Animals: Nutritional Aspects of Fish as Food"[2] and USDA publication "Handling Fish Fed to Fish-Eating Animals: A Manual of Standard Operating Procedures" 8 for additional details on freezing, storage, and thawing.

A fish substitute has been manufactured and is in the development and testing stage. The preliminary results proved promising in that body weight and condition were maintained for 10 months in feeding trials with three species of adult penguins.[18]

Nutrient composition
The nutrient composition of fish and marine invertebrates fed to captive piscivorous animals has been discussed by Bernard and Allen in NAG Handbook Fact Sheet 005.2 Dry matter, crude protein, crude fat, gross energy, mineral, and fat-soluble vitamins A, D, and E concentrations in common fish and marine invertebrates are presented in that report. These values vary with species, age, gender, physiologic state, and season and locale of harvest.

Dry matter. Dry matter concentrations range from about 14-37% in penguin foods, so water intakes would be 2-6 times higher than dry matter intakes when these foods are consumed. If metabolic water from tissue oxidation of absorbed food or stored fat is added to the water in food, there may be little need for consumption of liquid water. However, definitive studies on water requirements of penguins in captivity have not been conducted.

Crude protein. Crude protein concentrations, on a DMB, range from about 33-77%. True protein concentrations in marine fish may be overestimated slightly by the analytical method for crude protein (N x 6.25) because of the contribution of non-protein nitrogen in osmoregulatory cells.[37] Amino acid requirements of penguins are unknown. Since penguins consume whole fish or marine invertebrates, a specific amino acid deficiency is unlikely. Marine invertebrates contain more free amino acids than do fish, but the overall amino acid composition of fish and invertebrates is generally similar to that of other animals.[23]

Crude fat. Crude fat concentrations, on a DMB, range from about 8-48% and tend to be inversely related to protein concentrations. Fish lipids are highly unsaturated. Generally freshwater fish contain twice as many C10 and C18 fatty acids but less than ½ the quantity of C20 and 1/7th the quantity of C22 fatty acids as do marine fish.[1] Salmonids, such as rainbow trout, are the exception to this generalization. They are as high in C18 and C20 Omega-6 fatty acids and in C18 and C22 Omega-3 fatty acids as are marine fish. Krill are high in unsaturated fatty acids, and squid have 2-4 times the concentration of hexaenoic and pentaenoic fatty acids as do krill.[1] Krill and herring have substantial quantities of eicosapentaenoic acid (EPA), and krill, herring, rainbow trout, and squid contain substantial quantities of docosahexaenoic acid (DHA). Omega fatty acid concentrations in foods, and special requirements for these fatty acids for humans and other animals, are being actively researched. Specific fatty acid requirements for penguins have not been determined, but Omega-6 and Omega-3 fatty acids may be as important in the diets of penguins as they appear to be for other animals.

Minerals. Ash concentrations range from 5-24%, on a DMB, are low in invertebrates, and are related to the proportion of bone in fish. Essential mineral concentrations in fish appear to be sufficient, although a few fish have relatively low concentrations of copper and manganese.

Calcium concentrations in squid are likely to be inadequate, if used as a sole source of food. However, the mineral requirements of penguins have not been determined.

Fat-soluble vitamins. Concentrations of fat-soluble vitamins A, D, and E in freshly caught fish are probably adequate for penguins, and in some fish species, vitamin A and D levels are very high. However, as previously noted, vitamin E undergoes destruction during storage, and supplemental vitamin E should be provided. Vitamin K concentrations in whole fish have not been reported, but signs of deficiency in penguins are unlikely unless induced by feeding excesses of vitamins A or E.

Water-soluble vitamins. Water-soluble vitamin concentrations are not available for whole fish, although data have been published for the flesh of raw herring, mackerel, and squid.[22] Respective DM concentrations in the flesh of these three species were 36, 36, and 16%. The following water-soluble vitamin concentrations were found in flesh and are presented on a DMB in the same order as the species: thiamin – trace, 2.5, and 3.1 mg/kg; riboflavin – 5.0, 9.7, and 1.2 mg/kg; niacin – 114, 222, and 131 mg/kg; pantothenic acid – 28, 28, and not determined (ND) mg/kg; vitamin B_6 – 12.5, 19.4, and ND mg/kg; folacin – 139, ND, and 125 g/kg; vitamin B_{12} – 167, 278, and 156 g/kg; biotin – 278, 194, and ND g/kg. Assuming that the viscera of fish and squid contain higher concentrations of these vitamins than does flesh (as has been found in mammals and birds), it is unlikely that supplements of water-soluble vitamins, except for thiamin, are required when whole fish and squid are fed.

Food Preferences

It is generally accepted that captive penguins have food preferences. The types and species of prey available for captive feeding are limited and may be quite different from the variety with which penguins evolved. Even data from free-ranging penguins suggest that the food items most consumed may not be those most preferred but may be foods that are most available.[20,21] Differences in food choice also may be influenced by physiologic circumstances, such as stage of the reproductive cycle.

> Selection of particular food items may be an expression of food preference, but, lacking historical and long-term association with those foods, captive penguins appear not to make choices on the basis of nutritional wisdom. Food refusal, on the other hand, may be an indication of spoilage, and if fish are refused, their quality should be checked. Ultimately, the responsibility for provisioning captive penguins with nutritionally adequate and healthful food is ours. To avoid dependence on a particular food item, it is prudent to offer a variety. If a penguin becomes "imprinted" on a specific food item and if that item becomes unavailable, it may be difficult to coax acceptance of an alternative. In addition, offering a variety of foods will help ensure that the diet provides a complementary and complete nutrient profile.

Feeding Methods

The recommended method of feeding is to hand-feed individual penguins, particularly when offering fish that have been injected with nutrient supplements or in which supplement tablets or capsules have been placed. This ensures that each bird will receive intended nutrients and allows the keeper to monitor food and energy consumption.

Methods of self-feeding are sometimes used, but keepers should ensure that food items remain cool and clean and are consumed within a short time after being thawed. In exhibits held at or below 4° C, fish may be offered in feeding trays for several hours as long as birds are not defecating nor walking in the trays. However, fish should not be left in standing water because of the potential for nutrient loss. Supplemented fish should not be fed in trays because of the potential for under- or over-dosing if individual penguins consume either no or several fish containing supplements. If penguins are fed outdoors in hot, humid, or sunny weather, it is important to feed only the amount that will be consumed immediately or while still iced to avoid microbial proliferation, nutrient loss, and contact by disease-spreading pests.

Adult penguins are commonly fed to appetite early in the morning and late in the afternoon, although the number of feedings may be increased during pre-molt and breeding. Appetite usually increases during the pre-molt period and decreases during molt. In a study with captive rockhopper penguins, all birds gained about 23-38% in body mass just prior to molting.[26] Among the penguin species that have been studied, most will fast during incubation and molting. In the wild, mean loss of body mass during molt is as much as 40% in macaroni penguins and 47% in king penguins.[6,16] During molt in captivity, losses can be as much as 50% of body mass. After these periods, penguins consume vast quantities of food and deposit considerable body fat and protein.[16]

There is no need to limit food intake below ad libitum levels unless the penguin is extremely overweight. The quantity of food one might expect captive penguins to consume per day can be estimated, based on their body mass. An average captive but active adult penguin's daily food consumption on an as-fed basis is approximately 2-3% of body mass for the larger species, such as kings and emperors (*Aptenodytes forsteri*), and 10-14% for smaller species, such as Humboldts and rockhoppers.[12] However, the specific quantities consumed depend on the activity level and physiologic state of the individual. In one study, free-ranging king penguins consumed (wet basis) an average of 1.84 kg daily.[5] Estimated daily consumption (wet basis) in another study with free-ranging king penguins was an average of 2.32 kg. Mean body mass of the king penguins was 11.8 kg, resulting in a calculated daily intake equivalent to as much as 20% of body mass.[34]

The size of food items offered should be appropriate for easy manipulation and swallowing. Purchasing specifications for fish and squid should include size designations so that they can be fed whole. Whole food is accepted most readily, but if it must be cut because it is too large, all portions should be fed to ensure that the entire supply of nutrients contained in the whole food will be consumed. Lengths of fish consumed by free-ranging adult emperor penguins were 60 to 120 mm (~2.5-5 in), and lengths of squid consumed were 19 to 280 mm (<1-11 in). The largest squid consumed weighed 460 g.[36] Free-ranging adult king penguins consumed prey estimated to be 70 to 90 mm (2.8-3.5 in) long,[5] substantially smaller than the fish commonly fed in captivity.

Formulation of Appropriate Diets

When formulating diets for captive penguins, flexibility is needed to account for variations in food preferences, body mass, activity, physical condition, environment, and behavior, as well as food availability and nutrient content. Ideally, the items chosen (e.g., high-fat and low-fat fish) and supplements fed should complement each other so that nutrient and energy requirements are met. It should be noted, when examining nutrient data for whole fish and marine invertebrates, that nutrient concentrations can vary among species, among individual lots within a species, among individual fish within a lot, as well as over a period of storage. Thus, published values may or may not reflect the nutrients actually fed to penguins at a specific time. Both the need to sample fish for nutrient analysis and appropriate sampling techniques have been discussed elsewhere.[2,37] To identify changes in animal condition due to diet, the nutrient content of the diet being fed must be quantified.

Types of fish selected can be chosen for specific nutrient content, availability, price, and animal preference. It also is wise to consider quality as a major factor. Quality sufficient for human food should be insisted upon, and holding and shipping conditions should be monitored. Any item which, upon receipt, appears to have undergone degradation or shows evidence of thawing should not be accepted and should never be fed.

Selecting dietary items
Of the fish usually used for captive animal feeding, any will meet the protein requirement. However, to provide appropriate amounts of fat and energy, supplies of both low-fat fish and high-fat fish are desirable. Ratios between them can be changed depending upon their availability and individual penguin condition and intake.

Marine fish versus fresh-water fish
Historically, most captive penguins have been fed marine fish. Given current problems with commercial fish availability, it is becoming more common to offer fresh-water fish, as well. This trend may continue as commercial fresh-water fish farms increase in number and the yield from marine fisheries declines. Although fresh-water fish may be used, it may be prudent to also feed one or more species of marine fish.

Nutrient supplementation
Many institutions supplement with a variety of multivitamins and minerals. This is presumably to provide for any possible losses due to storage, thawing, or to ensure that these nutrients are always present on a daily basis regardless of fish offered. Several products are marketed specifically for marine animals but differ in composition. If a variety of high quality fish are fed, and if they are stored and thawed properly, it is unlikely that supplements, other than of vitamin E and thiamin, will be needed.

Thiamin can be purchased in tablets and vitamin E in capsules. They can be hidden inside the mouth or gills of fish, and the supplemented fish hand-fed to individual penguins. Alternatively, solutions or suspensions of these vitamins can be injected into fish and the injected fish hand-fed. Supplements of 25-30 mg of thiamin and 100 IU of vitamin E should be provided for each kg of food (wet basis). Adjustments in the amounts of supplement provided should be made in proportion to the mass of food consumed. Calculated gross energy and nutrient concentrations in an example diet for a 4.5-kg penguin are shown in Table 4.

Parent Rearing of Chicks
The most important dietary adjustment, when chicks are being reared by their parents, is to offer enough fish to the parents so they may adequately feed themselves and their offspring. During chick rearing, parents should be fed ad libitum and frequently. Free-ranging emperor penguins fed their single chick the equivalent of about 7.5% of adult emperor penguin body mass in a 24-hr period.[36] Adelie penguins have been found to feed exclusively on krill when nesting.[28]

Until more is known, it appears wise to feed a variety of whole fish to nesting penguins, in quantities adequate to supply energy and protein needs. It does not appear necessary to supply additional fat in the diet.

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[41]Wilson, R. P. 1985. Seasonality in diet and breeding success of the jackass penguin *Spheniscus demersus.* J. Ornithol. 126:53-62

Table 1. Prey items consumed by free-living penguins. 3,[5],10,11,21[, 24, 34,35,38-41]

Penguin Species	Krill[a]	Squid[b]	Sardines[c]	Round herring[d]	Pilchard[e]	Anchovies[f]	Lanternfish/ Myctophids	Maasbanker[g]	Mullet[h]	Icefish/ Nototheniids	Fish (various spp.)
Emperor	X	X								X	X
King		X								?	X
Adelie	X									X	X
Chinstrap	X										
Gentoo	X						X			X	X
Macaroni	X						X				X
Rockhopper	X	X					X			X	X
Little blue		X			X	X					X
Humboldt			?			X					X
African (pre-1960)	X	X			X	X		X	X		X
African (recent)	X	X		X		X		X			X
Magellanic	X		X								X

[a]Euphausiid crustaceans primarily in genera *Euphausia, Thysanoessa,* and *Nyctiphanes.*
[b]Cephalopods in genera *Loligo, Heteroteuthis, Argonauta, Nototodarus, Sepioteuthis, Teuthowenia, Psychroteuthis, Alluroteuthis, Kondakovia, Gonatus, Todarodes, Moroteuthis,* and *Loligunculus.*
[c]*Ramnogaster arcuata.*
[d]*Etrumeus teres.*
[e]*Sardinops ocellata, S. neopilchardus.*
[f]*Engraulis capensis, E. australis, E. ringens.*
[g]*Trachurus trachurus.*
[h]*Mugil* spp.

Table 2. Proposed minimum energy and nutrient concentrations (DMB) in adult penguin diets[a] based on requirements of domestic poultry,[31] cats,[29] and inferences from composition of wild foods.[2]

Nutrient	Minimum concentration
Gross energy, kcal/g	4.5
Crude protein, %	35
Fat, %	10
Calcium, %	0.8
Phosphorus, %	0.6
Magnesium, %	0.05
Potassium, %	0.5
Sodium, %	0.2
Iron, mg/kg	80
Copper, mg/kg	5
Manganese, mg/kg	5
Zinc, mg/kg	50
Selenium, mg/kg	0.2
Vitamin A, IU/kg	3,500
Vitamin D, IU/kg	500
Vitamin E, IU/kg	400[b]
Thiamin, mg/kg	100[c]

[a]Other nutrients, such as essential fatty acids, essential amino acids, vitamin K, and the other B-complex vitamins are probably required. Nevertheless, there is no evidence that inadequate concentrations are provided by fish and marine invertebrates. Whether vitamin C can be synthesized by penguin tissues has not been established. Freshly caught fish contain significant concentrations of this vitamin, and some destruction undoubtedly occurs during storage. However, signs of vitamin C deficiency in the penguin have not been described.

[b]Although this concentration of vitamin E may exceed the minimum requirement, about 400 IU/kg of DM provided by the supplement of 100 IU of vitamin E/kg of fresh fish is recommended to compensate for losses during peroxidation of unsaturated fatty acids.

[c]This concentration of thiamin undoubtedly exceeds the minimum requirement, but about 100-120 mg/kg of DM are provided by the supplement of 25-30 mg of thiamin/kg of fresh fish to compensate for destruction by thiaminases.

Table 3. Potential penguin foods, locale and usual months of harvest, and length and weight data.

Common name	*Scientific name*	*Locale & months of harvest/Length/weight*	
Anchovies	*Engraulis mordax*		
Capelin	*Mallotus villosus*	Canadian coast, July-Aug	5-7 in; 10-15 fish/lb
Capelin	*Mallotus villosus*	Iceland coast, Jan-Mar	5-7 in; 10-15 fish/lb
Herring, Atlantic	*Clupea harengus*	US-Canada coast, Jan-Dec	9-12 in
Herring, Atlantic	*Clupea harengus*	US-Canada coast, Apr-May	< 9 in
Krill, superba	*Euphausia superba*	Antarctic, May-June	300-400/lb
Mackerel, Atlantic	*Scomberomorus scombrus*		
Mackerel, Pacific	*S. japonicus*	Calif. coast, Jan-Dec	½ lb/fish
Sardines, California	*Sardinops caerulea*	Calif. coast, Jan-Dec	4 fish/lb
Sardines, Spanish	*Sardinella aurita*	Mar-May, Aug-Oct	
Smelt, fresh-water	*Osmerus mordax*	N. Lake Mich.	3-5 in; 23 fish/lb
Smelt, silver	*Hypomesus pretiosus*	Eureka, Calif, June-Aug	5-9 in; 12-16 fish/lb
Silversides	*Menidia andens*	P.E. Island coast, Oct-Dec	2-3 in; 85-95 fish/lb
Squid, Ilex	*Ilex illecebrosus*	US East Coast, May-Sept	4-5 squid/lb
Squid, Loligo	*Loligo opalescens*	Calif. coast, Sept-Feb	5 in; 7-9 squid/lb
Trout, rainbow	*Salmo gairdneri*	Idaho, farmed	
Whitebait	*Allosmerus elongarus*	Eureka, Calif.,Apr-June	4-6 in

Table 4. Calculated dry matter, gross energy, and nutrient concentrations (DMB) in an example daily diet for a 4.5 kg penguin consuming a mix (500 g total wet weight) of herring, capelin, and rainbow trout, with recommended vitamin E and thiamin supplements.

Item	Calculated concentration
Dry matter in diet as presented, %	25
Gross energy, kcal/g	5.7
Crude protein, %	61
Fat, %	24
Calcium, %	1.6
Phosphorus, %	1.5
Magnesium, %	0.14
Potassium, %	1.4
Sodium, %	0.6
Iron, mg/kg	103
Copper, mg/kg	7
Manganese, mg/kg	5
Zinc, mg/kg	84
Selenium, mg/kg	1.1
Vitamin A, IU/kg	50,000
Vitamin D_3, IU/kg	4,000
Vitamin E, IU/kg	500[a]
Thiamin, mg/kg	100[b]

[a]Supplement provides 400 IU vitamin E/kg.

[b]Supplement provides 100 mg thiamin/kg.

Table 5. Penguin diets from selected zoos. Amounts are per bird, per day, as fed.

Penguins & zoo	Capelin	Herring	Lake smelt	Krill	Marine smelt	Surf smelt	Vitamin E (IU)	Thiamin (mg)	Multivitamin	NaCl (g)	Cod liver oil (tsp)
Humboldt											
Brookfield	341g	170g			170g		100	25	0.4g Windmill Daily Max. Form.		
King											
Detroit		1.5-2.5 lb					50	50		1	
SWO[a]		2-3 lb of mixed fish[b]					+[c]	250	1(5 Mazuri tab)[d]		
Rockhopper											
Detroit	.25-.5 lb					.25-.5 lb	33	25		.5	
SWO		1-1.5 lb of mixed fish[b]					+[c]	250	1(2.5 Mazuri tab)[d]		
Chinstrap											
NYZS	275g	70g					76	19			
SWO		1.5-2 lb of mixed fish[b]					+[c]	250	1(2.5 Mazuri tab)[d]		
Macaroni											
Detroit	.25-.5 lb					.25-.5 lb	33	25		.5	
Little Blue											
Detroit	.125-.25 lb					.125-.25 lb	33	12.5		.25	1 tsp
Gentoo											
SWO		2-2.5 lb of mixed fish[b]					+[c]		1 (2.5 Mazuri tab)[d]		
Magellanic											
SWO		1.5-2 lb of mixed fish[b]					+[c]		1(2.5 Mazuri tab)[d]		

[a]Sea World Orlando
[b]All species of penguin are fed a mix of capelin, large herring, lake smelt and krill. Average total amount consumed is noted in the table.
[c]Vitamin E supplemented as part of the Sea World Mazuri multivitamin tablet.
[d]SWO also supplements with calcium gluconate at 650 mg (1 10-grain tablet) September-December for King penguins and 325 mg (1/2 10-grain tablet) Septemberovember for Rockhopper, Macaroni, and Little Blue penguins.

APPENDIX 1. Supplement Information

Brookfield Zoo

Windmill Daily Vitamin Maximum Formula: Windmill Health Products West Caldwell, NJ 07006
Vitamin B1 and E: Sundown Vitamins, Boca Raton, FL 33487

Detroit Zoo

Vitamin B-1 and E: ADH Health Products, Congers, NY
Sodium Chloride: Consolidated Midland Corp Research Division, Brewster, NY
Cod Liver Oil: Solgar Vitamin Co. Lynbrook, NY

Sea World

Vitamin B-1 and calcium gluconate (during breeding season): ADH Health Products, Congers, NY
Sea World Large Bird Tablet (2.5#) and Mammal (5#) Multi-vitamin: Mazuri Test Diets Richmond, IN

Nutrient Composition of Sea World Vitamins, per tablet

Nutrient	Large Bird Tablet 2.5#	Mammal Multivitamin 5#
Vitamin A, IU	1650	16500
Vitamin E, IU	25	250
Vitamin C, mg	25	250
Thiamin mononitrate, mg	20	200
Riboflavin, mg	1.5	15
Pyridoxine, mg	1.5	15
Pantothenic acid, mg	1.5	15
Folic acid, g	50	500
Biotin, g	25	250

Nutrient Composition of Windmill Daily-Vitamin Maximum Formula, per tablet

Nutrient	Amount per tablet
Vitamin A, IU	5000
Vitamin C, mg	60
Vitamin D, IU	400
Vitamin E, IU	30
Vitamin K, g	25
Thiamin, mg	1.5
Riboflavin, mg	1.7
Niacin, mg	20
Vitamin B-6 (pyridoxine), mg	2
Folate, g	400
Vitamin B-12, g	6
Biotin, g	30
Pantothenic acid, mg	10
Calcium, mg	162
Iron, mg	18
Phosphorus, mg	125
Iodine, g	150
Magnesium, mg	100
Zinc, mg	15
Selenium, g	20
Copper, mg	2
Manganese, mg	3.5
Chromium, g	65
Molybdenum, g	160
Chloride, mg	72
Potassium, mg	80
Boron, g	150
Nickel, g	5
Silicon, mg	2
Tin, g	10
Vanadium, g	10

CHAPTER 6 (revised July 2005)

Roberta Wallace and Michael Walsh

INTRODUCTION

Penguins, like all wildlife, are adapted for survival. Initial symptoms or signs of illness may be hidden or inconspicuous, unless the condition is acutely serious. Therefore, it is imperative that staff working with penguins be highly trained and attuned to subtle changes in behavior and physical conditions.

The most commonly reported behavioral manifestations of most illnesses are inappetence, lethargy, and isolation from the group. These observations, in combination with other indicators such as respiratory difficulty, weight loss, regurgitation, plumage condition, coloration of the mucous membranes, fecal appearance, etc., can lead to early diagnosis. Although there may be a long list of clinical signs for any given disease, all signs may not be present in every case. Some of the parameters used to detect illness may also be present during normal cyclic patterns, i.e., molt or breeding; therefore all behavioral, physical, and seasonal conditions need to be considered.

Some illnesses or injuries may necessitate isolation of an individual from the colony for treatment. However, considering the social nature of penguins, one should always attempt to provide conspecifics as company during the period of treatment or convalescent period. Alternatively, conspecifics can be kept within visual and vocal range of an isolated individual. This approach to decreasing the stress of isolation should be weighed against the potential of illness transfer to an unaffected individual if pathogenic organisms are involved.

GENERAL MANIFESTATIONS OF ILLNESS

The following are signs of illness:

- inappetence or decrease in appetite
- lethargy or increased irritability
- regurgitation or vomiting
- isolation from group
- abnormal or poor plumage condition
- weight loss
- lameness
- dehydration
- abnormal feces

Other signs may include a change in posture, such as lying down for extended periods at abnormal times, changes in respiratory character (open-mouth breathing, extended neck, increased air sac distention in neck, increased rate and depth of respiration), loss of vocalization, increased coughing or sneezing, decreased swimming activity.

DIAGNOSTIC TECHNIQUES

The most important factor for successful diagnosis and treatment is the early detection of abnormalities by the animal care staff. Appetite, feed intake, and general behavior of individual penguins should be monitored. Each bird should be weighed regularly. It is useful to have weights recorded during different seasons (pre-and post-molt, nesting period) since an individual penguin's weight may normally vary dramatically (15 –20% in some species) throughout the year. Normal weights can be compared with those obtained during periods of illness. In addition, accurate records regarding food intake, breeding, egg laying, and molting should be kept by the animal care staff. The importance of good record keeping cannot be stressed enough. A solid working relationship should be established between animal care and veterinary staffs to promote early intervention and so that both groups can learn from each episode of illness. Medical records should be maintained for each individual animal and should include: initial clinical signs, diagnostic tests performed and the results of each test, treatment and response to therapy. The following diagnostic techniques can be used if available:

- observations of the birds in an undisturbed state
- physical examination
- blood analysis - CBC, chemistry panel (designed to include uric acid and urea), serology, protein electrophoresis
- culture - tracheal, oral and cloacal
- cytology - fecal exam, gastric wash, cutaneous lesions
- radiology - foreign bodies, granulomas, egg retention, bone abnormalities
- endoscopy
- fecal examination for parasites
- ultrasonography - abdominal (coelomic), transtracheal

PHYSICAL EXAM ABNORMALITIES

Abnormal findings may include:

- changes in body weight (usually decreased)
- palpable and visual signs of weight loss in areas such as the keel, thoracic inlet, back, pelvis and shoulders
- pale mucous membranes
- dyspnea (difficult breathing) either at rest or when handled
- decreased response to handling
- depression
- feet abnormalities (including lameness, and change in stance)

COMMON DISEASE PROBLEMS

Aspergillosis

*A*spergillosis is one of the most commonly reported illnesses in penguins. It is a fungal infection caused by Aspergillus organisms. The organism is ubiquitous in the outdoor environment and is often found in various areas of indoor exhibits. It can exist in low numbers without causing problems if the birds are healthy and well adapted to their exhibit and social group. High standards in exhibit air quality for indoor exhibits are an important consideration in prevention of the disease. Disease may occur in stressed or debilitated animals. Stressors that have been associated with the occurrence of aspergillosis include:

substandard air quality, poor ventilation, and elevated ammonia levels.
social incompatibility
introduction to a new social group
inappropriate, prolonged or stressful relocation
introduction of new aspergillus species via new substrate, nesting, material, etc.
change in location, which may expose birds to new fungal species
excessive environmental heat or cold
concurrent illness

Clinical Signs:

open-mouth breathing
coughing
loss of vocalization
inappetence
lethargy
weight loss
isolation
lying down

Diagnostic tests: Symptoms are often nonspecific and early diagnosis is difficult. A CBC may show an increase in the white blood cell count with a monocytosis. Fungal cultures may be taken of the throat, trachea, or air sacs. Radiographs are helpful in looking for pulmonary or air sac granulomas or general cloudiness to air sac or lung fields. Fluroscopy, if available, is also useful to detect granulomas. Serologic titers to Aspergillus may be helpful but it is difficult to differentiate an acute infection from previous exposure. Changes in the protein electrophoretic pattern compatible with chronic inflammation may be present. See end of chapter for institutions that perform serologic assays.

Treatment: Method and success of treatment depends on the stage and severity of disease when diagnosed. The type of drug used and other therapy modalities must often be tailored by the veterinarian. If possible, consult with veterinarians experienced in the treatment of this disease in penguins. Antifungal drugs may be given systemically (oral or intravenous), by nebulization, or intratracheally. A couple of institutions have had success with refractory cases with first surgically removing isolated plaques or granulomas, then instituting long-term therapy. This is a last ditch option and should only be used in carefully selected cases with one or two large, iknown granulomas.

Supportive care: Fluids may be given orally by tube subcutaneously or intravenously. Intraosseous adminsitraion is very difficult because penguins have dense, non-pneumatic bones. Force feeding a fish gruel by tube can be used for short-term nutritional support; a gruel is recommended over force-feeding whole fish for anorexic penguins as it is easily digested with less chance of regurgitation. The animal's weight should be closely monitored.

Drugs utilized with some measure of success include:

Itraconazole
Fluconzole – oral
Voriconizole (new and expensive) oral 3-4 mg/kg BID
Ancoban - (5-flucytosine, no longer available in the United States
Amphotericin - intra-tracheal, intravenous, nebulized
Clotrimazole - nebulize (very thick – requires dilution)
Enilconazole - nebulized (very thick - requires dilution)

Terbinafine has been reported to be effective against mycosis in several species of waterfowl, and may prove useful in penguins with aspergillosis and other mycotic diseases as well.

Antibacterial: (for concurrent bacterial infections)

Prevention:

fungal vaccination - not widely available, efficacy not proven
proper air quality, including air quality
avoidance of complicating factors
regular fungal air cultures in exhibit area
keep social and environmental stress to a minimum (e.g. overcrowding)
prophylactic antifungal drug administration when shipping, relocating or introducing new birds to exhibit
do not ship or relocate birds to exhibit during the pre or immediately post molt period

Historically, many major outbreaks of Aspergillosis have occurred after major environmental changes. Early intervention may yield a better survival rate in Aspergillosis cases. It has been observed that during serious outbreaks, mortality of acutely affected birds follow a "bell-shaped curve," with sporadic deaths initially, a central period of increased deaths followed by another period of sporadic deaths. Loss of acutely affected birds is often followed by another rise in mortalities of birds that were chronically affected.

Treatment is typically long-term, frustrating, and often unsuccessful if begun in the latter stages of disease. Prevention of the disease is best. Maintaining high standards in exhibit air quality is crucial to prevention for species housed indoors. If it is necessary to shut down the air filtration system in a penguin exhibit, it is recommended to run the system for at least a week after it is restarted to clear the system before putting penguins back into the exhibit. Air cultures and disinfection for Aspergillus sp. should be taken at this time. Construction around the surrounding areas may affect the air quality inside the exhibit and should be monitored and precautions taken prior to the start of any construction.

Prophylactic treatment of penguins with antifungals before and after shipping or relocation appears to be effective in reducing the incidence of shipping of aspergillosis associated with the stress of shipping. Current recommendations are itraconazole 5-7 mg/kg SID begun a few days prior to shipping and *continued for 14 days after shipping. If animals are isolated in a quarantine area, then relocated to another exhibit, then anti-fungal prophylaxis should be reinitiated.*

Malaria

Malaria is a blood parasite carried by mosquitoes and/or biting flies. The causative agent is a Plasmodium organism, usually Plasmodium relictum or occasionally P. elongatum. Most cases of penguin malaria occur in animals that are or have been housed outside. Although penguins of all ages can be clinically affected, those particularly susceptible include chicks and juvenile birds, and naïve adults previously housed indoors or those that arrived from areas with low mosquito/malaria problems.

This disease is seen primarily in the Spheniscid and other species of temperate penguins, rarely in other species that require colder temperatures because they typically are kept indoors. However, if other species are housed outside, they should be considered susceptible and prophylaxis seriously contemplated.

The mortality rate from malaria infection is high, therefore, a regular screening program of birds in outside facilities is recommended. All birds considered high risk may have blood collected every two weeks and stained smears of the blood checked for the presence of malaria organisms. Unfortunately, death may often be acute, with malarial organisms visible only after the onset of severe clinical signs or on post mortem. The test is not very sensitive.

Clinical Signs: May vary and range from acute death with no signs to sudden onset of respiratory difficulty with death rapidly following, to lethargy, in appetence, pale mucous membranes, and separation from the group. Diagnostic tests: Organisms seen in blood smear, post-mortem smear of blood or splenic impression. Serologic test has been validated for black-footed penguins (*Spheniscus demersus*), and may be useful for other sphenscid species (see appendix),but is currently not commercially available.. Research is currently underway to try to detect malarial organisms in blood using PCR techniques, but accurate tests have yet to be developed. Some birds will persistently show low level of plasmodium organisms in the blood, but never develop clinical signs because of acquired immunity, thereby confounding the dignosis. Clinical pathology parameters may reveal a moderate to severe anemia, with a lymphocytosis.

Treatment: The most common therapy has been with Primaquine and Chloroquine. Primaquine (base) at 1.25 mg/kg Sid for 10-14 daus is initiated, as well as Chloroquine at 10 mg/kg at the time of diagnosis. Chloroquine is then continued at 5 mg/kg (base) at approximately 12 hour intervals for 3 more doses. Some institutions stop the chlorquine at this point, but other institutions continue the chloroquine at 5 mg/kg SID concurrently with the primaquine.

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Prevention: Either keep penguins inside during the mosquito season or bring them inside daily before mosquitoes emerge in the evening. If neither of these options is possible, test for malaria regularly (every 1-2 weeks) Use fans to circulate the air in outdoor exhibits to help control mosquito infestation. Test for malaria regularly. Prophylaxis using the following either of the following drug regimens has been used by various institutions.

Drug regimes –

1) Primaquine 1.25 mg/kg (base) SID throughout the mosquito season

2) Compounded capsule containing 125 mg sulfadiazine and 4 mg Daraprim (pyrimethamine). One capsule for 3-5 kg penguin given orally every other day throughout the mosquito season.

CAUTION: Daraprim is a folic acid inhibitor and, therefore, teratogenic (causes birth defects). One institution reported defects in chicks hatched, wheras several other institutions have not seen teratogenic effects. It's use in laying females at the time of laying must be careful weighed.. Because the parents regurgitate food to the chicks,

Some institutions supplement with folic acid while penguins are on this prophylactic regimen. Folic acid can be compounded into the capsule intelf or given separately.

Because the parents regurgitate food to the chicks, the safety of either of these drug regimens used when chicks are very small must be considered.

Break through cases of malaria have been seen despite prophylactic treatment, therefore malaria should not be ruled out simply because in animal is receiving preventive medicine. If receiving the daraprim/sulfasalazine therapy, discontinue this therapy while birds are being treated with chloroquine and primaquine.

West Nile Vrius

Penguins (at least the Spheniscid penguins) have proven to be highly susceptible to severe West Nile Virus infection and death. Death may be acute, or prolonged over several days if supportive care is given. Signs include severe lethargy and weakness, anorexia, and vomiting if tubed with fish gruel or fluids. A copious grayish mucoid phlegm may be produced and be present around the glottis, which requires suctioning in extremely weak birds. Penguins rarely show neurologic signs except late in the course of the disease, if they survive. Animals that have undergone a recent physiologic stressor, such as molt, or chick rearing, appear to be more likely to develop a fatal course of the diease.

Treatment – there is no specific treatment for the disease. Supportive care may allow some birds to recover. Care consists of intravenous or subcutaneous fluids with B vitamins and perhaps antibiotics to prevent secondary infections. The course in survivors can be prolonged with periods of moderate relapse.

Prevention: Mosquito control around penguin enclosures is imperative, and includes removal of standing water, larvicidal treatment of water that cannot be removed weekly, maintaining screens, and bringing penguins indoors during peak mosquito hours. The Fort-Dodge killed equine vaccine (1 ml) is currently recommended. Naïve birds should be vaccinated 3 times, 3 weeks apart, before being exposed to mosquitos. Thereafter the birds should be vaccinated annually prior to mosquito season. Dissease has occurred in penguins known to have been vaccinated.

Zoonotic potential

The zoonotic potential of infected penguins for the keeper staff is unknown. However, virus can be shed in the respiratory secretions, and possible urates/feces, therefore approapriate protective clothing should be worn when handling or working around infected birds. The should include N-95 masks if threre is a chance for inhalation of aerosolized matter (cleaning).

Other viral encephalitidis

Avian species that are susceptible to West Nile Virus are potentially susceptible to other viral encephalitidis. Although not previously reported, a facility recently published an article on an outbreak of Eastern equine encephalitis (EEE) in African penguins. A majority of the flock was affected, although the mortality rate for ill birds appears to be less than for WNV. Vaccination with a killed equine vaccine may be warranted for areas where EEE is endemic.

Chlamydia psittaci

C. psittaci is thought to be a pathogen primarily in psitticines and columbiformes.   However, C. psittaci has caused outbreaks of disease in penguins (Freeland Dunker, pers. comm.)

Signs: poor appetite, lethargy, lime green stools/urates. Bloodwork typically shows and elevated WBC with a heterophilia/lymphopenia with toxici changes. The total protein is elevated with increases in the beta -and gamma- globulins.

Post-mortem lesions: Splenic and hepatic enlargement, with pulmonary congestion.
Histopathologic lesions: Necrotizing splenitis, hepatitis, interstitial pneumonia and nephritis. Gimenez stain show elementary bodies in affected tissues. The organism can be ionfirmed using a C. Pssitaci PCR (DNA) probe and tissues, or by culture.

Diagnostic tests:

The general confusion surrounding the testing methods for C. Psittaci, and interpretation of test results to determine if a bird's illness is due to an active infection complicates the diagnosis in live birds.
Tests are offered by many labs and veterainry diagnostic laboratories. The veterinary clinician is urged to thoroughly investigate the latest diagnostic techniques, and to have a good understanding of what each test result signifies. Some available tests and the laboratories that perform them are listed below:

1) PCR (DNA) probe of C. Psittaci (feces, choanal/cloacal swabs, fresh tissue) – Veterinary Medical Diagnostic Lab, College Station, Texas. Useful in the diagnosis of infected birds and helps determine shedding status. Useful to determine if therapy is working

2) PCR (DNA) probe for C. psittaci (blood) –False negatives seen in birds begin treated with enrofloxacin. University of Georgia School of Veterinary Medicine Infectious Disease Laboratory. Questionable value as known infected birds in one outbreak tested negative.

3) Complement fixation (CF)(blood) – measures IgG antibodies. Useful to ascertain exposure to Chlamydia. However, uncertain of its value as a diagnostic aid for current infections, or as an indicator for cleared infections. Unsure how long titers remain elevated in affected or recovered penguins.

4) Elementary body agglutination (EBA) (blood) – Veterinary Medical Diagnostic Lab, College Station, Texas. Measures IgM antibodies indicating current infection. Uncertain of the value of this test in penguins.

Treatment:

Doxycycline is the drug of choice:

Either oral doxycycline (Vibramycin) 25-50 mg/kg orally once a day for 45 days (if possible) or parenteral doxycycline (Vibrovenos) 50-75 mg/kg IM once weekly for 6-7 wees (preferably)

Both of these drugs can cause inappetance and possible photophobia

Enrofloxacin 15 mg/kg PI SID-BID. In one outbreak, the bytril treatment resolved clinical signs but the blood picture did not change. Therefore it may not be an effective treatment to resolve infection.

Other supportive care measures such as fluids should be given to ill birds

Zoonotic potential

C. psittaci is a zoonotic disase, and risk of transmission to the public or animal care staff is real. Public Health officials should be notified if Chlamydia infectio is confirmed. Affected birds or flocks should be quarantined to protect other collection birds as well as animal keepers. Protective clothing, including N-95 masks should be worn by persons working with the birds. If birds are kept on display, area should be housed with a disinfectant prior to public hours.

Pododermatitis (Bumblefoot)
Foot problems are common in many species of birds. Penguins, like other birds, may be predisposed to pododermatitis by the following factors: change in normal activity patterns (decreased swimming; sedentary), prolonged standing on hard, abrasive surfaces or surfaces with excessive moisture or fecal contamination.

NOTE: In the past, hand-feeding has been done to more easily monitor individual food consumption and health status. However, birds conditioned to hand-feeding may develop poor swimming habits and, therefore, spend most of their time standing around on the exhibit surface. To encourage swimming and help prevent pododermatitus, institutions may opt to pool feed. Individual appetites must still be closely monitored during the feeding.

The original lesion may be the result of bacterial infection through a puncture wound or soft tissue damage caused by pressure necrosis. Once the epithelium is compromised, secondary bacterial invasions may occur, resulting in deep soft tissue infections. If left untreated, severe complications may occur such as mineralized soft tissue, deep graulomata and osteomyelitis.
Examination should include:
1. Evaluation of attitude and posture
2. Abnormal stance, lying down
3. Gait - presence of limp
4. Foot exam including:
    - pad ulceration/scab formation
    - epithelial thinning
    - laceration/puncture
    - drainage
    - swelling
    - increased heat, redness
    - discomfort on palpation
    - radiographs - soft tissue mineralization, osteomyelitis

Thermography may be useful both as a diagnostic technique and for monitoring response to therapy.

Many treatments for penguins are similar to those used for raptors. Therapy is aimed at protecting the foot from further damage, instituting local and systematic treatment of the current lesion, and changing conditions to prevent future occurrences (improve hygiene, change to an appropriate substrate or flooring).

Treatment that have been used include:

systemic antibiotics

local antibiotics with or without DMSO (chronic exposure to DMSO in a bandage can affect skin quality)
surgical debridement
cryotherapy
chronic bandaging in conjunction with various salves and ointments accompanied by intermittent debridement of devitalized tissue.
Ibuprofen has been used for short-term pain relief by a few institutions without adverse effects. Dosages have been 3-5 mg/kg once or twice a day.

Bumblefoot treatments have cycled in popularity. The results may differ dramatically depending on the experience level of the staff, but typically treatment is long-term and frustrating. While there is often initial improvement with many of the techniques, there is also a tendency for reoccurrence once therapy is discontinued. Since most treatments involve wrapping the affected feet, it is helpful to provide padding to minimize pressure on the wound site. If the wound site is not surgically closed, the area should be kept moist to encourage granulation. Gauze, Gortex, cast padding, ointment, vet-wrap, and waterproof tape or booties made from soft material have all been used. Healing efficiency can also be improved with proper debridement and the use of hydroactive dressings, which may retain moisture better than gauze and ointment. Booties made from old wet suits and Velcro can also be effective in bumblefoot treatment. Environmental temperature may affect healing rates. There is some evidence that allowing birds with bandages to swim in salt water during therapy may promote healing (the saltwater dries out the tissue). Prevention should be geared toward encouraging swimming and avoiding hard, rough, wet surfaces that retain contaminated water.

Commercially made neoprene booties of several standard sizes (not custom made) can be purchased from:

The Benik Corporation
Bremerton Washington
Ph: 1-800-442-8910
(website available)
contact: Dan Baumgarten

Preen Gland Infections
This problem is a significant problem in some collections. Diagnosis is based on the presence of an enlarged, swollen gland containing purulent or caseous material. Early diagnosis and treatment may prevent impaction.

The specific etiology of preen gland infections is unknown, but it is suspected there may be many potential factors including:

sedentary birds, with decreased swimming patterns
poor plumage; non preening birds who do not molt regularly
nutritional deficiencies

Cultures of preen gland fluid have contained numerous bacteria. *Candida* is commonly cultured even following antifungal therapy. Histologic examination of the gland suggests the possibility of vitamin A deficiency, although supplementation of vitamin A has not resolved the condition. While a limited number of birds may respond to symptomatic therapy such as flushing the glands or infusing it with a proteolytic enzyme ointment (Chloro-elase), surgical removal may be needed to avoid eventual rupture and secondary septicemia. It is important to encourage birds, particularly those that are nesting, to swim regularly as a preventative measure. If, for medical reasons, birds are housed without a pool, daily showers may be given to stimulate preening activity. For nesting birds, if one of the pair voluntarily leaves the nest to feed, it should be encouraged to swim before returning to the nest.

OTHER MEDICAL PROBLEMS

Gastrointestinal Disease

Penguins have intestinal diseases similar to other birds; diagnosis and treatment are also similar. Problems have included:

- regurgitation
- foreign body ingestion of coins, plant material, feathers, rocks and pieces of wood, occasionally resulting in perforation of stomach. Diagnostic tools include radiography and endoscopy.
- gastric ulceration: bacterial, yeast
- bacterial enterocolitis - salmonella, Plesiomonas, Clostridium and other bacteria
- cloacitis, prolapse, fecoliths.
- impaction

Anatomic note: Penguins have large stomachs in proportion to their size. Radiographically, foreign bodies may appear to be located very far caudally in the coelomic (abdominal cavity). This may lead to a radiographic interpretation that the foreign object has passed through the stomach into the intestines, or is located in the cloaca. Most likely this is not the case – it is probably still in the stomach.

Pulmonary Disease

While Aspergillosis is probably the most common problem involving the respiratory system, there are other respiratory problems that are primarily related to bacterial pathogens. In some cases, it is difficult to distinguish between primary or secondary aspergillosis.Upper respiratory diseases also include disease of the sinuses, and dyspnea can occur from plugged nares. Antibiotic therapy should be based on culture and sensitivity results whenever possible.

Renal Disease

The diagnosis of severe renal disease by serum chemistries is difficult. In some cases, the uric acid levels are elevated. However, normal increases in uric acid concentrations that occur after a meal must be differentiated from increases reflecting renal disease. Fluid supplementation, either orally, subcutaneously, or intravenously may be helpful, although systemic or visceral gout may result in rapid death with very few prior symptoms. On post-mortem there may be bright white flecks of uric acid deposits in the muscle, air sac, or serosa. Uric acid crystals can be visualized under polarized light. For histologic verification, tissues should be placed in alcohol, since formalin will dissolve the deposits.

Articular gout also occasionally occurs in penguins. Lameness is the primary clinical sign. Nephritis (renal infection) may be present without clinical signs of gout. Renal amyloidosis has also been seen.

Nervous System
Incoordination and "stargazing" are occasionally reported as clinical symptoms. Thiamine deficiency has been implicated as a cause when fish quality is compromised (Griner, 1983). Differential diagnoses for non-specific signs of central nervous system involvement should include disease problems seen in other species including viral or bacterial encephalitides, fungal granulomas, sepsis, nutritional deficiencies, and tumors.

Reproductive System
Pathology of this system is uncommon although salpingitis, egg binding, and oviductal (especially in King penguins) and cloacal prolapse have been reported. Treatment for egg binding is similar to that of other avian species. Manual extraction of the egg is preferable. If that is not possible, surgical removal of the egg may be required. Removal of the entire oviduct may be necessary if egg retention caused oviductal rupture or necrosis. Problem birds should have their calcium level checked periodically. Like other avian species, these birds may benefit from calcium supplementation.

Egg retention (egg-binding) has not seemd to be a major problem in most species of penguins. Anecdotally however, egg retention resulting in surgery to remove the egg, spaying, or death has been seen in birds that have ingested pennies and are suffering from a low level of zinc toxicity. Zinc and other heavy metals such as lead have adverse effects on smooth muscle, and therefore oviductal and uterine function.

Trauma
Problems with trauma include: bill injuries, punctures, head trauma, lacerations, eye lesions, leg injuries, toenail damage, and hemorrhage and fractures of the humerus from handling. Injuries may be inflicted by conspecifics during breeding season. Trauma may also occur from exhibit design, e.g. flipper abrasions from rough pools with steep sides. Standard treatment modalities may be used.

Excessive hemorrhage of the bill or toenail may require compression, bandaging, or cauterization. Care should be taken when using silver nitrate around mucous membranes to avoid excessive chemical burn of the soft tissues. If hemostasis is achieved using silver nitrate, it can be neutralized with saline. Tissue adhesive (Superglue) has also been used to cover small wounds or stop low-pressure hemorrhage. A weak Betadine or Nolvasan solution can be used to flush wounds after injury and during therapy.

Lameness
Limping or lameness may be acute or chronic and may be caused by developmental anomalies, trauma, infection, bumblefoot, gout, tumor, or foreign body ingestion. Some birds with sore feet fail to stand and should be differentiated from birds with systemic disease, who may also avoid standing. In cases of

traumatic foot injury, the individual may be held within a small, contained area for a few days. Diagnostic techniques are similar to other species.

Skin Anomalies
Parasites such as fleas, lice, ticks, and mites are uncommon in enclosed facilities but may be seen in those housed outdoors and in wild birds. Treatment includes dusting with pyrethrin products, Sevin dust (5% used lightly), or Ivermectin if appropriate (see appendix).

Molting
Abnormal, inconsistent, or incomplete molts have been noted in various species under different circumstances. Birds from the wild, or those recently acquired from another institution, may skip a molt the first year in captivity or at a new location. Molt could be affected by illness in an individual. One species of concern is the Chinstrap (*Pygoscelis antarctica*), which appears to be plagued with molting problems. Theories as to why molt problems have occurred have included:

improper light cycle
improper light intensity - coverage throughout exhibit
improper light spectrum - % UV, type, spectrum of artificial light
nutrition - weight gain, vitamins, protein components
fatty acids
humidity

The potential role of circulating thyroid and hormone levels has also been investigated. Treatment with medroxyprogesterone compounds (30mg/kg) has been shown to induce or speed up molting though there is some concern that this is symptomatic relief rather than a true cure. Timing of its use should coincide with the peak portion of the light cycle used in the exhibit. Fatal complications with this treatment have occurred, as has obesity with associated fatty liver syndrome. This treatment or other hormonal therapy should be used only when environmental (e.g. light) factors have been thoroughly investigated and all other changes in husbandry techniques and remedies have failed.

Frostbite and heat stress
Penguin species that naturally inhabit temperate climates (e.g. Spheniscid species) may suffer frostbite to the flippers if housed outdoors in cold climates with inadequately heated or accessed shelters. They may also suffer heat stress during hot, humid days if housed in outdoor exhibits. Heat stress problems are not confined to warm southern areas; hot, humid days in the upper mid-east of the United Sates are warm enough to cause problems. Signs include panting, lethargy, and decreased appetite. The penguins may not automatically go into their pool to cool off and may need to be forced into the water. Fans, sprinklers, and misters may be placed in or around the exhibit and indoor holding areas.

Heavy metal toxicity
Penguins may swallow shiny metallic objects such as coins, fence clips, lead pellets, etc. Zinc, lead, and other heavy metal toxicities are always possible when metal objects are ingested. Birds may show anorexia, lethargy, and a mild to moderate anemia which may be confused with malariaIn severe cases, birds may walk like they are drunk. Radiographs Will confirm the diagnosis of foreign metal object

ingestion. Blood samples should be taken according to recommended sample collection procedures and submitted to a laboratory for heavy metal analysis. Primary concerns are zinc toxicity, from ingested fence clips or pennies. After 1982 pennies went from being solid copper to copper coated zinc. These pennies breakdown very easily, exposing the bird to the zinc core. Although penguins regurgitate easily, the foreign articles are not always present in the regurgitated material. They frequently remain in the stomach (as opposed to moving further down the gastrointestinal tract), and treatment is preferably by endoscopic removal, or occasionally surgical removal if necessary. Chelation with Ca EDTA is necessary for clinically ill birds with confirmed lead or zinc toxicosis, or ill birds with a high degree of suspicion of toxicosis (presence of partially digested pennies).

Chick-Related Problems

Newly hatched penguins may present a number of problems not encountered in the adults. These concerns include:

- yolk sac infection or retention
- enteritis
- septicemia (any age)
- poor appetite
- dehydration
- constipation
- hypothermia
- hyperthermia
- weakness
- trauma
- poor parental care
- anemia
- splayed legs
- gastrointestinal impaction – accidental foreign body ingestion, seconday to dehydration

Early treatment must be based on the caretakers' observations and intervention must be rapid. Initial signs of chick morbidity may include lethargy, inappetence, poor weight gain or actual weight loss, dehydration, and loss of thermoregulatory abilities. Oral and cloacal swabs for cytology and culture, and radiology may aid diagnosis. Treatment should include:

proper temperature maintenance
treatment for bacterial and yeast infection
maintenance of hydration and nutritional intake

Systemic antibiotics may need to be started during early onset of a problem. Some institutions have improved the speed of intervention in hand-reared chicks by providing a consistent caretaker who is responsible for around the clock care. The health status of parent-reared chicks is obviously more difficult to assess, and animal care staff must be vigilant in their observations for subtle signs of illness.

IMMOBILIZATION

Inexperienced individuals may want to contact their colleagues about concerns related to anesthesia. Animals should be fasted 18-24 hours prior to anesthesia to prevent regurgitation and aspiration of gastric content.

Isoflurane is still the most commonly used gas anesthetic, although many institutions are now successfully using Sevoflurane. Induction may be accomplished by use of a facial cone with subsequent intubation.

Anatomic note: It should be noted that the trachea bifurcates at different levels in some species, therefore, use of a standard length endotracheal tube may result in unilateral intubation if the clinician is not careful. Because of the extensive pulmonary/airsac system, unilateral intubation does not lead to the problems of hypoventilation/hypooxygenation seen in mammals. If the tracheal size diminishes distal to the bifurcation however, tracheal trauma may occur if an inappropriately sized tube is used. If a clinician is unsure where the trachea bifurcates, radiographs may be helpful as a double trachea may frequently be seen. Maintenance of anesthesia may be complicated by shallow breathing in the patient, resulting in a chronic excitement phase indicated by swimming like behavior. A smoother plane of anesthesia may be achieved by assisting ventilation two to three times per minute. Ketamine has also been used, although recovery can be prolonged when compared to Isoflurane. One institution recommends Ketamine/Valium or just Ketamine given IM for induction over Isoflurane for Little Blue penguins (*Eudyptula minor*) because of the fragile nature of this species and its tendency to traumatize itself during anesthetic induction with Isoflurane. Once the Ketamine takes effect, anesthesia may be maintained with Isoflurane. If cold climate penguin species are immobilized for extended periods, some institutions use ice, ice packs, or other methods to prevent hyperthermia during the immobilization procedure.

BLOOD PARAMETERS

Each institution should establish its own set of normal blood parameters for every species maintained, preferably on MedARKS software. Outside laboratories of other institutions will often have different normal values (see appendix for normal blood values for each species). Blood may be collected from the inter-digital, medial tarsometatarsal, flipper, and jugular veins. It appears that more institutions are utilizing the jugular because of the speed and ease of acquisition of large quantities of blood. One institution collects blood from a venous sinus located on the dorsal aspect of the vertebral column at the base of the tail. The amount of blood that may be removed depends on the size of the individual, but generally follows normal avian standards (no more than 1% body weight) Complete blood counts (CBCs) are usually done by hand (using either the eosinophil method or Natt and Herricks method); estimates from a smear are considered less accurate. The Celldyne by Abbott Laboratories shows promise in accurately counting white blood cells. Chemistry profiles should include assays for glucose, alanine, aminotransferase (alt), asparginine aminotransferase (ast), calcium, urea, and uric acid. Increases in cholesterol, calcium, phosphorus, and occasionally alkaline phosphatase are often seen in reproductively active females beginning about a month prior to egg laying and persisting until shortly after the egg (s) is laid.

FLUID ADMINISTRATION

Fluid may be given to penguins by stomach tube, subcutaneously, intraperitoneally, or intravenously. Intravenous catheters for administration of fluids and therapeutic agents have been successfully placed and maintained in the flipper vein (brachial or medial) of several species of penguin (if the penguin is kept out of water). Penguin bones are not pneumatic and are much denser than those of other species of birds, therefore, intra osseous administration of fluids is quite difficult.

SURGERY

Surgery to assess airsacs, reproductive, and gastrointestinal tracts has been successfully performed in a variety of penguin species. It is important to remember to keep Antarctic and sub-Antarctic species cool during surgery. Standard surgical technique may be employed. Intubation, standard patient monitoring (ECG, oxygen saturation), and fluid administration are generally easy to perform. Birds should be kept out of the water until the skin incision has healed.

NOTE: Most institutions find that it is easy and less damaging to the patient's skin if the feathers are shaved in preparation for surgery, not plucked. The feather shafts will fall out and normal feathers will grow in during the next molt. Surgical scrubbing may be more gentle and avoid skin trauma. Where feathers are plucked, alcohol may cause excessive damage and impede skin healing.

BLOOD TRANSFUSIONS*

Transfusions may be performed when birds are severely anemic from malaria (blood phase), blood loss.or clotting disorders. Can stabilize a bird until a diagnosis can be made and treatment initiated. It is indicated when the Hct (PCV) drops rapidly into the teens or less and does not stabilize. If the Hct is stable, penguins generally have a good bone marrow response (if not old or debilitated by concurrent disease), and generally respond well to supportive care alone (fluids, oral or injectable iron supplementation, oxygen and B-vitamins.

In birds with malaria with a stable Hct in the teens, it has been reported that a transfusion appears to shorten the convalescent time until the treatment with chloroquine/primaquine takes effect.

Procedure

Donor bird – Approximately 1-1.5% of the donor's weight in blood volume can be safely collected (60 ml from a 4-5 kg bird), Use acid citrate dextrose (ACD) solution **(1)** as the anticoagulant at 0.15 ml ACD/ml blood collected. Collect blood slowly over 10-15 minutes using a butterfly catheter from the jugular or metatarsal vein while the bird is under anesthesia.
The donor bird is given supportive care post-blood collection:
Subcutaneous fluids 50 ml/kg, B-vitamins 0.5 ml in fluids or IM, iron dextran @ 10 mg/kg IM

Note: IV fluids up to or equal to the blood volume collected can be given using the same butterfly catheter used to collect blood.

Recipient bird – **Prior to administration of blood perform a partial craoss match. Use the donor blood and recipient bird serum. Absence of hemolysis or agglutination suggests compatibility.**

Give recipient bird dexamethasone sodium phosphate 0.25-1.0 mg/kg IM/IV. Administer blood through intravenous or intraosseous routes, using either an IV with either a disposable blood filter **(2)** or an inline filter **(3)**, both of which can be attached directly to a 60 ml syringe. Administer 60 ml blood over 45-60 minutes, while constantly rocking the blood in the syringe. Monitor recipient's heart and respiratory rates closely. If either increases, slow or stop the transfusion until parameters have returned to normal, then resume at a slower rate.

With 60 ml of blood (for 1 4-5 kg penguin) expect an increase in pre-transfusion Hct by 25-50%.

Homologous (same species) transfusions are preferred since the blood cells probably remain in the recipients circulation longer. However heterologous transfusions have been successfully used (black-footed penguin and turkey to Magellanic penguin.

1) Metrix Co., Dubuque, IA
2) Hemo-Nate Utah Medical products, Midvale UT
3) Abbott Lab, N. Chicago, IL

*A special thanks goes to Dr. Freeland Dunker for the transfusion protocol.

POST-MORTEM EVALUATION

Any individual who dies (including chicks) should be examined to determine the cause of death. This should include gross necropsy examination with cultures (where indicated), and histologic examination. Eggs that did not hatch should be opened and checked for fertility and age of embryonic death. Bacterial cultures should be taken of the yolk/albumin or embryo to identify bacterial infection as a cause of embryonic death. Necropsies should be performed in accordance with protocols developed by the Species Survival Plan (SSP) for each species. For those species without official protocols, the protocol for the Humboldt penguin may be used as a guide. This protocol is located at the end of the chapter. Further copies or updates may be found on the AAAV website under necropsy protocols.

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SUMMARY

The most important contributing factors to penguin health are maintaining a clean, stress-free environment, a proper plane of nutrition, good swimming habits, and early detection and treatment of illness. Animal care staff must constantly be aware of the normal physical and behavioral characteristics of the individuals in their care and the environmental conditions in which they live. Should any abnormalities occur, prompt communication with the veterinary, animal management, or mechanical facilities staff is essential. It is through early intervention and accurate record keeping of behavior, physical condition, and environmental parameters that we continue to increase our knowledge of and ability to effectively manage these unique and interesting birds.

SUGGESTED READING

This section is not intended to be an all-inclusive review of every aspect of penguin medicine; the reader is encouraged to refer to the references listed in Appendix III (Suggested Reading) for additional information.

APPENDIX 1:
PHARMACEUTICAL TREATMENTS

Few, if any, pharmaceutical studies have been performed on penguin species. Dosages are most often derived from those either scientifically or empirically used successfully in other avian species. The following is a list of pharmaceutical agents that have been used in various penguin species, with apparent success, and without known serious complications. This list is not complete, but rather is to be used as a guide for some of the more common medications used. Veterinary clinicians faced with medical problems requiring drug administration are urged to call experienced colleagues if there is any question regarding the safety and dose of any given drug.

DRUG	PURPOSE
Chloroquine	Malaria treatment
Primaquine	Malaria treatment or prevention
Daraprim/sulfadiazine	Malaria prevention (compounded formulation)
Amphotericin	Antifungal treatment
Intraconazole	Anitfungal treatment
Ancoban	Antifungal/prevention and treatment
Entrofloxacin	Antibacterial
Cephalexin	Antibacterial (may cause regurgitation/vomiting at higher doses)
Amoxicillin	Antibacterial

Ivermectin	Parasiticide
Pyrantel pamoate	Parasiticide
Fenbendazole	Parasiticide
Medroxyprogesterone	Molt induction
Ibuprofen	Pain relief – use with care because of renal toxicity

INSTITUTIONS FOR ASPERGILLUS TESTING

The Raptor Center
University of Minnesota
1920 Fitch Avenue
St. Paul, Minnesota 55108
Phone: 612-624-3013
Fax: 612-625-8220

Elisa test for antibodies – requires 0.3– 0.5ml plasma or serum. Call for submission forms.

University of Miami
Division of Comparative Pathology
1550 NW 10th Avenue, Room 105
Miami, Florida 33136
Phone: 305-243-6927 or 800-596-7390
Fax: 305-243-5662
Questions: Dr. Carolyn Cray

Elisa tests for both antibodies and antigens. Optional protein electrophoresis to aid diagnosis. Call for submission forms and shipping instructions.

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GLOSSARY TERMS

10% rule - refers to penguin hand-rearing protocol: never feed a penguin chick more than a calculated 10% of its first morning weight at any feeding.

Adult plumage - plumage from the time of sexual maturity onward.

Brood reduction - loss (mortality) of one or more chicks in a nest.

Central nest - a nest with at least one other nest between its location and the edge of the rookery.

Double-clutching - if a pair suffers a nest failure early enough in the breeding cycle, they may produce a second clutch within a short period. Also referred to as recycling.

Dry bulb - ordinary dry thermometer.

Dummy egg - a non-viable or artificial egg placed under a bird when its own egg is removed. Supplying a dummy egg can function to prevent recycling (double-clutching) in a pair, prolong incubation behavior in a target pair, or to allow removal of an egg or eggs during egg candling or other procedures.

Flipper-band - a color-coded band placed on the flipper (wing) used to individually identify penguins.

Fostering - a procedure where a fertile egg is transferred from one pair to another (target pair) to be hatched and reared by the target pair. This procedure can maximize reproductive success with proven target pairs or allow inexperienced pairs to acquire experience.

Fledging - when a chick achieves independence of parental care.

Hatch asynchrony - the difference in the hatch interval between chicks in a nest. In penguins, this interval is between the first and second chick, and can be between two and four days, depending on incubation conditions.

Immature plumage - plumage from approximately 14 months of age to the time of sexual maturity.

Isolation area - an area separate from the main exhibit and other penguins where ill, new, or transient birds may be held.

Juvenile plumage - plumage from the time of fledging to the nest molt (approximately 14 months of age).

Nesting failure - loss of eggs or chicks during the resting cycle resulting in loss of reproductive success.
Peripheral nest - a nest at the edge of the rookery area.

Quarantine area - a contained area to hold newly-acquired birds. A separate air and water system should be provided by this area.

Rookery - a communal breeding area.

Second-clutching - see double-clutching.

Target pair - in context, refers to a pair that is pre-selected by management staff to receive a foster egg (or eggs) from another pair. Also referred to as a foster pair.

Wet bulb - ordinary thermometer affixed with section of wicking which is continuously supplied with water. The thermometer reading is influenced by the relative humidity of incubator because of evaporation of water from the wick. If the dry bulb temperature is constant, and the wick is functioning properly, then the humidity in the incubator is directly proportional to the wet bulb reading.

APPENDIX I.

GROWTH DATA

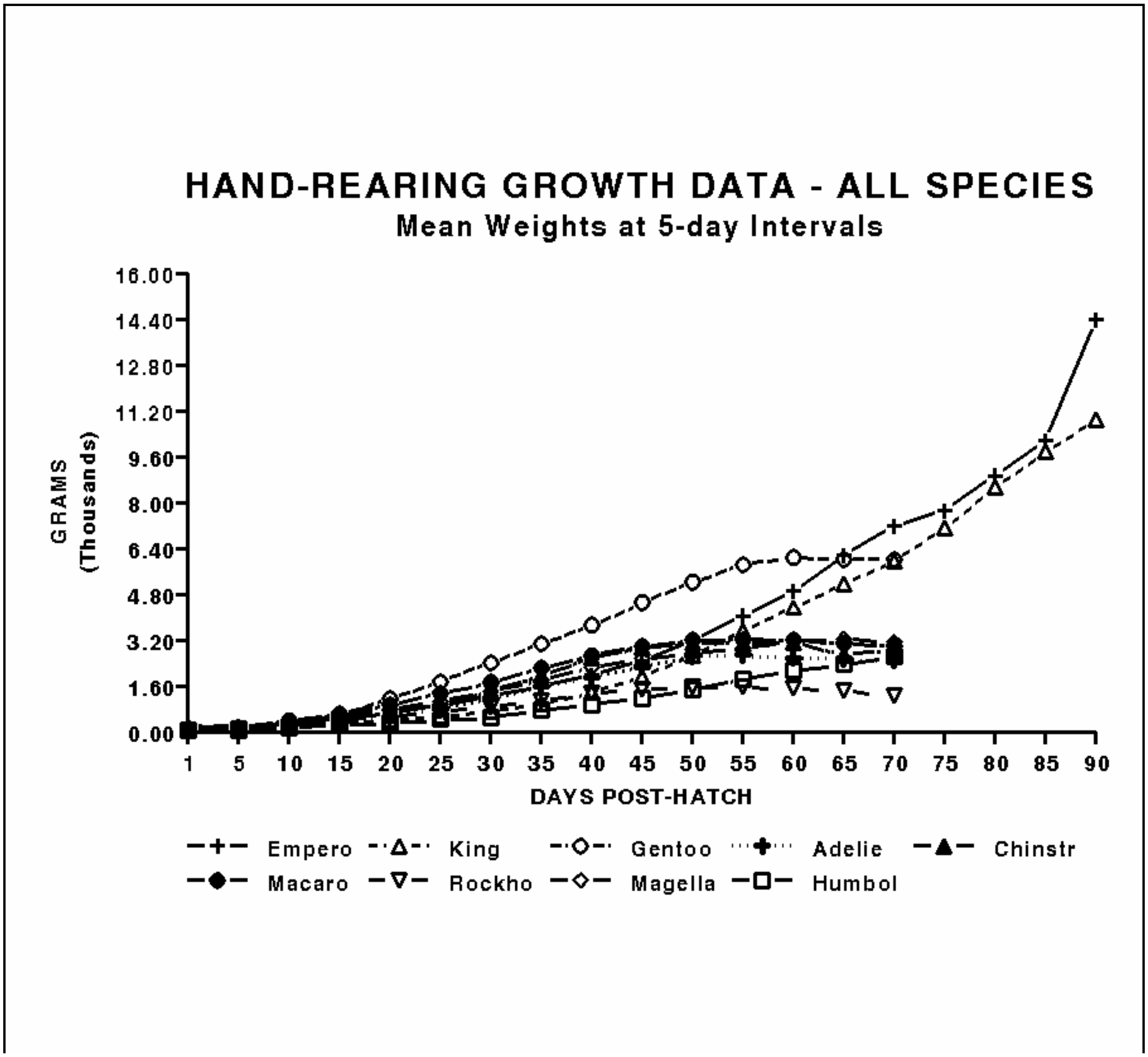

Figure 6. Growth data for penguin species commonly hand-reared in captivity.

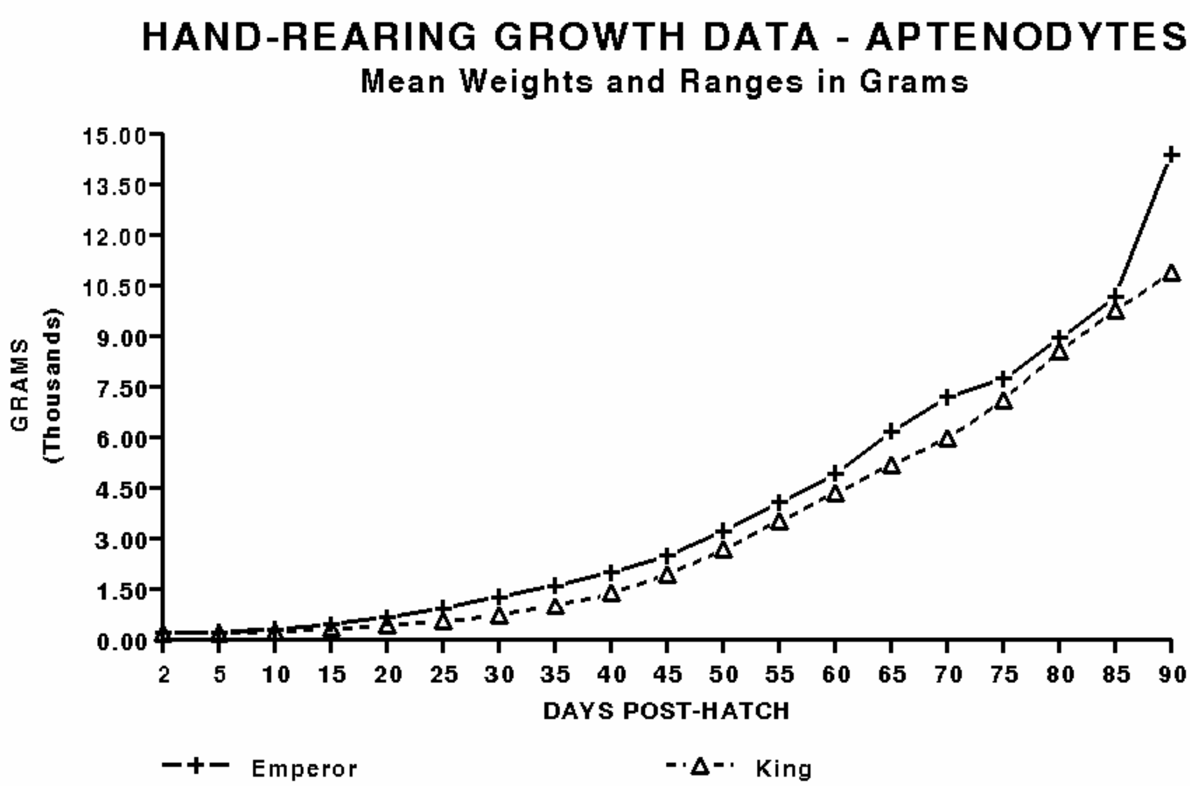

Figure 7. Growth data for hand-reared *Aptenodytes* penguins.

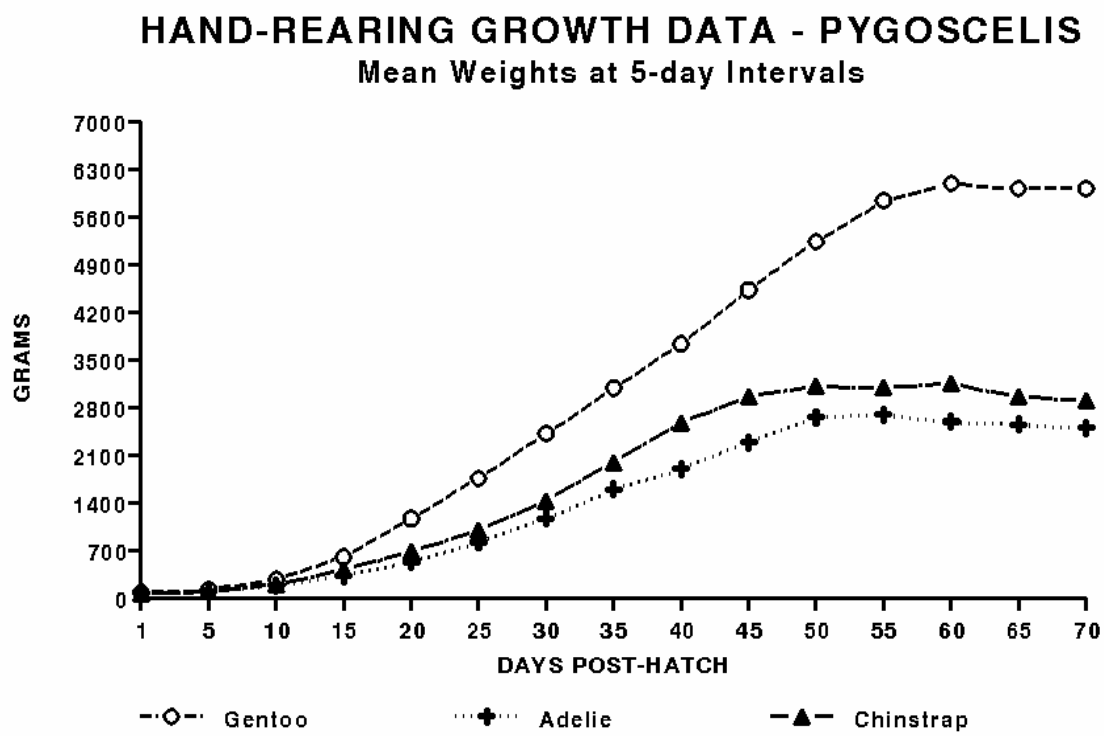

Figure 8. Growth data for hand-reared *Pygoscelis* penguins.

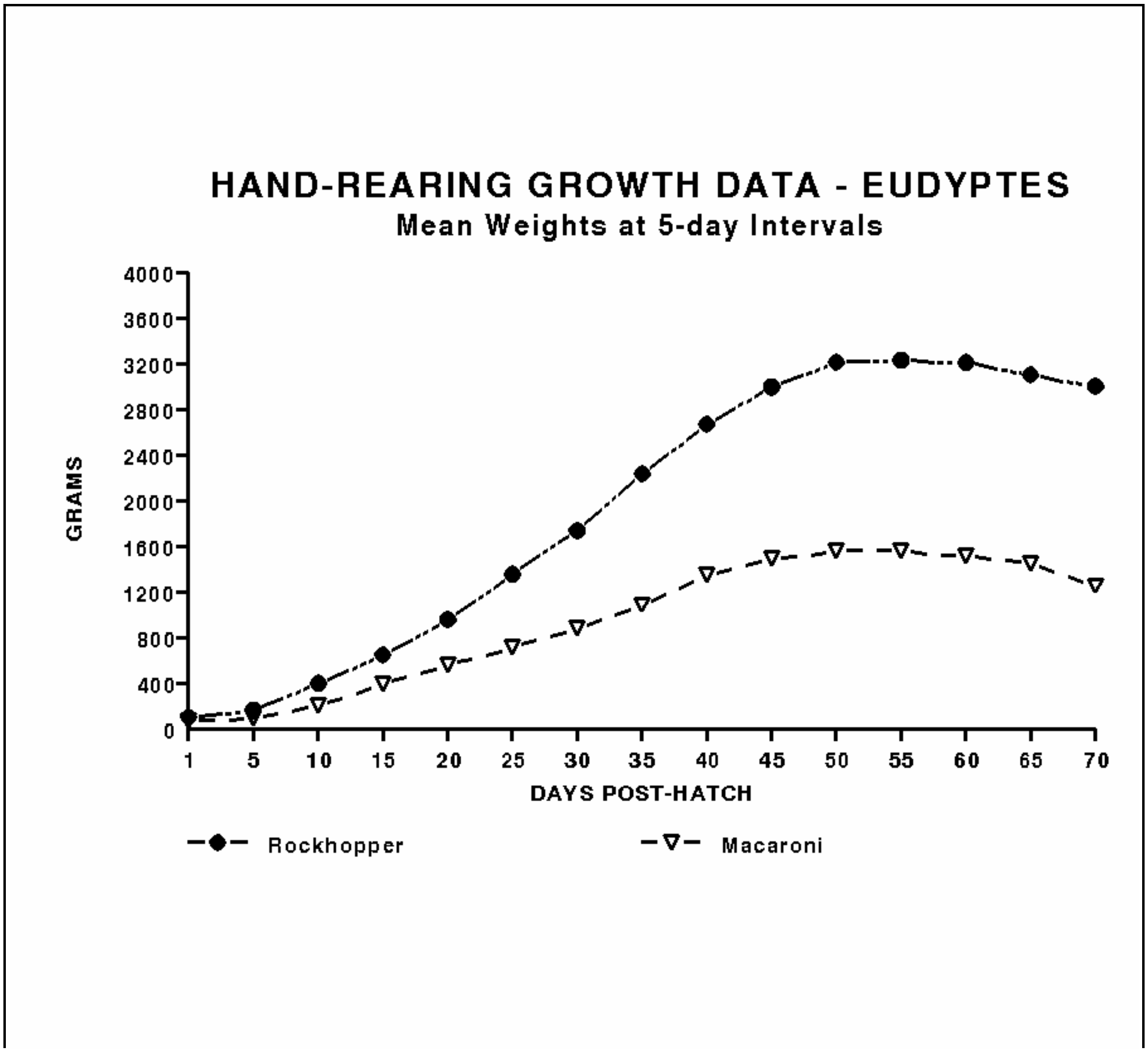

Figure 9. Growth data for hand-reared *Eudyptes* penguins.

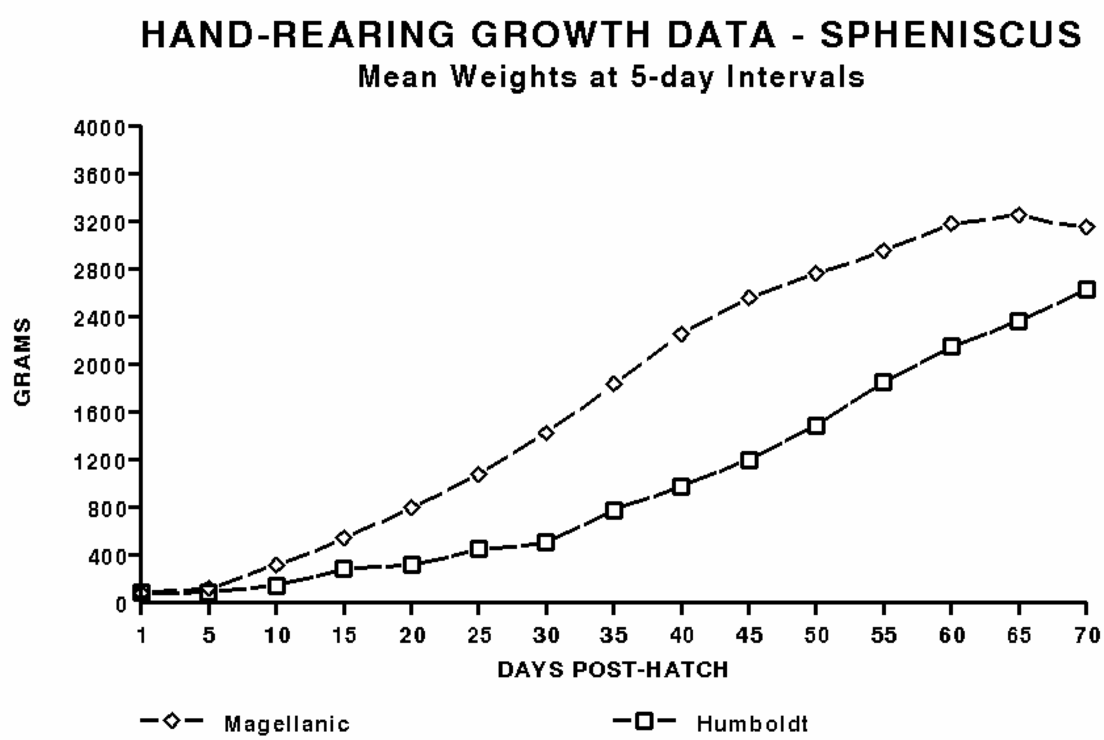

Figure 10. Growth data for hand-reared *Spheniscus* species.

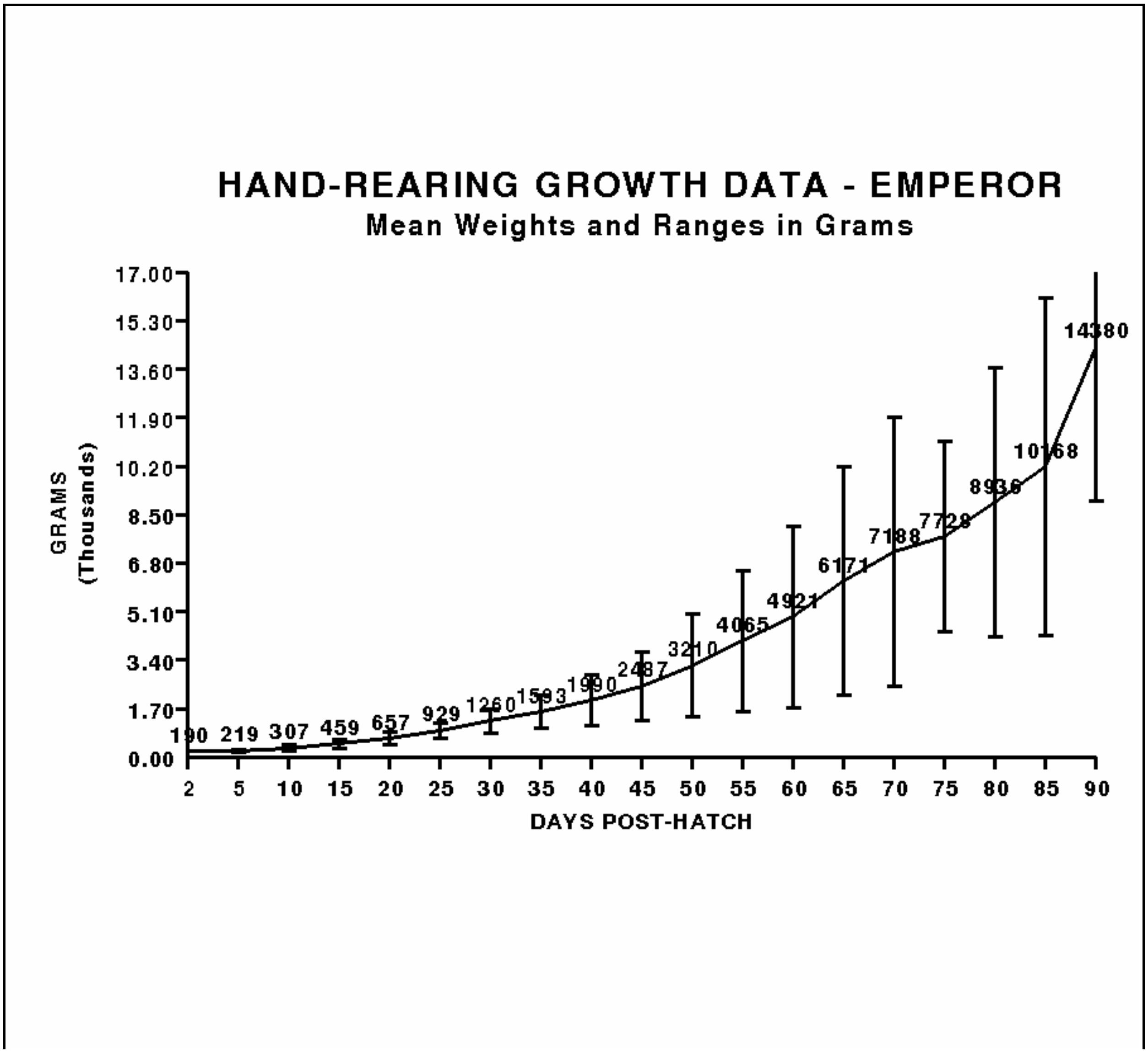

Figure 11. Growth data for hand-reared Emperor penguins.

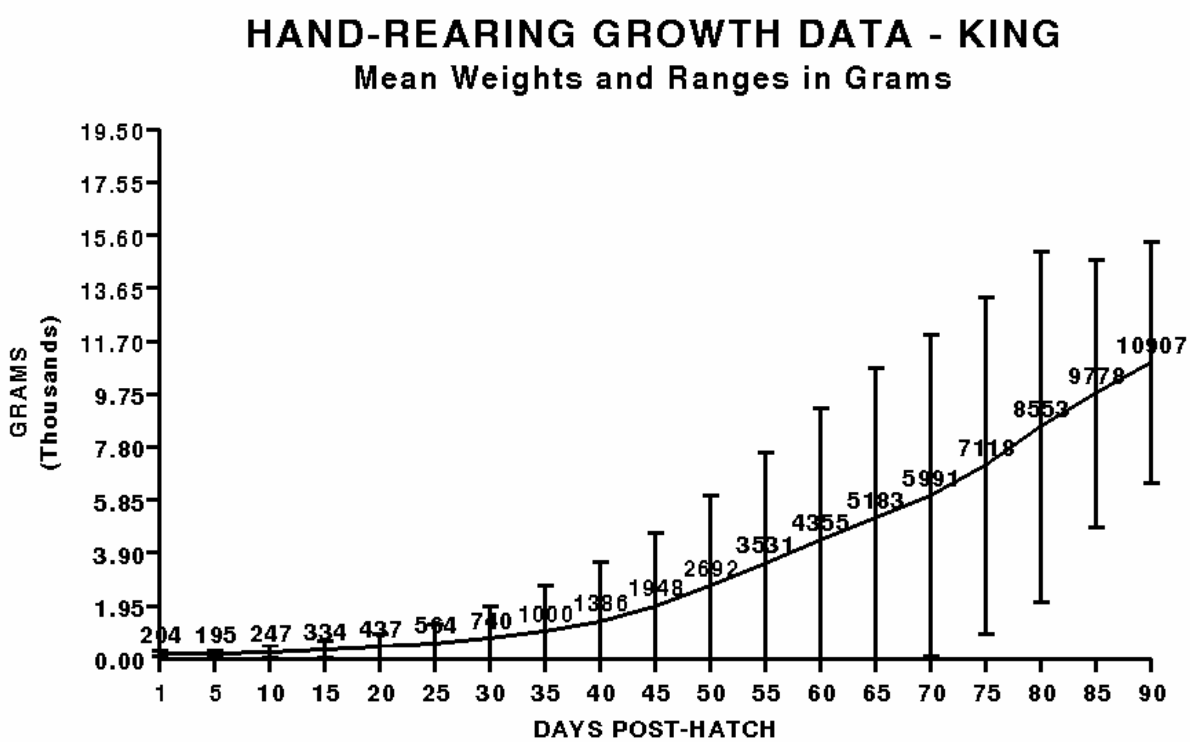

Figure 12. Growth data for hand-reared King penguins.

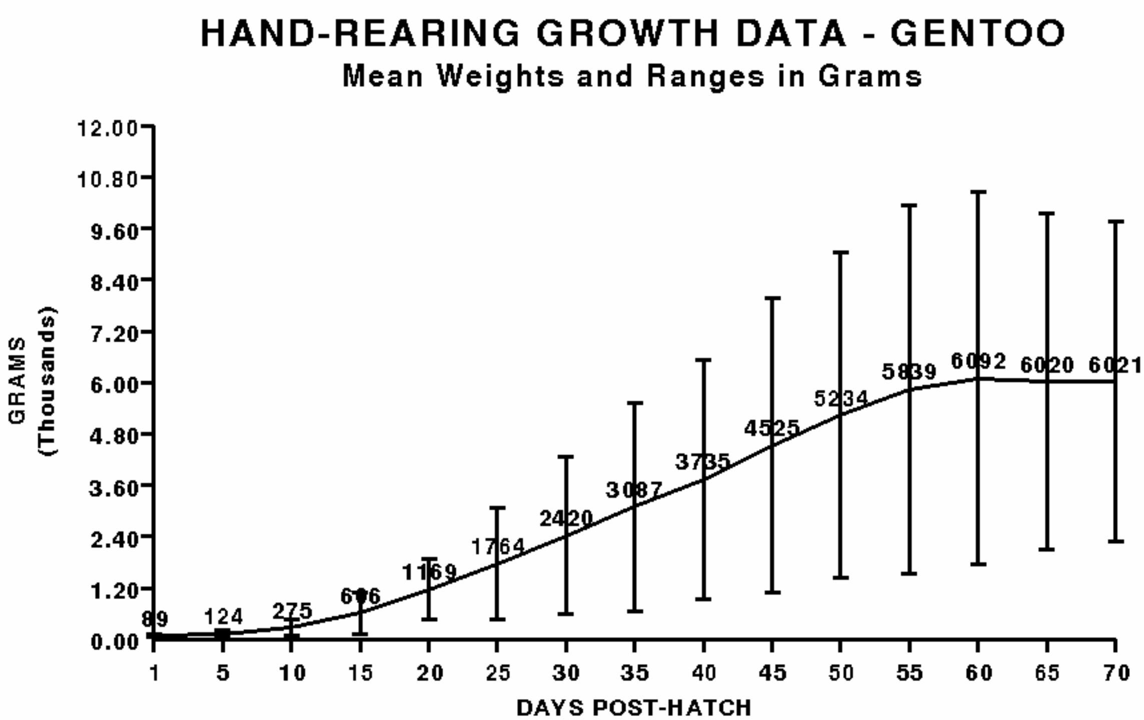

Figure 13. Growth data for hand-reared Gentoo penguins.

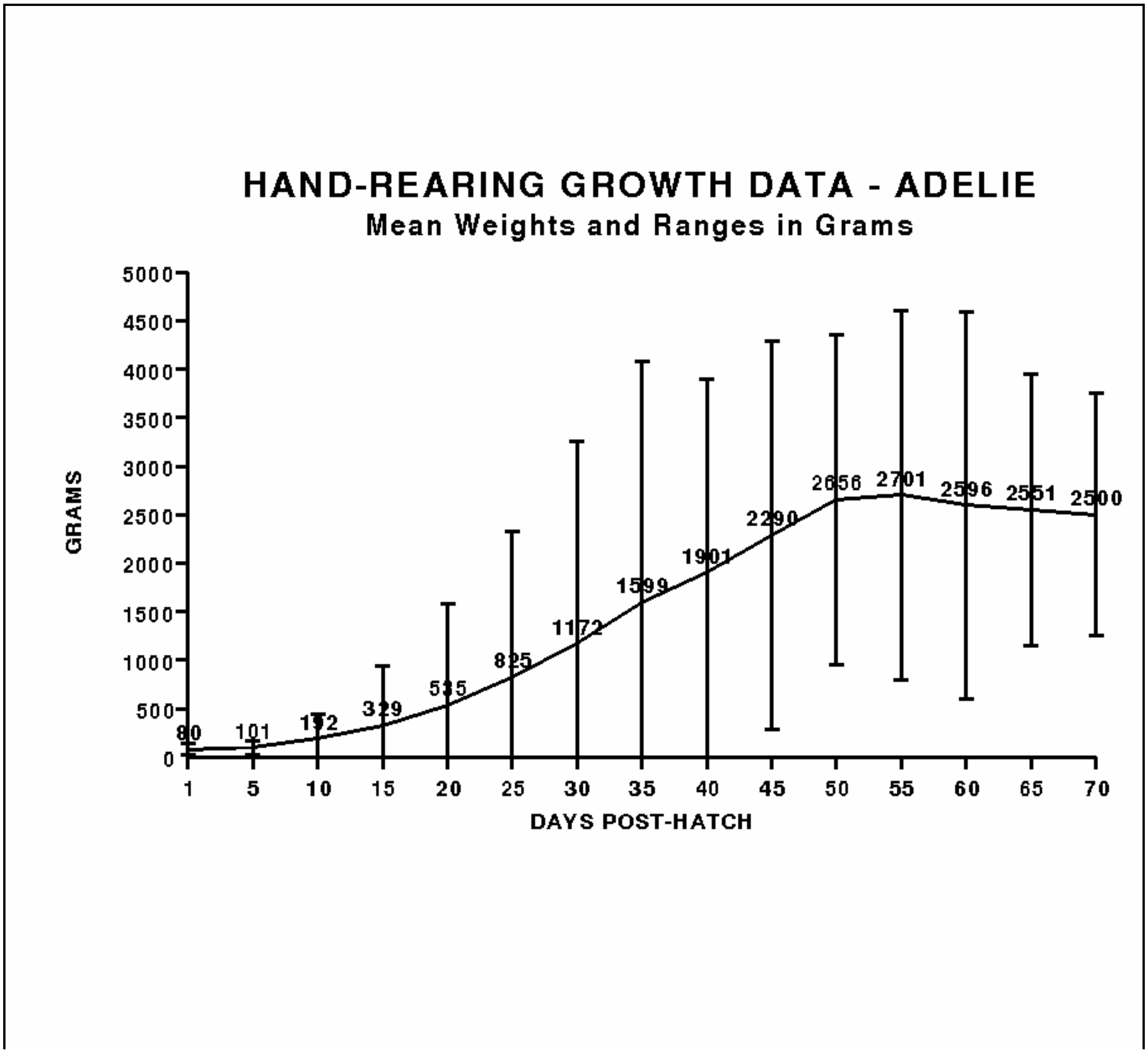

Figure 14. Growth data for hand-reared Adelie penguins.

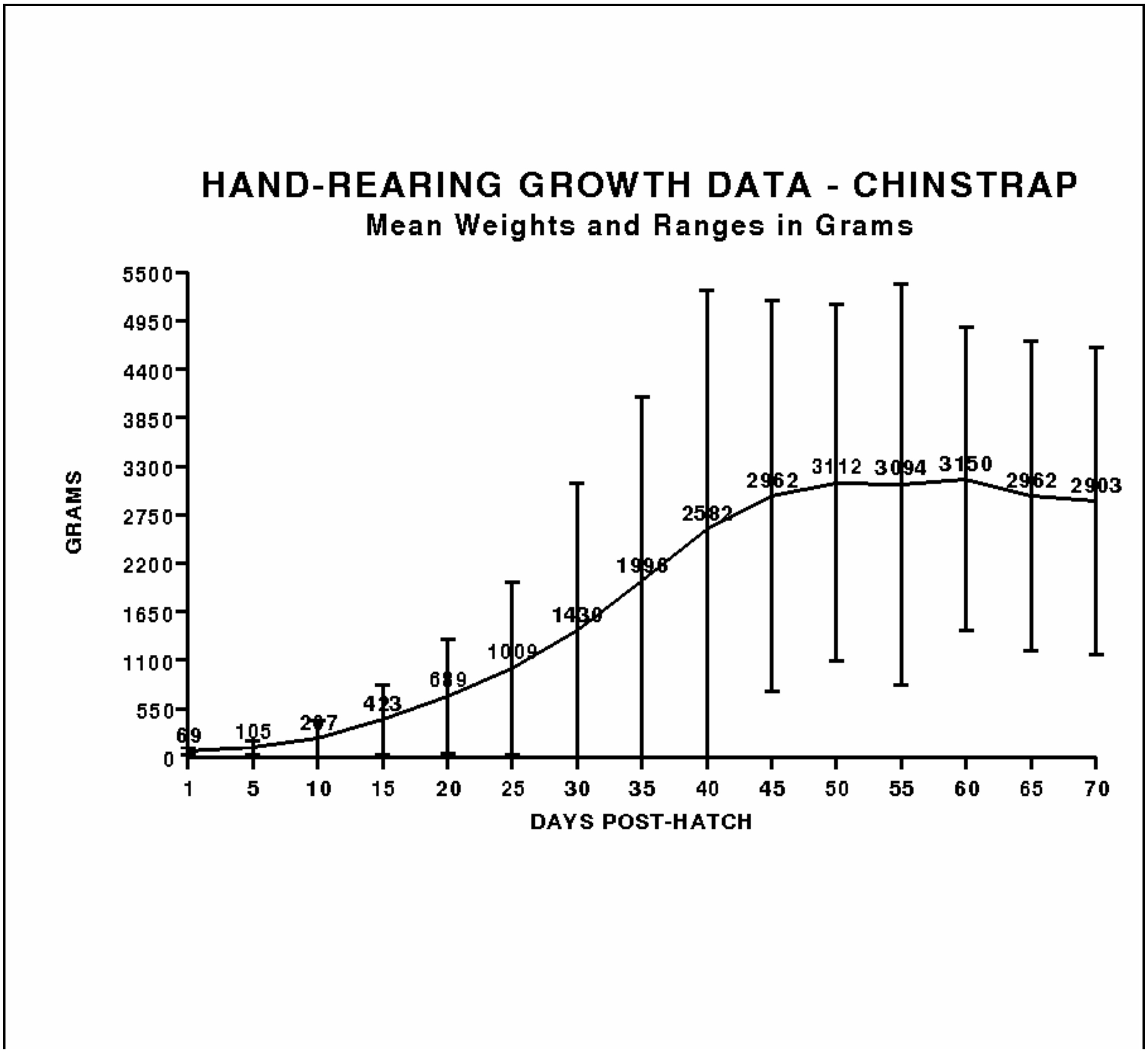

Figure 15. Growth data for hand-reared Chinstrap penguins.

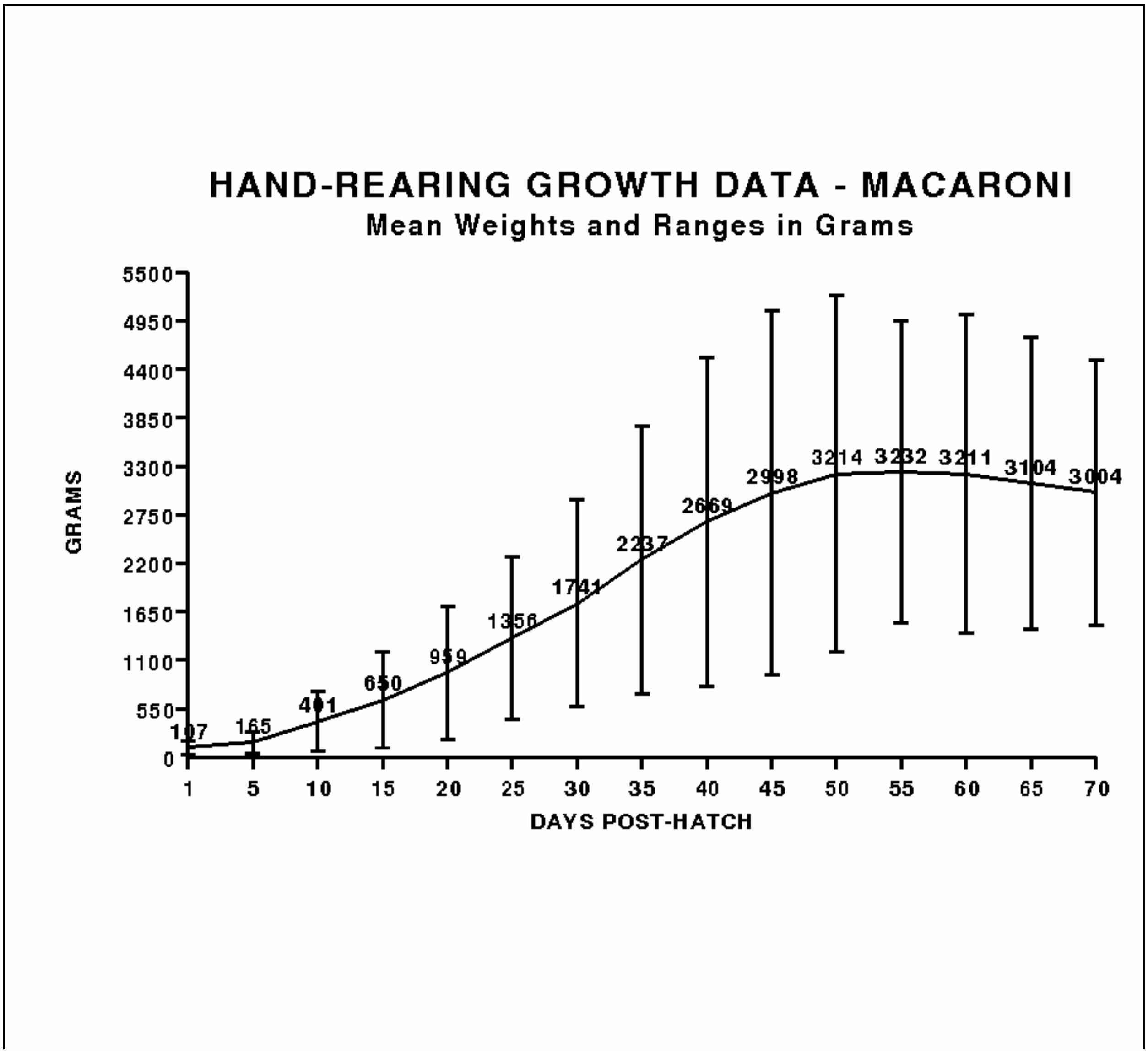

Figure 16. Growth data for hand-reared Macaroni penguins.

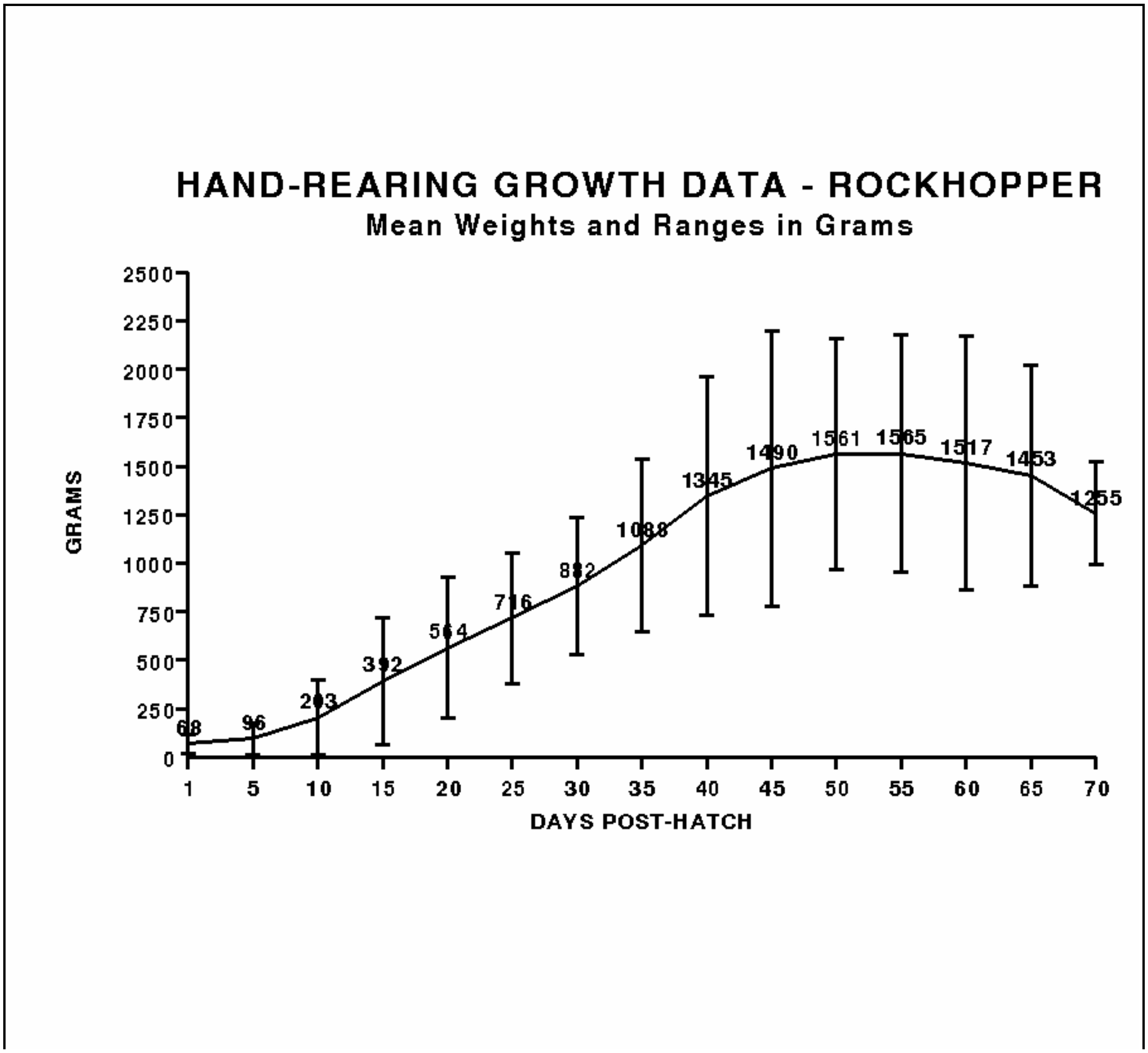

Figure 17. Growth data for hand-reared Rockhopper penguins.

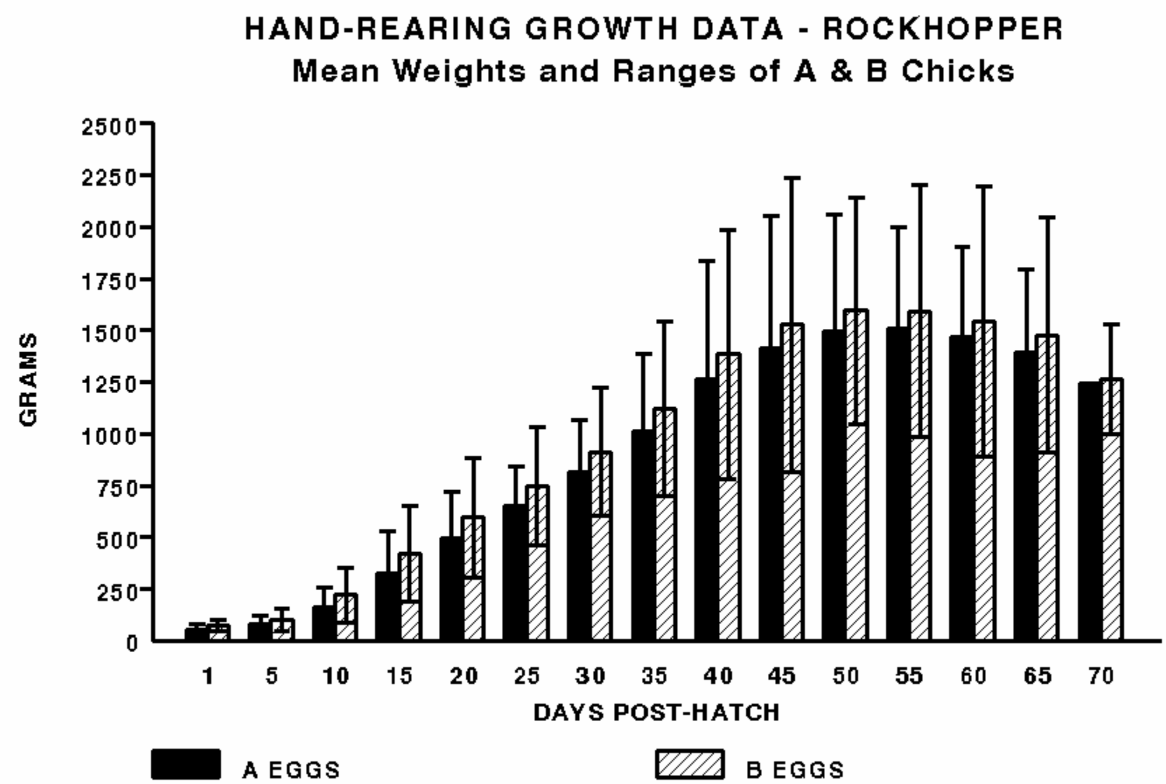

Figure 18. Growth data for hand-reared "A" and "B" Rockhopper penguin chicks.

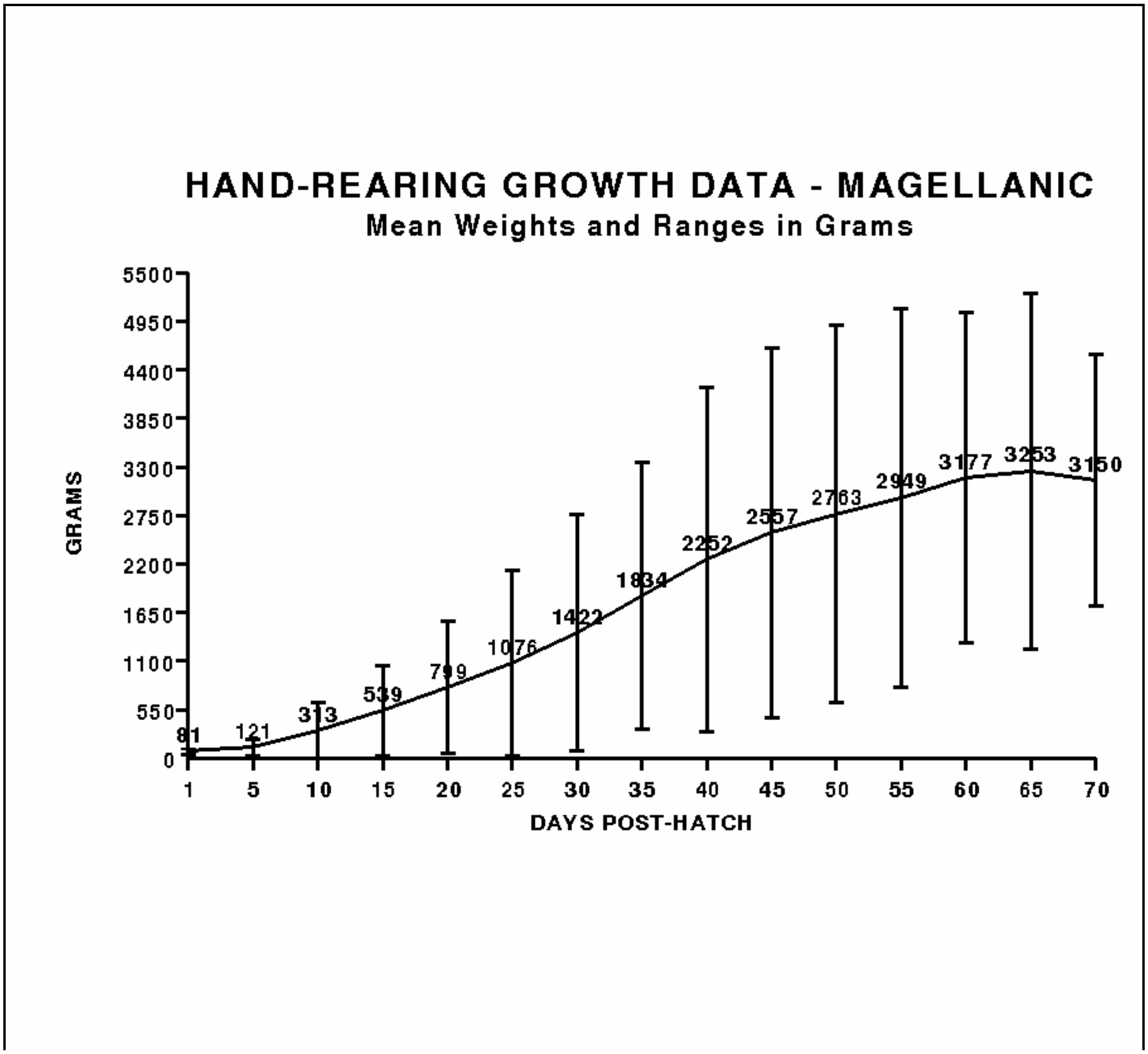

Figure 19. Growth data for hand-reared Magellanic penguins.

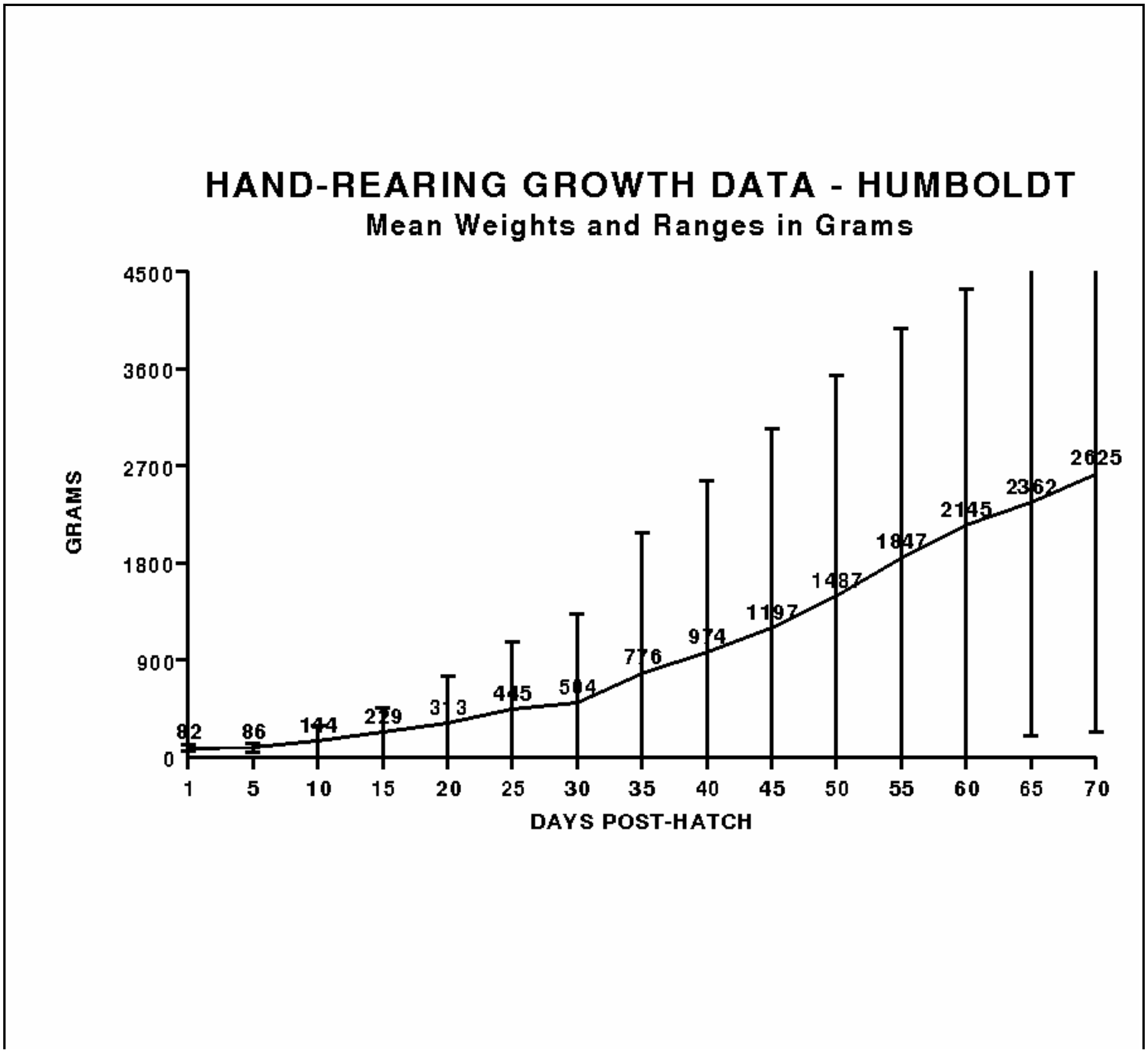

Figure 20. Growth data for hand-reared Humboldt penguins.

APPENDIX II.
RECOMMENDED SUPPLEMENTATION SCHEDULE
AND PRODUCT INFORMATION FOR ADULT PENGUINS.

1) MULTI-VITAMIN/MINERAL SUPPLEMENT Per Animal:

Birds with a body mass averaging:

* less than 15 kg should receive 1/4 tablet every day.
* between 15 - 35 kg should receive 1/2 tablet every day.
* more than 35 kg should receive 1 tablet every day.

Daily multiple vitamins and minerals
1 tablet contains:

Vitamin A	5000 IU
Vitamin D	400 IU
Vitamin C	60 mg
Vitamin E	15 IU
Folic Acid	0.4 mg
Thiamine	1.5 mg
Riboflavin	1.7 mg
Niacinamide	20 mg
Vitamin B6	2 mg
Vitamin B12	6 mcg
Biotin	10 mcg
Pantothenic acid	10 mg
Vitamin K	5 mcg
Calcium	100 mg
Phosphorous	100 mg
Iodine	0.15 mg
Iron	18 mg
Magnesium	100 mg
Copper	2 mg
Zinc w/gluconate	15 mg
Manganese	2.5 mg
Potassium	38 mg
Chromium	10 mcg
Molybdenum	10 mcg
Selenium	10 mcg
Chloride	34 mg

This supplement does not contain: sucrose sugar, starch, salt, or preservatives.
SUNDOWN VITAMINS, Ft. Lauderdale, FL 33334

2) SODIUM CHLORIDE SUPPLEMENT Per Animal:

Birds with a body mass averaging:

* less than 5 kg should receive 1/4 tablet every other day.
* between 5 - 15 kg should receive 1/4 tablet every day.
* between 15 - 35 kg should receive 1/2 tablet every day.
* more than 35 kg should receive 1 tablet every day.

Sodium chloride tablets, USP 1 g
100 tablets No. 967
Store at controlled room temperature 15 to 30 degrees Celsius
Eli Lilly & Co., Indianapolis, IN 46285 USA

3) VITAMIN E SUPPLEMENT per kg fish fed:

* birds consuming 500 g fish daily should receive 1 capsule every other day (or 1/2 every day but it's difficult to break).
* birds consuming 1 kg fish daily should receive 1 capsule every day.
* birds consuming 2 kg fish daily should receive 2 capsules every day, etc.

Vitamin E 100 IU
100 capsules
Vibrant Health
1 capsule contains 100 mg dl-alpha tocopheryl acetate
Contains no sugar, starch, sodium, artificial colors, flavors or preservatives.
Storage: Keep well closed in a cool, dry place
Distributed by Major Vitamin Auburn Hills, MI 48321

4) Thiamine SUPPLEMENT per kg fish fed.

* birds consuming 500 g fish daily should receive 1/4 tablet every day or 1/2 tablet every other day.
* birds consuming 1 kg fish daily should receive 1/2 tablet every day.
* birds consuming 2 kg fish daily should receive 1 capsule every day, etc.

Vitamin B-1 (Thiamine) 100 mg
100 tablets
Vibrant Health
1 tablet contains 100 mg thiamine hydrochloride
Contains no starch, sugar, sodium, corn, wheat, milk, yeast, salt, oats, eggs, artificial colors or preservatives.
Storage: Do not expose to excessive heat or moisture.
Distributed by Major Vitamin Auburn Hills, MI 48321

APPENDIX III

SEAWORLD PENGUIN FORMULA

WHOLE BATCH

440 grams	5-7 inch whole herring with head tail, fins and skin removed
440 grams	krill (squeeze water out after defrosting & before measuring)
800 ml	bottled drinking water
8 each	7 grain Brewers yeast tablets
550 mg	B - 1
1 each	5lb. Mazuri SeaBird vitamins
4 each	10 grain calcium gluconate tablets
1200i.u.	Vitamin E
2ml	Children's multi-vitamin drops

Blend ingredients thoroughly. Strain through large colander. Refrigerate formula, mark with date and time; use within 24 hours. Warm formula to 95F (35 C) before serving.

SEAWORLD PENGUIN FORMULA

HALF BATCH

220 grams	5-7 inch whole herring with head, tail, fins & skin removed
220 grams	krill (squeeze water out after

defrosting & before measuring)

400 ml	bottled drinking water
4 each	7 grain brewers yeast tablets
275 mg	B-1
2+1/2lb	Mazuri SeaBird vitamins
2 each	10 grain calcium gluconate tablets
600i.u.	Vitamin E
1 ml	Children's multi-vitamin drops

Blend ingredients thoroughly. Strain through large colander. Refrigerate formula, mark with date and time; use within 24 hours. Warm formula to 95F (35 C) before serving.

SEAWORLD PENGUIN FORMULA

QUARTER BATCH

110 grams	5-7 inch whole herring with head, tail, fins & skin removed
110 grams	krill (squeeze water out after defrosting and before measuring)
200 ml	bottled drinking water
2 each	7 grain brewers yeast tablets
150 mg	B-1
1+1/4lb	Mazuri SeaBird vitamins

1 each	10 grain calcium gluconate tablet
300i.u.	Vitamin E
½ ml	Children's multi-vitamin drops

Blend ingredients thoroughly. Strain through large colander.
Refrigerate formula, mark with date & time; use within 24 hours.
Warm formula to 95F (35C) before serving.

PENGUIN HAND REARING VITAMIN REGIME
FOR
GENTOO, CHINSTRAP & ROCKHOPPER CHICKS

Through 1000 gram A.M. weight:
3 days of age to 400g A.M. weight:
Just prior to feeding formula, stir in 1 pinch of ground B- 1 per 100cc formula prepared.

>400g A.M. weight through 1000g A.M. weight:
25mg B-1 BID

First daily weight = 1000g or when chick receives formula twice a day (BID)

A.M:
1/4 Children's Multi-vitamin
1/4 Calcium Gluconate tablet
1/4 of 25mg B-1

P.M:
1/4 Children's Multi-vitamin
100i.u. Vitamin E - every other day
1/4 of 25mg B-complex
1/4 Calcium Gluconate tablet

First daily weight = 2000g - start juvenile vitamins:

A.M:
1/2 Children's Multi-vitamin
1/4 Calcium Gluconate tablet

½ of 50mg B-1

P.M:
1/2 Children's Multi-vitamin
1/4 Calcium Gluconate tablet
1/4 of 25mg B-complex
100i.u Vitamin E - every other day

Juvenile Vitamins - Post-fledge:

Gentoo, Chinstraps & Rockhoppers:
A.M.
2.5lb Mazuri Multi-vitamin tablet
250mg B-1

P.M.
50 mg B-Complex
100 Vitamin E – every other day

Vitamins may be inserted into the gills of the fish before feeding, or, if no whole fish is being given - fed to the chicks with a feeding response, followed by the fish fillets.)

VITAMIN REGIME FOR KING PENGUIN CHICKS

DAY 4:
FIRST VITAMIN SUPPLEMENT
1/8 of a 100mg B-1, BID

DAY 10 or 400 grams, whichever comes first:
1/8 Children's Multi-vitamin, BID
1/4 of a 100mg B-1, BID

DAY 14 or 600 grams, whichever comes first:
1/4 Children's Multi-vitamin, BID
¼ Calcium Gluconate, BID
100i.u. Vitamin E, every other day, SID
A.M. 1/4 of a 100mg B-1
P.M. 1/4 of 100mg B-Complex

2000 GRAM VITAMINS:
1/2 Children's Multi-vitamin, BID

1/4 Calcium Gluconate, BID
100i.u. Vitamin E, every other day, SID
A.M. 100mg B-1
P.M. 1/4 of 100mg B-Complex

<u>3000 GRAM VITAMINS</u>:
3/4 Children's Multi-vitamin, BID
1/2 Calcium Gluconate, BID
100i.u Vitamin E, every other day, SID
A.M. 1/2 of a 250mg B-1
P.M. 1/2 of a 100mg B-Complex

<u>4000 GRAM VITAMINS</u>:
1 whole Children's Multi-vitamin, BID
1/2 Calcium Gluconate, BID
100i.u Vitamin E, every other day, SID
A.M. 1/2 of a 250mg B-1
P.M. 1/2 of a 100mg B-Complex

<u>5000GRAM VITAMINS</u>:
1/2 of a 2.5lb Mazuri Multi-vitamin, BID
1 Calcium Gluconate, BID
100i.u. Vitamin E, every other day, SID
A.M. One 250mg B-1
P.M. One 100mg B-Complex

<u>6000 GRAM VITAMINS</u>:
One 2.5lb Mazuri Multi-vitamin, BID
1 Calcium Gluconate, BID
100i.u. Vitamin E, every other day, SID
A.M. One 250mg B-1
P.M. One 100mg B-Complex

<u>8000 GRAM VITAMINS</u>:
One 5lb Mazuri Multi-vitamin, SID
1 Calcium Gluconate, BID
100i.u. Vitamin E, every other day, SID
A.M. One 250mg B-1
P.M. One 100mg B-Complex

King chicks remain on these vitamin until they have fully fledged and then go to regular adult King vitamins.

Important: It is extremely important to watch all hand raised birds for anemia and especially King chicks. Lethargic behavior over a period of time is the best indication of anemia. If anemia is suspected, a vet check and a blood test will be necessary to determine whether an iron supplement will be required.

PRODUCT LIST (VITAMINS)

Children's Chewable Multi-Vitamin Tablets
(various vendors & manufacturers)
Each tablet supplies:

Vitamin A, i.u.	2500
Vitamin C, mg	60
Vitamin D, i.u.	400
Vitamin E, i.u.	15
Thiamine, mg	1.05
Riboflavin, mg	1.2
Niacin, mg	13.5
Vitamin B-6, mg	1.05
Folate, mcg	300
Vitamin B-12, mcg	4.5
Sodium, mg	5

Children's Multi-Vitamin Drops (i.e. Poly-Vi-Sol)
(various vendors & manufacturers)
Each 1.0ml supplies:

Vitamin A, i.u.	1500
Vitamin C, mg	35
Vitamin D, i.u.	400
Vitamin E, i.u.	5
Thiamine, mg	0.5
Riboflavin, mg	0.6
Niacin, mg	8
Vitamin B-6, mg	0.4
Vitamin B-12, mcg	2

Mazuri Sea Bird Multi-Vitamin Tablets
Tablets are formulated for animals eating 2&1/2 lb (1.13 kg) and 5 lb (2.27 kg) fish per day.

Each 2&1/2 lb tablet supplies: Each 5 lb tablet supplies:

Vitamin A, i.u.	1650	16,500
Vitamin E, i.u.	25	250
Vitamin C, mg	25	250
Thiamin, mg	20	200
Riboflavin, mg	1.5	15
Pyridoxine, mg	1.5	15
Pantothenic Acid, mg	1.5	15
Folic Acid, mcg	50	500
Biotin, mcg	25	250

APPENDIX IV.

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APPENDIX IV

1993 PENGUIN TAG SURVEY RESPONDENTS

John Aiken, San Francisco Zoo
S. Albelt, Lake Superior Zoo
Mark Armstrong, Knoxville Zoological Gardens
Laura Benevoli, Stanley Park Zoo
Kevin Bell, Lincoln Park Zoo
Blank Park Zoo
Bruce Bohmke, St. Louis Zoo
Margaret Borg, Fort Wayne Children's Zoo
Sherry Branch, Sea World of Florida
Marlee Breese, Sealife Park Hawaii
Nancy Chapin, Aquarium of Niagara Falls
Cheyenne Mountain Zoo
Ron Cline, John Ball Zoological Gardens
Yvonne Clippinger, Columbus Zoo
Mike Cunningham, Los Angeles Zoo
Ed Diebold, Milwaukee County Zoo
Eric Elling, Denver Zoo
Byron Ford, Gulf World
Elizabeth Harmon, Great Plains Zoo
L. Heartman, Lake Superior Zoo
Carol Hesch, Memphis Zoo
Hogle Zoo
K. Kriese, Point Defiance Zoo
Seanna Lammers, Knoxville Zoological Gardens
Peter Luscomb, Honolulu Zoo
Robin Matos, Hilton Hawaiian Village, Hawaii
Marilyn McBirney, Pueblo Zoo
Patty McGill, Brookfield Zoo
Adrienne Miller, Roger William's Park Zoo
M. Miller-Lebert, Point Defiance Zoo
Dave Oehler, Cincinnati Zoo
Pam Osten, Baltimore Zoo
Dennis Pate, Metro Washington Park Zoo
Sharon Reilly, Central Park Wildlife Conservation Center
Herb Roberts, Memphis Zoo
Jim Robinett, Shedd Aquarium
Jack Roderick, AICO
Dianna Rubly, Omaha's Henry Doorly Zoo
Steve Sarro, Baltimore Zoo
Tom Schneider, Detroit Zoo
Christine Sheppard, International Wildlife Conservation Park
Bob Siebels, Riverbanks Zoological Park
Gayle Sirpenski, Mystic Marinelife Aquarium
Christina Slager, Aquarium of the Americas
Yvonne Strode, Racine Zoo
Greg Toffic, Woodland Park Zoo
Wendy Turner, Sea World of California
J. Whaley, Marineland of Florida
Wendy Worth, San Antonio Zoo