EFFECTS OF BROWSE, HUMAN VISITORS AND NOISE ON THE BEHAVIOUR OF CAPTIVE ORANG UTANS

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Abstract

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*This paper reports a study of the behaviour of captive orang utans (*Pongo pygmaeus*) at Chester Zoo, UK. The study addressed two questions: what is the effect of the presence of fresh browse on the animals' behaviour; and what is the effect of the presence of visitors? The first part of the study analysed the animals' time budgets. The results indicated that the provision of fresh browse led to a decrease in the time spent sitting inactive by both adults and infants; it also led to an increase in the time spent by adults foraging for small food items in the woodchip floor-covering beneath the branches of browse. The time-budget data also showed differences in the animals' behaviour between periods when large groups of visitors arrived and other periods on the same days when visitors were fewer. Specifically, adults used available paper sacks to cover their heads more during periods of high visitor density, and infants held onto adults more. The second part of the study comprised an experiment in which visitor behaviour was manipulated. Visitor groups of similar sizes were asked to behave either quietly or noisily (making vocal noise), in order to determine whether the observed effects of visitors were attributable to group size or to the fact that larger groups tend to be noisier. The experiment indicated that the animals responded particularly to noise: when confronted with noisy groups, all animals looked more at the visitors, and infants approached and held onto adults more. The findings suggest that zoo managers may need to take visitor behaviour into account in order to promote orang utan welfare.*

Keywords: *environmental enrichment, orang utan, responses to zoo visitors, zoo animal welfare*

Introduction

Two factors pose particular challenges to the welfare of zoo animals. One of these is the lack of variability and stimulation in the animals' lives. The second is the presence of human visitors, who may provide some stimulation but whose presence or behaviour might be stressful. Environmental enrichment is now commonly used to address the first of these problems, in order to counteract the problems of an unchallenging environment. The second problem is more difficult to address, as human visitors are clearly part of the reason for zoos' existence and their numbers and behaviour are very difficult to predict or control. This paper reports on a study of captive orang utans (*Pongo pygmaeus pygmaeus* and *Pongo pygmaeus abelii*) at Chester Zoo, UK, which addressed two questions: how is the animals' behaviour affected by enrichment; and how is their behaviour affected by the presence of human visitors? The aim of the study was to investigate the potential effects and produce recommendations for the future development of the orang utan facility at Chester.

Environmental enrichment for captive animals is used to promote their well-being, to give them 'something to do' and to address their behavioural needs (Duncan & Poole 1990;

Mench 1998). Conversely, lack of stimulation is undoubtedly a welfare issue, and it can be argued that being in an environment that presents active challenges to an animal is integral to its well-being (Wemelsfelder & Birke 1997). The provision of enrichment is not without problems, however, such as adverse effects on health (Baer 1998) or habituation to the stimuli provided. Habituation, resulting in reduced effectiveness of the enrichment device, is more likely if the environmental modifications involved have little functional significance to the animals — that is, if they are not biologically relevant (Newberry 1995).

Among the most biologically relevant modifications are those that promote foraging behaviour: a greater level of complexity in relation to food-acquiring activities increases information available to the animal and gives it more opportunity to make choices (Chamove 1989; Lindburg 1998). For orang utans, captive environments are considerably less complex than the wild forests of Southeast Asia to which they are adapted; in the wild, they seek out up to 400 different species of plant food, often travelling considerable distances (Kaplan & Rogers 1999; Utami *et al* 1997). Mench (1998) has pointed out how important exploratory behaviour — the process of obtaining and updating information — is to species such as orang utans which are generalists and/or live in a variable environment. Various kinds of enrichment devices, she argues, can help to promote exploration and hence to reduce the amount of time animals spend sitting idle. For example, several studies of captive orang utans have shown that the provision of small food items increases activity levels (Tripp 1985), as does the presence of objects such as furnishings in the enclosure (Perkins 1992; Wilson 1982; Stevenson 1983).

A significant part of the environment for a captive zoo animal, however, includes humans who may handle the animal in various ways, try to engage its attention, or simply stare at it. Their impact on the animal may be positive (as a source of stimulation), or negative (leading to stress). Some studies indicate that captive animals engage with human observers/visitors (eg Siamangs [*Hylobates syndactylus*] mimicking humans, Nimon & Dalziel 1991; chimpanzees [*Pan troglodytes*], Cook & Hosey 1995; Wood 1998). On the other hand, several studies suggest that humans' presence or behaviour can provoke fear reactions or stress. Fear responses in agricultural animals are of a lower magnitude if the human stockperson attempts to be 'friendly' in dealing with the animals (Hemsworth & Gonyou 1997; Rushen *et al* 1999) or if the human adopts a less upright posture (Miura *et al* 1996).

Studies of primates in zoos indicate that behaviour does sometimes change in the presence of visitors. Exploration may decrease (eg three lorisoid species, Oswald & Kuyk 1977) or intragroup aggression and stereotyped behaviours may increase if visitors are present (Chamove *et al* 1988; Mitchell *et al* 1991; Lambeth *et al* 1997). The number of visitors is also important; in Wood's (1998) study of chimpanzees, for example, high visitor density was associated with less foraging and object manipulation. It is, however, not always clear whether observed associations occur because human observers are attracted to animals behaving in particular ways, or because the animals are stressed by visitors and find the presence of humans aversive. Reviewing the evidence for each of these hypotheses, Hosey (2000) concludes that the studies generally support the interpretation that visitors bring about at least some stressful effects, even if visitors are also attracted to particular behaviours.

The reaction of orang utans to human visitors in zoos has not been as widely studied as that of chimpanzees. In Mackinnon's study of orang utans in the wild, he noted that the animals show strong reactions to unfamiliar humans (that is, humans other than the researcher to whom they were habituated): infants, for instance, show fear reactions, squealing and running back to their mothers, while adult females may try to hide (Mackinnon

1974). By contrast, Mather's study of captive orang utans suggested that there was little effect of visitors, perhaps because the animals were habituated to them (Mather 1999).

The present study was designed to investigate the effects of environmental enrichment and of visitors on orang utan behaviour. First, it assessed the effect of fresh browse, provided on some days as a form of environmental enrichment, on the animals' time budgets. Browse can be considered a biologically relevant form of enrichment, as it is a source of food (leaves and bark) as well as objects to manipulate. Moreover, the presence of browse encourages animals to use the woodchip-covered floor, where food items are scattered. Hence, it was predicted that provision of fresh browse would lead to an increase in time spent foraging for such food items (in addition to time spent eating or manipulating the browse material itself), and to a decrease in the time spent sitting inactive. Second, the study focused on the impact of visitors on behaviour, by analysing the animals' responses to large visitor groups as part of the time-budget study and then by experimentally manipulating visitor behaviour. In this case, the prediction was that large, noisy groups of visitors would lead to behavioural changes, particularly fear reactions by infants.

Methods: Time budget

Animals

The subjects were orang utans, housed at Chester Zoo, UK. These comprise:
Bornean subspecies (*Pongo pygmaeus pygmaeus*) — one adult male, aged 24 years; four adult or sub-adult females, age range 11–35 years; and two infants, aged four and five years.
Sumatran subspecies (*Pongo pygmaeus abelii*) — one adult male, aged 13 years; two adult females, aged 13 and 14 years (hand-reared); and their two infants (both two years).
One adult Bornean female and later her infant were not included, as this female was pregnant at the time at which observation began. All animals were captive-bred except the oldest Bornean female, who was wild-born.

Housing

When on exhibit, the animals occupy either an inner courtyard (approximately 16 x 12 m floor area or 10.5 x 12 m) with an adjacent moat and plant area approximately 3 m wide (where the observer sat among the plants), or an outdoor island surrounded by a moat. They are exhibited either alone (usually adult males) or with one other adult (usually females with young). This is variable, and is decided by the keepers on the basis of previous experience of individual preferences (see Yarwood 2000). Thus, there are no more than four animals in any one enclosure (two females with infants) at any one time. At night, all animals are moved to night cages, where they obtain most of their daily food ration. The day enclosures all have climbing frames crossed with ropes, and a small platform. One or two paper or hessian sacks are provided daily. Small food items are mixed daily into the woodchips on the floor of each enclosure. The public gallery is at the same level as the platforms for the indoor enclosures, while outdoors the public is at ground level, separated from the animals by a moat.

Observations

Behaviour was sampled using scan-sampling, for 90 min observation periods if animals were grouped or 60 min if housed singly. During each observation session, all animals in an enclosure (1 to 4) were scanned simultaneously every 30 s and their behaviour recorded; unusual behaviours were also noted as written comments (Martin & Bateson 1993). Observation sessions took place at different times of day for different groupings of animals over a six-month period; as far as possible, the day of the week, the time of day and the groupings were varied randomly. Fifty-five hours of observations were made (40 h in inner courtyards; 15 h on outside islands). Because of the variation in grouping from day to day (decided by the keepers), it was not possible to observe all animals for equal amounts of time. The number of hours of observation per animal is shown in Table 1.

Table 1 Orang utan time budgets: hours of observation per animal.

Animal	Hours
Martha: adult female Bornean	11
+ Leia: infant female	
Sarikei: adult female Bornean	14
+ Matu: infant male	
Pundu: adult female Bornean	11
Sibu: adult male Bornean	6
Emma: adult female Sumatran	9
+ Padang: infant male	
Subis: adult female Sumatran	9
+ Jambi: infant female	
Puluh: adult male Sumatran	5

The environmental enrichment given was fresh browse. The provision of this was variable, however; it was given on 14 of the days and not on the other 17 days on which observations were carried out. The browse consisted of five or six fresh branches, usually of willow, approximately 1–1.5 m in length, and placed on the floor in the centre of the daytime enclosures prior to the animals' emergence in the morning. Animals never consumed all browse items within a day; as a result, some small pieces (branches and twigs) usually remained in the enclosures on 'no browse' days, left over from the day before.

Behavioural observations were made during the autumn–winter, when visitors are fewer. As a result, it was possible to record changes in visitor density throughout all observations. Specifically, periods during which larger groups were present (defined as eight or more people, moving together) were recorded.

Behaviour and data analysis

To simplify analysis, the wide range of behavioural categories originally coded was grouped into six broad categories. It was predicted that the presence of fresh browse would lead to an increase in time spent foraging for small items and in object manipulation, and to a decrease in time spent inactive (sitting); other behaviours, such as locomotor activity, might be expected to change accordingly. The behaviour categories used were:

Sitting: this was scored whenever the animal was sitting not apparently doing anything specific.

Foraging: this included all foraging in the woodchip litter or the grass on the islands, as well as time spent sitting eating the small food items.

Manipulating browse: this included all observations of animals manipulating part of the browse material; for example, by pulling off pieces to chew. Use of pieces of browse as tools was scored separately.

Object manipulation: this included any manipulation of objects in the enclosure, such as paper sacks. Branches were sometimes used as tools to hit leaves from the adjacent plant area, so this was included in 'object manipulation'.

Sack use: this was recorded whenever the animal was sitting or lying underneath, or partly underneath, the sack(s) provided.

Active: this included all locomotor activity, such as walking, brachiating, and swinging from ropes or frame.
Social: all social encounters were recorded, including approaches to specific individuals, holding onto another, allogrooming, or playing. Aggressive acts were rare and so were excluded from analysis.

The total number of observations was pooled for each animal in order to calculate the mean time budgets for each condition (browse present or absent). The pooled data were then analysed using the Wilcoxon matched-pairs signed-ranks test. The small number of animals available in this study, however, meant that some aggregation of data would be necessary. Initial examination of the results did not indicate significant differences between subspecies within the small sample used, so data from both subspecies were aggregated. As there was only one adult male of each species, data from both sexes were also pooled (although some sex differences are noted below). Data were obviously different by age, however, so data for infants and adults are presented separately.

In addition, the data recording sheets were marked to indicate whenever large groups of visitors were present, dividing them into periods when large groups were present (at least eight people in a cluster = 'high visitor density' [HV]) and periods when few or no visitors were present (fewer than five = 'low visitor density' [LV]). These criteria were decided on the basis of pilot observations of visitor behaviour and the responses of the animals to visitors; any periods which could not be easily classified in this way (eg small groups of people spread out along the gallery) were discounted. So, for a 90 min period of observation, there were several shorter periods of HV and LV which could then be compared.

Because visitors could approach the outdoor islands on three sides, it was difficult to assess the start and end of 'visitor bouts' in those locations; hence, it was possible only to analyse data from observations made in the indoor courtyards. Observation sheets were also excluded from this analysis if there were no periods of high visitor density during that period of observation. Thus, these data draw on a limited subset of observation sessions on days when periods of both high and low visitor density were observed, totalling 21 h of observation.

Preliminary observations had suggested that adult animals often respond to large crowds of visitors by increased sack use, and infants by moving closer to adults. Accordingly, the following behaviours were compared during HV and LV periods:
Adult sack use: the animal moves or remains under the provided sack.
Infant holding: infant holds another animal (usually the mother).
Approach: approach by an infant to an adult. In preliminary observations, approaches were noted to occur immediately after visitor arrival. Approach, therefore, was also analysed by comparing the 3 min periods immediately before and after visitor arrival.
In addition, *sitting*, *foraging* and *object manipulation* were scored for both HV and LV periods, following Wood's (1998) finding that chimpanzees show reduced foraging and object use when visitor density is high. Data for LV and HV periods were then compared using a Wilcoxon test.

Methods: Experiment — The effect of visitor noise

Observations

Animals and housing were the same as for the time-budget part of the study, although observations were made only in the indoor enclosures. For the experiment, visiting groups of schoolchildren or university students were asked in advance to participate. On each 'experimental' day, the viewing gallery above the indoor courtyards was briefly closed to the public for 20 min before the experiment began. A record was kept of possible external noise (such as sudden noise from loud machinery or from heavy rain falling on the roof); in the event, there were no extra loud noises on any of the experimental days.

Prior to a group's arrival, behaviour of all animals in the indoor courtyards was scored for a 3 min period, scan-sampling every 30 s as before. The visiting group was then brought in and asked either to remain silent or to make plenty of noise by talking or singing loudly. The group was asked to remain close together and to move slowly along the viewing gallery, about 0.5 m away from the glass window, while behaviour was scored for another 3 min period. On the basis of analysis of time sheets from the time budget study, this time interval was considered adequate to observe specific effects due to visitors. The visitors then left the gallery. In order to keep to a minimum any possible adverse effects of noisy crowds, a short period of observation was necessary, after which the crowd would leave; 3 min was considered adequate on the basis of observations in the time-budget part of the study.

After another 20 min, the same procedure was repeated with the visitors returning, but this time behaving in the other way (ie first quiet then noisy, or first noisy then quiet). This procedure was followed on 10 different days, spread over six weeks (February–March). The 'quiet' test was given first for five replicates, and the 'noisy' test first for the remaining five; the order was random, decided in advance by tossing a coin. As far as possible, experimental days were separated by at least one day in between, with observations between 1000h and 1400h when school groups were attending.

A total of six adults (two Sumatran and four Bornean females) and four infants were included in this analysis, as these were the only animals using the indoor courtyards during the experimental period. The outdoor islands were not suitable, as the movement of people around them could not easily be controlled. Behaviours recorded in this experiment were:
Sack use: as before, this was scored whenever an adult animal put its head under the sack.
Looking: this was scored whenever any animal looked directly at the visitors.
Holding: infant holding onto an adult, usually the mother.
Approaching: approaches made to an adult by an infant.
Sitting: animal sitting still.
Object manipulation: manipulation of browse or sack.
Foraging behaviour occurred so rarely in preliminary trials of the experiment that it was not scored.

Data analysis

Although the experiment was carried out in a balanced design, preliminary analysis did not suggest that there were any significant differences resulting from order of testing (quiet then noisy, or noisy then quiet). So, for further analysis, quiet and noisy periods were compared irrespective of order of testing. Because of unavoidable slight variations in the specific animals that were in the enclosures on each day of testing (depending upon husbandry decisions by the keepers), data are not presented for specific individuals. Rather, data are summed for all animals, giving ten scores for each of the two conditions (quiet and noisy). The data are presented as differences between the scores after and before the arrival of the visitors; thus, these scores can be negative if an animal showed less of a particular behaviour when visitors were present than in the observation period before the visitors arrived. Data were analysed using the Wilcoxon matched-pairs signed-ranks test, to compare behaviour under quiet and noisy conditions.

Results: Time budget

Effects of fresh browse on behaviour

Data showing percentages of observations in which animals were engaged in different behaviours, in the presence or absence of fresh browse, are summarised in Table 2. As predicted, the presence of fresh browse led to a decrease in inactivity (sitting) by adults and infants, and to an increase in foraging for small food items beneath the browse by adults. Data for infants showed differences in activity and object use; these differences were just non-significant ($P = 0.068$). However, the number of infants was low ($n = 4$), and the observed differences were all in the expected directions (more activity and object use when fresh browse was present). A *post hoc* analysis of the time spent in different areas of the enclosures indicated that, when fresh browse was present, animals spent approximately 15.4 per cent of their time on the woodchip floor, compared to 3.4 per cent of their time when fresh browse was unavailable.

Table 2 Effects of fresh browse on behaviour of orang utans. Percent time in each activity (mean ± SE).

	Adults: fresh browse	Adults: no fresh browse	Infants: fresh browse	Infants: no fresh browse
Forage	18.8 ± 3.6	3.3 ± 2.2*	4.0 ± 2.1	5.8 ± 2.1
Manipulate browse†	6.5 ± 1.7	3.5 ± 2.2	6.0 ± 1.3	6.1 ± 1.7
Sitting	17.3 ± 2.9	42.0 ± 6.5*	7.6 ± 1.8	19.9 ± 2.7*
Objects	7.9 ± 2.2	5.6 ± 0.9	10.2 ± 1.9	6.8 ± 0.7‡
Active	14.3 ± 3.3	14.9 ± 3.9	35.4 ± 3.7	22.8 ± 5.7‡
Sack use	29.1 ± 5.7	21.3 ± 2.3	6.4 ± 2.7	7.8 ± 1.1
Social	5.4 ± 2.9	5.8 ± 1.5	30.6 ± 6.2	39.8 ± 11.1

† Some pieces of browse usually remained on days when no fresh browse was presented, so that browse manipulation could occur on all days of observation.

* Indicates significant effect of fresh browse on behaviour: $P < 0.05$, Wilcoxon matched-pairs signed-ranks test (adults: $n = 7$; infants: $n = 4$).

‡ These differences were just non-significant ($P = 0.068$). However, the n for infants was low ($n = 4$).

Not surprisingly, browse appeared to affect individual animals differently. Examination of individual differences indicated that the two adult males (one of each subspecies) both showed a decrease in 'activity' in the presence of fresh browse. In addition, three adults made more use of the sack when browse was present. It is likely that they took pieces of browse to eat when they sat under the sack; this was observed directly on several occasions, but was impossible to measure because the animals' behaviour was usually obscured by the sack. The three animals who did this were the oldest Bornean female, Martha, and the two adult males. Possibly the decrease in male activity can be accounted for partly by increased foraging/feeding activity which, for these animals, was often conducted out of view beneath the sacks.

Effects of visitors on behaviour

Table 3 shows each behaviour occurring during periods when there were few visitors (LV periods) or large groups of visitors (HV periods). These are expressed as proportions of all observations of each behaviour. However, because approaches to adults by infants tend to occur in the first three minutes of a HV period, data for approaches by infants were also analysed separately for the 3 min periods immediately before and after the arrival of a HV group. These data are presented in Table 4, which shows the mean and median number of approaches to adults in each 3 min period.

Table 3 Effects of 'high' or 'low' visitor density on the behaviour of orang utans†.

Behaviour	'High visitor' periods	'Low visitor' periods
Sack use by adults: mean (± SE)	0.59 ± 0.06	0.23 ± 0.06*
Sack use by adults: median	0.6	0.2
Holding onto adult by infants: mean (± SE)	0.48 ± 0.1	0.24 ± 0.09**
Holding onto adult by infants: median	0.4	0.22
Approaches to adult by infants: mean (± SE)	0.2 ± 0.03	0.04 ± 0.01
Approaches to adult by infants: median	0.2	0
Sitting by adults: mean (± SE)	0.6 ± 0.09	0.5 ± 0.06
Sitting by adults: median	0.7	0.5
Sitting by infants: mean (± SE)	0.7 ± 0.06	0.2 ± 0.03**
Sitting by infants: median	0.6	0.2
Foraging by adults: mean (± SE)	0.07 ± 0.03	0.2 ± 0.04*
Foraging by adults: median	0.04	0.14
Foraging by infants: mean (± SE)	0.05 ± 0.01	0.1 ± 0.03*
Foraging by infants: median	0	0.07
Object manipulation by adults: mean (± SE)	0.07 ± 0.01	0.08 ± 0.02
Object manipulation by adults: median	0.07	0.08
Object manipulation by infants: mean (± SE)	0.06 ± 0.02	0.12 ± 0.02
Object manipulation by infants: median	0.06	0.12

† Data are presented as proportions of all observations of each behaviour, for periods of high (HV; at least eight people in a cluster) or low (LV; five or fewer) visitor density. Rows will not add up to 1.00 because not all observations could be classified into HV or LV.

*$P < 0.01$, **$P < 0.001$, Wilcoxon matched-pairs signed-ranks test.

Table 4 Behaviour of infant orang utans immediately before and after arrival of large visitor groups: approaches to adults.

Behaviour	Mean approaches in 3 min before visitor arrival	Mean approaches in 3 min after visitor arrival
Approach: Infants (mean ± SE)	0.26 ± 0.07	1.43 ± 0.13**
Approach: Infants (median)	0	1.5

**$P < 0.001$, Wilcoxon matched-pairs signed-ranks test.

As predicted, the results indicate that both adult and infant animals respond to the arrival of large visitor groups. Specifically, adult use of sacks is significantly greater during periods of high visitor density, while infants were observed holding onto adults significantly more often. Foraging was less frequent during HV, while infants spent less time sitting still. The comparison of approaches by infants to adults during HV and LV periods did not reach significance; however, the comparison of approaches in the 3 min periods immediately before and after arrival of a large visitor group (Table 4) did indicate a significant difference. This suggests that approaching adults is an immediate response to visitor arrival and is possibly followed by a period of holding behaviour. Object manipulation did not differ significantly between HV and LV periods.

Some other behaviours occurred apparently in response to visitors, but too infrequently to be quantified. These included: begging at visitors (particularly the Sumatran females); hiding (behind treestumps on outdoor islands); and staring and displaying (the Bornean adult male, in response to prolonged staring by humans).

Results: Experiment — The effect of visitor noise

The results of the experiment comparing the responses of orang utans in the indoor enclosures to quiet versus noisy groups of visitors are summarised in Tables 5 and 6. The scores given in the Tables represent difference scores — that is, the difference in the incidence of each behaviour before and after the arrival of the visitor groups. Table 5 shows, for adult animals, the incidence of sack use and looking directly at visitors. Table 6 shows, for infant animals, the incidence of looking at visitors, approaching and holding.

Table 5 Responses of adult orang utans to experimental visitor groups: quiet versus noisy visitor behaviour.

	Difference scores under quiet condition		Difference scores under noisy condition	
	Mean	Median	Mean	Median
Looking	0.9 ± 0.3	0	3.5 ± 0.4	4**
Sack use	0.9 ± 0.3	0	0.14 ± 0.3	0
Sitting	3.24 ± 0.5	3	5.9 ± 0.1	6*
Objects	0.3 ± 0.2	0	0	0

*$P < 0.05$, **$P < 0.001$, Wilcoxon matched-pairs signed-ranks test.
Scores represent mean and median of difference scores (before and after visitor arrival), which could range from 0 ± 6. In the 'quiet' condition, the visitor group walked silently by; in the 'noisy' condition, the visitor group made a great deal of vocal noise.

Table 6 Responses of infant orang utans to experimental visitor groups: quiet versus noisy visitor behaviour.

	Difference scores under quiet condition		Difference scores under noisy condition	
	Mean	Median	Mean	Median
Looking	0.12 ± 0.12	0	3.2 ± 0.4	4**
Approaching	0.41 ± 0.13	0	2.1 ± 0.2	2**
Holding	0.12 ± 0.13	0	2.9 ± 0.4	3**
Sitting	2.45 ± 0.5	2.5	5.45 ± 0.2	5.5(*)
Objects	1.1 ± 0.2	1	0	0

**$P < 0.001$, Wilcoxon matched-pairs signed-ranks test (n = 7).
(*) indicates a difference that is just non-significant ($P = 0.068$; n = 4).
Scores represent mean and median of difference scores (before and after visitor arrival). Scores could range from 0 ± 6.

The results from this experiment indicate that noisy visitors are more likely to affect the animals' behaviour. When the group was quiet, there was relatively little change in behaviour on their arrival, as indicated by the zero difference scores. Looking behaviour increased slightly from that directed to the lone observer before the group arrived, as did infant approaches. Holding behaviour was slightly decreased when quiet visitors arrived, possibly because the infants turned to look at them.

Under noisy conditions, however, there were marked differences in behaviour. Looking by both infants and adults, and approaching and holding behaviour by infants, all increased significantly. The arrival of the visitors was usually followed immediately by infants moving towards adults, and glancing repeatedly at the visitors. Sack use, however, did not change in the direction expected from the time-budget observations; rather, it showed a slight decline. Sitting behaviour by adults was significantly greater under noisy conditions, possibly because they were more likely to be holding infants and looking at visitors. Sitting behaviour by infants was greater in noisy conditions, but was just non-significant, which may reflect the low sample size.

General discussion and animal welfare implications

Both browse and human visitors affected the behaviour of these captive orang utans. The presence of fresh browse increased overall activity and foraging for small food items beneath the browse material, as other studies of enrichment and activity have indicated (eg Wilson 1982; Perkins 1992). Browse is likely to be biologically significant for an arboreal species such as the orang utan, even if it is obtained from species native to Britain. Here, the browse was given as small branches of coppiced trees such as willow, and afforded both food and objects to manipulate. Animals readily ate the leaves and bark, and also used the branches in other ways. Sometimes, the branches were used to create a makeshift nest on the platforms; at other times, the branches were used as tools to try to get at leaves that were overhanging but out of reach.

Wild orang utans make and use tools extensively, for example to gain food or to mop up water (Kaplan & Rogers 1999). Similar events were noted in this study: paper sacks were occasionally used to collect water, and pieces of browse used to obtain leaves. Like other great apes, orang utans have a high level of cognitive ability; they are notoriously good at problem-solving (and hence escape attempts). Although animals raised in captivity may not demonstrate the cognitive skills of those reared in the wild, they do readily use objects as tools (Kaplan & Rogers 1999). The main significance of providing browse, then, may be less in enhancing foraging and more in the opportunities provided by pieces of browse for fashioning and using makeshift tools. Although the present study did not assess the effects of non-performance of tool use, it may be that the orang utans are expressing a specific behavioural need which could be directly tested in further studies (see Dawkins 1988; Veasey *et al* 1996).

This study, like others, used overall activity as a measure in the time-budget analysis, as well as more specific behaviours such as foraging. However, this makes the assumption that greater activity *per se* reflects better welfare. Inactivity may indeed be a problem for captive animals (Tripp 1985) but in what sense is activity the answer to the perceived welfare problem? Presumably, too much activity in the form of stereotyped pacing is not an improvement in welfare. It may be more useful to think in terms of optimal levels of activity (although that, too, may be difficult to determine; see Dawkins 1990). For the orang utans in this study, browse increased foraging and object manipulation time; by contrast, without browse, the animals spent a considerable amount of their daily time budget sitting still. An increase in overall activity thus seems to be an improvement in welfare as well as physical health. What requires further investigation, however, is the way in which greater 'activity' might be a response to an environment giving more information and opportunities to act within it (such as using branches as tools), so that the animal can exert control over aspects of its environment.

Zoo animals cannot, however, exert much control over the numbers or behaviour of human visitors. In the present study, the animals responded in specific ways to the arrival of larger groups of visitors. Observations of these animals during an earlier pilot study suggested that, during a period of high visitor density (mid-summer), several individuals responded to the arrival of the day's first visitors by immediately seeking and using the sacks. Similarly, in the first part of this study, adults often began to put the paper sacks over their heads when visitors arrived, while infants tended to approach and hold onto adults (usually mothers). Sack use, however, did not change significantly when visitor behaviour was manipulated experimentally to provide either noisy or quiet conditions. Possibly this was because the experiment was usually conducted at around mid-day, when the participating groups were able to attend. By this time, many animals are already using the sacks, and it would be difficult to observe any change.

In the experiment, however, animals readily looked towards the visitors, particularly when the visitors were noisy. This was usually a sustained gaze directly at the visitors. While zoo animals probably habituate to the presence of humans (Robinson 1998), they may not do so to loud noise produced by only some visitor groups. Looking at noisy visitors may partly reflect curiosity, but it may also indicate a stress response. Although facial expressions were not specifically measured in this study, it is noteworthy that, on six of the ten experimental days, the arrival of noisy visitors was followed by at least one of the infants pulling back the sides of the mouth; this is an expression described by some authors as indicating fear (Mackinnon 1974; Kaplan & Rogers 1999). Because infants also responded to the noisy visitors by moving rapidly towards their mothers, it would seem that noisy visitors are stressful, particularly to young animals.

In the present indoor enclosures, the animals spend most of their time on the climbing frames, particularly on the platforms. These platforms allow the animals to be up off the ground, so mimicking their natural arboreal habitat in some ways. However, the rigid platforms also limit the type of movement possible. In particular, the location of the platforms ensures that animals remain quite near to visitors and their gazes, as the platforms are at the same level as the visitor gallery.

Direct looking at another individual is not common among orang utans, who typically use 'sidelong glances'; direct looking is aversive (Kaplan & Rogers 1999). Although most zoo visitors do not spend long periods gazing at one animal, it is likely that captive orang utans find prolonged gazes aversive. Certainly, the adult Bornean male, Sibu, responded strongly to prolonged staring, by banging and calling. This occurred several times during observation periods, but too infrequently to be quantified. It is noteworthy, however, that on each occasion that such displays occurred, it was always a human male who had given a prolonged stare at Sibu, who presumably interpreted such staring as a threat.

Visitors undoubtedly provide complex stimuli for zoo animals. During observations, the orang utans often oriented towards visitors, and sometimes directed their behaviour towards people (eg begging by the Sumatran females). But zoo animals cannot readily escape the gaze of visitors, particularly during the high season. In that sense, visitors are a variable but uncontrollable stimulus. Lack of the ability to exert control over the environment is likely to compromise welfare, as several authors have argued (eg Sambrook & Buchanan-Smith 1997; Wemelsfelder 1993; Wiepkema & Koolhaas 1993). Clearly, the animals cannot directly control the behaviour of humans, except by interacting with them in certain ways. In captivity, the only other choice is for animals to seek some shelter from the constant gaze, perhaps by using materials such as sacks, or by escaping to some less visible part of the enclosure.

The findings presented here suggest that the orang utans at Chester Zoo sometimes find the presence and/or behaviour of human visitors aversive. In the present indoor enclosure at

Chester, humans view the animals through a glass window; outdoors, humans can view the islands from three sides. The impact of large visitor groups and/or noise on these animals may be exacerbated by the structure of this enclosure. It is also possible that the animals at Chester have learned their reactions to visitors from each other, although their reactions are similar to those noted for wild orang utans (Mackinnon 1974). Given these limitations of this study, it would be interesting to repeat the experiment at other locations, with enclosures of different design.

The data from this study suggest that housing for orang utans should include some opportunity for the animals to escape, at least partially, from the human gaze. One possibility is a partial screening with gaps for visitors to view the animals, an approach that has been taken in at least one zoo exhibiting apes (gorillas, Norcup 2000). Although the density of visitors may remain unchanged, they are not visible to the animals in large numbers with such a screen.

The present study emphasises the impact on these animals not only of large numbers of people but also of the noise they produce. Whether loud noise is sufficiently stressful to captive animals to bring about physiological stress responses is not clear (Stoskopf 1983; Bakken *et al* 1999). However, the orang utans in this study did seem to find high levels of noise — the kind of loud shouting and screaming generated by parties of schoolchildren — aversive, particularly the infant animals. Given the very low reproductive rate of great apes, zoos might need to develop careful management plans to include ways of presenting young infant orang utans to the public while simultaneously reducing potentially stressful effects of visitors on the public.

One more general consequence of these findings for zoos is that animals reacting to crowds may show less of the very behaviours that visitors find interesting or educational (Wood 1998). More importantly, there is evidence that zoo animals do sometimes find crowds stressful (Hosey 2000). What follows from this is that zoos urgently need to find ways to manipulate human — as well as animal — behaviour in order to promote the welfare of their animals. It may be necessary to design exhibits that control the movements of people in such ways that large numbers of people cannot congregate in one spot, and in ways that discourage noise.

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