A VETERINARY ASSESSMENT OF THE RISKS AND BENEFITS OF ENVIRONMENTAL ENRICHMENT

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INTRODUCTION

Environmental enrichment as a discipline has continued to gain momentum as the benefits to animals and to zoos are recognized and documented. Many zoological institutions have implemented formal enrichment programs and dedicated personnel to enrichment efforts. Enrichment-focused research and publication is increasing in quantity and quality. Zoo keepers continue to collaborate to improve enrichment techniques and strategies. Zoo visitors enjoy opportunities to see active animals and are increasingly made aware through education and media of our efforts to challenge and stimulate our captive charges. From a veterinary perspective, I have become specifically interested in the impact that enrichment can have on animal health.

As zoos become more adept at providing for the physical and medical needs of the animals under our care, we can turn our attention toward their psychological needs. Environmental enrichment (EE) should be recognized by animal caretakers as an important tool to promote both the mental and physical health of zoo animals. Animal caretakers may have concerns about adding complexity and unpredictability to animal environments. However, providing surroundings that stimulate a greater range of natural behaviors, lessen stress and increase physical activity is the next step towards optimizing the health and reproductive capacity for captive animals.

At most zoos, veterinarians and curators work together to decide which enrichment techniques can be used routinely for various animals in the collection. When a keeper asks, "Can I give ___ to the ___," there are really two parts to the question. First, does this item pose a risk to the animal and, second, will this item provide any benefit to the animal? One of the veterinary medical credos is "above all, do no harm", so it is logical for a veterinarian to want to err on the side of caution. As animal managers, we work hard to ensure the physical safety of our animals, but we should work just as hard to improve overall well-being. This paper will review literature demonstrating both the benefits and risks associated with enrichment and discuss a rational approach to managing the risks associated with enrichment.

DEFINING ENRICHMENT RISKS

There is no published compilation of information regarding negative consequences arising from use of enrichment items in zoos; this should not be surprising and is probably true for a variety of reasons. Most historical information is available only by word of mouth and is difficult to collect and validate. While publications like The Shape of Enrichment are a great source for ideas that work, most people are less excited about sharing ideas that don't work. Only a few zoos have initiated formal enrichment programs designed to record information about successes and failures and each is tracking this information individually. For compiled information to be useful, factors influencing the behavioral environment need to be specified. Otherwise it is difficult to extrapolate this information for use in the complex environments in which we house zoo animals. For each enrichment item application there are numerous factors to be considered: the natural history of the species, exhibit and holding area design, makeup of animal groupings (mixed or single species, breeding status, age, gender), individual animal personalities, anatomical characteristics, size of enrichment item relative to animal, underlying health conditions, body condition, degree of control over animals (ability to gate etc.), past history with enrichment items, natural and captive diet, keeper schedules, budget, acceptance of unnatural enrichment items on exhibit, and discretion of animal managers. The more we know about the conditions under which we apply enrichment, the more we can share this information with other institutions. Currently, formal research publications provide the most specific and useful information because the above variables are more clearly defined.

MEASURING THE EFFECTS OF ENRICHMENT

Often, enrichment strategies are based on our perceptions of what we think would be enriching to animals. While a good place to start, we rely on careful animal observations and research to prove or disprove our theories. Formal research projects, designed to gather objective behavioral data and correlate this with physiological measures are the ideal way to assess enrichment strategies. Less formal, keeper observations are also valuable in that they allow individual institutions to measure benefits in their own animal populations and can be done with fewer resources. It is important to understand the parameters available to define animal well-being and to measure the behavioral and physiological effects of enrichment.

Behavioral observation is the most basic tool used to evaluate enrichment techniques. These observations can be used to better define exhibit space utilization, measure preference for certain enrichment items, or quantify changes in frequency of desirable or undesirable behaviors. The presence/absence of abnormal behaviors or behaviors found in stressful environments is a measure by which animal well-being is approximated. Captive animal behaviors may also be evaluated to measure the degree to which they resemble behaviors in wild animals.

Maintenance of good physical condition is another measure of well-being. Body weights differ from some measures in that they indicate long-term well-being compared to other more fluctuating and acute measures. Both low and high body weights can be indicators of decreased well-being. Low body weights can occur in stressful or otherwise inadequate environments. Excessive weight might indicate low levels of activity. In one population of laboratory rhesus monkeys, providing enrichment caused animals to gain weight to values comparable with free-ranging and zoo-housed rhesus monkeys (Schapiro, 1993). In many situations body weights can be used to track efforts to make environmental changes.

Physiological measures are often paired with behavioral measures to help verify and quantify observations. The hormone cortisol is a sensitive measure of psychological stress, particularly stress induced by novel or intimidating environmental conditions (Carlstead, 1992). Serotonin and glucagon are also hormonal indicators of stress (Line, 1990). Several measures of immune competence have been used to assess animal well-being. White blood cell (leukocyte) patterns have been shown to change predictably in response to stressful changes in environment (Coe, 1989). A combination of total white blood cell counts, lymphocytes subsets, lung macrophage function tests and plasma cortisol levels were measured as possible indicators of stress in one study. Lymphocyte subsets showed the most promise, showing significant differences in certain lymphocyte numbers when comparing calves in enriched group pens to calves housed in nonenriched group pens or housed individually (Morrow-Tesch, 1996). These and other measures have helped correlate positive physiological changes with provision of enrichment items to captive animals. There is likely to be continued development and refinement of these and similar assays over time.

ENVIRONMENTAL ENRICHMENT PROVIDES SOLUTIONS

Research conducted in zoos and research conducted in laboratory settings both demonstrate that application of enrichment techniques can solve some of the problems we encounter in captive animals and can improve well-being.

1. One problem that has been decreased with the provision of enrichment is autoaggression or self-directed behavior. Hair plucking and self-biting in primates, feather plucking in birds and tail sucking/chewing in cats are all examples of self-aggressive behaviors. A paper exploring environmental influences on macaques, found that the frequency of self-aggressive behaviors was cut in half with the provision of a woodchip substrate for foraging (Chamove, 1984). Other studies have demonstrated a significant decrease in self-abusive behaviors with provision of a puzzle feeder and radio, or Kong toy (Line, 1990 and Bayne, 1993). Individually housed primates demonstrated a marked decrease in both stereotypic behaviors and autoaggression during the one hour each day they were housed in an enriched playpen. However, abnormal behaviors returned when animals were returned to their standard pen (Bryant, 1988).

When crimson-bellied conures with plumage problems were compared to those with good plumage it was determined that they spent more time on self-directed preening behaviors and were less active. Providing a variety of enrichment items, natural branches and foods caused the birds to have increased locomotion patterns and decreased preening behavior; the result was stabilization of their plumage problems (van Hoek, 1997). A female leopard under my care was alleviated of a chronic hair plucking/ tail sucking problem by providing whole chicken carcasses on a regular basis.

2. Aggression directed at other animals can also be reduced with certain enrichment strategies. There is concern that providing favored food and play items will cause competition or aggression, particularly in groups were agonistic behaviors are a problem. In a study offering varying numbers of novel objects to a group of chimps, aggression did not increase, even though dominant individuals secured most of the objects when fewer were available (Paquette, 1988). One study demonstrated a similar degree of positive behavioral change when comparing two feeding strategies; offering food in foraging racks suspended on walls, and scattering food in shavings on the floor. The shavings method had the advantage of reducing levels of agonism, most likely because animals were spread over a larger area and had to search for food within the shavings (Lutz, 1995). Other studies have also demonstrated decreased social aggression when providing woodchip foraging substrates to primates and apes (Chamove, 1984 and Baker, 1997).

3. Low activity level and stereotypic locomotion have also been alleviated with enrichment. Captive carnivores have a high incidence of stereotypic locomotion patterns. Enrichment has been shown to be an effective method of reducing these behaviors in some animals. Offering bears feeding devices that require manipulation, such as honey-filled feeder logs, can replace pacing and walking activities with more functional, goal-oriented behaviors. Providing several of these devices simultaneously and refilling them frequently, reduces habituation to the objects (Carlstead, 1991). Hiding food on exhibit in manipulatable objects has been shown to be a very effective technique, reducing stereotypic pacing from an average of 150 min/day to only 20 min/day in one bear studied (Carlstead, 1991). Feeding leopard cats by hiding food on exhibit several times each day increased exploring from 5.5% to over 14% and caused time spent pacing to fall from 18% to less than 9% (Shepherdson, 1993). In fennec foxes it was demonstrated that stereotypic running is stimulated by several different environmental stimuli that evoke a flight response. Although offering enrichment items to these foxes improved behavioral diversity, providing large enclosures with secure hiding places was the most effective method of decreasing stereotypic running (Carlstead, 1991). A pharmacological approach to treating stereotypy has been successful in a polar bear, however, stereotypy returned when drugs were discontinued (Poulsen, 1996). We should utilize enrichment techniques and enclosure manipulation in lieu of long-term drug therapy whenever possible. Behavioral medicine is a growing field, and drugs therapies are likely to expand our options for treating abnormal behaviors.

Low activity level is a problem in other species as well. Researchers investigated husbandry practices and exhibit features at multiple zoos housing a total of 43 groups of gorillas and 68 groups of orangutans. This information was then correlated with activity level observations to determine which factors favored high activity. For both species, the factors most highly related to activity level were the number of animals, and number of objects found within the enclosure, whether permanent or temporary/movable. Size or usable surface area of the enclosure and feeding frequency were not related to activity level (Wilson, 1982). In other studies it was shown that providing novel objects, an enriched playpen, foraging racks, and shaving substrates also increase activity level (Lutz, 1995 and Paquette, 1988 and Bayne, 1993 and Bryant,1988).

4. Urinary cortisol assays have been used to document stressful conditions for small cat species, and determine environmental features that alleviate this stress (Carlstead, 1992). Urinary cortisol was used to monitor the effects of providing an enriched environment to cats previously housed in aversive conditions. Simultaneous behavior observations revealed that cats subjected to a stressful environment responded by becoming less active. When this same environment was made more complex by the addition of "furniture", these cats were better able to adapt and showed increased exploratory behavior, decreased pacing and had decreased urinary cortisol concentrations (Carlstead, 1993).

It is well documented that stress can suppress reproductive function. An analysis of husbandry factors influencing breeding success in small exotic felids found that keeper interaction was positively correlated with breeding success (Mellen, 1991). This suggests that enrichment techniques involving interaction and operant conditioning might provide hidden breeding benefits in some species.

5. Specific veterinary concerns have also been addressed with EE. Regurgitation and reingestion (r/r) is an abnormal captive behavior noted in numerous species, but of particular concern in great apes. Observations of 17 captive gorillas showed that their duration of time feeding was 11% (17% if regurgitation and reingestion time was included) compared to 45% in the wild. Time spent feeding was increased to 27% with the provision of browse, and r/r behaviors fell from 45.8% to 11.2% in one animal and 11.5 % to 5.7% in another (Gould, 1986). Providing straw and forage to a group of 13 chimpanzees caused r/r behaviors to be eliminated in four individuals and to decrease by two-thirds in all subjects combined. These chimps also had reduced levels of other abnormal and antagonistic behaviors and higher levels of locomotion and play (Baker, 1997).

Dental health can also be improved with enrichment. Feeding tigers large bones twice weekly improves periodontal health and reduces plaque formation (Haberstroh, 1984). Rawhide chew toys were found to decrease dental calculus in domestic dogs, and were more effective than biscuits marketed for this purpose. This study also determined that regular consumption of up to 3 rawhide strips/day for 3 weeks did not cause any health problems (Lage, 1990).

Specific veterinary challenges can be addressed through operant conditioning, which is itself a form of enrichment. With these techniques it has been possible to manage a diabetic chimpanzee via regular venipuncture and urine collection, perform venipuncture and give insulin injections to a diabetic drill, train a macaque to present her neonate for supplemental bottle feedings and use a blood pressure cuff to monitor woolly monkeys with hypertension (Logsdon, 1995 and Laule, 1996). Hoofstock have been able to be conditioned for venipuncture and other veterinary procedures. Mean cortisol, CPK and glucose levels measured in these animals were several fold lower than published “normals” demonstrating the stress associated with immobilization (Grandin, 1996).

Environmental enrichment is an effective tool for solving specific problems found in captive animals and can be used to increase overall well-being where problems do not exist.

CRITICALLY EVALUATING OUR ENRICHMENT STRATEGIES

While it is important and instructive to document the beneficial outcomes of enrichment efforts, scientific evaluations also allow us to recognize and address ineffective manipulations and negative consequences. In a study evaluating the behavioral effects of providing a food puzzle to a group of chimps, it was found that the group’s level of agonistic interactions and undesirable behaviors was not significantly changed. Evaluating behavior on an individual level revealed that there were some animals with either significantly increased or decreased levels of aggression, emphasizing the importance of careful evaluation (Bloomstrand, 1986). A rhesus monkey study revealed that after ending a successful enrichment trial, there was a one month rebound of stereotypic and self-directed behaviors to a level above pre-enrichment conditions (Bayne, 1991). In a chimp study, after familiarization to novel objects occurred, manipulation frequency decreased and self-grooming and abnormal behaviors increased above original levels for the short period studied (Paquette, 1988). These studies demonstrate that it is important to provide enrichment as a regular part of husbandry routines instead of as short-term enhancement. Without assessment of our efforts we risk cluttering environments with objects that are of little interest to animals and have no positive impact on behavior. Perhaps the greatest risk associated with enrichment is spending valuable time on enrichment techniques that are not effective or do not provide the greatest potential benefit.

RISK MANAGEMENT- CREATING A FORMAL ENRICHMENT PROGRAM

Other physical/medical hazards associated with enrichment or naturalistic exhibits have been documented in the literature. Sixteen silver leaf langurs developed 22 cases of gastrointestinal linear foreign bodies from ingestion of nylon rope and an exhibit plant, screwpine (Pandanus utilis) (Calle, 1995).

One researcher found that Kong toys supported nonpathogenic bacterial growth, even after sanitation in a commercial cagewasher (Bayne, 1993). This is of particular concern in situations where enrichment items are shared. Accounts of physical hazards are not well represented in the literature, and animal managers find it necessary to anticipate possible hazards. I have compiled a list of conceivable hazards associated with enrichment items used in zoos (Table 1). This list is not meant to discourage use of these items, but instead to illustrate the nature of the problems we might encounter. It is my impression that the incidence of enrichment related injury/death is very low, however all enrichment items pose some risk. An enriched environment is by definition more complex and therefore more dangerous. Complex environments also require more maintenance to ensure they remain safe. Most accidents occur for two reasons; poor coordination/communication and lack of maintenance of enrichment items and exhibit features over time. These mistakes can be avoided by setting up a program to administer and assess enrichment efforts.

An enrichment program should possess the following features:
1. Promote enrichment that is carefully executed and effective
2. Define conditions under which an item can be provided (to whom, when, how etc.)
3. Encourage formal or informal assessment of enrichment ideas
4. Ensure enrichment items are regularly inspected for wear and tear and remain safe
5. Initiate a method of documenting and evaluating enrichment efforts
6. Foster imagination and creativity and allow free exchange of information
7. Determine ways to minimize the cost and labor associated with enrichment
8. Increase safety and efficiency by designing enrichment features into new exhibits

I have heard zoo keepers express concerns that their veterinarian is hesitant to approve certain enrichment ideas. Veterinarians are more likely to support an enrichment idea if it is part of an organized program. Our exotic animal therapeutic options have grown after keeping detailed and careful records that support efficacy and safety. The same principle applies to enrichment applications. Paperwork need not be complex or time-consuming, but should provide basic information to allow enrichment options to be evaluated and improve in efficacy over time. Individual enrichment ideas can be thought of as falling somewhere on a continuum of low risk to high risk and a continuum of low benefit to high benefit. The goal should always be to maximize benefit with the lowest risk. Keepers should be encouraged to try new and creative ideas that meet this goal while learning to fine tune techniques and make simple ideas more effective.

CONCLUSION

Environmental enrichment has the potential to improve both psychological well-being and physical health. EE is still a fairly young discipline and will continue to grow and improve in efficacy over the coming decades. The zoo community needs to help advance the science of environmental enrichment by committing to careful record keeping, continued collaboration and research. The importance of scientifically evaluating attempts to enrich captive animal environments cannot be over-emphasized.

The public is increasingly exposed through television to the behaviors that animals express in the wild. Along with more natural and spacious exhibits, zoo visitors have come to expect more normal and diverse behaviors. EE provides an opportunity to show the public and animal welfare organizations that we are addressing all of the needs of animals in captivity. Environmental enrichment combined with graphics will promote more appreciation and understanding of zoo animals as ambassadors for their wild counterparts.

TABLE 1 POTENTIAL HAZARDS RELATED TO ENRICHMENT

Toys or parts of toys might be swallowed and cause choking or asphyxiation.
Enrichment foods fed in excess may cause bloating or diarrhea.
Frayed cargo nets and ropes and deteriorated support structures may cause physical injury.
Favored foods or items may cause competition and aggression.
Clothing, towels, burlap bags, ropes and hair might cause linear foreign body impaction.
Rawhides, pig ears, bones and other items may cause gastrointestinal impaction.

Bones or other hard objects may cause teeth to chip or fracture.
Excessive enrichment stimuli may cause stress.
Ropes and chains can cause trauma or choking.
Natural substrates can harbor parasites, bacteria, viruses, and fungal organisms.
Burlap, fabric, and natural fiber threads can cause constriction injuries to fingers and toes.
Metal hardware used to construct enrichment items may cause heavy metal intoxication or foreign body trauma.
Introduced items act as fomites- rotating items between animals can transmit disease.
Fecal material, body fluids, antlers, elephant foot trimmings, etc. have potential to transmit disease if used for enrichment.
Insects fed in large numbers can cause impaction or stool changes due to high chitin content.
Carcasses, raw meat and other non-processed food items like turkey necks and pig ears are potential. carriers of food-borne illness: salmonella, pseudomonas, e. coli, etc.
Buttons, string, tape, staples, inks, and some dyes must be removed from items offered.
Volunteers may not always build enrichment items to your specifications.
Browse toxicity is not known in all species.
Live fish are potential carriers of disease.
Food items not eaten must be removed before spoiling occurs.
Animals that are difficult to gate may be difficult to retrieve broken or spoiled items from.
Enrichment foods might cause animals to consume a lower proportion of their formulated diet.
Excessive feeding enrichment can cause obesity.

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