MODIFYING AVIAN FEEDING STRATEGIES TO PROVIDE FORAGING OPPORTUNITY, ALLOW FOR CONTRAFREELOADING, AND IMPROVE THE HEALTH OF COLLECTION BIRDS

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The Philadelphia Zoological Gardens opened its gates to the public in 1874. At that time, zoo animals rarely survived more than several years in their captive environments.[1] Little was known about the natural diet and behaviors of these wild animals, and keepers typically provided their charges with a variety of inappropriate food items. Nutrition programs for zoo animals simply did not exist.

As zoos evolved, so too did animal diets. In 1935, at the Philadelphia Zoo's Penrose Research Laboratory, Dr. Herbert Ratcliffe developed a complete feed later known as "zoo-cake."[1] Consisting of meat, wheat meal, soybean meal, cornmeal, rolled oats, peanut meal, alfalfa-leaf meal, oyster-shell flour, salt, and cod-liver oil, "zoo-cake" revolutionized zoo diets. This diet was fed to large variety of species, including prairie dogs, squirrels, porcupines, agoutis, raccoons, coatis, kinkajous, and primates. Although still quite high, the death rate for some species following the addition of "zoo cake" to their diets decreased dramatically. This early attempt at providing adequate nutrition in a single diet item was the precursor to many of the modern "complete feeds" available for waterfowl, passerines, psittacines, primates, hoofstock, and many more.

Many small zoos rely on the keepers themselves to design and administer animal diets. Others make use of the knowledge and skills of staff veterinarians, and enlist their aid in developing diets. At the Philadelphia Zoo, the long history of research in captive animal nutrition continues. The zoo supports a structured nutrition program, complete with a full-time nutritionist. Diets are designed and developed by the nutritionist, who then works closely with keepers to ensure that diets are modified as needed to reflect the preferences of individual animals.

Clearly, zoos have come a long way in the field of nutrition, and research into the nutrient needs of individual species continues. More captive diets are now based on field and laboratory research than in the past, and consequently more zoo animals live longer, healthier lives. However, as the components of animal diets evolve, an interesting question arises. Is it possible to improve the health and well-being of zoo animals not only by changing *what* they are fed, but by also altering *how* they are fed?

Traditionally, animals in zoos received their entire diet at one time, typically first thing in the morning. This food frequently arrived on a dish, and was placed at a standard location within the enclosure. There was little diversity in the day-to-day foods offered; instead, various items were offered every day. Animals quickly acclimated to this type of feeding method, and it rapidly became simply another factor in their environment. In many zoos, this feeding strategy continues today. It is assumed to be the most efficient method for both animals and keepers. However, it has one major drawback; it drastically reduces the opportunity for captive animals to engage in one of the most critical natural behaviors: foraging. Animals fed in this way spend little time searching for food, and a very small amount of time consuming it. This reduction of foraging opportunity has quite a significant effect on their overall physical and mental health. At least one recent study indicates that animals provided with the opportunity to forage on a regular basis exhibit fewer aberrant behaviors and manifest as healthier specimens than conspecifics denied this chance.[3] Research into the free food phenomenon, also known as contrafreeloading, indicates that given the option, many animals choose to work for food even in the presence of equivalent free food.[4] This suggests that traditional zoo feeding strategies fall short of fulfilling a natural tendency for animals.

Many zoos are beginning to include operant conditioning in the daily husbandry of captive animals. With the incorporation of training into feeding methods, keepers are able to provide the animals in their care with ample opportunity to express their natural tendencies towards contrafreeloading and to increase their time spent foraging for diet items. This paper will examine the benefits to considering operant conditioning in a zoo nutrition program and increasing opportunity for contrafreeloading and foraging, with specific examples from the Philadelphia Zoo's Bird Department.

By now, the theory of contrafreeloading has been well documented.[4] A wide array of species have been tested, including rats, mice, chickens, pigeons, crows, cats, fish, gerbils, and humans. Different studies were designed to test various aspects of the phenomenon. While the species tested and the methods used in each study varied, the overall result remained largely the same; animals continued to perform a learned behavior to obtain food even when a dish of identical food was freely available. Behavioral scientists have struggled to explain this result, as it seems to be in opposition to two important behavioral ideas: reinforcement theory and the concept of least effort. In his 1977 review of contrafreeloading studies, Osborne concludes that this phenomenon is a combination of a conditioned reinforcer and the stimulus-reinforcer effect. Reinforcement theory suggests that when a particular stimulus change is repeatedly paired with a reinforcer, it begins to assume the role of a conditioned reinforcer. Osborne argues that the stimulus change that occurs when the animal performs the learned behavior to earn reinforcement is a conditioned reinforcer; consequently, when animals are given the option of performing the learned behavior or eating freely available food, it is actually more reinforcing to earn the food, as doing so not only earns the primary reinforcer (food), but allows the subject to earn the conditioned reinforcer (stimulus change) as well. Viewed in this way, contrafreeloading is consistent with reinforcement theory.

The least effort hypothesis suggests that animals should strive to maximize reward while minimizing effort.[4] At first glance, contrafreeloading appears to be in direct conflict with this hypothesis, as surely consuming freely available food must involve less effort than performing a learned behavior for equivalent food. Osborne reconciles this issue by pointing out that the least effort hypothesis can only be applied when reinforcers are equivalent. In most experiments, the primary reinforcers are equivalent in both the free food option and the response-dependant option; because of the added conditioned reinforcer of stimulus change, the two options are no longer equivalent, thus the least effort hypothesis is not contradicted by contrafreeloading. During experiments designed to eliminate the conditioned reinforcer by removing the stimulus change attached to the response-dependant behavior, animals show a marked preference for free food. Research therefore suggests that contrafreeloading does not in fact violate the least effort hypothesis.

Once the free food phenomenon is understood in relation to reinforcement theory, zoo staff can evaluate its value in a captive setting. Many keepers and curators already strive to design exhibits which encourage their animal inhabitants to perform natural behaviors, such as climbing, swinging, bathing, etc. If, as experimental data suggests, contrafreeloading is a universal phenomenon, it is only logical that providing opportunities for captive animals to earn response-dependant food could have many benefits, both physical and mental. Animals that experience the chance to perform natural behaviors tend to be less easily stressed, making them less prone to develop health problems. They are able to develop muscles and improve their cognitive abilities. Providing opportunities for animals to express contrafreeloading also serves to increase foraging time, another important natural behavior.

Animals in the wild spend a great deal of time foraging for food. They first need to locate a potential source of food, find a way in which to access it, and prepare the food for consumption if necessary, all prior to actually eating. In addition, animals must compete with conspecifics, with additional species seeking similar resources, and with predators. In a traditional feeding method, zoo animals have little opportunity to forage for food. Many keepers seem to feel that providing pre-chopped, easily edible food is the most effective way of feeding collection birds. However, recent research suggests that reducing foraging opportunity may have a very negative impact on the health of birds. As shown by Meehan et al. in a 2003 study conducted at the University of California, young Amazon parrots deprived of the opportunity to forage and manipulate physical enrichment objects rapidly developed feather picking behaviors.[3] When provided the chance to spend part of the day foraging for diet items, these same birds showed a rapid and significant improvement in feather condition, indicating a decline in the self-mutilating behavior. Feather picking has long been considered an abnormal behavior and is often an indicator of stress in captive birds, particularly psittacines. The appearance of feather picking in birds exposed to a foraging-deprived environment suggests that foraging opportunity is an important factor in maintaining the mental, and consequently the physical, health of captive birds. While there is no definitive answer for why feather picking occurs in birds that are not provided with foraging opportunities, Meehan et al. liken it to a similar phenomenon in chickens, known as feather pecking. Meehan et al. point out that chickens raised with no opportunity to forage for food rapidly develop feather pecking behaviors towards other flock members. They theorize that providing environmental enrichment that creates opportunity for foraging fulfills a behavioral need to forage, and decreases the likelihood that a lack of foraging behavior will be directed towards plumage instead. In addition, because increasing opportunities for foraging results in animals spending more time actively obtaining food, there is less time available for them to engage in undesirable behaviors, such as feather picking. Increased foraging creates behavioral competition for abnormal behaviors. Along with improvements in feather condition in parrots provided with ample opportunity to forage, Meehan et al. noted a decrease in the development of stereotypic behaviors and fearfulness in the test subjects. Because stereotypic behaviors have been associated with compromised neural development, the reduction of these behaviors in captive animals should be of primary importance to all keepers.

The use of operant conditioning in a zoological setting can also play a role in modernizing feeding strategies to improve avian health. This form of behavior modification allows the learner to determine the outcome, or operate on its environment. Future behavior is determined by the prior consequences. A reinforcing outcome leads to an increase in the behavior, while a punishing consequence will cause decreases in the behavior. Animals are given the option of choosing whether or not to perform a specific behavior. In a recent article, Dr. Susan Friedman argues that a consequence may be made even more reinforcing to an animal simply because it was provided the opportunity to control the outcome of its own behavior.[2] Keepers who introduce operant conditioning to their animals provide them with a chance to affect their own environment, something noticeably lacking in most captive settings. Studies even suggest that giving animals opportunities to experience choice may reduce their stress and prevent the side effects typically present with learned helplessness, a phenomenon which occurs when animals are unable to escape aversive stimuli due to restraint.[2] Animals accustomed to having some level of control over their environment due to operant conditioning seem less prone to learned helplessness during inevitable events where they are unable to dictate the outcome, such as veterinary procedures. In addition, it is likely that a lack of control over environmental factors may contribute to abnormal, undesired behaviors as mentioned previously, such as feather picking.[2]

So how can keepers and nutritionists incorporate contrafreeloading, increased foraging opportunity, and operant conditioning into an efficient and effective diet and feeding strategy for captive animals? There are many possible avenues, from fairly simple to somewhat complex. The nutritionist at the Philadelphia Zoo has worked closely with the Bird Department keepers to modernize the avian diets and develop new methods of feeding that more closely mimic natural behavior. These changes have occurred across a vast array of species and have been implemented in a variety of ways by different keepers. The following are examples of these updated feeding strategies, along with some of the benefits keepers have observed.

Finding ways to allow for the contrafreeloading phenomenon to occur in a zoological setting can be challenging. While most captive animals have routine access to free food, developing methods for response-dependant food may be difficult. However, it may be as simple as adding basic puzzle feeders to an enclosure which contain the same dietary items found in food bowls. For example, keepers found that the female kea (*Nestor notabilis*) would readily eat soaked dog food. This was typically left on the ground, scattered across a small area of the exhibit. When a large plastic ball with multiple small holes was added to the exhibit and filled with soaked dog food, the kea would *always* forgo eating the food freely available on the ground to instead manipulate the ball in order to remove the dog food. These were equivalent primary reinforcers, but the addition of the conditioned reinforcer of the moving ball was enough to allow the free food phenomenon to occur. Keeper effort was minimal, and the kea was given the opportunity to express an apparently natural behavior. The addition of simple puzzle feeders, food hidden in boxes, and other standard food enrichment items can greatly increases the likelihood that zoo animals will express contrafreeloading while having little impact on a keeper's daily schedule.

Similarly, food enrichment items such as puzzle feeders and boxes can serve to increase the time animals spend foraging. It typically takes a good deal longer to retrieve food from these objects than it does to simply eat it from a dish. At the Philadelphia Zoo, bird keepers give boxes, PVC feeders, bamboo feeders, piñatas, and a variety of other enrichment items to a diverse group of birds, including psittacines, passerines, raptors, and many more. Along with simply making food less accessible through the use of food enrichment devices, keepers are able increase the time birds spend foraging by altering the way diets are presented to them. By resisting the temptation to chop food into readily edible pieces, keepers cannot only increase foraging time, they can reduce time spent prepping diets. Even small passerines are able to consume most fruits when left in large chunks, and it often takes them longer to do so. At the Philadelphia Zoo, keepers have observed starlings ripping pieces of off papaya, doves eating corn kernels directly from the cob, parrots tearing into whole apples, and mynahs picking pieces of banana off of larger chunks. These birds spend more time processing their food to prepare it for consumption than birds fed small, pre-chopped bits of fruit. Not only is it more efficient for the keepers to cut large chunks of fruit and leave the fine-tuning to the birds, but it results in a significant increase in foraging time and all the benefits associated with it. Another, often entertaining, way to increase foraging time for insectivorous birds is by providing live insects. The Philadelphia Zoo uses live crickets, mealworms, waxworms, and superworms with a variety of bird species. Obviously birds must spend more time chasing and killing live insects than they would consuming dead insects from a dish. Once again, a simple alteration in feeding method can elicit significant increases in foraging time. For many animals, simply hiding diet items, such as live insects, in some form of substrate can drastically increase foraging time as well as inducing a variety of natural behaviors such as digging and pecking.

One of the most significant changes to feeding strategies was made through the addition of operant conditioning as a routine part of the daily husbandry of many of the zoo's birds. Working closely with the keepers, the nutritionist designed diets which provide keepers with flexibility in what and how much is fed out daily. Keepers are able to adjust what they feed birds on a regular basis to enable them to create and maintain motivation for training sessions without negatively impacting the nutritive value of the animal's diet. The addition of operant conditioning not only allows keepers to train birds to cooperate in husbandry behaviors such as scaling, crating, and allowing for voluntary nail trims, it has enabled the collection animals to influence their environment in a previously unobtainable way. The birds quickly learn the consequences to certain behaviors, and they can then choose how to behave. This added element of control has resulted in a great deal of positive change in the behaviors of many of the birds. The Philadelphia Zoo currently houses 1.1 hammerkops (*Scopus umbretta*). When first introduced, the male spent a large portion of the day displacing the female from her perch. This behavior was clearly less than desirable, and prevented the pair from expressing any breeding behaviors. Through operant conditioning, using only positive reinforcement, the male quickly learned that earning reinforcement in the form of his daily diet was only possible if he remained on a fixed station and allowed the female to be fed first on a separate station. His behavior changed rapidly, as he more frequently chose to remain stationed rather than displace the female. Shortly afterwards, the displacement behavior was extinguished, and both birds began actively nest building. They currently continue to lay fertile clutches of eggs, and incubate them in the midst of a continued training program. The male eclectus parrot (*Eclectus roratus*) in the Philadelphia Zoo's collection also demonstrated a rapid change in behavior with the onset of an operant conditioning program. As keepers worked to train him to perform a variety of husbandry behaviors, he became far less easily stressed by changes in his routine. Prior to training, he would vocalize excessively when environmental factors startled or frightened him, such as the presence of nets or any novel object in his exhibit. Recently, a stray bird from an adjoining exhibit needed to be netted out of his enclosure, and he remained quiet and stationary throughout the entire process. This bird clearly reacts to stressful situations in a much calmer way then he did prior to the initiation of a training program, and appears to be responding well to his new freedom to operate on his environment.

As illustrated by examples from the Philadelphia Zoo's Bird Department, keepers and nutritionists can work together to find simple and effective ways to allow for contrafreeloading, increase foraging time, and allow animals to affect their environment through operant conditioning. These changes in traditional feeding strategies can be highly beneficial to both the health of the birds and to the zoo itself. Visitors have the opportunity to view the same natural behaviors which keepers are now observing. They can watch parrots use their feet to hold onto a whole nut while they use their strong beak to crack it, or be amazed by terns diving into their pool to retrieve fish. Modifying feeding methods for birds can be incredibly simple, and in some cases even save keepers time. Research is just beginning to understand the benefits to these new methods of feeding captive animals, and undoubtedly additional benefits will become apparent as more and more zoos begin re-evaluating traditional methods of feeding their collection animals.

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