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Commentary: Improving Well-Being for Captive Giant Pandas: Theoretical and Practical Issues

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Here we present the outcome of a panel discussion from Panda 2000, an International conference held in San Diego, California. The discussion addressed how to use animal motivation theory to develop enrichment programs that will improve physical and psychological well-being for giant pandas in captivity. Wild animals held in captivity too often develop behavioral abnormalities such as stereotypies. The motivational basis for these problems is related to species-specific behavioral needs that arise from evolutionary processes adapting the animal to its environment. A more general need is the need for animals to exercise some control over their environment. We discussed these general principles of environmental enrichment with regard to past and future attempts to devise enrichment programs for giant pandas, *Ailuropoda melanoleuca*. Where possible, we looked to nature for guidance, but agreed that creative attempts to develop functional analogues of natural tasks and challenges is appropriate, regardless of ''naturalness.'' A holistic enrichment program should include improved enclosure design and husbandry practices; feeding enrichment modeled after bamboo feeding when possible; species-appropriate opportunities for social interaction and communication; and routine exposure to a diverse array of novel objects to stimulate play and exploration. These enrichment efforts should attempt to address specific behavioral needs or give the animal more choice and control over its environment. Zoo Biol 22:347–354, 2003. © 2003 Wiley-Liss, Inc.

Key words: stereotypy; enrichment; well-being; behavioral needs; giant panda

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INTRODUCTION

The fundamental differences between captivity and nature, and how these differences often give rise to poor psychological well-being in captivity must be considered in the design of any program that seeks to create an optimal environment for captive-living animals. The concept of environmental enrichment, and its reliance on nature as a model for creating captive environments, is fundamental to the process. The captive environment differs markedly from that experienced by free-ranging animals living in the wild [Carlstead, 1996; Poole, 1998]. In nature, animals are exposed to a constantly changing and challenging environment that places physical and cognitive demands on the individual. Daily life involves avoiding predators, finding and acquiring food, navigating through difficult terrain, and competing, socializing, and mating with conspecifics. In doing so, the animal is exposed to an infinite variety of changing stimuli. By contrast, captive individuals often occupy relatively small, barren enclosures wherein the day-to-day routines are dictated by human caretakers, and the animal has little control over the environment. The environment is static, and captive animals may rarely encounter novelty. Options for controlling variables fundamental to comfort and well-being are often limited. For example, animals may be unable to escape aversive stimuli, such as noise, proximity to humans, conspecifics, heat, sunlight, etc. The diet is often processed and highly concentrated, so the animals have few opportunities to engage in normal feeding activities. Food is often offered in one or two lump feedings at the same time each day, which makes the feedings highly predictable. Moreover, the food is "free" and the animal does not have to work to obtain it.

These departures from behavioral opportunities present in the wild inevitably give rise to dramatic behavioral differences between captive and wild animals. Faced with more "free time" due to the ready availability of food, shelter, and other resources, and with few opportunities for normal behavioral expression, captive animals often fill the empty time with excessive inactivity or, worse yet, a repertoire of rigid, highly repetitive "stereotypic" behaviors, such as pacing [Hughes and Duncan, 1988; Mason, 1991]. These behaviors are abnormal in that they do not occur in the wild, or are greatly altered in the form, frequency, or context in which they occur. As a general rule (although there are certain exceptions), the more barren and stimulus-poor the environment, the more prone the animal is to develop stereotypies [Mason, 1991; Carlstead, 1996]. Insofar as stereotypies reflect a suboptimal environment, they are also associated with stress, poor psychological well-being, and failure to mate or successfully reproduce [Mason, 1991; Carlstead and Shepherdson, 1994; Carlstead, 1996]. Animals may be especially prone to develop stereotypies at times when they are highly aroused but can do nothing to change their circumstances (i.e., attempts to achieve a goal are thwarted). This situation occurs most frequently when animals can anticipate feeding time [Falk, 1977]. While waiting for food to be delivered on a set schedule, animals may become highly agitated and expend a great deal of energy anticipating its arrival. However, their behavior has no influence on whether or when the food is delivered, and they have no opportunity to perform the natural behaviors that are normally associated with food acquisition. This situation appears to provide the motivational substrate for the development and performance of many stereotypies.

WHAT IS ENVIRONMENTAL ENRICHMENT?

Enclosure design and environmental enrichment are the most important tools that animal caretakers can apply to the myriad of problems potentially associated with captive living. Environmental enrichment has been defined as "an husbandry principle that seeks to enhance the quality of captive animal care by identifying and providing environmental stimuli for optimal psychological and physiological well-being" [Shepherdson, 1998, p. 1]. Modern practitioners of enrichment advocate a holistic approach that addresses all aspects of the captive environment and husbandry practices. There are no "quick fixes," and simply throwing a plastic ball in an impoverished enclosure will not produce any long-lasting beneficial consequences. Attention to the biological relevance of enclosure design is a prerequisite for an effective enrichment program. In designing enclosures, it is essential to consider space, structural complexity (e.g., vertical dimension, visual barriers, substrate, topography, and vegetation), and microclimate variations in temperature, humidity, and light [Forthman and Bakeman, 1992; Forthman et al., 1995; Poole, 1998]. It is important to give the animals choices across a continuum for each of these biologically relevant variables. Other elements of an enriched environment include providing access to conspecifics for species-typical social interactions, opportunities to work for food, and manipulable objects for play; exposing the animals to novelty and a changing environment; and offering the animals more control over their environment [Shepherdson et al., 1998, and references therein]. The documented benefits of enrichment include improved physical health, enhanced immune function, decreased stress, enhanced reproduction and maternal care, neural changes associated with improved learning abilities and coping mechanisms, greater behavioral diversity, and fewer abnormal behaviors [Carlstead and Shepherdson, 1994]. Thus, enrichment is an essential ingredient of any captive breeding program.

DEVELOPING AN EFFECTIVE ENRICHMENT PROGRAM FOR GIANT PANDAS: LESSONS FROM WOLONG

Since 1997, researchers from the San Diego Zoo have collaborated with the staff of the Wolong giant panda breeding center in Sichuan, China, to develop an enrichment program at Wolong [e.g., Swaisgood et al., 2001]. The rationale for an enrichment program grew out of two observations: some pandas at the facility were failing to reproduce [Zhang et al., in press], and many pandas were performing stereotypic behaviors. These highly repetitive behaviors included pacing, pirouetting, head-tossing, self-biting, somersaulting, masturbating, swaying, tongue-flicking, sitting up, paw-sucking, cage-climbing, and regurgitating. Efforts to remedy these problems have included 1) constructing larger, more naturalistic enclosures; 2) increasing the structural complexity of existing enclosures; 3) improving crowd control; 4) encouraging more positive animal–keeper interactions; 5) providing more bamboo and high-fiber biscuits, which take longer to consume; 6) increasing the frequency and scheduling variability of feedings; 7) providing opportunities for species-appropriate social interaction and olfactory communication; and 8) providing novel manipulable objects and feeder devices that require pandas to work for food [Swaisgood et al., 2000, 2001, in press; Zhang et al., 2000, in press].

Detailed behavioral studies were conducted to assess the efficacy of some aspects of this enrichment program [Swaisgood et al., 2001]. Although the range of enrichment items offered has since been expanded, the initial tests were conducted with five items: fresh spruce branches, plastic objects, a burlap sack stuffed with straw, apples frozen in an ice block, and apples in a puzzle feeder that required the extraction of apple pieces through a small hole. The results indicate that these items had a dramatic beneficial effect on panda behavior, at least initially. Pandas spent significantly more time being active, and displayed a greater variety of behaviors when enrichment was present. There was also a significant reduction in stereotypic behaviors and behaviors indicative of feeding anticipation. Although all enrichment items were equivalent in their ability to increase or reduce behavioral measures related to well-being, each item promoted a distinct behavioral profile. For example, spruce branches promoted a great deal of olfactory investigation and oral exploration, whereas the plastic objects and the burlap sack promoted much more vigorous play, such as swatting, biting, shaking, pouncing, and rolling with the object. By choosing enrichment items that vary in qualities such as manipulability, malleability, and destructibility, a greater variety of behavioral opportunities are created, maximizing the probability that at least some important behavioral needs will be met.

IN SEARCH OF UNIFYING THEMES TO HELP GUIDE ENRICHMENT EFFORTS

The panel discussion opened with a critical evaluation of unifying themes that could be used to guide the development and study of environmental enrichment programs. All of the panelists agreed that the most important starting point for any enrichment program is obtaining a thorough understanding of normal behavioral patterns in the wild. As foraging behavior accounts for the majority of activity budgets in nature, studies detailing the feeding ecology of a species are of the utmost importance. The complex interactions with conspecifics comprise an equally important aspect of the animal's natural ecology, even for relatively solitary species. Field data pertaining to the mother–infant relationship, age of independence, and social relationships with other conspecifics during development, as well as to competition, cooperation, and mating in adulthood, can provide important guidelines for developing a biologically relevant social environment in captivity. It is important that the normal channels of social communication, such as access to scent signals in many olfactory-oriented mammalian species, not be ignored. Studies of how animals interact with their environment will assist in the identification of "behavioral needs" for the species. The behavioral needs hypothesis has played a major role in the development of the enrichment ethos. It states that animals are intrinsically motivated to *perform* certain behaviors that they normally perform in the service of acquiring some important biological resource, regardless of whether the behavior itself is required to obtain the resource [Hughes and Duncan, 1988]. For example, many animals prefer to find, dig for, or extract food using ecologically relevant feeding behaviors even when acquisition of the food is not contingent upon such behaviors.

Another point that has been made repeatedly, and has perhaps become the most important unifying theme, is that it is important for animals to have some

control over their environment. In nature, animals are free to adapt their behaviors to reach certain functional endpoints. If the animal is cold, warm, or wet, it can seek shelter; if it fears something, it can retreat or hide; if it is hungry, it can search for food or otherwise work to obtain it. The wild animal interacts constantly with its environment. Its access to important biological resources is inherently contingent upon the use of behaviors to obtain them. In creating captive environments, then, we need to ensure that animals are given choices (e.g., to interact with or avoid conspecifics, and to hide from human visitors or not), and that their behavior influences whether certain resources are acquired (e.g., by offering feeding devices or live prey to encourage animals to work for food) [Shepherdson et al., 1998, and references therein].

NATURALISM VS. FUNCTIONALISM

With all this emphasis on reconstructing nature, the question was raised as to whether it is important to provide only ''natural'' enrichment items, or opportunities to perform only ''natural'' tasks. A consensus was reached that while it is always important to look to the wild for guidance, functionalism rather than naturalism per se may offer a better frame of reference. Adherence to the principle of functionalism would require that captive animals have the opportunity to interact with their environment in a manner that is functionally equivalent to the natural animal–environment interaction. Thus, it may not be important to replicate exactly the feeding tasks that animals face in the wild, but to ensure that the captive animal is given a variety of different behavioral tasks to obtain food. For example, feeder devices might not mimic natural foraging tasks, but they could still stimulate goal-directed feeding behaviors, allow the animal to work for food, and provide cognitive stimulation and learning opportunities. Again, choice and contingency may be more important than strict adherence to ''naturalism,'' which is an ill-defined concept at best [Forthman-Quick, 1984].

IDENTIFYING GOALS AND MEASURING RESULTS

This philosophy also allows managers to adopt more flexible and pragmatic enrichment strategies, guided by feedback from the animal's response and the success of the outcome. It thus becomes essential to identify the goals of enrichment and devise methods for measuring success. Common goals of enrichment include reducing abnormal behavior and/or stress, promoting a natural or more diverse behavioral repertoire, and facilitating mating and reproduction. Measurement tools include detailed, formal behavioral observations, less labor-intensive record-keeping, and the measurement of ''stress hormones'' (corticoids) in urine, feces, and blood. Thus the effectiveness of different enrichment items or strategies can be compared, and future research can be guided by the success or failure of previous efforts, rather than by adherence to any philosophical stance. This approach opens the door for many strategies that may include very ''artificial'' components, such as training programs or even cognitive experiments that stimulate basic problem-solving or learning abilities. To some extent, this approach is a scientifically guided process of trial and error. Of course, trial strategies are not developed blindly, but rather are guided by the intelligent application of knowledge regarding the

animal–environment interaction in the wild, and creative attempts to develop functional analogs. This combined approach, therefore, does not necessarily embrace artificiality, but it does allow it. With regard to public perception, all of the panelists concurred that enrichment—regardless of where it lies on the "naturalness" continuum—should be presented in a way that does not create a circus atmosphere, but rather provides an educational explanation of enrichment that does not diminish the conservation message.

APPLYING THE ENRICHMENT PHILOSOPHY TO GIANT PANDAS

In the case of the giant panda, we did not develop a nuts-and-bolts approach to panda enrichment programs, but did discuss strategies for some aspects of the conceptual framework as outlined above. It was readily evident that enrichment efforts for pandas are seriously compromised by the dearth of information available regarding the species' behavioral ecology in nature. However, one very important fact concerning panda life is that they spend about 55% of their time consuming bamboo [Schaller et al., 1985]. An enrichment program for giant pandas, therefore, should include ample provisioning of bamboo, and preferably give the animals the opportunity to select from among different types of bamboo. Realistically, however, pandas cannot be sustained on bamboo alone in captivity, and the provision of other foods will reduce the amount of time spent consuming bamboo to well below 55%. This "free time" can be filled in part by efforts to increase time spent consuming supplemental foods, for example, by increasing the mastication, extraction, or search effort required. Different types of feeder devices and scatter feeds can be employed toward this end. Non-feeding-enrichment items may also promote behavior analogous to feeding–for example, the stripping of leaves and bark from spruce branches is similar in form to processing bamboo [Swaisgood et al., 2001].

Social behavior is perhaps the most interactive and *contingent* behavior in the mammalian repertoire. Social interaction is characterized by constant modification of one's behavior in response to behaviors displayed by other parties. Thus, captive pandas must also be given access to other pandas to engage in normal social interactions. This is particularly important for a developing young animal, which remains with its mother for a period of 18 months or more in the wild [Lü et al., 1994; Zhu et al., 2001]. When mother-rearing to that age is not feasible, at least it is essential that the cub be reared among other cubs. Since pandas are a solitary species, it is equally important that adult pandas have the opportunity to remove themselves from the presence of other pandas at will. Communication through the use of scent signals is perhaps the most frequent form of social interaction among wild pandas, and pandas possess sophisticated abilities to extract information from these chemical signals [Swaisgood et al., 1999, 2000, 2002]. A comprehensive enrichment program should attempt to give pandas access to conspecific odors in a way that approximates such exposure in wild pandas. It has also been found that non-social odors can enhance responsiveness to novel objects [Swaisgood et al., 2001].

Finally, the other enrichment categories discussed above (e.g., enclosure design) are no less important for giant pandas. Any alteration of the captive environment or husbandry practices that can stimulate productive, healthy activity

may help fill free time and prevent the development of abnormal behaviors, and have beneficial consequences for psychological well-being.

The more practical considerations of promoting enrichment in China, which houses the majority of the captive population of giant pandas, must also be addressed. Many animal-care managers in China, as in the West, have opted for more high-tech approaches to problems with captive breeding, ignoring simpler solutions at the level of basic husbandry and behavioral management. However, these latter approaches are often more successful [Kleiman, 1994; Lindburg and Fitch-Snyder, 1994], and apparently have had substantive positive effects on the giant panda breeding program in Wolong [Swaisgood et al., in press; Zhang et al., 2000, in press]. Our Chinese colleagues readily acknowledge that enrichment is a new concept in China, but they also believe that most animal-care managers at panda breeding facilities are ready to embrace the concept and are eager to establish an enrichment program of their own. In this light, a workshop in China emphasizing the ''hows'' and ''whys'' of enrichment to promote good husbandry practices is planned. Such efforts are crucial for the exchange of information and enrichment techniques between Western practitioners and their Chinese counterparts. It is important that these efforts result in policies that involve more than just adding toys to suboptimal environments, and encourage instead the development of an all-encompassing enrichment program.

REFERENCES

Carlstead K. 1996. Effects of captivity on the behavior of wild mammals. In: Kleiman DG, Allen ME, Thompson KV, Lumpkin S, editors. Wild mammals in captivity. Chicago: University of Chicago Press. p 317–33.

Carlstead K, Shepherdson DJ. 1994. Effects of environmental enrichment on reproduction. Zoo Biol 13:447–58.

Falk JL. 1977. The origin and functions of adjunctive behavior. Anim Learn Behav 4: 325–35.

Forthman DK, Bakeman R. 1992. Environmental and social influences on enclosure use and activity patterns of captive sloth bears (*Ursus ursinus*). Zoo Biol 11:405–15.

Forthman DL, McManamon R, Levi UA, Bruner GY. 1995. Interdisciplinary issues in the design of mammal exhibits (excluding marine mammals and primates). In: Gibbons EF, Durrant BS, Demarest J, editors. Conservation of endangered species in captivity: an interdisciplinary approach. Albany, NY: State University of New York Press. p 377–99.

Forthman-Quick DL. 1984. An integrative approach to environmental engineering in zoos. Zoo Biol 3:65–77.

Hughes BO, Duncan IJH. 1988. The notion of ethological 'need': models of motivation and animal welfare. Anim Behav 36:1696–707.

Kleiman DG. 1994. Mammalian sociobiology and zoo breeding programs. Zoo Biol 13:423–32.

Lindburg DG, Fitch-Snyder H. 1994. Use of behavior to evaluate reproductive problems in captive mammals. Zoo Biol 13:433–45.

Lü Z, Pan W, Harkness J. 1994. Mother–cub relationships in giant pandas in the Qinling mountains, China, with comments on rescuing abandoned cubs. Zoo Biol 13:567–8.

Mason GJ. 1991. Stereotypies: a critical review. Anim Behav 41:1015–37.

Poole TB. 1998. Meeting a mammal's psychological needs: Basic principles. In: Shepherdson DJ, Mellen JD, Hutchins M, editors. Second nature: environmental enrichment for captive animals. Washington: Smithsonian Institution Press. p 83–94.

Schaller GB, Hu J, Pan W, Zhu J. 1985. The giant pandas of Wolong. Chicago: University of Chicago Press. 298 p.

Shepherdson D. 1998. Tracing the path of environmental enrichment in zoos. In: Shepherdson D, Mellen J, Hutchins M, editors. Second nature: environmental enrichment for captive animals. Washington: Smithsonian Institution Press. p 1–12.

Shepherdson D, Mellen J, Hutchins M, editors. 1998. Second nature: environmental enrichment for captive animals. Washington: Smithsonian Institution Press.

Swaisgood RR, Lindburg DG, Zhou X. 1999. Giant pandas discriminate individual differences in conspecific scent. Anim Behav 57:1045–53.

Swaisgood RR, Lindburg DG, Zhou X, Owen MA. 2000. The effects of sex, reproductive condition and context on discrimination of conspecific odours by giant pandas. Anim Behav 60:227–37.

Swaisgood RR, White AM, Zhou X, Zhang H, Zhang G, Wei R, Hare VJ, Tepper EM, Lindburg DG. 2001. A quantitative assessment of the efficacy of an environmental enrichment programme for giant pandas. Anim Behav 61:447–57.

Swaisgood RR, Lindburg DG, Zhang H. 2002. Discrimination of oestrous status in giant pandas via chemical cues in urine. J Zool Lond 257:381–6.

Swaisgood RR, Lindburg DG, White AM, Zhou X, Zhang H. Chemical communication in giant pandas: experimentation and application. In: Lindburg DG, Baragona K, editors. Panda Conservation. Berkeley, CA: University of California Press (in press).

Zhang GQ, Swaisgood RR, Wei RP, Zhang HM, Han HY, Li DS, Wu LF, White AM, Lindburg DG. 2000. A method for encouraging maternal care in the giant panda. Zoo Biol 19:53–63.

Zhang G, Swaisgood RR, Zhang H. An evaluation of behavioral factors influencing reproductive success and failure in captive giant pandas. Zoo Biol (in press).

Zhu X, Lindburg DG, Pan W, Forney KA, Wang D. 2001. The reproductive strategy of giant pandas: infant growth and development and mother–infant relationships. J Zool Lond 253:141–55.