Journal of the American Association for Laboratory Animal Science
Copyright 2007
by the American Association for Laboratory Animal Science
Vol 46, No 4
July 2007
Pages 8–15

Overviews

Psittacine Birds as Laboratory Animals: Refinements and Assessment of Welfare

Isabelle D Kalmar,[1,*] Christel PH Moons,[2] Lieve L Meers,[2] and Geert PJ Janssens[1]

We address housing, refinements of husbandry, and some concerns regarding the use of parrots as laboratory animals. Because the duration of a project is most likely brief relative to the lifespan of the bird, among the most important goals is a well-established socialization program to maximize success of rehoming the birds after laboratory housing. We also present appropriate methods for catching and restraining parrots during experimental procedures. We discuss factors that contribute to appropriate laboratory and cage environments, such as the importance of cage location in the animal room as well as providing birds with suitable perching and enrichment devices. Finally, we review a few methods for scoring signs of compromised welfare in psittacine birds.

Abbreviations: CITES, The Convention on International Trade in Endangered Species of Wild Fauna and Flora.

The use of psittacine birds for scientific purposes and its reporting is subject to national legislation, which varies greatly between countries and states. In the United States, for example, any use of nonhuman vertebrate animals must be approved by an institutional animal care and use committee. In addition, scientific research activities involving endangered species, as defined by the Washington Convention on International Trade in Endangered Species (CITES), require permission from the US Fish and Wildlife Service. However, the US Department of Agriculture does not include birds in official statistics on animal use.[1] Statistics for fiscal year 2004 report only 1.1 million animals used in scientific procedures in the United States, but these do not include birds, rats of the genus *Rattus*, and mice of the genus *Mus* that are bred for research purposes.[1,52]

In comparison, member states of the European Community prohibit use of CITES I species (threatened with extinction; trade permissible only in exceptional circumstances) in animal research unless the objectives are preservation of the species or whenever the examined species is the only available model in fundamental biologic studies. In Europe, experiments on nonhuman vertebrate animals that do not involve invasive procedures (the prick of an injection needle is regarded as the threshold) need not be reported to or approved by ethics committees; humane killing also is excluded from reporting. Official statistics include all vertebrate animal use in reported experiments.[10,11] Of the 10.7 million total nonhuman vertebrate laboratory animals registered in Europe in 2005, fewer than 5% were birds, which were divided among 3 broad categories: domestic fowl, quail, and "other birds."[12] As another example, annual statistics of various Australian states are highly detailed and include all scientific use of vertebrate and higher invertebrate animals of the order Cephalopoda (octopus, squid, cuttlefish, nautilus). The 2004 annual report of the Queensland Department of Primary Industries and Fisheries, for instance, categorizes birds into exotic captive (575), exotic wild (492), native captive (124), native nonendemic (243), native wild (22413), and other (3294) birds.[45] Nevertheless, despite lack of official statistics, the number of psittacine birds used for scientific purposes is presumed to be quite limited.[22] Notwithstanding the limited use of parrots, specific guidelines for their housing and husbandry in laboratory settings are unavailable to date.

Concerns about the Use of Psittacine Birds in Laboratories

Domestication. Domestication is the process of adaptation to captive environments through genetic changes.[35] Domestication requires more than 1 individual lifespan of an animal species, and only a couple of dozen animal species have ever been domesticated. In Belgium and the rest of Europe, the total number of parrots kept in captivity is estimated to be 3 and 45 million, respectively.[17] The vast majority of these birds are either wild-caught or belong to one of the first few generations born in captivity;[35] adaptation to captivity occurs within their lifespan. Consequently, wild and captive psittacines share the natural behavioral repertoire and the response thresholds that trigger them to perform these behaviors. Therefore, parrots should be regarded as wild animals, which implies that they are not adapted to limitations in their natural behavior that may be caused by captive housing conditions.

Longevity. The most reliable records regarding the lifespan of free-ranging parrots mainly originate from a large-scale study in Australia, in which native birds were banded starting at the beginning of the 20th century. Among these tagged birds was a little corella (*Cacatua sanguinea*) that was at least 71 y old when it died. In captivity, larger species have a potential lifespan of 30 to 50 y, with individual birds living as long as 80 y.[3] Given the considerable lifespan of parrots, research projects involving parrots are merely briefs episode in these birds' lives. In general, considering the fate of animals after completion of research projects is essential, and this consideration is especially

Received: 10 Nov 2006. Revision requested: 27 Dec 2006. Accepted: 1 Mar 2007.
[1]Faculty of Veterinary Medicine and [2]Department of Ethology, Faculty of Veterinary Medicine, Ghent University, Ghent, Belgium.
[*]Corresponding author. Email: Isabelle.Kalmar@UGent.be

important in the case of long-lived animals such as psittacines.[24] Careful plans regarding the long-term fate of laboratory parrots are essential prior to beginning of research projects using these species. Three options are available for parrots upon the completion of their use in research: they can be placed under private care, humanely euthanized, or reintroduced into their natural habitat. However, performing euthanasia on healthy animals often is considered ethically questionable, particularly when dealing with endangered species or those with such long lifespans.

Release of the birds into their natural habitat implies an expensive and long-term commitment and should only be considered for species that have become critically endangered, globally or locally, according to the CITES criteria.[27] Reintroduction of previously captive parrots into the wild has 2 main drawbacks. First, despite inclusion of a preconditioning period to the local environment and food supply, the survival rates of released captive-reared parrots remain poor due to persisting deficits in basic survival skills such as foraging behavior, social interacting, and avoiding predators.[47] Second is the potential hazard of dispersal of infectious diseases to wild populations. Therefore, a thorough veterinary examination and quarantine period should always precede the release of birds.[2,46]

The survival of critically endangered species may be enhanced—and inbreeding abated—through the introduction of new individuals to very small populations. However, successful release into the wild is difficult to achieve and involves infection hazards, as mentioned previously. Therefore, placing the birds in private care or zoological collections can be considered as a valuable alternative independent of conservation status. For this purpose, all possible strategies that facilitate future placement should be incorporated into the research husbandry for these species to avoid the need for euthanasia of healthy animals.[24]

Encouraging acceptable behavior in the birds during their stay in the laboratory will enhance the willingness of people to become involved in their lasting care.[29,34,56] At the same time, the incidence of undesirable behavior, such as excessive screaming, feather destructive behavior, aggression, and extreme fearfulness—most of which behaviors are considered signs of psychologic distress[33-35]—can be reduced through environmental stimulation and behavioral training. For example, enrichment of barren enclosures significantly reduced the fear of Amazon parrots toward both novel objects and unfamiliar human handlers.[34] In addition, when used for studies that involve intensive human interaction (for example, studies involving avian cognition), parrots develop the need for a consistent amount of human attention, regardless of the continuation of the project.[24]

Intelligence. Although any interspecific comparisons of intelligence must be made loosely, parrots can exhibit levels of intelligence, for instance symbolic learning, similar to those of great apes and some marine mammals, as demonstrated in studies of the cognitive capacities of African grey parrots (*Psittacus erithacus*).[42] For instance, the main study subject in this work, 'Alex,' was taught meaningful use of the English spoken language, including the labelling of 50 different objects and materials, 7 colors, 5 shapes, and 3 categories (material, color, and shape). Furthermore, Alex can process queries involving concepts of relative size, absence versus presence, same versus different, and quantity up to 6.[43] Other psittacine subjects learned mirror-mediated discrimination and spatial location.[41] Altogether, these cognitive abilities suggest a level of intelligence that leads to questions regarding the psychologic welfare of parrots that are confined for lengthy periods in barren enclosures without behavioral diversions.[7,43]

Figure 1. Manual restraint of an African grey parrot. Note that the sternum is left unrestricted, one hand is used to immobilize feet and wings, and the thumb of the other hand presses towards the lower jaw, preventing the bird from biting.

Refinements in Manual Restraint

Some aspects of animal experimentation require catching and restraining birds, which will inevitably induce stress, but this is diminished by regular handling and appropriate handling techniques. In birds, catch and restraint efforts may provoke panic flights, which can result in feather damage or serious injuries such as fractures.[7,50] Appropriate environmental conditions and handling techniques can reduce the distress and fear the birds experience, chasing–capture time, and the risk of injury to both bird and handler. When attempting to capture birds, loud noises and other disturbing elements should be avoided, the environment preferably is lit dimly, and if possible the inside of the cage should be dark, as this situation is known to calm parrots.[50]

In addition, animal caretakers and all other personnel responsible for laboratory parrots should be instructed in appropriate handling techniques. Often parrots are considered dangerous to handle because they have large and powerful beaks. However, biting mainly occurs after it has been conditioned through inappropriate handling. In contrast, wild birds use their beaks almost exclusively for social interaction and to clasp onto or grasp objects. Because parrots are curious animals, they will often attempt to climb approaching objects, for instance a human hand that comes into close proximity. However, inexperienced or fearful caretakers may respond with hesitation or quick withdrawal, hereby teaching the bird to grab the hand with their beak. As a result, these birds might learn how they can use their beaks as a forceful method to manipulate humans.[56] When using a towel to catch a parrot, the animal must be approached from the front and never attacked from the rear or above, as this stance may incite the parrot to react as it would to an assault from a predator.[55]

To restrain the parrot safely, the lower jaw of the beak, the feet, and the wings should be immobilized. Both the legs and the long primary feathers of both wings can be held safely in a single hand (Figure 1), preventing scratching and wing flapping. The other hand is used to prevent biting, which can be done by gently placing the fingers around the neck of the bird, with the thumb firmly but gently pressing toward the lower jaw. The

Figure 2. Towel method to safely restrain a parrot by using one hand. (a) A right-handed handler wraps the towel around the neck of the parrot using the right hand. Subsequently, the wings have to be fold tightly along the body by using the left hand, so that wing flapping is prevented. (b) Next, the left hand folds the left flap of the towel firmly from the upper left to the lower right of the parrot's body, and the right flap is folded in the other direction. (c) Then, the upper edge of the towel has to be shaped into a large collar that forms a barrier between the handler and the beak of the parrot. (d) Having wrapped the bird in a towel, the handler can use the other hand to perform procedures on the parrot without the assistance of a second person.

bird's sternum must be unrestricted at all times; otherwise, respiration will be compromised.[50]

With an alternative method for restraining a towel-wrapped parrot with one hand (Figure 2), the handler can use the other hand to perform research procedures or veterinary care on the parrot without the assistance of a second person. A right-handed handler is best seated with legs crossed, left leg over right, holding the parrot between body and left forearm while the left hand clutches the parrot's legs through the towel.

Held in either of these ways, the parrot is unable to bite the handler yet other head movements are still possible. The towel serves as a type of collar (Figure 2), which the bird can bite or nibble and which provides a substrate for redirection of any reactions during the restraint. In addition, stroking the head and talking to the parrot can help to calm the bird and habituate it to being touched and handled by humans. Using the right hand, the handler can manipulate the legs, cloaca, or head. A disadvantage to these holds is that the body and wings are inaccessible. In hot environments, the temperature inside the towel can rise quickly; thin cotton towels are preferred in those circumstances.

Limiting the time of restraint is important to avoid undue stress and a potentially life-threatening increase in the parrot's body temperature. In one study, healthy amazon parrots (6 blue-fronted amazons [*Amazona aestiva*] and 11 Hispaniolan amazons [*A. ventralis*]) were monitored by measuring rectal temperature, heart rate, and respiratory rate every minute for 15 min during routine manual restraint.[21] Respiratory rate and temperature increased significantly within 4 min, and both parameters continued to increase during the 15-min restraint, with 1 bird's body temperature reaching lethal levels (46.1 to 47.2 °C). The authors concluded from these data that manual restraint of psittacines should be restricted to 4 min; prolonged restraint should be used only when absolutely necessary, and overheating should be monitored by measuring respiratory rate if restraint lasts more than 4 min.[21] The use of digital thermistor thermometers is preferred over mercury thermometers to assess avian rectal temperature for 2 reasons. First, the upper sensory limit of mercury thermometers (approximately 42.2 °C) does not cover normal avian body temperature, which ranges from 41.7 to 44.4 °C. Second, mercury thermometers require a longer time to reach a stable reading than do digital thermometers.[21,23]

Because birds possess relatively fewer peripheral nociceptors, they had been thought to have a higher pain threshold than mammals. However, because birds show comparable behavioral and physiologic responses to painful stimuli,[16] they should be assumed to experience pain to the same degree as do mammals unless scientifically refuted. Painful conditions in birds, which may inevitably be associated with certain laboratory procedures, should therefore be avoided or alleviated whenever possible.

Refinements in Housing and Management

With regard to the laboratory environment, parrots—like most warm-blooded animals—tolerate a relatively wide range of environmental temperatures and humidity levels, although extremes should be avoided.[6] Further, a disturbed diurnal cycle may contribute to behavioral problems.[13] Most psittacines originate from equatorial areas where the days are 12 h long year-round. Consequently, when considering the lighting schedule in laboratory confinement, psittacines should be allowed 10 to 12 h of darkness daily to promote normal sleep, regardless of whether light is supplied naturally, artificially, or both.[6] Furthermore, in their natural habitat, transition between darkness and light occurs gradually at twilight, and this transition should be imitated in the laboratory environment.[56] To the best of our knowledge, no published study addresses the perception of the flicker frequency associated with discontinuous illumination in parrots. However, poultry perceive light emitted from fluorescent lamps driven by high-frequency (100 Hz) alternating current as continuous light, whereas they experience light emitted by low-frequency (50 Hz) lamps as stroboscopic light.[40,44] Therefore, high-frequency lamps also might be advisable in laboratory housing of parrots.

Table 1. Minimal and optimal space allowance (length of pen, m) for pair-housed psittacines[24]

Species	Minimal	Optimal
Budgerigar	0.5	1
Parakeet	3	4.5
African grey	3	6
Amazon	3	6
Macaw	4	8
Cockatoo	7	7

Light intensity requires special consideration in albinotic animals. In albino rats, for instance, light-induced retina damage is well documented. For example, albino rats develop retinal damage within 13 wk of exposure to light intensities as low as 50 lux.[51] However, microscopic and anatomic examination of the retinae of budgerigars (normally pigmented and 2 hypopigmented strains [albino and lutino]) revealed no evidence of light-induced injuries.[53] This study noted the presence of melanin granules in all investigated eyes; therefore, these birds cannot strictly be considered albinotic.[53] In accordance with these findings, cones dominate the avian retina whereas the retinal underdevelopment in hypopigmented mammals is confined to rods, which may result in only a relatively minor deficit in the retinae of albino bird strains.[31]

Because parrots are prey species, the placement of the cages may contribute to or detract from their sense of security.[13] Placement along a solid wall and away from doors or windows allows at least one side of the cage to be removed from possible disturbances.[6] In contrast, when cages are placed near windows, birds may be disturbed by passing vehicles, cats, or birds. When placed near doors, birds can be startled or disturbed by the sudden appearance of people.[56] In addition, providing background noise is considered to reduce stress in parrots, because their natural habitat is nearly always noisy, and silence is often related to the presence of a predator.[13] Finally, parrots should have access to a dark box or nest box in their cage for use as a hiding place.[13,32]

Systematic studies on space requirements of psittacine birds do not exist. However, guidelines on cage specifications are available for a number of parrot species, based on their physical characteristics and natural behavior (Table 1).[24]

With regard to cage design, the proportions of the enclosure are even more crucial than its absolute volume.[6] To allow flying, the length of the enclosure should be greater than the height and width, keeping in mind that free-ranging parrots may fly considerable distances between feeding and roosting sites on a daily basis.[18,37] In addition, the cage should be wide enough to allow wing-stretching in every direction.[6] These considerations are important with respect to providing adequate opportunities for locomotion and exercise.

Wild parrots spend large proportions of their active time clambering among trees during play or foraging activities.[14] Therefore, box-type cages with solid walls are unsuitable for housing psittacine birds, because such enclosures deprive the birds of opportunities to climb. In contrast, cages made of stout wire stimulate climbing, provided that mesh or horizontal bars are used rather than vertical wires.[24] Double wiring and sufficient space between cages should be present to prevent neighboring birds from reaching across and mutilating others' toes and so forth.[21,48]

Galvanized wire (steel wire coated with zinc to prevent corrosion) constitutes a toxic hazard unless all zinc sources in the form of lumps or white rust are removed prior to first use. Washing in dilute acetic acid (vinegar) will hasten the removal of these oxidized deposits, yielding soluble salts that are easily brushed off. Otherwise, toxic concentrations of zinc could be ingested causing 'new-wire disease,' an important differential diagnosis in birds showing neurologic symptoms.[21,26] However, the toxic hazard associated with new galvanized cages—whether it is the zinc itself or other metal contaminants—has been questioned.[26] Ingestion of pure zinc, stripped zinc coating containing 1% lead, or white rust all resulted in dose-dependent illness and mortality in adult cockatiels (*N. hollandicus*).[26] The main clinical signs were dullness, lethargy, periodic dysphagia, ataxia and muscle wasting, and greenish diarrhea.[26]

Aside from the cage dimensions and construction materials, the structure inside the aviary or cage should maximize the usable space.[24] Optimal use of all 3 dimensions can be attained by well-placed perching or swinging devices that take into account species-specific requirements. For example, macaws have long tail feathers, and perches therefore should be placed at a suitable height. In general, perches should be placed as far apart as possible to stimulate flight. In addition, birds should be able to sit and turn around on perches without rubbing their tail against the wire cage walls.[6,50] The birds' feet should be allowed to grip the perch firmly, without resulting in toes overlapping each other.[50] Further, some psittacine species spend much of their time on the floor of their cages; cockatiels, for example, display a distinctive running behavior when given the opportunity. Therefore, a solid, nonslippery, or abrasive cage bottom is recommended when housing more terrestrial species.[6,24]

Rooms housing birds should be swept daily to prevent accumulation of feather dust and other waste, and should be disinfected at least weekly with an appropriate solution, such as a diluted chlorinated phenolic compound (for example, 5% Dettol in water [active ingredient, chloroxylenol]). Thorough cleaning and disinfection of cages with solid bottoms can be facilitated if the cage design permits complete removal of the bottom. When spares of such drawer-like bottoms are available for every cage, hygienic procedures can be done daily outside the cage, which is less disturbing to the birds and more ergonomically sound for the husbandry staff. Food and water bowls should be cleaned, disinfected, thoroughly rinsed, and dried daily, and toys and perches similarly cared for when heavily soiled. Further, wood perches will be chewed and must be replaced when supportive ability is lost, with the frequency depending on wood hardness and the parrot species.

Perching devices are commercially available in a wide range of materials, each having its own advantages and disadvantages. Concrete grooming perches offer good grip texture, help abrade nail tips, and give parrots an opportunity to trim their continuously growing beaks. However, the rough texture might cause skin lesions on the soles of the feet[11]—especially if no other perch materials are provided. Woody branches of the cholla cactus (*Opuntia* subspecies) have natural holes that can be filled with a hardened clay-based mixture of minerals, yielding a source of occupation as well as essential nutrients. Cuttlebone perches are a good source of calcium, especially for parrots fed seed mixtures, all of which are severely deficient in calcium.[51] Perches made of branches of untreated, nontoxic wood have the advantage of providing good gripping surface, chewing opportunities, and some flexibility, which stimulates balancing exercises. Moreover, branches and twigs have natural curvatures, vary in diameter, and are soft. All of these features promote pedal blood circulation and thus foot health.[6,13]

Hardwoods, such as manzanita woods, are relatively indestructible, but they are not recommended because their hardness deprives birds of chewing opportunities and can induce foot lesions.[13,21] In addition, manzanita wood becomes very slippery when wet, which might cause the birds to fall and injure themselves.[55] Another alternative is the use of electrically heated polymer perches. These perches provide comfortable footing through their texture, variable diameter, and agreeable temperature, unlike, for example, the cold, slippery surface of aluminum bars.

Other types of perches frequently seen in avian enclosures include plastic or compressed wood, sometimes covered with sandpaper. None of these perches is recommended, because they are all uniform in thickness, forcing the birds to continuously bend their toes the same way, which contributes to poor foot health. Moreover, they are often too slippery to provide secure footing, resulting in birds falling when startled. If covered with sandpaper, these perches are abrasive to the plantar surface of the foot, inflicting skin lesions, which may become infected and can cause bumblefoot, an inflammatory condition recognizable by the appearance of erythema, local swelling, and the presence of abscesses.[13,21] Aside from faulty perches, obesity, inactivity, and nutritional imbalances also contribute to the development of bumblefoot.[19]

Nutritional deficiencies are a common cause of disease in parrots;[39] therefore, well-considered feeding strategies should be established. Despite the inherent nutritional imbalances of seeds, parrots still often are fed mainly seed and nut mixtures. Noteworthy nutritional drawbacks of feeding seeds and nuts to parrots include an overall extremely low calcium:phosphorus ratio and low concentrations of iodium, selenium, fat-soluble vitamins (A, D, E, and K), and B12 in the edible part of seeds.[25,46,51] Further, when provided a multicomponent seed diet, parrots usually have a strong tendency to consume mainly oilseed out of the diet, introducing or aggravating the nutritional disproportions inherent to seed mixtures.[30] Some data suggest that the amount of voluntary energy intake of seed mixtures and thus obesity can be decreased through the provision of fruit.[30] However, avocado is highly toxic to parrots.[22] Fortification of nutrients through the drinking water is not recommended because vitamins are very unstable in aqueous solutions,[25] and because mineral and vitamin supplementation reduce the palatability of water, introducing a risk of dehydration due to diminished water intake.[8] Pelletted diets, in contrast, can be formulated to meet the energy and nutrient requirements according to available guidelines. Therefore, pellets are preferable as the main ration of parrots, with supplementation with fruits and vegetables and a limited amount of seeds and nuts. The metabolizable energy requirements of adult parrots housed in the thermoneutral zone in indoor cages can be estimated by using the formula

$$647 \times \text{body weight in kg}^{0.63},$$

whereas the formula for birds housed in aviaries is

$$739 \times \text{body weight in kg}^{0.63}.$$

In contrast, the metabolizable energy requirements of wild parrots is estimated as

$$959 \times \text{body weight in kg}^{0.63}.$$[31]

Table 2. Five-component scoring test to determine response of parrots to handlers

	Score		
Test component	0	1	2
Extend finger	retreat or aggression	no response	approach
Touch back	retreat or aggression	accept with flinch or vocalization	accept
Touch head	retreat or aggression	accept with flinch or vocalization	accept
Offer food	retreat or aggression	no response	accept
Position 15 s after placed next to handler	>90 cm	30–90 cm	0–30 cm

Adapted from references 33 and 34.

Environmental Enrichment

The ecology of wild parrots is currently only poorly known, with most information available for species that inhabit dry or open areas.[14] Most neotropical parrots inhabit closed-canopy forests, which renders research on ecology very difficult.[18] Nonetheless, foraging behaviors and social interactions are thought to be the 2 main classes of behaviors that are reduced in the environment of captive parrots.[33,35]

Sources of environmental enrichment can be subdivided into inanimate and animate enrichment. Inanimate enrichment is categorized further into those that stimulate physical activity and those that enable natural behaviors (for example, foraging and nesting). Group housing and human interaction are classified as social (or animate) enrichment.[33,34]

Among inanimate enrichment elements are cotton ropes, which provide opportunities for chewing, balancing, and climbing. These ropes should be knotted every 15 cm to minimize the risk of injury due to toes or feet becoming entangled in loose fibers.[13,50] Nylon ropes should be avoided because their fibers may be ingested.[13] Toys, preferably destructible items or objects with safe, moveable units that can be manipulated with the beak or feet, also provide physical stimulation.[35] Rubber and printed cardboard should be avoided because such materials may contain toxic levels of heavy metals. Plastic toys—except for commercially available acrylic parrot toys—should be excluded as well, because small pieces can be chewed off and swallowed, causing alimentary impaction. Furthermore, items like split rings might trap and injure the beak.[13] Toys last much longer when hung or placed in difficult-to-reach places.

A foraging enrichment provides the opportunity to manipulate objects in order to retrieve food items, which is a highly motivated behavior in parrots. For example, parrots may prefer to work for food even when provided with the same food that is freely available.[4] Food balls can be used to increase efforts and time needed to forage. In addition, food items such as fruits, nuts, and rawhide can be placed in difficult-to-reach locations (for example, near swings) in a hanging stainless-steel wire box, on top of or outside of the cage. In addition, because many psittacine species originate from tropical forest habitats, regular bathing or misting with a plant sprayer may improve the well-being of captive parrots.[13]

Most parrot species do not construct nests. Instead, they occupy natural cavities, chewing the wood inside the hollow to provide bedding material.[21,49] A few exceptions include Quaker parakeets (*Myiopsitta monachus*) and some lovebird species (*Agapornis* subspecies, namely *A. personate*, *A. fischeri*, *A. lilianae*, *A. nigrigenis*, and *A. roseicollis*).[8] Those lovebird species gather nesting material from the environment to line an existing cavity, whereas Quaker parakeets build large, communal nests out of twigs.[21]

Free-ranging parrots—except for the solitary kakapo (*Strigops habroptilus*)—usually live in social groups. Amazon parrots, for example, live in social units composed of a pair together with their offspring, whereas African grey parrots (*P. erithacus*) are known to roost in groups of hundreds.[14] Owing to their social nature, the well-being of parrots may decline if they are housed individually.[13,24] Moreover, social interaction promotes the use of inanimate enrichment devices. One group investigated the influence of group housing on activity patterns and development of abnormal behavior in orange-winged amazons (*A. amazonica*).[33] For 1 y, 21 parrots were housed either singly or in pairs, with social contact restricted to sight and sound of other birds for the singly housed animals. At the end of the year, 57% of the singly housed parrots performed stereotypes including pacing, route-tracing, sham chewing, bar-biting, flipping, and tongue rolling. Group-housed parrots did not develop stereotypes, spent less time screaming, were more active, and made greater use of enrichment devices. Pair-housed parrots also responded less aggressively and fearfully toward unfamiliar handlers.[33] In addition, budgerigars (*M. undulatus*) showed a significant decrease in vocalization and an increase in activity when housed in groups compared with those that were housed singly.[38] However, note that loud vocalizations for 15 to 20 min several times daily is consistent with the normal behavior of parrots.[56] In conclusion, solitary housing should be used only when justified by well-considered scientific investigations. If psittacines are singly housed, human interaction should be provided on a daily basis to diminish social deprivation, especially for hand-reared birds.[24]

Evidence-based Evaluation of Psychologic Well-being and Aberrant Behavior

Fear is generally considered to be an undesirable emotional state; therefore assessment of fear in a standardized manner can be a useful tool for evaluation of well-being. Two behavioral tests have been described for assessing fear in parrots: fear towards novel objects (neophobia) and fear towards humans.[34] The former test measures the latency to interact with a novel object, whereas the latter consists of a 10-point handler-response test. This handler-response test comprises 5 components that are scored from 0 to 2, depending on the response of the bird. The components include the willingness of the bird to approach a familiar or unfamiliar handler and the acceptance of touch to different parts of the body (Table 2).[33,34]

Fear toward novel objects also was assessed by observing the behavior of a parrot for 1 min after the introduction of a novel toy into the cage.[15] The response was scored according to a 5-point rating scale. In addition, the position of the bird relative to the new object and any interaction with the object was recorded 30 min after introduction. Neophobia also can be assessed through the latency of approach to a feeding dish in the presence of a novel object; longer latencies are indicative of higher levels of neophobia.[15,36] Despite the use of standardized tests, data always should be interpreted with caution, particularly if different parrot species are compared, because exploratory behavior and neophobia are influenced by species.[36]

Psychogenic feather destructive behavior is a common

Table 3. Scoring system to determine feather condition in parrots

Chest, back, and legs			
Score	Feathers	Down	Skin
0	all or most removed	all or most removed	exposed and injured
0.25	all or most removed	all or most removed	exposed but not injured
0.5	all or most removed	some removed	patches exposed
0.75	all or most removed	exposed but intact	not exposed
0.75	more than half removed	some removed	patches exposed
1	less than half removed	some removed	patches exposed
1.25	more than half removed	exposed but intact	not exposed
1.5	less than half removed	exposed but intact	not exposed
1.75	marked fraying or breakage	not exposed	not exposed
2	little or no fraying or breakage	not exposed	not exposed
Wings			
Score	Coverts, primaries (I), and secondaries (II)	Down	Skin
0	all or most coverts, I, and II removed	removed	exposed and injured
0.5	all or most coverts, I, and II removed	removed	exposed but not injured
1	more than half of coverts removed	exposed and intact	not exposed
1	more than half of I and II removed	exposed and intact	not exposed
1.5	less than half of coverts removed	exposed and intact	exposed and intact
1.5	less than half of I and II removed	exposed and intact	exposed and intact
1.5	I and II markedly frayed or broken	exposed and intact	exposed and intact
2	little or no fraying or breakage	exposed and intact	exposed and intact

Adapted from reference 35.

problem of captive-kept parrots. Frustration—resulting from inappropriate husbandry or a barren environment that conflicts with the species-specific behavioral repertoire of the animal—is often the underlying cause of this and other aberrant behaviors.[29] However, evaluation of signs of feather or skin mutilation should as well consider possible medical conditions that trigger this aberrant behavior. Such causes include, but are not limited to, infectious diseases of the feather follicles or skin. In addition, genetic influences can contribute to this behavior, explaining the strong predisposition of certain psittacine species, such as lovebirds (*Agapornis* subspecies), African grey parrots (*Psittacus erithacus*), and cockatoos (Cacatuidae), to feather-pick.[19] Finally, self-inflicted damage must be differentiated from aggression from conspecifics. A 10-point scoring system has been developed to quantify the plumage condition of parrots, allowing reliable evaluation of change over time (Table 3).[35] This system uses a questionnaire to score feather, down, and skin condition on 5 body areas, with an overall score is attained by combining these subscores.

In conclusion, as with other species, appropriate husbandry and handling during laboratory confinement promotes health, reduces behavioral discomfort, and is essential to the well-being of parrots maintained for research use. Furthermore, attention to these issues will facilitate placement of the birds after projects have ended. This attention is particularly crucial given the longevity and endangered status of some species.

Acknowledgments

The authors would like to acknowledge Katty Caewerts for her contribution to the section on manual restraint. Many thanks are due to WE Samuels for critical reading of the manuscript.

References

1. **Applied Research Ethics National Association.** 2002. Institutional animal care and use committee guidebook, 2nd ed. Bethesda (MD): Office of Laboratory Animal Welfare.
2. **Australian Government, Department of the Environment and Heritage.** 2005. Advice to the minister for the environment and heritage from the threatened species scientific committee on a key threatening process under the Environment Protection and Biodiversity Conservation Act 1999.
3. **Collar NJ.** 1997. Family Psittacidae (Parrots). In: del Hoyo J, Elliott A, Sargatal J, editors. Handbook of the birds in the world, volume 4. Barcelona: Lynx Editions. p 280–497.
4. **Coulton LE, Waran NK, Young RJ.** 1997. Effects of foraging enrichment on the behaviour of parrots. Anim Welf **6:**357–363.
5. **Diamond J.** 1999. Zebras, unhappy marriages, and the Anna Karenina principle. In: Guns, germs, and steel. New York: WW Norton and Company. p 157–175.
6. **Dilger WC.** 1982a. Caging and environment. In: Petrak ML, editor. Diseases of cage and aviary birds, 2nd ed. Philadelphia: Lea and Febiger. p 11–17.
7. **Dilger WC.** 1982b. Behavioral aspects. In: Petrak ML, editor. Diseases of cage and aviary birds, 2nd ed. Philadelphia: Lea and Febiger. p 18–20.
8. **Donoghue S, Stahl S.** 1997. Clinical nutrition of companion birds. J Avian Med Surg **11:**228–246.
9. **Eberhard JR.** 1998. Evolution of nest-building behaviour in Agapornis parrots. The Auk **115:**455–464.
10. **European Community.** 1986. Council Directive 86/609 on the approximation of laws, regulations and administrative provisions of the member states regarding the protection of animals used for experimental and other scientific purposes. Official Journal of the European Communities. Luxembourg: European Community, (OJ L.358).
11. **European Community.** 1986. ETS No. 123. European Convention for the Protection of Vertebrate Animals used for Experimental and other Scientific Purposes.
12. **European Community.** 2005. Fourth Report from the Commission to the Council and the European Parliament on the Statistics on the number of animals used for experimental and other scientific purposes in the member states of the European Union. Brussels: European Community, (COM2005 7 final).
13. **Evans M.** 2001. Environmental enrichment for pet parrots. In Pract **23:**596–605.
14. **Forshaw JM.** 1989. Parrots of the world, 3rd ed. Sydney: Landsowne Editions.
15. **Fox RA, Millam JR.** 2004. The effect of early environment on neophobia in orange-winged Amazon parrots. Appl Anim Behav Sci **89:**117–129.
16. **Gentle MJ.** 1992. Pain in birds. Anim Welf **1:**235–274.
17. **Ghysels P.** 2005. Personal communication.
18. **Gilard JD, Charles AM.** 1998. Patterns of activity, flocking, and habitat use in parrots of the Peruvian Amazon. Condor **100:**641–653.

19. **Gill JH.** 2005. Avian skin diseases. In: Rupley AE, editor. Veterinary clinics of North America, exotic animal practice: avian pet medicine. Philadelphia: WB Saunders Company. p 145–156.
20. **Greenacre CB, Lusby AL.** 2004. Physiologic responses of Amazon parrots (*Amazona* species) to manual restraint. J Avian Med Surg **18:**19–22.
21. **Harcourt-Brown NH.** 2000. Psittacine birds. In: Tully TN, Lawton MCP, Dorrestein GM, editors. Avian medicine. Oxford: Butterworth Heinemann. p 112–143.
22. **Hargis AM.** 1989. Avocado (*Persea americana*) intoxication in caged birds. J Am Vet Med Assoc **94:**64–66.
23. **Harrison GJ, Ritchie BW.** 1994. Making distinctions in the physical examination. In: Ritchie BW, Harrison GJ, Harrison LR, editors. Avian medicine: principles and application. Lake Worth(FL): Wingers. p 144–175.
24. **Hawkins P.** 2001. Laboratory birds: refinements in husbandry and procedures. Lab Anim **35:**1–163.
25. **Hawley SB.** 1997. Futtermittel und -mischungen für Ziervögel—ein Vergleich aus futtermittelkundlicher Sicht. Proceedings of the First International Symposium on Pet Bird Nutrition; 1997 Oct 3-4; Hannover, Germany. p 54.
26. **Howard BR.** 1992. Health risks of housing small psittacines in galvanized wiremesh cages. J Am Vet Med Assoc **200:**1667–1674.
27. **International Union for the Conservation of Nature and Natural Resources (IUCN) Species Survival Commission.** 1995. Guidelines for re-introductions. Approved by the 41st Meeting of the IUCN Council; 1995 May; Gland, Switzerland.
28. **Jeffery G, Williams A.** 1994. Is abnormal retinal development in albinism only a mammalian problem? Normality of a hypopigmented avian retina. Exp Brain Res **100:**47–57.
29. **Jenkins JR.** 2005. Feather picking and self-mutilation in psittacine birds. In: Rupley AE, editor. Veterinary clinics of North America, exotic animal practice: avian pet medicine. Philadelphia: WB Saunders Company. p 181–192.
30. **Kalmar ID, Geeroms B, Bürkle M, Reinschmidt M, Waugh D, Werquin G, Janssens GPJ.** 2006. Effects on nutrition of the specific feeding behaviour of parrots. Proceedings of the 10th International Conference of ESVCN; 2006 Oct 5-7; Nantes, France. p 225.
31. **Koutsos EA, Matson KD, Klasing KC.** 2001. Nutrition of birds in the order Psittaciformes: a review. J Avian Med Surg **15:**257–275.
32. **Lawton MPC.** 2005. Behavioural problems. In: Price CJ, editor. Manual of parrots, budgerigars, and other psittacine birds. Gloucestershire: British Small Animal Veterinary Association. p 163–169.
33. **Meehan CL, Garner JP, Mench JA.** 2003. Isosexual pair housing improves the welfare of young Amazon parrots. Appl Anim Behav Sci **81:**73-88.
34. **Meehan CL, Mench JA.** 2002. Environmental enrichment affects the fear and exploratory responses to novelty of young amazon parrots. Appl Anim Behav Sci **79:**75–88.
35. **Meehan CL, Millam JR, Mench JA**. 2003. Foraging opportunity and increased physical complexity both prevent and reduce psychogenic feather picking by young amazon parrots. Appl Anim Behav Sci **80:**71–85.
36. **Mettke-Hofmann C, Winkler H, Leisler B.** 2002. The significance of ecological factors for exploration and neophobia in parrots. Ethology **108:**249–272.
37. **Meyers MC, Vaughan C.** 2004. Movement and behaviour of scarlet macaws (*Ara macao*) during the post-fledging dependence period: implications for in situ versus ex situ management. Biol Conserv **118:**411–420.
38. **Nicol CJ, Pope SJ.** 1993. A comparison of the behaviour of solitary and group-housed budgerigars. Anim Welf **2:**269–277.
39. **Nott HMR, Taylor J.** 1993. Nutrition of pet birds. In: Burger IH, editor. The Waltham book of companion animal nutrition. Pergamon Press: Oxford. p 69–84.
40. **Nuboer JF, Coemans MA, Vos JJ.** 1992. Artificial lightening in poultry houses: do hens perceive the modulation of fluorescent lamps as flicker? Br Poult Sci **33:**123–133.
41. **Pepperberg IM.** 1995. Mirror use by african grey parrots (*Psittacus erithacus*). J Comp Psychol **109:**182–195.
42. **Pepperberg IM.** 2002. The Alex studies: cognitive and communicative abilities of grey parrots. Boston: Harvard University Press.
43. **Pepperberg IM.** 2004. Cognitive and communicative capacities of grey parrots—implications for the enrichment of many species. Anim Welf **S13:**203–208.
44. **Prescott NB, Wathes CM, Jarvis JR.** 2003. Light, vision and the welfare of poultry. Anim Welf **12:**269–288.
45. **Queensland Government, Department of Primary Industries and Fisheries.** 2006. Scientific Animal Use Report 1 January 2004 to 31 December 2004.
46. **Sanz V, Grajal A.** 1998. Successful reintroduction of captive-raised yellow-shouldered amazon parrots on Margarita Island, Venezuela. Conserv Biol **12:**430–441.
47. **Snyder NFR, Koenig SE, Koschmann J, Snyder HE, Johnson TB.** 1994. Thick-billed parrot releases in Arizona. The Condor **96:**845–862.
48. **Stoodley AAJ, Hadgkiss IM, Rance LA.** 1992. Feeding, housing and breeding. In: Price CJ, editor. Manual of parrots, budgerigars, and other psittacine birds. Gloucestershire: British Small Animal Veterinary Association. p 189–202.
49. **Symes CT, Perrin MR.** 2004. Breeding biology of the greyheaded parrot (*Poicephalus fuscicollis suahelicus*) in the wild. Emu **104:**45–57.
50. **Turner WT.** 1992. Handling and clinical examination. In: Price CJ, editor. Manual of parrots, budgerigars, and other psittacine birds. Gloucestershire: British Small Animal Veterinary Association. p 7–15.
51. **Ullrey DE, Allen MA, Baer DJ.** 1991. Formulated diets versus seed mixtures for psittacines. J Nutr **S121:**193–265.
52. **US Department of Agriculture** [Internet]**.** 2006. Report on USDA administration and enforcement of the Animal Welfare Act during fiscal year 2004 [cited 6 Jan 2007]. Available at http://www.aphis.usda.gov/ac/awreports/awreport2004.pdf.
53. **Wilken H.** 1998. Mikroskopisch-anatomische Untersuchungen an den Augen "albinotischer" und normalpigmentierter Farbschläge des Wellensittichs (*Melopsittacus undulatus*) [dissertation]. Hannover (Germany): Tierärztliche Hochschule Hannover.
54. **Williams RA, Howard AG, Williams TP.** 1985. Retinal damage in pigmented and albino-rats exposed to low-levels of cyclic light following a single mydriatic treatment. Curr Eye Res **4:**97–102.
55. **Wilson L.** 2005a. Psittacine restraint in the examination room. In: Rupley AE, editor. Veterinary clinics of North America, exotic animal practice: avian pet medicine. Philadelphia: WB Saunders Company. p 168–171.
56. **Wilson L.** 2005b. Biting and screaming behaviour in parrots, In: Rupley AE, editor. Veterinary clinics of North America, exotic animal practice: avian pet medicine. Philadelphia: WB Saunders Company. p 173–179.
57. **Wolf P.** 2002. Nutrition of parrots. Proceedings of the V International Parrot Convention; 2002 Sep 18-21; Puerto de la Cruz, Spain. p 197–205.