CHAPTER 5. CAPTIVE MANAGEMENT

A. Overview

Maintaining wild birds in captivity is expensive, time-consuming, and requires expertise. That expertise can often be found outside the community of ornithologists. The captive living conditions should be appropriate for each species of bird and should contribute to both health and comfort. Investigators maintaining captive flocks of wild birds may refer to King et al. (1977) and Ritchie et al. (1994), and especially Ritchie et al. (2008) for a thorough discussion of topics related to captive maintenance, health issues, and veterinary care of birds. Zoos are a potential source of help and information. The American Zoo and Aquarium Association (AZA) publishes a series of species- or taxon-specific captive management guidelines: Animal Care manuals (which will replace the Husbandry Manuals) and Feeding Program Guidelines) that will be very helpful.

Choosing appropriate veterinary assistance is critical. A veterinarian with experience in avian medicine is preferred. The American Board of Veterinary Practitioners offers board certification in avian medicine and offers a list of boarded veterinarians. Attending veterinarians on the staff of a research institution with vertebrate animal facilities can help a researcher find a veterinarian knowledgeable about birds, if s/he is not. Often, a suitable veterinarian must be identified as part of a vertebrate animal protocol. Other sources of information about wildlife veterinarians include your local zoo, the American Association of Wildlife Veterinarians, the American Association of Zoo Veterinarians, and the American Association of Avian Veterinarians. For routine care and maintenance, it is advantageous to have an animal health technician who has obtained a degree from a program accredited by the American Veterinary Medical Association or the Canadian Veterinary Medical Association (or such other veterinary associations as exist in your country) and who has been licensed in your state on staff. The American Association for Laboratory Animal Science offers certification at three levels of competence: assistant technician, technician, and technologist. Each requires a certain amount of experience and an examination.

B. Regulatory requirements and oversight

Federal and state agencies require permits to remove birds from the wild. See the scientific collecting permit information (U.S. Fish and Wildlife Service), state permit information, and

Canadian provincial information provided by the Ornithological Council. Outside the United States or Canada, check national and provincial or state laws.

Under the Animal Welfare Act regulations, Institutional Animal Care and Use Committees "must inspect at least once every six months, all of the research facility's animal facilities, including animal study areas, using title 9, chapter I, subchapter A-Animal Welfare, as a basis for evaluation; Provided, however, That animal areas containing free-living wild animals in their natural habitat need not be included in such inspection" [9 CFR 2.31(c)(2)]. A study area is any building room, area, enclosure, or other containment outside of a core facility or centrally designated or managed area in which animals are housed for more than 12 hours (9 CFR 1.1). To the extent that a research facility or study area is subject to inspection, the housing standards established by the Animal Welfare Act regulations are applicable. As of January 2010, however, the Animal Care program of the U.S. Department of Agriculture, Animal and Plant Health Inspection Service had not yet promulgated regulations pertaining to birds. It is anticipated that the regulations will be proposed in 2010 and will become final by 2011. When this occurs, these Guidelines will be updated accordingly.

C. Quarantine of animals

Introducing new birds to a facility, whether from the wild or from another captive setting, carries the risk of disease transmission between new and established birds. The increased stress of capture stress and acclimation to captivity for wild birds or a new environment for birds already in captivity, as well as shipping, has the potential to reduce immunity, making them more susceptible to new infections or resulting in subclinical infections becoming life threatening (Ferrell et al. 2007). Thus, quarantine procedures should protect both incoming birds and any established birds. Quarantine assumes that new arrivals may have been exposed to a contagious pathogen and are therefore kept apart from others to prevent disease spread. Though in practice quarantine and isolation entail the same procedures, the term isolation is used when the individual is known to have contracted an infectious disease.

Research institutions with vertebrate animal facilities will have standing quarantine procedures covering all animals. The avian researcher may, however, want to consult with the avian veterinarian to make sure that these procedures adequately protect birds from specific avian

diseases and from additional stress during quarantine, e.g. from social isolation or inadequate space.

Generally, all newly acquired birds must be strictly quarantined from other captive birds for a minimum of 30 days. If the birds were imported from outside the United States, they must, by law, be quarantined for 30 days in a U.S. Department of Agriculture quarantine facility. Special regulations [9 CFR 93.106(b)] apply to psittacines and ratites. Quarantine times (pre-shipping and post-arrival) vary from one country, as will import permit requirements. As government quarantine facilities test only for diseases of concern to the government agency (primarily non-native diseases that can impact poultry) it is advisable to re-quarantine the birds when they arrive at your facility. For more information about the complex process of importing live birds, see the Ornithological Council's Guide to Importing Live Birds.

During daily care, caretakers should deal with quarantined birds last and not return to other housing areas. If you must return to other areas, wear disposable outer garments and wash hands and other exposed areas before moving between quarantined and post-quarantine birds. The quarantined birds should be observed for symptoms of disease by personnel familiar with birds. Fecal examinations for intestinal parasites and visual examination for external parasites should always be performed on arrival and when the quarantine period ends, before exposing quarantined birds to other captive birds. Diagnostic procedures for *Salmonella, Chlamidia,* tuberculosis, and other significant diseases of concern should be considered; an avian veterinarian should be consulted to determine which tests should be performed. For West Nile virus-susceptible species (e.g. corvids, vultures, and raptors) maintained in outside aviaries, an assessment of serologic status with respect to West Nile virus or other vector-borne disease should be considered if there is evidence of recent and localized increase in West Nile virus activity. Outdoor housing, which is often needed for large flight areas and normal social groups, remains appropriate except in case of outbreaks. In that case, indoor housing may be appropriate on a temporary basis. At present, vaccines for birds are not yet considered effective and are not commercially available (Davis et al. 2008; Jarvi et al. 2008). A wildlife health professional should be consulted for assessment and testing.

Plan ahead for post-quarantine disease protection. Some infectious agents (e.g. *Coccidia* and *Mycoplasma spp.*) are shed in feces by infected birds and may contaminate the housing or substrate (Dhondt et al. 2007a; Dhondt et al. 2007b). Replace or sterilize perches, substrates, and especially soil substrate, in outdoor aviaries where new birds are to be quarantined or

released. If infected, these birds should be treated and when cleared of infection moved to enclosures with clean substrates. The substrate in the original enclosure should be disinfected or replaced. Any potentially contaminated soil from the quarantine aviary should be disposed of off-site and replaced before that space is again used to house birds. Check local and state regulations for disposal.

Specific protocols may require some modifications of strict quarantine. For example, in song learning experiments, nestlings or fledglings taken in the field at a known age may have to be transferred directly into a laboratory experiment such as an anechoic chamber, which should thus serve as a quarantine space if possible.

D. Prevention and control of animal disease

The investigator and all animal care staff should observe all laboratory birds closely at least once a day for clinical signs of illness, injury, or abnormal behavior. Investigators and animal care staff should familiarize themselves with common problems and signs of illness. All deviations from normal conditions and deaths from unknown causes should be reported at once to the investigator and person responsible for veterinary care. Common signs of illness include:

a. unwillingness to move; listlessness;

b. "fluffed" feathers - a bird looking cold when others are fine;

c. closed or half-closed eyes; an unusually sleepy bird;

d. drooping wings;

e. limping or unwillingness to put weight on a foot;

f. any change in stool consistency;

g. feces adhering to feathers around vent;

h. obstructed nares or matted feathers around the nares;

i. decreased consumption of food, increased consumption of water;

j. open-mouthed breathing, panting

Consult a veterinarian immediately if any of these signs are observed.

Generally speaking, by the time a bird looks ill, the illness is usually well advanced. Therefore, an immediate response to apparent illness is required. The potentially ill bird should be isolated immediately. A sick bird should be moved to a room designated at least temporarily as a treatment room. Small incubators or commercial brooder units are ideal to hold ailing birds, but be sure that the unit provides adequate ventilation and can be disinfected later. Food and water may need to be placed on floor if bird is too weak to continuously perch. Do not come into contact with the sick bird before caring for healthy birds without taking precautions (such as disposable outer garments and hand-washing) to prevent transmission of illness.

If the illness is contagious, by the time it is detected, other birds have probably been exposed, and treatment of additional birds may be necessary. Regular monitoring of feces for both macro and micro-parasites is prudent and non-invasive, especially for birds in outdoor flight cages, exposed to local wild birds.

All laboratory or aviary birds that die from causes other than a planned portion of the experimental design should be submitted for necropsy. A diagnostic facility that deals with diseases of wild birds will be the best choice if birds were brought in from the wild. Some avian diseases are zoonotic, so determining cause is both a research care issue and a human safety issue. The USGS National Wildlife Health Center provides a wealth of information, including a Field Manual of Wildlife Disease: General Field Procedures and Diseases of Birds (Friend and Franson 1999).

E. First aid

Bleeding is the most common emergency. Bleeding from the mouth or nares usually indicates serious internal injury that requires immediate veterinary attention.

Newly forming feather that still have a blood supply in the feather shaft may break. These broken blood feathers may clot on their own, but if they do not, one of several actions may need to be taken. If the damage to the feather shaft is minimal, then the blood flow can be stopped by applying corn starch or a styptic to the site. If the break is close to the skin, corn starch should be used as the coagulant since styptic may irritate soft tissue. Some use needle-nosed pliers to pull the broken feather. This is rarely necessary and should be performed only by experienced

personnel. Broken blood feathers and small flesh wounds can be closed using new, fast-drying versions of cyanoacrylate surgical glues such as Dermabond®, LiquiBand®, SurgiSeal®, and Nexaband® which take under a minute to set and are far less toxic than earlier surgical glues. Older cyanoacrylic tissue glues (e.g., Tissu-Glu®, Ellman International, or Vetbond®, 3M Corp. took several minutes to dry, which markedly increased handling time. Household super glues are toxic to tissues It may be advisable to flush the wound with sterile saline solution and apply antibiotic ointment on the wound.

Overgrown toenails and beaks are also common problems. Beaks can be trimmed using a small dremel tool. Toenails can be cut with blunt scissors or a toenail clipper, avoiding the quick (which can be impossible to see in birds with dark nails). Veterinarians often have an assistant hold the bird in a towel but this can be difficult for large or strong birds as they are often able to free their wings. A stockinette may be useful in restraining these birds. Kwik-Stop styptic powder or gel should be available to stop bleeding in case the quick is cut. Never use styptics on skin or soft tissue. Natural methods of beak growth regulation can be achieved by providing birds with hard surfaces upon which they can rub their beaks.

F. Separation by species

Several species may be routinely held in a single area or facility, provided the requirements or habits of the species are not in conflict and social factors such as interspecific dominance over food or nervous responses of one species to another's calls does not result in additional stress (Hahn and Silverman 2007). Although some experiments may necessitate physical separation of species, others may require mixed-species housing (e.g., a study of brood parasitism by viduine finches on estrildids, or a study of interspecific song acquisition).

Studies of social behavior of group-living species may require housing birds in groups in the same enclosure. Because of the diversity of housing needs, the method of housing must rely upon the expertise of the investigator. Care should be taken not to mix species if one may carry a disease that is easily transmitted or fatal in the other.

G. Daily care

Staple food

Animals should be fed palatable, uncontaminated, and nutritionally balanced food daily or according to their particular requirements, unless the experimental protocol requires otherwise. Birds need to have food readily available to them in the morning, due to their high metabolism and energy expenditure throughout the night to perch and maintain body heat. Feeding *ad lib* can be problematic with some species, such as psittacines, which may become obese due to the constant food supply and the relative lack of activity in confinement. Diet should take into consideration the natural diet, including micronutrients, such as carotenoids that are involved in immune function as well as normal mate choice (Blount et al. 2003). One major problem with formulating diets is the greater diversity of foods available in the wild, even to specialist species (Koutsos et al. 2001). For instance, seed eaters may eat dozens of different seed types and a mix of only two or three seed types will greatly reduce the total nutritional breadth (Pruitt et al. 2008). Consider time of year, ambient temperature and breeding activities, all of which may alter the optimal diet even within species (Harper 2000).

Because diets can be highly specialized, they must be tailored to the species in question, with attention paid to role of the natural diet in beak maintenance such chewing materials and the role in social behavior. Where possible, food should be presented in ways that foster natural foraging behaviors. A zoo nutritionist, avian veterinarian, or other expert should be consulted before formulating a diet or adding grit, vitamins, or other supplements to an existing diet that is specific to the species, feeding behavior and possible formulas for cleanliness versus nutrition.

The form of food and its presentation are important to many species. Wild birds may prefer more caloric food items when offered beside less caloric food items, and it would be unwise to assume a bird would select a balanced diet (but see Boa-Amponsem et al. 1991; Steinruck and Kirchgessner 1992, 1993; Denbow 1994; Lee 2000 for evidence that poultry can seek specific nutrients). Some species may become "addicted" to certain preferred or easily eaten foods, e.g., sunflower seeds, and will refuse anything else, even to the point of severe malnutrition. Placement of the food in the cage may alter its appeal, e.g., vigilant, predator-phobic birds may be unwilling to feed on the floor if newly placed in a large cage. Alternatively, feeding on the

floor or other location that requires flight to and from perches may increase energetic expenditure and help maintain fitness (Schnegg et al. 2007).

If hand-rearing birds, consider that experience with a varied diet early in life may help prepare them to accept a broad healthy diet as adults and will be especially important if they are released (Liukkonen-Anttila et al. 1999; van Heezik et al. 2005; Moore and Battley 2006).

Grit

Many birds may require grit in their gizzards to process their food or as a source of minerals. The need for grit differs based on both diet and taxon; not every species needs or will benefit from the addition of grit to the diet (Amat and Varo 2008). While some birds may require grit to digest their food, there is concern among some bird researchers that improper grit in the diet could lead to an increased risk of impaction (Gionfriddo and Best 1999). López-Calleja et al. (2000) found that grit consumption varied greatly with season in the Rufous-collared Sparrow (*Zonitrichia capensis*) and laboratory experiments suggested that grit consumption is voluntary behavior rather than an incidental ingestion. However, grit use is less common in insectivores and frugivores (Gionfriddo and Best 1996) and while it may reflect a need for minerals such as calcium, it is best to avoid offering grit *ad lib* to avoid impaction.

If grit is needed, commercial sterilized bird grit is available from feed stores or pet stores in bulk. Crushed oyster shell or sterilized crushed hen's egg shells may be mixed in the grit as a source of calcium and other minerals. Some investigators may prefer incorporating calcium and minerals directly in the staple diet. Calcium and other minerals can also be offered in other forms. See Dhondt and Hochachka (2001) and Dawson and Bidwell (2005) for information on calcium requirements of breeding birds.

Vitamins

Supplemental vitamins might be needed, depending on the quality of the bird’s rations. Commercial diets, such as the pellets available for psittacines, already contain vitamin and mineral supplements; additional vitamins and minerals should be provided only after veterinary consultation. Overdoses of some vitamins can be toxic (e.g., Vitamin A, Allen and Ullrey 2004), and can produce symptoms similar to vitamin deficiency (Koutsos et al. 2001). Vitamin

deficiencies may show up in varied ways. Physical symptoms of vitamin A deficiency include thickening of the skin, especially around mucous membranes, and poor body condition (Koutsos et al. 2001). Vitamin deficiencies in psittacine species can manifest themselves in behavioral problems; for example, vitamin A deficiency can result in feather picking (Torregrossa et al. 2005) and alter production of vocalizations (Koutsos et al. 2003).

Vitamins may be given in food or water. Most pet stores sell water-soluble vitamin powders. Some supplements are meant to be placed in bathing water or misted on feathers and ingested during preening. This is a handy technique for finicky eaters. Drinking water supplements should be avoided in species that do not drink large amounts of water (e.g. arid zone species), because the birds may ingest very little. Conversely, in species that dunk their food (e.g., many corvids), vitamins in the water could increase the risk of vitamin toxicity (Allen and Ullrey 2004). Researchers should consider the lack of control over the amount of vitamins taken by individuals when vitamins are added to a communal water dish.

Water

Give fresh water daily. For species that normally bathe in water, water should be provided in open, shallow containers to allow bathing. Some birds may be misted for feather maintenance. Containers should be made of non-porous materials such as heavy, tempered glass, glazed porcelain, or stainless steel.

Perches should not be placed directly over open water containers. Drinking water may also be provided in commercial bird-drinking tubes. Drinking tubes for small mammals (nipple waterers) may be used if birds will adapt to use them, but some birds will refuse to drink from these. Automatic tube watering systems reduce spillage onto cage liner material, thus reducing the growth of fungus and allowing the main water source to be cleaned without opening the cage. Open water containers should be washed daily with soap and water and at least twice weekly with diluted household bleach. Rinse thoroughly with clean water. Prepare a fresh dilution for each use, as bleach breaks down in water after 24 hours and loses its disinfecting properties. Other options include A-33® or Simple Green®. Simple Green® is non-toxic and biodegradable and has even been used to clean oiled wildlife. It does not pose the risk of soil contamination if water tubs for large birds need to be cleaned on site. Closed water bottles may not need daily cleaning.

Cleaning

Cages should be thoroughly cleaned at appropriate intervals determined by how quickly they are soiled as well as problems with mites or other pests. Cages should always be cleaned with disinfectant and/or in commercial cage washers after use by one bird is completed and before another is introduced.

Change cage liners often enough to maintain good hygiene. Seed-eaters usually have relatively dry feces and, for such species, cage bottoms may be lined with newspaper and changed less frequently than other species. Insect and fruit eaters tend to have messier (and smellier) droppings and should have the cage trays (bottoms) cleaned as often as necessary to maintain a clean landing and feeding area. Species-appropriate cleaners should be used on cage trays and cage wires. Cage liner materials range from wood particles or pelletized paper to newspaper or commercially available cage liner paper. Newspaper is now generally printed with soy-based inks, but some inks may be toxic to birds that chew or shred cage paper. Water absorbency and the ease of thoroughly cleaning out and replacing used lining material are considerations. Cage lining material should be stored in an area secure from rodent or other contamination.

When choosing cleaners, it is wise to consult the Material Safety Data Sheets to make sure the chemicals involved are safe for birds. The amount of ventilation should also figure in the choice of cleaning agents. Other considerations include the effectiveness of cleaners in reducing or killing specific disease organisms or whether a bird might contact or even ingest cleaning agents through food being dropped on the floor and then eaten or through chewing on washed perches or hanging on cage wire by their beaks (as do psittacines). For species that dunk food in their water dishes, researchers should take extra care to rinse water dishes thoroughly after washing.

Wash seed dishes twice weekly using a safe and effective disinfectant such as sodium hypochlorite (household bleach) diluted 1/10. Prepare a fresh dilution for each use. Rinse thoroughly with clean water. The amount of ventilation may also influence in the choice of cleaning agents. Other considerations include: the effectiveness of cleaners in reducing or killing specific disease organisms; whether a bird might contact or even ingest cleaning agents such as through food being dropped on the floor and then eaten or through chewing on washed

perches or hanging on cage wire by their beaks (as do psittacines). See Patnayak et al. (2008) on the effectiveness of different disinfectants and hand sanitizers. Industrial wet/dry vacuum cleaners are useful aids in floor maintenance. Small, hand vacuum cleaners are useful for spot cleaning. Investigators should not use these when birds are breeding, as undue disturbance may cause nest disruption.

H. Caging and housing

Birds in captivity can be held in cages, aviaries, and outdoor pens. Depending on the species, one or another might be more appropriate, and the maintenance of each differs. The size, shape, and design of the enclosure shall be appropriate for the species being housed and allow space, without overcrowding, for the normal movements of each bird. If experimental design requires that birds be housing individually, it may not be possible to provide enclosures large enough to permit flight.

Cages

Stainless steel, galvanized steel, fiberglass, or plastic cages permit easy cleaning as they may be steam-cleaned when necessary. New cages containing galvanized steel or galvanized mesh should be brushed with a wire brush and vinegar solution before they are first used to reduce the possibility of zinc poisoning (Howard 1992). Soldered joints should have a protective coating to prevent lead poisoning or have lead-free solder, though the content of lead-free solder should be investigated to rule out other possible toxicity. Painting metal surfaces with a durable, moisture-proof substance such as epoxy paint or spar-varnish can protect against rust. These paints should resist cleaning agents, disinfectants, and scrubbing. Wood cages be more difficult to clean and maintain and thus, may not appropriate. Cages, runs, and pens should be in good repair and devoid of sharp protrusions that might injure the birds or hook on bands.

If experimental designs require the use of wood-and-wire cages, these should be checked frequently for mites. Pyrethrin sprayed into cracks and corners will kill these pests. Always consider the toxicity of pesticides to birds that may inhale or ingest them. Post (2007) provides information on low risk pest management. Cages that have been infested with mites must be free of them before being reused.

Minimum Cage Size

Cages should provide sufficient room for normal maintenance behavior and wing-flapping. Minimum size depends on whether birds are just being maintained in the laboratory or whether breeding is desired. Because of the diversity of avian species, investigators must assume ultimate responsibility in determining adequate cage size, but there are published minima for some species (e.g., Hawkins 2001). Cage shape is also important in allowing normal movement; for instance, a cage with a greater length supports flight better than a tall cage of the same volume. Conversely, a tall cage can allow birds to get above care personnel and feel safer. Zoo publications (e.g. Association of Zoos and Aquariums Animal Care Manuals) can provide information on specific species.

Cage Bottom

Paper, fine sand, wood-shavings, or newspaper are among the materials that may be used on cage bottoms. Newspaper is now generally printed with soy-based inks, but some inks may be toxic to birds that chew or shred cage paper. In choosing material, consider the need for water absorbency and the ease of thoroughly cleaning out and replacing used lining material. Avoid ground, dried corncobs (Sanicel®), walnut shells, or any other substrate that may promote the growth of fungi, especially *Rhizopus* and *Isospora.* The probability of fungal infections accrues over time, so even large flight cages or aviaries need to be disinfected at regular intervals. (Bocetti and Swayne 1995) recommend disinfecting aviaries annually with a combination of A-33 (Ecolab, Inc), 5% sodium hypochlorite, and a methyl bromide fumigant. Wire bottom cages may be appropriate for some species (e.g., some galliforms), but effects on birds' feet should be considered. They should be avoided for seed-eating song birds as some individuals may knock their entire seed allotment through the wire. Cage lining material should be stored in an area secure from rodents or other sources of contamination.

Perches

Perch type should be appropriate to the species. Perches should provide good footing. They should be made of durable and sanitizable materials such as metal, plastic, or PVC, or of economically replaceable material such as wood. Wooden perches are preferred for small birds;

ideally, natural branches of different sizes should be used. As long-term use of metal or plastic perches may increase the incidence of foot sores due to slippage, it may be necessary to wrap the perch with a non-abrasive, non-slip surface. For example, raptor keepers often wrap rope around a perch. Perches should not be covered with sandpaper. Inappropriately sized perches will lead to leg swelling. A variety of perch sizes provides more foot exercise and relieves repeated pressure on the areas of the feet and toes that come into contact with the perch. This pressure can lead to bumblefoot, a common affliction in captive birds. The initial inflammation can lead to infection, degeneration of the bone, and ultimately the loss of the foot or entire leg. Concrete perches may be good for toenail and beak maintenance.

Aviaries

The natural behavior of some species entails social groupings. In such cases, housing of groups may enhance well-being. Naturalistic social groupings may also be desirable in behavioral studies. Where space is available, aviaries can accommodate groups and allow birds to fly and maintain their flight musculature. It may be harder to catch individuals flying free in an aviary. Double entry doors are essential to prevent escape. Ideally, the doors will interlock to prevent the exterior door from being opened before the interior door is closed.

Every substrate has drawbacks. Concrete, for example, can lead to foot ailments in ground-dwelling birds (Martrenchar et al. 2002). The floors of indoor aviaries may be covered with newspaper, washed and sterilized sand (commercially available, often as playbox sand), or wood shavings. Sand and wood shavings should be replaced at regular intervals to reduce the build-up of enteric bacteria and fungus. Wood shavings may require the use of prefilters to prevent clogging of air filtration systems. Such systems may rapidly accumulate, and become a source of fungal spores. They should be changed monthly (Bocetti and Swayne 1995).

Surfaces constructed from porous materials should be coated with a durable moisture-proof, seamless substance (e.g., epoxy paint, spar-varnish, etc.). These paints and glazes should resist cleaning agents, disinfectants, and scrubbing.

Climate and facilities permitting, birds may be housed in outdoor aviaries. At least one side of the aviary and part of the roof should be covered to protect birds from wind and rain. Larger outdoor aviaries may contain a permanent covered enclosure to serve this purpose. Shrubs and trees in pots or planter boxes, or planted on the ground in the aviary, enables birds to hide when

potential predators or unfamiliar human are sighted. This gives the birds a sense of security and promotes well-being. Bunches of leafy boughs lashed together with rope or wire and hung on the aviary sides or shelter walls can provide the same effect. Grass may be planted on the ground. Plantings may attract insects relished by many birds. However, vegetation may make it difficult to detect and exclude pests and predators and to clean the enclosure. A black-light trap may also be installed to attract live insect food.

Extreme care must be taken with outside cages to prevent access by predators. Climbing predators and snakes are especially dangerous. Single raccoons are known to kill confined birds as large as cranes and pull sleeping birds through chain link fencing; additional protective barriers should be placed near perimeter perching sites. Further, raccoon droppings may carry parasites *(Baylissascaris procyonotis*) capable of attacking the avian central nervous system (Ritchie et al. 1994). Electrified fencing outside the enclosure fencing but out of reach of the birds' beaks can be effective in deterring some predators as well as enhancing security.

Nest Boxes and Nesting

Although metal boxes can be used for some species (e.g., large psittacines), many species prefer (or require) wicker or wooden nest boxes into which they can carry grass, coconut fibers, excelsior, or feathers. Parrots also breed in wooden boxes into which a layer of wood shavings may be introduced. Nest boxes should be made of materials that don't allow buildup of heat and moisture. Some birds may build nests in bushy boughs tied together in a bunch to simulate a bush, or in a potted Boston fern or ornamental bunch grass. Consult the literature and zoo experts for species-specific information about successful captive breeding of individuals. Consider cleaning problems during nesting (e.g. parrots do not remove feces from the nest box).

Lighting

Many bird species see into the ultraviolet range (Cuthill and Partridge 2000; Rajchard 2009) and use ultraviolet cues in various visual behaviors such as mate choice and foraging (Maddocks et al. 2001) so it may be advantageous to use full spectrum light sources in indoor facilities. Young birds may also benefit from full spectrum light (Maddocks et al. 2001) and is important for health and avoiding diseases such as rickets (Edwards et al. 1994). A small night light placed near the

food source is desirable in outdoor aviaries during cold weather, to allow late evening feeding. A night light may also alleviate stress in recently captured birds and in certain experimental protocols but it is important that night lighting be minimal so as not to interfere with natural photoperiodicity (except, of course, where manipulation of photoperiodicity is part of the experimental design).

Unless experimental protocols dictate otherwise, birds normally should be maintained on photoperiods natural to the species. These may vary with the species, and the schedules of long and short photoperiods must be left to the discretion of the investigator, as these schedules are often tied to an experimental time table and may differ according to species. Breeding and molting may be facilitated or suppressed by photoperiod and thus affect research goals inadvertently if not properly planned. Some birds will produce eggs continually, which can deplete calcium levels; egg-binding is also a potential problem. Bird breeders commonly reduce the incidence of egg production by increasing the duration of the periods of darkness. Behavioral problems such as aggression resulting from increasing hormone levels may also be managed by increasing the duration of the periods of darkness.

Temperature

Maintain a temperature range appropriate to the species with a thermostat-controlled heating source. The recommendations for several common species offered by the Guide for the Care and Use of Laboratory Animals (ILAR 1996) are based on professional judgment and experience. Although the Guide also recommends that daily temperature fluctuations be kept to a minimum to avoid repeated large demands on the animals' metabolic and behavioral processes to compensate for changes in the thermal environment, it also recognizes that the recommended temperature ranges might not apply to captive wild animals, wild animals maintained in their natural environment, or animals in outdoor enclosures that are given the opportunity to adapt by being exposed to seasonal changes in ambient conditions. The same would be true of daily fluctations. However, extreme temperature changes may be stressful to the immune system or even lethal, and birds should be kept away from areas with appreciable fluctuations in temperature. Normally, room temperatures should be checked daily. In outdoor aviaries, a heat source may be necessary. Infrared bulbs, which will not interfere with light/dark cycles are available in pet stores. Portable heaters can pose a fire hazard. The Consumer Product Safety Commission recommends that portable heaters be turned off when no one is in

the area to monitor them. They may be necessary for emergency use, but be sure that the units meet current safety standards, that they are kept at least three feet from combustible materials, and be sure someone is present at all times.

Humidity*, *ventilation, and air exchange

Standards for humidity, ventilation, and air exchange have not been established for birds other than poultry species. Keep humidity within the normal range of the natural environment of the species, particularly if normal behavior and reproductive success are expected. Tropical species can incur health problems such as skin flaking and feather plucking if housed in an environment that is too dry. Hatching success of eggs of some species is sensitive to humidity. The ILAR Guide (1996) stipulates that 10-15 fresh air exchanges per hour is an acceptable general standard.

I. Enrichment for birds in captivity

The concept of behavioral enrichment for captive animals as a welfare issue extends to birds in captivity (Dawkins 2006). The goals of enrichment range from providing opportunities for natural behaviors such as exercise, foraging, or social interaction to providing new challenges that engage birds cognitively, relieve “boredom” and offset the development of abnormal repetitive behaviors (Meehan et al. 2003). The latter may be particularly important for specific groups (e.g., Psittacidae and Corvidae) but the concept is relevant to all species. The need for and nature of enrichment will vary depending on the research protocol, time in captivity, space and numbers of individual birds housed, and other factors. There are numerous treatments of enrichment techniques in the aviculture literature, zoo publications, and increasingly in academic literature. A nonprofit organization known as The Shape of Enrichment organizes workshops and regional and international annual conferences on environmental enrichment, publishes a quarterly journal, and maintains a lending library of training videotapes.

J. General maintenance

Storage of feed and supplies

Store supplies and equipment in cabinets or rooms that can be fumigated, i.e., that are not used to house animals. Store feed and bedding supplies in rodent-resistant, covered, labeled containers that are easily cleaned and disinfected. These may be housed in close proximity to the bird colonies or aviaries. Post (2007) provides information on low risk pest management.

Keep food at appropriate temperatures to maintain freshness and avoid bacterial or fungal growth or deterioration of fats. The shelf life recommended by the manufacturer should be noted and containers marked with expiration (discard) dates.

Disposal of waste material

Keep garbage cans holding waste material outside the immediate area of the laboratory or away from the aviary. Use of garbage liner bags and daily removal of garbage is encouraged. It is a good idea to label the contents of garbage cans as they may be used for either garbage or storage of food or bedding.

Cleaning laboratory floors

Sweep or mop laboratory floors regularly and maintain in a clean condition. Choose floor cleaners both for their ability to disinfect and inhibit the growth of harmful organisms and also for safety for inhalation, ingestion, or contact exposure.

Provisions for emergency care

Post the names, addresses, and phone numbers (including emergency numbers) of consulting veterinarians, physical facility personnel, and individuals responsible for the animals in a prominent place. Animals should be observed and cared for every day, including weekends and holidays, to safeguard their well-being and to satisfy research requirements.

Dead animals

Wash and disinfect the cage after the carcass has been removed. It is advisable for all dead animals to be necropsied by a veterinarian familiar with wildlife diseases. "Fresh" necropsies are preferable, but if that is not possible, dead birds should be refrigerated in a sealed plastic bag and taken to the veterinarian as soon as possible. If a delay of longer than 24 hours is likely, the carcass may be frozen and sent to the National Wildlife Health Center. See the National Wildlife Health Center video for shipping guidelines.

Depending on the condition of the carcass, dead birds may be valuable to museums, teaching collections, or other researchers. However, if the bird is not properly preserved and the data needed by scientists is not recorded, the time and energy it takes to bring the specimen to a museum or other research institution may be wasted. These instructions will help to ensure that your donation will be useful.

Prepare a label with the following information written in waterproof ink or pencil: date bird taken from the wild; date bird brought to you; date bird died; your name and contact information; (optional) cause of injury, if known; medical reports, including lab results (especially toxicology), medications, necropsy. Place bird and its associated label in a separate clear plastic bag. Using clear plastic bags is helpful when possible because then the receiving party can immediately see the specimen and determine its identity, quality, and preparation or sampling future. Close the bag and squeeze out as much air as possible. Ziploc bags or heat-sealed bags are best. It is helpful to place this bag in a second closed bag, particularly if the specimen is going to be stored in a freezer for some time before it is donated. For large birds, kitchen trash bags or larger trash bags are acceptable, but be sure to close the bag tightly. If you really want to do a professional job, put a wad of absorbent cotton or tissue down the bird's throat to prevent fluids from seeping out onto the plumage, then arrange the bird in the bag so the feathers (especially the tail) aren't bent and the head, neck, wings, or legs aren't projecting at awkward angles (they are easily broken when frozen).

If you need assistance finding an institution to accept your salvage specimens, the Ornithological Council can provide a list of museums that are willing to accept specimens. It is helpful to contact museum staff in advance, to determine if they have specific requirements, and to work out arrangements for shipping and shipping costs. Not every museum will accept every

bird. There is a cost associated with this process, and the specimen may not be of sufficient interest to warrant the cost.

K. Special considerations for aquatic birds

Aquatic species have special needs mainly to do with the anatomy of their feet and the importance of waterproofing in their plumage. Species differ widely, so no single prescription will apply to all aquatic birds. Researchers should consult species-specific information such Animal Care manuals of the American Zoo and Aquarium Association.

Waterproofing of plumage

Maintenance of waterproof plumage is fundamental to the comfort and health of all aquatic birds and requires access to absolutely clean water. Aquatic birds must be allowed to bathe at least once a day. Diving or pelagic birds require enclosures that allow swimming and an easy exit from the water. In general, a pan of water in the cage is insufficient unless it is large enough to allow bathing *and* water is changed frequently. How frequently will depend on how rapidly a dirt, feces, or dropped/dunked food accumulates. If a film appears on the surface, the water should be changed. Even very light films will interfere with waterproofing. In most cases, pans of water should be changed at least twice daily. If it is possible to provide it, a flow-through system for water is less labor-intensive, more effective, and less disturbing to the birds. Such systems should have a constant input of clean water and drain constantly from the surface. Drainage from the surface can be accomplished either by use of a standpipe in the drain, or by overflow over the top edge of the pool/pond/container. Very simple systems can be created by putting a running hose in a commercially available, plastic, child's swimming pool, and letting the water overflow the top. Where standpipes are used, the top of the pipe must be covered with screen or netting of small enough mesh to exclude the birds' legs and toes. If drain water is filtered instead of thrown away, filtration must remove bacterial and viral pathogens as well as particles that cause surface films. Rubega and Oring (unreported pers. obs.) report excellent results keeping shorebirds in a filtered system that employs activated charcoal and a UV sterilizer, and filters particles larger than two micrometers. In any flow-through system, feces and food will tend to accumulate at the bottom. These must be removed by siphoning or wet-vacuuming at least

twice weekly, but as frequently as is required to prevent decomposition and/or stirring up into the surface layer.

Flooring and foot problems

Aquatic birds are highly susceptible to wounds and infections of the feet and legs that result primarily from pressure sores developed when the bird is forced to stand for long periods on hard flooring. These sores become infected when birds walk in feces or dropped food. Infections of this kind are painful and debilitating, and can cause the loss of digits or limbs. Untreated infections can lead to slow and painful death and always lead to some loss of function. Any bird that shows signs of limping, reluctance to put weight on a foot or leg, redness, or swelling in the feet or legs should be closely examined immediately. The presence of foot sores requires immediate (and repeated) treatment with a topical disinfectant, isolation from other birds, and modification of cage flooring. Contact a veterinarian immediately.

For birds that will be held for more than two to three days, cage and, in some cases, wading pool bottoms must be lined with some resilient material. Possibilities range from natural materials such as sand or small gravel to plastic or rubber mats. All have their pros and cons, including risk of ingestion and impaction (sand), and buildup of bacteria or fungi and hence frequent replacement (sand, wood shavings) to slipperiness and the risk that taller wading birds or keepers will fall. Rubber or plastic mats (e.g. carpet padding) and a commercially available, slip-proof, rubberized waterproofing system called Tufflex□ are among the possible flooring materials. Flushing these surfaces with running water is reported to give good results (Rubega and Oring, unpublished pers. obs).

L. Raptors

Standards applicable specifically to raptors are discussed in several books (Carpenter et al. 1987; Redig et al. 1993; Naisbitt and Holz 2004; Arent 2007; Bird and Bildstein 2008). As raptors comprise a large percentage of rehabilitated wild birds, rehabilitation guidelines are useful resources for those holding raptors in captivity. The U.S. Fish and Wildlife Service in 2003 published a new regulation establishing rehabilitation housing standards using as a guideline the standards developed by the National Wildlife Rehabilitators Association and the

International Wildlife Rehabilitation Council (Miller 2000). Copies may be obtained by contacting either the National Wildlife Rehabilitators Association or The International Wildlife Rehabilitation Council. These guidelines address housing for both waterbirds and raptors, including enclosure size.

M. Identification and records

A durable label attached to each experimental cage should contain the following information:

a. Species; number of animals and individual identifying information

b. Date experiment started, and projected end (approximate);

c. Feeding instructions;

d. Name of responsible investigator and contact information, including emergency contact numbers if the investigator is unavailable.

Metal label holders will be helpful if the birds chew readily (e.g. psittacines).

Records should include source and eventual disposition of each animal. Permit and protocol numbers should be prominently displayed in the animal holding room. The investigator is responsible for maintaining records concerning the histories and dispositions of all individual birds as required by local, state, and federal law.

It is recommended that birds be leg-banded with plastic or metal bands to facilitate identification of individuals. Open bands can catch on caging but it is difficult, if not impossible, to put a closed band on an adult bird. See the chapter on Capture and Marking for detailed information about methods of marking individual birds. Implanted microchips are a good option if birds can be approached with a microchip reader or if microchip readers can be incorporated into perches or food stands.

N. Disposition of birds after studies

Upon completion of studies, researchers should release field-trapped animals whenever this is practical and allowed under national, state, or local laws and under permit conditions. Even

then, do not release animals if release might be detrimental to the existing gene pools in a specific geographic area or if the animal has been exposed to potential pathogens that could be released into wild populations. Never release animals if their ability to survive in nature has been irreversibly impaired by major structural or physiological damage, e.g., surgical deafening. Birds that have been so impaired, but are otherwise healthy may be donated to zoos or other appropriate organizations that hold permits to maintain such birds. Animal should also be assessed for the presence of stereotypic or otherwise detrimental behaviors that may have been acquired in captivity. Pre-release conditioning, such as housing in a large flight cage or aviary to improve flight musculature, is essential. Be sure they recognize natural food and gradually remove any supplemental foods that they will not encounter in the wild. Post-release supplemental feeding may increase the chance of survival by giving the bird adequate nutrition while it learns where to find natural food sources. Each bird should be examined for signs of injury.

Release birds at or near the site of the original capture, unless conservation efforts or safety considerations dictate otherwise. Otherwise, release them into areas where conspecifics exist. Some states prohibit the release of animals or require a permit, so always consult the state wildlife agency in the state where birds are to be released. Birds should be released early in the day so that they will be able to feed and locate suitable roosting sites before dark. Wait for favorable weather conditions and release birds when seasonal conditions are conducive to survival. If birds are wearing color bands, remove them prior to release or check with the U.S. Bird Banding Laboratory to determine who is using color bands in your area on that particular species. Contact those researchers to avoid color combination overlap.

Captive animals that cannot be released should be properly disposed of, either by distribution to colleagues for further study, by donation to a zoo or aviary as permitted by law, or by preservation and deposition as teaching or voucher specimens in research collections.

In both field and laboratory, the investigator must be careful to ensure that euthanized animals really are dead before disposal. When carcasses are unacceptable for deposition as museum specimens, other research purposes, or teaching purposes (as may be the case if necropsy has been performed), disposal of carcasses must be in accordance with applicable regulations. Animals containing toxic substances or drugs (including euthanasia agents such as barbiturates) or that have died from transmissible diseases such as West Nile virus must not be

disposed of in areas where they may become part of the natural food web. Incineration is a better option.

O. Variations on standard procedure

In most experimental protocols it is desirable to keep disturbance resulting from routine inspection, maintenance, and feeding activities to a minimum. Captive-breeding birds may desert nests if disturbed frequently and behavioral patterns may be disrupted for several hours (or even permanently) if subjects can detect intrusion or potential intrusion (noise/sight of investigator or animal keeper). In these cases, suspend routine daily inspection, and establish a schedule for feeding, watering, and cleaning that minimizes interference with data collection but simultaneously ensures health and well-being of the experimental subjects. For example, cages can be cleaned less often and birds checked with video monitors or through one-way glass. For some species, fresh water and food can be provided to last for several days. Containers can then be removed, washed, and sterilized twice weekly. In some circumstances, it may be possible to reduce intrusion even further by providing food and water mechanically, e.g., automatically filling or rotating food hoppers, drip tubes, etc. Frequency of disturbance can be left to the discretion of the investigator provided that the well-being of the subjects is not compromised and that the procedure has been included in an approved experimental protocol. Facility inspections should be performed with sensitivity to the possibility of disturbance by unfamiliar individuals.

P. Zoonoses and other risks to humans

The routine handling of animals entails certain personal risks. Steps must be taken to protect the handler. Training is the best way to learn how to handle a bird without injuring the bird or running the risk of a bite. Any wild animal, even if not aggressive, may attack with painful if not serious results.

A variety of diseases are transmittable from birds to humans (Evans and Carey 1986; Abulreesh et al. 2006). Common among these are campylobacteriosis, histoplasmosis, ornithosis, tuberculosis, salmonellosis, and *Yersinia spp.* (enterocolitia and pseudotuberculosis) as well as tick-borne diseases. The most well-known of these is a form of chlamydiosis known as

ornithosis, and often, but inaccurately, termed psittacosis or parrot fever. In fact, this highly contagious agent (*Chlamydia psittaci*) is known from more than 120 nonpsittacines and several domesticated mammals (Gerlach 1994). Its symptoms are flu-like, and, because it is not a common disease, it is often misdiagnosed. Bird handlers suffering from atypical pneumonia, recurring fever, or from otherwise unaccounted-for chest pain, anorexia, dyspnea, or profuse sweating should inform their physician of the possibility of ornithosis. The standard antibody test is subject to a cross-reaction with *Chlamydia trachomatis,* a human venereal disease.

Depending on the source of the birds and the time of year, they could also carry West Nile virus. Some species, particularly corvids, will become ill or die while others may have subclinical infections for a short time (Komar et al. 2003). Both saliva and feces may contain infectious virus (Komar et al. 2002; Kipp et al. 2006). Healthy adults may experience mild flu-like symptoms; the disease has been dangerous only for the elderly and the immune-compromised. Avian influenza variants such as H5N1 pose new threats for handling many species including but not limited to gallinaceous birds and waterfowl (Redrobe 2007; Siembieda et al. 2008). As of 2009, extensive monitoring of wild birds in North America has detected no highly pathogenic H5N1-positive birds. For recent information, see the American Veterinary Medical Association publication *Zoonoses Updates*. See also the Ornithological Council's peer-reviewed fact sheets on precautions researchers can take to avoid contracting West Nile virus or H5N1 highly pathogenic avian influenza (should the latter occur in North America; live birds cannot be imported from countries and regions where H5N1 highly pathogenic avian influenza occurs) and other zoonotic disease.

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