Managing primates in zoos: Lessons from animal behaviour

Avanti Mallapur

Culture, Cognition and Consciousness Unit, National Institute of Advanced Studies, Indian Institute of Science Campus, Bangalore 560 012, India

The use of animal behaviour in primate husbandry and management is discussed here through two studies conducted on non-human primates in Indian zoos. Abnormal behaviours such as begging from humans, floating limb, self-biting and stereotypic pacing were observed only in omnivorous primates in these two studies. The factors influencing the exhibition of abnormal behaviours were identified to be group composition and size, enclosure design and rearing history. Methods to reduce and increase proportions of behaviour pathologies and natural behaviours, respectively, have been suggested. The behaviour of captive non-human primates differs vastly from their free-ranging counter-parts. This difference is primarily because captive environments lack appropriate environmental and social stimuli, which often leads to the development of bizarre behavioural patterns unique to captive animals, technically referred to as 'abnormal behaviours'. In this paper, presence of abnormal behaviours in the behavioural repertoire of a captive primate is used to demonstrate the need for animal behaviour studies to be included in the management strategies towards improved primate husbandry in Indian zoos.

Keywords: Abnormal behaviour, primate husbandry, stress, zoos.

NON-HUMAN primates, due to their level of intelligence when compared to other animals, and also due to their evolutionary closeness to man are maintained in several types of captive facilities like laboratories, zoological parks, animal circuses and conservation breeding centres. Being popular exhibits, most zoos maintain primates in their collections. In some cases, these zoo primates are maintained in environments, which are unstimulating and sub-optimal[1]. Captive environments such as these biologically and spatially restrict the animal from performing its species-specific behaviour. Such an inability to adapt to their artificial surroundings results in the exhibition of behavioural patterns typical to captive animals and are called abnormal behaviours[2]. Today, considerable research is focused on zoo primate behaviour[3–5]. A large proportion of these studies focus on abnormal behaviour and the factors that influence them[6–9].

e-mail: avantim@yahoo.com

Several environmental factors influence the behaviour of primates in zoos, one of these being enclosure space. Primates housed in unnaturally barren environments or small exhibits, are deprived of appropriate stimuli for the expression of a natural behavioural repertoire[10,11]. It has been observed that animals housed in sub-optimal environments develop a wide range of abnormal behavioural patterns[12–14] and that those housed in smaller indoor enclosures are less active than those housed in larger outdoor enclosures[15]. Rearing history also influences the behavioural repertoire of zoo primates[5]. There is a high incidence of abnormal behaviour in captive primates having a history of social deprivation[6,9,16,17]. Housing animals singly or in group compositions that are inappropriate for the species, results in a reduction in exploratory and social behaviour and also stimulates an exhibition of abnormalities[18–21].

Applied behaviour studies are the most popular and easiest way to identify problems in primate husbandry and are carried out regularly in most modern zoos. In this paper, the use and significance of behaviour studies in primate husbandry and management in zoos is demonstrated through two studies conducted on captive non-human primates in Indian zoos. The need to include behavioural research and monitoring of zoo animals as a part of zoo husbandry and management protocol has also been emphasized in this paper.

Methods

Subjects and housing

Study 1: The behaviour of 11 species of non-human primates (NHPs) found in India (five species of macaques and langurs each and one species of ape) was recorded across 10 zoos in India[6].

Study 2: The behaviour of 52 lion-tailed macaques housed in 12 zoos in India was recorded[7].

In both studies, the NHPs were either wild-caught (caught from the wild), captive-reared (wild-caught but been in captivity for > 5 years), zoo-born (born in the zoo) or confiscated (confiscated from small, unrecognized zoos and circuses). They housed in diverse group sizes and compositions in different enclosures types, which varied in their degree of complexity (Table 1).

Behavioural and analytical methods

Study 1: Observations were conducted between November 1999 and June 2000. NHPs were observed for eight hours between the time the zoo opened in the morning, i.e. 9:00 hrs to the time they closed, i.e. 17:00 hrs. The behaviour was recorded using instantaneous scans every five minutes during each sampling period[22,23].

Study 2: The study on captive lion-tailed macaques was conducted between May 2002 and December 2003. The lion-tailed macaques were observed for nine hours during the day between the time the zoo opened in the morning, i.e. 08:30 hrs to the time they closed, i.e. 17:30 hrs. Behaviour was sampled using instantaneous scans every 15 minutes during the sampling period.

The display of behavioural states, as recorded in the instantaneous scans, has been expressed as percentage time spent in particular states to the total time that an individual was observed. Data for different individuals in each group were also pooled at the end of the observation period to obtain group averages. In both studies 1 and 2, the behaviours that were recorded were abnormal, active, foraging, rest-related and social behaviours (Table 2).

Mann–Whitney *U*-Wilcoxon Rank Sum *W* Test was used to test the differences among the sexes, age classes and rearing history in both studies[24]. In study 1, Kruskal–Wallis (KW) test was used to analyse the differences with group sizes and compositions[24]. Kruskal–Wallis test was also used in study 2 to analyse the differences across group size and composition and enclosure design. Spearman's correlation test was used in study 1 to examine the relationship between behaviour and the factors (for example enclosure complexity, enclosure type and rearing history) that influence them[24]. All *P* values that have been reported are two-tailed.

Table 1. Factor categories used to compare behavioural data of NHPs

Group size and composition[1]
- Singly housed[2]
- One male, one female
- Single adult with young
- One male, female/s and young

Enclosure type
- Cage: enclosed by wrought iron bars
- Wet-moated enclosures: enclosure surrounded by a moat containing water
- Dry-moated enclosures: enclosure surrounded by a steep walled moat that is maintained dry.

Enclosure complexity
- Barren enclosures: enclosures devoid of any structural features other than the four walls, floor and the roof
- Barren but enriched enclosures: barren enclosures that have been structurally enriched
- Complex enclosure: enclosures that possess several natural features such as trees, bushes, water body, etc. that resemble the animal's natural habitat

Enclosure substrate
- Enclosures with a hard substrate: such as cement or concrete
- Enclosures with a soft substrate: such as grass, sand or soil

[1]Factors, [2]Categories.

Results

In study 1, only omnivorous NHPs (primates that feed on leaves, fruits, insects and even meat) were found to behave abnormally while the folivorous NHPs (primates that feed almost exclusively on leaves and young shoots) did not (Figure 1). Of the 28 groups of omnivorous NHPs observed, individuals from 13 groups (46.43%) were found to exhibit abnormal behaviours (Figure 2). Study 2 was carried out on an omnivorous species of NHP and individuals from 17 groups (out of a total of 26 groups; 65.39%) exhibited abnormal behaviours.

Housing macaques singly or pairs, was found to be inappropriate in study 1 where male–female macaque pairs and singly-housed macaque individuals exhibited significantly higher levels of abnormal behaviour than did group-housed macaques and mother–offspring pairs (KW test, $\chi^2 = 8.250$, df = 3, $N = 6$, 14, 4 and 1, $P = 0.041$).

Table 2. Behaviours exhibited by captive NHPs

Abnormal behaviour (total of all abnormal behaviours recorded in the study)
- Begging from humans – when NHPs beg for food from visitors and zoo staff
- Floating limb – when hind limbs move involuntarily
- Self-clasping – holding parts of ones body (only exhibited by NHPs in study 1 and hence recorded)
- Stereotypic pacing – move along same path repetitively. This behaviour is idiosyncratic with no obvious function or goal
- Hair-plucking – plucking ones own hair (only exhibited by NHPs in-study 2 and hence recorded)
- Self-biting – biting oneself (only exhibited by NHPs in study 2 and hence recorded)

Active behaviour (total of all active behaviours recorded in the study)
- In study 1, only total active behaviour was recorded
- In study 2, total active behaviours included climb, run, stand and walk

Rest-related behaviour (total of all rest-related behaviours recorded in the study)
- In study 1, only total rest-related behaviour was recorded
- In study 2, total rest-related behaviour included lie-down, sit and sleep

Foraging behaviour (total of all foraging behaviours recorded in the study)
- In study 1, only total foraging behaviour was recorded
- In study 2, total foraging behaviour included active and passive foraging

Social behaviour (total of all social behaviours recorded in the study)
- In studies 1 and 2, total social behaviour included auto- and allogrooming, and play behaviour

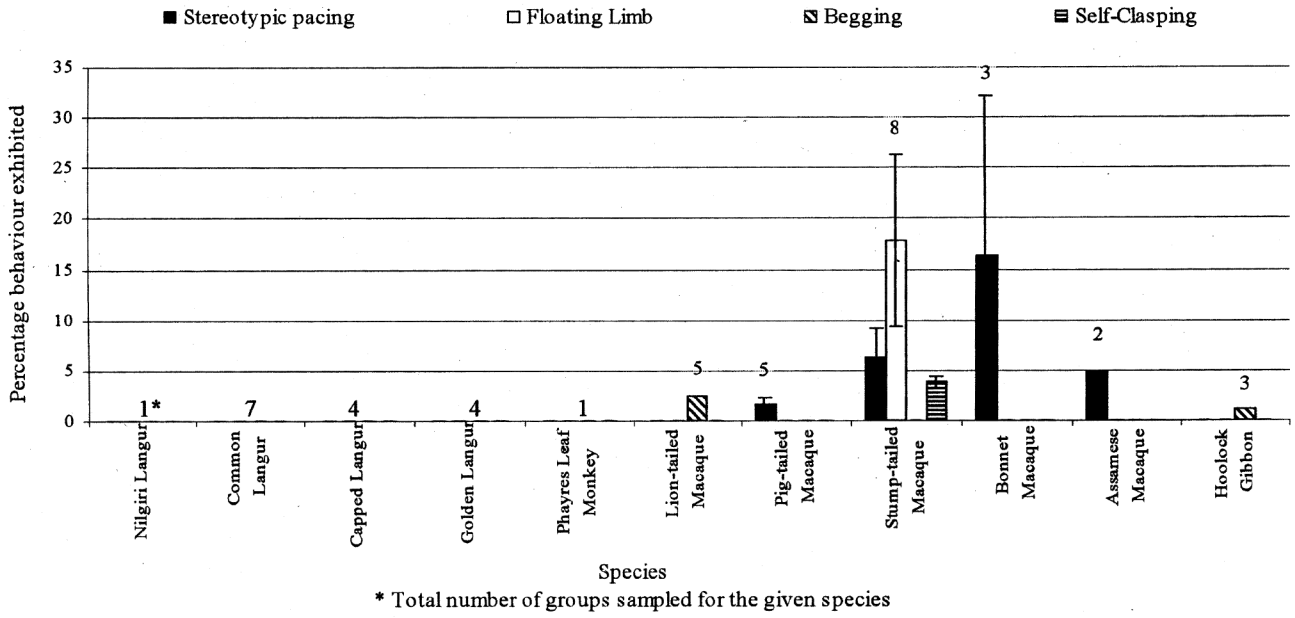

Figure 1. Proportions of abnormal behaviour exhibited by captive NHPs observed in study 1.

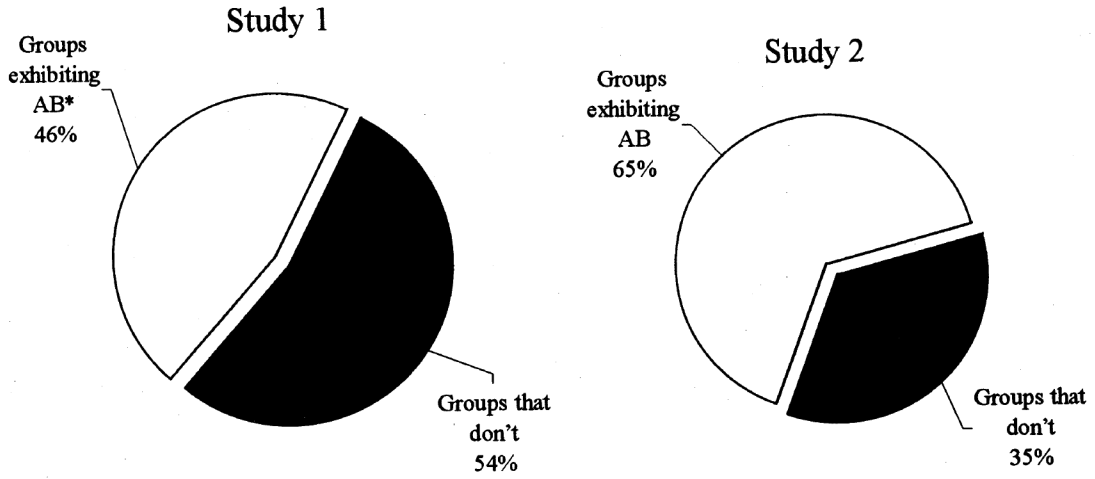

Figure 2. Percentage of captive NHP groups that exhibited abnormal behaviours (AB) in studies 1 and 2, to the total number of NHP groups sampled. *Abnormal behaviour, **Proportions of NHP groups exhibiting these AB to total number of NHP groups sampled.

(This test was run only for macaques since the gibbons ($N = 3$) observed during the study were housed only singly or in pairs.) For example, macaques housed in cages and enclosures with a hard substrate exhibited higher levels of abnormal behaviour than those housed in open-moated enclosures and in enclosures with a soft substrate respectively (Spearman's co-efficient, enclosure complexity, rho = – 0.35, $N = 47$, $P = 0.01$; enclosure substrate, rho = – 0.35, $N = 47$, $P = 0.009$). Similarly, group-housed langurs maintained in complex enclosures were significantly more active than group-housed langurs maintained in barren-but-enriched enclosures ($U = 0.0$, $N = 2$ and 5, $P = 0.05$). Fascinatingly, in both studies 1 and 2, enclosure design had a profound influence on foraging behaviour too. In study 1, NHPs housed in complex and open-moated enclosures exhibited significantly higher proportions of foraging behaviour than individuals housed in barren enclosures and cages respectively (enclosure complexity, rho = 0.589, $N = 47$, $P < 0.001$; enclosure type, rho = 0.561, $N = 47$, $P < 0.001$). Similarly, in study 2 captive lion-tailed macaques housed in complex and dry-moated enclosures were observed to forage for significantly greater proportions of time than those maintained in barren enclosures and cages respectively (enclosure complexity (for active foraging), KW test $\chi^2 = 15.74$, df = 2, $N = 9$, 10 and 7, $P = 0.001$; enclosure

type (for passive foraging), $\chi^2 = 24.29$, df = 2, $N = 19$, 5 and 2, $P < 0.001$).

Discussion

These behaviour patterns were identified and defined as begging from humans, floating limb, self-clasping and stereotypic pacing[5] for study 1 and begging from humans, floating limb, hair-plucking, self-biting and stereotypic pacing for study 2 (Table 1). Animal behaviour studies such as these provide information on an individual's needs, preferences and internal states[25]. Changes in the natural pattern of behaviour to an out-of-context exhibition of behaviour such as the abnormal behaviours listed above provide cues that the individual in question is under stress. Individuals from approximately 50% of the NHP groups observed in studies 1 and 2 behaved abnormally. Since both studies 1 and 2 sampled NHP groups from zoos situated in different parts of India, a high incidence of abnormal behaviour such as this in the Indian captive NHP population, suggests that the husbandry and management protocols followed by Indian zoos should be carefully scrutinized and probably revised. Moreover, the protocols followed should be taxa- or even species-specific especially when some taxa such as macaques and gibbons are more prone to be affected by captivity than others (e.g., langurs). Incidence of abnormal behaviour could be influenced by variance in diet and food acquisition techniques that NHPs use in the wild[8,5]. Free-ranging omnivores spend more time foraging, especially for insects, in comparison to folivores. Marriner and Drickamer[9] in their study on stereotypy in captive primates observed that, in the absence of insects and a variety in the diet, the foraging time spent by omnivores could be as low as that of folivores and suggested that this could be the reason why omnivores exhibited abnormal behaviours while folivores did not. Their higher cognitive capacities could also render gibbons and macaques more prone to the adverse influences of captive environments (A. Sinha, pers. commun. 11/05/03).

Captive environments impose on wild animals a setting that differs vastly from that in which they have evolved. To thrive in captivity, a species must accommodate these differences. A species ability to respond to captive conditions with behaviour from its normal behavioural repertoire depends on the degree to which the particular captive condition resembles its natural environment[26]. In order to reduce the levels of stress in a captive population of NHPs, scientists conduct applied behavioural studies to identify the environmental factors that influence the behaviour of these individuals[5–9,27]. Several factors influence the behaviour, reproduction and health of NHPs in zoos. Some such factors identified were group composition and size, enclosure design and rearing history.

In the wild, non-human primates live in large, complex social groupings[28]. In Indian zoos, NHPs are rarely housed in group sizes of more than five individuals, the most common sight being an individual housed in isolation or with one other individual. Several other studies have also suggested that housing NHPs in pairs or in isolation or even in species-inappropriate groupings gives rise to abnormalities in their behavioural repertoire[10,16,19,29]. In Indian zoos, NHPs are often maintained in species-inappropriate groups because of the lack of suitable enclosures to house large groups.

NHPs are also sensitive to the enclosures in which they are housed and enclosure features such as enclosure complexity, enclosure type and enclosure substrate (Table 1) tend to influence their behavioural repertoire[12–14].

In studies 1 and 2, individuals housed in barren cages with hard substrates exhibited higher levels of abnormal behaviour and lower levels of foraging and active behaviours compared to individuals housed in complex open-moated enclosures with soft substrates. Most outdoor, open-moated enclosures are naturalistic with trees, shrubs and water-bodies, and usually have a soft substrate of grass, sand or soil. Enclosures such as these provide the appropriate environmental stimuli, which in turn promote the exhibition of exploratory, foraging, and other natural behaviour patterns. On the contrary, barren cages usually have concrete floors, with no water bodies or any greenery. The lack of sensory input from these cages hinders the development of a natural behavioural repertoire. In the absence of environmental stimuli from their relatively stark environments, NHPs housed in cages and barren enclosures tend to develop behavioural abnormalities[6,8,16,17,19]. Similarly, rearing history also influences behaviour in captive NHPs[5].

An individual's rearing history significantly influences its behavioural repertoire[5]. Strikingly, abnormal behaviours were only exhibited by confiscated and zoo-born individuals, and never by wild-caught and captive-reared animals. NHPs (macaques and hoolock gibbons) confiscated from small, unrecognized/mobile zoos and circuses exhibited higher levels of abnormal behaviour than zoo-born, wild-caught or captive-reared animals. (Study 2 (for captive lion-tailed macaques), $U = 27.0$, $N = 12$ and 11, $P = 0.016$.) In study 2, confiscated lion-tailed macaques tended to stand more and climb less than zoo-born, captive-reared or wild-caught individuals (climbing, rho = -0.55, $N = 26$, $P = 0.004$; standing, rho = 0.61, $N = 26$, $P = 0.001$). Confiscated individuals usually have an early history of social deprivation. Due to the absence of social stimuli, in these captive environments, NHPs develop abnormal behaviours which probably increase sensory inputs in poor environments. At the same time, confiscated individuals exhibit lower levels of natural behaviours such as climbing. Several studies conducted on the development of abnormal behaviours have inferred that self-mutilatory (e.g. self-biting) could have developed at an early stage in life in isolate-reared macaques[6,16,17]. Anderson and Chamove[16] have suggested that self-mutilatory

behaviours are a form of redirected social behaviours exhibited by individuals in the absence of social targets. A study of breeding behaviour in Mangabeys showed that socially deprived individuals exhibited abnormal behaviour and did not breed even when they were later housed in pairs[3].

The behavioural repertoire of captive non-human primates varies considerably in proportions, frequencies exhibited and behavioural diversity from their free-ranging cousins. The main reason for this difference is the lack of appropriate environmental stimuli in their captive environments. To solve these problems, the environmental factors that influence the behavioural repertoires of the captive animals need to be identified and methods to alleviate stress in these individuals need to be devised. The influence of enclosure design, group composition and rearing history on the activity budget and the development of behavioural abnormalities in captive NHPs was recorded. Only individuals that were either housed in barren cages or in species inappropriate groupings or had experienced social deprivation during their early years of life exhibited bizarre behavioural patterns. These individuals exhibited fewer natural behaviours and to a lower proportion in comparison to other captive individuals. The environmental factors mentioned above play an important role in the behavioural management and husbandry of NHPs; it would be imperative to take these factors into consideration while building new exhibits or forming new groups of any given primate species.

Conclusions

The topic of stress and its influence on captive animals has intrigued the international zoo-community increasing the quantum of applied behavioural research and monitoring conducted in the zoo setting by tenfold. Simultaneously, zoos around the world have realized the vital importance and have included applied behavioural research and monitoring as a part of their basic husbandry and management protocol. This in turn has led to barren cages being phased out in most zoos only to be replaced by large, complex open-moated enclosures to maintain large groups of NHPs. Apart from this, enrichment is constantly administered to stimulate these NHP groups to exhibit natural behaviours. Shockingly, Indian zoos still house NHPs in barren, sub-optimal surroundings and zoo staff do not provide enrichment either, which has resulted in as high as 50% of the captive NHPs behaving abnormally, probably due to stress. As a result of the absence of behavioural monitoring in Indian zoos, the zoo staff is oblivious of the pathetic condition of captive NHP populations maintained in their zoos. The exhibition of abnormal behaviour not only suggests that the individuals exhibiting these behaviours are under stress, but also that they constitute poor exhibits and could convey an inappropriate impression to visitors. Lack in awareness on the significance of such studies to zoo animal husbandry and management has resulted in a dearth of behavioural literature from Indian zoos. There is a great need for long-term or periodic short-term applied behavioural and welfare studies in Indian zoos to manage our captive wild animal populations as well as to contribute information to the zoo community. Some of the recommendations suggested in the two studies are:

Enclosure design: Enclosure features such as enclosure complexity, type and substrate influence the behavioural repertoire of captive non-human primates. Studies have shown that large, complex, out-door (open-moated) enclosures with a substrate of sand, soil or grass are ideal for housing primates. Large enclosures also make it easier to house larger NHP groups. This would prove advantageous while planning an exhibit for langurs or macaques that live in groups consisting of > 10 animals in the wild. Providing enrichment such as fruits hidden at strategic points within the enclosure, logs and branches places at various elevations to give an access to the vertical dimension or even a swing.

Group composition: Most langurs and macaques live in large groups of > 10 animals in a group while hoolock gibbons live in bonded pairs often seen with young. Housing these species in groups consisting of males, several females and young similar to the group compositions of their free-ranging counterparts would help them cope with their artificial surroundings. Such groups will also provide a good environment for the development of natural behavioural repertoire in the young. Mixed species exhibits could also be used to house NHPs that live in the area in the wild.

Rearing history: Young NHPs that are reared in isolation in small, barren cages develop bizarre behaviour patterns. To prevent the development of abnormal behaviours in young primates, housing them in an environment similar to their natural habitat would prove highly beneficial. If infants are being hand-reared, it would be imperative to provide the infant with a soft toy or any other soft surface for the infant to cling onto. Housing young even with individuals of another species would prove beneficial in comparison to isolation.

1. Erwin, J. and Deni, R., Strangers in a strange land: abnormal behaviors or abnormal environments? In *Captivity and Behavior: Primates in Breeding Colonies, Laboratories and Zoos* (eds Maple, T. L., Erwin, J. and Mitchell, G.), Van Nostrand Reinhold, New York, 1979, pp. 1–28.
2. Duncan, I. J. H. and Fraser, D. Understanding animal welfare. In *Animal Welfare* (eds Appleby, M. C. and Hughes, B. O.), CAB International, Oxon, 2000, pp. 19–32.
3. Boorer, M. K., Some aspects of stereotyped patterns of movement exhibited by zoo animals. *Int. Zoo Yrbk.*, 1972, **12**, 164–168.

4. Mitchell, G. *et al.*, Descriptive accounts of the behavior of breeding and nonbreeding pairs of golden-bellied mangabeys (*Cercocebus galeritus chrysogaster*). *Zoo Biol.,* 1987, **6**, 391–399.
5. Johnson, L. D. *et al.*, Survival and reproduction as measures of psychological well-being in cotton-top tamarins. In *Through the Looking Glass: Issues of Psychological Well-being in Captive Non-human Primates* (eds Novak, M. A. and Petto, A. J.), American Psychological Association, Washington DC, 1991, pp. 93–102.
6. Mallapur, A. and Choudhury, B. C., Behavioral abnormalities in captive non-human primates. *J. Appl. Anim. Welfare Sci.*, 2003, **6**, 275–284.
7. Chamove, A. S. *et al.,* Social and environmental influences on self-aggression in monkeys. *Primates*, 1984, **25**, 319–325.
8. Mason, G. J., Stereotypies: A critical review. *Anim. Behav.*, 1991, **41**, 1015–1037.
9. Marriner, L. M. and Drickamer, L. C., Factors influencing stereotyped behaviour of primates in a zoo. *Zoo Biol.*, 1994, **13,** 267–275.
10. Mootnick, A. R. and Baker, E., Masturbation in captive *Hylobates* (gibbons). *Zoo Biol.*, 1994, **13,** 345–353.
11. Reinhardt, V. *et al.*, Space requirement stipulations for caged nonhuman primates in the United States: a critical review. *Anim. Welfare,* 1996, **5**, 361–372.
12. Reinhardt, V., Refining the traditional housing and handling of research macaques in Monograph online available at http://pantheon.yale.edu/~seelig/pef/new/new.html, 1997, 1–9.
13. Clarke, A. S. *et al.*, Behavioural effects of a change in the physical environment: a pilot study of captive chimpanzees. *Zoo Biol.*, 1982, **1**, 371–380.
14. Goerke, B. *et al.*, Behavioral changes of a juvenile gorilla after a transfer to a more naturalistic environment. *Zoo Biol.*, 1987, **6**, 283–295.
15. O'Neill, P. L. *et al.*, Normalizing laboratory-reared rhesus macaque (*Macaca mulatta*) behavior with exposure to complex outdoor enclosures. *Zoo Biol.,* 1991, **10**, 237–245.
16. Macedonia, J. M., Effects of housing differences upon activity budgets in captive sifakas (*Propithecus verreauxi*). *Zoo Biol.*, 1987, **6**, 55–67.
17. Anderson, J. R. and Chamove, A. S., Self-aggression and social aggression in laboratory-reared macaques. *J. Abnorm. Psych.*, 1980, **89**, 539–550.
18. Anderson, J. R. and Chamove, A. S., Early social experience and the development of self-aggression in monkeys. *Biol.Behav.,* 1985, **10**, 147–157.
19. Kiley-Worthington, M., *Behavioral Problems of Farm Animals,* Oriel Press, Stockfield, 1977, pp. 153.
20. Rendall, D. and Taylor, L. L., Female sexual behaviour in the absence of male–male competition in captive Japanese macaques (*Macaca fuscata*). *Zoo Biol.,* 1991, **10**, 319–328.
21. Buchanan-Smith, H. M., Enriching the lives of marmosets and tamarins in captivity. *Shap. Enrich.,* 1996, **5**, 3–5.
22. Buchanan-Smith, H. M., Environmental control: an important feature of good captive callithricid environments. In *Marmosets and Tamarins in Biological and Biomedical Research* (eds Pryce, C., Scitt, L. and Schnell, C.), DSSD Imagery, Salisbury, 1997, pp. 47–53.
23. Altmann, J., Observational study of behaviour: sampling methods *Behaviour*, 1974, **49**, 227–267.
24. Martin, P. and Bateson, P., In *Measuring Behaviour,* Cambridge University Press, Cambridge, 1986, pp. 120.
25. Siegal, S. and Castellan, N. J., In *Nonparametric Statistics for the Behavioral Sciences*, McGraw-Hill, New York, 1988, pp. 170.
26. Mench, J. A. and Mason, G. J., *Behaviour in Animal Welfare* (eds Appleby, M. C. and Hughes, B. O.), CAB International, Oxon, 2000, pp. 127–142.
27. Carlstead, K., Determining the causes of stereotypic behaviour in zoo carnivores: Towards developing appropriate enrichment. In *Environmental Enrichment for Captive Animals* (eds Shepherdson, D. J., Mellen, J. and Hutchins, M.), Smithsonian Institute Press, Washington DC, 1998, pp. 285–297.
28. Fritz, J. *et al.,* Abnormal behaviors, with a special focus on rocking, and reproductive competence in a large sample of captive chimpanzees (*Pan troglodytes*). *Am. J. Primat.,* 1992, **27**, 161–176.
29. Coe, C. L., Is social housing of primates always the optimal choice. In *Through the Looking Glass: Issues of Psychological Well-Being in Captive Nonhuman Primates* (eds Novak, M. A. and Petto, A. J.), American Psychological Association, Washington, 1991, pp. 78–92.