Change of Enclosure in Langur Monkeys: Implications for the Evaluation of Environmental Enrichment

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A group of Hanuman langurs (Presbytis entellus) was studied before and after it was moved from an old cage-style enclosure to a novel naturalistic environment at the London Zoo. Eating and locomotion occupied more of the langurs' time in their new enclosure, whereas dozing, allogrooming, and aggression decreased, along with an increase in inter-individual distances. These changes are attributed to the larger area, the stimulating new environment, and the langurs' increased distance from visitors. Nevertheless, the study raises questions about how to define standards of desirable environmental enrichment, as the activity patterns recorded in both the old and new enclosures are within the variation observed in the wild. Zoo Biol 21:549–559, 2002. © 2002 Wiley-Liss, Inc.

Key words: Hanuman langurs; environmental enrichment; mixed-species enclosure; naturalistic exhibits; activity budget

INTRODUCTION

Many zoological gardens have redefined their objectives in recent years, from being menageries for entertainment to organizations dedicated to public education, and the conservation and well-being of the animals they hold [Seidensticker and Doherty, 1996]. This transformation is increasingly being attempted through environmental enrichment [e.g., Maple and Perkins, 1996]. Although it is vague, a useful definition of environmental enrichment is “an improvement in the biological

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functioning of captive animals resulting from modifications to their environment” [Newberry, 1995, p. 229]. This includes such measures as improved reproductive success, physical health, and psychological well-being [Committee on the Well-Being of Nonhuman Primates, 1998] which should reduce stress and stereotypies [cf., Carlstead, 1996].

One approach of environmental enrichment is to create so-called “naturalistic” environments [Polakowski, 1987; Taff and Dolhinow, 1989]. Ideally, such exhibits should not only reproduce esthetic aspects of the wild environment, but, more importantly, functional attributes such as topography, physical complexity, and vegetation. These properties are believed to allow the animals to exhibit more “species-typical” [Maple et al., 1995, p. 222; see also Kohn, 1994] or “appropriate natural” behaviors [Carlstead, 1996, p. 327], for example, in their choice of when to feed, their regulation of distance from one another, and their opportunities for social interactions with conspecifics [Ogden et al., 1993].

However, “our scientific understanding of how animals interact with naturalistic environments is very limited” [Stoinski et al., 2001, p. 431]. Few data exist about activity budgets before and after animals are moved into “naturalistic” enclosures [e.g., Clarke et al., 1982; Goerke et al., 1987; Wormell and Brayshaw, 2000] and comparisons with wild populations [Kerridge, 1997] are particularly limited.

In the present study we attempted to fill this gap by measuring activity budgets and social interactions of a captive group of Hanuman langurs in two different enclosures at the London Zoo: the small, older-styled Sobell Pavilion, and the large, newly refurbished Mappin Terraces. This mixed-species exhibit was designed to elicit a wider repertoire of behavior from the langurs by providing more stimulation and space, the opportunity to demonstrate their considerable agility, and the possibility of interspecific interactions. Our study addresses the problem of how to judge whether or not such a change should be categorized as successful by comparing the zoo data with those of wild populations.

METHODS

Study Species

Hanuman langurs (Presbytis entellus) are the best studied and most adaptable of the south Asian colobines [Dolhinow, 1972; Hrdy, 1977; Sommer, 1996]. They live in a wide range of habitats, from the Himalayas and peninsular forests to semi-arid woodlands, in villages and towns, and on cultivated land [Oppenheimer, 1977; Vogel, 1977; Roonwal and Mohnot, 1977]. In addition to their remarkable ecological adaptability, the species also has a highly variable social organization. The two basic types of social groups are bisexual troops and all-male bands. Troops are matrilineal groups of adult females and offspring with either one adult male (one-male multi-female troops or “harems”) or more than one adult male (multi-male multi-female troops). The percentage of one-male troops vs. multi-male troops, and the corresponding number of extratroop males living in all-male bands vary from site to site [Srivastava and Dunbar, 1996].

The London Zoo study population (Table 1) recreated a one-male, multi-female troop. All animals could be recognized individually.
Housing Conditions

The langurs were initially housed in the Sobell Pavilion at the London Zoo. The indoor area on view (ca. 5.5 × 5.5 × 4 m) was heated and furnished with beams, wooden platforms, ledges, and ropes. A slide in the wall led to the outside enclosure (10 × 6 × 4 m), which contained wooden platforms suspended by ropes, and grass and other vegetation on the ground. The langurs were fed in both the inside and outside areas by scatter feeds of mixed fruit, vegetables, and monkey chow at varying times throughout the day. An indoor non-viewing area was much smaller (3.5 × 3.5 × 4 m), with a few ledges, and was not available for observation during the study.

The new enclosure, the Mappin Terraces, covered ca. 0.8 ha. It contained both natural and artificial features: the front area was landscaped and planted with a variety of trees and shrubs, and a large network of telegraph poles joined by thick ropes extended along the rear half. The langurs were moved to this enclosure in April 1997, along with a pair of sloth bears (Melursus ursinus), a muntjac (Muntiacus reevesi reevesi), peafowl (Pavo cristatus), and various waterfowl, e.g., ruddy shelducks (Tadorna ferruginea). The langurs had exclusive access to one area of the terraces, and had free access to the main area where there was the possibility of interaction with the other species, all of which are found in similar habitats in Sri Lanka. Thus, it is not inconceivable that the species in the enclosure might encounter one another in the wild [Beck and Tuttle, 1972; Ripley, 1965]. The langurs also had a heated indoor area (5 × 4 × 4.5 m) where no observation was possible. They received the same scatter feeds as they had in the Sobell Pavilion.

Data Collection

The analyzed behaviors (see Dolhinow [1978] for an ethogram of Indian langur monkeys) included:

1. Resting awake (sitting/lying awake, observing).
2. Eating (foraging for and ingesting food).

### TABLE 1. Langur study group at London Zoo

<table>
<thead>
<tr>
<th>Name (abbreviation)</th>
<th>Age-sex class&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Age (Feb 97)&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Origin&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Arrival at London Zoo&lt;sup&gt;d&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Billy (Bl)</td>
<td>AM</td>
<td>5 y 11 m</td>
<td>c (Bristol)</td>
<td>11 Apr 96</td>
</tr>
<tr>
<td>Bilbo (Bi)</td>
<td>JM</td>
<td>2 y 4 m</td>
<td>c (London)</td>
<td>08 Oct 94 b</td>
</tr>
<tr>
<td>Ashley</td>
<td>IM</td>
<td>—</td>
<td>c (London)</td>
<td>28 May 97 b</td>
</tr>
<tr>
<td>Alfa (Al)</td>
<td>AF</td>
<td>17 y</td>
<td>w (Sri Lanka)</td>
<td>26 Feb 96</td>
</tr>
<tr>
<td>Aquilla (Aq)</td>
<td>AF</td>
<td>6 y 7 m</td>
<td>c (Twycross)</td>
<td>10 May 93</td>
</tr>
<tr>
<td>Tasmin (Ta)</td>
<td>AF</td>
<td>4 y 1 m</td>
<td>c (Twycross)</td>
<td>26 Aug 93 b</td>
</tr>
<tr>
<td>Gelda (Ge)</td>
<td>AF</td>
<td>3 y 6 m</td>
<td>c (London)</td>
<td>10 Aug 93 b</td>
</tr>
<tr>
<td>Patti (Pa)</td>
<td>JF</td>
<td>2 y 3 m</td>
<td>c (London)</td>
<td>02 Nov 94 b</td>
</tr>
<tr>
<td>Lulu</td>
<td>IF</td>
<td>—</td>
<td>c (London)</td>
<td>09 Mar 97 b</td>
</tr>
</tbody>
</table>

<sup>a</sup>A, adult; J, juvenile; I, infant; M, male; F, female.

<sup>b</sup>y, year; m, month(s).

<sup>c</sup>c, captive born in Zoo; w, wild born.

<sup>d</sup>b, birth.
3. Dozing (stationary, usually sitting with eyes closed, head down; slight body movements possible).
4. Allogrooming (picking through the fur of another individual, using hands and/or mouth).
5. Autogrooming (grooming own body).
6. Locomotion (movement over a distance of >3 m, or at a running pace).
7. Aggression (hitting, biting, baring teeth, chasing, tail biting, or aggressive vocalizations).
8. Embracing (A puts arms around neck or back of B, who often reciprocates).
9. Out of sight (not visible to the observer).

Quantitative data collection was carried out from 10 March 1997 to 29 March 1997 in the old enclosure, for 53 hours in total, and from 28 May 1997 to 7 July 1997, for a total of 53 hours in the new enclosure. In addition, casual observations of the group were made for a month following their rehousing on 18 April 1997.

Data were collected by K.L. via scans and ad libitum sampling, while focal animal sampling (30-min periods of one-zero sampling with 1-min intervals; cf., Altmann [1974]) on other topics was simultaneously carried out on all five adult and two juvenile group members. The focal animal was decided according to a predetermined schedule which ensured that each individual was observed for the same amount of time, equally distributed across the observation day (10:00 to 17:30 hr). This method ensured that there was no bias in the observation of any individual.

Every 15 min the whole group was scanned for activity budget categories and nearest-neighbor distances, yielding 1,304 scans for the old enclosure and 1,556 for the new (resting awake: 489 scans in the old enclosure/633 scans in the new enclosure; eating: 345/584; dozing: 285/126; allogrooming: 131/54; autogrooming: 33/12; locomotion: 11/42; out of sight: 10/105). Individuals were always scanned in the same sequence, starting with the current focal animal, to minimize bias towards more active or visible animals. Data on interactions were collected ad libitum (aggression: 195/94; embrace: 60/5; allogroom: 133/89).

Activity budget data were compared with a paired *t*-test, using the means of all individuals for each category paired across the observation day in each enclosure. Ad libitum and distance data were compared using a 2 × 2 chi-square ($\chi^2$) test (2 × 6 for distance). Birth intervals were calculated from studbook data kept at the London Zoo. Intervals following stillbirths were discounted. Significance levels were set two-tailed at 0.1 because our predictions for differences between enclosures were nondirectional.

**RESULTS**

**Qualitative Description of Behaviors**

In the old enclosure, the langurs spent much of the day sitting together inside, either resting awake or dozing. They did not have to move far to get food. When outside, they ate from the hedge surrounding the enclosure, and chased across the suspended platforms and through the beams of the ceiling, though they often appeared to be limited by space.
The langurs explored the entire area of their new enclosure within a few days of their introduction. Within a few weeks they had destroyed most of the new shrubs and saplings by removing and eating the leaves and bark, and only elder trees, holly, and pampas grass survived, presumably because they were unpalatable.

There was concern that the monkeys might be in poor physical condition through lack of exercise in the old enclosure, yet in the first days of moving to the new enclosure the langurs were seen to perform leaps of up to ca. 6 m. Generally, all animals appeared more active.

From the first day of their transfer, the langurs interacted with the species kept in the new enclosure, e.g., on 11 recorded occasions JM Bilbo chased or hit the muntjac, and regularly chased the peafowl and waterfowl. The langurs clearly perceived the sloth bears as a threat. Initially they appeared wary, and would rapidly retreat, often to a high beam, when the bears came within about 5 m. With time, however, they approached the bears when they were sleeping, and would let them come within 2 m before moving nonchalantly away. On three occasions, AM Billy made barking vocalizations toward a bear, appearing to challenge it before retreating.

Quantitative Measurements

The langurs spent a much larger percentage of their time within 1 m of other langurs in the old enclosure (63.7%) than in the new (45.5%) (Fig. 1). Time spent at greater distances from one another was correspondingly increased in the new enclosure. The difference between enclosures was significant across distance classes ($\chi^2 = 146.88$, d.f. = 5, $P < 0.001$, n = 2776).

Activity Budget

Resting awake occupied the greatest proportion of the langurs’ time (Fig. 2), with no significant difference between the two enclosures ($t = 0.80$, d.f. = 6, ns). Time spent eating and in locomotion increased significantly in the new enclosure (eating: $t = 6.40$, d.f. = 6, $P < 0.001$; locomotion: $t = 2.62$, d.f. = 6, $P < 0.05$), whereas more stationary behaviors occurred at much lower levels (dozing: $t = 10.61$, d.f. = 6, $P < 0.001$; allogrooming: $t = 2.35$, d.f. = 6, $P < 0.1$; autogrooming: $t = 2.21$, d.f. = 6, $P < 0.1$). A greater proportion of time was spent out of sight in the larger new enclosure ($t = 2.88$, d.f. = 6, $P < 0.05$).

Interactions

Allogrooming interactions decreased from 2.5 events/hr in the old enclosure to 1.7 events/hr in the new enclosure ($\chi^2 = 8.72$, d.f. = 1, $P < 0.005$, n = 222) Embracing was likewise reduced (1.1 events/hr in the old enclosure, 0.1 events/hr in the new enclosure; $\chi^2 = 23.3$, d.f. = 1, $P < 0.001$, n = 65), as were aggressive interactions, from 3.2 events/hr in the old enclosure, to 1.6 events/hr in the new ($\chi^2 = 35.3$, d.f. = 1, $P < 0.001$, n = 289).

Birth Intervals

Birth intervals were not different between the old enclosure (n = 4, mean = 427.0 days, standard error (SE) = 36.5 days; data from three females) and the new (n = 4, mean = 416.0 days, SE = 21.5 days; data from four females) (Mann-Whitney U-test, $P > 0.1$).
Fig. 1. Nearest-neighbor distances for the two enclosures. $0 = < 1$ m, $1 = 1–2.9$ m, $3 = 3–4.9$ m, $5 = 5–6.9$ m, $7 = 7–9.9$ m, $10+ = > 10$ m. Based on 1,352 scans in the old enclosure and

Fig. 2. Activity budgets of the study langurs.
DISCUSSION

Modern zoos have adopted conservation, education, science, and recreation as basic directives which cannot be achieved without proper care and welfare of captive animals [Maple et al., 1995]. Comparisons of animals before and after a change in enclosure can help to supplement subjective judgments with empirical measures of well-being [Committee on the Well-Being of Nonhuman Primates, 1998]. However, our study reveals that even the interpretation of quantitative data is not an easy task.

Old and New Enclosures: Behavioral Responses

Quantitative data collection resumed about a month after the move. However, it was clear from casual observations that any potential neophobia, or fear of novelty [Ogden et al., 1990] was not long-lasting, since the langurs explored and used the whole area available to them within a few days.

The langurs spent more time in solitary behaviors (eating and locomotion) and less time in stationary or social behaviors (dozing and allogrooming) in their new enclosure. It is unlikely that the langurs restricted their social and stationary behaviors to when they were inside, and hence unobserved, in the new enclosure because they were also at times “off show” in the old enclosure. The increased time spent feeding in the new enclosure may be due to a greater variety of food available; not only did the langurs receive food allocated to them, but they were also seen eating the bears’ food, bird seed, shrubs, saplings, and mature poplar leaves. The energy content of food eaten in the new and old enclosures is unknown. However, there was an increase in locomotion after the langurs were moved to the new enclosure, which may have led to greater energy demands that translated into a need for more food.

The overall reduction of aggression in the new enclosure was probably a result of the opportunity to disperse. In a previous study [Nieuwenhuijsen and de Waal, 1982], less crowded conditions also reduced aggression in chimpanzees. An opposite effect was found for captive macaques, probably because males in close spatial contact inhibit aggression among females [Erwin, 1979]. However, langur males do not police female–female aggression [Sommer, 1996]. Chamove et al. [1988] found that visitors can also be stressful to primates, causing aggression. The increased distance (at least 10 m, as opposed to within 1 m) of visitors from the langurs, may therefore have likewise reduced langur aggression.

In addition, lower frequencies of allogrooming and embracing (both interpreted as tension-reducing behaviors [McKenna, 1977]) suggest that the reduced crowding and increased visitor distance in the new enclosure led to a reduction of tension in the langur group.

Naturalistic Habitats: How Natural?

It is clear that there were differences between the two enclosures in the langurs’ behavior. Nevertheless, it is still difficult to define standards by which to assess the relative desirability of each living condition [Committee on the Well-Being of Nonhuman Primates, 1998]. This lack of criteria is especially problematic if the objective is to produce a repertoire of “natural” behavior. Zoos are very selective about the types of “natural” behavior that are considered acceptable both from an animal husbandry viewpoint as well as with respect to the public’s reactions [Kreger
<table>
<thead>
<tr>
<th>Site</th>
<th>Doze</th>
<th>Rest</th>
<th>Eat</th>
<th>Groom&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Locomote</th>
<th>Other</th>
<th>Remark</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>c: London Zoo (old enclosure)</td>
<td>23</td>
<td>37</td>
<td>25</td>
<td>12</td>
<td>1</td>
<td>1</td>
<td>0.6 months</td>
<td>This study</td>
</tr>
<tr>
<td>c: London Zoo (new enclosure)</td>
<td>8</td>
<td>41</td>
<td>38</td>
<td>4</td>
<td>3</td>
<td>7</td>
<td>1.3 months</td>
<td>This study</td>
</tr>
<tr>
<td>w: Himalayas, troop</td>
<td>–</td>
<td>39</td>
<td>–</td>
<td>4</td>
<td>6</td>
<td>9</td>
<td>5 months</td>
<td>Sugiyama [1975]</td>
</tr>
<tr>
<td>w: Jodhpur, harem troop Daijar</td>
<td>28</td>
<td>15</td>
<td>31</td>
<td>8</td>
<td>7</td>
<td>11</td>
<td>Annual mean</td>
<td>Winkler [1981]</td>
</tr>
<tr>
<td>w: Jodhpur, harem troop Bijolai</td>
<td>26</td>
<td>24</td>
<td>24</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>Annual mean</td>
<td>Srivastava [1989]</td>
</tr>
<tr>
<td>w: Jodhpur, harem troop Kailana-I</td>
<td>24</td>
<td>35</td>
<td>20</td>
<td>9</td>
<td>9</td>
<td>2</td>
<td>Annual mean</td>
<td>Sommer [1996]</td>
</tr>
<tr>
<td>w: Jodhpur, male band Machiya</td>
<td>32</td>
<td>26</td>
<td>29</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>Annual mean</td>
<td>Sommer [1996]</td>
</tr>
<tr>
<td>w: Jodhpur, male band Canal</td>
<td>30</td>
<td>31</td>
<td>29</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>Annual mean</td>
<td>Sommer [1996]</td>
</tr>
<tr>
<td>w: Jodhpur, male band Chopasani</td>
<td>28</td>
<td>36</td>
<td>25</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>Annual mean</td>
<td>Sommer [1996]</td>
</tr>
<tr>
<td>w: Jodhpur (data range)</td>
<td>8–53</td>
<td>11–56</td>
<td>12–42</td>
<td>0–15</td>
<td>1–17</td>
<td>0–23</td>
<td>Individual months</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>c, captive; <sup>w</sup> wild; Jodhpur, Northwest-India.
<sup>b</sup>Auto- and allogrooming.
and Mench, 1995]. For example, langurs in the wild experience predation, infanticide by incoming males, high infant mortality, increased aggression due to spatial proximity around clumped food sources, and fierce male–male competition for females, including mutual killings [cf., e.g., Hrdy, 1977; Sommer, 1996]. However, zoos will try to minimize the occurrence of such “natural” events [cf., Böer and Sommer, 1992], thus defeating the very goal of inducing “species-typical levels of behavior” [Maple et al., 1995, p. 222].

On the other hand, the London langurs were subjected to stimuli that evoked predator-avoidance behavior: bears. Conﬁned animals that are not able to actively avoid fearful situations may suffer chronic stress (long-term adrenocortical activation; reviewed in Carlstead [1996]), whereas the langurs seemed to be able to predict and control the adverse situation. This facet of the multi-species exhibit may thus produce a level of “eustress” that is desirable since it counteracts “boredom.” Nevertheless, we still lack criteria to determine which environmental stressors should be encouraged to occur [Committee on the Well-Being of Nonhuman Primates, 1998].

Equally problematic is the assumption that increased reproductive rates indicate improved captive conditions. Although birth intervals were not signiﬁcantly reduced in the new enclosure, reproductive performance will remain an ambiguous yardstick of the quality of captive conditions. In wild langurs, shorter birth intervals are largely correlated with better food availability, but again, food stress is a natural phenomenon [Podzuweit, 1994]. Conversely, dramatic increases in captive populations would soon require “unnatural” birth control measures, such as vasectomy.

Finally, can activity budgets help deﬁne desirable captive conditions? A comparison of langur activity in the wild and in captivity reveals that the small enclosure produced the relatively highest grooming and lowest locomotion scores, whereas the new enclosure produced the relatively lowest score for dozing and highest for resting awake (Table 2; note that no other published activity budgets are available for wild langurs). Thus, we are left with the conundrum of deciding which of the unusually high activities are “better.” It is not easy to arrive at an answer, given that ecological and behavioral ﬂexibility is the very hallmark of the langur. Moreover, all scores recorded in the London Zoo are within the range of the wild data, if monthly rather than annual means are considered. Variations largely reﬂect climatic conditions. For example, langurs doze much and eat little during hot months, and doze less and eat more during cooler months. Thus, even in a zoo in a temperate climate, considerable variation of activity is to be expected.

Since so many conditions can be classiﬁed as “natural” or “normal,” it is necessary for zoos exhibiting langurs to decide which of the behavioral repertoires observed in the wild they wish to present to the public. Moreover, the changes in behavior observed in the new large enclosure may or may not reﬂect an increase in the physical and psychological well-being of the study animals, because behavioral measures can only serve as operational indices of well-being [Committee on the Well-Being of Nonhuman Primates, 1998] and they are certainly distorted by our “anthropomorphically biased opinions” [Wuichet and Norton, 1995, p. 244].

The psychological state of other animals is notoriously difﬁcult to judge, but larger enclosures that look more naturalistic can at least make us feel better about keeping fellow primates in captivity [Wuichet and Norton, 1995]. Studies have shown that visitors watch free-ranging monkeys longer than they do caged animals
[Price et al., 1994]. This certainly seemed to be true for the new London exhibit. One should not disregard this aspect as long as “recreation” is still a vital goal, even in modern zoos [Maple et al., 1995], particularly because happy visitors are probably more receptive to learning about conservation problems nonhuman primates may face in their natural habitat.

CONCLUSIONS

1. A troop of Hanuman langurs at the London Zoo was studied before and after its move from a small, cage-style enclosure to a large, outdoor, naturalistic enclosure.

2. The langurs’ activity budgets changed considerably in the direction of less stationary behavior (foraging/locomotion) in the new enclosure.

3. The rates of affiliative and aggressive behaviors were reduced in the new enclosure, which might be due to a reduction in stress caused by crowding and proximity to visitors in the older, more confined enclosure.

4. The refurbished multi-species Mappin Terraces at the London Zoo, of which the langurs are an integral part, may create a greater public awareness of the need to conserve not only species, but also their habitats.

5. Standards for the classification of desired and undesired patterns of behavior are still lacking and are difficult to define for all animals, especially for animals such as the Hanuman langur, which shows tremendous behavioral flexibility in the wild.

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