Federation of Zoological Gardens of Great Britain and Ireland

Proceedings of

The 2nd Annual Symposium on Zoo Research

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Preface

The Federation of Zoological Gardens of Great Britain and Ireland (Federation of Zoos) is a conservation, education and scientific wildlife charity (Registered Charity Number: 248553), founded in 1966, out of a mutual desire within the zoo community to see sound principles and practices of animal management widely adopted. Today, the Federation is the principal, professional zoo body representing the zoo community in Britain and Ireland.

The Research Group, which operates under the auspices of the Federation's Conservation and Animal Management Committee, supports basic and applied research of conservation relevance both *in situ* and *ex situ*. As part of its role in promoting zoos as scientific institutions the Research Group holds an annual symposium on zoo research. Since most zoo researchers are students the symposiums' primary aim is to create a supportive and encouraging atmosphere in which young scientists can share their experiences of conducting research within a zoo setting.

The 2nd Annual Symposium was attended by approximately 80 delegates from 15 zoos and 16 universities and research institutes. Over two days delegates presented 21 talks, 18 posters and a workshop covering a wide range of research fields and taxa. Most of the symposium presentations are reproduced in this proceedings volume; some are not reproduced in full but are included as abstracts in order to show the full range of subjects covered. The presentations included here are divided into four sections to facilitate use of this volume, although there is inevitably some overlap and many would have been appropriate in more than one section.

Overall the symposium was of a high standard and the interest and enthusiasm of speakers and audience contributed greatly to its success. Winners of the prizes for the best student speaker and poster were, respectively, Elly Rustiati (University of Exeter, page 1) and Rosie Gloyns (Unversity of Wales, Cardiff and Paignton Zoo, page 69). The workshop on the use of non-invasive hormone measurement was particularly interesting and gave delegates an excellent insight into the possible uses and pitfalls of these new techniques for monitoring stress in zoo animals. I am very grateful to Tessa Smith for organising this part of the symposium. I would also like to thank all the delegates for their contribution to a lively and informative two days.

A.B.P.
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Saving the Sumatran tiger: the important role of captive animals in leading the fieldwork

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Abstract

In the dense, tangled vegetation that is so characteristic of many areas in Sumatra, home of the Sumatran tiger, visibility is very limited. Many ecological field studies have used sign survey techniques for gaining information about the animals, including scat analysis. These methods have advantages in that they are relatively inexpensive, logistically straightforward and they do not require direct contact with the animal or animals in question. There is no need to manipulate or to sacrifice the animals and large samples can be expected. It is a good way to examine the diet and feeding habits of endangered species such as the Sumatran tiger. One problem with this is that in most field studies there is no prior information about the prey base. By developing hair references from captive animals, the prey species of Sumatran tiger in the wild were revealed. Individual animals may not be identifiable from the scats, but species, site and seasonal information are obtainable.

Introduction

Once home to three subspecies, the Bali, Javan and Sumatran tigers, Indonesia now has only the Sumatran tiger. Only found on the island of Sumatra, this species, once so abundant, is reaching a critical stage in its survival (Plowden & Bowles, 1997). Small and isolated Sumatran tiger populations are at risk of extinction from the interaction of some major threats including attrition of their habitats, poaching and depletion of their prey populations. Adult tigers are solitary animals that establish territories in areas with enough prey, cover and water to support them. (Schaller, 1967). They occur and will continue to reach their greatest densities where populations of essential prey concentrate (Seidensticker, 1976). Therefore, to ensure effective management strategies for Sumatran tigers research into the prey species is needed.

Tigers have all the secretiveness typical of the cat family, in addition dense, tangled vegetation is so characteristic of many areas in Sumatra that visibility is very limited (Santiapillai & Ramono, 1985). Tigers cannot be seen even only 3m away, they are perfectly camouflaged in the not so thick bush and kills usually occur in dense under-growth (Neginhal, 1990). Therefore, detailed information concerning their diet can only be deduced through indirect observation (Santiapillai & Ramono, 1985).

Scat analysis is widely used for determining food habits of carnivores (Ciucci *et al.*, 1996; Corbett, 1989; Karanth & Sunquist, 1995; Stoen & Wegge, 1996). Compared with other techniques, this method is relatively inexpensive, easy to apply, allows relatively large sample sizes, needs no direct contact with the animal, and, most importantly, is non-intrusive so suitable for endangered or threatened species (Ciucci *et al.*, 1996). In some animals the remains of prey may be found although there are considerable problems in interpretation. The lack of readily identifiable bone fragments, teeth, or other tissues of mammalian prey complicate qualitative analysis of the gut and faeces contents; tooth and bone remains were usually either absent or too fragmented to be of use. Large carnivores can ingest sufficient teeth or bone to permit identification of the prey taken (Day, 1966), but identification of prey remains often depends on other hard indigestible parts of the food left in the gut such as hair (Bang & Dahlstrom, 1972).

Since there is no guide available, a reference collection of hair specimens of the Sumatran tigers' potential prey was needed. This hair reference is compiled from the medullar configuration including the scale patterns, the types of medullae and the shape of the cross-section (Day, 1966). The only possibility to get hair from many potential prey of Sumatran tigers is from captive animals both from zoo and private owners. Captive breeding is often seen as being important in terms of conserving the species and providing potential animals for re-introduction but it can also be important for field ecologists studying rare species to have access to zoo collections. This study of Sumatran tiger prey would not have been possible without the availability of potential prey species in captivity. The references developed from the captive animals lead the fieldwork in saving the Sumatran tiger through its prey, one of the factors that play an important role in its survival.

Methods
Hair and scat collection
Hair samples were collected from captive animals in Ragunan Zoo, private owners and captured animals by related institutions. The potential prey is based on the common species found in Sumatran tiger habitat. Hair collection from different parts of the body and sex/age classes of potential prey species was done whenever possible. Age classes were adults and young individuals/juveniles. Ten hairs for each sample were used for analysis. Hair morphology including colour, shape and width of hair (Sass, 1958) was recorded. Scat collection was conducted in the Tiger Intensive Monitoring Area (TIMA), Way Kambas National Park, Sumatra, Indonesia for two years (September 1995-July 1997) by the Sumatran Tiger Project.

Hair and scat analysis
The analysis was based on medullar configuration. The techniques used by Bothma & le Riche (1994), Bryce (1994) and Day (1966) were adopted with a few modifications.
i)   Cuticular scale pattern. A cast of the hair in gelatine was made: a film of 5% gelatine was made on a microscope slide, the hairs were laid in this film and after allowing about 3-5 minutes for the gelatine to harden, they are peeled off leaving behind a cast of the scales. The scale pattern on three different parts of hair (proximal, medial and distal) was observed.
ii)   Medulla type. The hair was mounted whole in 70% alcohol and observed under a lower power of magnification (x10) microscope.
iii)   Cross-section shape. The paraffin method by Soetjipto (1968) was adopted for analysing hair-cross section. Laboratory work using a microtome was conducted by and in collaboration with the Laboratory of Histology, Faculty of Biology, University of Gadjah Mada, Indonesia. Paraplast was used to replace the paraffin and Mallory triple stain was used for staining.

Results and discussion
Among 16 different species, four different scale patterns were found: flattened, crenate, acuminate and elongate serrate. Medulla types were: absent, fragmental, latticed, multiserate and discontinuous. The shapes of cross-section were round, oval, or elongate shapes with certain patterns on each cross-section. There were no differences within species in hairs from different parts of the body, sex or age of the animal but the sections could be densely pigmented depending on whether or not the hair is sectioned through the pigmented portion of the shield. However, such differences in degree were not serious enough to invalidate the key. Based on the three medullar patterns, hair references of Sumatran tigers' potential prey species were developed.

With these hair references from captive animals, the diet and food habits of Sumatran tigers were revealed; 11 prey types were found. They were six species of ungulates (napu or larger mouse deer, mouse deer, barking deer, sambar, Malayan tapir and wild pig), four species of primates (pig tailed and long tailed macaques, silvered langur and siamang) and one species of carnivore (Malayan sun

bear). 15% of scats contained two prey types, with most of the combinations including wild pig. For nine prey types, it was shown that they were preyed upon by tigers in different locations.

Seasonally, the results show that the Sumatran tigers preyed more often on wild pig and mouse deer during the wet season. Instead of wild pig, they preyed more on pig-tailed macaque and barking deer during the dry season. There is a high correlation between prey types taken in the dry and wet season. The main diet includes five prey types: wild pig (39.28%), mouse deer (11.60%), long tailed macaque (8.92%), pig tailed macaque (8.03%) and barking deer (6.25%).

Diet and availability of prey species is a crucial factor in the survival of the Sumatran tiger. Captive animals in zoos have played an important role in revealing the wild animals' diet and hence contributed to their continued survival.

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A glimpse into the lemur mind

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Abstract

Studies on learning and cognitive abilities of lemurs have been very sparse, and usually restricted to small numbers of individuals of just one or two species. Part of the problem is a belief by many researchers that lemurs are in some way "primitive" compared to other primates, but there is also a difficulty in that lemurs seem to be distressed by separation into laboratory cages. Zoos therefore provide an alternative site for this kind of research, and can potentially provide a variety of species. Because the very strict laboratory paradigms cannot usually be achieved with zoo animals, alternative approaches can be tried in an attempt to understand the extent of problem solving abilities and cognition in lemurs. Here I give some examples from three different approaches: first, the systematic observation of spontaneously occurring significant behaviours; secondly, experimentation within the zoo cages of the lemurs; and thirdly, the use of anecdotal observations.

Introduction

The lemurs comprise a varied group of primates, ranging from the small, 30g, pygmy mouse lemur *Microcebus myoxinus* up to the 6kg indri *Indri indri* (Mittermeier *et al*., 1994). They also show a diversity of social structures, including apparently solitary (*Lepilemur* species), pair-bonded (e.g. *Indri*) and multi-male, multi-female forms (e.g. *Lemur*) (Jolly, 1998). Within relatively recent times there have also been a number of larger, now extinct, species; many, like the sloth lemurs, with a body form quite unlike any living species (Simons, 1997) and these should be considered as part of the modern assemblage of species. The extant and subfossil forms are thus the modern result of a radiation which has occurred on the isolated island of Madagascar. Because of its antiquity, it is appropriate to regard this as a kind of "alternative" primate radiation to the more familiar anthropoid radiations in Africa, Asia and South America.

This potentially gives us a comparative perspective on behavioural evolution in the primates. For example, although relative neocortex size correlates with mean group size with virtually the same regression whether or not strepsirhines are included (Dunbar, 1992), thus implicating the same social correlates of brain evolution in all primates, there do nevertheless appear to be differences between the intelligence shown by lemurs and that demonstrated by the Old World primates. Alison Jolly posed this apparent paradox that "the lemurs seem to have 'monkey-type' societies without having evolved monkey-level intelligence" (Jolly, 1966); more recently she has questioned whether lemurs really do show 'monkey-type' societies at all (Jolly, 1998). If this is true, then we can ask how and why lemur societies have gone in a different direction to those of the Old World monkeys.

Lemur learning and the role of zoos

Questions such as this are difficult to answer, partly because our knowledge of lemur learning ability is so meagre. A comprehensive review of published studies (Ehrlich *et al.,* 1976) showed that there was some overlap in performance between lemurs and other primates across a range of learning tasks; but also that most studies used only one or two animals, usually the ringtailed lemur *Lemur catta*. Reading some of these studies, it becomes clear that lemurs do not take easily to being tested in the laboratory. In one of the earliest studies, where a single female ringtail was compared to several monkeys, the author stated that "The experiments always threw her into a state of heightened activity and we tried to avoid everything likely to increase her excitement" (Kluver, 1933). Other authors have referred to "long and exasperating training and testing sessions" with

lemurs (Gillette *et al.,* 1973); and in one of the most comprehensive sets of tests with lemurs, Jolly (1964) reported that "When removed from the home cage, lemurs grew hysterical, lorisoids sulked, and both refused to work". It also seems likely that the lemurs were tested in some of these cases with inappropriate tasks, and without due regard for their normal natural history. The example, quoted by Osman Hill (1953), of *Avahi* ("mentally, stated to be stupid, but this must be taken with reserve as the animals may have been half asleep when tested") is extreme, but it does seem to be the case that many of the learning trials have been done in the assumption that lemurs can be tested with the same apparatus and in the same situation as monkeys.

A further problem for the researcher is that, with the exception of the grey mouse lemur, *Microcebus murinus*, lemurs are not commonly kept as laboratory animals, and bringing them into the laboratory situation from outdoor cages, and particularly separating them from the rest of their group, would almost certainly result in the "hysterical" behaviour referred to above.

From this perspective, zoos have much to offer. A range of species is available for study, usually in naturalistic enclosures, and often reasonably well habituated to human proximity. Within this context, testing of animals must take account of their normal behaviour, and also the fact that they are being tested as a group in a situation where they have the control over whether or not they interact with any apparatus. This probably violates most of the carefully designed controls that go into laboratory testing procedures, although this doesn't mean that such group testing is not rigorous. But more importantly, the benefits are enormous, not least that testing can be done which would probably never really be possible in a laboratory setting. It also provides insights into social variables which influence learning, which is, after all, the context in which primate intelligence is thought to have evolved.

In the rest of this paper I give examples from three different kinds of approach which have yielded information about lemur learning, using zoo groups. They are: i) the systematic observation of spontaneously occurring novel behaviours, ii) experimentation within the group of animals, and iii) the collection of anecdotal material.

Novel behaviours
Novel behaviours, which have not previously been seen in that group, sometimes occur apparently spontaneously (i.e. not as a result of experimental interference) in groups of primates. Such novel behaviours *may* be elements of that species' natural profile of behaviours, which have not previously been seen being expressed. But if that can be ruled out as unlikely, then the behaviour must be due to new learning. If, in addition, the behaviour spreads through the group, then it is likely that this spread is through social learning rather than repeated independent individual learning. Perhaps the best known example of such a phenomenon is the spread of potato washing in Japanese macaques (Kawai, 1965).

Zoos provide good opportunities for looking for such behaviours, because they provide novel situations for behavioural innovation, and also because the close association between humans and animals makes the behaviours more likely to be noticed. Sometimes the novel behaviour is just seen as a curiosity, but if its implications are understood, then systematic observation and collection of quantitative data are possible.

An example of this is our own work on drinking from tails in ringtailed lemurs, *Lemur catta*, (Hosey *et al.,* 1997). This behaviour, which involves the animal in lowering its tail into the moat, and then licking the water from the tail (fig. 1), is performed by a number of the individuals in the semi-free ranging island group at Chester Zoo. Individuals of all age/sex classes except infant males were seen to perform the behaviour. A number of instances were observed of non-immerser

lemurs watching immerser lemurs going through this behaviour pattern; and also of some lemurs being allowed to share the wet tail of others.

Figure 1. Ringtailed lemur (*Lemur catta*) at Chester Zoo drinking water from its tail, which it has just immersed in the moat

This study tells us several things about lemurs. It tells us that they can be innovative in their behaviour and that they can learn new behaviours by observing others. There are also indications of possible other social variables that might be involved in learning. The tail sharing, for instance, is similar to what we might call alternative "producer" and "scrounger" strategies that surface in other lemur learning situations. Finally, this study shows us that if we make the effort to investigate what start out as casual observations, we may be able to discover interesting things about our animals.

Experimentation
It is possible to undertake simple learning trials with lemurs in groups in their home cages in zoos. Clearly, the kinds of tests that can be done and the interpretation of the results obtained are rather different from those that have traditionally been undertaken in laboratories, and the research questions being asked must therefore be formulated within this context.

This approach has been little used in the past. An early experiment (Harlow *et al.,* 1932) adapted a delayed reaction test for use on zoo primates at Vilas Park Zoo in Madison. Included in the trials was a single ruffed lemur, which was apparently reluctant to get involved in the tests, but eventually performed satisfactorily. In a further set of trials at Bronx Zoo, Maslow and Harlow (1932) included three lemurs in their tests, and noted that "it took them a long time before they could even grasp the problem", though it is unclear from the description whether these were even healthy animals in their own cage. Both the single subject design and the adverse comments about the motivation of the lemurs to take part are regular features of these and other studies, such as Glickman *et al.'s* (1965) visual discrimination testing of a brown lemur at Lincoln Park Zoo, and numerous laboratory and primate centre studies.

Our own attempts to undertake learning experiments with lemurs have taken a different approach, because the research questions that interest us are not particularly to do with formal measurement and comparison of lemur performance with that of a range of anthropoids, which is what drove many earlier studies. We are more concerned with identifying the effects on learning of a range of other variables, such as species, sex and social variables. Thus the tasks we set the lemurs are relatively simple, and not designed to test the limits of their ability. An example is the plate-flipping test, currently being used by Saul Molloy with ringtailed lemurs. In this test, which is modified from an experiment done by Kappeler (1987) on free-ranging lemurs at Duke Primate Center, the animals are required to flip over an inverted bowl covering a food reward (fig. 2).

Figure 2. Ringtailed lemur lifting a bowl to reveal a grape underneath. Note the lemur on the left about to snatch the grape. (*Photograph courtesy of Saul Molloy, Bolton Institute*)

Although the experiments are still in progress, there are already intriguing hints that social variables may influence the learning abilities of males and females in different ways; and there is evidence of the same "producer/scrounger" roles that were emerging in the tail drinking observations, in this case where animals wait for someone else to flip the plate, but then steal the reward. This is similar to the "workers" and "profiteers" which emerged in a food searching task in white-fronted lemurs (and also vervet monkeys) in experiments at Berlin Zoo (Vossing, 1990); and possibly also the dominance-related monopolisation of apparatus seen in black, brown and ringtailed lemurs by experimenters in Strasbourg (Fornasieri *et al.,* 1990; Anderson *et al.,* 1992).

Anecdotal evidence
People who have a close working relationship with animals acquire a deep knowledge of those animals as individuals. Unsystematic and unquantitative though this knowledge may be, its significance should not be underestimated. It was, for example, precisely this kind of knowledge which helped in the development of the concept of Machiavellian intelligence (Whiten & Byrne, 1988). While not constituting data in the accepted scientific sense, anecdotal evidence can be useful in providing a context in which data can be interpreted, and also in developing new testable hypotheses. For example, the possibility that seems to be emerging from our learning trials that

learning performance may be different in male and female lemurs seems very unlikely to us, but is supported by some anecdotal evidence from Vallee des Singes that female ruffed lemurs are poorer at finding their way home than the males (Vermeer *pers. comm.* 2000).

Unfortunately, anecdotal knowledge usually goes unreported. As far as lemurs are concerned, I would be delighted to receive such information from anyone who has any, about lemur abilities, unusual behaviours, or unquantified (or quantified) outcomes of enrichment trials that may involve problem solving.

Conclusions

There is nothing particularly outstanding about any of the results outlined here. Indeed it would be surprising if lemurs *weren't* able to learn through observation or turn a plate over to retrieve a grape. The likelihood is that their learning abilities are entirely appropriate for animals of their morphology, size, ecology and social organisation. The intriguing possibility that their learning may be different from that of anthropoids is what currently drives our research. But researchers interested in primates must beware of falling into the trap, set by the early experimenters, of believing that lemurs are stupid. The token lemur included in learning trials designed for monkeys tells us little of value about lemurs. Appropriate tasks and appropriate measures on a range of species may tell us a lot.

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Where was that tree? Cognitive mapping in captive Bornean orang utans

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Abstract

Remembering where an individual is in their environment, based on their previous experience, is one aspect of an animal's mental map. The use of a vector-map, least effort route, increases the probability that the animal will choose a direct path to the hidden goal. An experiment was designed to allow captive orang utans to find hidden food in their enclosure. By blocking all sensory cues other than a remote visual cue, the animals needed to use their memory of the enclosure to successfully complete the task. A monitor allowed the animals to see a video of food being hidden in one of five feeding boxes in their enclosure. Preliminary results suggest that the animals significantly increased their chances of going to the correct feeder by watching the monitor than if they had not watched the video. Preliminary results also suggest that the individuals were employing a vector map of the environment to reach the baited site first before the other animals.

Introduction

Animals knowing where they, con-specifics, food or water are in their environment, based on their previous experience, is one aspect of an animal's mental map (Tolman, 1948). Two types of these mental maps are network and vector. Network maps contain a series of interconnecting routes, which eventually lead to the goal. The use of a vector-map, least effort route, increases the probability that the animal will choose a direct path to the hidden goal.

Method

Using Menzel's (1973) design as a base an experiment was designed to allow captive orang utans to find hidden food in their enclosure. One of the five Bornean orang utans at Paignton Zoo, Senja, a 22-year-old was tested in the groups' indoor enclosure. By blocking all sensory cues other than a remote visual cue, the animal needed to use her memory of the enclosure to successfully complete the task. A monitor allowed the animal to see a video of food being hidden in one of five feeding boxes in her enclosure.

Results

The preliminary results for Senja suggest that the animal significantly increased her chances of going to the correct feeder first by watching the monitor than if she had not watched the video. Six categories were recorded with relation to whether or not the animal looked at the monitor: looked at the stimulus and searched correctly; looked and was incorrect; did not look and correct; did not look and incorrect; looked and ignored all feeders; did not look and ignored all feeders.

Results of a chi-square test (table 1) found that Senja choose the correct feeder significantly more times when she looked at the monitor than if she did not: N=28, χ^2=9.7, d.f. = 1, p < 0.01. Scores for looking at the monitor and searching incorrectly were increased by being pooled with the sessions where once released into the enclosure, Senja ignored all the feeders and started searching for scatter feed on the floor, or nested.

Since Senja was tested with another animal, Chinta, and both animals had access to the monitor, preliminary results also suggest that the individual was employing a vector map of the environment to reach the baited site first before the other animal.

	Looked at monitor	Did not look at monitor	Total
Correct search	11 (exp. 7.1)	0 (exp. 3.9)	11
Incorrect or no search	7 (exp. 10.9)	10 (exp. 6.1)	17
Total	18	10	28

Table 1. Observed (and expected) frequencies of correct and incorrect searches for Senja

Conclusion

Preliminary results would suggest that watching the monitor resulted in a direct route to the baited feeder. The results also suggest that the individual was employing at the minimum a least-effort cognitive mapping strategy. In addition to this, with the added problems of a limited supply of fruit pieces and competition the direct routes the animal took to the correct feeder would suggest that she was using a vector-map to be successful.

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Using zoos for course-related practicals

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Abstract
A student-centred approach to undergraduate level teaching of observational data collection methodology on animal behaviour is described. Students are involved from the experimental design stage through data collection, analyses and interpretation to the presentation of an assessed report. They get valuable hands-on experience of the methodology and a greater understanding of the processes and limitations of collecting behavioural data. In addition, the large number of students is used to our advantage in designing studies, as each student is assigned a focal animal, providing information on every member of a group simultaneously. I describe how we go about running practical classes in zoos, the considerations we take into account and the learning outcomes for students. To illustrate this, I provide an example of one study that the Animal Behaviour (46AK) course students from the University of Stirling conducted on the effect of food distribution on feeding and other associated behaviours in four groups of captive Old World primates. The results show how food distribution, and the resulting foraging demand it imposes, affects the rates of acquisition, distribution of food between age/sex classes, foraging behaviour and aggression. I conclude that zoo based practical classes can encourage active and co-operative learning. Not only are they an excellent method of teaching students, but they can also provide useful results that have implications for the management of captive animals.

Background to the practical programme

Zoological Gardens have a unique potential as sites for research and can provide a setting for good quality basic and applied science. The aim of this paper is to describe how we have developed a co-operatively based practical system at The Royal Zoological Society of Scotland (Edinburgh Zoo) for Animal Behaviour (46AK) undergraduate students in the Psychology Department at the University of Stirling, Scotland. I describe the basic format, the considerations we take into account, examples of topics we have studied and the learning outcomes for students. As an illustration, I focus on one study in depth that compared food consumption, rates of acquisition, foraging, and aggression across four different methods of food distribution in four groups of Old World primates.

The process

In order to conduct practical work in zoos, it is first necessary to establish a good relationship with the zoo, and especially with the keepers who will be involved. It is important to ensure that there is a complete understanding about what is required from both parties. For example, the keepers at Edinburgh Zoo assist with identification of animals at the beginning of the study, and then introduce our experimental manipulations after we have collected pilot and baseline data. Practical classes cannot be easily repeated so one must be fully prepared to ensure the study works first time. It is advisable that any payment required is agreed in advance.

It is our practice to decide on a general topic and what options might be possible with the zoo staff, approved by the zoo, and within the Association for the Study of Animal Behaviour (2000) guidelines. We do not finalise the details until after we have met with the practical class. During this first meeting with students, we provide the background and previous research on the topic, details of the animals available for observation, and describe the different recording methods for collecting data. We run through the basic process for designing a study (e.g. see Altmann, 1974; Dunbar, 1976; Martin & Bateson, 1993).

We then let students get involved in the design of their study. We have found that splitting the class into smaller groups of four to six students is best to generate ideas. Based on the background research we have presented, each group is asked to produce a series of questions they wish to investigate, and an appropriate experimental design. For example, in a practical on food distribution, a suitable question may be "What method of food distribution causes the least aggression amongst group members?". The students then decide which behavioural measures should be recorded to answer their questions and determine the most appropriate method of recording. We distinguish between behavioural states (long duration behaviours) and behavioural events (short duration behaviours). Behavioural states are best recorded by instantaneous point sampling where the observer notes down whether the behaviour was being performed on the dot of regular pre-determined sampling intervals. This method can be used to estimate the proportion of time spent in that activity. All occurrences sampling is recommended for use with behavioural events where the observer records each time a given behaviour occurs at any time during the time interval. It provides a frequency. Demonstrators circulate to keep students on the right tracks. A student spokesperson for each subgroup will then present the design for their group to the rest of the class. The demonstrator will explain if it is feasible, and if not provide the reasons. Feasible projects are listed, and the class then vote on which of the viable experimental designs they will use. We have found that this student-centred approach in which students design their own study increases their motivation to be involved.

We strive to ensure that practical work is always original research, and not simply a demonstration of methodological techniques or concepts. On occasions this is simply a replication of a previous study with different study species. On other occasions, it involves a completely original design, or modifications of a previous study. The keepers at the zoo will sometimes suggest a study they would like to be conducted. For example, they may like quantitative data on a new enrichment technique, or a comparison of how different feeding routines affect behaviour. It is, of course, important that the keepers who suggested the study are fully informed of the findings.

In our experience, it is optimal for logistical reasons that the class is spilt into groups of no more than 25 students for data collection (we usually have four groups). Therefore our studies are designed around being able to study the same group of animals on several different occasions, and allow the methodological concept of counterbalancing to be demonstrated. At the end of data collection we ask students to add up totals for each of the checksheet columns, and then we collect the checksheets in to ensure no data are lost. This allows the demonstrators to compile the data and enter them into a spread sheet for class analyses. Although this is a time-consuming process for the demonstrator, we have in the past, encouraged enthusiastic undergraduates to assist (sometimes as a part of a final year project in which they have access to all data, and may collect some additional data themselves). Students are required to write up a report of the study for assessment. For logistical reasons, students are given access to data from just two groups and the analyses that they are expected to do are detailed, together with guidelines as to how to write a scientific report. Given the variation in statistical expertise amongst the class (who range from 2nd to 4th year students), we ensure that the statistics are simple (e.g. means, standard errors and t-tests) so each student is capable of the analyses. For many students, this is the first time they have done statistics on their own data, and several comment on how this increased their understanding of statistical techniques. Given the quantity of data produced, we generally have two set analyses which we provide the rationale for doing, and then allow students to conduct two analyses of their own to allow for originality in the reports. Extra help is provided for those who find the analyses difficult. In the example provided below, the data from the whole class have been re-analysed using analysis of variance.

Considerations in the design of the study
Purely observational studies without experimental manipulations are probably the most simple to conduct, for example comparative studies of different species, but they are limited as a teaching tool. Zoos generally just keep one group of each species and therefore statistical comparisons between groups are generally not possible. Furthermore, as one of the aims of our practical work is to teach students experimental design, we prefer to make experimental manipulations.

In our experience, we have found it better to restrict our studies to indoor enclosures due to unpredictable weather. We base ourselves in just one area where several species are on exhibit so that the demonstrators are constantly available to deal with the problems as they arise. In addition we only study groups in which individual identification is unproblematic. If differences in age and sex classes are of interest, this obviously affects choice of species. Furthermore, it is really only feasible to study animals that are relatively active as we need data on a number of behavioural measures to analyse. Choosing animals in enclosures where visibility is good is important for the same reason. It is sometimes necessary to prevent access to outside runs during the data collection periods. If the experiment does not work its usefulness as a teaching tool is limited.

Given the time limitations (students spend less than two and a half hours at the zoo) we have to ensure the study is simple, and that sufficient data can be collected within this time period. Given the lack of experience the majority of students have in data collection, we take great care to ensure the behavioural categories are unambiguously defined. The demonstrator produces a handout, defining each behaviour, and the method that will be used to record it. Checksheets (for pilot, baseline and experimental conditions) for each student are made up. If a behavioural category includes a measure of distance (e.g. neighbour within 1m) then a 1m measuring tape is provided. As well as verbal descriptions of behaviour, pilot data are collected under supervision to ensure each student understands and records accurately. Sufficient demonstrators are required to ensure that this is the case, and every pilot checksheet is inspected before proceeding. In addition, we carry out inter-observer reliability to ensure the data are being recorded accurately, and to demonstrate this methodological concept (Caro *et al*., 1979). Two students are assigned to the same focal animal and informed that they must not confer during the data collection. Back in the classroom we use a simple formula to calculate the reliability of each of the behavioural measures, and those that fall below 75% agreement are not used in analyses. Sometimes, data collected by all occurrences sampling, are collapsed to one zero sampling (Martin & Bateson, 1993) to improve reliability. We have found it best to have a baseline data collection before introducing an experimental manipulation. This can act as a further pilot data collection session if necessary and need not be analysed if students have not grasped the methodology, or are having problems with the identification of their focal animal. However, if everything goes smoothly it allows students to examine how the experimental manipulation affects behaviour.

Previous topics
So far, we have limited ourselves to the study of primates and we have conducted quite a number of studies related to food and novelty. In the case of food we have looked at its spatial distribution (more details below and in Buchanan-Smith, 1995), its size, colour and ease of acquisition. In relation to food size, the aim of the study was to determine how the size of food pieces presented affects food processing time, foraging time and social interactions. The study on food colour was designed to determine whether primates had preferences for food of a certain colour, and to determine if they avoided unfamiliar colours of food. In the study of ease of acquisition of food, shelled and unshelled nuts were presented, to determine whether there were differences in feeding behaviour amongst age and sex classes in relation to the demand of food processing. For novelty we have presented objects to determine what properties of objects constitute enrichment (this research was published, see Sambrook & Buchanan-Smith, 1996) and we have looked at laterality and responsiveness to objects.

Learning Outcomes
The students get valuable hands-on experience at data collection, and a greater understanding of the methodology of collecting behavioural data, including the problems associated with it. We utilise the high quantity of students to our advantage in designing studies, as each student can be assigned a focal animal, providing a rare opportunity to collect information on every member of a group simultaneously. The students experience the whole scientific process of conducting research from start to finish. During the practical they should learn about experimental design, observational data collection methodology, data analyses and interpretation. The work requires co-operation, and this is stressed. Students are aware that they will be letting the whole group down if they fail to participate to their best ability. In addition, given that they know that the results may be published if they work co-operatively, they are generally very serious and enthusiastic about the programme.

Example of practical work: Spatial distribution of food
Introduction
Ecological variables such as food distribution and availability are widely recognised as major determinants of animal behaviour (e.g. Oates, 1987). Whilst food distribution and related foraging behaviours have been the focus of much field research (e.g. Clutton-Brock, 1977) there have been few investigations into how the distribution of food affects the social interactions and activity budgets of non-human primates in captivity. Such minimal research is significant, as one of the first effects of captivity is to remove an animal's need to forage, a key factor in its natural environment (Hediger, 1964). In the wild primates often spend up to 50%-60% of their time foraging (e.g. Garber, 1984) and this has serious implications for the method of food distribution in captive primates.

Zoological Gardens aim to provide an environment that maintains behaviour patterns similar to those found in the wild. In this context it is important to determine how the food distribution affects behaviour, and to ensure that all individuals within a group get sufficient food, an equal share of preferred food items, and that aggression is minimised. Those studies which have been conducted on primates in captivity have tended to focus upon the social response to food shortage and competitive access to food (e.g. Tardif & Richter, 1981; de Waal, 1984; Deutsch & Lee, 1991). Investigations related directly to food distribution, and ease of access to food in captive primates have found differences between age and sex classes in consumption, rate of acquisition and levels of aggression (e.g. Plimpton *et al.,* 1981; Brennan & Anderson, 1988). The aim of the present study was to compare food consumption, rates of acquisition, foraging and aggression across four different methods of food distribution in four groups of Old World primates and to make recommendations as to the best method of feeding them.

Study animals and enclosures
The primates observed were four groups from the subfamily Cercopithecinae: the Diana monkey (*Cercopithecus diana*) group consisted of an adult male and female with two offspring (one male and one female); the Allen's swamp monkey (*Allenopithecus nigroviridis*) group consisted of an adult male and female with their male offspring; the lion-tailed macaque (*Macaca silensus*) group were an adult pair with a male and female offspring and the Hamlyn's monkey (*Cercopithecus hamlyni*) group were an adult pair with three female offspring, the youngest of which was not studied.

Each species had large enclosures which consisted of an indoor and outdoor area. All observations were made in the indoor areas which were well furnished with branches and ropes. The roof was wire mesh and both the roof and floor were covered with straw. Covering the roof with straw has two important effects: it provides an additional area to scatter food on, which encourages greater activity and better use of three-dimensional space and, as most of the primates studied are forest dwellers, the straw covering on the roof provides a more natural simulation of dappled light.

Design and procedure
The observers were 60 students taking an animal behaviour course at Stirling University. Clipboards, stopwatches, checksheets and a beeper, set to sound every 30 seconds were used for data collection purposes. There were four experimental food conditions that were separated from each other by at least a week. The conditions were: (1) Food scattered throughout the floor coverings (2) Food scattered throughout the roof coverings (3) Food placed in a single pile on the floor (4) Food placed in a single pile on the roof. Baseline data were collected prior to each condition. A different group of students collected data for each condition and inter-observer reliability was performed to ensure consistency in data recording. For all behavioural measures agreement was greater than 75%. The food consisted of apples and oranges cut up into small pieces. When food was placed on the roof it sat on the straw covering the wire mesh, although some pieces did fall through to the floor.

Observers used focal sampling recording, that is each observer was assigned to a different monkey. The observation sessions lasted 30 minutes for each condition which were divided into 30 second time intervals, indicated to observers by an audible tone. Behaviours recorded included each time the focal monkey put food in its mouth, each time (s)he was involved in an aggressive interaction, and every 30 seconds the observer noted whether their focal monkey was foraging. The data across all species were pooled for analysis. The data were tested using a one way ANOVA with repeated measures, with the four feeding conditions as factors. When significant main effects were found, Tukey's post-hoc tests were conducted to identify the source of the effect. The data for "food in mouth" were divided into 3-minute blocks to allow the rate of acquisition of food to be examined. The monkeys were divided into age/sex classes (adult males, N=4; adult females, N=4; offspring, N=7) to examine differences between them.

Results
There was no significant difference in the amount of times individuals put food in their mouths per 30 minute observation session across the four conditions ($F_{(3,14)} = 0.21$, $p > 0.05$; fig. 1). The mean number of times individuals put food in their mouths was approximately 75 per condition although overall adult males tended to put more food in their mouths than adult females or offspring.

Figure 1. Mean (+/- standard error) food in mouth score per individual per food distribution condition (N = 15).

Figure 2. Mean cumulative food in mouth scores (%) by age/sex class, for the four different food distribution conditions. (Adult males: N = 4 ; Adult females: N = 4; Offspring: N = 7).

However, the rates of food acquisition differed across the four conditions. The cumulative food in mouth scores were calculated for each age/sex class and are plotted in figure 2. A steep curve indicates that the monkeys are eating quickly, and therefore spending little time acquiring food. There are some consistent differences across all age sex classes. When the food was placed in a single pile on the roof (an unfamiliar presentation method to the monkeys), there was a more consistent rate of acquisition than other food presentation methods. The monkeys were still eating at the end of the 30 minute observation session, while for other food presentation methods the monkeys completed their feeding sooner. However, more in-depth analysis of the data indicates that there were the greatest individual differences in food intake in the single pile of food on the roof condition. Some individuals acquired very little food (and in the case of one monkey, no food at all during the observation session), and hence this method of food distribution cannot be favoured. There were few differences between the rates of acquisition for the age/sex classes when food was scattered (either on the floor or roof). However, when it was placed in a single pile on the floor, there were clear differences. The adult males were able to eat the food quickly, followed by the adult females, and the offspring took the longest time to acquire it, and therefore are less likely to have succeeded in getting a fair share of the preferred food items.

There was also a significant difference in the amount of time individuals spent foraging across conditions ($F_{(3,14)} = 7.2$, $p < 0.001$, fig. 3). As expected, when food was scattered, the monkeys spent significantly more time foraging for it than when the food was placed in a single pile. Finally, an analysis of the amount of aggressive interactions across conditions indicates that there were no significant differences ($F_{(3,14)} = 1.9$, $p > 0.05$), although there was a tendency for aggression to be higher in the single pile of food on the floor condition than in the others (fig. 4).

Figure 3. Mean (+/- standard error) percent of scans individuals spent foraging in four food distribution conditions (N = 15).

Figure 4. Mean (+/- standard error) number of aggressive interactions per individual in four food distribution conditions (N = 15).

Discussion

This study highlights the way in which food distribution, and the resulting foraging demand it imposes, affects the rates of acquisition, distribution of food between age/sex classes, foraging behaviour and aggression in captive groups of primates. It is suggested that the usual method of feeding the monkeys, which is scattering food throughout the floor or scattering it over the roof coverings is the best method. It results in more equal distribution of food items and similar rates of acquisition across age/sex classes, more time spent foraging (therefore more closely resembling natural activity budgets) and fewer aggressive interactions than the other presentation methods. It is suggested that varying the presentation method from day to day may be beneficial for captive primates as it gives some degree of uncertainty as to where to find the food.

Little is known about any of the primates studied in this experiment in the wild. Therefore, research on captive animals is important if we are to learn about their behaviour and group interactions, and to determine the best way to feed them. It should be stressed however, that the interplay between species-typical social structure and response to varied feeding situations is likely to be complex, and this aspect was not addressed in this study.

Conclusion

Overall we have found that zoo-based practicals are an excellent method of teaching. Student evaluations consistently emphasise that they would much rather be involved in original research conducted in the zoo that provide useful results that have implications for the management of captive animals, than simpler practical work used to demonstrate the concepts and methodological issues.

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Working together for conservation: a win-win strategy for zoos and universities

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Abstract
The survival of a large number of taxa is severely threatened and the 21st century will bring many extinctions unless urgent conservation action is taken. To ensure species survival research is needed in all areas, as we are still relatively ignorant about biological diversity and especially about effective means of preventing its loss. Moreover, there is also a lack of people trained to acquire the information and/or implement conservation actions.

Research in many academic disciplines can be carried out with zoo animals. By combining their resources, zoos and universities can carry out research and training which individually they would not be able to do. The main benefits to universities of collaboration with zoos are access to a wide range of animals and samples, naturalistic environments, the expertise of zoo personnel, and specialist libraries. In turn, zoos benefit from access to specialised analytical laboratories, the expertise of research personnel, research students, and extensive libraries. In many research areas zoos gain directly in terms of information of relevance to captive management and conservation goals, while university researchers have opportunities to test hypotheses. Zoos are thus ideal locations in which to carry out both basic and applied science of high quality.

Zoos are also excellent locations for the training of future researchers and conservationists. Under- and post-graduate courses in conservation biology, etc. are rapidly increasing in number, so zoos provide training grounds in the practical aspects, through both work experience and research programmes. Several zoos also offer courses, e.g. in animal management and captive animal welfare, often taught in collaboration with university staff from both biological and veterinary sciences. Zoos can also act as sites for university conservation "field studies" courses.

In summary, together zoos and universities can achieve more for research and training of relevance to conservation than either could alone.

Introduction

As we enter an extinction spasm, the Earth's biodiversity is under severe threat (Myers, 1987). The 21st century is likely to bring numerous extinctions unless urgent conservation action is taken. Human actions are the primary cause of species decline, yet we are still struggling to find ways of ensuring species survival. This increasingly desperate situation has been largely responsible for the development of the science of conservation biology, which draws together many more traditional academic disciplines to develop ways of understanding and combating the process of extinction (Soulé, 1985, 1986; Gilpin & Soulé, 1986; Western & Pearl, 1989; Fiedler & Jain, 1992; Primack, 1993).

The World Zoo Conservation Strategy has outlined ways in which zoos and aquaria can play a role in conservation (IUDZG/CBSG (IUCN/SSC), 1993): 1) by actively supporting the conservation of endangered species populations and their natural ecosystems; 2) by offering support and facilities to increase scientific knowledge that will benefit conservation; and 3) by promoting an increase in public and political awareness of the necessity for conservation, natural resource sustainability and

the creation of a new equilibrium between humans and nature. These can be summarised as *in situ* conservation, conservation research and conservation education.

Research is a fundamental part of zoos' role in conservation (Kleiman, 1992, 1996; Gansloßer *et al.*, 1995; Ryder & Feistner, 1995; Hardy, 1996; Hutchins e*t al.*, 1996). We need to understand biodiversity, population biology, conservation status, and the variety of threats posed by human populations. Lack of knowledge is not the only obstacle, however - particularly in those areas of the world where the problems are most acute, there are relatively few people trained in research techniques and the management of wild and captive populations of endangered species to develop and implement conservation strategies.

Zoo–university collaborations: benefits for all

Zoos have a clear role to play in conservation and this is an area of expansion (Olney *et al.*, 1994; Gibbons *et al.*, 1995; Hutchins *et al.*, 1996; Baker, 1996/1997; Wallis, 1997). Collaboration between institutions is a mutually beneficial strategy to enhance the conservation contribution of each participant, as has been shown for zoos and museums (Kitchener, 1997; Cooper *et al.*, 1998). In this paper we focus on the roles that zoos and universities can play in conservation, emphasising that there is plenty of opportunity (and need) for them to contribute enormously to this field, and, in particular, to stress the enhanced benefits of collaborations between zoos and universities, for the institutions themselves, and for conservation in general.

Benefits to universities

The range of species housed in dedicated research facilities is limited, and largely confined to a few species of birds, rodents and primates.   In contrast, zoos and aquaria frequently maintain a wide variety of species, many of which are of conservation concern and may be otherwise absent from captivity. Thus one of the main benefits to universities from collaborating with zoos is access to animals (table 1). This provides numerous opportunities for both basic and applied studies (Kleiman, 1992, 1996).

Access to a wide range of animals
  - rare and endangered species
  - individually identifiable animals with known histories
  - single species and comparative studies
  - descriptive and experimental studies

Access to a wide range of samples
  - tissue
  - blood
  - hair
  - feathers
  - urine
  - faeces

Naturalistic environments
  - semi-free- and free-ranging animals

Access to the expertise of zoo personnel
  - specialist knowledge of particular taxa, behaviour, management and conservation status

Access to specialist libraries

Table 1. Benefits to universities from zoos

Apart from whole animal biology, zoos may often provide samples (e.g. hair, faeces, blood) which are not readily obtainable elsewhere. Zoos also contain specialist staff, who can provide expertise to university researchers and may frequently generate ideas for both basic and applied research. Zoos also often maintain small but specialist libraries, which may contain information difficult to obtain elsewhere.

Benefits to zoos
The other half of the win-win strategy is the benefits which zoos can get from collaborating with universities (table 2). Developments in the technological aspects of conservation biology are leading to large improvements in our understanding, but these more sophisticated activities are rarely possible in zoos. The increase in the use of samples which are collected non-invasively also increases the opportunities for zoos to contribute material for analyses. Relatively few zoos have dedicated research personnel, so another advantage for zoos is access to trained scientists as professional collaborators.

Access to analytical facilities
- molecular genetic techniques
- endocrinology laboratories
- food biochemistry

Access to the expertise of university personnel
- data collection and analysis
- laboratory analyses
- specialist techniques

Access to researchers
- trained academic staff
- student researchers

Access to broad literature databases

Table 2. Benefits to zoos from universities

The ways in which zoos and universities provide resources for each other across a range of scientific disciplines is illustrated in figure 1 and examples of collaborations between Jersey Zoo and universities are shown in table 3.

Training researchers and conservationists
The popularity of courses in conservation biology, environmental science and wild and captive animal management is growing all the time. Zoos and universities work together to provide training opportunities for students in all these fields, as well as locations for research projects and courses in many different subject areas (table 4). Work experience and research students at Jersey Zoo have been drawn from a wide variety of academic disciplines (table 5). They include both traditional "pure" sciences as well as the more applied subjects for which zoo work has direct relevance.

Practical training
Experience in the practical aspects of captive animal management and conservation is an important component of training the people who will carry on this work in the future. Jersey Zoo offers a range of opportunities for students and others wishing to acquire practical experience in zoo work, and since September 1997, the zoo has hosted 21 work experience students from 11 different institutions (table 6).

Zoo provides

University provides

Anatomical studies

Diet and nutrition

Specimens or samples

Reproductive biology

Genetics and population management

Individual histories

Laboratory facilities and analytical expertise

Pathology and disease investigation

Expertise

Specialised resources

Education and visitor studies

Access to animals in appropriate settings

Ethological studies

Personnel for data collection

Environmental enrichment

Figure 1. How zoos and universities can collaborate in various research areas

Example	Zoo provides	University provides
Reproductive suppression and contraception in lion tamarins	Faecal samples Reproductive history	Hormonal analysis
Reproductive problems in female gorillas	Urine samples Reproductive history	Hormonal analysis
Diet and nutrition of Alaotran gentle lemurs	Food and faecal samples	Biochemical analysis
Survey of Yersinia pseudotuberculosis in callitrichids using PCR techniques	Faecal samples Access to specimens	PCR techniques
Atoxoplasmosis in Bali starlings	Faecal samples Blood smears	Parasitology techniques
Aye-aye musculature	Access to specimens	Anatomical expertise
Free-ranging New World monkeys	Animals in naturalistic settings Management expertise	Student personnel
Taxonomic studies of southern hemisphere ducks	Blood and feather samples from animals of known origin	Genetic analysis
Inbreeding/outbreeding depression in Goeldi's monkey	Blood samples from animals of known parentage (maternity)	Genetic analysis
Determining paternity in fruit bats	Skin samples from animals of known maternity	Genetic analysis
Effectiveness of education information	Access to facilities Educational expertise	Student personnel

Table 3. Examples of collaboration between Jersey Zoo and universities for research

Training
- as part of degree courses
  - sandwich year, 9-12 months
  - short-term work placement (minimum 3 months)

Research
- work experience students
- degree projects
  - undergraduates
  - postgraduates (MSc/MRes/PhD)
- postdoctoral scientists

Courses
- university-ratified courses
  - 4-month Diploma in Endangered Species Management, ratified by the University of Kent
  - 3-month Certificate in Endangered Species Management
- short courses
  - 3-week summer school in Captive Management and Breeding of Endangered Species
  - short research courses (7-10 days) e.g. Anthropology Institute (University of Zürich)

Table 4. Opportunities available to university students and staff at Jersey Zoo

Pure	Applied
Anatomy	Animal Management
Anthropology	Applied Animal Behaviour and Animal Welfare
Biology	Applied Biology
Ecology	Applied Parasitology and Medical Entomology
Human Biology	Applied Zoology
Psychology	Conservation Biology
Zoology	Environmental Management
	Environmental Science
	Veterinary Science
	Wildlife Biology
	Wildlife Conservation

Table 5. Academic disciplines studied by placement and research students at Jersey Zoo

	Number of individuals	Number of institutions
Captive management experience	21	11
Research: Jersey projects		
Bachelor's	6	4
Masters	4	3
Doctorate	-	-
Post-doctorate	1	1
Other	2	-
Total	13	7
Research: independent projects		
Bachelor's	8	5
Masters	3	3
Doctorate	5	5
Post-doctorate	2	2
Total	18	13

Table 6. Students and external researchers at Jersey Zoo, September 1997 to June 2000

Research

Zoos also have a major role in the provision of opportunities for training in research techniques. Since September 1997, Jersey Zoo has hosted 31 student and other researchers, at levels ranging from undergraduate to post-doctoral scientists (table 6). Nearly half have worked on projects designed and run by zoo staff as part of our in-house research programme; the others have developed independent projects.

Zoo-based courses

Both short- and long-term courses based in zoos are becoming increasingly common, as zoos and universities collaborate to provide more training opportunities. Some zoos, for example, run short courses in animal welfare, environmental enrichment, captive animal management, etc. (Waugh, 1988; Waugh & Wemmer, 1994; Fa *et al.,* 1995).

Conclusion

By working together to carry out crucial research and train the essential scientists and animal managers of the future, zoos and universities not only gain mutual benefits in achieving their own aims, but can make a vital contribution to the theory and practice of conservation. Such

collaborative efforts are becoming increasingly important as we face up to the impact of human activities on biodiversity.

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Current zoo research at Anglia Polytechnic University

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Abstract

Of some 60 students currently in their final year of reading for a degree in Animal Behaviour at Anglia Polytechnic University, more than a third chose to carry out zoo-based research projects, as the basis for their undergraduate dissertation.

This report is a brief summary of some of their work over the past year and also a look ahead at future zoo research projects involving a new initiative developed in North America, the Methods of Behavioural Assessment (MBA) Project.

Stress, welfare and social status in the mara (*Dolichotis patagonum*) at Whipsnade Wild Animal Park.

This study was funded by a UFAW vacation scholarship and was carried out by Francesca Di Marco in July-September 1999.

The mara is a socially monogamous animal and previous studies have suggested that there may be negative welfare implications for unpaired or "bachelor" males, based on evidence of enlarged adrenal glands (suggesting chronic stress) and reduced access to food sources in the winter months. Behavioural, pathological and physiological indicators were used to assess the welfare of fifteen paired and fifteen unpaired male maras at Whipsnade over two months in 1999. Contrary to expectations, unpaired males experienced fewer incidences of male-male aggression than paired males during this study, but unpaired males were significantly more likely to be the recipients of female aggression at localised food sources. Pathological data, based on faecal egg counts, showed that unpaired males have a significantly higher intensity and prevalence of infection by gastro-intestinal parasites than a comparable sample of paired males. Faecal cortisol measurements, using a standard ELISA kit, were unsuccessful and it appears that maras excrete a cortisol metabolite which is not recognised by the most commonly available anti-sera, at least for use in ELISAs.

Olfactory enrichment for captive tigers (*Panthera tigris*)

The aim of this study, by Heidi Mitchell, was to test whether the provision of olfactory stimuli reduced stereotypic pacing in six captive tigers (three males and three females) housed at two zoos; Dartmoor Wildlife Park and Chester Zoo. Three different scents were used. These were firstly, prey scent (branches scent-marked by fallow deer); secondly, *2-acetylpyrroline*, a compound responsible for the characteristic aromatic smell of tiger urine and thirdly, scent from an unfamiliar conspecific (logs scent-marked by tigers at other zoos).

For all three scent trials, olfactory exploration behaviours such as sniffing and cheek-rubbing increased during the enrichment period in comparison to baseline data collected during a pre-enrichment period. Stereotypic pacing decreased significantly during the prey scent trial and during the trial of *2-actylpyrroline*, but did not show a significant change during the third trial using conspecific scent from a strange animal.

Branches scent-marked by fallow deer produced the greatest decline in stereotypic pacing by the captive tigers, suggesting that the provision of such "prey scent" may form an effective and inexpensive form of olfactory enrichment for this species in captivity.

Management of the wolverine (*Gulo gulo*) in captivity: institutional differences in breeding success

Attempts to breed wolverines (a large mustelid) in captivity at a number of European zoos have met with variable success, with a large proportion of zoos failing to breed this species. Data on enclosure design, management procedures and breeding success were collected by Brigitte Grov, via a comprehensive questionnaire sent to 32 zoos in Northern Europe. These data were supplemented by behavioural observations of captive wolverines at six zoos in Scandinavia. Breeding success for the wolverine was found to show a significant positive correlation with enclosure size. The presence of a rocky scree (favoured topography for den building) also significantly improved the probability of breeding success. Zoos which had not bred wolverines successfully had smaller enclosures with a significantly higher proportion of bare concrete. Feeding frequency was also significantly correlated with breeding success, with successful zoos feeding large pieces of meat less frequently (every second or third day), thus allowing the animals to show the caching and retrieval behaviour which has been reported for this species in the wild.

Current research and The Methods of Behavioural Assessment Project

Studies such as Brigitte Grov's work on wolverine show that questionnaire-based surveys can, if conducted properly, make a useful contribution to the successful management and breeding of animals in zoos. The Methods of Behavioural Assessment (MBA) Project is a recent initiative which has been developed collaboratively by researchers from ten North American zoos. The aim of the Project is to create a behavioural tool for rapidly assessing the behaviour of individual animals across a large number of institutions and, in particular, for analysing how variability in the behaviour of individual animals is influenced by environmental conditions in captivity. Standardised behavioural profiles are built up by means of keeper surveys and observational assessment. These profiles are then compared at a multi-institutional level with aspects of the captive environment and the reproductive success of individual animals.

To date, the MBA project has surveyed 50-80 individual animals from four model species at 15-20 zoos in North America. The species surveyed are the black rhinoceros, great hornbill, maned wolf and cheetah. Supported by a UFAW vacation scholarship, an APU undergraduate, Andrew Mayo, will be applying the MBA project to captive black rhinoceros in the UK this summer. Other APU students will be using aspects of the MBA project to assess the captive welfare of tapirs, Asian elephants and timber wolves.

The utility of public aquariums to research on the biology and ecology of fish

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Abstract

Our current understanding of the biology and ecology of many fish is based on specific laboratory studies. Although many advances in understanding depend on this type of target research, one consequence is that we are left with large gaps in our knowledge of many other species particularly in relation to the natural environment. This can be problematic when we consider such important topics as species diversity, community dynamics and habitat management. To address this lack of knowledge, we have been exploring the utility of research within the setting of public aquaria, which represent huge investments in simulating the natural environment for display species. These facilities far exceed anything that could be contemplated in a research environment other than work in the field. However, a constant criticism that is levelled at field and ecology based research is the lack of control of extraneous variables. In the context of a public aquarium we have an example of a more controlled environment that is more closely related to the real situation than a research laboratory. There is huge potential for research utilising current behavioural ecology techniques within a relatively controlled setting where standard, repeatable data can be obtained on a variety of species. The data obtained can be categorised (list not exhaustive) into: species distribution, locomotion, feeding, intra and inter specific interactions, reproduction, activity rhythms, resource requirements, human interactions, environmental conditions (abiotic), habitat association and learning

The effect of enclosure complexity on activity levels and stereotypic behaviour of three species of the genus *Panthera* at Dublin Zoo

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Abstract
Three species of the genus Panthera *were studied over a four-year period in Dublin Zoo. During this time behavioural observations were recorded on each species as they occupied a series of enclosure types that varied in complexity and novelty. Four specific enclosures were defined. These consisted of 1) a familiar unenriched enclosure, 2) a novel complex enclosure, 3) a familiar complex enclosure and finally 4) a familiar complex enclosure with added platforms. Activity levels and pacing behaviour were analysed for all individuals in each enclosure. Overall increased enclosure complexity did not alter activity levels for the big cats. However the results show that within their consistent activity levels, the behaviours expressed could be modified so that stereotypies were reduced. The addition of platforms in particular, reduced pacing behaviour to very low levels for most individuals.*

Introduction

Dublin Zoo along with London and Paris are the oldest European Zoos. First opened in September 1831, its history of keeping big cats began in 1855 when it acquired a pair of African lions (Went, 1963).

Notoriously inactive in captivity, big cats still remain one of the most popular species housed in zoos. Like other carnivores, they have a tendency to carry out locomotory stereotypies in captivity (Carlstead *et al.,* 1991; Mason, 1991a,b). The growing awareness of animal welfare and a desire to maintain animals under optimal conditions has meant significant changes in enclosure designs and the way animals are kept in captivity (Hediger, 1964). The image of zoos is changing with enclosures becoming more naturalistic in appearance, some appearing more like parks than the traditional zoo (Rabb, 1994; Forthman-Quick, 1984). The primary objective of this study was to investigate activity levels and stereotypies for three species of big cat over a range of enclosures each varying in complexity and novelty.

The captive environment plays a significant role in the development of primate behaviour (Taylor-Holzer & Fritz, 1985; Clarke *et al*., 1982). McClusky (1978) documented the beneficial effect of enclosure complexity on the reproductive success of both primates and carnivores while Carlstead (1993) documented the importance of enclosure complexity in small cats and the beneficial effect on pacing levels. This implies that zoo animals benefit from the environmental complexity provided by naturalistic enclosures.

Materials and methods

Behavioural data was collected on three species of the genus *Panthera*, jaguars (*Panthera onca*), lions (*Panthera leo*) and snow leopards (*Panthera uncia*) over a variety of enclosure conditions (Kelly, 1998; McDevitt, 1998; Sloane, 1998). The study animals consisted of a male and female jaguar aged 13 and 16 years respectively, a male and female lion aged 17 and 13 years respectively and a male and female snow leopard aged 9 and 8 years respectively. This study provides data on the behaviour of the same individuals in four enclosure types and over varying degrees of enclosure complexity. The four enclosures consisted of:

1. Enclosure 1, a familiar unenriched exhibit with one platform and only earthen substrates
2. Enclosure 2, a novel naturalistic exhibit, which provided the cats with increased space (table 1) and complexity. All three species' exhibits had pools, raised natural mounds and a variety of substrates and hiding places out of public view.
3. Enclosure 3, the same naturalistic enclosure as enclosure 2 but data were collected when the cats had become habituated to it after six months.
4. Enclosure 4, the same naturalistic enclosure as enclosure 2 which had been modified with artificial raised platforms increasing the number of visual barriers and complexity within the enclosure.

Therefore, the four enclosure types represent an unenriched enclosure (low complexity and low novelty), a novel enclosure (high complexity and high novelty) a habituated enclosure (high complexity, low novelty) and a modified enclosure with platforms (high complexity, high novelty).

Enclosure	Jaguar	Lion	Snow leopard
Old, unenriched	80.25 m^2	1330 m^2	85.32 m^2
New novel	320 m^2	2100 m^2	475 m^2

Table 1. Approximate old and new enclosure sizes for big cats at Dublin Zoo

Five replicates of two hour-long focal animal samples were taken, one hour in the morning and the other in the afternoon for each individual, and the data recorded on a check-sheet (Altmann, 1974). The jaguars were recorded from 09:00-10:00 and from 13:00-14:00, the lions were recorded from 10:00-11:00 and from 14:00-15:00, and the snow leopards were recorded from 11:00-12:00 and from 15:00-16:00. This method was repeated for all four enclosure types.

A variety of behavioural categories were recorded. In order to interpret the information more effectively all behaviours were condensed into two categories, active or inactive. The category active contained all behaviours such as 'locomotion', 'pacing', 'standing', 'grooming', and 'feeding'. The second category inactive contained the behaviours 'rest', and 'not seen' (which was recorded when the animal could not be found). 'Not seen' is categorised as inactive as the areas within the enclosure in which they can remain unseen are small so it is assumed that if the animal had been active it would have been observed.

Results
Morning and afternoon activity data for each individual in each of the four enclosures was compared using a Mann Whitney U-test. No significant differences were found and the morning and afternoon data were then pooled for each enclosure type. Using this pooled data, the next stage of analysis was a Kruskall-Wallis one-way ANOVA in order to compare activity levels in the four enclosure categories for each individual.

The male jaguar (fig. 1a) was significantly more active in the habituated enclosure than in any other (post hoc test, enclosure 3 vs. 1 p = 0.05; 3 vs. 2 p = 0.01; 3 vs. 4 p = 0.01). He also showed higher activity levels in the unenriched enclosure than when the platforms were present in the final enclosure (enclosure 1 vs. 4 p = 0.01). The graph of the female jaguar (fig. 1b) follows the same pattern of activity, however her results do not reach significance.

The male lion (fig. 1c) was also significantly more active in the new enclosure, whether it was novel or after habituation, than when platforms were added (post hoc test enclosure 4 vs. 3 p = 0.01; 4 vs. 2 p = 0.05). He was also more active in the habituated enclosure than he had been in his
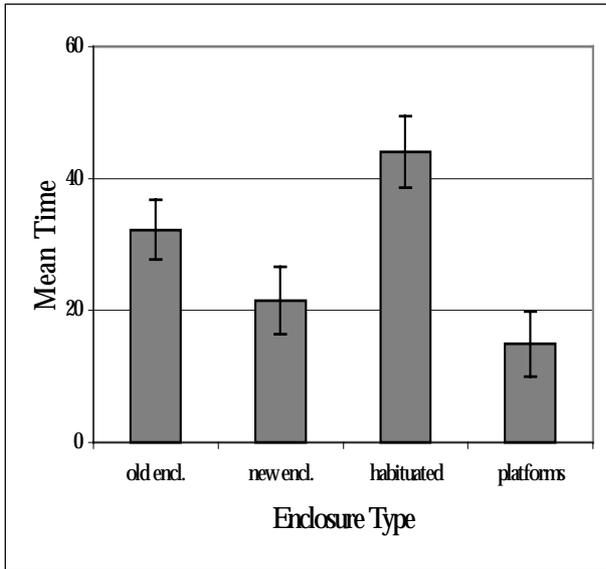
Figure 1a. Activity levels for the male jaguar   Figure 1b. Activity levels for the female jaguar
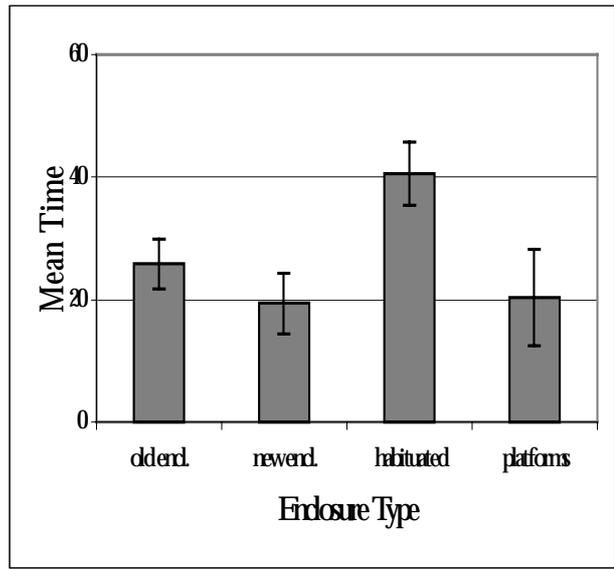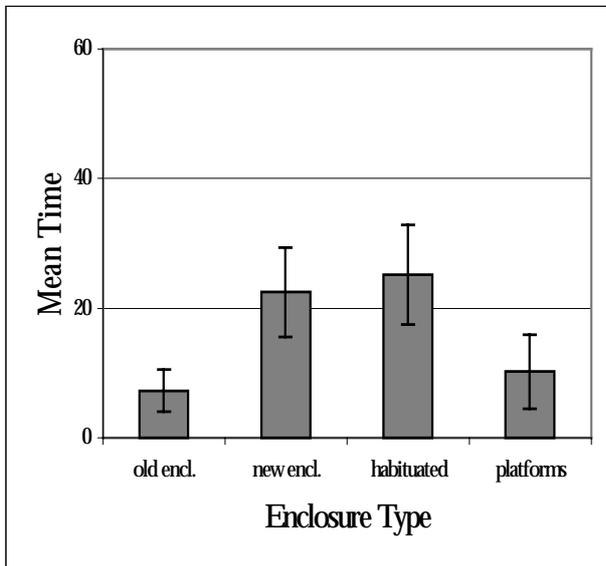
Figure 1c.   Activity levels for the male lion Figure 1d.   Activity levels for the female lioness
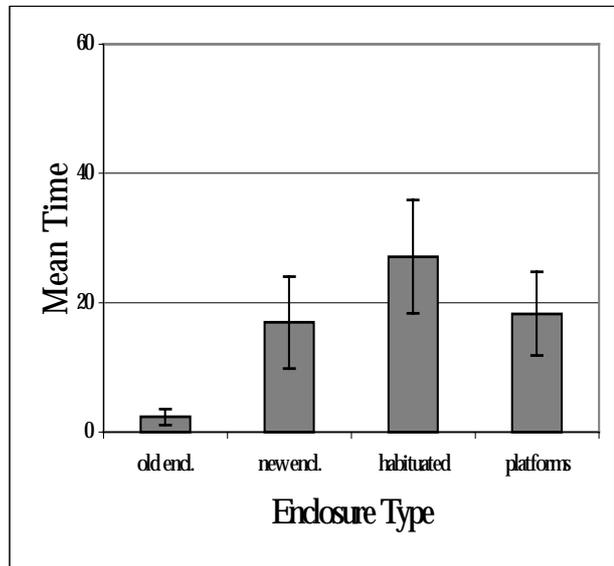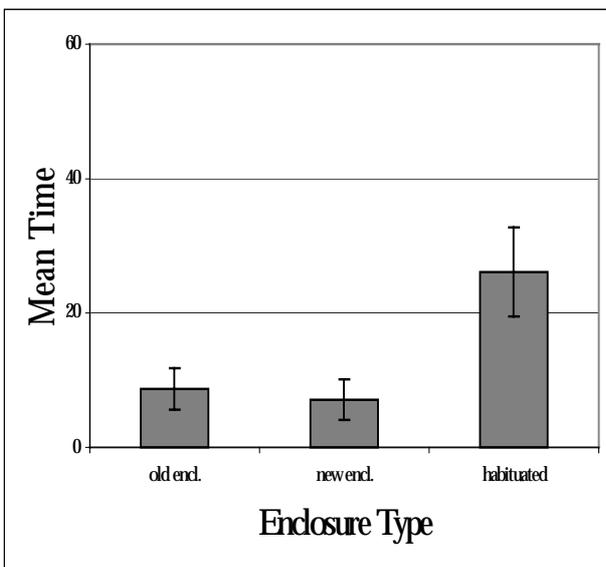
Figure 1e. Activity levels for male snow leopard Figure 1f. Activity levels for female snow leopard
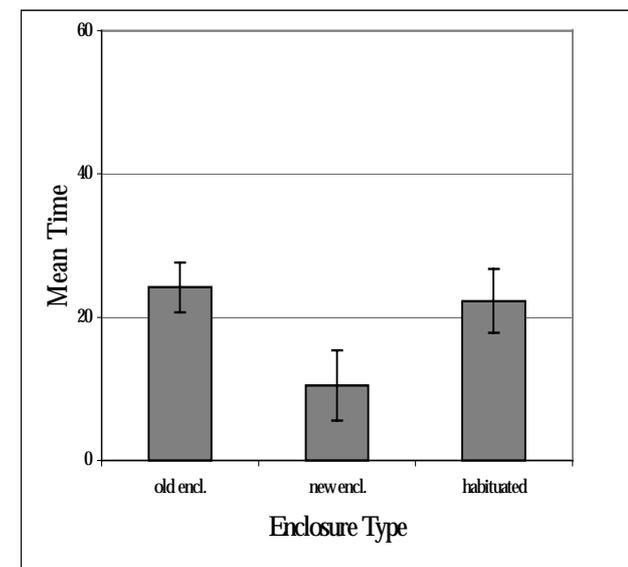
unenriched enclosure (post hoc test enclosure 3 vs. 1 p = 0.01). Again, the female lion followed the same pattern of activity, however her results do not reach significance.

Unfortunately, due to the topography of the enclosure, platforms could not be safely added to the snow leopard enclosure. Therefore data is only available across the first three enclosure types (unenriched, novel and habituated). The male snow leopard showed significant differences in activity levels across the three enclosure types (fig. 1e). In contrast to the jaguars and lion the male snow leopard was significantly more active in the habituated enclosure than any other enclosure type (post hoc enclosure 3 vs. 1 p = 0.05; 3 vs. 2 p = 0.05).

Finally the female snow leopard (fig. 1f) showed less activity in the novel enclosure than in either the unenriched old enclosure or in the novel one (enclosure 1 vs. 2 p = 0.05; 2 vs. 3 p = 0.05).

These results show that the activity levels changed significantly for four of the six individuals over the four enclosure types, but not necessarily in the directions expected from previous work. The overall activity rose to its highest levels when the animals were habituated to their complex enclosures, and was least when they were in the novel complex enclosures, which might be expected to be the most stimulating. However not all activity can be viewed as equally beneficial. All three species were prone to a pacing stereotypy in varying degrees in their unenriched and habituated enclosures. The next step of analysis was to compare pacing levels for all individuals across all four enclosures.

Pacing behaviour was extracted from the 'active' data. Analysis of the results by Kruskall-Wallis one-way ANOVA was carried out for each individual over the four enclosure types (fig. 2)
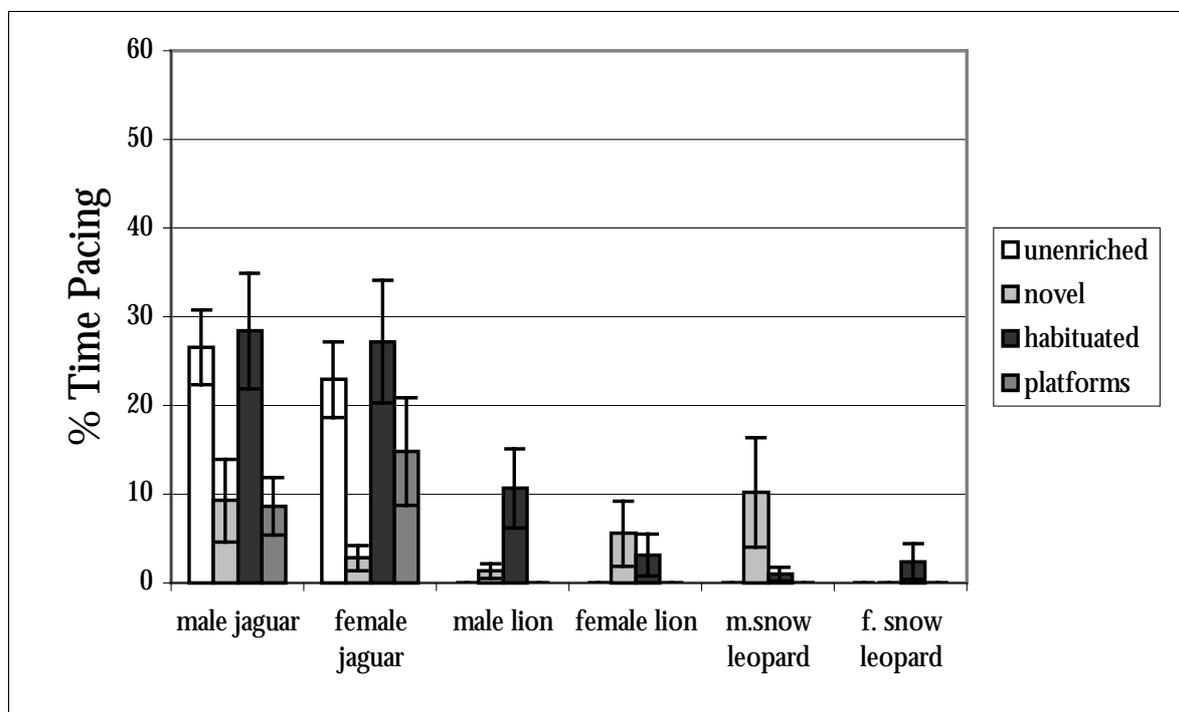
Figure 2. Pacing levels for all individuals across all four-enclosure types

The male jaguar paced more in the unenriched, old enclosure and in the new enclosure once he was habituated to it than he did in the novel enclosure (enclosure 1 vs. 2 p = 0.01; 3 vs. 2 p = 0.01) or than when the platform had been added (enclosure 1 vs. 4 p = 0.01; 3 vs. 4 p = 0.01).

The female jaguar also showed a significant decrease in pacing between the unenriched and novel enclosure (enclosure 1 vs. 2 p = 0.05). However, pacing increased again after habituation (p = 0.05). Although pacing reduced again when the platforms were added this change did not reach statistical significance.

The male lion shows a significant increase in pacing from very low levels in the unenriched to medium levels in the habituated enclosure (p = 0.05). This significantly decreases again after the addition of the platform (p = 0.05).

Pacing results for the three remaining individuals did not reach statistical significance, however all three follow the same pattern of increased pacing when they are moved to a novel enclosure which decreases again after habituation occurs, and reduction of pacing to very low levels when platforms are provided.

The final stage of analysis (fig. 3) looked again at the activity levels once pacing was removed from the data. A Kruskall-Wallis one-way ANOVA was again carried out for all individuals for all four-enclosure types. Results show that the activity levels did not change significantly for any of the individuals. Once pacing was removed from their activity budgets, their activity levels did not change significantly regardless of enclosure complexity or novelty.
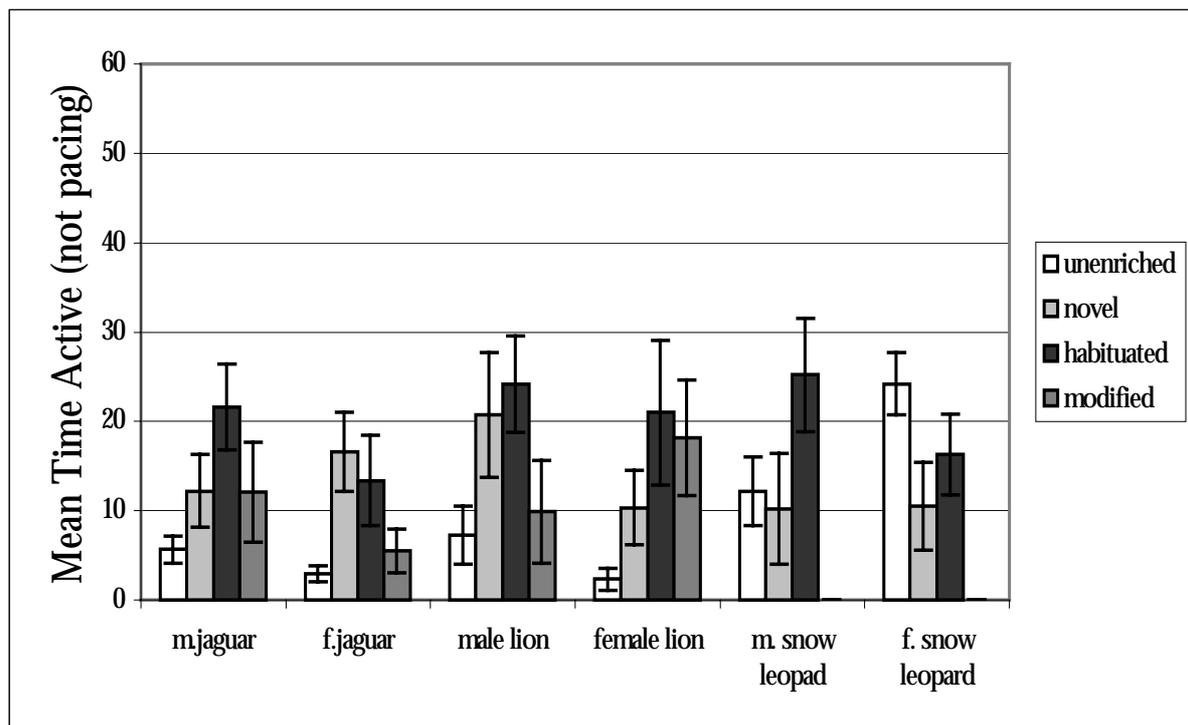
Figure 3.   Activity levels for all individuals without pacing data

Discussion

These results provided us with a number of surprises. Firstly neither novelty nor complexity of enclosure guarantees an increase in overall activity; instead habituation to an enclosure increases activity. However, overall activity comprises all active behaviours, including classically negative behaviours such as pacing , which all the individuals carried out to varying degrees.

When pacing data was analysed on its own it was found that pacing levels varied depending on novelty and enclosure complexity, with more pacing being found in enclosures to which the animals were habituated, and in the case of jaguars, enclosures which were less complex. These findings support those found by Carlstead *et al.*(1993) who showed that complexity of enclosures was important in reducing stereotypic behaviours.

The addition of platforms decreased pacing levels in all the animals involved in the study, and virtually eliminated it in the lions. The height and view provided by the platforms may have given the cats an added sense of security which had the effect of causing a subsequent decrease in pacing levels. It is not clear from this study whether this is because of the height provided by the platforms, or the visual barriers that they provided. All the animals had landscaped mounds in their new enclosures which raised them to about the same level as the platforms did, and furniture forming visual barriers so neither of these features was entirely missing from the second enclosure. Further studies of different platform designs are needed to elucidate exactly how they are working to reduce pacing.

Once pacing was removed from the data, far from showing high levels of activity in the novel complex environment, as might be expected, the cats all showed activity levels which did not change significantly for any of the six individuals across the different enclosures. Thus the only consistent and significant change in behaviour shown by the animals in these very different housing situations are changes in the level of pacing behaviour.

Conclusions
1. Non-stereotypic activity levels can be surprisingly consistent for big cats in captivity regardless of enclosure complexity.
2. Stereotypic activity can be manipulated by the addition of platforms. This supports Carlstead *et al.'s* (1993) findings that by increasing visual barriers within an enclosure pacing levels can decrease.
3. A habituated environment can have high levels of stereotypic behaviour regardless of enclosure complexity.

Acknowledgements
We would like to thank Trinity College, Dublin Zoo and FÀS for their support for the project. We would also like to acknowledge Ciara Kelly, Sheena McDevitt and Alison Sloane whose data was also presented here. Special thanks must also go to all members of the Zoo Research Group for their help and comments on earlier drafts of the manuscript.

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The lifestyle of the loris: an investigation into the activity and husbandry of pygmy slow lorises (*Nycticebus pygmaeus*) at Paignton Zoo Environmental Park.

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Abstract
The pygmy slow loris is a small nocturnal prosimian primate, of the subfamily Lorisinae. They are native to the secondary forests of Viet Nam, Laos, and Kampuchea. Pygmy lorises have been part of the Paignton Zoo's collection since 1993 when six individuals were obtained from several institutions. At the time of study the zoo held six individuals (3.3); 1.1 were housed on public display under reverse lighting conditions. The other animals were maintained under natural lighting conditions, in an off-show area. These animals were housed as one pair (1.1), and two singles.

This project aimed to evaluate the current husbandry of this species within the zoo by investigating how accurately the reverse lighting regime in the nocturnal house recreates natural light conditions for this species, whether the captive individuals maintained under reverse lighting regime have a comparable activity budget to those maintained under natural lighting conditions, by evaluating the effects of various enclosure modifications and analysing the nutritional content of their diet. Results of the first two aims are presented here.

Introduction
The pygmy slow loris is a small nocturnal prosimian primate, of the subfamily Lorisinae. They are native to the secondary forests and shrub land of Vietnam, Laos, and the Yunnan province of China (Fitch-Snyder *et al.*, *in press*). Pygmy slow lorises have been part of the zoo's collection since 1993 when six individuals were obtained from several institutions. During this study the zoo housed six individuals (3.3); 1.1 were housed on public display under reverse lighting conditions. The other animals were maintained under a natural lighting regime, in an off show area. These animals are housed as one pair (1.1), and the two remaining animals were housed separately. Since the completion of the research discussed in this work, the on-show female has given birth to a single young and the male has been moved to an off-show enclosure.

The aims of this work were:
1. To discover how accurately the reverse lighting regime, in the nocturnal house, recreates the natural light conditions for this species.
2. To discover whether the captive individuals maintained under the reverse lighting regime have a comparable activity budget to those maintained under natural lighting conditions.
3. To evaluate the effectiveness of various enrichment techniques.
4. To analyse the current diet of this species.
5. To evaluate the current husbandry of this species within the zoo.

Only the first two aims of this study will be discussed here.

Methods
Light measurement
The illumination level in the nocturnal house was measured using a light meter at five random locations within the loris enclosure. Readings were repeated at different time periods throughout the day, starting during the full illumination of the day phase and ending at the least illumination of the

night phase of the lighting cycle. The results from each of the five locations were averaged for each of the time periods.

Behaviour observations
Preliminary observations were taken to form an ethogram. Behaviours were then recorded by instantaneous scan sampling at one-minute intervals for 30-minute sample periods. For the on-show pair data was collected discontinuously between 08:30-17.00 and totals five sample days (42.5 hours). Off-show animals (not under reverse lighting conditions) were studied with the use of an infrared night vision camera and time lapse VCR. They were recorded continuously from 18:00-09:00 for a total of five sample days (75 hours). Observations made using the camera were limited to the activities of feeding and locomotion because these were the only two behaviours that could be clearly identified from the recordings. Together these two categories encompass the majority of 'active' time.

Camouflage netting
After baseline recordings were completed camouflage netting was hung across the public viewing window to reduce disturbance of the lorises by the public knocking on the glass and to disguise the public from the lorises. It was hoped that this would minimise stress from environmental disturbance and reduce cryptic locomotion making the lorises more active and more easily spotted by the public. Observations were made as above for three sample days.

Results
Light levels
The level of illumination of the dark phase of the lighting cycle in the nocturnal house is 11.0 lux (table 1). This is far in excess of the preferred value for slow lorises of 0.07– 0.19 lux (Kavanau & Peters, 1979). The activity of lorises can be inhibited in very bright light and in complete darkness (Kavanau & Peters, 1979); twilight light intensities produce the highest activity in the slow loris (Trent *et al*., 1977).

Time	Average level of illumination (lux)	Phase
08:30	52.5	Light
10:00	39.5	↓
10:30	10.4	
11:00	11.0	Dark

Table 1 Illumination readings in the pygmy slow loris enclosure in the nocturnal house at Paignton Zoo.

Behaviour
Figure 1 shows the total combined feeding and locomotion behaviour of the on-show and off-show lorises. A two-way ANOVA was used to test the effects of location and time of day on the combined time spent engaged in feeding and locomotion.

- There was a significant effect of time on the activity of the lorises ($F_{[1, 139]} = 2.00$, $p < 0.05$). The lorises in both the on- and off-show areas show varying activity levels through the dark phase.
- There was a significant effect of location on the activity of the lorises ($F_{[1, 139]} = 68.53$, $p < 0.001$). The on-show lorises have considerably higher activity levels than off show.

- There was no significant interaction effect of time and location ($F_{[1, 139]} = 0.672$, $p > 0.05$). Although overall activity levels are different the on-show and off-show lorises respond in a similar way to time of day.
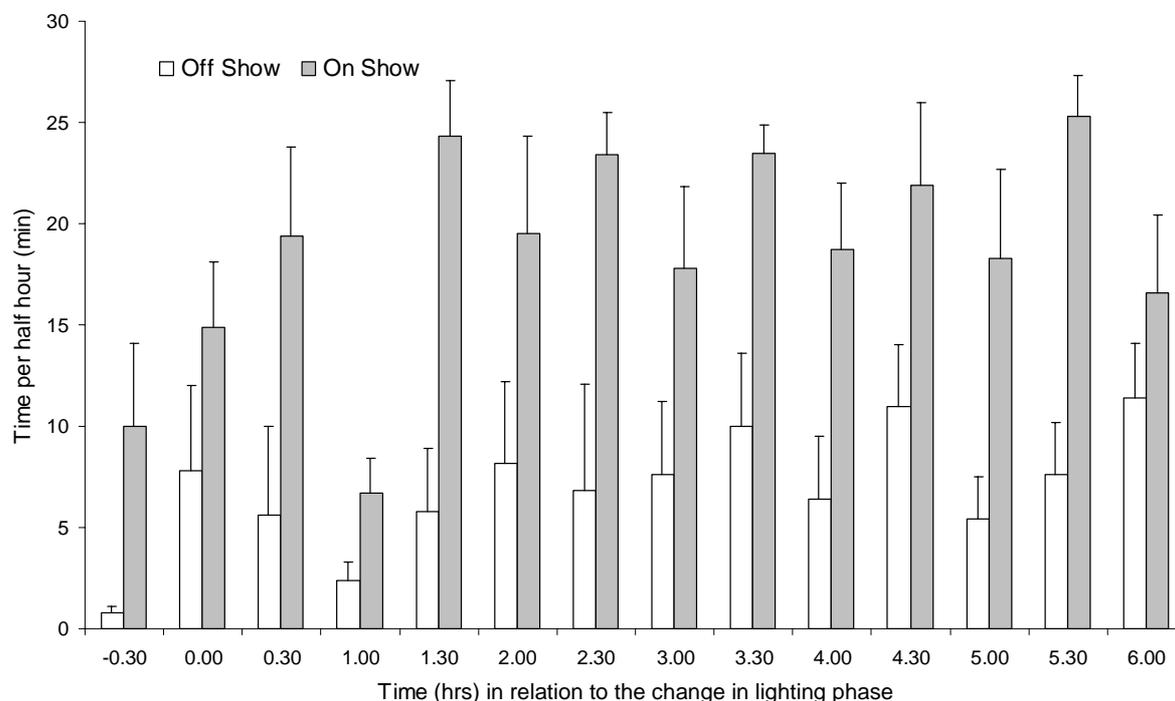
Figure 1. The total feeding and locomotor activities, over several hours, of pygmy slow lorises maintained under a reversed lighting cycle (On Show) and normal lighting cycle (Off Show). Error bars are standard error; 0 hours is the start of the dark phase.

Camouflage netting: Figure 2 shows the behaviour of the lorises on-show before and after a camouflage net was hung in front of the public viewing window. Differences in the time spent performing each behaviour with and without netting were tested using Mann-Whitney tests. The only significant difference was for 'allogroom' ($U = 87$; $p = 0.05$).

The significant decrease in the allogrooming cannot be attributed wholly to the introduction of the camouflage netting as the female loris in the nocturnal house was pregnant during the study period. As she approached parturition (shortly after the netting was added) she became increasingly inactive and unreceptive to allogrooming by the male.

Conclusions
- The current lighting regime in the nocturnal house does not accurately recreate the natural light conditions for this species.
- Daily activity patterns of individuals kept under reverse lighting and normal lighting are comparable
- Overall there is a greater level of activity in the nocturnal house which may be due to the larger enclosure size rather than lighting conditions.
- The introduction of a camouflage net in front of the public viewing area had very little effect on the behaviour of the lorises in the nocturnal house.
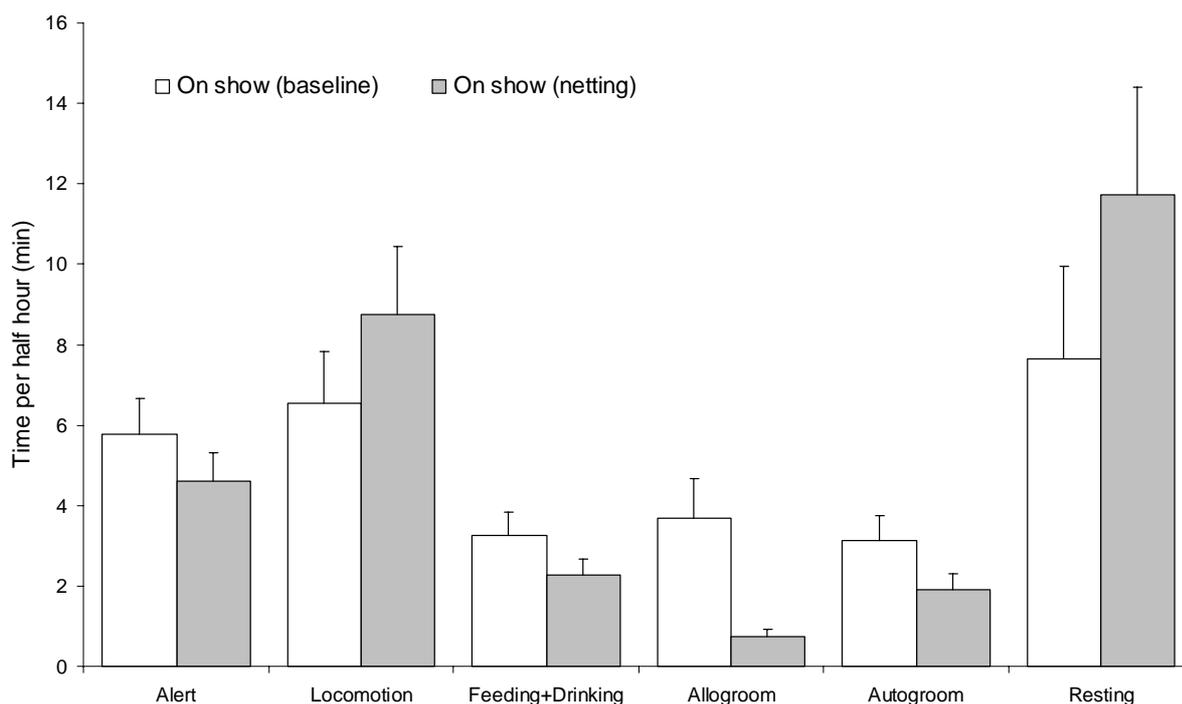
Figure 4. Time spent performing various activities by the on-show lorises, before (baseline) and after (netting) a camouflage net was introduced in front of the public viewing window in the nocturnal house. Error bars are standard error.

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Black and white ruffed lemurs (*Varecia variegata variegata*) at Shaldon Zoo. Can environmental enrichment affect their behaviour?

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Abstract

Lemurs are an important group due to increasing population decline in the natural environment. Black and white ruffed lemurs (Varecia variegata variegata*) are an endangered species of lemur that are regularly housed in zoos, and which need the benefit of stimulation to perform a range of behaviours to promote well-being. This study involved observations on two out of the group of four lemurs housed at Shaldon Zoo in Devon before, during and after an enrichment period. The enrichment period involved the use of a suspended feeding device designed so as to stimulate a common natural feeding posture.*

Behaviour was recorded using a focal sampling method with a reading being taken at one minute intervals for a period of one hour. 24 hour sessions of one hour were recorded during each of the three phases (pre-, during and post-enrichment). The enrichment device was found to alter the types of behaviour exhibited with post-enrichment behaviours reverting back to pre-enrichment levels. In particular the enrichment device enhanced the time spent actively foraging for food and reduced the time when the lemurs were inactive.

Introduction

Environmental enrichment is a concept which describes how the environment of captive animals can be changed for the benefit of the inhabitant (Shepherdson *et al.,* 1998). Environmental enrichment gives animals the stimulation to perform their special abilities that have been adapted in the wild for daily living. Environmental enrichment has been determined as a process to increase "desirable" behaviour yielding positive consequences (Lacinak *et al.,* 1995), reducing "undesirable" behaviour, and not producing unnecessary stress. It needs to be able to motivate the animals into driving or directing some internal force or urge to perform the "natural" types of behaviour by provision of the relevant stimulus (Halliday, 1983).

Abnormal behaviour in captive animals is quite common in some species and is exhibited due to the animals coping with problems. There are four main reasons:
- Lack of security and shelter
- Simple designs of the enclosure giving lack of stimulation
- Lack of opportunity to gain rewards
- Extensive complications of the enclosure showing no variation (Poole & Law, 1996).

Responses to these factors can be displayed in an extensive range of ways depending on the species. The most conspicuous form of abnormal behaviour is stereotyped repetitive action which is a behaviour pattern that is repetitive, invariant and has no goals or functions (Mason, 1991).

Black and white ruffed lemurs *Varecia variegata variegata* were selected for this study as within their natural environment lemurs are in decline due to the loss of natural habitats in Madagascar and the Comoro Islands. Their natural environments are primary dense rainforests that are used by man for logging and settlements. This has reduced and fragmented the remaining habitats, they are categorised as a high priority risk. Ruffed lemurs are the largest existing quadruped lemurs and have gained their name due to the pelage, especially around the face and ears. They are arboreal browsers, and are the most frugivorous of the extant lemurs eating nectar, seeds and leaves

depending on the season (Tattersall, 1982). They use their hands to exploit the forest canopy and spend large proportions of their active time foraging and feeding. This is either done on the ground in a seated position or suspended from trees by hind feet. They are mostly active during the early morning and in late afternoon / early evening. Ruffed lemurs are social animals living in small groups of 2-5 individuals; they live within this group moving, feeding and defending territories together (Jolly, 1985).

Around 400 black and white ruffed lemurs are currently being kept in approximately 100 institutes within the zoological community. The purpose of this study was to design an enrichment device based on natural foraging postures and to investigate its effect on the behaviour of a captive group of black and white ruffed lemurs.

Methods
Subjects
The selected site was Shaldon Zoo, Devon, England. The study was conducted within a group of four black and white ruffed lemurs, two females and two males, all of which have been captive bred. Two of the four individuals were selected as subjects for the experiment, a juvenile male and the dominant female.

Enclosure
All specimens were housed within the same enclosure during the study. The outside enclosure measures 5.5m wide, 7m long, and 2.5-3m high. Deep wood bark is used for ground covering. Numerous branches and ropes are placed at different heights throughout the enclosure to encourage locomotion and create multi-dimensional space. The enclosure has a wire mesh front and ceiling, with the remaining walls being covered with wood planks that could be utilised for climbing. The indoor enclosure 2m wide, 2.5m long, and 3m high, has a ground covering of wood chips.

Light and temperature within the enclosure were not controlled, but allowed to alter according to the normal seasonal cycles. The food provided varied on a weekly basis due to the availability of food items. It was given to the lemurs in one midday meal and consisted of different fruits, vegetables and bread. Factors involving human interactions with the lemurs remained the same, within the zookeepers' time parameters, thus enabling the lemurs to maintain a normal daily routine.

Enrichment
The enrichment device was designed to enhance natural feeding postures (Mittermeier *et al.,* 1994). It was designed to enhance foraging within the surrounding area as well as suspension feeding (fig. 1) due to interactions with feeder cups.   A standard circular terracotta pot measuring 120mm height, open top diameter 270mm and closed base diameter 130mm was used as the main part of the enrichment. The pot was suspended from the wire mesh roof by a chain 430mm long, which was supported by a mountaineering hook capable of sustaining 50kg. From the upturned pot, a wire framework was constructed allowing a further four chains to hang down separately. From each of these, a plastic pot 60mm in height, 50mm diameter and 40mm base diameter was suspended. These four pots acted as feeder cups (fig. 2). The enrichment device was suspended in the enclosure located near to branches to encourage its use. It was filled twice daily, once at the midday feeding time and again at clean out time (15:00). Raisins were placed into each cup and scattered underneath to encourage foraging and decrease any competition for access to the enrichment device. The enrichment device remained continuously in the enclosure throughout the three week enrichment period and was then removed.

Behaviour
The following behaviours were recorded on data sheets: lemurs indoors (activity unknown), human
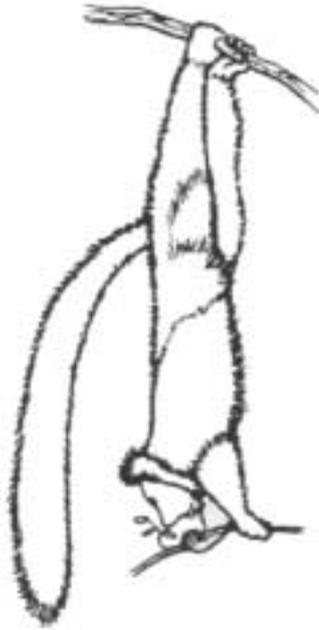
Figure 1. Ruffed lemur suspension feeding posture
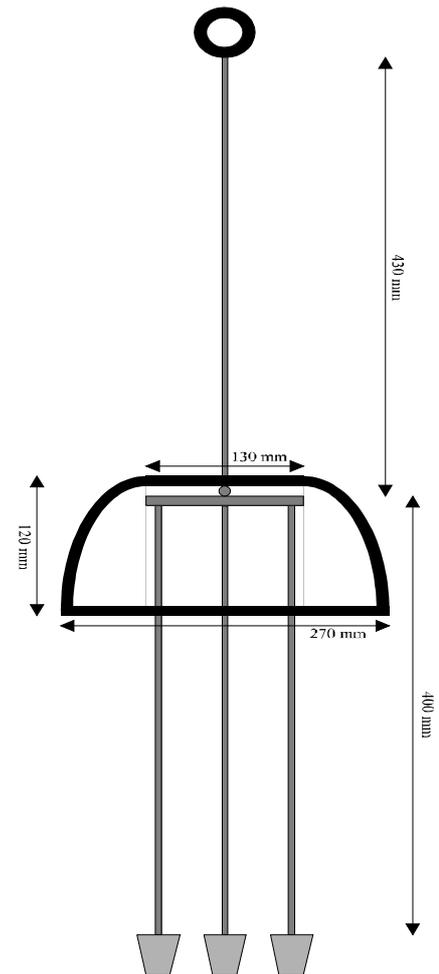
Figure 2. The enrichment device

interactions, aggression, inactivity, communication (vocal), grooming (allo- or auto-grooming), drinking, sunbathing, play, excretion, locomotion, smelling/scent marking, licking, feeding, and foraging. Feeding here means feeding from the normal food bowls; foraging is defined as interacting with the enrichment device (feeding from it, touching it) and searching through the ground covering for food items.

Recording methods
Behaviour was observed using a focal sampling method (Altmann, 1974) for both individuals and recorded by instantaneous time sampling (Martin & Bateson, 1993) at one minute intervals. Each subject was studied for two one-hour periods during the day for six days for each of the three periods: the female between 05:00-06:00 and 17:00-18:00, and the male between 06:00-07;00 and 16:00-17:00. The study was conducted over a ten week period. The pre-enrichment observations were conducted during weeks one to three, enrichment during weeks five to seven, and post-enrichment during weeks eight to ten.

Results
The behaviour scores for the two lemurs are shown in table 1. Since the two are different sexes and different ages, they will be considered separately. Similarly, the morning and afternoon observations will also be treated separately. For the purposes of statistical analyses, infrequent behaviours were pooled with other behaviour categories. Data from the six days has also been

Behaviour	Pre-enrichment				Enrichment				Post-enrichment			
	female		male		Female		male		female		Male	
	am	pm	am	pm	am	pm	am	pm	am	pm	am	Pm
Indoors	5	48	0	23	17	9	0	3	0	1	0	3
Human interaction	0	2	0	4	0	3	0	4	0	0	0	0
Aggression	0	3	0	3	0	2	0	0	0	2	0	1
Inactive	239	100	234	53	153	111	36	70	270	174	179	77
Foraging	0	2	1	12	27	35	39	38	0	1	0	1
Communication	11	10	18	15	3	11	5	9	4	9	3	8
Grooming	41	49	34	78	46	94	61	76	32	52	47	57
Feeding	6	3	3	26	1	12	2	19	3	12	11	12
Drinking	0	0	0	2	0	1	1	1	0	1	0	1
Sunbathing	0	1	0	4	0	2	0	2	0	0	0	1
Play	0	2	28	28	0	0	27	7	0	0	18	5
Excretion	1	1	0	5	3	0	2	0	1	1	0	1
Locomotion	55	83	41	96	100	52	155	92	47	90	87	170
Smelling	0	9	1	8	3	5	10	6	3	8	15	23
Licking	0	47	0	3	3	7	7	4	0	9	0	0
Other	2	0	0	0	4	16	15	29	0	0	0	0
Totals	360	360	360	360	360	360	360	360	360	360	360	360

Table 1. Behaviour scores for two (one male, one female) black and white ruffed lemurs *Varecia variegata variegata* at Shaldon Zoo before, during, and after environmental enrichment. Behaviour of each lemur recorded at one minute intervals for one hour blocks in both the morning and afternoon on six days for each of the three periods.

pooled. Chi-square analyses show that for each of the four groups (male am, male pm, female am, and female pm) there are highly significant differences ($p < 0.001$) in the frequencies of different behaviours between the pre-enrichment, enrichment, and post-enrichment periods. Further analyses show that, in each of the four groups, behaviours during enrichment differ significantly ($p < 0.001$) from that in the other two periods. In the descriptions below, where two figures are given, the first refers to the female and the second to the male.

During the morning observations, the most dramatic changes were seen in activity. At this time, during pre-enrichment both lemurs were inactive for a large proportion of the time (66%, 65%). However, during enrichment the amount of inactivity decreases (43%, 10%) for both lemurs and is especially marked in the male. When the enrichment device was removed, inactivity levels rise again (75%, 50%). The main changes in activity are in foraging behaviour and locomotor activity. Foraging during pre- and post-enrichment is virtually non-existent at this time of the day, but during enrichment, both lemurs forage in the morning (8%, 11%). They also spend a large proportion of

the time moving around (28%, 43%) which is about twice as much as during pre- and post-enrichment periods. The male also spent more time (17%) grooming, but female levels (13% during enrichment) did not alter significantly. Feeding levels (from the bowls) are low in the morning, and do not change much during enrichment.

In the afternoon during pre-enrichment, the lemurs spent about 10% of their time indoors, but this dropped to less than 2% during enrichment and post-enrichment. However, inactivity levels actually increased slightly during enrichment (female 28% to 31%, male 16% to 20%) and post-enrichment (48%, 22%). Despite this, foraging behaviour on and around the enrichment device during enrichment occupied about 10% of the lemurs' time, whereas foraging in the floor covering is a very minor activity (2%) during pre- and post-enrichment. In the afternoon sessions, the male spent about 20% of his time grooming with no significant changes between periods, whereas the female increased her grooming activities during the enrichment period (14% to 26%). In the post-enrichment period, locomotor activities increased markedly in both the male (26% to 47%) and female (14% to 25%). Feeding from bowls, which occupies about 4% of the lemurs' time, did not show marked changes during the three periods of study.

Discussion

Behaviours here were recorded on just two animals, one young male and a dominant female. Also, behaviours were not recorded continuously, but by sampling two one-hour periods on a number of days. Using different combinations of individuals, sexes, ages, and sampling periods would perhaps be expected to give different behaviour frequencies. Nevertheless, the results from this study do show that the behaviour of black and white ruffed lemurs can be modified by the use of the enrichment device.

The device was designed to encourage suspension feeding and foraging behaviour (Mittermeier *et al.,* 1994) and to provide a choice between working for food or taking freely available food from food dishes (Osborne, 1977). Without the device, during the time when they were observed, the lemurs fed almost exclusively from the feed bowls and did not forage in the ground covering. When the device was present, activity levels increased and the lemurs utilised the device for feeding and also spent time actively foraging in the ground covering. Free feeding levels (from bowls) did not alter.

When the enrichment device was removed, levels of some activities changed back to levels similar to those in pre-enrichment, for example, grooming and morning locomotor activity. However, the amount of time spent indoors by the lemurs, which had decreased during enrichment, remained low in the post-enrichment period. The observation of post-enrichment behaviour followed immediately on from enrichment observations. With any enrichment device, the effectiveness needs to be evaluated over time. How long do changes in behaviour persist if a device is present continuously? If the device is used intermittently, what time periods with and without the device are the most beneficial?

Lemurs exhibit relatively limited manipulation of objects with their hands compared to higher primates owing to the different morphological axis of the hands (Tattershall, 1975). The device used here took that into account thus enabling the lemurs to achieve a goal of obtaining the food without undue stress (Jolly, 1966). The enrichment device is simple to maintain and needs only limited time, thus allowing it to easily be included as part of the normal husbandry procedures for the lemurs.

Acknowledgements

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The benefits of social enrichment for zoo-housed primates

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Abstract
There are many welfare problems associated with keeping wild animals in captivity and environmental enrichment techniques are widely used as a means of improving captive conditions. Previous research on environmental enrichment has been biased towards non-social techniques; here, social housing as enrichment for captive primates is considered. Housing social animals, such as most primates, in compatible groups is thought to be an effective method of providing them with complex, dynamic and long-lasting enrichment. Social housing provides numerous opportunities for species-specific behaviour and social learning, which are important for welfare, and, in zoo-housed species, for conservation, education and research. Some primates live in such large and complex groups in the wild that few zoos are able to keep them in groups that are representative, in size and demographic composition, to those which might occur under natural conditions. However, little research has been carried out to investigate the effects of group size on the behaviour and welfare of captive primates. Natural group size of mandrills (Mandrillus sphinx) in the Lopé Reserve, Gabon, has been estimated as 620, whereas median group size of this species in European zoos in 1997 was three.

A study was carried out to determine the effects of group size on the behaviour of captive mandrills. It was hypothesised that mandrills kept in larger groups would exhibit more naturalistic behaviour, and possibly experience better welfare, than those kept in smaller groups. Increased group size appeared to be positively correlated with amounts of travel, foraging, solitary play, exploration and social play, and negatively correlated with amounts of stationary behaviour, social grooming and abnormal behaviour. Increases in many of the behaviours observed more frequently in larger groups are believed to be indicative of improved welfare.

Introduction
Modern zoos are deeply committed to conservation, education and research, rather than concentrating purely on entertainment, which is now thought to be insufficient reason to keep wild animals in captivity (Stevenson, 1988). Primates are thought to show more variety and complexity in their social relationships and interactions than any other group of animals (Wrangham, 1983). Because of this complex social organisation, they are thought to be particularly adversely affected by captive environments (Hediger, 1969; Erwin & Deni, 1979; Dickie, 1994; Reinhardt & Roberts, 1997). There have been many empirical studies focusing on the design, implementation and effectiveness of non-social enrichment techniques for primates, such as feeding enrichment (see Reinhardt & Roberts, 1997, for a review) and the provision of novel objects (e.g. Pruetz & Bloomsmith, 1992; Sambrook & Buchanan-Smith, 1997). However, relatively little research has investigated the effects of differing social environments on primates' behaviour and welfare (Visalberghi & Anderson, 1993). This is despite the fact that social housing is generally believed to provide a very complex set of stimuli and hence be more enriching than inanimate artefacts (Harris, 1988; Novak & Suomi, 1988; Poole, 1991; Visalberghi & Anderson, 1993).

Benefits of social housing for primates
The addition of conspecifics to the environment of social species has been described as 'an obvious as well as cost-effective means of providing a dynamic form of environmental enrichment' (Baer, 1998). Interest in inert objects provided as enrichment has been shown to wane once the novelty

has worn off, often within a few hours (Markowitz & Line, 1989). However, the provision of a dynamic and responsive aspect, such as a social companion, to an otherwise static environment appears to sustain interest (Ranheim & Reinhardt, 1989).

Social housing may lead to an increase in activity levels and a reduction in the frequency of stereotypic and abnormal behaviours (Baer, 1998). Social housing is thought to provide primates with numerous opportunities to perform many components of their species-typical behavioural repertoire (Schapiro *et al.,* 1997), such as courtship, mating, playing and grooming (Baer, 1998). Many species-specific behaviours performed by primates are believed to be culturally transmitted; these are learned by individuals, and then passed on from generation to generation (de Waal, 1982; Shepherdson, 1994). Behaviours critical for survival in the wild, such as parental behaviour, predator avoidance and foraging skills are all thought to be at least partially socially learned (Snowdon, 1989); a social environment is vital for their development.

Group size and composition
The International Primatological Society (1993) states that 'unless absolutely essential, primates should not be housed alone in a cage on a long term basis'. Most zoos in the Western world now keep the majority of their primates in groups or, at the very least, in pairs. However, many primates naturally live in very large and complex groups, and, due to space restrictions and availability of animals, few zoos are able to maintain captive groups that correspond with these in terms of size or demographic composition. The age and sex composition of captive groups is thought to be important in avoiding social stress, which may have severe physiological and behavioural consequences (Monaghan, 1990). Nevertheless, there has been very little research focusing on the composition of social groupings and its effects on the behaviour and welfare of primates. It may be the case that a minimum number of animals is necessary for the formation of a psychologically healthy group which is able to express a wide range of species-specific behaviour. There may be an optimal age range and sex ratio, and changes in group membership may also have an important effect (Novak & Drewson, 1989).

Although all primates are to some extent social, the structure of primate societies varies greatly; for example, many prosimians (suborder Prosimii) are solitary foragers (review by Rowe, 1996), whereas the highly gregarious Hamadryas baboon *(Papio hamadryas hamadryas)* may congregate in troops of up to 750 animals (Kummer, 1990). It is often useful to base captive group composition on the type of social grouping seen in the wild; captive cotton-top tamarins *(Saguinus oedipus)* kept in natural social groupings have shown increased reproductive success (Johnson *et al.,* 1991). However, this is not always the best strategy. Aggression in captive macaques kept in naturalistic multimale-multifemale groups is often problematic, possibly due to constraints such as limited cage size. Because of this aggression, many captive breeding groups consist of harems, with one male and several females (IPS, 1993). Orang utans *(Pongo pygmaeus)*, although semi-solitary in the wild, are often kept in social groups in captivity and are seen to perform social behaviours such as grooming, food sharing and paternal care (Edwards & Snowdon, 1980). However, a recent study (Beaver, 2000) on a social group of seven orang utans, has shown a significant correlation between increased social interactions and abnormal behaviour, indicating that these animals may not benefit from an artificially social captive environment.

Effects of group size on behaviour of captive mandrills (Mandrillus sphinx).
It was decided to investigate the effects of group size on the behaviour and welfare of captive primates, using the mandrill (*Mandrillus sphinx*) as a study species. Mandrills are the largest cercopithecine monkey (Lahm, 1986), and inhabit forested areas of Cameroon, Gabon, Equatorial Guinea and southern Congo (Feistner *et al.,* 1992). The thick vegetation of their forest habitat, along with their largely terrestrial nature has made them, along with their sole congener, the drill (*Mandrillus leucophaeus*), the least studied of all members of the baboon family (Feistner *et al.,*

1992). However, recent data (Abernathy & White, 1999) has shown that they naturally live in extremely large groups. The mean group size for wild mandrill hordes in the Lopé Reserve, Gabon, was found to be 620, the groups remaining cohesive throughout the year.

Mandrills are popular zoo exhibits, and 79 institutions in Europe held this species in 1996 (Bogsch, 1997). Median group size in these zoos was three, and 40% held only one or two individuals (Bogsch, 1997)(fig. 1).
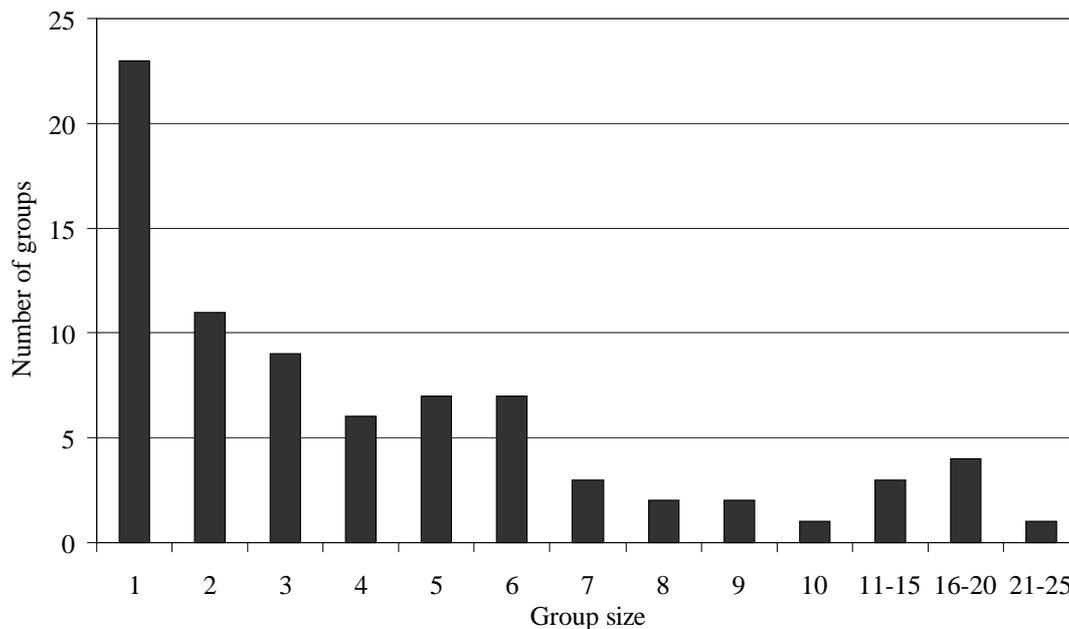
Figure 1. Group sizes of mandrills held in European zoos (as of 31 December 1996)

These group sizes are obviously very different from those observed in the wild, and it has been suggested (Feistner, 1989) that such numbers are not beneficial for successful captive breeding or adequate socialisation of mandrills. The present study aims to determine the effects of group size on the behaviour of captive mandrills, in the light of species-typical behaviour patterns and welfare. It is hypothesised that mandrills kept in larger groups will exhibit more naturalistic behaviour, and may consequently experience better welfare, than those kept in small groups.

Method
Five groups of mandrills were observed in four zoos (table 1). All individuals in each group were observed, making a total of 32 subjects. Sex and age compositions of the groups varied, as did group size.

Instantaneous scan sampling (Martin & Bateson, 1993) was used to generate a general picture of time distribution of behavioural states, and hence activity budgets, across each group (Altmann, 1974). The sample interval was set at 15 minutes, and sampling took place from left to right of the enclosure. Scans were taken throughout the day, beginning at 10:00 and ending at 17:00. It was ensured that a similar amount of scans were taken for each sample point throughout the day, so animals were equally represented over the whole period. A total of 258.5 hours of observations was collected.

Zoo		Number of mandrills

Chester		4 - in a mixed-species exhibit with:
		    2 Campbell's guenons *(Cercopithecus campbelli)*
		    3 Grivet monkeys *(Cercopithecus aethiops aethiops)*
		    3 African porcupines *(Hystrix cristata)*

Colchester		13
Paignton		2
Southport	-Group 1	9
	-Group 2	4

Table 1. Zoos in which the study was carried out, and number of mandrills in each group

Statistical analysis
The number of groups studied was small (due to the fact that there were only five groups in mainland Britain), and the animals in each group were housed together. This meant that the behaviour of each animal was likely to have been influenced by that of its cagemates, and so data from each individual could not be treated as independent. Statistical tests widely presume that data are comprised of a random sample from a population and that individual data points are independent of each other (Martin & Bateson, 1993). For this reason, analysis of the data was largely descriptive rather than statistical, and any statistical significances quoted should be treated with caution. The data were not normally distributed and therefore non-parametric tests were used throughout.

The analysis of the data was divided into two sections:
1.   Intergroup comparison of activity budgets, which were established by calculating the mean percentage of sample points observed performing each categorised behaviour.
2.   Groups were then categorised into Small (Paignton, Southport 2 and Chester) and Large (Southport 1 and Colchester), and behavioural expression between large and small groups was compared. Mann-Whitney U-tests (Siegal & Castellan, 1988) were used for this.

Results
Intergroup comparison of activity budgets
There was an increase in foraging, travel, and social and solitary play with group size (fig. 2); the smallest group, at Paignton, showed the lowest levels of these behaviours, whilst the largest group, at Colchester, showed the highest levels. Conversely, the relationships between stationary behaviour, social grooming, abnormal and sexual behaviour and group size appear to be generally inverse.

Differences in behaviour between large and small groups
There was no significant difference in the activity budgets of small and large groups, except in relation to social grooming. Smaller groups showed significantly more social grooming (median 7.6% of sample points) than large groups (median 2.8% of sample points) (Mann-Whitney $W = 226.5$; $n_1 = 10$; $n_2 = 22$; $p < 0.05$). Although it was not tested statistically, the Chester group appeared, from its activity budget, to behave more like a 'large' group than a 'small' group in terms of stationary behaviour, foraging, social grooming and abnormal behaviour.
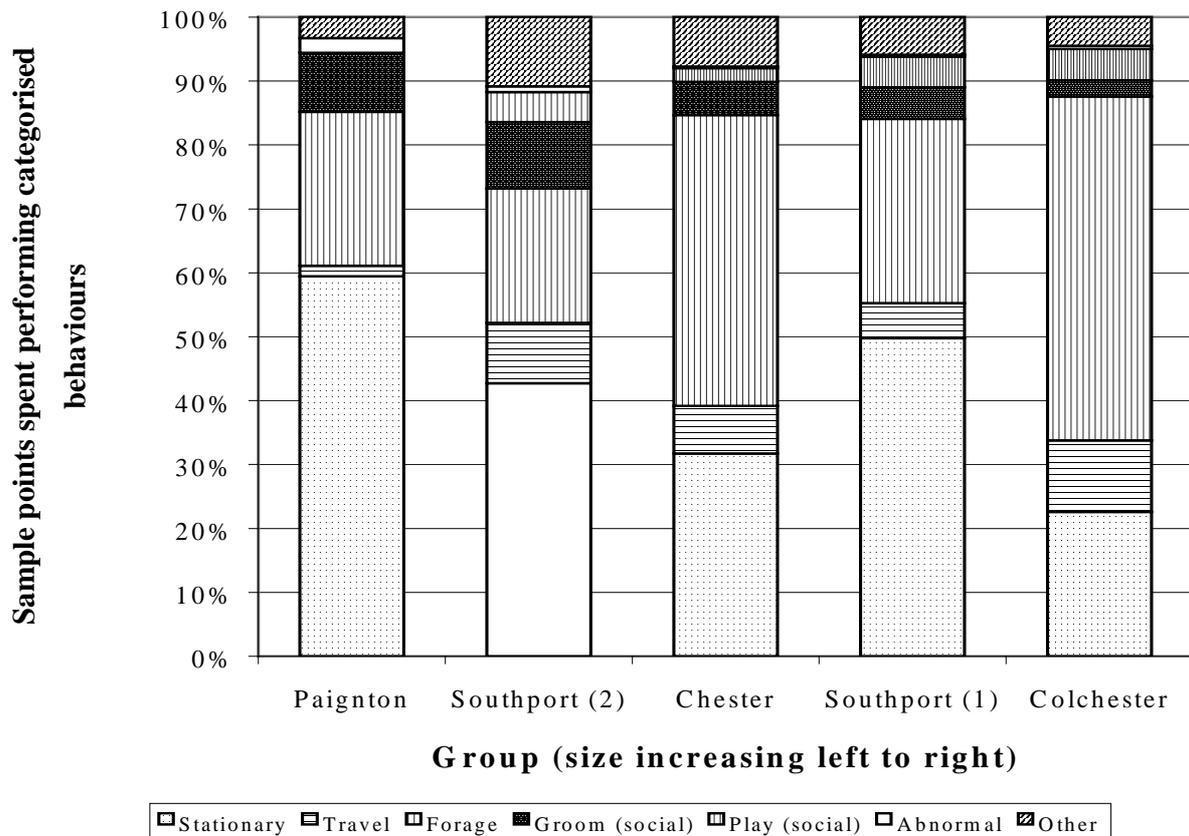
Figure 2. Percentage sample points spent performing categorised behaviours by mandrills in five different captive groups

Discussion

Increased group size in captive mandrills appeared to be associated with an increase in travel, foraging, solitary play and exploration, and social play. An increase in these behaviours may represent an increase in welfare. Increased group size also appears to be associated with a decrease in stationary behaviour, abnormal behaviour and social grooming. Decreases in these behaviours may also indicate increased welfare.

Stationary behaviour appeared to decrease with increasing group size. This effect has also been recorded in a study on the effects of group size in wild long-tailed macaques *(Macaca fascicularis)* (van Schaik *et al.,* 1983). One of the goals of environmental enrichment is commonly agreed to be the reduction of the level of inactivity of captive animals, especially where individuals are initially inactive and apathetic (Tripp, 1985; Shepherdson, 1989; Laule & Desmond, 1998).

Travel appeared to increase with group size. This effect was also found by van Schaik and co-workers (1983), and may be due to increased feeding competition, which results in animals in large groups having to expend more energy in order to search for and obtain food.

Foraging also appeared to increase with group size, which conforms to the results of van Schaik and co-workers' (1983) study on long-tailed macaques. This effect, in wild primates, is thought to be due to a decrease in foraging efficiency with increased group size due to feeding competition (Alexander, 1974; van Schaik *et al.,* 1983). Feeding competition is also a factor in captive groups,

and subordinate animals may be subject to undernourishment (Novak & Suomi, 1988). The fact that food is provisioned means that competition may be relaxed somewhat, as survival does not depend on it to such a degree. It appears that enrichment of the environment through social housing, which has received little attention in the literature (Visalberghi & Anderson, 1993) as compared with feeding enrichment (see Reinhardt & Roberts, 1997, for a review), may in fact have a similar effect on foraging. An increase in foraging, such as is seen in large groups, may be beneficial for the welfare of these animals.

Social grooming appeared to decrease with increasing group size. Van Schaik and co-workers (1983) also found this effect in their study on wild long-tailed macaques. Grooming is thought to be as important in the development and maintenance of social bonds and group cohesion as it is for hygiene (Schino *et al.,* 1988; Dunbar, 1991). It is believed (Schino *et al.,* 1988; Boccia *et al.,* 1989; Nieuwenhuijsen & de Waal, 1992) that another function of grooming in primates is as a tension reduction mechanism. Receiving grooming appears to be associated with a reduction in heart rate in the pigtail macaque *(Macaca nemestrina)* (Boccia *et al.,* 1989). It is possible that tension was higher in the smaller groups of mandrills studied, and that the increased grooming seen was functioning as a mechanism to reduce this.

Social play seemed to increase with increasing group size. However, it is difficult to attribute this to any real effect, as the smallest group, at Paignton, contained only adult animals, and the proportion of juveniles and infants to adults in the other groups increased with group size. Social play is more common in young, developing animals than it is in adults, and is thought to have an important role in the development of motor and social skills (Fagen, 1976; Martin & Caro, 1985). Therefore, changing group composition is likely to have a strong effect on the amount of social play performed; in this case, it is impossible to separate the effects of group composition and group size on the frequency of social play.

Abnormal behaviour was highest in the smallest group, at Paignton, which may have negative implications for the welfare of the animals in this group. The high levels seen were due to the adult male mandrill frequently engaging in 'frenzy' (Terdal, 1996), in which he spun around rapidly, grabbing and biting at a hind leg. The fact that there were only two animals in this group is likely to have biased the results, as the activity budget of each individual would have more influence on the overall mean activity budget than would that of each animal in a larger group. This individual performed more abnormal behaviour than any other in the study, and this may have been a reflection of inadequacies in the environment, such as the artificially small group size, not sufficiently addressing its social needs. This idea, however, cannot be tested or stated with confidence based on the data of only one animal.

Solitary play and exploration appeared to increase in with increased group size, although levels were low in all cases. Inadequate captive environments are thought to provide little stimulation for exploratory behaviour as they generally lack novel stimuli (Stevenson, 1983). Exploration and play behaviour are thought to be important for the welfare of animals, especially those with a complex social structure (Wemelsfelder & Birke, 1997; Mench, 1998). The increase in exploration and social play seen in larger groups of mandrills may indicate a more stimulating environment, due to the presence of a number of conspecifics, and so represent an increase in welfare for animals so housed.

The only statistically significant difference in behaviour between large and small groups was in the level of social grooming. Although general trends were identified in several different behaviours, as discussed above, no statistical differences were found. It is possible that a statistically significant result may have been obtained had sample sizes been larger, but geographical and time constraints

prevented this. Additionally, the obvious differences in enclosures and husbandry routines make interpretation and generalisation of the observed results difficult.

Another factor that may have influenced the statistical tests on behaviour for small and large groups is that the small Chester group of mandrills was kept as part of a mixed-species exhibit. This exhibit contained only four mandrills, but nine primates overall. Mixed species exhibits are thought to provide additional stimulation to the animals through their contact with each other (Thomas & Maruska, 1996). Although little social interaction was seen between the different primate species during the study, social interaction such as grooming, play and even sexual activity was seen to occur at other times (*pers. obs.*). The primates of other species housed with the mandrills at this zoo provided another dynamic and responsive aspect to the environment. It is possible that the Chester group behaved more as a large group than as a small group because of the other primates present. More significant results may therefore have been obtained had this group been classified as 'large' rather than 'small' for the purposes of the analysis. This, however, was not done, as the factor under scrutiny in this study was group size of *mandrills*, and hence the other species in the enclosure were viewed as an environmental variable. However, the subject of mixed species exhibits and their effect on behaviour is an important one. It is possible that housing small groups of different species in mixed species exhibits makes them behave more similarly to large groups. It is impossible to test this idea with the data from only one group of animals, and the fact that there are so few comparable mixed-species primate exhibits in this country means that empirical study on this factor is difficult. However, if it were supported by empirical data, it would suggest that the welfare of animals held by zoos in small groups could be enhanced by housing them in mixed-species exhibits with other compatible animals.

Conclusion

The study has shown that different group sizes are associated with variations in the behaviour of captive mandrills. It appears that mandrills housed in larger groups may experience better welfare than those housed in small groups. Group size does not necessarily have to be increased to the level of natural (i.e. wild) group size to represent an increase in welfare. Based on the observations of this study, it appears that, in order to maximise their welfare, captive mandrills should be housed in large groups wherever possible. Obviously, constraints such as numbers of animals available, and space restrictions, will affect potential group size. In situations where, for a variety of reasons, it is impracticable to house them in sufficiently large groups, maintaining mandrills in exhibits with compatible animals of other species may be beneficial to their welfare, although this idea has yet to be fully investigated.

Acknowledgements

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The effect of feeding station numbers on the behaviour of Rodrigues fruit bats (*Pteropus rodricensis*) at Paignton Zoo

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Abstract
*The effects of increasing the number of feeding stations on the behaviour of the Rodrigues fruit bats (*Pteropus rodricensis*) at Paignton Zoo are described. Six bats (three males and three females) were each observed for eight hours - a total of forty eight hours of observations. Observation periods were broken up into 30 minute or 60 minute blocks throughout the day, and behaviour was recorded at one minute intervals. For enrichment purposes, the number of morning feeding stations was increased by 30% and afternoon feeding stations by 50%. Overall aggression levels did not alter as a result of enrichment. However, individual bats did exhibit changes in aggressive, feeding, and resting behaviours. To some extent, these changes seem to be linked to the social status of individual bats.*

Introduction
The Rodrigues fruit bat (*Pteropus rodricensis*), endemic to the small island of Rodrigues in the Indian Ocean, has endangered IUCN status with numbers in the wild falling to a population low of around 70 in 1975 (Cheke & Dahl, 1981; Carroll, 1984). Conservation breeding programmes were established in 1976, and there are now several colonies established throughout the international zoological community. These are being actively managed for long term retention of genetic variability (Carroll & Mace, 1988). Environmental and behavioural enrichment as part of the management strategy to increase the well-being of captive animals is now a well established concept. Most captive colonies of Rodrigues fruit bats use a variety of enrichment devices such as natural branches, mesh climbing walls, hanging food, food kebabs, etc. (e.g. Porter, 1993). However, there is a relative lack of knowledge concerning the optimal use of such enrichment devices, and their effects on various aspects of behaviour such as aggression.

In natural settings one of the most important constraints on feeding patterns is the availability of food, and most models of optimal foraging behaviour emphasise the dimension of cost of time and energy expended in obtaining food (Collier & Rovee-Collier, 1981). In captivity, activity is more restricted and food availability more constant. Dominance hierarchies and the relatively limited space can affect feeding and roosting territories (Carroll, 1979). Thus, feeding strategies and aggressive behaviour patterns may change.

The purpose of this preliminary study was to determine the effects of simply increasing the number of feeding stations available in a captive colony of Rodrigues fruit bats. Would there be any overall change in behaviour? Would patterns of aggression or other specific behaviours be altered?

Methods
The bat colony
The Paignton Zoo colony of Rodrigues fruit bats currently numbers 28 individuals. The stock originated from Jersey Zoo in 1988, and was supplemented with three bats from Dublin Zoo in 1997. In March 1999 there were 11 males and 15 females. Individual bats can be distinguished by the presence of small plastic coloured rings. Their enclosure measures 5m wide, 7m long, and 3m high. Temperature is kept between at 23-25°C during the night period and 28-35°C during daylight hours. The exhibit is kept on a 12 hour reverse day/night cycle with lighting being switched over at

10:30 and 22:30. Natural branches allow climbing movement throughout the cage, and perching so that bats can gather food from nearby food dishes. Wire mesh attached to the walls also allows climbing and facilitates landing after flight.

Feeding
The bats are fed twice daily at 09:30 and then a smaller feed at 14:30. Before the first feed the cage is cleaned, removing all food from the day before. Food for the first feed is presented in 13 dishes dispersed throughout the cage, either hanging from the roof or attached to the mesh on the walls. For the second feed, food is presented in the form of six fruit kebabs hung around the cage from branches. Water is supplied in dishes spread around the enclosure. Feeding stations were placed in the same locations throughout the period of observation. For the enrichment period, the number of feeding stations was increased to 17 in the morning and to nine in the afternoon, but the total amount of food was kept the same as in the pre-enrichment period.

Observations
Observations were made by focal sampling (Altmann, 1974). Six bats (three male, three female) were chosen at random for observation. Recording was done by instantaneous time sampling (Martin & Bateson, 1993). Each bat was observed on different days for the following periods of time: 09:30-10:30, 11:00-11:30, 12:00-12:30, 13:00-13:30, 14:30-15:30, and 16:00-16:30. Recordings were made each minute during these periods of observation (240 per day). After observing all six bats in this way, the number of food stations was increased, and the observations were repeated on each bat. Thus, each individual bat was observed for eight hours, a total of 48 hours observation. All observations were completed within an 18 day period.

The bats were observed from the public viewing gallery, through two large windows which affords a view of nearly all of the enclosure. Due to the low light conditions, bats were identified during observation by briefly shining a torch on their forelimbs to see the rings. Following preliminary observations, and after consulting papers by Carroll (1979) and Courts (1996), the following behavioural categories and specific behaviours were recorded:
1. Resting postures: roosting, roosting in a pair, bipedal hanging alert, quadrupedal hanging alert
2. Locomotion: flight, floor movement, shuffle, vertical movement, horizontal movement, slow and fast ambulation.
3. Grooming: autogrooming, allogrooming.
4. Wing gesture: wing spread, wing stretch, wing flick.
5. Feeding: location
6. Aggression: static flight, cuffing, air cuffing, chase, vocalisation, flight wrestle.

More detailed descriptions of these behaviours can be seen in Carroll (1979). The enclosure was mentally divided into a 4 x 4 grid so that approximate locations of each behaviour point could also be recorded.

Results
Although each of the behaviours listed in the methods were recorded separately, these have been grouped into the six main categories for data analysis (table 1). Analysis of the totals shows that whereas enrichment did not cause an overall change in the behaviour of males, there were highly significant changes ($\chi^2 = 22.3$, df = 5, p < 0.01) in the female bats. In particular, the amount of time spent feeding increased, whereas the overall amount of locomotion and aggression decreased. Differences between the sexes were apparent both before enrichment ($\chi^2 = 13.19$, df = 5, p < 0.05) and afterwards ($\chi^2 = 13.82$, df = 5, p < 0.05). However, there are also highly significant differences (chi-square tests, p < 0.001) between the three males both before and during enrichment, and similarly between the three females. Hence, it is more appropriate to consider the behaviour of

individual bats before and during enrichment.

Bat	Resting Posture	Locomotion	Grooming	Wing Gesture	Feeding	Aggression
Before enrichment						
Males						
LC	87	49	19	1	70	14
LG	116	21	21	1	55	26
LW	117	17	24	24	45	13
Totals	320	87	64	26	170	53
Females						
RG/O	144	34	22	10	20	10
RR/Y	114	38	21	11	41	15
RW	88	46	16	1	64	25
Totals	346	118	59	22	125	50
After enrichment						
Males						
LC	87	29	31	2	62	29
LG	106	33	13	1	71	16
LW	119	17	22	20	46	16
Totals	312	79	66	23	179	61
Females						
RG/O	112	20	27	5	66	10
RR/Y	106	38	18	2	58	18
RW	139	20	20	4	49	8
Totals	357	78	65	11	173	36

Table 1. Behaviour scores for six Rodrigues fruit bats *Pteropus rodricensis* at Paignton Zoo before and after additional feeding stations were added to the enclosure. Behaviour recorded at one minute intervals for 4 hours per bat per period (480 minutes total per bat).

Two of the male bats (LW and LG) show no significant change in their behaviour patterns between the two periods whereas bat LC does ($\chi^2 = 14.06$, df = 5, p < 0.05). During enrichment, this bat moves around less, spends more time grooming, and is a greater participant in aggressive encounters (see below). Among the three females, changes are more marked. Bat RR/Y does not significantly alter its behaviour, but there are highly significant changes in the behaviour of both RW ($\chi^2 = 34.69$, df = 5, p < 0.001) and RG/O ($\chi^2 = 34.41$, df = 5, p < 0.001). The amount of time RW spends resting increases markedly, whereas time spent in locomotion, feeding, and in aggressive situations all decrease. The main change in RG/O's behaviour is a large increase in the time spent feeding, with less time spent resting or in locomotion during enrichment.

The scores for aggression in table 1 mask the fact that a bat participating in such behaviour may be either the aggressor or the recipient of an aggressive act. These distinctions are clarified in table 2. The proportion of time spent by bats acting aggressively varies significantly between bats ($\chi^2 = 15.95$, df = 5, p < 0.01) as do the levels of aggression received by individual bats ($\chi^2 = 46.35$, df = 5, p < 0.001). The most aggressive male (LW) and female (RG/O) are also the two bats which are the recipients of the least amount of aggression towards them (virtually zero). Conversely, the least aggressive male (LC) and female (RR/Y) are the two bats which are subject to most aggression by other bats. One male (LG) exhibits high levels of aggression, but is also the recipient of a moderate amount of aggression from other bats. The number of aggressive acts by these six bats decreased

by 24% following the addition of the extra feeding stations, although the number of occasions when they received aggression showed an overall rise.

Bat		Aggression Scores						
		Giving Aggression				Receiving Aggression		
		B	A	T		B	A	T
Males								
LC		5	8	13		9	21	30
LG		18	8	26		8	8	16
LW		12	16	28		1	0	1
Females								
RG/O		9	9	18		1	1	2
RR/Y		7	2	9		8	16	24
RW		11	4	15		14	4	18
Totals		62	47	109		41	50	91

B before enrichment, A after enrichment, T totals

Table 2. Aggression scores for six Rodrigues fruit bats *Pteropus rodricensis* at Paignton Zoo before and after additional feeding stations were added to the enclosure. Behaviour recorded at one minute intervals for 4 hours per bat per period (480 minutes total per bat).

Discussion

In discussing these results, it must be remembered that they relate to just six bats out of the colony of 28. Also, behaviours were not recorded continuously so that sample frequencies do not necessarily reflect total frequencies of the various behaviours. Nevertheless, the results clearly show differences in behaviour of individual bats. To some extent these can be explained by the different dominance relationships in the bats. Two types of territory, a feeding and a roosting territory, which dominant males maintain have been described by others (Carroll, 1979; Young & Carroll, 1989). Sometimes, in the confines of an enclosure, these may overlap and this occurs here. In this study, LW is the dominant male and is mainly seen in one area controlling food dishes and a roosting site. Also found in this same area was the RG/O female. This is one of the largest bats, and LW and RG/O spend most of the time together in this area. Certain bats are tolerated in certain positions within the enclosure, whereas others are displaced, presumably reflecting dominance relationships. Subordinate bats are more active as they are displaced from one feeding station to the next. For example, the ratio of locomotion to resting is greater in the subordinate LC male than other more dominant bats. Subordinate bats will try to grab food from the food dishes and then fly to a "retreat zone" to eat food away from dominant bats.

Following enrichment, the behaviour of the males did not change greatly, except for that of LC. Dominant males, with an established territory, are less likely to be affected by changes outside their territory. LC has no territory of it's own, and was observed being displaced from almost all areas of the enclosure. Aggressive encounters with LC rose following enrichment. Females exhibited greater changes. The dominant female RG/O spent more time feeding as did RR/Y. However,

RR/Y was also subject to more aggression. Female RW spent less time moving around and feeding, and more time at rest. Overall changes in the behaviour of the six bats following enrichment were a 23% decrease in locomotion, a 19% increase in feeding, and a slight (7%) decrease in aggression.

Although the number of bats observed was low, and the observation periods limited, these results have shown that what seems to be a relatively small change in the environment of Rodrigues fruit bats (the increase in the number of feeding stations) can cause significant changes in the behaviour of the bats. In the case of Rodrigues fruit bats, the use of environmental enrichment affects individual bats differently suggesting that this should be taken into account in enrichment programmes. More generally, the results suggest that in environmental enrichment programmes, careful evaluation of the variables involved is desirable if the maximum benefits of enrichment are to be obtained. For example, with Rodrigues fruit bats, variation in both the number of feeding stations and their location relative to bat territories may affect behaviour.

Acknowledgements

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Long-term enrichment for captive elephants

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Abstract

*Captivity places spacial, temporal and behavioural restrictions on all animals, especially the elephant due to its huge size, complex social system and intelligence. Environmental enrichment can help alleviate the possible negative impacts of these restrictions but it is a constant challenge to maintain an ever-changing and stimulating enrichment programme. Paignton Zoo currently holds two mature elephant cows: one Asian, Gay (*Elephas maximus*) and one African, Duchess (*Loxodonta africana*). The elephants each exhibit individual behaviour patterns of some concern: Gay has a swaying or weaving stereotypy and Duchess is inactive for considerably longer than is typical for free-living elephants. The Zoo has been developing enrichment methods for the elephants for the last three years and to date these have been very successful at reducing the occurrence of these behaviour patterns. This poster reports on the effects of the latest enrichment methods: a scratching post, a hanging double tyre, two double tyres chained to a tree, a hanging barrel and wind chimes. Swaying and inactivity were reduced further by these additions but not significantly. Time spent outside and utilising enrichment were both increased significantly.*

Introduction

Captivity places spatial, temporal and behavioural restrictions on all animals, especially the elephant due to its huge size, complex social system and intelligence. Environmental enrichment can go some way to reducing the possible negative impacts of these restrictions but it is a constant challenge to maintain an ever-changing and stimulating enrichment programme.

Paignton Zoo currently holds two mature elephant cows. One Asian, Gay (*Elephas maximus*) and one African, Duchess (*Loxodonta africana*) aged 31 and 32 respectively. The elephants each exhibit individual behaviour patterns of some concern: Gay has a swaying or weaving stereotypy and Duchess is inactive for considerably longer than is typical for free-living elephants.

Specific aims

- To provide new enrichment measures to mentally and physically stimulate captive elephants, particularly to increase activity levels, increase interactions with their environment and use of their enclosure (especially outside) and to decrease swaying behaviour.
- To evaluate these measures with statistically analysed behavioural data collected before and during enrichment.

Methods

Data collection

Data was collected by instantaneous scan sampling at one minute intervals for half-hour sample periods. Sample periods were spread randomly throughout the day between 08:00 and 17:00 to give a total of 15 hours in each of the baseline and treatment conditions.

Baseline and treatment conditions

The baseline condition consisted of a regular timetable of existing enrichment methods, introduced twice daily (11:30 and 14:00). During the treatment condition new enrichment methods were incorporated into the baseline timetable. These new items included: a scratching post, a hanging double tyre, two double tyres chained to a tree, a hanging barrel and wind chimes.

Ethogram
Many behaviour types were recorded and for simplicity in analysis were grouped into major classes. The four main classes of interest in this poster are:

SW   Swaying or weaving from side to side (Asian elephant only)
I   Inactivity
ED   Using or interacting with an enrichment device (existing or new)
IB   Investigative and interactive behaviour, including foraging, reaching with the trunk, digging, dust bathing, eating browse and grass

Statistical analysis
Differences in time spent performing the various behaviours in the baseline and treatment conditions were tested for significance using Mann-Whitney U-tests for each elephant separately.

Results
Gay
Time spent in the outside paddock (fig. 1a) and time spent using enrichment devices (fig. 2a) both increased significantly in the treatment condition ($p < 0.01$ for both). Time spent swaying decreased during the treatment condition (from 1% to 0.2%) but this was not statistically significant (fig. 2a). Time spent on investigative and interactive behaviour increased and time spent inactive decreased, but also not significantly (fig. 2a)

Duchess
Time spent in the outside paddock (fig. 1b) and using enrichment devices (fig. 2b) increased significantly during the treatment condition ($p < 0.01$, $p < 0.05$ respectively). Time spent in investigative behaviour increased and time spent inactive decreased (from 12% to 6%) but neither were statistically significantly (fig. 2b).

Existing enrichment   *Additional enrichment*
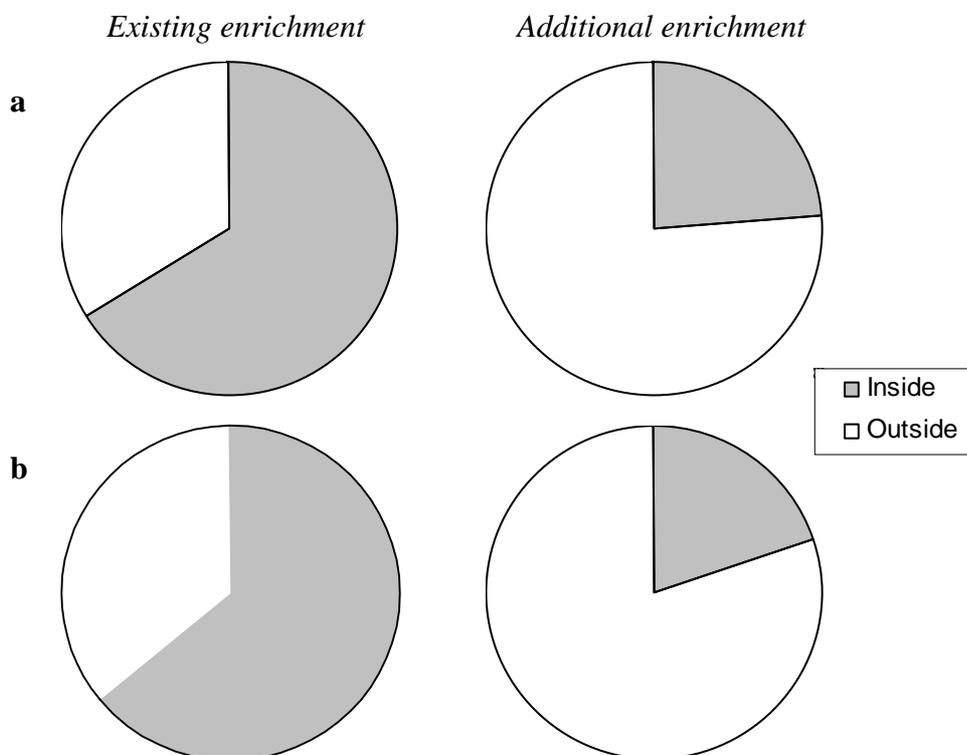
Figure 1. The proportion of time spent in indoor and outdoor enclosures by captive elephants at Paignton Zoo, before and after the addition of several new items to an existing enrichment programme: a- Asian elephant, Gay; b-African elephant, Duchess.
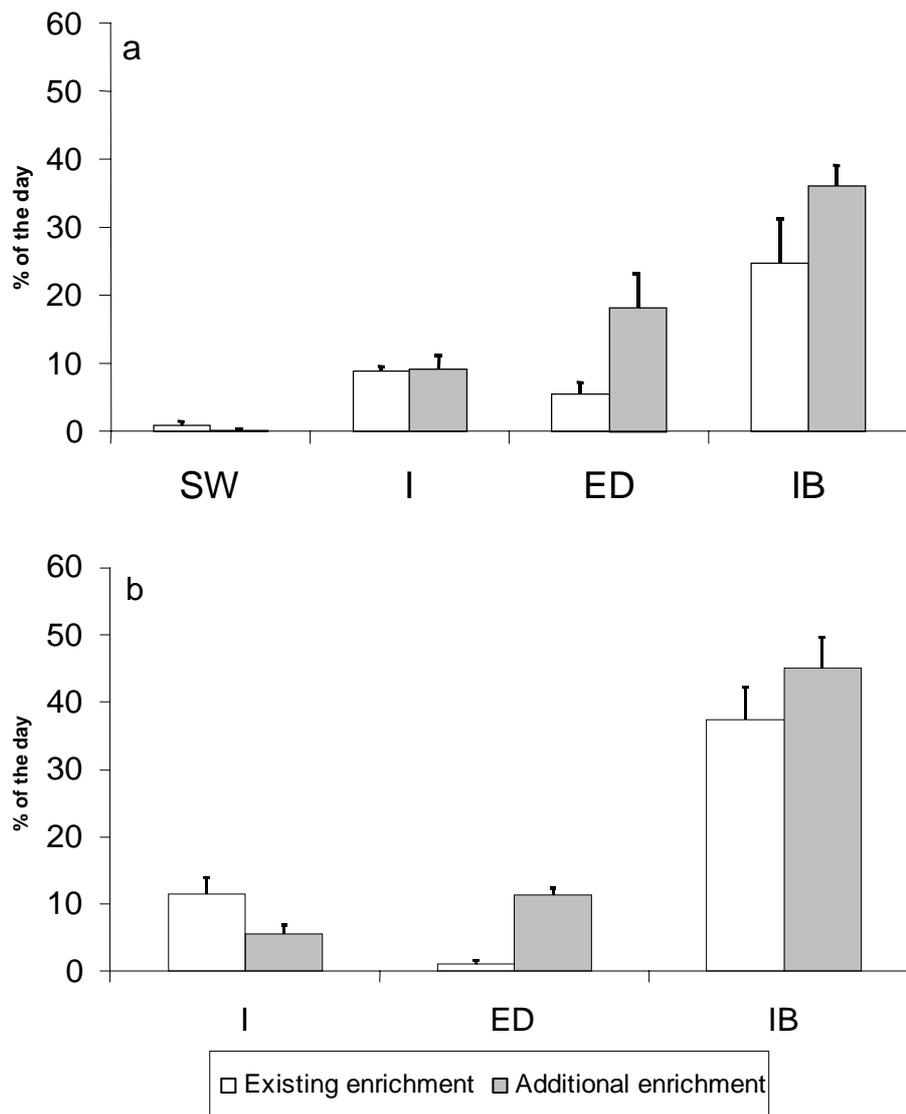
Figure 2. The proportion of time spent engaged in: swaying (SW), inactivity (I), utilising an enrichment device (ED) and investigative/interactive behaviour (IB), by captive elephants at Paignton Zoo before and after the addition of several new items to an existing enrichment programme: a- Asian elephant, Gay; b-African elephant, Duchess. Error bars are standard error.

Conclusions

- The existing enrichment programme, now in its third year, was improved by the addition of new items. Interaction with and use of enrichment devices and time spent in the outdoor paddock were significantly increased for both elephants. Inactivity in the African cow and swaying by the Asian cow were both reduced although not significantly.

- To maintain its effectiveness in the long term environmental enrichment needs to be continuously reviewed and developed.

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An example of changing management to facilitate successful breeding in a group of semi-intensively kept black rhino (*Diceros bicornis*)

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Abstract

The purpose of this study was to examine the lack of breeding in a herd of seven rhino, kept on a game ranch in Zimbabwe. The herd of four females and three males spent the day out on the ranch herded under armed guard and the night penned to protect them from poachers. Despite all females showing behavioural signs of oestrous, at the time of the study (January 1996) only one had produced young. The maintenance activity displayed by the herd was typical of wild rhino. The typical distances of only 5m and 15m between individuals were very different from those displayed by 'solitary' or 'semi-solitary' rhino in the wild, thus proximity relations were compromised. There was some evidence of associations between pairs of rhino - as seen in the wild. All individuals were more socially involved in the pen than out in the day (p < 0.05), although the tendency of an individual to be a 'performer' or a 'receiver' remained the same irrespective of location. Penning the rhino at night increased aggressive activity, particularly by the breeding female. It was suggested that the ability of the three 'non breeding' females to reproduce, was being inhibited by both enforced proximity with other individuals (both during the day and at night) and the presence of an aggressive, breeding female. A number of improvements to the management of these rhino were implemented. These included physical modifications to the pen to permit greater individual privacy at night, and allowing individuals to maintain greater distances from each other when herded during in the day. These changes were deemed successful, since by the end of 1998 all of the three 'non breeding' females had bred, and four more calves were born.

Introduction

The black rhinoceros (*Diceros bicornis*) population in Africa has suffered a dramatic decline (first noted by Ritchie, 1963). In 1975 the black rhino was listed in Appendix II of CITES since it was thought that the species could become threatened if their trade was not regulated. By February 1977 it had been moved onto Appendix I as they had become threatened with extinction and subject to international trade. However, despite the trade ban, the African black rhino population continued to decline (Berger, 1993; Thorne & Whalen, 1996). Some 40,000 individuals were killed between 1970 and 1987 to provide over 100 tonnes of rhino horn (Tudge, 1991). The IUCN's African Rhino Specialist Group (AfRSG) reported that in 1980 there were 14,785 individuals, but in 1997 only 2599 black rhino remained (1043 in South Africa, 707 in Namibia, 424 in Kenya and 339 in Zimbabwe).

A number of approaches has been taken in order to secure a sustainable population of African black rhino. The major programmes are protection *in situ*, management to maximize productivity and produce surplus animals, translocation to fenced reserves (intensive protection zones), development of informer networks and specialized investigation outside reserves and ban on the trade of rhino horn. An alternative approach taken in the late 1980s was the dehorning of wild rhino in order to discourage poaching. However, there has been considerable debate regarding the usefulness of this approach (see Leader-Williams, 1989).

Some believe that the survival of rhino can be assured by keeping them in captivity (e.g. Wells, 1997), but captive black rhino tend to be poor breeders. Kock *et al*. (1991) and Miller (1993) both attributed the failure of captive rhinos to breed to an haemolytic syndrome about which very little is known. Although, Miller (1993) did suggest that, in some individuals, the occurrence of haemolytical aenemia may be linked to the spirochete bacterium *Leptospirosis interrogans;* a relative of *Leptospirosis hardjo*, a bacterium known to cause sub-fertility in dairy cattle world wide (Peters & Ball, 1995). Despite this, the basic reproductive biology of the black rhino remains unclear (Blumer, 1996; Mehrdadfar, 1997). To date successful breeding of rhino kept in zoos and wildlife parks is poor (Gould, pers. comm.). Thorne and Whalen, 1996, stated 208 captive born individuals around the world. Whilst this low success may be due to a 'haemolytic syndrome', there may be other causes.   One aspect of breeding in captivity which has received very little research attention in black rhino is 'behavioural inhibition of breeding' - where the behaviour of some individuals may inhibit others from reproducing. This phenomenon has been reported in a wider range of other species including dairy cattle (Kiley-Worthington, 1977), mole rats (Bennet *et al*., 1996), alpine marmots (Arnold & Dittami, 1997) and common marmosets (Saltzman *et al.,* 1998).

When keeping wild species in captivity it is important to understand both their social and sexual behaviour in the wild in order to manage them as well as possible in captivity, minimising 'stress' and to encourage breeding (see Mehrdadfar, 1997).   In the wild, female black rhino have home ranges (Mukinya, 1973; Estes, 1995). They tend to be solitary (Goddard, 1967), although sometimes associate in pairs (usually a cow and her calf, or a male and a female) or in groups of three (usually a cow and two calves) (Ritchie, 1963). Rhino are both polygynous and polyandrous (Goddard, 1966) and tend to reproduce slowly with an annual birth rate of 6.8-10.9% (Goddard, 1970).   Males are fully sexually mature by seven or eight, but can successfully cover females at the age of four. Females reach sexual maturity by four years (Estes, 1995). Oestrous lasts between one and six days. Mating can take place at any time of the year (Ritchie, 1963) and gestation lasts approximately fifteen months (Estes, 1995).

Clearly, since relatively few black rhino remain, the establishment of small breeding herds, kept in appropriately managed systems (Blumer, 1996) in which they can be guarded against poachers, yet still breed successfully, is essential for their preservation. One of these herds was established at Imire Game Ranch in Zimbabwe in 1987. However, by January 1996, only one of the four females had reproduced. Her first calf died within three months of birth and her second was born shortly after this study had ended. The purpose of this study therefore, was to examine the lack of breeding in this herd, using a detailed assessment of the behaviour exhibited by the seven individuals to provide a basis for improving their management. Since evidence of the influence of the behaviour associated with social relationships on breeding success exists for other mammalian species, a detailed assessment of the relations between individuals within the herd was also conducted.   This assessment was not limited to the use of 'dominance hierarchies', since these have give an inadequate, oversimplified description of the social relations between individuals within a group (see Syme, 1974; Kiley-Worthington, 1977; Syme & Syme, 1979; Giacoma & Messeri, 1992). Individual attributes have been demonstrated to be important determinants of social relations (Kiley- Worthington, 1977), two of which, 'Total social involvement' (Kiley-Worthington, 1978; Bradshaw, 1992; Arnold & Grassia, 1983) and the tendency to be either a 'performer' or a 'receiver' (Kiley-Worthington, 1978; Berk, 1989; Freeman *et al.*, 1992) are used in this study. Two possible causes of inhibition of breeding (by whatever mechanism) were identified prior to the study: first, enforced proximity and second, the nature of the social relations between individuals in the herd.

Method
Animals and study site
Seven black rhino belonging to the Zimbabwe Department of National Parks and Wildlife Management were involved in this study: four females (Cuckoo, D.J., Mvu and Amber) and three

males (Sprinter, Noddy and Fumbi). At the time of the study all individuals were nine years old. All were born in the wild between April 1987 and June 1987 and had been separated from their dams shortly after birth as their dams were poached and/or died. They were brought to Imire Game Ranch between two and six months of age, and thereafter lived as a single herd. Imire Game Ranch is a 1500ha park in Zimbabwe (30° latitude, 20° longitude) with *Brachystegia* woodland and *Eucalyptus* coppice, and some *Themeda* dominated grassland. Imire supports populations of various antelope, elephants and buffalo, but there are no large predators. The game ranch is run in conjunction with a commercial farm producing cattle, tobacco and maize.

Rhino husbandry
The rhino were kept as a single herd all of the time for security reasons. They spent the night in the 'rhino boma' (pen), surrounded by sand bags within an electrified compound. The males and females were separated on entry to their boma. The females occupied a total area of 15m x 25m (with 3 smaller sub pens each measuring 5m x 4m which they could go into if they wished). The males occupied a similar sized area (15m x 8m) which was not subdivided into smaller areas. At 08:00 they were let out into the game park under the close surveillance of at least three armed scouts. Wire whips were used to discourage individual rhino from straying from the herd (during this study individuals were never observed to be more than approximately 200m from the remainder of the herd). At 13:30 the rhino were herded to a pre-arranged site and fed a small quantity of cattle cubes (approximately 1.5kg each) to enable visitors to the Ranch partaking in a 'wildlife observation drive' to view the rhino at close range. At this time the rhino typically met up with the group of six elephants who were also herded while browsing and grazing.   The rhino spent the remainder of the afternoon browsing before being herded back to the rhino boma between 16:30 and 17:00, where they received *ad libitum* hay, minerals and water. At 17:30 they each suckled 5l of a milky solution from a teated container given to them from outside their pens. This was done daily in order to facilitate the administration of medication at any time.

Pregnancy testing was carried out by testing faecal hormone levels. At the outset of the study it was suggested that one female, D.J., was unlikely to breed as she had a prolapsed uterus as a result of a vaginal injury (caused by horning by a male).

Observations
The head rhino scout had notes on the 'sexual activity' of the rhino since January 1995, which included the dates and behavioural indicators of oestrous (frequency of chasing, mounting without copulation and mounting with copulation for each individual. The rhino were observed from 7th - 31st January 1996 (inclusive), between 08.00 and 16.30 when out in the game park and a further hour immediately after penning between 17:30 and 18:30.

The rhino were observed for 407 rhino hours during the day and 119 rhino hours in the pen, i.e. 524 rhino hours in all.

Maintenance activity
The maintenance activities of all of the rhino were recorded onto a check sheet every 15 minutes using scan sampling (Altmann, 1974). Maintenance activity was divided into browsing, walking, standing, drinking, lying resting, engaging in social activity or eliminating (urinating and defecating).

Proximity relations
Proximity relations were also recorded every 15 minutes using scan sampling. The identity of each rhino's nearest neighbour, and the distance to the nearest neighbour was noted onto a check sheet. Distances were coded as follows: 1 = touching; 2 = up to 5m; 3 = 5-15m; 4 = 15-30m; 5 = 30-50m;

6 = 50-100m and 7 = over 100m (adapted from similar work by Kiley-Worthington & de la Plain, 1983; Randle, 1994).

Social interactions
Social interactions between the rhino were observed using 'all-occurrences' sampling (Martin & Bateson, 1986), as and when they occurred (Altmann, 1974). The identities of the 'performer' and the 'receiver', and the behaviours in which they were engaged were either recorded using a programme (Social) written by Lea and Randle (1991) for a Psion 3a organiser (first author), or a dictaphone (second author, two trained scouts).

For the purposes of this study social activity was divided into four broad categories: aggression, withdrawing, affiliation and 'other'. The 'other' category contained behaviors for which the meaning was not clear from the 'receivers' response (Kiley-Worthington & Randle, in prep.).

During the hour directly after penning, the social interactions occurring within the male group were observed by one author, while the social interactions occurring within the female group were observed by the other author, both using 'all-occurrences' sampling. The two authors alternated between the male and female groups on a daily basis.

Data analysis
All of the data were transcribed into the Minitab statistical package. The P/R (performing to receiving) measure was derived from the number of interactions performed divided by the number of interactions received. A ratio of >1 indicates that an individual is a 'performer', while a ratio of <1 indicates that an individual is a 'receiver'. The TSI (total social involvement) measure was calculated from the total number of interactions an individual was involved in (irrespective of whether as a performer or a receiver.) Data analysis was largely qualitative, and where quantitative, mainly nonparametric due to the small sample size.

Results
Behaviour associated with breeding
Only one female (Cuckoo) had calved at the game park (in 1993, then again on 23rd January 1996). At the time of the study none of the other three females were pregnant, however, all had exhibited 'behavioural signs' of oestrous between 1st January 1995 and 1st January 1996: D.J. was observed being chased by a male 14 times, mounted without copulation 10 times and with copulation six times. Mvu was chased by a male 43 times, mounted without copulation eight times and with copulation 11 times. Amber was chased by a male 12 times, mounted without copulation twice and with copulation once.

Maintenance activity
The black rhino spent the majority of their time browsing and grazing (51.4%), walking (19.3%) and standing (16.6%). The remainder of the time was spent resting (7.8%), engaging in social interaction (4.1%), drinking (0.7%) and eliminating (0.1%).

Proximity relations
All three of the males, the breeding female and one of the non breeding females were typically 5-15m from their nearest neighbour. The remaining two non breeding females (DJ and Mvu) were typically 0-5m from their nearest neighbour.

Table 1 summarises the proximal relations between the seven individual rhino, based on 1752 observations, 251 per rhino, over the three week period. Each figure is the total number of times an individual was the nearest neighbour of another individual. An index of 'popularity' (based on

		Nearest Neighbour						
Focal Individual		Males			Females			
		SPR	NOD	FUM	CUC	DJ	MVU	AMB
Males	SPR	---	33	39	31	50	43	22
	NOD	35	---	33	18	81^{1}	33	14
	FUM	41	47	---	22	43	31	32
Females	CUC	19	25	22	---	30	30	89^{2}
	DJ	33	57^{1}	37	32	---	31	24
	MVU	32	36	39	37	41	---	31
	AMB	27	19	24	90^{2}	18	37	---
Total times a nearest neighbour		187	217	194	230	263	205	212
Rank popularity'		7	5	6	2	1	4	3

Table 1. Summary of the proximity relations between the seven individual black rhino. [1,2] indicate alliances based on analysis of standardised residuals subsequent to a significant Chi-squared test. Obvious alliances are evident between [1] a male and a female (DJ and Noddy) and [2] two females (Cuckoo and Amber). [3] The 'popularity' of each individual is derived from the number of times that he/she is the nearest neighbour of other individuals. DJ is the most popular and Sprinter is the least popular.

ranks of the number of times an individual is the nearest neighbour of any other rhino) is also shown on the last row of the table.

Both males and females preferred females as their nearest neighbours (χ^{2} [with Yate's correction] = 5.84, $d.f. = 1$, $p < 0.05$). There were two obvious alliances, one between two of the females (Cuckoo and Amber), and a slightly weaker one between a female (D.J.) and a male (Noddy).

Social interaction
1778 interactions were observed over 405 rhino hours during the day. 46% of these were of an affiliative nature, 7% aggressive and 5% withdrawing. The remaining 46% were classified as 'other' since their nature was unclear. Analysis of the 867 interactions observed over 119 rhino hours during the first hour of penning for the single sex groups indicated that the types of interactions occurring were similar. Most of the interaction was affiliative (males 18.3%, females 22.5%), with more aggression (males 14.6%, females 16.1%) but less withdrawing (males 1.2%, females 2.5%) when in the pen than when out during the day. During penning males and females also exhibited similar amounts of 'other' social interaction (65.9% and 58.9% respectively). Penned females typically exhibited 7.00 interactions/individual/hour, whilst penned males typically exhibited 7.67 interactions/individual/hour.

More detailed analysis of the social activity (during the day and in the boma during the first hour of penning) established whether an individual tended to be a 'performer' (i.e. perform more than he/she received) or a 'receiver' (i.e. receive more than he/she performed) (fig. 1) and how socially involved he/she was overall (fig. 2).
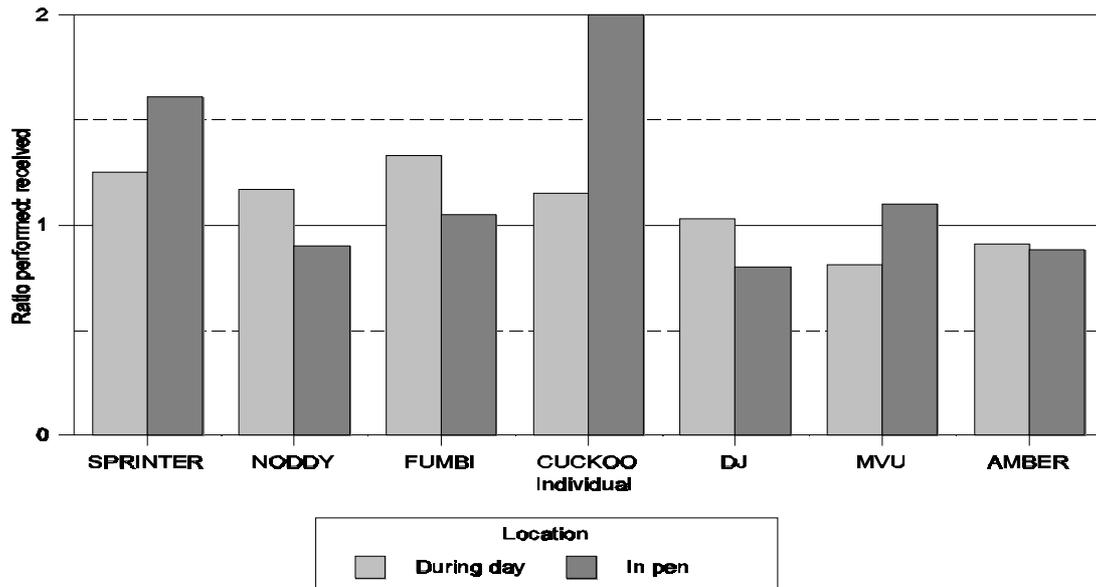
(A value of less than 1 means 'receiver', more than 1 means 'performer'.)

Figure 1. The tendencies of individual rhino to be 'performers' or 'receivers' during the day and the first hour of penning at night.

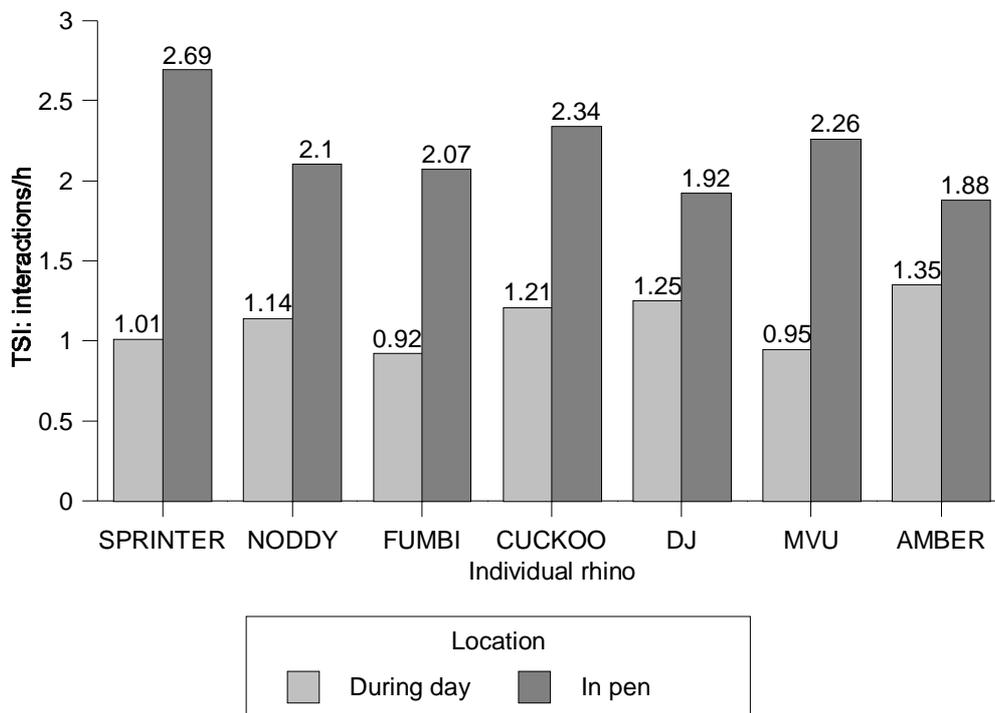Figure 2.   The TSI (total social involvement) occurring per hour during the day and the first hour of penning at night.

Whilst there was no significant difference in the performing/receiving tendency when out in the day and being penned at night (Wilcoxon T = 12; N =7; ns), there was significantly more total social

involvement (TSI) exhibited during the first hour of penning (2.18 interactions/rhino/h ± 0.28) than during the day (1.12 interactions/rhino/h ± 0.17) (Wilcoxon T = 0; N = 7; p < 0.05).

The amounts of aggression performed either as an initiator of an interaction ('performer') and as a response to another ('recipient response') by each of the four females and three males within the single sex groups during the first hour of penning at night are shown in Table 2.

Performer	Recipient				
Females	Cuckoo	DJ	Mvu	Amber	**Total**
Cuckoo	---	6	11	15	**32**
DJ	2	---	4	5	**11**
Mvu	0	2	---	6	**8**
Amber	3	7	13	---	**23**
Males	Sprinter	Noddy	Fumbi	**Total**	
Sprinter	---	15	17	**32**	
Noddy	9	---	2	**11**	
Fumbi	6	1	---	**7**	

Data are frequencies and consist of the sum of number of times aggression is performed by the initiator of an interaction (the 'performer') and the number of times that aggression is performed by a recipient as a 'recipient response'.

Table 2. Amount of aggression occurring between individuals within the single sex groups.

Breeding after implementation of suggested changes
A number of changes were suggested regarding both the physical design of the pen and the herding of the rhino during the day. These were implemented in spring 1996 and by the end of 1998 a further four calves had been born. The breeding female (Cuckoo) had her third calf (a female), while the three non breeding females (Amber, Mvu, DJ) each had a male calf. In January 2000 all four females were pregnant again.

Discussion
If, as a result of this study, just one individual of this threatened species (Thorne & Whalen, 1996) breeds successfully, that is an important result of international relevance. Since all of the non-breeding females exhibited behaviour typical of oestrus prior to the study, they should have been breeding, given the multi-male, multi-female structure of the herd.   Since, the maintenance activity exhibited was typical of wild individuals (Estes, 1995) there was no evidence of the disrupted time budgeting often seen in individuals kept inappropriately in terms of their physiological requirements (e.g. time spent feeding reduced, leaving more time for 'boredom').   Their environment consisted of mainly low veld with some *Brachystegia* woodland, therefore the ecological carrying capacity would be in the region of one rhino per 1000-1500 ha. Whereas there were actually seven rhinos/1500ha which clearly constitutes a very high stocking density. It could also be argued that a lack of palatable browse could lead to a vitamin and/or mineral deficiency, which may have resulted in the observed extended delay to first calving. While these are both possible contributing factors to the apparent lack of breeding in the females, it must be pointed out that the land the rhino were grazing/browsing was part of a farming system, achieving more growth than that of typical unmanaged low veld.   Furthermore, there were no visual signs of poor condition and the rhino were

fed balanced concentrates (cattle cubes) and had access to *ad libitum* hay and mineral supplements when penned in the boma at night.

It was considered more likely that the factors contributing to the lack of successful breeding were behavioural, and more specifically, social. As Ritchie (1963) stated black rhino in the wild tend to be solitary. The rhino in this study were forced to be within 5-15m of their nearest neighbour (by the scouts herding them together in order to protect them from poachers). This enforced proximity must be considered as a possible cause of the lack of breeding. The findings that females were the preferred nearest neighbours of both males and females and there were two clear alliances (one between two females and one between a male and a non breeding female) demonstrate that first, there was opportunity to mate (male-female association) and second, associations typical of truly wild rhino populations occurred (i.e. between two females; see Ritchie, 1963).

It is difficult to determine if the social behavior exhibited by this herd of black rhino was typical of truly wild individuals since very little detailed information has been published to date. All individuals were significantly more socially involved when penned than during the day and, more specifically, there was a substantial increase in aggression on penning (at least doubled), a phenomenon seen in other species such as pigs (Mount & Seabrook, 1993). It is therefore likely that penning the rhino at night was also a major contributing factor to the lack of breeding. Given the size of the females' pen (15 x 25m in total, with three internal pens) it was not possible for each female to maintain a distance of at least 5m from her nearest neighbour. It is therefore likely that the confinement, coupled with the increase in aggressive activity, could exacerbate the tendency of some females to be 'performers' and others to be 'receivers'.

It is suggested that the three non breeding females were being inhibited from breeding by a number of factors; first, enforced close proximity with other individuals when herded during the day and confined with other females in the pen at night and second, increased levels of aggression from the breeding female. Indeed the breeding female was clearly a 'performer' at all times, involved in most of the social interaction occurring in the female pen (particularly aggression), whilst the three non breeding females tended to be 'receivers', especially of aggression (similar tendencies were apparent when out in the herd during the day.)   Whilst the amount of aggression occurring was not resulting in obvious physical damage, it might very well have been having a psychological effect on breeding (Skinner, 1972). Obviously the high levels of aggression exhibited by the breeding female may have been due to her imminent calving. However, the reason why is not as important as the fact that she was by nature an aggressive individual and the 'inhibiting' effect she was having on the other three females.

 In summary it seems that the lack of breeding in this small group of black rhino was caused (at least partly) by their management. It was acknowledged that the herding by day and penning by night had to continue (in order to protect them from poaching), however, some changes were suggested in attempt to encourage breeding. First, when out in the game park during the day, individual or pairs of rhinos should be allowed to achieve a semi-solitary status, maintaining considerable distances (at least 200m) from the rest of the herd.   The guards were instructed to allow the herd to split and to follow different groups of rhino or even a single rhino if necessary. As Kiley-Worthington (1977) pointed out, wild female and male ungulates need to spend a considerable amount of time together in pairs in order to achieve a prolonged courtship, and consequently successful mating. In the reported situation it was likely that the herding was disrupting courtship. Second, measures were also suggested to reduce the aggressive interactions occurring during penning, especially between the females. For the females, this could be achieved in the short term by gating off the existing sub pens in order to separate individuals and allow them privacy. In the long term it was suggested that a larger pen should be constructed where individual

females could withdraw and isolate themselves. A gate between the male and female pen would also be advisable for transfer of individuals for breeding purposes.

 It is commonly found that hand rearing individuals and raising white rhino siblings together leads to a failure in breeding in captivity. This could be avoided in this herd of black rhino by allowing voluntary separation of individuals within the herd. There may be more flexibility in such a semi-intensive system as in the game park, however such considerations should be included in the environmental design in urban zoos.

The improvements to the management of this herd of black rhino were implemented in 1996, subsequent to the breeding female having her second offspring in January 1996. To date the breeding female has had another two calves, and all three of the non breeding females have successfully bred on more than one occasion. This successful breeding group has facilitated the reintroduction of black rhino to the wild (under surveillance).

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Environmental enrichment: not just monkey business. Techniques for two southern white rhinoceros, *Ceratotherium simum simum* at Paignton Zoo Environmental Park

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Abstract

Environmental enrichment is now generally recognised as an important part of the husbandry of captive animals. However, much of the enrichment effort is concentrated on primates, with the exception of elephants, hoofstock often seem to be benignly neglected. As with many grazing herbivores, free-living white rhino spend much of their day feeding or in the search for food whereas in captivity nourishment is plentiful and generally easily accessible. This can lead to behavioural problems; particular concerns with the pair at Paignton Zoo being inactivity and lack of breeding. An enrichment programme was instigated which aimed to: decrease the time spent inactive, increase amount of foraging behaviour, decrease aggression between the pair and possibly through these effects encourage oestrus activity in the anoestrus female. Initial results are encouraging: small quantities of browse mixed with the normal diet and a tyre feeder significantly reduced inactivity and aggression of both individuals and increased time spent foraging. Areas for further study include olfactory enrichment and devices to improve the animals' dermatological condition.

Introduction

In recent years the importance of environmental enrichment for captive animals has been an important area of husbandry research. However, possibly due to their greater dexterity, much of this work has concentrated on primates. Hoofstock in general and ungulates in particular seem somewhat short-changed by this 'revolution' in animal husbandry.

Concerns with Paignton's rhinos are not due to the occurrence of abnormal behaviours but rather to the absence of some natural behaviours. Like many megaherbivores, free-living rhino will spend much of their day feeding or in the search for food. This can cause a problem in captivity where nourishment is plentiful and generally in a very accessible form.

Aims

- To decrease the amount of time both animals spend in inactivity
- To increase the amount of foraging behaviour shown by both animals
- To decrease any aggression directed at each other
- Through the enrichment of the environment stimulate oestrus activity in an anoestrus female (a long shot!)

Methods

Animals

The male rhino, Mickey, was wild caught and is thought to be 31 years old, he arrived at Paignton in 1992 from Blackpool Zoo. The female, Gracie, was born at Whipsnade in 1979 and moved to Paignton in 1981.

Enrichment

Two forms of enrichment were tested initially: fresh browse mixed with the normal ration of hay and a 'tyre tower' consisting of several car tyres bolted together was chained to a tree stump in their

enclosure. As white rhino are not naturally browse-eating and may suffer adverse effects of tannins or other secondary compounds if too much browse is eaten, care was taken to ensure this supplement could constitute no more than 20% of their daily intake on those days it was used and a mixture of several species was used. The tyre tower was designed to be pushed around and could also have food hidden in it. To date the two enrichments have not yet been provided at the same time.

Data collection and analysis
Observations were taken of both individuals using instantaneous scan sampling. Recordings were made every 30 seconds for half hourly periods throughout the daylight hours. Simultaneous continuous recordings of infrequent behaviours, especially those related to courtship, were also taken. Similar amounts and times of data have been collected for non-enrichment and enrichment days. For this poster three behaviour types have been compared before and during enrichment using Mann-Whitney tests: inactivity, foraging and aggression. Preliminary results are shown

Results
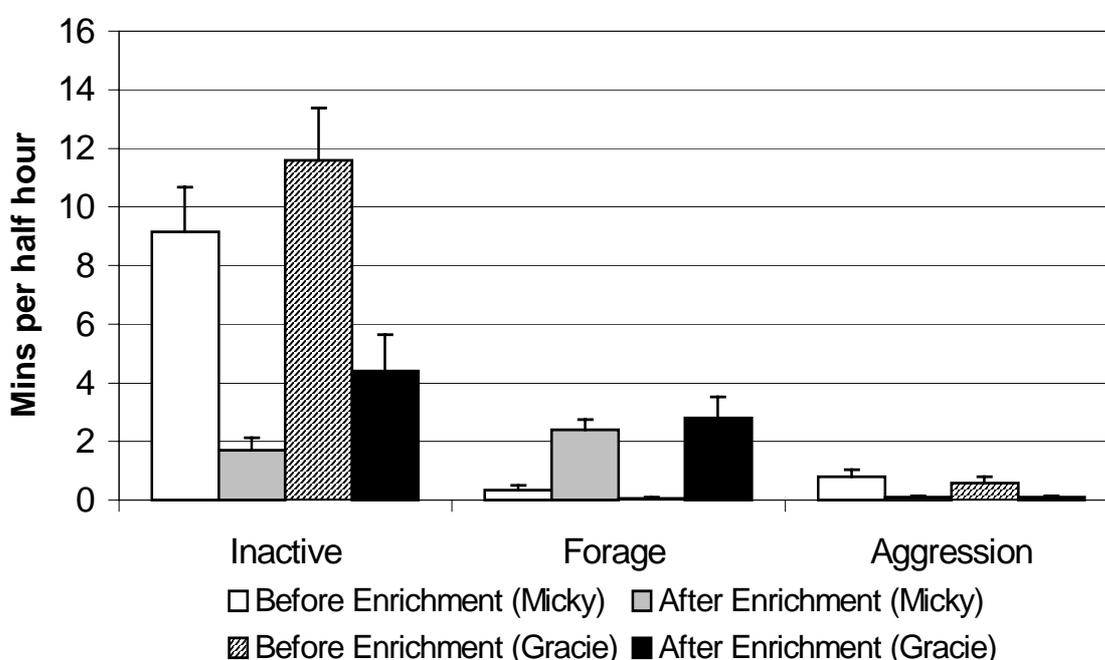
Figure 3. Mean time spent performing three behaviour types by two white rhino before and during enrichment.

Discussion and conclusions
The preliminary enrichment results look promising: the time spent inactive by both individuals has dropped significantly ($p < 0.05$ for both) and time spent foraging has increased significantly ($p < 0.05$ for both). Aggression has also decreased but since these levels are very low more data are needed to confirm whether this change is significant. So far there has been no effect on Gracie's anoestrus state. Areas for further study include olfactory enrichment and devices to improve our animals' dermatological condition.

Acknowledgements
I would like to thank keepers Jason Knight and Julian Chapman, Neil Bemment, my supervisor Amy Plowman and many others who have helped in the course of my study.

It's a cat's life! The effectiveness of simulated prey on a pair of Sumatran tigers (*Panthera tigris sumatrae*)

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Abstract

*In the wild tigers spend most of their time patrolling their territory or hunting and foraging for food. With little opportunity to perform these behaviours in captivity animals may become frustrated and can develop abnormal behavioural patterns known as stereotypies. Kali and Suma, two male Sumatran tigers (*Panthera tigris sumatrae*) have been at Paignton Zoo since 1996. They both tend to spend a large part of the day pacing the perimeter of their enclosure. Three different enrichment methods, designed to simulate various aspects of live prey, were tested for their effectiveness in reducing this pacing behaviour, increasing behavioural diversity and promoting interactions with the environment. All three had a significant effect on the tigers' behaviour, stimulated hunting-type behaviour and reduced the time spent pacing.*

Introduction

In the wild tigers spend most of their time patrolling their territory or hunting and foraging for food. Many of these behaviours such as hunting become redundant in captivity. With little opportunity to perform these behaviours the animal may become frustrated and can develop abnormal behavioural patterns known as stereotypies. This study investigated the effects of various enrichment methods designed to simulate aspects of live prey on the behaviour of captive tigers at Paignton Zoo Environmental Park.

Aims

- To provide environmental enrichment that will increase behavioural diversity, promote natural behaviour and interactions with the environment, and reduce the occurrence of stereotypies such as pacing.
- To collect behavioural data with and without various types of enrichment in order to assess the effectiveness of the enrichment.

Methods

Study Subjects

Kali and Suma, two male Sumatran tigers (*Panthera tigris sumatrae*). The brothers were born in Yarmouth in August 1994 and transferred to Paignton in 1996.

Data collection and analysis

Baseline and enrichment time budgets were derived by instantaneous scan sampling at one-minute intervals for half-hour sample periods. Key behaviours for the purposes of this poster are pacing, exploring enclosure, interacting/playing with enrichment and resting. Baseline (with no enrichment) and the three different enrichments were randomly assigned to different days, with each treatment being tested for a minimum of three days. Observations were taken for a minimum of three hours each day. The results were analysed as a Single Case Randomisation Trial for each tiger separately.

Enrichment methods

- A straw-filled sack on a hanging spring which 'fights back'
- Watermelons which roll away when 'chased'
- Barrels containing stones which also roll and make a noise

Results

Suma

The amount of time Suma spent pacing differed significantly between treatments ($p < 0.001$), decreasing to very low levels compared with baseline during the melon enrichment and not occurring at all during the spring and barrel enrichment (fig. 1). Time spent exploring and playing also changed significantly ($p < 0.05$ for both), increasing above the baseline level during all three enrichments. Time spent resting did not differ significantly between any of the treatments
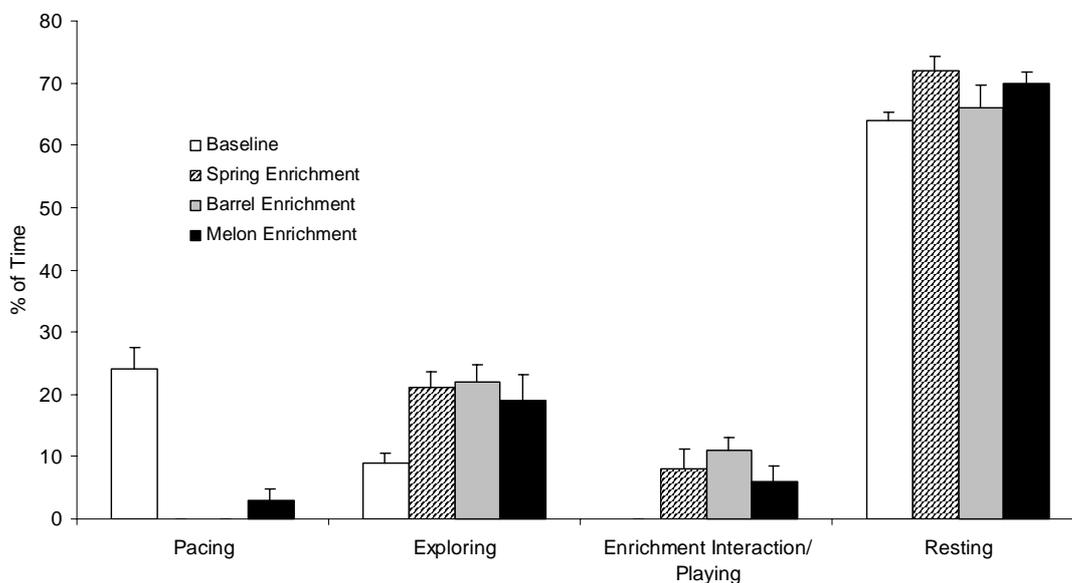
Figure 1. Time spent performing four types of behaviour by Suma, with no enrichment and three different enrichments. Error bars are standard error.

Kali

There was a significant difference in time spent pacing between treatments ($p < 0.001$) with none during the spring and barrel enrichment but similar levels in baseline and melon enrichment (fig. 4). Time spent exploring and playing differed significantly ($p < 0.05$ for both) occurring more often in all three enrichments than the baseline. Time spent resting also differed significantly between treatments ($p < 0.05$) mainly due to a lower level during melon enrichment.
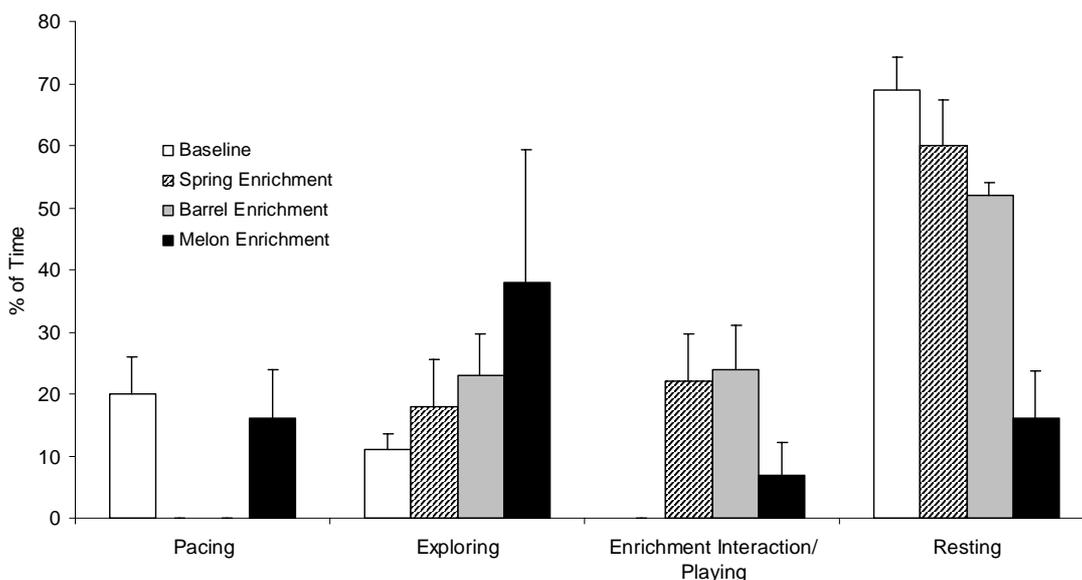
Figure 2. Mean proportion of time spent performing four types of behaviour by Kali, with no enrichment and three different enrichments. Error bars are standard error.

Conclusions

- Environmental enrichment had a substantial effect on the tigers' behaviour, greatly reducing pacing and increasing the amount of time spent performing more active, natural behaviours.
- Overall the spring device and the barrels were more successful, having the most effect and stimulating types of behaviour previously unseen in our tigers.
- Kali was more responsive to the enrichments, possibly due to his dominance over Suma which enabled him to monopolise some of the items.

Acknowledgements

Environmental enrichment and the behaviour of hyacinth macaws at Paignton Zoo

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Abstract

The effects of an enrichment device on the behaviour of a pair of hyacinth macaws at Paignton Zoo were investigated. The enrichment device consisted of a eucalyptus log (77cm length, 43cm circumference) suspended by a hessian rope to branches in the flight. The log had 18 holes (16mm, 18mm, 20mm) drilled into the surface. The holes were filled with four different types of nuts that were replaced each time the device was placed into the flight. During the enrichment period, the device was placed into the flight for periods of four hours. 20 hours of behavioural observations were made before enrichment, 20 hours during enrichment, and 10 hours post-enrichment. Behaviour of both birds was recorded at one minute intervals.

A large amount of time (38%) was spent using the enrichment device whilst it was included in the flight. Although baseline levels of aggression were lower in the pre-enrichment period than seen previously, they significantly dropped to zero during enrichment. Other forms of destructive behaviour such as cage biting also significantly decreased during this period. In the post-enrichment period, levels of aggression increased to pre-enrichment levels. Time spent eating freely available food declined during the enrichment period – the macaws spent about the same amount of time working for their food on the enrichment device. These results show that a relatively simple form of enrichment can have positive effects on the well-being of hyacinth macaws by increasing the complexity of the flight and allowing a degree of choice over their activities.

Introduction

Hyacinth macaws are native to the Pantanal region of South America, with the main population found in Brazil. Hyacinths are endangered; a survey carried out in 1987 estimated the number of wild hyacinths as 3,000. Since then they have been placed on the Convention on International Trade in Endangered Species (CITES) Appendix I list (Sweeny, 1992). With so few wild hyacinth macaws remaining, captive breeding programmes are of great importance.

Environmental enrichment has been defined as 'an improvement in the biological functioning of captive animals resulting from modifications to their environment' (Newberry, 1995). These modifications can sometimes be very simple; focussing on only a single aspect of an animal's captive life, but can sometimes have dramatic effects. Feeding in zoos is often very different from the ways in which the animal would obtain its food in the wild. Some 90% of a wild macaw's time is spent foraging and preening other birds in its' social group (Birchall, 1990). In captivity by contrast, a set amount of food is provided at the same time each day. The result is that the macaws' time must be spent on other activities. They may become bored and exhibit unwanted behaviour patterns. It has been shown in many studies that a wide range of species will work for food even if identical food is easily available (Markowitz, 1982; Coulton *et al.,* 1997).

For this reason, this study utilised an enrichment device with a pair of hyacinth macaws which focussed on making the birds work for their food using methods similar to those they would employ in the wild. This would not only occupy their time, but also encourage species specific behaviours. The aims of the study were to produce an enrichment device that would be beneficial to the macaws, easy to incorporate into the flight, and acceptable to the public eye.

Methods

Study subjects

The subjects were a young pair of captive bred, unrelated hyacinth macaws housed in an outdoor flight at Paignton Zoo. Both birds were born in 1993 and moved to the zoo in January 1994. The female is easily distinguishable from the male as she is slightly smaller and has a missing toe on her left foot. The pair has been observed mating in the summer months but have not as yet successfully bred.

Flight and diet

The pair of hyacinths are permanently housed in an outdoor flight measuring 5m by 10m and 5m high. The flight has a sheltered area at the rear that contains two food bowls and a large wooden nest box. Four large branches are used as perches, and water is available from a large metal bowl on the floor of the flight. The macaws are fed daily between the hours of 09:00 and 10:00. They have a set diet, which includes some variation each day. Their diet consists of a variety of fruits, nuts, and seeds. Occasional extras include cooked pulses and cooked chicken necks.

Enrichment device

The enrichment device was designed to encourage species specific foraging behaviour. It was made from a eucalyptus log cut to a size large enough to allow both macaws to use it at once (77cm length, 43cm circumference), but also light enough to lift. Eucalyptus was chosen as it is non-poisonous. Hessian rope (3m length, 20mm diameter) was threaded through a hole drilled in the centre of the log, and knotted securely so the log could hang from the existing perches. Eighteen holes of different sizes were drilled randomly along the log: four sized 16mm, six sized 18mm, and six sized 20mm. These holes were approximately 25mm deep.

The holes were filled with an assortment of walnuts, hazelnuts, peanuts, and macadamia nuts before the enrichment device was hung in the flight. These nuts were removed and replaced each time the device was removed from the flight. The device was attached to one of the existing branches by knotting the rope tightly a number of times. The enrichment device was included in the flight for periods of four hours, during which observations were made. Five minutes were allowed at the beginning of each enrichment session for the macaws to adjust before observations began.

Observational methods

Focal sampling and instantaneous time recording was used when observing behaviour (Altmann, 1974; Martin & Bateson, 1993). Before recording began, the macaws were observed for a number of hours in order for a list of their behaviours to be made (table 1). Observations were carried out over four months, from September 1999 to January 2000. The macaws were observed for periods of three to four hours between 10:00 and 15:00. There were three observational periods as shown below:

Pre-enrichment: 20 hours of observations made before the introduction of the enrichment device to the flight.

Enrichment: 20 hours of observations made whilst the enrichment device was included in the flight for periods of four hours at a time.

Post-enrichment: 10 hours of observations made after the enrichment period, with the device having been removed from the flight.

Behaviour was noted separately for each macaw once a minute on data sheets containing a list of all behaviours, a total of 3,000 observations for each macaw. Time and weather were noted on each sheet. Observations were all carried out under similar weather conditions. During bad weather, the macaws are very inactive, and no observations were carried out whilst it was raining heavily.

Behaviour	Description
Aggression	Behaving aggressively towards other macaw
Allopreening	Preening each other
Autopreening	Preening itself
Biting cage	Biting wire of flight, either sides or top
Cage hanging	Hanging from flight wire, not moving
Climbing	Climbing, either on perches or wire
Drinking	Drinking from water bowl
Flying	Flying, usually from perch to perch
Free eating	Eating food provided in food bowls
Nesting	In nesting box
On floor	Walking on floor of flight
Perch stripping	Stripping bark or pieces of wood form perches
Playing with food bowl	Picking up food bowl in bill
Sitting (eyes open)	Sitting alert
Sitting (eyes shut)	Sitting with eyes shut, not alert
Watching visitors	Hanging from wire at front of flight watching visitors
Enrichment behaviours:	
ED feeding	Feeding on nuts in the ED
ED stripping	Stripping bark or wood from the ED
Playing with rope	Biting or playing with the rope of the ED
Sitting on ED	Sitting alert and not moving on the ED

ED = Enrichment Device

Table 1. Behaviour categories for hyacinth macaws *Anodorhynchus hyacinthinus* observed at Paignton Zoo.

Results
Sex differences in behaviour
From a preliminary examination of the data for the male and female macaws, it appeared that a similar amount of time was allocated each behaviour by both macaws. There were some minor differences in the pre-enrichment period: the female spent more time cage hanging and climbing whereas the male spent longer sitting still. For both the enrichment and post-enrichment periods, chi-square analyses showed that the differences between the two macaws in proportion of time spent on various behaviours was not significant ($p > 0.05$). The data from both macaws were therefore pooled and subsequent analyses applied to the pooled data (table 2).

Behaviour	Observation Period					
	Pre-enrichment		Enrichment		Post-enrichment	
	N	%	N	%	N	%
Aggression	15	0.63	0	0.00	6	0.50
Allopreening	237	9.88	121	5.04	67	5.58
Autopreening	200	8.33	96	4.00	93	7.75
Biting cage	139	5.79	37	1.54	69	5.75
Cage hanging	159	6.63	127	5.29	122	10.17
Climbing	290	12.08	257	10.71	214	17.83
Drinking	7	0.29	15	0.63	4	0.33
Flying	22	0.92	13	0.54	7	0.58
Free eating	215	8.96	153	6.38	93	7.75
Nesting	10	0.42	0	0.13	11	0.92
On floor	14	0.58	5	0.21	10	0.83
Perch stripping	232	9.67	3	0.13	61	5.08
Playing with bowl	7	0.29	0	0.00	2	0.17
Sitting (eyes open)	709	29.54	647	26.96	441	36.75
Sitting (eyes shut)	110	4.58	4	0.17	0	0.00
Watching public	34	1.42	2	0.08	0	0.00
Enrichment:						
ED feeding	0	0.00	158	6.58	0	0.00
ED stripping	0	0.00	315	13.13	0	0.00
Playing with rope	0	0.00	354	14.75	0	0.00
Sitting on ED	0	0.00	93	3.88	0	0.00
Totals	2400		2400		1200	

ED = Enrichment Device

Table 2. Behaviour scores during an environmental enrichment study for a pair of hyacinth macaws *Anodorhynchus hyacinthinus* at Paignton Zoo. Behaviour recorded at one minute intervals in blocks of 3 or 4 hours (3000 minutes per macaw). N = number of minutes.

Changes in behaviour over the three observational periods
During the enrichment period, the enrichment device was used by the macaws for a large proportion of their time (38%). Consequently, the proportion of time that they spent on most other behaviours decreased. During post-enrichment time spent on these behaviours increased again, although the extent of the recovery to pre-enrichment levels varied between behaviours. A few minor

behaviours varied only slightly throughout the three periods (drinking, flying, playing with bowl, time spent on the ground).

The behaviour which showed the most significant changes between the three periods was perch stripping (χ^2 = 236.5, df = 2, p < 0.001). The macaws spent 10% of their time on this activity during pre-enrichment, but this declined to virtually zero during enrichment. Post enrichment, levels rose again to 5%. Both allopreening (χ^2 = 47.72, df = 2, p < 0.001) and autopreening (χ^2 = 41.13, df = 2, p < 0.001) activities changed significantly. Time spent preening dropped by nearly 50% during enrichment. Post-enrichment, autopreening almost recovered to pre-enrichment levels, whereas allopreening only rose slightly. Cage biting (χ^2 = 65.98, df = 2, p < 0.001), cage hanging (χ^2 = 30.19, df = 2, p < 0.001) and climbing (χ^2 = 37.97, df = 2, p < 0.001) were three activities which decreased significantly during enrichment only to increase markedly post-enrichment. Post-enrichment, the macaws also spent more time sitting alert with their eyes open and less time with their eyes shut compared to pre-enrichment and were less concerned with watching the public. Free-feeding levels dropped by 29% during enrichment, but increased again post-enrichment.

Use of the enrichment device
A large amount of the macaws' time (38%) was spent using the enrichment device when it was available to them. 38% of that time on the device was allocated to playing with the rope, and a further 34% was devoted to stripping the bark and pieces of wood from the enrichment device. The macaws spent about the same proportion of their total time feeding from the enrichment device as they did free feeding (6.58% versus 6.38%). However, this meant that the total time spent on feeding activities when the enrichment device was present was increased by 45% over pre-enrichment levels and is 67% greater than during post-enrichment.

Discussion
Marked changes in the behaviour of the hyacinth macaws were observed following the inclusion of the enrichment device into their flight. Positive effects of enrichment included a decrease in destructive and aggressive behaviours as well as an increase in activity. Although aggression was not a common behaviour, it ceased completely during enrichment. This is an effect that is in agreement with the findings of Coulton *et al.* (1997), and with previous enrichment work carried out with the same pair of macaws (Harcourt-Smith, 1999). Other negative behaviours, such as biting the cage, also showed significant decreases during enrichment.

Perch stripping is a natural behaviour which occupies a large proportion (10%) of the macaws time, but, during enrichment, the macaws spent very little time stripping their existing perches. Instead, these activities were transferred by the macaws to the enrichment device, where much of their time was spent stripping the bark and wood.

There was a slight decrease in eating the free food from the food bowls. However, there was an overall increase in feeding as the macaws chose to spend as much time working to obtain nuts from the enrichment device. This demonstrates that the enrichment was successful in encouraging species specific behaviours by focussing on foraging. The finding that the macaws would work for their food when identical food is easily available is accordance with many other scientific studies carried out on a variety of birds and mammals (Markowitz, 1982; Bohm, 1997).

The macaws were more active during enrichment as less time was spent sitting and nesting during the enrichment period. This is not only beneficial to the macaws' welfare, but also to the visitors to the zoo. The enrichment encouraged the macaws out of the sheltered area at the rear of the flight and into the centre of the flight where they could easily be seen.

The decrease in time spent preening during enrichment could be seen as cause for concern as preening is essential to keep the macaws' feathers in good condition. The enrichment device was only included in the flight for periods of four hours at a time, during which time the macaws were largely preoccupied with the device, so this is not a problem. The macaws spent much time playing with the rope that held the enrichment device and clearly relished doing so. However, there is some concern that the macaws may ingest fibres from the rope, or that they may become entangled in it. It may be better to look for alternative ways of suspending the enrichment device.

The high proportion of time that the macaws spent on the enrichment device, the decrease in negative behaviours and increase in positive ones, clearly show the value of the device. Would it be beneficial for the macaws if a permanent enrichment were to be included in the flight? If this were done, it may be that the benefits would decrease over time as the 'novelty value' diminished.   If enrichment were to be included in the flight it would possibly be worth removing or replacing the device at intervals in order to maintain the macaws' interest.

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Environmental enrichment using a variety of methods of food presentation for Illiger's macaws and eclectus parrots

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Abstract
This study was developed to enrich the study species' environment by presenting food in ways that increase foraging behaviour. Food use during the different feeding methods was also compared as parrots have specific food preferences. Results indicate that food presentation does not affect food preference. However, food presentation does affect the total amount of food consumed. Behaviour of the birds, including activity levels, was also affected by food presentation leading to a preferred feeding method. The birds benefited from the environmental enrichment, which has implications for future reintroductions.

Introduction

Of the world's 332 parrot species, 86 are at risk of extinction. This is mainly due to a combination of habitat destruction and trapping for trade (Low, 1994). The parrot species studied in this project were the Illiger's macaw and the eclectus parrot. The Illiger's macaw is found in Brazil, Argentina and Paraguay. It is on Appendix 1 of CITES and classed as vulnerable. It may already be extinct in Argentina and is extremely rare in Paraguay. The eclectus parrot inhabits New Guinea, Indonesia and the Solomon Islands. Numbers are in rapid decline but they are not yet classed as vulnerable.

The study species are part of a captive-breeding programme at Harewood Bird Garden. Captive breeding is becoming increasingly important as an aid for long term species conservation and although it is seen as less important than habitat protection it still has a very important role to play. For some species captive breeding is becoming the only way to ensure high enough numbers for their survival.

It has been suggested that keeping birds in enclosures as natural as possible will facilitate captive breeding (Coulton *et al.*, 1997). Various forms of abnormal behaviour have been observed in captive parrots and it has been suggested that these are caused by a lack of stimuli due to restricted space and limited opportunities for social interaction (Birchall, 1990). Environmental enrichment can facilitate captive breeding and future reintroduction by providing opportunities to learn the characteristics of natural food items and environments, thereby enabling individuals to develop behavioural flexibility in response to a dynamic environment (Newberry, 1995). If carried out correctly environmental enrichment will generally increase activity and specific activities will be stimulated. Environmental enrichment should enhance the well being of captive animals by addressing welfare problems and helping to preserve natural behaviour patterns.

Wild birds commonly spend a large proportion of their time foraging and eating. In the wild, food procurement is often the predominant activity in which a bird engages (Klasing, 1998). In captivity most food is provided in a single dish and this reduces foraging time substantially. Dangerous domestication effects are linked with the feeding of captive birds. This means that one method of environmental enrichment is to introduce feeding methods that will encourage exploratory or manipulative behaviour. If foraging time is increased then captive birds will spend their time more like their wild counterparts. Learning such behaviour would enable captive parrots to behave appropriately for future release into the wild.

In captivity food is usually dispensed in highly expected locations and in easily consumed form, resulting in minimal searching and handling times. Also food may only be presented once or twice a day. Changing feeding methods through research into environmental enrichment could reduce stereotypical behaviour in captivity. This can be achieved by:

- Providing smaller more frequent meals,
- Scattering and hiding food in unusual locations,
- Increasing time and skill required to extract food,
- Increasing time required to process and ingest food (Newberry, 1995).

Methods

Four different feeding regimes were tested:

1) Each food type separated into a different dish with food placement in same area.
2) Each food type separated into a different dish and placed at unpredictable areas of the aviary.
3) Each food type in separate dish at unpredictable areas of the aviary plus the introduction of a foraging device.
4) All food in same dish, as in current feeding method, and in same place as current feeding method.

Food preference

To determine food preference each food type was weighed at regular intervals throughout the day. A null hypothesis was proposed that food presentation does not affect food preference or total amount of food consumed.

Behaviour

The categories of behavioural data collected are shown in table 1. A null hypothesis was proposed that food presentation does not affect behaviour.

Behaviour	Description
Feeding	Eating from feeding dishes
Sitting	Sitting still
Climbing	Climbing either wire mesh or branch
On front perch	Moving or sitting on front perch
On back perch	Moving or sitting on back perch
On outside perch	Moving or sitting on outside branch/rope
Top of nest box	Moving or sitting on top of nest box
In nest box	In nest box (out of view)
Preening	Preening self
Allo-preening	Preening another individual
Barkstripping	Stripping bark from branch, nest box or cage with beak
Alert	Alert with eyes open
Asleep	Sitting still and apparently not alert with eyes closed

Table 1. Ethogram of recorded parrot behaviour types

Results and discussion

Food preference

In feeding methods one to three fruit and vegetable types were preferred over any other food type when total weights over 24 hours were compared (F = 70.07, p < 0.01). Illiger's macaws showed a little more variety in their diet with at least two food types that were consumed being over 10% of the total diet. Fruit and vegetables were preferred with the next preference being sunflower seeds. More diversity in the diet of both Illiger's macaws and eclectus parrots was seen in feeding method two as amounts of other food types consumed increased when compared to fruit and vegetables. In feeding method two the Illiger's macaws consumed more budgie mix than fruit and vegetables in the first 180 minutes.

Food consumption

The differences between total food consumed in different feeding methods was statistically significant (F = 13.24, p < 0.05); for both the Illiger's macaws and the eclectus parrots less food was consumed in feeding method four than the other feeding methods. The Illiger's macaws consumed the most food in feeding methods two and three. This was expected, as the birds had to expend most energy to feed in methods two and three. The eclectus parrots consumed the most food in feeding method 1. This is likely as in methods two and three the birds had to move around the cage to feed and some dishes were closer to the front of the cage (and therefore the general public) than they were in methods one and four and these birds are particularly timid. The amount consumed within species for methods two and three were very similar. This was expected, as the foraging device was not used at all. Without the use of the foraging device feeding methods two and three are identical.

Behaviour

The male eclectus parrot was seen feeding more in feeding methods one and three but not quite significantly (F = 2.5, p > 0.05). The female eclectus parrot was significantly more active in feeding method one than method two. More self preening (F = 5, p < 0.05) and less sitting occurred (F = 7.5, p < 0.05) in method one. However, this could be due to illness and not differences in feeding methods. Illiger's macaws were more active in feeding methods one to three than method four. Less feeding occurred in method four for the male (F = 37.32, p < 0.01), and the female (F = 3.087, p > 0.05 but close to significance). More motivation was displayed in getting to the feeding dishes in feeding methods one to three. The birds started feeding as soon as the dishes were presented, possibly due to lack of stimulation offered by feeding method four. More sitting occurred in feeding method four for both the male (F = 7.39, p < 0.01) and the female (F = 8.91, p < 0.01), also more time was spent inactive on top of the nest box by the male (F = 68.12, p < 0.01) and the female (F = 90.01, p < 0.01). More feeding behaviour was observed in feeding method one by both species. In feeding method one the birds did not have to move around the cage to get to the food, making it easier to find preferred food, but did not encourage the birds to explore their surroundings. Enclosure usage was enhanced for both species in feeding methods two and three increasing behavioural diversity and encouraging a more natural temporal patterning of behaviour. The foraging device was not used by either species in feeding method three, but did appear to affect the behaviour of the Illiger's macaws. The female Illiger's macaw spent more time climbing around the cage and on the wire. Both the male and female Illiger's macaws spent a higher proportion of time on the outside perches in the first 10 minutes in feeding method three than in the other methods. This suggests that the environmental change was observed and more time was needed than the study allowed for the birds to learn the appropriate behaviour to use the device.

Conclusion

Further investigation is needed to investigate the influence of extraneous factors, such as: general public, change of routine, weather. Feeding enrichment can aid captive birds in a variety of ways. It can alleviate obesity and improve the general fitness of the bird, as well as providing

psychological benefits through increased stimulation. This, in turn, can lead to more successful reproduction of captive birds. Environmental enrichment also encourages and aids captive birds to learn more natural behaviour patterns. This can be passed on to the young and in the long term will make the birds more adaptable for reintroduction into the wild.

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The effect of feeding enrichment on the behaviour of three large macaw species: the blue and gold macaw (*Ara ararauna*), the green-winged macaw (*Ara chloroptera*), and the scarlet macaw (*Ara macao*)

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Abstract
Of the 332 known species of parrot, 86 are currently classed as either endangered or at risk from extinction; with modern practices of deforestation and habitat destruction this number is set to rise in the near future unless drastic action is taken to protect those species most at risk along with their habitat. The larger species of parrot such as the large macaws are especially vulnerable to man's destruction of their habitat due to their need for large areas and their selectivity over nesting sites. These birds are also easy victims of the illegal trade in wild caught birds for the pet trade due to their large size and colourful plumage. Encouraging captive birds to breed and rear young is one way of combating this trade, environmental enrichment plays an essential part in giving these birds a more stimulating (if not natural) environment and can lead to nesting and breeding behaviour by reducing stress and boredom.

The species I intend to study are listed in CITES appendices, Ara macao in Appendix I and A. chloroptera and A. ararauna in Appendix II, and are species commonly found in the pet trade. As these birds spend roughly 90% of their time in the wild looking for and consuming food I propose to study the affect that feeding enrichment devices have on the behaviour of these birds. The study group consists of 10 individuals, (three pairs of scarlet, one pair of green-winged and one pair of blue and gold macaws), located in four separate enclosures. The main enrichment device under consideration is one that encourages search behaviour by concealing food items in holes covered by starch paper. The holes are made in a plank of wood, which is placed in the aviaries, along with the normal food bowl (minus the food in the holes). Not all the holes will be filled to further encourage foraging and increase the time spent searching to something closer to their natural state. In increasing foraging time I hope to reduce the birds boredom and increase the chances that they will breed successfully.

Introduction
Eighty-six of the world's 332 known parrot species are known to be at risk from extinction (Del Hoyo, 1997; Birchall, 1990). With modern practices of deforestation and habitat destruction this number is set to rise in the near future unless drastic action is taken. Larger species are generally more vulnerable to habitat destruction due to their need for large territories and their relatively slow reproduction rates. Due to the popularity of these species as pets and their endangered state in the wild it is necessary to breed these birds in captivity to reduce the demand for wild caught birds and ensure their survival in the future. Thus it is essential to provide for all aspects of these birds well-being in captivity, both physical and mental, to ensure their good health and breeding potential. Encouraging captive birds to breed and rear young is one way of combating the illegal trade in wild caught birds and environmental enrichment plays a vital role in giving these birds a more stimulating environment.

Despite the urgency for captive breeding of parrots and the obvious need for optimising housing conditions there is still a bias in enrichment studies towards primates and carnivores (Shepherdson, 1991) despite the occurrence of many abnormal behaviours in captive parrots (Birchall, 1990). It has been argued that non-mammalian species suffer less than mammalian species in poor conditions

(Poole, 1992). However, many disagree as similarities exist between the complex social behaviour of primates and parrots (Birchall, 1990; Coulton *et al.,* 1996).

Species studied
The species I am studying are listed in CITES appendices: *Ara macao* in appendix 1 and *A. chloroptera* and *A. ararauna* in appendix 2, and are species commonly found in the pet trade. The study group consists of 10 individuals, five males and five females: two blue and gold macaws, two green winged macaws and six scarlet macaws.

The home range of the blue and gold macaw is from Panama to Southern Peru and Bolivia. The bird is on average 80cm in length, half of which is taken up by the tail. The home range of the green winged macaw is across eastern Panama and South America to northern Argentina. These birds are some of the largest macaws at 73-95cm with a long tail. The scarlet macaws have a similar range to the other two species and are of similar size to the blue and gold macaws, the three species are often found associating together in the wild.

Method
Identification
The first problem that had to be solved before the project could even start was the identification of the individual birds; particularly in the first scarlet aviary which contained four individuals in two pairs. This was resolved by careful observation of all individuals to identify characteristics that were easily observable. The task was made slightly easier by the presence of orange rings on the right legs of the female scarlets. The blue and gold macaws were the most difficult of the pairs to tell apart; the male and female are virtually identical so in this case behavioural differences were used initially for identification. The female spent the vast majority of her time in one corner of the aviary where she had located her nest. Later small details became apparent such as the males missing toe and the females unusual claws that have grown at strange angles. Also the female is slightly larger than the male and has a fuller tail. The male and female green-winged macaws were also very similar in appearance. Again behavioural differences such as the females presence on her nest were good indicators of identity. Physical differences were present such as the males larger blockier head and the females growth of fluffy brown feathers on her breast, probably for incubation of her eggs.

With the scarlet macaws it was harder to rely on behavioural differences for identification and I spent the weeks preceding the start of my observations trying to identify individual characteristics. Female 2, or Halftail, as her name suggests, has lost part of her tail making identification easier. In the second scarlet aviary there is only one pair of birds, making identification less difficult; male 3 is easily distinguished by his larger size. When the pair are separated the female can be identified by the distinctive pattern of spots on her upper beak, unlike the other scarlets her beak does not have a solid black patch but has two separate patches (fig. 1).

Ethogram
One week was spent developing a comprhensive ethogram of all the birds' behaviours. I identified 24 different behaviours some of which cover several forms of the same behaviour. For analysis behaviour types will be grouped into four major categories. During this initial week the birds became habituated to my presence such that during the experimental observaiton period they behaved as they normally would.

The feeding devices
The feeding devices were constructed from dried logs of approximately 90cm in length, these were split in half to produce a flat surface, into which two rows of 12 holes were drilled. These holes were approx. 3-5cm in diameter and 2-3cm deep. The holes were originally filled with nuts and
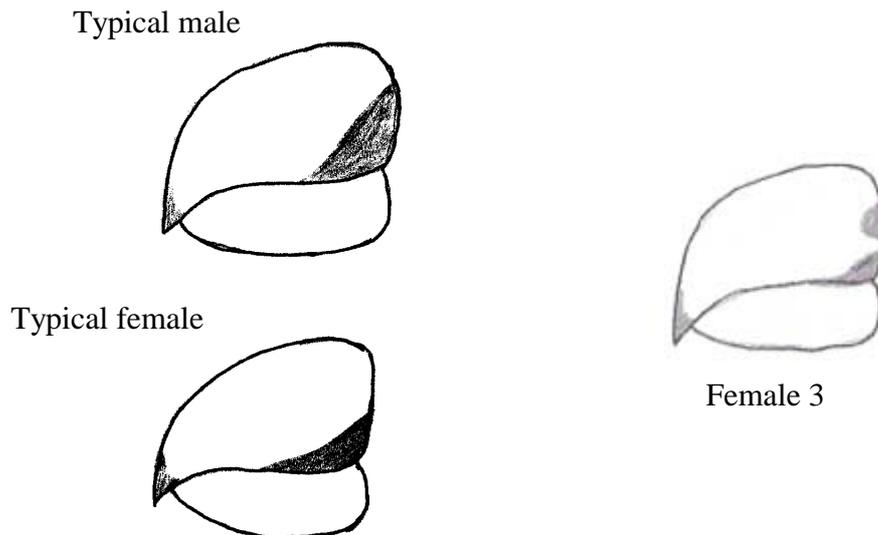
Typical male

Typical female

Female 3

Figure 1.   Beak patterns of scarlet macaws.

seed normally found in the birds diet and covered with brown paper, this was later replaced with cellotape so that the birds could see the food as they appear to be mainly visually orientated.

Data collection and analysis
Observations were taken in two week blocks before enrichment, during and after enrichment. The observations were taken for one hour sessions at two minute intervals. The two sets of aviaries were observed on alternate hours for three hours each per day giving a total of 28 hours of observations. This data will be used to produce time budgets for the parrots behaviours and eventually statistical analysis of the data will be carried out to determine if any changes in behaviour are statistically significant.

Expected behavioural changes
I expect to see a shift in the budget away from sitting and resting behaviours and towards feeding and foraging behaviours if the enrichment has been successful. The third observation period without the feeding device is needed to determine if any differences seen are due to improvements in the habitat or just caused by altering the habitat as behavioural changes can be induced by deprivation of a habitat as well as improving it.

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Food selection and interspecific interactions in a large aviary at Bristol Zoo Gardens

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Abstract
*The Wallace Aviary was opened in 1998 and houses a number of species of birds. Many of the birds are from the family Columbidae from the Philippines. Food for the Columbids was offered at several feeding stations in the aviary. There was some evidence of inter-specific competition in some trees and at the feeding stations. The number of birds and species around the feeding stations was recorded before and two, four, six and 24 hours after the feeding stations were provisioned. Food selection was investigated by offering the six main food types in a compartmentalised food tray and was weighed before being offered and at intervals through the day. The proportion of the most preferred food type was varied to establish whether the birds would switch to other food types. Dried fruit was consistently ranked the highest and taken in a higher proportion than was offered. Typically all food types were still present after 24 hours with the exception of the most preferred food when given in small proportions of the total food. Most of the interspecific agonistic interactions occurred in two trees near one of the feeding stations and at the feeding stations. The pied imperial pigeons (*Ducula bicolor*) consistently displaced chestnut naped pigeons (Ducula aenea paulina). Although there was evidence of inter-specific competition the total food ration distributed was sufficient to allow a wide choice even after dominant individuals or the dominant species had fed.*

Introduction

Good quality foods, making up best practice diets, are offered to captive animals, but what is actually eaten depends on individuals. Food may be taken in proportion to that available or individuals may be selective. The situation may be compounded by intra- and inter-specific competition. Food selection was investigated in the Wallace Aviary which is situated alongside the Tropical Bird House at Bristol Zoo Gardens. It houses many species of bird, particularly those from the family Columbidae from South East Asia, many of which are endangered. The Aviary itself provides a large outdoor enclosure covering approximately 530m^2 most of which reaches a height of 8m.

During the first part of the study basic behavioural observations were made on all species that fed at the elevated feeding stations within the Aviary. The main findings presented here concentrated on one feeding station where up to five species of bird (out of the 26 species within the aviary) were observed taking food. The dominant species in terms of use of the feeding station were the pied imperial pigeon (*Ducula bicolor*) and the chestnut naped pigeon (*Ducula aenea paulina*). The main constituents of the diet were presented separately and gross preferences ranked on the basis of weight of food taken to determine whether the birds took foods in proportion to that encountered or were being selective. The most preferred types were then offered in different proportions to see if the birds would switch from one to the other depending on the proportions offered (Krebs *et al.,* 1977).

Method

The study was carried out between October and December 1999. During the first period of the study the numbers and species of birds feeding at one of the three raised feeding stations were recorded over 20 minute periods between 09:00 and 13:00 over 20 days, it was not possible to

identify individual birds. The food was presented as a mix. Food type eaten was recorded where possible. Any interactions between birds at the feeding station or in nearby trees were also noted. The usual diet offered to the birds was a mix of six major food types (table 1). In the second part of the study the major foods types were given individually in a compartmentalised tray instead of being mixed together. The total weight of food was as supplied by the bird section keepers. The weight of each food type was recorded before the food was presented (between 08:00 and 09:00) and when removed 24 hours later. The location on the food tray of each food type was randomised from day to day. The number of birds of each species were noted over 20 minute periods every two hours until 17:00 over ten days.

FOOD NAME	CONTENTS
Fresh Fruit	Chopped pear/apple, stored in fridge over night.
Dried Fruit	Raisins, sultanas, and candied peel. Soaked overnight in water.
Grains	Small grains: canary seed, millet, dari; large grains: wheat + cut maize
Insectivorous Mix	A dietary supplement which is fruit based
Rice + Pulses	Rice and pulses pre-cooked and cooled
Egg	Hard boiled and crushed egg

Table 1 Main food types offered to birds in the Wallace Aviary. Zoo diet A, a dietary supplement, soaked in either tea or water was added to food mix or individual food types. Other foods such as mealworms, grated cheese, grated carrot and chickweed were added on occasion. These were recorded but are not included in the results presented.

In the third part of the study the two most preferred food types as identified from the previous results were systematically varied. These two foods, dried fruit and insectivorous mix, were presented in the following ratios: 20:80, 30:70, 40:60, 50:50, 60:40,70:30, 80:20 in random order. Each ratio was repeated three times. The weight of each food type remaining was recorded after two, four, six and 24 hours. The results after two hours are presented here. The other food items offered were held constant.

Results

The mean number of birds, number of different species and inter-specific interactions at the feeding station per day are given in table 2. A total of five different species were seen at the feeding station. The pied imperial pigeons dominated the feeding station and displaced other species. Only one recorded interaction did not involve pied imperial pigeons but was between two chestnut naped pigeons.

Bird visits	Species	Interactions
26.3	3.2	2.1

Table 2 Mean number of bird visits, species and interactions per day

The ranking of the major food types is given in table 3. The total food ration offered was between 775 and 1016 g. The mean weight of food taken was 311g. When the major food types were offered separately dried fruit and insectivorous mix were consistently ranked either first or second and were completely cleared from the tray on some days.

Rank	Day									
	1	2	3	4	5	6	7	8	9	10
1	IM	DF	DF	DF	DF	DF	DF	DF	DF	DF
2	DF	IM	IM	IM	IM	IM	IM	IM	IM	IM
3	FF	GR	GR	PR	PR	PR	GR	FF	EGG	FF
4	PR	PR	PR	GR	GR	GR	PR	PR	PR	GR
5	EGG	FF	FF	FF	FF	FF	FF	EGG	FF	EGG
6	GR	EGG	-	EGG	EGG	EGG	EGG	GR	GR	PR

Table 3 Ranking of major food types eaten after 24 hours: FF – fresh fruit, DF – dried fruit, GR – grains, IM – insectivorous mix, PR – pulses and rice, EGG – egg.

The amount of dried fruit eaten as a proportion of the total of dried fruit and insectivorous mix after two hours was greater than the proportion offered at all ratios (fig. 1).
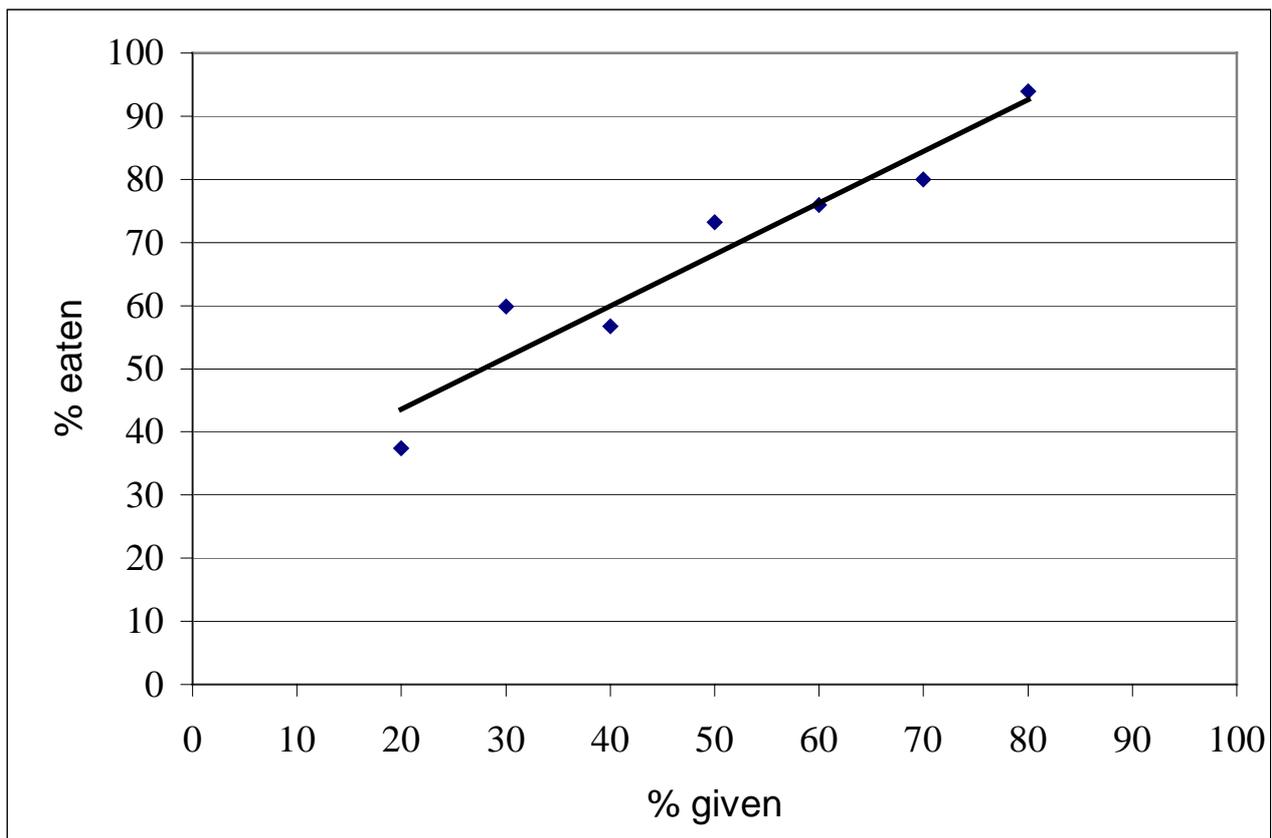
Figure 1 Proportion of dried fruit eaten compared with proportion offered.

Discussion

The food provided for a mixed species exhibit should allow all individuals to satisfy their dietary requirements. If there were no selection food would be taken in proportion to that provided, which was not the case here. The same foods were consistently taken in larger proportions and were sometimes completely depleted after 24 hours. Dried fruit was always taken preferentially and

most pied imperial pigeons took this food first although the position in relation to other foods and orientation on the feeding station were varied. There was no evidence of the birds switching from the preferred food as the proportion of the less preferred food increased (Kreb *et al.,* 1977). Nutritional analysis can be carried out on the food types to ascertain the relative importance of different parts of the diet at this time of year (autumn). There was evidence of inter-specific dominance with the pied imperial pigeons consistently displacing the chestnut naped pigeons. The agonistic interactions often continued into the trees nearest the feeding station. However, after the dominant species had eaten there was still a range of food items available allowing others to be selective.

Conclusions
There was evidence of inter-specific competition and agonistic interactions between individuals and species. Some food types were consistently preferred over others but were available through the day. The total food ration distributed was sufficient to allow a wide choice through the day and after dominant individuals had fed.

Acknowledgements
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Assessing Norplant as a contraceptive in female Rodrigues fruit bats at Jersey Zoo

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Abstract

Population management through control of reproduction by chemical contraception is an important tool in captive breeding programmes. In the Rodrigues fruit bats Pteropus rodricensis *programme it is now necessary to control reproductive output, whilst maintaining genetic viability. Previous use of melengesterol acetate contraceptive implants in this species at Jersey Zoo resulted in significant weight gain and localised alopecia, so when further bats were scheduled for contraception in 1999, it was decided to use the levonorgestrel implant Norplant as an alternative. Since Norplant had not been used in fruit bats before, this study was designed to evaluate its use. The first study group consisted of 17 adult females; 12 were implanted in November 1999, and five formed a control group. For husbandry reasons, four of the controls were implanted in January 2000, as were an additional five juvenile females (<18 months, group 2). Behavioural observations were carried out in four-week blocks: one immediately pre-implantation (October 1999), one commencing a week post-implantation (December 1999) and one a week post-implantation on group 2 bats (February 2000). Activity and social interactions were recorded during 20 15-min focal samples per bat per block. The bats' physical condition was assessed immediately pre-, and two and four months post-implantation. No significant weight gain or alopecia were detected at four month follow-up. The implants did not appear to have any effects on the bats' behaviour. Any variation between the control and implant groups, both pre- and post-implantation, was mainly related to pregnancy and parturition in the control group. Ten implanted bats gave birth, but all offspring were conceived prior to implantation. Six months post-implantation there are no signs of adverse behavioural or physical side effects of Norplant. However, we plan to continue longer-term monitoring of its efficacy in controlling reproduction, and of any potential side-effects, as well as comparing contracepted nulliparous and parous females.*

Introduction

The Rodrigues fruit bat *Pteropus rodricensis* is endemic to the Indian Ocean island of Rodrigues, and is critically endangered. In 1976 the population had slumped to only 70 individuals, so a captive breeding programme was set up (Cheke, 1974; Durrell, 1976). From a founder population of 18 bats, captive colonies have now been established in collections world-wide (Carroll *et al.,* 1995). The captive population of *P. rodricensis* is now increasing rapidly, and this may create various problems for zoos, in terms of the optimal use of space and resources, welfare issues, and the maintenance of genetic diversity. So a means of controlling reproductive output, whilst maintaining a genetically viable population, is required. Prevention of inbreeding in the captive *P. rodricensis* population is particularly important, due to the small number of founding animals. It is also important to reduce the breeding of animals with over-represented genetic lines. One method of controlling potential inbreeding and over-representation is by manipulating which females breed.

Contraception as a tool for managing captive populations
The control of populations through the management of reproduction has become an essential tool in captive breeding programmes (Asa *et al.,* 1996). No single contraceptive method will meet the requirements of all species, but some general principles apply (Gerlofsma *et al.,* 1994): 1) there should be no effect on the behaviour, health or condition of the animal; 2) there should be no

interference with the social structures in a group; 3) the contraceptive should be highly effective, but to be of most value to a breeding programme the method should be reversible; and 4) the contraceptive should be easily administered.

Using contraceptives conforming to these criteria it should be possible to meet the objectives of the *P. rodricensis* population management plan, and accommodate both welfare and genetic considerations. Progestin-based contraceptive implants have now been in use in zoos for over 20 years (Gerlofsma *et al.*, 1994). At Jersey Zoo, two types of progestin implants have been used in Rodrigues fruit bats: melengesterol acetate implants and the levonorgestrel implant Norplant.

Melengesterol acetate (MGA)
The most widely utilised implants to date have been based on MGA, which has been used in a variety of mammalian species since the 1970s (Asa *et al.*, 1996). MGA contraceptive implants were used in female *P. rodricensis* at Jersey Zoo in 1992, and a study was carried out to investigate any behavioural or physical effects on the bats (Hayes *et al.,* 1996; Dutton & Allchurch, 1998). The bats were observed for three four-week periods: prior to implantation, immediately post-implantation, and six months after the implant procedure. There were no significant differences in behaviour between non-implanted and implanted bats over this time period. However, the MGA implants were found to cause significant weight gain and localised alopecia at the implant sites (Hayes *et al.*, 1996).

MGA has also been found to have significant adverse effects in some other species. For example, in various felids, canids and primates, the longer-term use of MGA can result in diseases of the reproductive tract, some of which may be severe or even fatal (Munson *et al.,* 1995). Another potential disadvantage of MGA, particularly in small animals such as bats, is that the implant can be bulky, and so requires a moderately invasive surgical procedure for intramuscular implantation (Dutton & Allchurch, 1998). MGA implants may thus be more likely to be rejected, and may also cause more localised side effects at the implant sites.

Norplant
An alternative to the MGA implant is Norplant, which was developed for human use in the 1970s. Each Norplant implant consists of a thin capsule, 34mm long and 2.4mm in diameter. One set of six implants will effectively prevent conception in humans for five years. As with MGA, Norplant has been associated with weight gains in humans and other primates (Bettinger *et al.,* 1997). However, Norplant has previously been used with other species at Jersey Zoo, and no significant adverse effects have yet been found (Dutton & Allchurch, 1998). Another potential advantage of the Norplant implant is that it is less bulky than an MGA implant, and can therefore be implanted subcutaneously. It may even be possible to insert using local rather than general anaesthesia. Norplant was thus chosen as an alternative to MGA when further bats were targeted for reproductive management in 1999.

Study aims
Since Norplant has not previously been used in fruit bats, this study was set up to monitor any effects of the contraceptive implant. Thus the main aim of the study was to establish whether Norplant effectively fulfilled the criteria of an "ideal contraceptive" when used in female Rodrigues fruit bats. Ideally, most of the criteria should be evaluated over the short, medium and long term. This study presents the results of the first, short-term phase of evaluation.

Methods
Study animals
The study group consisted of 17 adult females (>18 months old) with varied reproductive histories. Twelve bats were implanted in November 1999 (Group 1), with five forming a control group

(Group 2). For husbandry reasons, four of the five controls were also implanted in January 2000, as were an additional five nulliparous juvenile females (12-18 months old)(Group 3). Details of the study bats are given in table 1. As the implanted bats varied in age, reproductive history and stage of inter-birth and pregnancy, we hoped to be able to assess the effects of the implant over a wide variety of conditions.

Group	International Studbook No.	Age at start of study [1,2]	No. births prior to study
Group 1	35	~14 y 3 m	17
	52	14 y 5m	13
	58	14 y 9 m	18
	900	4 y 5 m	3
	916	3 y 9 m	2
	921	3 y 8 m	1
	923	3 y 6 m	2
	929	3 y 3 m	2
	1379	1 y 8 m	0
	1380	1 y 8 m	0
	1382	1 y 6 m	0
	1383	1 y 6 m	0
Group 2	24	~14 y	7
	30	14 y 9 m	5
	69	12 y	14
	103	10 y 5 m	8
	152	8 y 7 m	7
Group 3	1387	1 y 7 m	0
	1393	1 y 5 m	0
	1395	1 y 4 m	0
	1396	1 y 3 m	0
	1399	1 y 0 m	0

[1] = Groups 1 and 2, ages in November 1999.

[2] = Group 3, ages in January 2000.

Table 1. Ages and reproductive histories of study bats

Behavioural observations
Behavioural observations were carried out over three four-week periods. The first was scheduled immediately prior to implantation in November, with the second commencing a week after

implantation. The individuals implanted in January were then observed for a further four weeks. Observations took place between 11:00 and 20:00, with the samples for each bat evenly balanced throughout this period. Behaviour was recorded using focal animal sampling; each bat was observed for one 15 minute period each day, for a total of six hours data per bat per period. Four aspects of the bats' behaviour were noted. The focal bat's activity and nearest neighbours were recorded by instantaneous point samples taken at 30 second intervals, prompted by an automatic stopwatch bleep. The bat's activity was divided into six categories (table 2). In addition, all displacements by or of the focal bat and incidences of mating behaviour involving that individual were recorded throughout the duration of the 15 minute observation period.

Behaviour	Definition
Roosting	Inactive, with eyes closed and no ear movements
Hanging alert	Stationary, but eyes are open, and there may be movement of head or body
Moving	Flying or climbing between locations
Feeding	Consuming or selecting food items
Self-grooming	Grooming itself (also used if not possible to tell if bat is grooming a suckling infant or itself)
Social behaviour	Involved in interaction with other bats

Table 2. Behaviour categories scored by point sampling

Physical examination
As progestin implants may cause weight gain and localised alopecia at the implant site, the bats were weighed and examined immediately prior to implantation, and then at approximately two month intervals after the procedure. The implant sites were also inspected to ensure that the implant was retained and to check for any alopecia or scarring. Bats with dependent infants were not caught up to be weighed.

Implantation procedure
Each implanted bat received a single identical Norplant capsule. All bats to be implanted were caught, weighed, and given a general anaesthetic. The implant was then inserted subcutaneously on the back of the bat, on the midline posterior to the inter-scapula region so as not to interfere with flight. The bats were then allowed to recover for two to four hours, and then returned to the main colony. The control bats were also caught and weighed, but were not anaesthetised and were absent from the colony for less time than the implanted individuals.

Results and evaluation
The results of the study were evaluated in terms of the four criteria for a suitable contraceptive method.

Criterion 1. There should be no effect on the behaviour, health or condition of the animal
This was monitored by assessing behaviour in terms of activity, i.e. do the bats behave the same after being implanted with Norplant as they did prior to implantation? For example, the physical presence of the implant may cause discomfort, which might manifest itself in an alteration of the bats' behaviour (e.g. increased grooming). Health and condition were assessed using the weight data; any large changes in weight might reflect deteriorating condition.

The implants did not appear to have any significant short-term effects on the bats' activity (fig. 1). This may be due to various reasons: for example, the dimensions of the implants make them unlikely to cause discomfort, and the hormone is released at a relatively low steady level. Neither were there any obvious effects on the bats' health or condition. There was no significant weight gain when the bats were examined four months after implantation, and no alopecia or scarring at the implant sites.
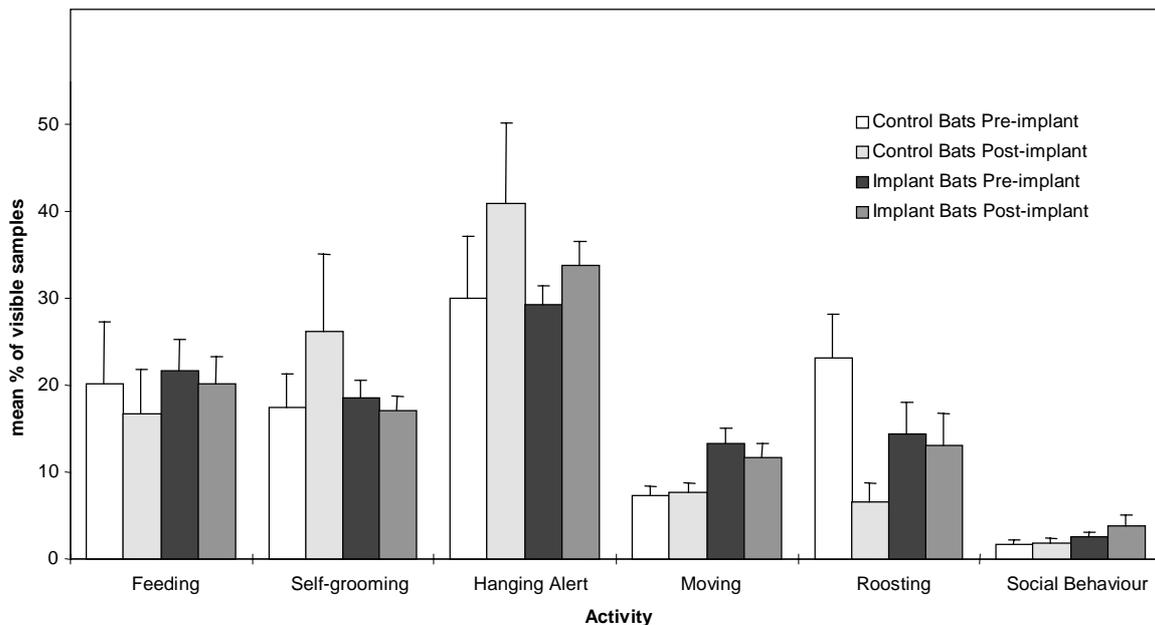

Figure 1.　Activity of control and November implanted bats, pre- and post-implantation.

Criterion 2. There should be no interference with the social structures in a group
This was monitored by assessing social interactions, i.e. do the hormones in the contraceptive influence the way implanted females interact with other bats, and vice versa? Norplant did not appear to have any significant short-term effects on the implanted females' interactions with other bats in the colony, and therefore had little, if any, effect on the short-term social structure of the group. In the long term, the structure of the colony may be affected by the decreased birth rate and resultant changes in the age range. However, additional breeding females of different genetic stock may be introduced at a later date, thus overcoming this potential problem.

Criterion 3. The contraceptive should be highly effective, but to be of most value to a breeding programme the method should be reversible
Contraceptive effect can only be assessed one gestation length after implantation to allow for birth of infants to bats who were pregnant when implanted. Thereafter no more pregnancies and births should occur. The gestation period of *P. rodricensis* is approximately five months, with a minimum inter-birth interval of around eight months. Eleven implanted bats gave birth, between one week and five months after the implants were inserted. All these offspring were conceived prior to implantation, so it is not yet possible to assess how effective Norplant is as a means of birth control in *P. rodricensis*. However, implantation does not appear to have had any significant serious effects on either early or late pregnancy.

Reproduction in the colony will need to be monitored over a longer period to assess how long one Norplant capsule is effective in fruit bats. Also, to assess the reversibility of the contraception, some implants may need to be removed at a later date. Moreover, the varying effects on bats of different age classes was monitored by comparing young nulliparous bats with older parous females. It is possible that reversibility may vary with previous reproductive state.

Criterion 4. The contraceptive should be easily administered
This was assessed by the veterinary personnel who performed the implant procedure. Because of its small diameter, the Norplant implant can be inserted subcutaneously in a manner very similar to that used with the microchips routinely implanted to identify captive animals. Although it was necessary to use a brief general anaesthetic in these bats, it may also be possible to use a local anaesthetic, or no anaesthetic at all, as with microchip insertion. The Norplant implants are therefore relatively easily administered, particularly when compared to MGA implants which require a more invasive and time consuming intramuscular insertion.

Conclusion
This study, and the previous work on MGA implants, has shown that contraceptive implants may be a useful tool for the captive management of fruit bats. Captive breeding has been recommended for a further 15 species of fruit bats of conservation concern (Mickleburgh *et al.,* 1992), and the management tools being developed and tested as part of the Rodrigues fruit bat programme will be invaluable. From the results of this study, Norplant appears to be a good alternative to contraception using MGA. In Rodrigues fruit bats, Norplant has been shown to have fewer short-term side-effects than MGA.

Further work is needed to investigate the effectiveness and longevity of contraception using Norplant in Rodrigues fruit bats. It is also necessary to monitor the long-term health effects. This is particularly important, as these bats may live for over 25 years, and long-term use of progestins has had serious adverse effects on health in other species.

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The effect of Norplant on a captive troop of Hamadryas baboons

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Abstract

Due to the prolific breeding of Hamadryas baboons, measures often have to be taken to contain numbers in captive troops. In January 1999, all 25 adult female baboons in the troop at Paignton Zoo were implanted with Norplant, This inhibits ovulation but does not eliminate oestrous, perineal swellings and the subsequent associated behaviour types still occur. A long term study of the troop since implantation aims to: assess the effect of Norplant on the female baboons' cycle lengths compared with those documented in the wild; examine the gestation and lactating periods of females for whom the implants appears to have had no effect; evaluate the success of the implants as a viable method of contraception and assess any behavioural effects on the troop.

Cycle lengths are similar to those of free-living baboons and since implantation total oestrus-cycle lengths have not changed, however, perineal swellings last for more days of the cycle. To date (18 months after implantation) there have been seven births (five surviving) resulting from conception after implantation.

Introduction

Due to the prolific breeding of Hamadryas baboons, measures often have to be taken to contain numbers in captive troops. Free-living female baboons have an oestrous cycle length of approximately 30 days. Gestation lasts around 170 days; they spend 10 to 12 months in postpartum amenorrhea when lactating and average four cycles post-weaning before conceiving again. This results in a birth interval of almost two years unless the process is accelerated by the death of a previous infant.

In January 1999, all 25 adult female baboons in the troop at Paignton Zoo were implanted with Norplant, a levenorgestrol (LNG) steroid hormone with a progesterone-like activity that is released continuously into the bloodstream for up to two years. This inhibits ovulation but does not eliminate oestrous; perineal swellings and the subsequent expected behaviours still occur. A long term study since implantation is looking at several aspects of Norplant including its effectiveness as a contraceptive and its effects on oestrus cycles and on behaviour of animals in the troop. This poster reports on the first two aspects.

Aims
- Assess the effect of Norplant on the female baboons' cycle lengths compared with those documented in the wild.
- Examine the gestation and lactating periods of females for whom the implants appears to have had no effect.
- Evaluate the success of the implants as a viable method of contraception

Method

The oestrous states for every adult female in the troop were assessed visually on a daily basis continuously from six months after the time of implantation to the present time (18 months post-implantation).
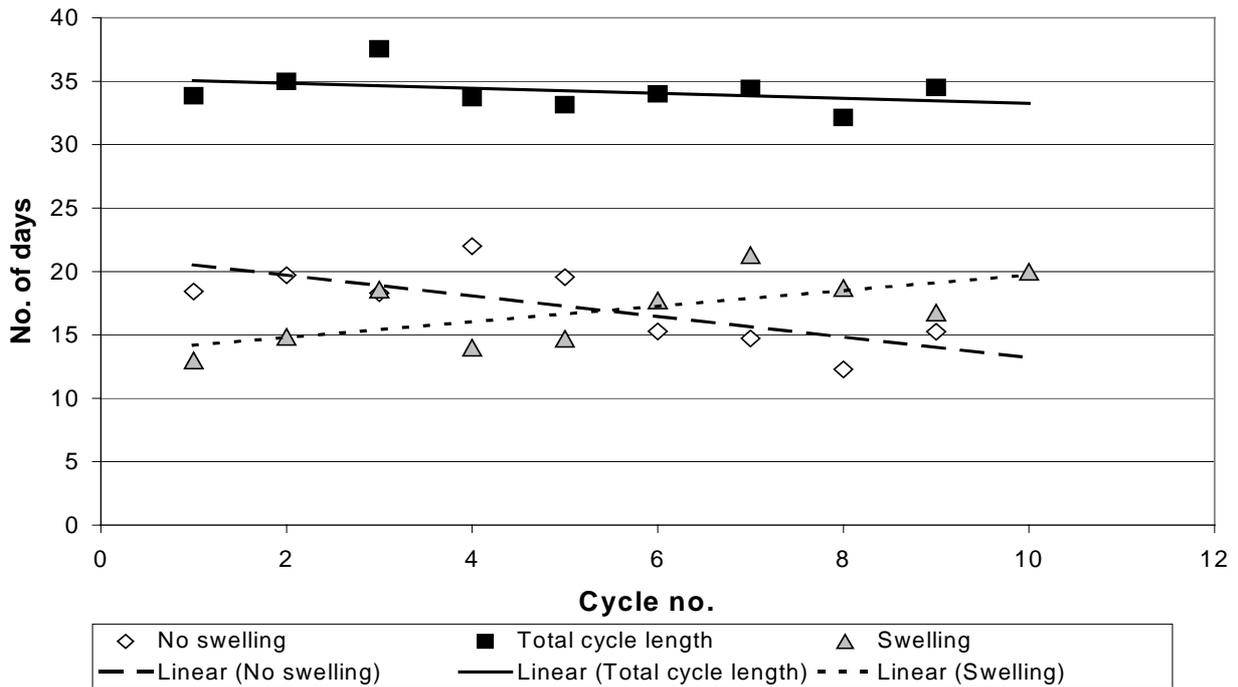
Results

Figure 1. Mean oestrus cycle lengths from six to 18 months post-implantation of the seven adult female baboons who have cycled regularly throughout this period. Regressions indicate that there was no significant change in the total cycle length through the year ($p > 0.05$) but the time spent in some state of swelling during the cycle has increased significantly ($p < 0.05$)
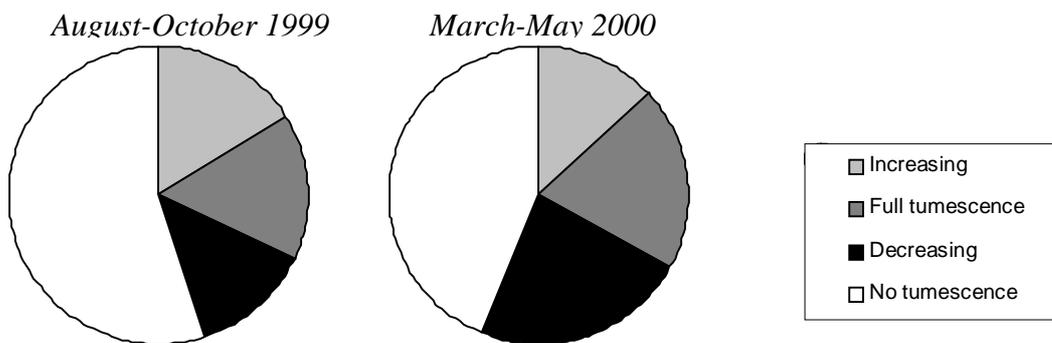

Figure 2. The percentage of time spent in each phase of the oestrus cycle during the first and last three cycles of the sample period. A chi-squared test shows that the distribution of phases has changed significantly ($\chi^2_{[3]} = 31.5$, $p < 0.001$).

	Number of females
Implant apparently working	**15 females** (7 cycling regularly)
Implant not working	**7 females** 5 live births and 2 stillbirths (at least 7 months after implantation so excluding females already pregnant when implanted)
Not known	**3 females** 2 anoestrous (1 old individual since died) 1 still suckling infant conceived before implantation
Matured since implantation	**3 young females** now cycling regularly

Table 1. Status of 28 adult female Hamadryas baboons 18 months since 25 were implanted with Norplant contraceptive in January 1999.

	Free-living	*Captive*
Mean cycle length	30 days	34.3 days
Mean gestation	170 days	174 days

Table 2. Mean oestrus cycle and gestation lengths of free-living baboons and those in the captive troop at Paignton Zoo.

Conclusion
- Since implantation total oestrus cycle lengths have remained constant but the period of perineal swelling has significantly increased
- Seven babies (two stillborn) have been born at least seven months after implantation indicating a 28% failure rate of implants
- Oestrus cycle and gestation lengths of these captive baboons are both four days longer than those reported for free-living animals. More detailed wild data are required to test if this is a significant difference

Development of a comprehensive enrichment programme in an ageing monkey house

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Abstract

At Paignton Zoo an enrichment programme is being devised for the residents of the ageing monkey house and associated section – a total of 15 different species in 16 enclosures. Our aim is to provide all the enclosures with a different enrichment each day, the programme evolving and becoming more complex as more techniques are tried and tested. Therefore, we are evaluating the effectiveness of all enrichment methods so that only those that are of benefit are incorporated into the programme. Evaluation is by detailed behavioural studies and rapid assessment forms.

Many different enrichment methods have been tested including scatter feeds on floor, enclosure roof and in pond, fir cones, feathers, rope balls, browse baskets, hammocks, scent trails, hidden food in various boxes and tubes, kong toys, whole fruit or nuts, mirrors, sand or bark forage pits and numerous puzzle feeders of differing difficulties.

Using the results of previous and current studies, we have developed an initial programme of evaluated enrichment methods. As new methods are tested they will be included in the schedule provided they are proved to be effective. It is hoped that the implementation of this programme will lead to more time- and cost-effective enrichment and help us to achieve our ideal – regular, varied enrichment, achievable with current staffing and resource levels, as a standard component of husbandry in this section of the zoo.

Environmental enrichment research into the effects of different feeding devices upon the behaviour of a group of red-ruffed lemurs

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Abstract

An area of zoo animal husbandry which is being researched, but still requires more research is environmental enrichment.

This paper details the results of altering feeding devices, and the effects on the feeding behaviour of a captive group of red-ruffed lemurs.

Often environmental enrichment devices are put into enclosures and, due to the constraints on time, only the initial reactions of the animals to the devices are observed, but these observations are rarely recorded or analysed.

With the use of simple check sheets and short periods of observation the effects that the enrichment devices have on behaviour can be evaluated and quantified. With this information the extent to which the aims of the device have been achieved can be analysed.

The aims of enrichment are to:
1) To try to prevent or reduce abnormal behaviours in captive animals.
2) To provide opportunities to express normal behaviour, and fuller behavioural repertoires.

The devices used for red-ruffed lemurs at Chester Zoo encouraged longer periods of feeding/foraging, increased activity, and the opportunities to use natural feeding postures.

Rearing methods for captive-bred pheasants

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Abstract
*The aim of this project was to establish factors relevant for successful parental rearing of pheasants in a captive environment. It involved looking at husbandry methods, relating these to breeding success and examining the way in which adult birds interacted with chicks. Differences in behaviour between incubator, foster-reared and parent-reared chicks was compared. The species studied for the behavioural element of the investigation were red junglefowl (*Gallus gallus*), grey junglefowl (*Gallus sonneratii*)*, Temminck's tragopan (*Tragopan temmincki*)*, Himalayan monal (*Lophophorus impeyanus*) and Swinhoe's pheasant (*Lophura swinhoii*)*. Recommendations for successful breeding and rearing of chicks were outlined, bringing together different elements from successful breeders to provide husbandry and rearing guidelines.*

Factors affecting breeding success in captive Carnivora

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Abstract

The breeding success in captivity of 165 species of carnivores is being analysed. Data on breeding in captive collections worldwide, published in the International Zoo Yearbooks, and in the web-based International Species Information System - ISIS (http://www.isis.org/, 2000), have been collected from 1975 to 1996. These data will be used to yield each species' mean litter size and offspring survival rate. They will also be compared with the information from the wild (Gittleman, 1986, 1989, 1996; Novak, 1989) available for 88 species. From this work, we intend to determine which Carnivora species are reproducing well in captivity, and which badly, and if captive born parents are performing better or worse than wild born parents. Using comparative techniques to control for phylogeny (e.g. the Comparative Analysis of Independent Contrasts – CAIC), we will also determine the relationship between captive breeding success and conservation status in the wild, as 48 of the studied species are listed in IUCN reports as endangered. Finally, previous analyses of mean frequency and prevalence of stereotypy across the Order Carnivora will also be used to determine if breeding success and abnormal behaviour in captivity are correlated.

Behavioural studies on captive tapirs *Tapirus terrestris* and giraffes *Giraffa camelopardalis*, with particular attention to feeding

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Abstract

A variety of behavioural and welfare studies were conducted on two species of herbivore at Dublin zoo. The two species with which this project was concerned were Brazilian tapirs Tapirus terrestris *and giraffes* Giraffa camelopardalis*. The behaviour of both species was quantified over twenty-four hours. Results show that both species feed for a significantly lower proportion of time than their wild counterparts. Experiments showed that when extended feeding opportunities were provided, the animals did not necessarily conform to wild-type behaviour. Additional investigations showed that both species demonstrate certain elastic and inelastic properties suggesting that captive animals may have needs which could be different to their wild counterparts. Furthermore, this study suggests that recreating wild type behaviour may in fact not be beneficial to certain captive individuals.*

Introduction

In order to meet nutritional requirements herbivores must feed for a large proportion of their activity budgets. In captivity herbivores are often prevented from performing this behaviour to the same frequency as demonstrated in the wild. There is much controversy regarding how animals should perform in captivity and the welfare implications surrounding zoo animals. Often wild type behaviour is considered to be a valid indicator when assessing how captive animals should behave (Heidiger, 1950; Thorpe, 1965, 1967; Chamove, 1989a). However, whether wild type behaviour is necessarily a requirement or an indication of good welfare for captive animals is controversial (Chamove, 1989a; Veasey *et al.,* 1996).

The concept that animals possess a need or are motivated to perform certain behaviours is not a new (Lorenz, 1950; Hughes & Duncan, 1988; Jensen & Toates, 1993; Mason *et al.,* 1998). These needs can be examined using preference testing (Hughes & Black, 1973; Dawkins, 1983; Hunter & Haupt, 1989). To date preference testing has been conducted on lab (Cooper & Mason, 2000) and farmed animals (Bubier, 1996) and is currently underway on zoo animals (Kinahan, unpublished). Behavioural properties in animals can be classified as either "elastic" or "inelastic". This can be explained using Laidler's (1981) economic "consumer demand theory" (Dawkins, 1983) in which elastic behaviours are defined as those which are reduced or excluded from the repertoire when time or energy is restricted, while inelastic behaviours are carried out at the same level regardless of time or energy constraints. This classification of behaviours allows us to investigate the ranking of behavioural priorities shown by the animal, by adding a cost to carrying out each behaviour.

This study addresses the following behavioural questions and welfare issues with respect to tapirs and giraffes.

 (i) How do the animals behave in a 24 hour period?
 (ii) Is their activity budget similar to that of their wild counterparts?
 (iii) Can wild type behaviour be elicited in a captive environment?
 (iv) How should animals behave in captivity?
 (v) Is wild-type behaviour necessarily the best welfare?
 (vi) Do the animals demonstrate any elastic or inelastic behaviours?

Materials and methods

Animals

Dublin Zoo currently houses two Brazilian tapirs (1: 1) and three giraffes (1:2). All individuals in both species were captive born, and are currently reproductively viable adults.

Feeding experiments

During October 1998 data for both species were collected for each hour throughout the 24 hour day using an instantaneous scan sampling technique, with 30-second inter-sample intervals (Martin & Bateson, 1993). Five replicates of each hour were taken. Behaviours were classified as "events" if they lasted for less than 15 seconds and as "states" if they lasted longer. Events were recorded as frequencies of occurrence, while the total duration of states was recorded as percentages (Altmann, 1974). Hourly records provided the baselines with which experimental records were compared. Daily and 24 hour records provided an overall picture of the individuals' activity budgets in captivity.

Tapirs

The tapirs were observed and their behaviours recorded onto checksheets for 50 minutes of each hour. Feeding experiments were conducted in two sessions during the day; morning observations (10:00-13:00) and afternoon observations (14:00-17:00). The behaviours were divided into seven behavioural categories:

resting	- lying down with eyes open or shut
feeding	- the actual ingestion of food items
locomotion	- movement from A to B
exploratory	- sniffing ground and/or environment, either while stationary or during locomotion
sexual	- any sexual behaviours
aggressive	- any aggressive behaviours
other	- all other behaviours not previously stated

The area of the enclosure in which the animals were at each scan, i.e. inside or outside, and the proximity of the animals to one another were also recorded. Proximity was recorded if the animals were less than a metre apart.

Usually the tapirs were fed in their inside quarters in the morning. Food was provided to them in a single trough from which they both fed. During the experiment the tapirs were provided with four feeding buckets dug into the ground of their outside enclosure. Each day, three out of the four feeding buckets were filled, chosen randomly by the keepers, so the animals did not know which buckets contained food. The ten days of this experiment, "experimental days", in which the buckets were filled, were alternated daily with "baseline days" in which no food was placed in the buckets and the tapirs were fed in their normal trough inside.

Giraffes

The giraffes were observed diurnally from 10:00 to 17:00 for 50 minutes of each hour and data was collected on cheeksheets. Their behaviour was recorded between the hours of 10:00-13:00 and 14:00-17:00. The giraffes' behaviours were classified into 11 behavioural categories:

feeding	- ingestion of food items
foraging	- moving or stationary with heads lowered examining ground
standing	- standing but not moving along
locomotion	- movement from A to B engaging in no other activity
rest	- lying down with eyes open or closed
rumination	- chewing the cud
licking	- licking of inanimate objects such as walls, poles, etc.

   tongue playing - manipulation of the tongue, such as tongue rolling or flipping
   sexual   - any sexual behaviour
   sparring - head butts to another individual or necking
   other   - any other behaviour not previously recorded

Although sparring may be classified as an event, most bouts of sparring lasted over 15 seconds and so, sparring was treated as a state.

Usually the giraffes were provided with one batch of browse in the morning, which was rapidly defoliated by the afternoon. In this experiment, giraffes were provided with plentiful fresh browse piles which were available throughout the day. Browse was tied to their browse poles and gates surrounding the enclosure. This experiment followed a similar pattern to the tapir experiment, alternating experimental days with baseline days in which only their normal browse quantity was provided. Again, for statistical purposes five replicates of each observational hour, on both experiment and baseline days were made.

Statistical analysis
All statistical analysis was carried out on SPSS version 6. Comparisons between two samples were carried out using a non-parametric Mann-Whitney U-test for unmatched samples. This test uses the mean ranks of the observations and demonstrates differences in medians. For comparisons between three or more samples a non-parametric Kruskal-Wallis test for unmatched samples, followed by a post-hoc analysis was used. Similar to the Mann-Whitney U-test, this test uses the mean ranks of the observations and demonstrates differences in medians.

Results
Tapirs
Table 1 shows the difference in the amount of time both individuals spent in each activity when comparing the baseline and experiment, for the morning period of observation. The female showed significant differences in some behavioural categories: a significant increase in locomotory ($U = 50$, $N = 5,5$, $p < 0.01$) and exploratory behaviour ($U = 52.5$, $N = 5,5$, $p < 0.02$). These increases were expected as the tapirs had to move and forage/explore in search of the food filled buckets. These increases coincided with a significant decrease in resting behaviour ($U = 59$, $N = 5,5$, $p < 0.03$) The male showed a similar pattern of increased and decreased behaviours to the female, but these changes did not reach significance.

| | MORNING | | | | AFTERNOON | | | |
| | Male | | Female | | Male | | Female | |
Behaviour	Increase	Decrease	Increase	Decrease	Increase	Decrease	Increase	Decrease
Feed	NS		NS			NS		*
Stand	NS		NS			*		*
Rest		NS		*	NS		*	
Loco	NS		**			NS		NS
Explore	NS		*			*		NS
Sexual	NS		NS			NS		NS
Aggression	NS		NS			NS		NS
Other	NS		NS			NS		*

Table 1. The changes in contribution to the tapirs' activity budgets of each behaviour in the morning and afternoon sessions when food was hidden in buckets outside rather than freely available in a trough inside. NS = p > 0.05, * = p < 0.05, ** = p < 0.01

Comparing these morning results with those obtained in the afternoon, the results appear to be mirrored, such that, behaviours shown to have increased in the morning period, decreased in the afternoon session when the food was no longer available and *vice versa*. There was a significant decrease in the amount of time the male and the female spent standing (male: $U = 64$, $N = 5,5$, $p < 0.04$; female: $U = 55.5$, $N = 5,5$, $p < 0.02$). In addition, the male showed a significant decrease in the amount of time he spent engaged in exploratory behaviour ($U = 57$, $N = 5,5$, $p < 0.02$). The female did not show a significant difference in exploratory behaviour but did however, show a significant decrease in the amount of time spent feeding ($U = 65$, $N = 5,5$, $p < 0.05$). Other significant differences between the baseline and the experiment in the female were a decrease in 'other' behaviour ($U = 59$, $N = 5,5$, $p < 0.05$) and a significantly higher percentage time spent resting ($U = 58.5$, $N = 5,5$, $p < 0.02$). Note that the significant increase in rest for the female in the afternoon mirrors the significant decrease observed throughout the morning period.
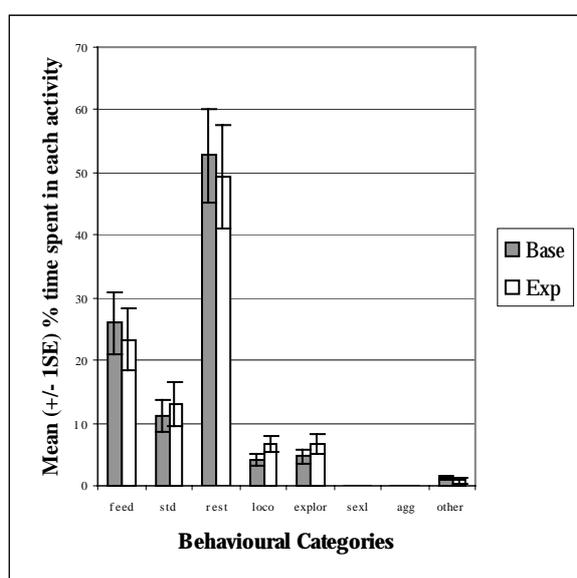

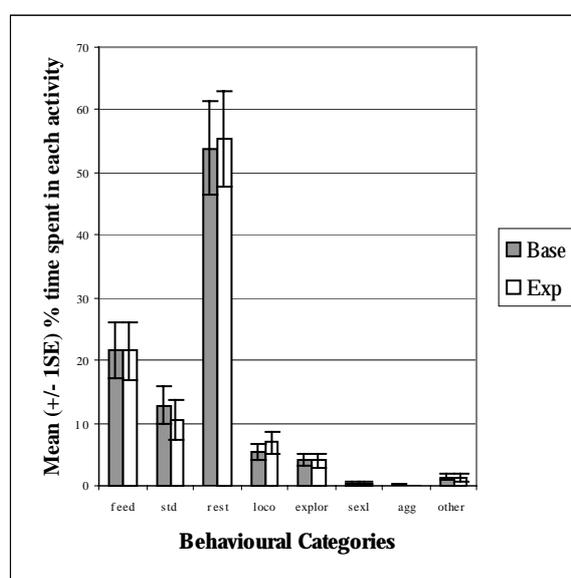Figure 1. Mean (+/- SE) % time spent in each activity for the male for the whole day

Figure 2. Mean (+/- SE) %time spent in each activity for the female for the whole day

Both individuals did show some significant differences in their behavioural repertoire during the morning and afternoon sessions of observation. However, interestingly, when the overall repertoire was examined as a whole day i.e. morning and afternoon combined, both individuals showed no significant differences between the baseline and experiment in any behavioural category (figs. 1 and 2). The mean proportion of time each individual spent in each behavioural category was virtually unchanged under the two treatments. Results of this experiment suggest that tapirs may in fact demonstrate very inelastic behavioural properties. This will be discussed further below.

Area Usage
As expected, due to the fact the tapirs were being fed outdoors, both individuals showed a highly significant decrease in the amount of time they spent indoors throughout the morning observation period ($U = 57$, $N = 5,5$, $p < 0.001$ for both animals). As with the behavioural categories though, this extra time outside in the morning was compensated for by extra time spent inside in the afternoon, so there were no significant differences overall when both sessions were pooled. Thus, time inside shelter also appears to be an inelastic behaviour of captive tapirs.

Proximity
Proximity was recorded where there was less than 1m distance between the two individuals. Both sessions showed a marked decline in the amount of time the individuals spent in proximity to one another. Although this decrease did not reach significance in either the morning or afternoon session analysed separately, it did so when the data for the entire day were pooled ($U = 294$, $N = 10,10$, $p < 0.02$). One possible explanation for this decline in proximity may be the fact that their baseline routine provided food in one feeding trough only, so the two individuals had no choice but to feed together. When the tapirs feed together, perhaps some sort of social bonding takes place, and in the absence of this bonding first thing in the day, the tapirs may remain out of proximity for the rest of the day. These results contrast with those obtained from behavioural categories and area usage, as they do show a significant difference between the experimental situation and baseline. This suggests that proximity may be more elastic than the other categories measured.

Giraffes
Behavioural categories
Table 2 shows the difference between the baseline and experiment in the amount of time each individual spent engaged in each activity recorded, for the morning and afternoon observation periods for the male and two females, F1 and F2.

	MORNING						*AFTERNOON*					
	Male		**F1**		**F2**		**Male**		**F1**		**F2**	
Behav	Incr	Decr	Incr	Decr	Incr	Decr	Incr	Decr	Incr	Decr	Incr	Decr
Feed		NS	NS			NS	NS			NS	**	
Forage		*		**	NS			NS		**		***
Stand	*			NS		*		NS	NS			NS
Loco	NS		NS		NS			NS	NS		NS	
Rumin	NS		NS			NS		NS	NS		NS	
Lick		*		NS		**	NS			**		**
Play		*		NS	NS			NS	NS			NS
Sex		**		NS		NS		NS		NS		NS
Sparr		NS		NS		NS		NS	NS			NS
Other		*		NS		NS		NS		NS		NS

Table 2. The changes in contribution to the giraffes' activity budgets of each behaviour in the morning and afternoon sessions when browse was available all day rather than only briefly in the morning. NS = P>0.05, * = P< 0.05, ** = P<0.01, *** = P<0.001

In the morning session both the male and the F2 female demonstrated a significant decrease in the amount of time they spent in licking behaviour (male: $U = 18$, $N = 5,5$, $p < 0.04$; F2: $U = 12$, $N = 5,5$, $p < 0.007$). The male and female F1, showed a significant decrease in foraging activity (male: $U = 18$, $N = 5,5$, $p < 0.02$; F1: $U = 9$, $N = 5,5$, $p < 0.005$). In addition, the male demonstrated a significant decrease in tongue playing behaviour ($U = 15$, $N = 5,5$, $p < 0.02$), sexual behaviour ($U = 9$, $N = 5,5$, $p < 0.004$) and other behaviour ($U = 15.5$, $N = 5,5$, $p < 0.02$). However, he did show a significant increase in the amount of time spent standing ($U = 15.5$, $N = 5,5$, $p < 0.03$). The female F1 showed no other significant differences. However, female F2 in contrast to the male, showed a significant decrease in the amount of time spent standing ($U = 19$, $N = 5,5$, $p < 0.05$).

The afternoon session revealed no significant difference in any behavioural activity recorded for the male. However, similar to the morning period, both females demonstrated a significant decrease in foraging (F1: $U = 7.5$, $N = 5,5$, $p < 0.005$; F2: $U = 2.5$, $N = 5,5$, $p < 0.001$) and licking (F1: $U = 6$,

N = 5,5, p < 0.003; F2: U = 8, N = 5,5, p < 0.004). Despite all three individuals showing an increase in the amount of time they engaged in feeding, these differences were not significant for the male and the female F1 but were for the female F2 (U = 6.5, N = 5,5, p < 0.002). This increase in feeding was expected since experimental conditions made browse available to them in the afternoon, which previously was not.

Combining the two sessions, an overall diurnal difference can be seen in figures 3, 4 and 5. All three showed a significant decrease in the amount of time spent foraging (male: U = 82, N = 5,5, p < 0.005; F1: U = 35, N = 5,5, p < 0.001; F2: U = 55.5, p < 0.0005) and a significant decrease in licking (male: U = 101, N = 5,5, p < 0.03; F1: U = 63.5, N = 5,5, p < 0.002; F2: U = 43, N = 5,5, p < 0.001). Both the male and the F2 female demonstrated a significant decrease in 'other' behaviour (Male: U = 94, N = 5,5, p < 0.02; F2: U = 98, N = 5,5, p < 0.03). The F2 female showed a further significant decrease in standing (U = 63.5, N = 5,5, p < 0.00). The male also showed a decrease in tongue playing behaviour and sexual behaviour (U = 100, N = 5,5, p < 0.003; U = 96, N = 5,5, p < 0.02). Overall, all three did show a slight increase in the percentage time they spent feeding however, again, it was only the female F2 who showed any significant increase (U = 72, N = 5,5, p < 0.003). In addition to feeding the F2 female also demonstrated a significant increase in locomotory behaviour (U = 103, N = 5,5, p < 0.0001).

Further analysis showed that under experimental conditions there were statistical differences between the individuals. With the male feeding for a significantly lower proportion of his time than either female (χ^2 = 6.1396, df = 2, p < 0.04). Differences also occurred in the amount of time spent standing between all individuals (χ^2 = 6.6572, df = 2, p < 0.05).

Discussion
In captivity, giraffes feed for about 25 – 40% of their activity budget (Kinahan, unpublished), which is significantly lower than the 74% (females) and 50% (males) which is shown by their counterparts in the wild (Pellow, 1984a). Unfortunately, there is no quantifiable data on the activity budgets of Brazilian tapirs. However, the 11% of their time they spend feeding in captivity (Kinahan, unpublished), is significantly lower than the majority of herbivores in the wild. In order for herbivores to meet their daily nutritional requirements, they must feed for a large proportion of their active day; this proportion is usually higher then 50%. Using this as a marker, it is quite reasonable to assume that the 11% spent feeding in captive tapirs is probably significantly lower than their wild counterparts.

Using feeding as an indicator, therefore, the captive giraffes and Brazilian tapirs were not behaving similar to their conspecifics in the wild. To see whether this wild type behaviour could be elicited in captivity greater foraging and feeding opportunities were offered to the animals. The results of these feeding experiments on giraffes showed that despite there being small increases in the time spent feeding, these were not significant in two out the three individuals. The significant increase observed in the F2 female may be explained in terms of hierarchy. Female F2 is the subordinate individual in the group. She was never observed feeding from the same browse poles if either of the other two individuals were present. This meant that the F2 female had to wait until the other two had fed for a sufficient amount of time before she could gain access to the browse that was left. In the afternoon session the F2 female had uninterrupted access to the browse which was now made available, resulting in a significant increase in feeding in the afternoon session and hence, an overall significant increase. However, this increase only raised the F2 female's feeding time to the same level as the F1 female. Despite the availability of browse in the afternoon, none of the individuals increased their levels to the same proportion as their wild counterparts. Similar to the wild however, captive giraffes did follow a pattern of the females feeding for a significantly higher proportion of their time than the male (Pellow 1984b).
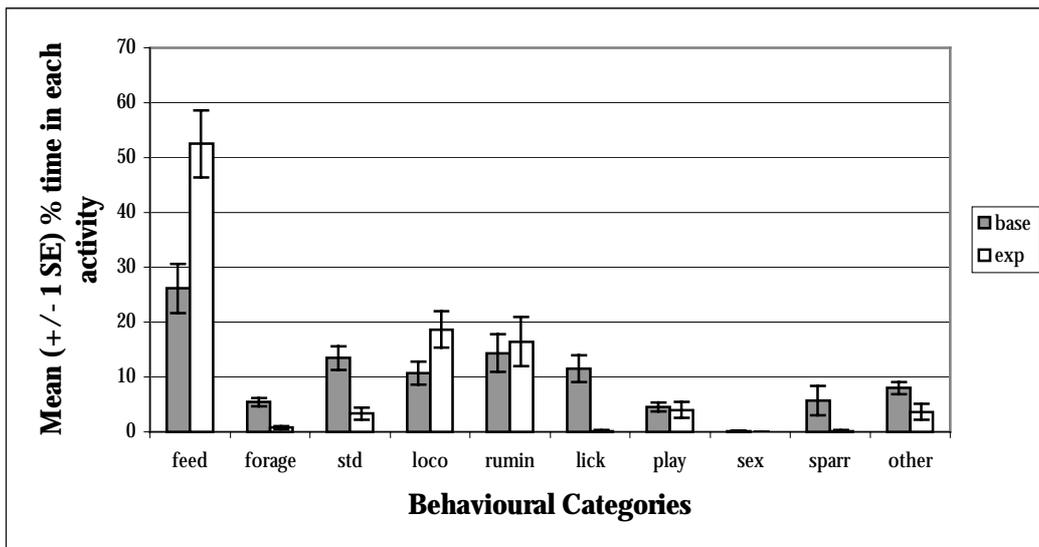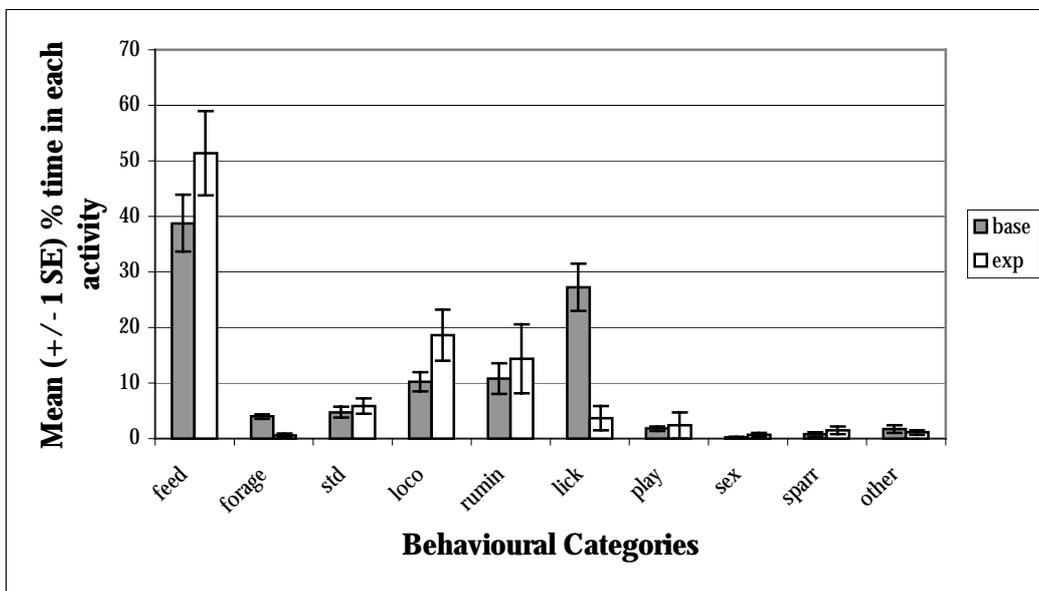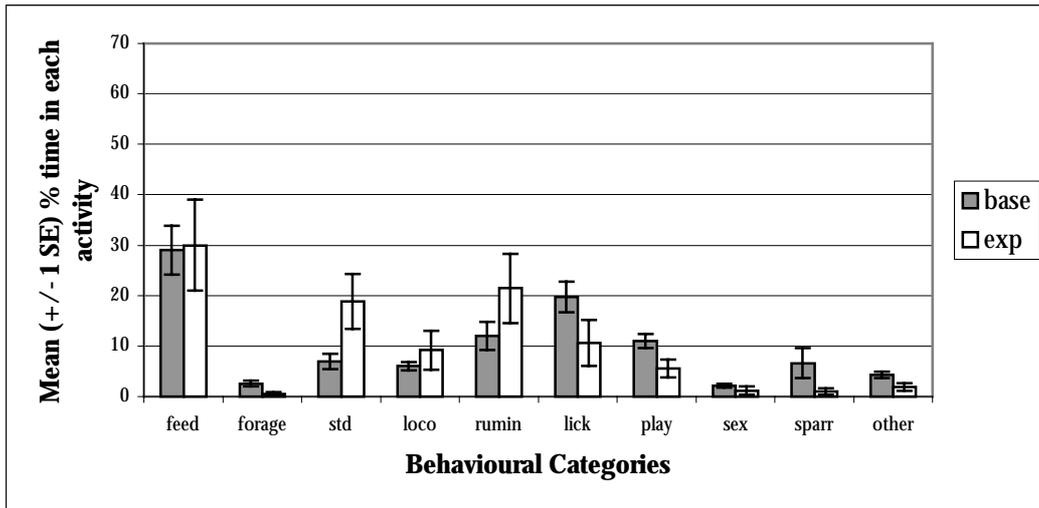
Figures 3, 4 and 5. Time spent performing various behaviours by the male (top), female F1 (middle) and female F2 (bottom) giraffes during baseline and experimental trials over the entire observation period.

Results show that despite being given the opportunity to perform feeding to the same frequency as the wild, the giraffes did not conform to wild type behaviour. This then begs the question of whether it is indeed important and necessary, or even beneficial, to stimulate wild type behaviour in captivity. The fact that the giraffes did not increase their levels of feeding to the wild levels, perhaps suggests that in captivity, they are obtaining sufficient nutrients in their diet in a much shorter time, and have no motivation to extend their feeding time beyond this.

The reduction in feeding time leads to available time in their budget, therefore the animals must utilise this time to perform other behaviours that are perhaps not seen to the same frequency, if at all in the wild. An example of this may be tongue playing and licking, both of which were seen to be reduced in the presence of browse in this experiment, and grazing in captive giraffes, which is a behaviour not seen at all in the wild. An analogous example can be seen in the hunting behaviour of big cats. It has been suggested that the inability of large cats to perform hunting behaviour in captivity has consequences on their welfare (Leyhausen, 1979), however, Lindburg (1988), demonstrated that in the wild, cats will refrain from hunting if scavenging becomes an available option to them. Therefore, the absence of this hunting behaviour is neither unnatural nor necessarily an indication of poor welfare. In other words, if an animal is prevented or is not performing a particular behaviour in captivity, in its absence another behaviour may be created or performed to replace the lacking behaviour. Studies on captive primates have also shown that wild type behaviours are not essential for welfare to be improved (Chamove, 1989a).

In addition to these arguments against recreating wild type behaviour in captivity, whether wild type behaviour is optimal welfare is debatable. Wild animals' welfare is often compromised by starvation, disease, predation, poaching, habitat destruction etc. (Veasey *et al.,* 1996), and so, in terms of welfare and criteria for assessing welfare, wild situations may not necessarily reflect the best welfare.

Similar to the giraffes, the tapirs did not show significant increases in their feeding behaviours. In fact if the whole day is considered, the tapirs demonstrated no significant changes in any of their behaviours performed. The idea that animals possess a "need" to perform certain behaviours is not a new concept. Some argue that animals have a need to perform all the behavioural activities as shown by their wild counterparts (Thorpe, 1967). However, from the arguments presented above perhaps captive animals have different needs than those of their wild counterparts. Behavioural needs and their importance can be equated with elasticity and inelasticity using Laidlers' (1981) economic "consumer demand theory" (Dawkins, 1983). Relating this theory to animal issues and biology, inelastic properties are properties which should remain despite an energetic or time constraint and elastic behaviours or properties should be eliminated or reduced greatly under these constraints. The implications for this with respect to captive studies is that behaviours which are considered abnormal in frequency or occurrence should be examined for elasticity before attempting to eliminate them and replace them with wild type behaviours. This would indicate whether the animal possesses a "need" to behave this way in captivity, despite it being different from wild counterparts.

This study demonstrated a definite inelastic "need" in the proportion of time the tapirs spent in each activity during their budget. This inelasticity proved to be so stringent that the proportion of time allotted to each behaviour remained virtually unchanged. The giraffes however, showed greater elasticity for all behaviours except feeding. This suggests that unlike the tapirs, giraffes may be more elastic when it comes to altering their captive behaviour.

Conclusion

There are implications here for possible reintroduction. It is extremely important when captive animals are on a reintroduction programme that they posses the ability to survive in the wild. This

ability will largely depend on their behavioural skills (Beck *et al.,* 1994). Therefore, it is vital to recreate wild type behaviours when dealing with captive breeding and reintroduction programmes. A knowledge of the animals' inelastic and elastic qualities becomes important when dealing with this issue, as elastic qualities may be easier to mould into desired behaviours than the animals' inelastic qualities.

However, this study provides a dilemma. The dilemma occurs when we are dealing with captive individuals which are neither on a reintroduction program nor are endangered, as in the case of giraffes and Brazilian tapirs. The problem lies in the fact that if captive animals do have different needs and behavioural requirements than their wild counterparts, surely by trying to force them into behaving in a similar way to their conspecifics in the wild their welfare is being compromised. So do we jeopardise the welfare of the individuals in order to increase the welfare of future species and populations? Unfortunately, like many welfare issues there does not seem to be a concrete answer to this problem, and the only answer lies in personal opinion and decision.

Acknowledgements

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Oral behaviours performed by giraffes at Chester Zoo

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Abstract
As large herbivores, wild giraffes spend a large proportion of their daily activity engaged in feeding and feeding-related behaviours. Captive giraffes will be expected to also display high levels of feeding-related (oral) behaviours. The six giraffes (January-March 2000) at Chester are housed in an indoor enclosure with access to a larger outdoor area. The feeding regime carefully reflects likely wild giraffe feeding activity and seeks to eliminate the possibility of oral behaviours becoming stereotyped. The main aim of this study was to simply compare performance of a range of behaviours, focussing on oral ones, in the indoor and outdoor areas. Equal numbers of scan samples were carried out to measure behaviour performance. Focal sampling data were also collected on individuals. Preliminary analysis of scan sampling data indicate significant differences in performance of a range of oral behaviours indoors and outdoors e.g. 'bark stripping', 'eating', and 'licking the bars' were performed more indoors and 'rumination' was performed more outdoors. Overall levels of oral behaviours that could be described as stereotyped are low but clear differences in performance of behaviours by individuals were also shown. The findings emphasise the need for consideration of individuals in providing enrichment in captivity. They may be of value in the further development of enrichment regimes at Chester.

Introduction

In the wild giraffes spend a large proportion of their day feeding and searching for food. Pellew (1984) determined that males on average spend 43.2% and females 53.2% of their day feeding, depending on seasonal factors. Intense feeding occurs post-dawn and pre-dusk when temperatures are lower. Around the middle of the day, giraffes are less mobile and tend to ruminate (Pellew, 1984). At all times of year females tend to feed more than males.

Giraffes have been kept in zoos for over 150 years and are a popular exhibit. They are expensive to keep as they require large amounts of food (Dagg & Foster, 1982). More importantly, they are noted for the performance of oral behaviours which may be stereotyped in nature (Dittrich, 1976; Mason, 1991) and may make up a large proportion of daily activity (Koene & Visser, 1997). These present a particular problem for keepers and a range of strategies are employed to help reduce performance of such behaviours. Increasing the amount of fibre increased rumination levels in one study (Baxter, 1999) and reduced stereotypies. Addition of extra browse had a similar effect in reducing stereotypic tongue-playing in another study (Keone & Visser, 1997).

This study was purely observational and involved no manipulation of the environment. The giraffes at Chester were observed indoors and outdoors and their behaviour measured and compared in these two environments. The aim was to examine, in detail, observed levels of oral behaviours, including those that might be described as stereotyped. This may reveal detailed differences in performances of oral behaviour and be of value in the further development of enrichment programmes.

Study animals

At the time of the study (January-April 2000) there were six giraffes at Chester Zoo (2 males: Cormac [dominant] and Bentley; 4 females: Penny, Samara, Geraldine and Mia), though the younger male was transferred elsewhere towards the end of this period. Penny and Samara were pregnant at the time of data collection.

The giraffes are fed twice daily, morning and late afternoon, simulating natural peaks in feeding behaviour. Their diet includes pellets, fresh fruit and vegetables. Once or twice a day they are given browse to promote natural bark-stripping behaviour. Water is freely available. The indoor enclosure is separated from the outside by large metal doors and subdivided to keep Cormac separate from the females at night. Bedding, lucerne hay and water are available. Outside the area is concrete, soil and grass. Five of the six trees have their bark protected, the other has been stripped. A moat separates the enclosure from the public and provides water.

Methods
Many hours were initially spent devising a detailed ethogram (table 1), with reference to Baxter (1999) and allowing the observer to become thoroughly familiar with the behaviours and recording techniques. Scan and focal sampling were carried out; nine hours total scan observations for each condition: indoors and outdoors. This experiment was a within-subjects design with six giraffes compared for frequency of performance of oral behaviours indoors and outdoors. Data were not normally distributed so a non-parametric Wilcoxon signed rank test was used for each comparison. A Friedman two-way ANOVA was also used to examine the focal data for consistent differences in performances of those behaviours that could be described as stereotyped (LB, LD, LW, TP – see ethogram).

Abbreviation	Description of behaviour
W	Walking
D	Drinking, bending head in water trough and lapping water using tongue
E	Eating of pellet food, browse or other food provided e.g. fruit including obtaining hay from hay trough and fresh grass
S	Standing still, no movement of body
BS	Bark stripping of browse provided and trees within enclosures indoor or outdoor, includes using the tongue to wrap around the branches to bring close to the mouth
TP	Tongue playing, expelling tongue from mouth and moving it side to side in the open air
LB	Licking bars of enclosure including gates. Outdoors this was the metal poles and the trees that could not be accessed because of the wire mesh.
LW	Licking stone walls of enclosure inside or outside
LD	Licking large metal doors of enclosure either inside or outside
RUM	Rumination of a bolus including regurgitation, chewing and swallowing of a bolus (cud)
SF	Searching for food, head lowered to the floor and moving forward
L	Lying down on floor of enclosure
SL	Licking the salt lick provided within the indoor enclosure
SLEEP	Sleeping, different from lying down as head is curled round on the body
INT	Interactions between giraffes e.g. biting, kicking and bodily contact e.g. necking i.e. one giraffe rubbing its head against another
OS	Animal out of sight
OT	Other behaviours including head rubbing, scratching, urination, excretion and flehmening or urine testing of females

Table 1. Ethogram of giraffe behaviour at Chester Zoo

Results

Table 2 shows the results of Wilcoxon tests performed for each oral behaviour, comparing frequency of performance indoors and outdoors. For LB, BS and E these behaviours were performed significantly more indoors than outdoors while the reverse is true for R.

Oral Behaviour	Significance level (2-tailed)
Tongue Playing	Not significant
Licking the Doors	Not significant
Licking the Bars	$p < 0.05$
Licking the Walls	Not significant
Bark Stripping	$p < 0.01$
Rumination	$p < 0.01$
Eating	$p < 0.01$

Table 2. Results of Wilcoxon signed rank tests to compare frequency of oral behaviours performed inside and outside.

Figure 1 illustrates the different behaviours and the variation in performance shown by individuals. There are clear differences in individual behaviour. A graph for tongue-playing is not shown as only Cormac performed this behaviour and for only around 1% of total observation time.

Figure 2 summarises the behaviours performed at an individual level, again illustrating clear differences in how giraffes perform oral behaviours. This is borne out statistically; Friedman two-way ANOVA indicates a significant pattern in levels of performance of behaviours ($\chi^2 = 12.63$, $p < 0.01$).

Discussion

There are clearly significant differences in performance of oral behaviours in the indoor enclosure compared with the outdoor enclosure. Some of these may be simply due to the different opportunities afforded by the two different areas but these results provide a basis for further detailed investigation. It is very clear that different individuals perform behaviours at very different frequencies including those that are usually described as stereotypic. Overall the performance of such behaviours was very low, a tribute to the careful husbandry employed at Chester Zoo. In most cases where these behaviours are shown, levels of rumination are lower, as previous studies have shown. The dominant male only showed tongue-playing and at very low levels. Two females showed relatively high (compared to the others) levels of 'stereotyipc' behaviour: bar and wall licking (Penny) and door licking (Geraldine). Reasons for these results are presently being explored and further, *a postiori* analyses will be undertaken.
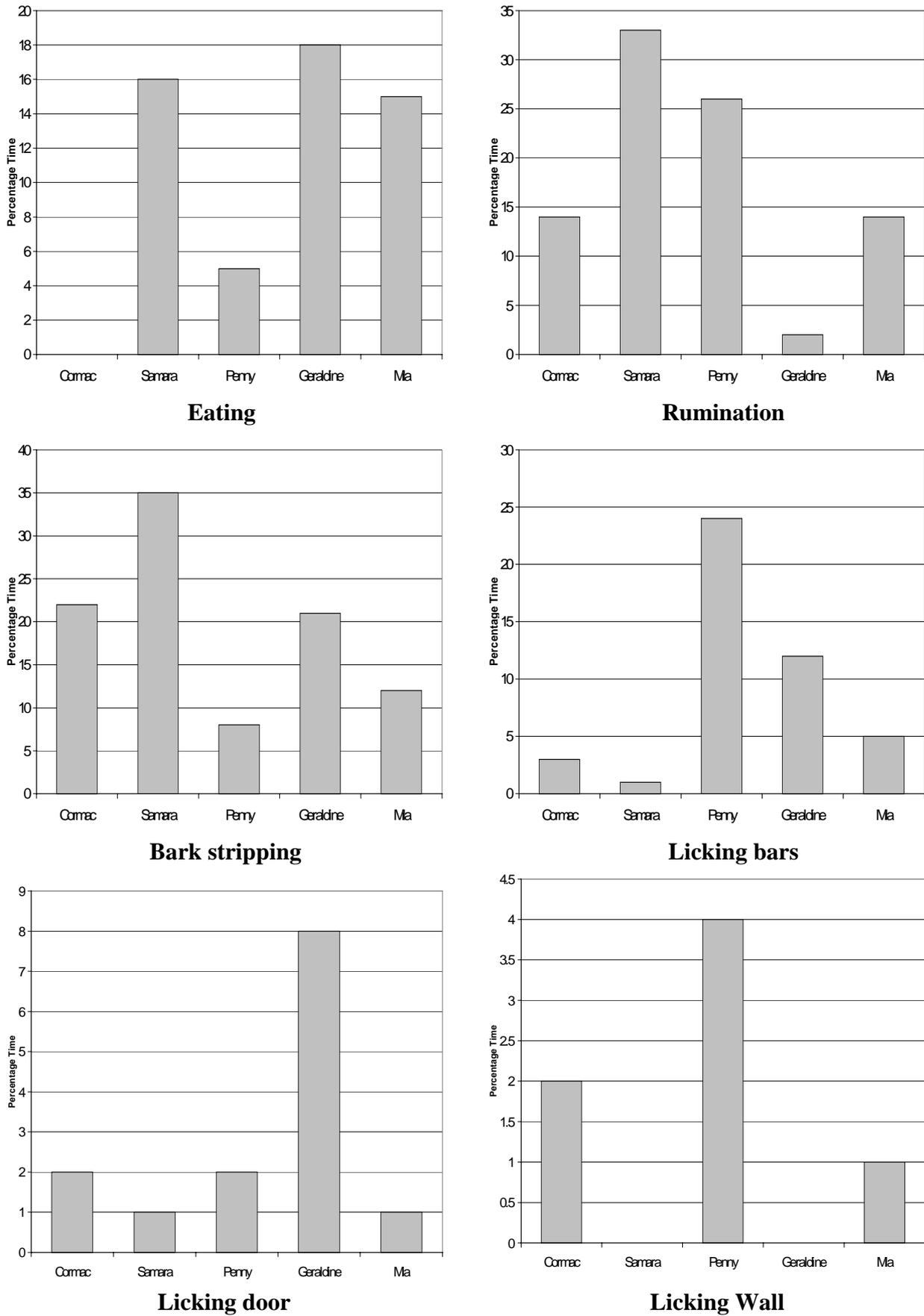
Figure 1.   Percent time (pooled from all observation periods) spent performing various oral behaviours by all giraffes at Chester Zoo.

Cormac

Samara

Penny

Geraldine

- ■ Tongue playing
- ▫ Eating
- □ Bark stripping
- ▨ Ruminating
- ▨ Licking bars
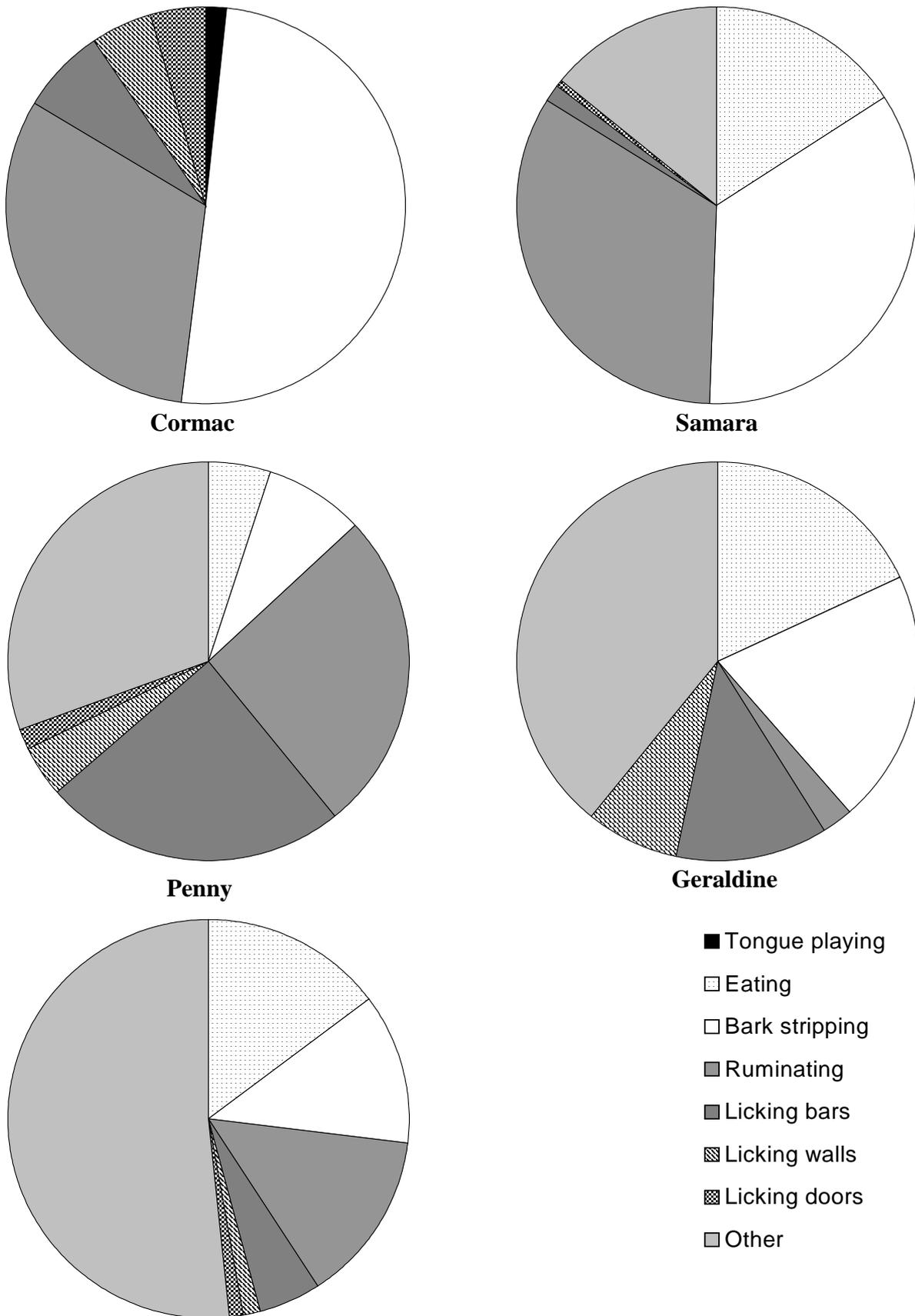- ▨ Licking walls
- ▨ Licking doors
- ▫ Other

Figure 2. Proportion of time (pooled from all observations) spent performing various behaviours by all giraffes at Chester Zoo

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Behavioural implications of prolonged natal-group residency: the integration and social behaviour of non-dispersing Burchell's zebra (*Equus burchelli*) and Przewalski's horses (*E. przewalskii*) at Chester Zoo

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Abstract
In harem-living equid species young individuals disperse from their natal groups; sexually-immature males join bachelor groups, females are abducted into new harems by young stallions. As wild populations become increasingly isolated dispersal opportunities decline. This is also the case in captivity for some species with low transfer rates between zoos. This study is a first step towards assessing the behavioural effects of non-dispersal in Przewalski's horses and Burchell's zebras at Chester zoo.

Individuals in both groups had preferred partners for proximity. All horse mother-daughter dyads were reciprocal nearest neighbours significantly more often than expected by chance. For zebra all three mother-second daughter dyads exhibited significant preferences for proximity partners. Responsibility indices indicate that the daughter was primarily responsible for proximity maintenance. Two distinct subgroups were apparent within the zebra group, and importantly both foals with younger siblings appeared to have undergone limited transfer within the group. The young zebra stallion appears to have successfully integrated into his natal group by breaking contact with his mother, establishing bonds with peripheral females, and maintaining a stable (but probably subordinate) relationship with the harem stallion, by initiating regular affiliative contact.

It appears that individual equids can adapt to prolonged natal-group residency without causing disruption to the existing social structure. This result bodes well for the future of similar wild populations, but more long-term study is recommended.

Introduction
Dispersal from the natal group is a common feature of many animal populations. In harem-living equids, immature males join bachelor groups whilst females are abducted into new harems by young stallions (Klingel, 1975). As wild habitats become increasingly fragmented, populations become isolated and dispersal opportunities decline. This may also be true in captivity, as 'common' species are often maintained with low transfer rates. In both cases the duration of natal-group residency is likely to exceed puberty. Whilst the potential genetic implications of non-transfer are well researched and understood, the behavioural effects remain less so. This report represents an initial step towards assessing the behavioural effects of non-dispersal, detailing an investigation of social relations within an all mare group of Przewalski's horses *(Equus przewalskii)* and a harem-group of Burchell's zebras *(E. burchelli)* at Chester Zoo.

Methods
Animals studied
The Przewalski's horse group (fig. 1) consisted of six adult mares housed as an all mare group. No males were present throughout the study period. The Burchell's zebra group (fig. 2) was maintained as a harem, made up of a single adult stallion with five adult mares and two juvenile offspring (one male, one female). The stallion ('B') was responsible for all breeding within the group.
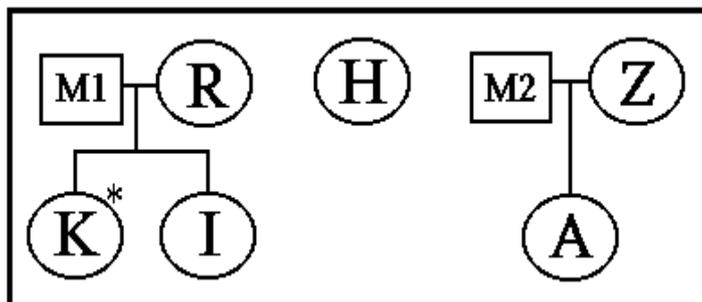
Figure 1. Genetic relations within the *E. przewalskii* group at Chester Zoo. Males M1 and M2 were not present during the study. Squares represent males, circles females, * indicates the older sibling where appropriate.
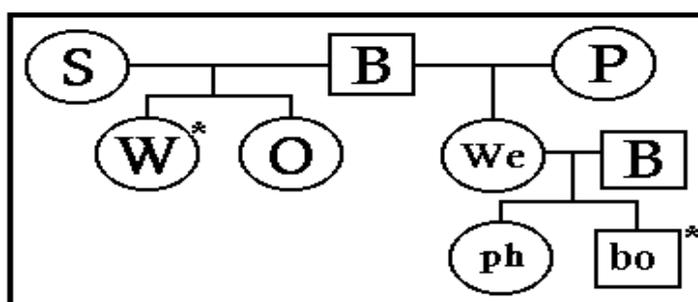

Figure 2. Genetic relations within the *E. burchelli* group. 'B' is the same individual. Squares represent males, circles females; lower-case lettering indicates immature animals, * indicates the older sibling where appropriate.

Husbandry
Both groups had access to two indoor feeding stalls, a hardstand area and a non-grass paddock. Individuals were fed once daily on hay hung in racks and concentrated feed in shallow rubber buckets.

Observations
The Przewalski's horse and Burchell's zebra groups were studied over a five month period (October 1999-April 2000) at Chester Zoo. Individuals were recognised by coat colour/striping pattern. Fifty hours of data were collected for both groups. As it was not possible to observe all areas of the enclosure simultaneously, the section containing the largest number of individuals was observed. When the group was split evenly between sections, the house section was observed as group proximity was likely to be higher and the probability of interaction greater.

Group scan samples were taken at five minute intervals (Altmann, 1974), noting position (of right fore-foot) and activity onto enclosure plans. The percentage of time that each individual spent in close proximity (within 3m) to all other individuals was estimated from the maps. Additionally, each individual's nearest of these 'neighbours' was recorded from each map. Chi-square analysis was applied to these data to test for non-random spatial association. In determining expected values, it was assumed that each individual had an equal probability of associating with all other individuals within the group.

All social interactions were recorded *ad lib.* (Altmann, 1974) and were later classified as either agonistic or affiliative (Wells & Goldschmidt-Rothschild, 1979).

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Responsibility indices (Hinde & Atkinson, 1970) were calculated for all interacting dyads. The function used was:

$$RIa = [(APa) / (APa + APb)] \times 100$$

where: RIa = responsibility index for individual A (i.e. the percentage of dyad specific interactions initiated by individual A); APa = the number of approaches for interaction which are due to individual A; APb = the number of approaches for interaction which are due to individual B.

Responsibility indices were interpreted as an estimate of an individuals relative contribution towards dyadic proximity maintenance.

Non-parametric statistics were applied throughout, using the Statistical Package for the Social Sciences (SPSS).

Results
Spatial association
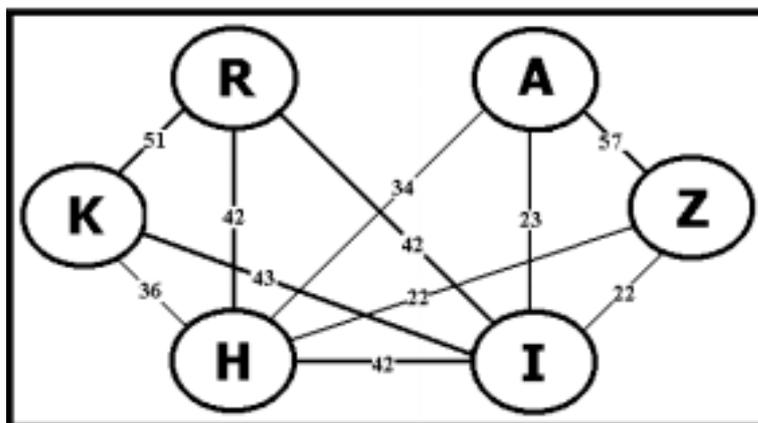Sociograms for both groups (figs. 3 and 4) indicate that sociospatial distribution is non-random.

Figure 3. Proximity sociogram for *E. przewalskii.* The percentage of scan samples in which individuals were in close proximity (within 3m) during 50 hours observation. Values <20% are not included. Circles represent females, squares males, letters distinguish individuals.
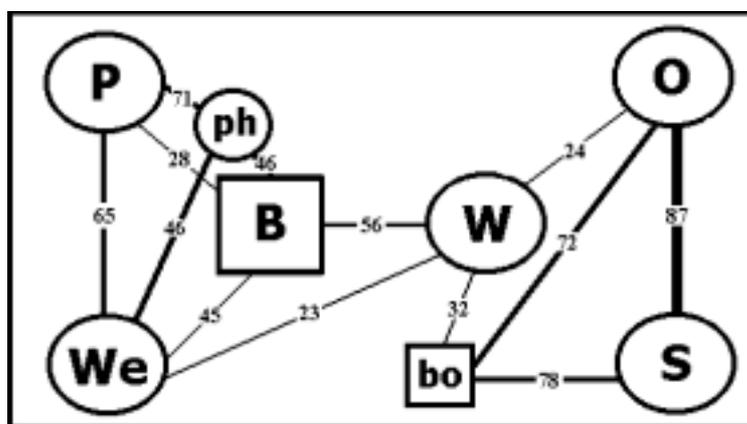

Figure 4. Proximity sociogram for *E. burchelli.* The percentage of scan samples in which individuals were in close proximity (within 3m) during 50 hours observation. Values <20% are not included. Large shapes represent adult animals, smaller shapes subadults, circles females and squares males, letters distinguish individuals.

This is confirmed by chi-square analysis (tables 1 and 2), showing that individuals spent a significant (p < 0.05) percentage of time as the nearest-neighbour of particular individuals within the group. The following dyads were each others nearest neighbour significantly often, regardless of which is the focal individual:

Zebra group   Horse group
P – We   R - K
Ph – We   R - I
O – S   A - Z
Bo – S
Bo – O
B – W

Of eight mother-offspring dyads, six were nearest-neighbours significantly often (p < 0.05). Importantly, the two zebra mother-offspring dyads (We-Bo & S-W) that were not nearest neighbours significantly often both involved the older of two siblings. The zebra group appears to consist of two sub-groups based on proximity.

Focal indiv.	chi-sq.	Nearest Neighbour					
		R	K	A	I	H	Z
R	Obs.		206	18	127	104	8
	Exp.		92.6	92.6	92.6	92.6	92.6
	Chi-		138.87 *	60.10	12.78 *	1.40	77.29
K	Obs.	219		18	113	57	12
	Exp.	83.8		83.8	83.8	83.8	83.8
	Chi-	218.13 *		51.67	10.17	8.57	61.52
A	Obs.	16	21		69	176	125
	Exp.	81.4	81.4		81.4	81.4	81.4
	Chi-	52.54	44.82		1.89	109.94 *	23.35 *
I	Obs.	142	102	86		85	42
	Exp.	91.4	91.4	91.4		91.4	91.4
	Chi-	28.01 *	1.23	0.32		0.45	26.70
H	Obs.	127	68	67	142		44
	Exp.	89.6	89.6	89.6	89.6		89.6
	Chi-	15.61 *	5.21	0.25	31.04 *		23.20
Z	Obs.	9	14	272	49	45	
	Exp.	77.8	77.8	77.8	77.8	77.8	
	Chi-	60.84	52.32	484.75 *	10.66	13.83	

Table 1. Chi-square values for nearest neighbour percentages in *E. przewalskii.* Significance (at the 0.05 level) is indicated by *, and these are only shown where observed exceed expected values, indicating non-random association.

Focal Indiv.	chi-sq.	Nearest Neighbour							
		B	We	W	P	S	O	Bo	Ph
B	Obs. Exp. Chi-		97 71.43 9.15	187 71.43 186.99 *	10 71.43 52.83	22 71.43 34.21	21 71.43 35.60	49 71.43 7.04	114 71.43 25.37 *
We	Obs. Exp. Chi-	57 69.43 2.23		5 69.43 59.79	123 69.43 41.33 *	1 69.43 67.44	0 69.43 69.43	21 69.43 33.78	279 69.43 632.57 *
W	Obs. Exp. Chi-	211 56.86 417.85 *	4 56.86 49.14		13 56.86 33.83	10 56.86 38.62	31 56.86 11.76	79 56.86 8.62	50 56.86 0.83
P	Obs. Exp. Chi-	10 52.85 34.74	216 52.85 503.65 *	6 52.85 41.53		3 52.85 47.02	1 52.85 50.87	4 52.85 45.15	130 52.85 116.62
S	Obs. Exp. Chi-	10 69.29 50.73	4 69.29 61.52	2 69.29 65.35	1 69.29 67.30		250 69.29 471.30 *	214 69.29 302.22 *	4 69.29 61.52
O	Obs. Exp. Chi-	16 70.57 42.20	20 70.57 36.24	0 70.57 70.57	1 70.57 68.58	302 70.57 758.96 *		153 70.57 96.28 *	2 70.57 66.63
Bo	Obs. Exp. Chi-	38 56.14 5.86	75 56.14 6.34	20 56.14 23.26	2 56.14 22.21	114 56.14 59.63 *	126 56.14 86.93 *		18 56.14 25.91
Ph	Obs. Exp. Chi-	88 68.14 5.79	263 68.14 557.24 *	35 68.14 16.12	73 68.14 0.35	3 68.14 62.67	2 68.14 64.20	13 68.14 44.62	

Table 2. Chi-square values for nearest neighbour percentages in *E. burchelli*. Significance (at the 0.05 level) is indicated by *, and these are only shown where observed exceed expected values, indicating non-random association.

Interactive behaviour
In both groups, dyad-specific interactions are primarily either agonistic or affiliative, dyadic interaction initiation often being primarily one-sided. Responsibility indices suggest that mother-offspring proximity is maintained by offspring initiated affiliative contact.

Discussion
Despite superficially exhibiting species-typical social organisation, group demography may be skewed by enforced natal-group residency. This is expected particularly within captive groups of 'common' species that are not included in cooperative breeding programmes.

Individuals in both study groups had preferred partners for proximity, which is consistent with other studies where preferred associate relationships are a common feature of group life (Kimura, 1998). All horse mother-daughter dyads, and all three zebra mother-second daughter dyads were nearest neighbours significantly often. In all cases, daughters appeared primarily responsible for proximity maintenance through initiation of affiliative contact as indicated by 'responsibility indices'.
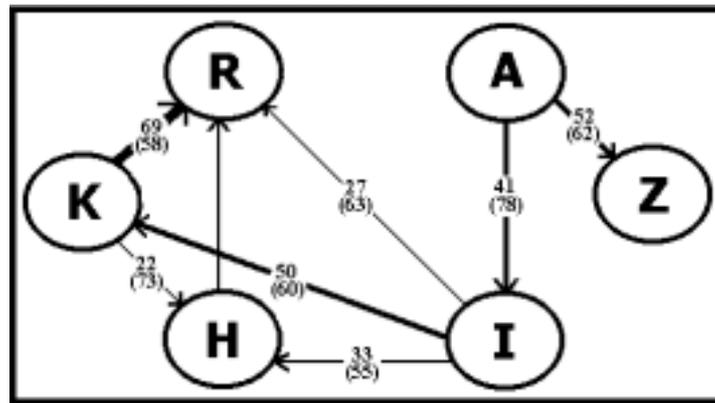
Figure 5. Affiliative interactions between dyads in the *E.przewalskii* group. The total frequency of affiliative interactions between group members where the identity of the initiator was known. Arrows represent the most frequent direction of initiation. Numbers in brackets represent the responsibility index for that dyad in the direction of the arrow. Frequencies <15 are excluded.
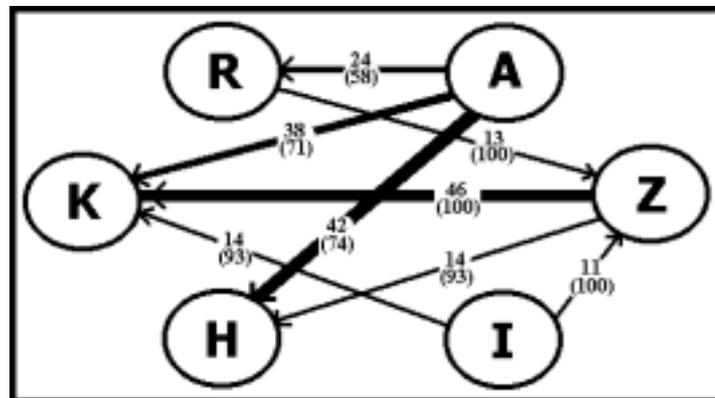

Figure 6. Agonistic interactions between dyads in the *E.przewalskii* group. The total frequency of agonistic interactions between group members where the identity of the initiator was known. Arrows represent the most frequent direction of initiation. Numbers in brackets represent the responsibility index for that dyad in the direction of the arrow. Frequencies <10 are excluded.
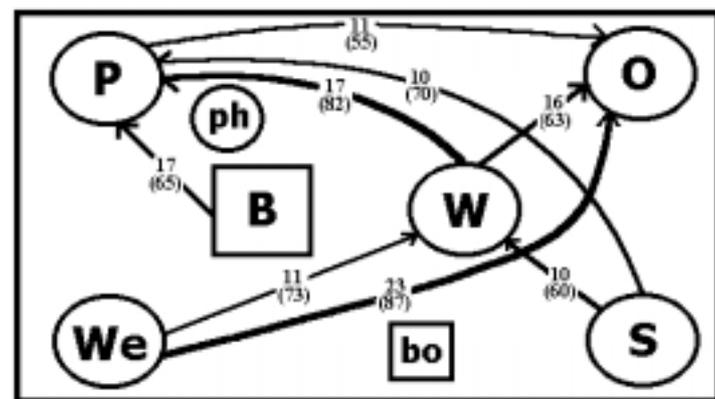

Figure 7. Agonistic interactions between dyads in the *E.burchelli* group. The total frequency of agonistic interactions between group members where the identity of the initiator was known. Arrows represent the most frequent direction of initiation. Numbers in brackets represent the responsibility index for that dyad in the direction of the arrow. Frequencies <10 are excluded.

Figure 8. Affiliative interactions between dyads in the *E.burchelli* group. The total frequency of affiliative interactions between group members where the identity of the initiator was known. Arrows represent the most frequent direction of initiation. Numbers in brackets represent the responsibility index for that dyad in the direction of the arrow. Frequencies <10 are excluded.
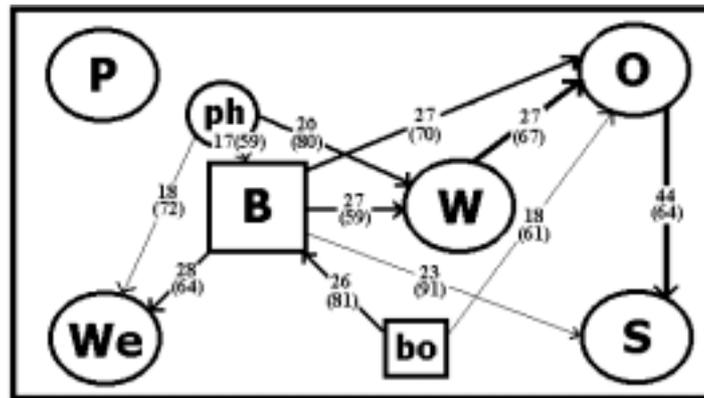
The apparent existence of two subgroups (based on proximity) within the zebra group is probably not surprising, as the enclosure contains two feeding stalls of restricted size. The fact that each subgroup contains one of the two males is, however, worthy of note. Additionally, both foals with younger siblings (Bo and W) appear to have undergone limited (intra-group) transfer, moving out of their mother's subgroup. The young stallion (Bo) appears to have successfully integrated into his natal group by establishing bonds with peripheral females and initiating regular affiliative contact with the harem stallion (B).

These results show that non-dispersed, sexually mature equids may successfully integrate into their natal group apparently without disruption to the existing social structure. This bodes well for the future of similar populations worldwide, and has important implications for the captive management of endangered species. Socially adapted individuals in biologically sound groups are an important prerequisite for successful reintroduction (van Dierendonck & de Vries, 1996). Natal group transfer is therefore proposed as an important and as yet poorly researched aspect in this respect.

Conclusions
Longer-term study of a greater number species is important. Particular attention should be paid to the time when dispersal would normally occur, and when subsequent foaling occurs.

Acknowledgements

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How different captive environments affect the behaviour of Sulawesi crested black macaques (*Macaca nigra*)

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Abstract

The genus Macaca *includes 15 species which are widespread in habitat and whose behaviour varies considerably. Species typical behaviours have to be understood when housing macaques in captivity, as the same environmental feature can stimulate different behaviours in different species e.g. providing visual barriers within a stump-tailed macaque enclosure decreases aggression, while visual barriers increase aggression in pig-tailed macaques (reported in Carlstead & Shepherdson, 1994). In this context, it is important to study identified species of macaque to develop management plans for those held in captivity. Sulawesi crested black macaques (*M. nigra*) are highly endangered due to anthropocentric threats (Kinnaird & O'Brien, 1996) and so ex-situ conservation programmes are their only chance of survival in the short term. This study investigated the activity budget of eight troops of captive Sulawesi macaque held in seven zoos across the UK and Ireland. Different troops were exposed to different environmental factors (social composition, enclosure size and complexity, feeding regime etc.). The activity budgets of macaques held at different zoos were significantly different. In this study suggestions are made which link certain environmental factors with types and levels of behavioural expression.*

Introduction

Sulawesi crested black macaques are highly endangered in the wild, due to hunting and deforestation (Kinnaird & O'Brien, 1996). Until these threats are controlled the only definite route to survival is through a captive-breeding programme in which a population of Sulawesi macaques can be protected *ex situ* and re-introduced into the wild when they would be safe. Frankham *et al.*, (1986) discussed the effect of selection pressures on captive populations and concluded that they were sufficiently different from the wild as to reduce the chance of captive-bred animals surviving in the wild if re-released. Five main behavioural categories have been identified as those required by primates to survive in the wild: orientation and locomotion; feeding and foraging; obtaining suitable places to rest; interspecies interactions including predator avoidance and finally, intraspecific interactions (Box, 1991). To establish the impact of captivity on behaviours essential for survival in the wild it is necessary to identify environmental features that affect behaviour, as they vary considerably between zoos.

Activity budgets can provide general information about how the environment is affecting broad state behaviour categories e.g. whether an animal spends more time resting and less time foraging, but not whether the behaviour pattern used for foraging is any different from that expressed in the wild. The effect of captivity can be established through comparing the activity budget between wild and captive con-specifics or captive con-specifics held at different zoos (Veasey *et al.,* 1996; Ogden *et al.,* 1993). It is this latter comparison which will be made in this paper.

The genus *Macaca* is diverse in distribution and behaviour, including 15 species, which live between Gibraltor (Europe) and the mountains of Japan (Asia) (MacDonald, 1984). Seven macaque species are endemic to Sulawesi, Indonesia including the Sulawesi crested black macaque, *Macaca nigra* (Fooden, 1969). The effect of captive environmental variables on macaque behaviour has been observed as species specific e.g. the inclusion of visual barriers lead to increased aggression in pig-tailed macaques and reduced aggression in stump-tailed macaques (reported in Carlstead &

Shepherdson, 1994). To understand the implications of holding populations of Sulawesi black crested macaques in captivity it is essential to know how environmental variables affect their behaviour.

This study compares the behaviour of Sulawesi black crested macaques at several zoos in the UK and Ireland, to establish whether different environmental conditions and management regimes affect their behaviour.

Method
Eight troops were included in this study, which were housed in zoo collections in the UK and Ireland. Data were collected for 10 days at each zoo, from 07:00-19:00. Instantaneous scan sampling recorded behaviour, location and substrate use for each individual in the troop. Scans were made every 30 minutes and finished when the last individual was identified. Individuals were classified into one of five sex-age categories although infants were excluded from analysis. Sex-age groups were defined as follows: infant - under 2 years; small juvenile - 2 years; big juvenile - female 3-5years or male 3-7years; adult female – 5 years and older; adult male - 7 years and older.

Analysis
As the data were normally distributed a two-way ANOVA was carried out with zoo and sex-age class as the fixed factors. As most of the behaviours were significantly correlated a Bonferroni inequality post-hoc test was carried out on the data (Bryman & Cramer, 1999). The analyses were conducted on SPSS version 8.0 for windows (1997).

Results
Activity budgets were constructed, firstly representing the pooled mean time per day spent on each behaviour by animals in a given zoo (fig. 1) and then pooled for all zoos, by animals in the same age-sex class (fig. 2).

A study of wild Sulawesi crested black macaques found sex-age differences in behavioural expression, so a two-way ANOVA was performed to investigate whether the different environments (zoo) were affecting behaviour, or if it was just a function of the sex-age class composition at each zoo. The two-way ANOVA (table 1) showed that zoo alone affected the miscellaneous category, while an interaction between zoo and age-sex class affected feeding behaviour, while only independent effects of zoo and age-sex class significantly affected all the other behaviours (social, moving, resting and foraging). There was little variation in the data, which is illustrated by the small standard error bars present on the graphs (figs. 1 and 2). This reflects a consistency in behavioural expression of the individuals across all the zoos within this study.

Behaviour	Zoo*sex/age (df = 7)		Sex/age (df = 3)		Zoo (df = 20)	
	F value	*P value*	F value	*P value*	F value	*P value*
Social	0.627	0.875	8.521	0.000*	3.477	0.004*
Moving	0.650	0.856	13.797	0.000*	4.382	0.001*
Resting	0.905	0.583	36.742	0.000*	5.326	0.000*
Foraging	1.013	0.462	19.512	0.000*	3.953	0.001*
Feeding	2.085	0.016*	4.265	0.009	17.539	0.000
Mis	0.933	0.506	0.946	0.424	63.910	0.000*

Table 1. Summary of two-way ANOVA results investigating how zoo and sex-age class relates to % time spent performing behaviour.
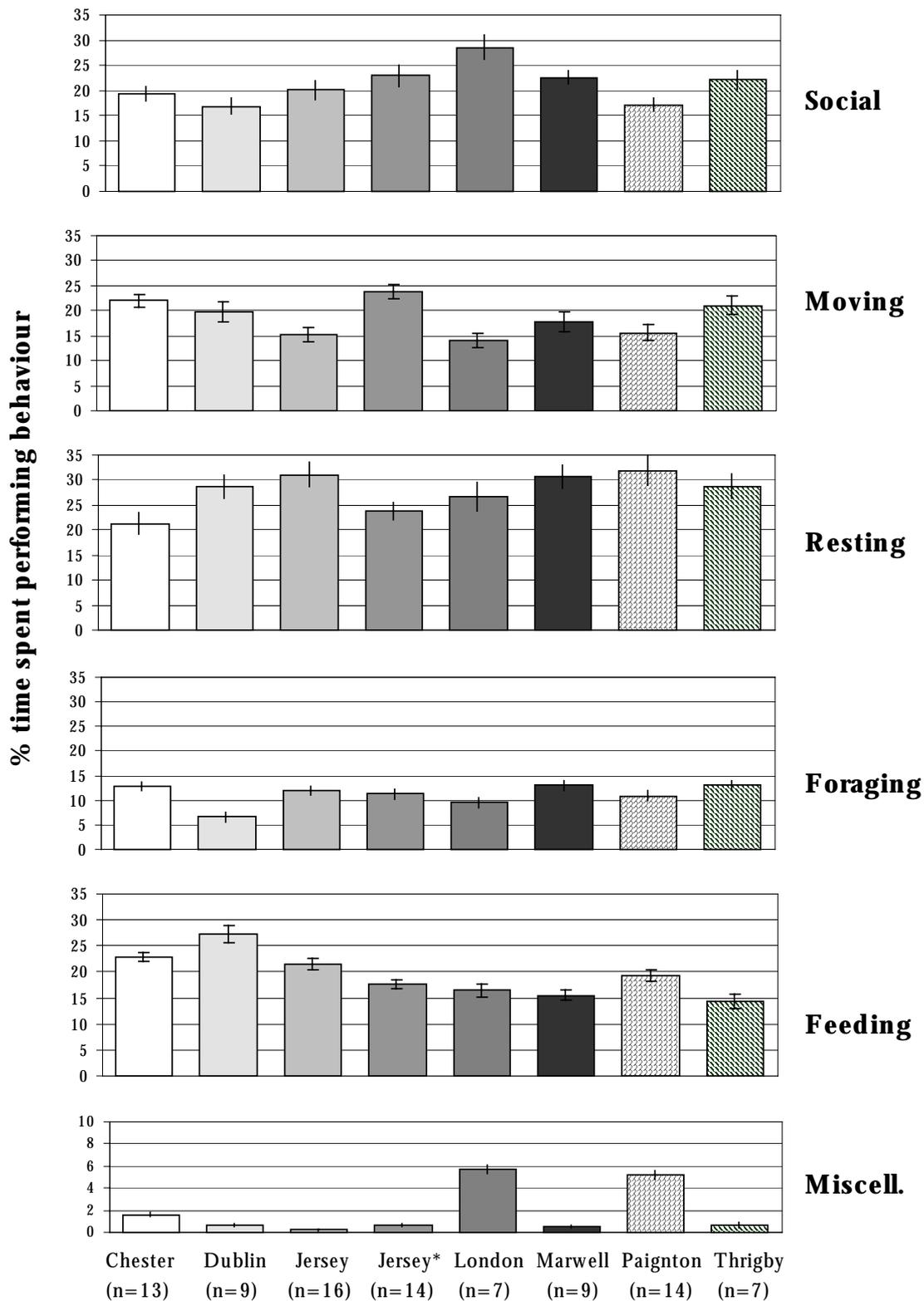
Figure 1. The percentage time spent performing behaviours by each zoo (miscell = miscellaneous category, two activity budgets were generated for Jersey zoo troops before and after composition changes).

The activity budgets generated for the zoos, highlight that at Chester zoo the macaques rest the least, at Dublin zoo they forage the least but feed the most and at London zoo they score the most in the miscellaneous category (table 2).

Behaviour	Zoo comparisons		Mean difference
Resting	Chester (n=13)	Dublin (n=9)	-7.33*
		Jersey I (n=16)	-9.8***
		Jersey II (n=14)	-2.5
		London (n=7)	-4.37
		Marwell (n=9)	-9.33*
		Paignton (n=12)	-10.62***
		Thrigby (n=7)	-7.52*
Foraging	Dublin	Jersey I	-5.29*
		Jersey II	-4.61*
		London	-2.92
		Marwell	-6.33**
		Paignton	-4.17
		Thrigby	-6.15**
		Chester	-6.15*
Feeding	Dublin	Jersey I	5.89***
		Jersey II	9.7***
		London	10.89***
		Marwell	11.8***
		Paignton	8.01***
		Thrigby	12.99***
		Chester	4.46*
Miscell.	London	Jersey I	5.5***
		Jersey II	5.06***
		Marwell	5.21***
		Paignton	0.51
		Thrigby	5.04***
		Chester	4.11***
		Dublin	5.02***

* *P = 0.05* level of significance; ** *P = 0.001* level of significance; *** *P = 0.0001* level of significance

Table 2. Summary of results from a Bonferroni inequality post-hoc test, comparing the % time spent performing behaviours by zoo pairs.

Analysis of the sex-age classes (fig 2) showed that adult females were the most social, while adult males rested the most and foraged the least and small juveniles rested the least. The behaviour expressed by the adult categories (female and male) appear to be more similar to each other when compared to the juveniles, which is also true for the similarity seen between the small and big juveniles (table 3).

Discussion
Feeding behaviour was significantly influenced by an interaction between zoo and sex-age class; such interactions are often hard to interpret. However, it appears that a combination of food availability and number of small juveniles (which ate the most) determined the level of feeding behaviour.

The zoo significantly affected the miscellaneous category but age/sex class did not. As miscellaneous behaviours were categorised as unusual infrequent behaviours, we would expect different sex-age classes to perform them at random. In the same way different sex-age classes would be expected to be not visible at random. However, the access and size of the off-show area
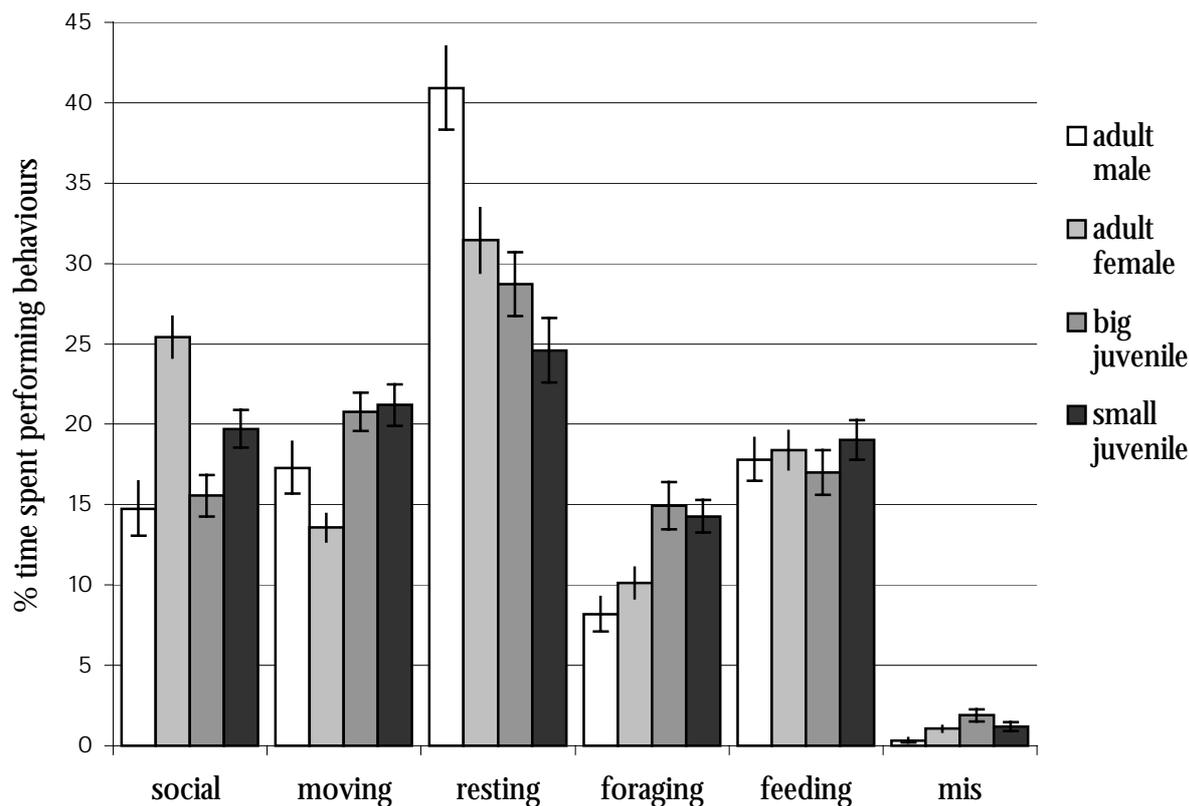
Figure 2. The percentage time spent performing behaviours by the different sex-age classes (mis = miscellaneous behaviour and not seen).

Behaviour	Sex-age class comparisons		Mean difference
Social	Adult female (n=33)	Adult male (n=13)	10.07***
		Big juvenile (n=16)	7.13*
		Small juvenile (n=27)	4.45***
Moving	Adult female	Adult male	-6.81***
		Big juvenile	-7.47***
		Small juvenile	-3.19
Resting	Small juveniles	Adult female	-7.3***
		Adult male	-20.2***
		Big juvenile	-3.35
	Adult male	Adult female	12.9***
		Big juvenile	16.85***
		Small juvenile	20.2***
Foraging	Adult male	Adult female	-3.05*
		Big juvenile	-6.76***
		Small juvenile	-6.02***
Feeding	Adult male	Adult female	-3.1*
		Big juvenile	-4.015*
		Small juvenile	-4.39***

 * $P = 0.05$ level of significance; ** $P = 0.001$ level of significance; *** $P = 0.0001$ level of significance

Table 3. Summary of results from a Bonferroni inequality post-hoc test, comparing the % time spent performing behaviours by sex-age class pairs.

should significantly influence the time spent not visible e.g. the macaques at London zoo had 24 hour access to a large off-show area and they scored highest for the miscellaneous category.

Social, moving, resting and foraging behaviours were significantly influenced by both zoo and sex-age class independently. This means that both the environment and the composition of the troops were determining the behaviour expressed. At some of the zoos the environmental cues affecting behaviour seem obvious, for example at Dublin Zoo the macaques foraged very little but feed a great deal. Through observation of their situation it would seem that because of the abundance of vegetation in the enclosure, little time is spent foraging as food is easily available to be consumed. However, further work is underway to give a breakdown of the environmental factors that may have led to the significant differences in behaviour observed between the zoos.

The activity budgets recorded for the different sex-age classes followed a pattern observed in a study of wild Sulawesi crested black macaques (O'Brien & Kinnaird, 1997). The females were most social, which is probably an indication that female-female interactions are most desirable. This may be the result of females showing their preference for other females as group companions, due to their similarities and greater dependability (Dunbar, 1988). A high level of resting and low level of foraging in the adult males demonstrates a low level of activity in captivity. One of the principal roles the adult male performs is patrolling and guarding his troop which may be restricted in captivity by the relatively small enclosure areas and group sizes would often permit the male to view the enclosure and troop members without moving. As expected small juveniles rested the least, though the behaviour of the juveniles was similar with both small and big juveniles moving and foraging more than the adult classes. The state behaviours recorded did not allow for the evaluation of play behaviours which young mammals are known to perform at greater levels than adults. The social behaviour category would have included chasing, moving would have included self-directed play, i.e. jumping and leaping, and foraging would have included manipulation of objects, all of which the juveniles performed to a greater extent than the adults (with the exception of social behaviour as explained previously).

In conclusion, the time spent performing each behaviour by the different sex-age classes in captivity were similar to those recorded for macaques in the wild. This similarity may indicate motivation to perform behaviours at certain levels that has evolved over time and whose inelasticity is sex-age dependent, e.g. the expression of social behaviour by sex-age classes is different but relatively stable for that developmental stage. The sex-age class differences in activity budgets remain regardless of the environmental conditions and management regime. However, the general expression of a behaviour type is influenced by the environment, e.g. more vegetation provides greater opportunities for foraging, and so the captive enclosure and management routine implemented does have a significant influence on the behaviour of captive Sulawesi crested black macaques.

Further work is currently underway to identify the environmental factors that are most highly correlated with certain behaviours. Experiments will then be undertaken to test the validity of these correlates.

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Selected behavioural observations of female orangutans and their offspring at Chester Zoo

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Abstract

Chester Zoo provides a valuable opportunity to observe five infant orangutans being parent-reared in one place. The enclosures and husbandry at Chester are carefully designed with compatibility of conspecifics in mind and to reflect their semi-solitary wild behaviour. Two related females are housed with their offspring of different ages in each of three enclosures. This study aimed to gather observational data to examine a range of behaviours shown by adult females and their offspring in this captive environment. This aims to provide, ultimately, a basis for developing an understanding of female-female interaction and parenting behaviour in captivity.

Scan sampling provided data on postural behaviours and space use. Observations in morning and afternoon were compared to examine any difference time of day might make to frequency of expression of behaviour for adult females and juveniles. Data were also collected to assess levels of proximity between individuals: adult-adult, adult-juvenile and juvenile-juvenile. Preliminary analyses indicate significant differences in frequencies of behaviours shown by individuals at different times of the day. Significant differences in the frequencies of 'movement', 'sessile', 'feeding' and 'object use' behaviours morning and afternoon were found. Individuals were recorded present on the ground (terrestrial) significantly less than above ground (arboreal). They were found to use the periphery of the enclosure significantly less than the front and back. Proximity data showed adult-juvenile contacts to be highest and adult-adult were the least observed.

Further analyses from this study and later work are planned to examine more closely the interactions between adult females and their offspring at Chester. It is hoped that this work may also be of value in further development of the enrichment of their captive environment.

Introduction

As traditional zoos evolve from zoological parks to conservation centres, there is a constant need to improve and update captive environments (Mallinson *et al.,* 1994). Knowledge crucial to this has been gained both from studying orangutans in the wild (e.g. Mackinnon, 1974; Rijksen, 1978; Galdikas, 1988), and as a consequence of the experience gained in the process of establishing genetically viable captive populations. To observe five infants being parent reared in one place at the same time is a rare opportunity. Chester Zoo is also only one of four zoos in Europe and the only zoo in Britain to hold breeding groups of both sub-species. At Chester the design of the Orangutan Breeding Centre and husbandry methods used echo the sentiment that orangutans are semi-solitary and, unlike some other animal collections which hold the orangutans as a single group, take consideration of the relationships between conspecifics and their compatibility (Yarwood, 2000, *pers com*). The generally accepted social groupings found in the wild have been found to be the most successful and the ability of female orangutans to raise their own young greatly increases with exposure to other females rearing offspring (Yarwood, 2000, pers com).

Around two years ago two hand-reared Sumatran orangutans (Emma and Subis) were introduced to two of Chester's Bornean mothers (Martha and Sarikei) and their respective offspring (Leia and

Matu) to allow them to observe maternal behaviours. The results of this procedure suggest that adult orangutans can learn maternal behaviour, which may be useful for assisting orangutans in captivity that may have been hand reared or orphaned, with maternal skills. This study aims to provide a baseline picture of adult female and juvenile behaviours which may be developed to examine more closely female-female interactions and the learning of parenting behaviour.

The study specifically aims to find out whether there are clear differences in the frequency of performance of behaviours in the morning and afternoon and in the particular behaviours performed. This includes a range of 'postural' behaviours (see ethogram) and the use the animals make of the enclosure space. Measures of proximity between the individuals in an enclosure were also taken to determine how adults may relate to each other and to the juveniles present.

Methods
The six female and five juvenile orangutans (table 1) are contained in three indoor yards, in the Orangutan Breeding Centre at Chester Zoo. These are heated and high humidity levels are maintained within. There are two concrete walls built to prevent each group from mixing. A moat along the back of the enclosure deters the orangutans from climbing into the neighbouring yard and also acts as a source of drinking water. A climbing frame/platform with ropes etc. is present in the central area of each enclosure and paper/cloth mail sacks are available for the orangs to interact with.

Enclosure 1	NAME	SEX	DATE OF BIRTH	SUB-SPECIES	MOTHER
FEMALE A	BELLA	F	05.10.80	BORNEAN	LOLA
FEMALE B	PUNDU	F	20.04.89	BORNEAN	LOLA
JUVENILE A	BENGARA	M	24.12.99	BORNEAN	BELLA
Enclosure 2					
FEMALE A	MARTHA	F	01.01.65	BORNEAN	UNKNOWN
FEMALE B	SARIKEI	F	22.11.83	BORNEAN	MARTHA
JUVENILE A	LEIA	F	06.02.96	BORNEAN	MARTHA
JUVENILE B	MATU	M	26.11.95	BORNEAN	SARIKEI
Enclosure 3					
FEMALE A	EMMA	F	14.11.87	SUMATRAN	RAMONA
FEMALE B	SUBIS	F	30.11.86	SUMATRAN	RAMONA
JUVENILE A	PADANG	M	22.11.98	SUMATRAN	EMMA
JUVENILE B	JAMBI	F	23.08.98	SUMATRAN	SUBIS

Table 1. Individuals observed during the study

A single experimenter (SW) observed the orangutans to allow behaviours to be recorded in the same way throughout the study. The orangutans were observed from behind glass from the visitor's gallery, level with the top of the climbing frames. Over about five weeks each of the three groups was scanned for 20 minutes at two-minute intervals and the behaviour of each individual at that instant recorded using the ethogram (table 2). Ten samples were taken from each group during morning sessions (09:30 – 12:00) and afternoon sessions (12:00 – 16:00). This enabled patterns of behaviour in these two periods of the day to be compared for each individual (within-subjects design).

Behaviour codes	Behaviour	Description
Postural categories		
Movement		
CL	Climb	Hand over hand vertical movement.
BR	Brachiate	Forward movement using arms.
W	Walk	Forward movement using legs.
A4	All-fours	Forward movement using all four limbs
Sessile		
S	Sitting	Sitting on floor, platform or frame.
LSS	Lying Side Stretched	Lying on side of body stretched out.
LSC	Lying Side Curled	Lying on side of body curled up.
LFS	Lying Front Stretched	Lying on front of body stretched out.
LFC	Lying Front Curled	Lying on front of body curled up.
Feeding		
S	Suckling	Infant suckling from mother.
CH	Chewing	Biting or working food in the mouth.
DR	Drink	Cupping hands into moat, putting water into mouth and swallowing.
FO	Foraging	Searching for food items in wood-chip litter.
Object Use		
MPS	Manipulating Sack	Using or carrying paper or cloth sack in any way other from putting sack on top of head.
SOH	Sack On Head	Putting sack over head covering head and/or body.
R	Ropes	Using ropes in any way other than to swing or climb on (e.g. unwinding threads or chewing).
NB	Nest Building	Arranging browse, sack or wood-chip into nest, or carrying browse from ground up to platform.
Space use categories		
Vertical Position Arboreal		
PL	Platform	On platform
FR	Frame	On frame
RO	Rope	On rope
Terrestrial		
PFW	Peripheral Front Wall	On the ground near the front wall of the enclosure.
PSW	Peripheral Side Wall	On the ground near either of the side walls of the enclosure.
PBW	Peripheral Back Wall	On the ground near the moat in the enclosure.
Horizontal Position	(either arboreal or terrestrial)	
PF	Peripheral Front	The front part of the enclosure, either arboreal or terrestrial.
PS	Peripheral Side	Either the left hand side or the right hand side of the enclosure, either arboreal or terrestrial.
PB	Peripheral Back	The back part of the enclosure, either arboreal or terrestrial.

Table 2. Ethogram for orangutans at Chester Zoo

Results

Behaviour

Data collected were not normally distributed so non-parametric statistics were used. Data from all scan samples were pooled as one measure for each individual under each condition (morning and afternoon). The detailed behaviours observed under each category in the ethogram were grouped together for the purposes of this preliminary analysis; these behaviour categories are shown underlined in the ethogram.

Figure 1 shows the pattern of frequencies of performance of the 'postural' behaviour categories. The behaviours were performed at significantly different levels (Kruskall-Wallis ANOVA $p < 0.01$). This figure shows the data for adult females in the afternoon period but is representative of the pattern for morning also. However when each behaviour category was compared between morning and afternoon, significant differences were found. 'Movement' and 'object use' were performed significantly more in the morning than afternoon (Wilcoxon tests $p < 0.01$) whereas 'sessile' and 'feeding' are performed more in the afternoon (Wilcoxon tests $p < 0.01$).
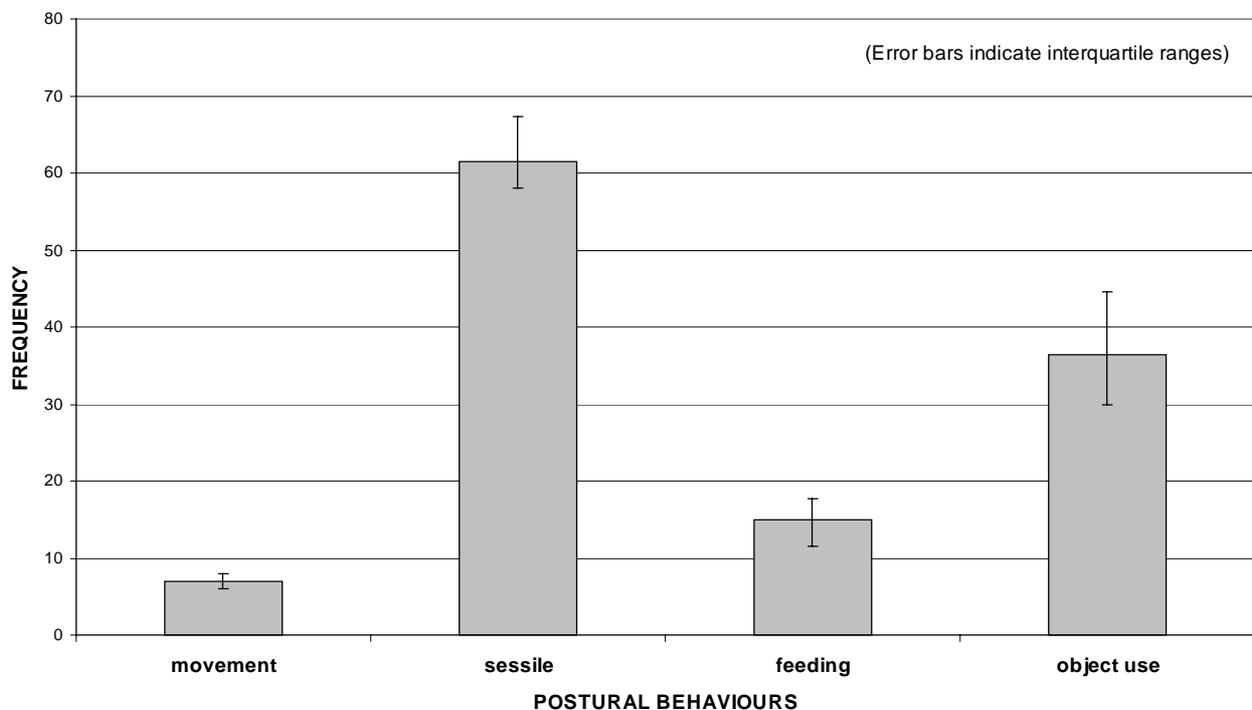

Figure 1. Median frequencies of postural behaviours performed by all female adults, data pooled from all afternoon observation periods.

Figure 2 shows postural behaviour performance for juveniles in the morning period. This pattern is similar for the afternoon but both are clearly different from the patterns of these behaviours shown by adult females during these periods (note the different scaling of the axes in figs. 1 and 2). Data could only be collected for four juveniles (the youngest is continually in contact with his mother) and is not sufficient for statistical analysis.

Unlike postural behaviours (figs. 1 and 2), patterns of vertical space use were simliar for adult females and the juveniles. Figure 3 shows the data for the juveniles to illustrate the general pattern. Adult females were found 'arboreal' (see ethogram) significantly more than 'terrestrial' (χ^2 $p < 0.001$). However, they were found 'arboreal' significantly more in the afternoon than the morning

(Wilcoxon test p < 0.01) and, consequently, fewer times 'terrestrial' in the afternoon (Wilcoxon test p < 0.01).
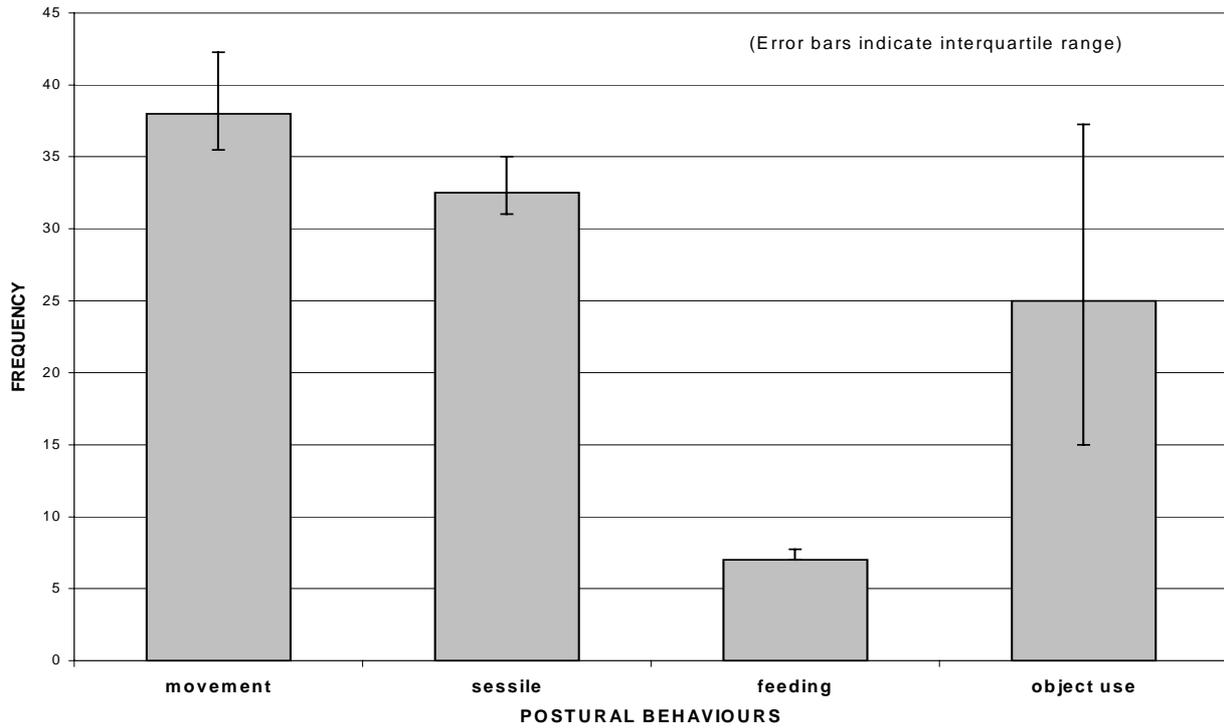

Figure 2.   Median frequencies of postural behaviours performed by four juveniles, data pooled from all morning observation periods.
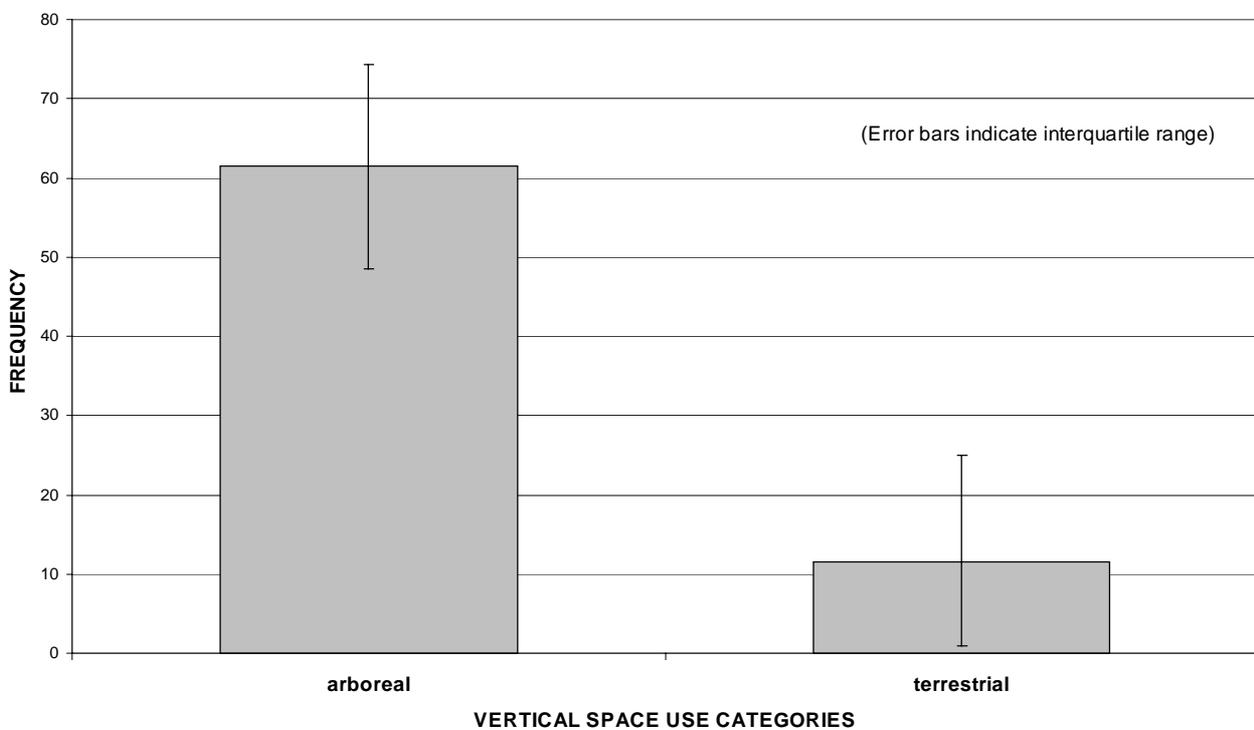

Figure 3.   Median frequencies of two vertical locations (arboreal or terrestrial) of four juveniles, data pooled from all afternoon observation periods.

Figure 4 illustrates the data for juveniles for the space use in a horizontal plane (morning). This pattern is similar for afternoon and for adult females, morning and afternoon. This pattern of differential use is consistent and significant (Kruskall-Wallis ANOVA $p < 0.01$). Comparing morning and afternoon however, adult females were found at the front of the enclosure significantly more in the afternoon (Wilcoxon test $p < 0.01$).
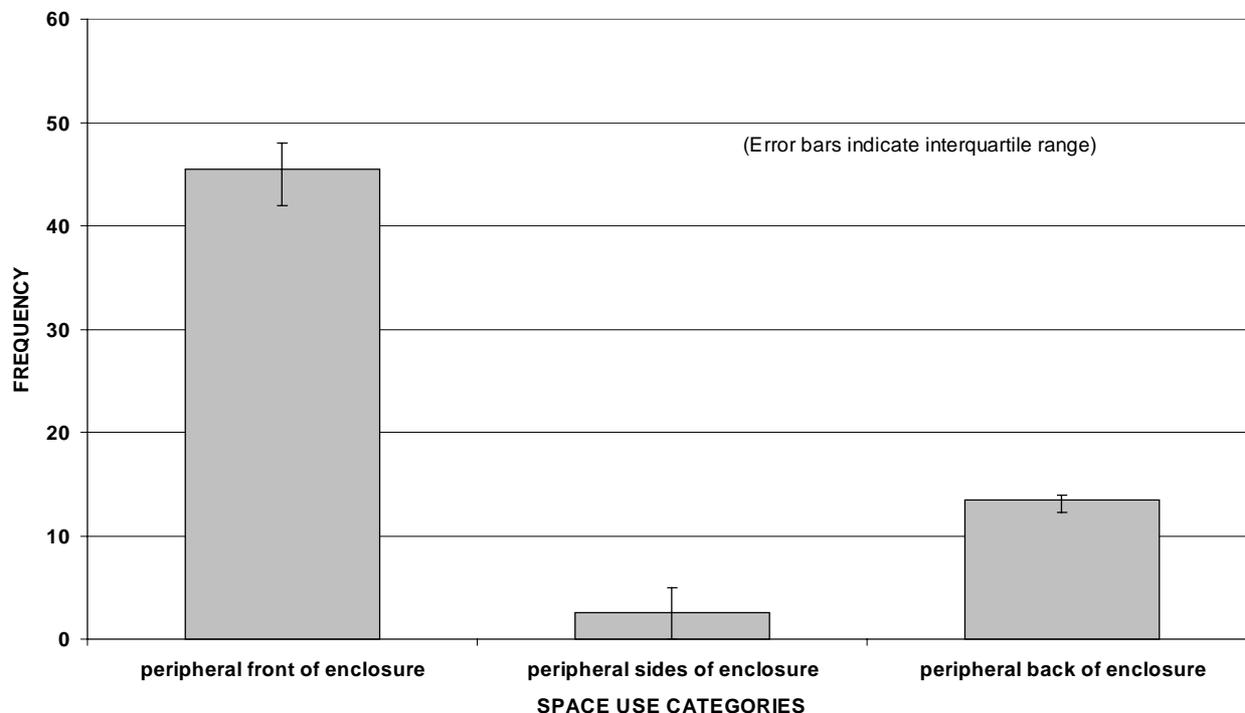

Figure 4. Median frequencies of three horizontal locations (arboreal or terrestrial) of four juveniles, data pooled from all morning observation periods.

Proximity
During scan sampling the proximity of individuals to each other was recorded at each scan. This was recorded as 'contact' or 'near' (i.e. orangutans were less than 2m away from each other but not in contact– as judged by the observer). The status of the two individuals was also recorded (i.e. whether juvenile or adult). Data for proximity were pooled across all observation periods. The observed frequencies of three combinations of 'contact' and of three combinations of 'near' are shown (table 3). The frequencies for 'contact' are highly significantly different from chance expectation ($\chi^2 = 224.8$, $p < 0.001$) as are the frequencies for 'near' ($\chi^2 = 87.9$, $p < 0.001$). Not surprisingly adult-juvenile dyads were most commonly found in the 'contact' category, three times more often than juvenile-juvenile 'contact' and far more often than adult-adult 'contact'. For 'near' proximity adult-juvenile is still most common but only twice juvenile-juvenile and adult-adult. Interestingly adult-adult 'near' was recorded as much as for juvenile-juvenile dyads.

PROXIMITY BEHAVIOUR	OBSERVED FREQUENCY	PROXIMITY BEHAVIOUR	OBSERVED FREQUENCY
Contact **juvenile-juvenile**	98	< 2 metres **juvenile-juvenile**	266
Contact **adult-juvenile**	306	< 2 metres **adult-juvenile**	471
Contact **adult-adult**	50	< 2 metres **adult-adult**	258

Table 3. Observed frequencies of three classes of 'contact' and 'near' between captive orangutans

Discussion
Clear patterns of behaviour for adult female and juvenile orangutans are shown at Chester Zoo. Behaviour was consistent across the study period but it was also clear that individual differences were shown that are hidden by this preliminary analysis. For example the tendency to be found in 'arboreal' positions rather than 'terrestrial' was very different, e.g. Bella and Sarikei were frequently found in 'terrestrial' positions but the others not. This does not appear to be clearly related to age (see study animals section). In addition, the two subspecies appear to behave broadly similarly. Further, detailed analysis will be carried out to examine this more closely. Further analysis of the detailed behaviour of individuals is planned to focus further work. This study provides interesting baseline data, which can be built upon to help understand female-female interactions and the learning of paenting behaviour in this group. It is hoped that it may also provide useful information for the further development of the enrichment programme at Chester Zoo.

Acknowledgements

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The activities of a captive group of gorillas in relation to females' oestrous cycles

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Abstract

An adult male and two adult female gorillas were mixed to form a new group in the recently built facility at Bristol Zoo Gardens. The keepers maintained oestrus charts using observations of mating as confirmation of oestrus. Both females appeared to be cycling during 1999 but with different cycle lengths and times. Students undertook a more detailed behavioural study.

Behaviour was monitored on 22 days over a four month period at the end of 1999 with the aim of establishing behavioural correlates with pre-oestrus. The activities, locations and nearest neighbour were recorded using a scan sampling technique. The behaviour observation results were compared from three categories: a) +/- 2 days of matings of both females, b) +/- 2 days of mating of one female, c) +/- more than 7 days before or after matings. Urine samples were also collected over a similar time scale and hormone levels were measured as part of a veterinary investigation into the reproductive status of the females. The behavioural observation results were checked against the hormonal levels.

Not surprisingly the male spent significantly more time in the proximity of a female in oestrus, either standing or sitting near them. Interactions of all types increased around the time of oestrus. The results are discussed in terms of how and where the animals spent their time and the relationship between behaviour and hormone levels.

Introduction

Following the construction of a new gorilla facility at Bristol Zoo Gardens a new group of Western lowland gorillas (*Gorilla gorilla gorilla*) was formed. The male, Claus, arrived in January 1998 aged 15, a young female, Undi, in March 1998, aged 7 and an older female, Salome, in November 1998 aged 22. The general behaviour of the group was recorded to determine how and where the animals spent their time, and how they related to one another.

The gorillas had been together for about one year when the study started. Mating had been observed but there were no signs of pregnancy. While this is not exceptional in a new group, veterinary checks were initiated to ascertain the reproductive status of the animals, starting with the females. Urine samples were collected for hormonal analysis. The aim of combining the behavioural and hormonal studies was to ensure that there were no underlying behavioural or physiological problems that could result in infertility.

Methods

A behavioural study was carried out between September and December 1999. A follow-up was undertaken at the end of February 2000. Behaviour was recorded using a scan sampling technique over a 20-minute period with 1 minute between observations. At each sample time the activity, location and nearest neighbour were recorded for each animal in view. The categories of each type of behaviour were relatively broad allowing a high degree of reliability between observers' behaviour. Location results are not presented here. Data were recorded at various times of day on 30 days.

Urine samples were collected opportunistically from October to March with a total of 80 samples from the two females. The primate keepers maintained charts of the females' oestrous cycles and these were compared with the behaviour records with the aim of establishing correlates with the pre-oestrus phase.

Results
The records of various behaviour categories were pooled to compare gross behaviour. The pooled categories were locomotion, foraging, still (sitting or standing but alert, head movements) resting (sitting still or lying) and interactions (chase, threaten, court, fight).

Not surprisingly there were more interactions between the animals when one or both females was in oestrus. Both females increased the time they spent foraging when in oestrus. Salome moved about less frequently than the others, but increased her movements when Undi was in oestrus.
The nearest animal to Claus varied significantly with the females' reproductive state. He was usually nearer Undi unless Salome was in oestrus. Salome spent less time within 5m of either of the others. The females tended to be closer to one another than to the male when either of them was in oestrus. Agonistic interactions were few and were usually initiated by the male but the females co-operated with each other to counter the threat if the male became aggressive.
The oestrus charts showed that the cycles of both females were very variable in length. Particular body postures and behaviours were noted one to three days prior to the mating period. These behaviours coincided with a sharp rise in progesterone which is associated with ovulation.
The hormonal analysis showed that Salome probably became pregnant in January 2000 but was unable to maintain the pregnancy beyond three weeks. Undi conceived in December 1999. The date of conception was not clear from the oestrus charts but was established from the urine sample assays. Her pregnancy has been maintained to date (July 2000).

Discussion
All three gorillas have had to adapt to a new social environment. Over the time period of this study there have been noticeable changes in the behaviour of the male, Claus. In particular his aggressive reactions to novel situations or changes in husbandry have decreased. There were significant differences in how the animals associated and interacted depending on the hormonal status of the females. The females co-operated if the male became aggressive.

The reproductive rates of captive gorillas are lower than in wild populations. One factor may be hormonal level, particularly of progesterone. Undi showed higher levels of progesterone in the luteal phase of her cycle and she has been able to sustain pregnancy whereas Salome was unable to maintain a pregnancy on at least one occasion. The combination of behavioural and hormonal studies has revealed more about the reproductive status of the animals.

Acknowledgement

How rearing influences behaviour and personality of captive chimpanzees

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Abstract

*This study investigated the long-term effect that removing from their mother and/or other chimpanzees has on chimpanzees behaviour and personality. The aim was to provide an insight into the social development of the species and to investigate human influence on this process. Chimpanzees (*Pan troglodytes*) were studied at six zoos in the United Kingdom. Chimpanzees were categorised into one of three rearing conditions; mother-group-reared (MGR), reared with others but separated from mother (RO), and reared alone for a period of time during infancy (RA). It was predicted that, regardless of the environment, captive chimpanzees with a 'deprived' background would show behavioural differences, specifically that their social skills would not show the complexity of 'normal' chimpanzees. Rearing background did indeed have significant effects on some aspects of behaviour and personality. However, it was also found that environmental effects influence their behaviour and ratings of personality traits suggesting that the zoo environment may go some way to reduce the influence of a deprived background.*

Introduction

This study investigated the long-term effects that maternal separation and social deprivation have on the behaviour and personality of captive chimpanzees (*Pan troglodytes*). Over the years chimpanzees have been used by humans in numerous ways, for example, as pets, photographers' aids, performers on television and in circuses, zoo exhibits and research subjects. In all these trades, apart from zoo and laboratory animals, infants almost exclusively are used, and this requires the infant to be separated from its mother. Nowadays most zoo-born infant chimpanzees are mother-reared but this was not the case in the past with hand-rearing being common place. For these reasons there are many chimpanzees in zoos today who have been removed from their mother, either in the wild or in captivity, for human use. These individuals have been subjected to varying degrees of social deprivation and loss of opportunities to learn and experience relationships with their mothers and with other members of their species. Previous studies have looked at the short-term effects of maternal deprivation but no studies have looked at the long-term effects on behaviour. The aim of this study was to provide an insight into the social development of the species and to investigate human influence on this process. Individuals were assessed over a variety of measures in an attempt to assess possibly subtle behavioural differences between individuals with different backgrounds. It was predicted that, regardless of the environment, captive chimpanzees with a 'deprived' background would show behavioural differences, and specifically that their social skills would not show the complexity of those of 'normal' chimpanzees.

Methods

Chimpanzees were studied at six zoos in the United Kingdom. They were housed in social groups ranging from five to 29 group members. Chimpanzees were categorised into one of three rearing conditions; mother-group-reared (MGR) (n = 28), reared with others but separated from mother (RO) (n = 12), and reared alone for a period of time during infancy (RA) (n = 29). Sixty-nine individuals were observed in total.

Results

The total time an individual spent active and performing abnormal behaviours was compared across the three rearing conditions. MGR individuals had higher activity levels than either RO or RA chimpanzees. When the different age classes were examined it was found that this rearing effect was strongest in infants through to young adults. Prime, mature and old adults showed no differences across the three rearing conditions. Abnormal behaviour levels differed across the three rearing conditions, with total time performing abnormal behaviours increasing with increasing severity of deprivation. Infants and juveniles were most affected by their rearing condition and, as for activity levels, adults showed little difference for rearing. Recovery of these behaviours to levels comparable to 'normal' chimpanzees appears to have occurred in older individuals.

In addition, the social skills of adolescents and adults showed few detrimental effects of maternal separation. RO and RA individuals had the same number of play and grooming partners as their MGR counterparts. They also performed a comparable percentage of polyadic grooming interactions, which were as complex as those performed by MGR individuals, and their role within grooming interactions was also as complex. The structure of their play and grooming interactions was also unaffected by rearing condition. The use and performance of initiators, the latency of the interaction and of the bout, and the performance of reciprocation and mutualisation did not differ across rearing conditions. However, there was some indication that deprivation reduced the successful use of repeat initiators during play and initiators during grooming interactions.

Individual chimpanzees were rated for 25 personality adjectives by humans who knew them as individuals. Inter-rater reliability was found to be affected by the rearing condition of the chimpanzee being rated. MGR chimpanzees were found to be easier to rate reliably than their deprived rearing peers. Only the ratings of adjectives 'active', 'slow' and 'tense' were affected by rearing condition. MGR individuals were rated as more 'active' and less 'slow' than their deprived rearing peers. These results supported the behavioural observations made for activity levels. RO chimpanzees were found to be more tense than RA individuals.

Although the effects of deprivation appear in the long-term to be negligible, the main influence appears to be suppression of activity, both as measured through observation and as perceived by raters. This is probably related to depression caused by maternal separation and restricted rearing. With time, social housing and the presence of infants, behavioural and social recovery occurs. Indeed deprived individuals may be indistinguishable from MGR chimpanzees by the time they reach adulthood; however, some individuals remain permanently affected. It was also found that environmental effects influence their behaviour and ratings of personality traits suggesting that the zoo environment may go some way to reduce the influence of a deprived background. These results have implications for the management and conservation of this species.

Nest attendance by Bali starlings (*Leucopsar rothschildi*) during incubation and while feeding nestlings

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Abstract

*Video camera recordings were made of the activity around a nest box of Bali starlings (*Leucopsar rothschildi*) in Tropical Bird House at Bristol Zoo Gardens. Eighteen days of time lapse recordings were available covering a period that corresponded with the last days of incubation and the first two weeks of feeding nestlings. The numbers of times the adult birds entered and exited the nest box in each hour were recorded from the video. The mean number of nestbox visits per hour was four before hatching and doubled after hatching. The number of nest visits per hour peaked at 10 visits per hour between 06:00 and 07:00 then remained between six and eight until 19:00 after which time it declined steeply. The birds in the Tropical Bird House were fed at feeding stations that were replenished each morning. The peak of nest visits in the morning showed that the adults are most active before the first daily replenishment of food suggesting they were able to find other food items in the House. The implications for providing food for birds feeding nestlings are discussed.*

Introduction

Bristol Zoo Gardens is committed to a wide range of conservation breeding programmes. Programmes such as these ensure that standards of both husbandry and genetic demographic management are met. It is through studying captive breeding success that improvements can be suggested that could lead to increasing the numbers of offspring raised. The Bali starling (*Leucopsar rothschildi*) is listed in the IUCN Red Data Book as endangered. Captive breeding success rates, and in particular, rearing success rates are very varied (Williams, 1998). Bali starlings are among the birds housed in the Tropical Bird House and Wallace Aviary at Bristol Zoo. The birds in the Tropical Bird House were fed at feeding stations that were replenished each morning. As well as the usual food, dishes of invertebrates (mealworms or wax moth larvae) were provided several times a day allowing birds feeding young to extend their foraging opportunities. The dish of invertebrates was replenished first thing in the morning (between 07:00 and 08:00) and several times during the day. The activity periods of the Bali starlings were compared with times that food was provided.

Methods

The Tropical Bird House and Wallace Aviary house a variety of bird species. Potential nest sites are provided including nest boxes. A video camera was set up on a nest box where a pair of Bali starlings were nesting. Time lapse recordings were made over an 18 day period from 20 July 1999 to 18 August 1999. The number of adult bird movements in and out of the nest box each hour were recorded from the video. It was not possible to identify individuals or what food was taken to the nest from the video. Each nest box entry and exit was recorded but were very similar so only the number of entries are presented here. Prior to the video analysis, the date of hatching was estimated from other information and observations as day 5 of the recordings.

Results

There were no movements in or out of the nest box between 21:00 and 05:00 (all times given are BST). Sunrise was 05:20 at the start of recording and 05:46 at the end. The corresponding sunset times were 21:14 and 20:47. The mean number of nest visits per hour through the day are shown in

figure 1. The birds started activities between 05:00 and 06:00. The peak number of nest visits per hour occurred between 06:00 and 07:00 and then declined slowly through the day before dropping steeply before sunset.
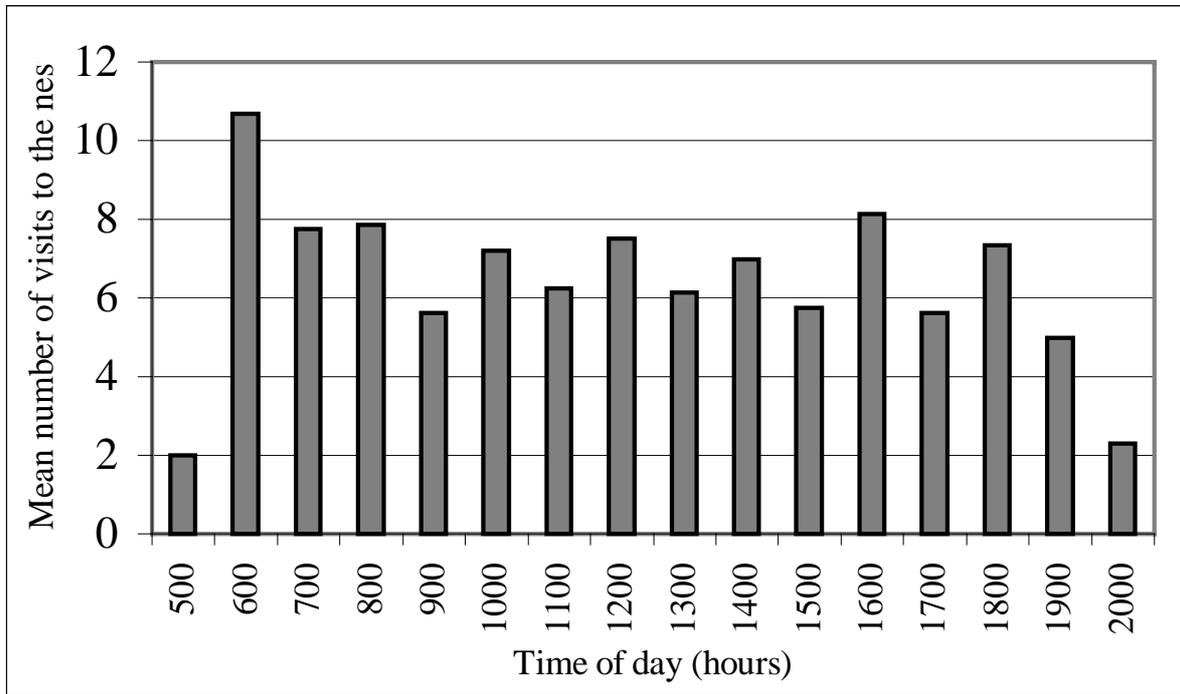

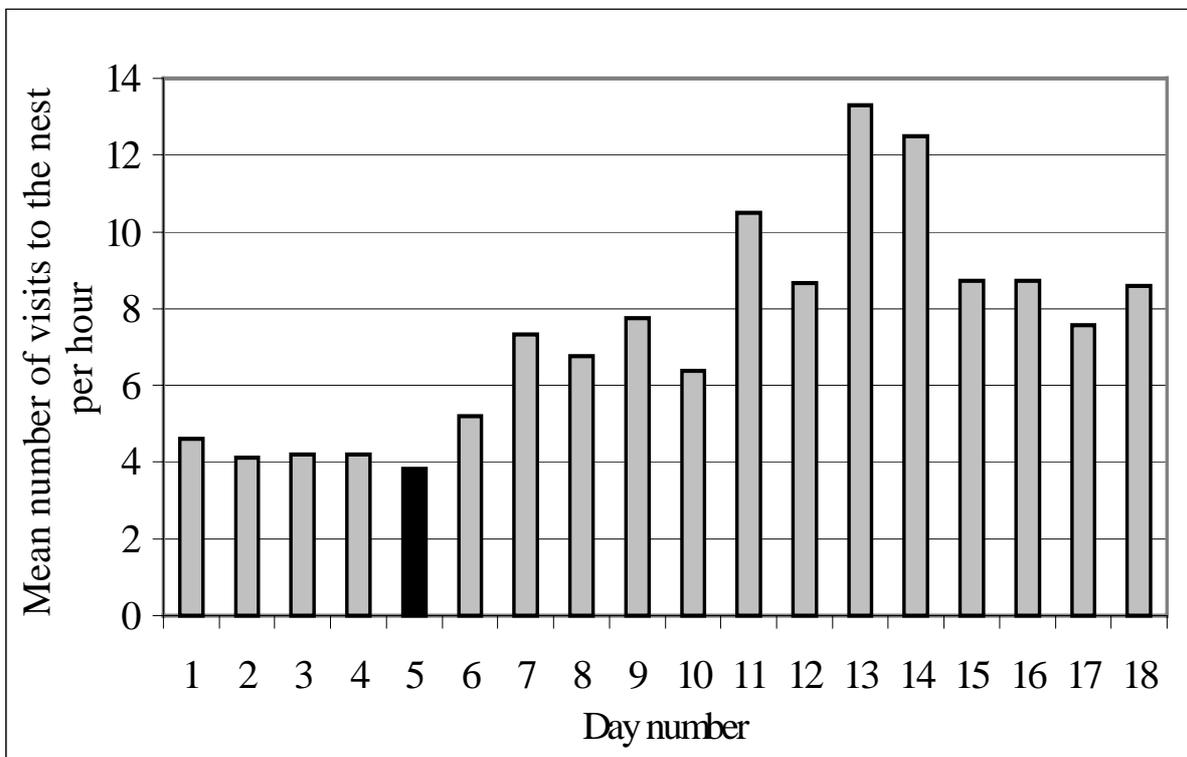Figure 1. The mean number of nest visits by Bali starlngs per hour through the day.

Figure 2: The mean number of nest visits by Bali starlings per hour during each day (day 5 is estimated date of hatching).

The mean number of nest entries per hour across days are shown in figure 2 with the estimated date of hatching indicated by the black bar. The mean number of nest box visits per hour was 4.2 before hatching and 8.6 over the following two weeks.

Discussion

The birds were active from soon after sunrise until about half an hour before sunset. Most activity occurs over a 14 hour period. The estimated day of hatching was supported in the increase in the number of nest visits per hour. Williams (1998) reports that nest material is added throughout the breeding cycle. It was assumed that the increase in number of nest visits after the eggs had hatched was due to visits with food items.

The rationale for providing supplementary feeds was to ensure that actively foraging birds had access to good quality food items especially while feeding young. However the peak of activity of nest box visits occurred within an hour of sunrise but before food had been replenished by the keepers. Thus, the first food of the day for the chicks may not be of the same quality as later food. Consideration will be given to automated feeders to provide food of known quality to the birds during the peak of their nest visiting time.

Conclusions

Bali starling adults were active from soon after dawn to shortly before dusk. The number of nest visits per hour doubled after the eggs had hatched. The peak of nest visits occurred within an hour of sunrise and before food had been replenished in the bird house.

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Light level and its effect on activity levels in the Mexican blue scaled quail (*Callipepla squamata*) in the Desert, Paignton Zoo

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Abstract

*The Mexican blue scaled quail (*Callipepla squamata*), a resident of the southern United States and Mexico, were observed displaying distinct periods of roosting and activity whilst in captivity. A captive group of scaled quails in the Desert, Paignton Zoo, were observed and studied in order to elucidate the effect of light level upon the quails. Using direct observation methods the number of quails active and non-active (roosting) were recorded. The activity of the captive quail in the Paignton Zoo Desert was compared to the activity shown by those in the wild, which show a distinct midday break in activity. The quail in this study did not display such a break, and the reasons for this are discussed. It became apparent during the study that temperature also had a major effect on activity level in the quail and temperature is discussed in the context of its effect upon activity levels in the quail. The role of temperature in conjunction with light levels is also discussed in terms of the two factors joint effect upon activity levels; also in terms of their influence upon the physiology of the birds which may affect the birds activity levels. A short climatic survey of the quails' natural habitat and the area around the Desert house was carried out in order to help determine the importance of temperature relative to light level in influencing activity in the birds. The role of such a study is also examined in the light of previous studies concerning the response of ground dwelling birds such as quails to varying light levels.*

Introduction

The main aim of this study is to explore the effect that light level has upon the activity of the scaled quail. The second aim of this project is to compare such responses to light levels with those shown by populations in the wild. The third aim of this study is to use the data gathered to investigate other patterns of activity (related to light levels) that may be displayed by the quail population.

In order to obtain a picture of the natural conditions under which the quail live in the wild a short climatic survey of the quails home range was carried out. Of particular interest was hours of sunshine measurement at each recording station as this obviously has a bearing on the light levels which the quail are experiencing in the wild. Data from the World Survey of Climatology (Aleman & Garcia, 1974) was used and the mean hours of sunshine measurement for five sites situated within the habitat range of the scaled quail examined. It was found that the quails' natural range encompassed a great variety of light conditions. For example, the mean hours of (uninterrupted) sunshine varied from just 2.0hours at the Oklahoma (USA) site to 8.1hours at Sonora (Mexico). Likewise cloudiness varied accordingly. In the context of this information it was felt that a study concerning the effect of light levels could be carried out using the scaled quail as a subject and that direct observation would be a suitable method of data collection.

Materials and methods
Study animals
The Paignton Zoo Desert contains a group of 12 scaled quail: ten female and two male. There is no easy way of distinguishing between the sexes as they are very similar in terms appearance, size and behaviour but they have been tagged with a black ring indicating a male and an orange ring indicating an immature bird (born in the previous breeding season), females are untagged. The zoo operates a captive-breeding programme for the quails and all of the young (orange tagged) birds were hatched at the zoo from eggs laid within the Desert.

Observation
Observations were made manually, The data, collected during separate observations, included the time at which an activity occurred, the light level at that time (measured in lux, using a Lutron LX 101 meter), the number of birds active (i.e. not roosting) and the number of birds which were roosting (i.e not active). The Desert was divided into three zones and the location of the activity was noted.

Data collection occurred between 10/11/99 and 25/1/00. A total of 449 observations were made over 14 days in 38.5 hours. There were three periods of observation: 09:00-11:00, 11:00-15:00 and 15:00 to 17:00. In the period 11:00 to 15:00 observations were made whenever the number of birds roosting or active changed however, in the case of the periods 09:00 to 11:00 and 15:00 to 17:00 observations were made every 5 min. This was to save time and it was felt that changing the observation regime in such a way would not adversely affect the quality of the data collected.

Observation categories
In this study a bird was recorded as active if it was displaying any of the following activities:

1. preening
2. feeding (includes foraging activity)
3. drinking
4. chasing activity
5. mating activity
6. pecking activity (used by birds to confirm dominance)
7. avoidance activity (avoidance of another more dominant bird)

A bird was recorded as roosting if it had settled and was dormant for at least 30 seconds (during which time it displayed none of the activities listed above). This "thirty second rule" was based upon preliminary observations which suggested that if a bird was inactive for thirty seconds it was likely that the bird had entered a state of inactivity.

Light intensity
Light intensity was measured using a lux meter (Lutron type LX 101) which was placed in the same position in zone one throughout the observation period. Care was taken to place the light meter away from shade at all times of day.

Climate
Background data of the climatic conditions in the area of the Desert house were obtained from local weather stations. The Desert is unheated so local climatic data should provide a reasonable picture of conditions; obviously excluding rainfall. Temperature was adjusted to allow for the typical thermal properties of a glasshouse of this size (1000m^2).

Results
Population covariance analysis was carried out to compare time and light level to numbers roosting and active. The data was interrogated for general relationships and for a more detailed relationship between activity and light level (figs. 1-4). The graphs show polynomial best-fit lines.

Examination of the plots prompted resolution of the following questions:
1. When all, half or no birds are active what is the average light level?
2. At what times of day do high, medium and low light levels occur?

Average light levels when zero, six, and 12 birds were active are shown in table 1.
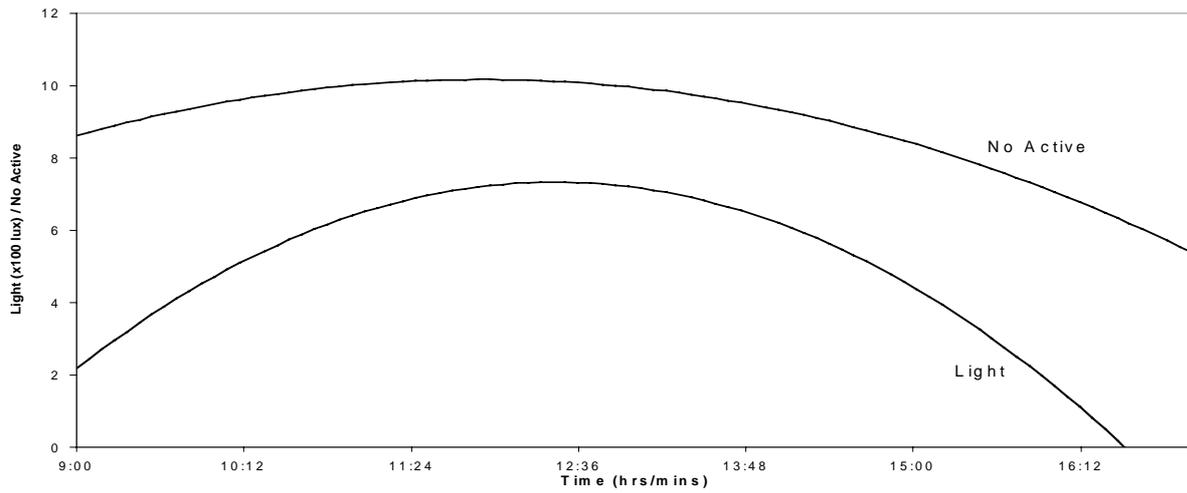
Figure 1. Light level and number of quail active 09:00 to 17:00
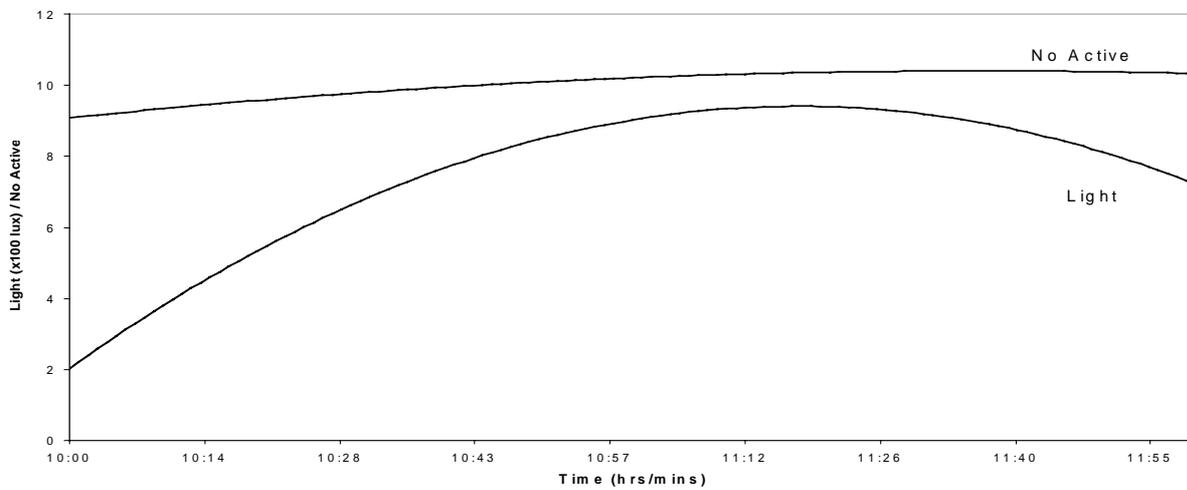

Figure 2. Light level and number of quail active 10:00 to 12:00
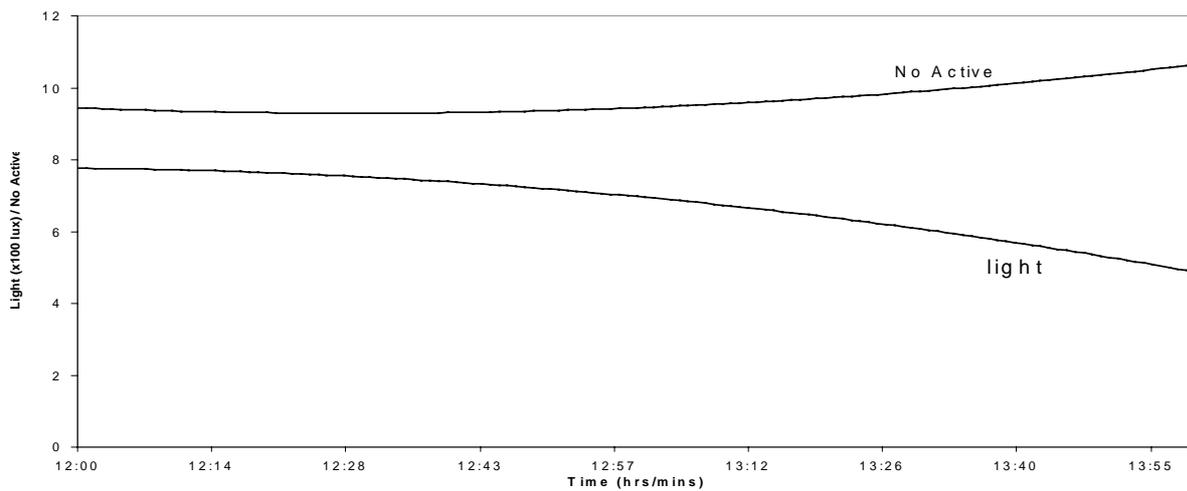

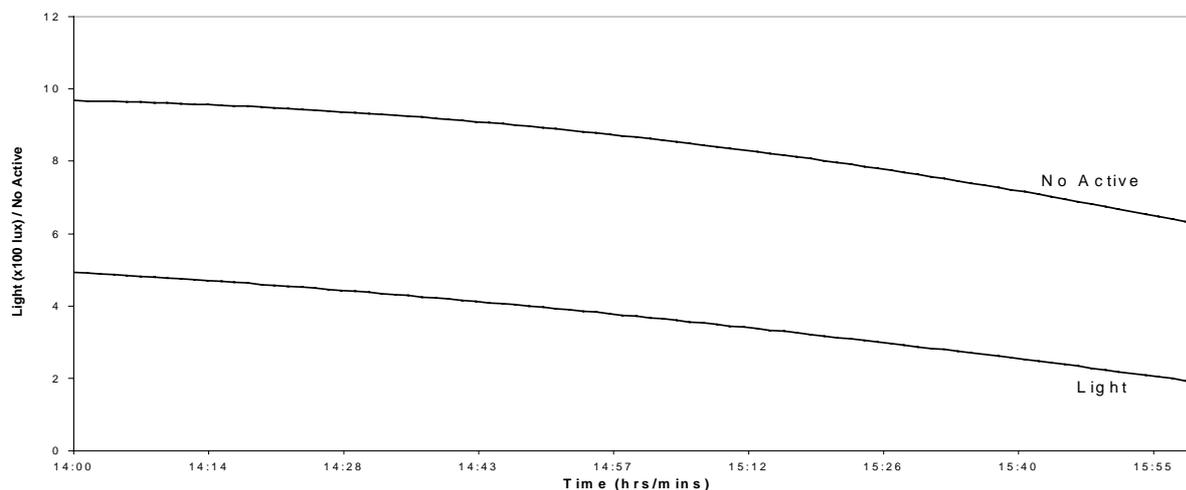Figure 3. Light level and number of quail active 12:00 to 14:00

Figure 4. Light level and number of quail active 14:00 to 16:00

When all 12 birds are active average light level is "medium" (650 lux). When six birds are active (half the total population) light levels are "low" (220 lux). And finally when no birds are active light levels are "high" (1010 lux)

No Active	Average light level (Lux)
0	1010
6	220
12	650

Table 1. Average light levels when zero, six and 12 birds active.

Average light levels are shown in relation to time in table 2. Figures are expressed as percentages. The lux bands defined as low, medium and high light levels were chosen to encompass the figures in the previous table as the average light level at which none, half and all the quails were active.

Light Levels	Occurring Early (%)	Occurring Midday (%)	Occurring Late (%)	Average No. Active
<300	18	0	82	7.1
550 – 640	37	31.5	31.5	9.5
1200	28	62	10	9.6

Table 2. Occurrence of light levels throughout day.

Apart from the direct, observational data collected for this study a number of smaller surveys and calculations were made to provide background information regarding the climate in which the birds live (in the wild and within the desert house area). The World Survey of Climatology (Aleman & Garcia, 1974; Manley, 1970) was used extensively to provide background information on light levels and temperature regimes (table 3). The data used is average daytime temperature for the period November to January (the period of data collection for this study). The data for the natural habitat was taken from four stations within the quails natural wild range.

Station	Daily mean (°C)	Maximum (°C)	Minimum (°C)
Amarillo, Texas			
Jan	2.3	27	-24
Nov	7.5	29	-16
Dec	3.8	27	-15
Tulsa, Oklahoma			
Jan	2.9	26	-22
Nov	9.5	31	-12
Dec	4.8	27	-16
Albuquerque, NM			
Jan	1.7	19	-17
Nov	6.7	23	-12
Dec	2.8	22	-16
Guaymas, Mexico			
Jan	17.9	33.3	3.2
Nov	22.7	37.5	3.8
Dec	19.4	32.5	6.0

Table 3.   Temperature data for selected locations in the quails home range.

Discussion

Based on figure 1 a positive parallel relationship between light and activity can be seen. This relationship is as expected with the birds being less active at low light levels in the early morning and late evening and then becoming more active towards midday and the higher light levels associated. Such a pattern of activity, dependent upon light level is similar to those previously described for general bird behaviour (Elkin, 1988; Schemnitz, 1961). On closer inspection using smaller two hour periods one finds that the relationship is not as expected. In the early morning period there is little relationship between light level and activity; possibly because the birds are engaged in routine "maintenance" activities such as preening and feeding after the night period with no food. This period of activity may be essential and not dependent on light level. Schemnitz (1961) provides limited evidence of this in the daily routine of quails living in the Oklahoma panhandle. After mid-day, however, wild quails seem to have no 'typical' activity pattern until roosting behaviour is initiated by the onset of darkness.

Schemnitz (1961) recorded that during the winter season the quail always had a midday 'break', during which time they sheltered under rocks and farmyard machinery. There is little evidence for such a midday break occurring in the captive Desert birds. On the contrary there was an increase in activity (fig. 3). Evidence for this lack of a midday break and an unexpected increase in activity was also provided when analysis of the data available proved that medium light levels were most likely midday and that during periods of medium light levels all the birds were most likely to be active.

One reason for this observation could be the short day length (approximately nine hours during the study period) in comparison to that in their natural habitat which would be approximately 12 hours. It is possible that the quails are making maximum use of the limited amount of daylight available in a temperate environment with frequent cloud cover and low light conditions.

Later in the afternoon the activity/light relationship returned to the positive relationship expected. Possibly because the low light levels after 14:00 (especially in a dull, cloudy temperate environment in winter) are triggering them to reduce activity in preparation to roost.

The evidence so far suggests that there may be an upper and lower light level above or below which the quail are directly influenced by light level. Evidence for a lower limit can be seen in the plots that show that below approximately 900lux the quails remain inactive or reduce their activity in preparation for roosting. Evidence for an upper light level limit on activity is more difficult to show but can be seen in the analysis presented in table 4. This table shows that during periods of high light level there is the greatest chance that no birds will be active. The existence of such a higher limit may explain the occurrence of a midday break in the wild and the lack of a midday break in the Zoo.

Time	Proportion Roosting %	Proportion Active %
09.00 – 10.00	23.4	76.6
10.00 – 11.00	20.0	80.0
11.00 – 12.00	12.4	87.6
12.00 – 13.00	23.4	76.6
13.00 – 14.00	16.4	83.6
14.00 – 15.00	22.2	77.8
15.00 – 16.00	35.5	64.5
16.00 – 17.00	49.5	50.5

Table 4. Percentage of quail roosting and active through the day

Schemnitz (1961) observed that the midday break was usually associated with the hottest part of the day, my evidence suggests that light levels also play a part in the initiation of such a break. If this is the case it might also explain why the captive birds do not display a similar break; light levels within the Desert during the winter are not high enough to trigger such a break. A similar study during the summer months might confirm this although it may be difficult to separate the effects of light and temperature. Dorst (1971) suggests that heat rather than light is the dominant factor in influencing such midday breaks when he observed that most desert species try to screen themselves as much as possible from the effects of direct insolation (exposure to high solar light and heat levels). He comments that desert dwelling birds tend to feed in the early morning and evening and that around midday the birds rest in the most sheltered places. This confirms the existence of a general midday break in desert birds. The maximum temperature range in the Desert (4.3°C) was much lower than the quail might experience in the natural habitat (39.3°C). In the Desert the roof vents are set to open when the temperature exceeds 20°C in order to reduce further increase. This is not a high temperature for birds adapted to tolerate daily maximum temperatures in excess of 27°C. These results suggest that the quail are well adapted to temperature variations so are not experiencing extreme conditions in the Desert that might cause physiological stress. However, the quail may not be experiencing appropriate conditions to replicate natural behaviour patterns.

Whether the break in activity is triggered by light or temperature may be influenced by the extent to which birds associate high light levels with high temperature levels. Little is known about this subject (Whittow, 1986); Macdonald (1957) described a strange behaviour of the three-banded sand plover (*Charadrius tricollaris*) in which the birds protected eggs laid in direct sunlight even when threatened, but did not protect eggs laid in the shade. The temperature difference between light and shade was minimal so it was suggested that plovers might associate high light levels with high temperature levels.

This study has shown that light levels almost certainly influence the general activity of the scaled quail; most obviously by preventing a midday break period. The study also showed that light level and temperature are almost certainly linked in some way in influencing the activity of the quail as a desert dwelling bird adapted to climatic extremes. It is clear that temperature is a major factor in influencing the activity of quail. This was confirmed from observations of the birds: a small group of birds spent a large amount of time under the ceramic heat lamps; many of the birds chose to roost under the infra red lamps; quail were also occasionally observed huddling, presumably in order to conserve heat. Future studies of this nature should, therefore, include regular temperature readings.

The study also raises many questions such as: do the quail display torpidity?; what effect may it have on quail activity? The activity of the scaled quail in temperature controlled conditions is a potentially interesting area of study to elucidate more concisely the relationship between light levels and temperature in influencing the activity levels. The study was limited in its treatment of quail behaviour, treating behaviours as either active or non-active (roosting). There remains much scope for a researcher who wishes to look in more detail at the variety of behaviours the quail display and how such specific behaviours are (or are not) related to light level, temperature or to both parameters.

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Study of the captive social behaviour of the Roulroul partridge, *Rollulus roulroul*

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Abstract
The Roulroul partridge Rollulus roulroul *is the single species of the galliforme genus* Rollulus. R. roulroul *are a ground dwelling species that live in social flocks of 5-15 individuals. The species inhabits plains and foothills of Burma and Thailand south to Malaysia and Borneo. In captivity* R. roulroul *are generally kept in pairs in sandy-bottomed well-planted aviaries. This captive environment is seen to encourage breeding. They are not usually kept in social flocks. The study that I am undertaking intends to investigate the behaviour patterns of the birds within the social group and if these behaviour patterns are changed with environmental enrichment. It will involve the formation of ethograms and time budgets of the behaviour patterns before the habitat enrichment, after the inclusion of the enrichment and a final set with the aviary returned to its original state. The enrichments added to the aviary will be introduced in an attempt to make the aviary a more natural environment in an order to promote better understanding of the behaviour of captive* R. roulroul *flocks. This understanding can then be used for the research of this little known species where research in their natural environment cannot be done due to the dense nature of the* R. roulroul *natural habitat. The information gathered on the captive behaviour of the* R. roulroul *flock could be used in an attempt to encourage parental rearing of the young, that is not widely seen in captivity.*

Introduction

Rollulus roulroul is the single species of the genus *Rollulus,* there are no known congenerics or subspecies with which to compare their behaviour. Their behaviour may be compared with other species of partridge although it is not known how reliable this will be (Robbins, 1998).

R. roulroul live in social groups of 5-15 individuals. They are mainly ground dwelling but may perch. They inhabit the bamboo groves and clearings of the tropical forest on the plains and foothills of Burma and Thailand, south to the Malaysia, Borneo, and Sumatra (Robbins, 1998; Del Hoyo *et al.,* 1994). In the wild *R. roulroul* is omnivorous eating seeds, large fruits, beetles, wood ants, insects and small molluscs (Robbins, 1998; Del Hoyo *et al.,* 1994). In their natural environment *R. roulroul* live in association with wild pigs and feed on fragments of larger food that have been discarded by these animals. Egg laying occurs from December to April in tunnel shaped nests built by the male birds. The clutches contain five to six eggs, which are incubated by the female for 18-19 days (Del Hoyo *et al.,* 1994).

The male *R. roulroul* is approximately 25cm tall, and has a maroon crest, red orbital skin patches, a white patch on the crown of its head and red eyes. The body is covered with a dark purplish glossy plumage. The wings are a dark brown in colour and the bird has reddish legs. The female *R. roulroul* is a similar height, they have no crest but do have red eyes and a grey head. The body is covered with glossy green plumage with rusty brown wings. The female also has chestnut scapulas and reddish legs.

R. roulroul in captivity are generally kept in pairs to encourage breeding. They are kept in well planted, sand bottomed aviaries and fed on tropical partridge mix, some fruit and a small amount of mealworms. In captivity it is found that the newly hatched young will not feed themselves and it is

common practise that young button quail are incorporated into the group to help teach them to feed (Robbins, 1998).

The *R. roulroul* is stated as vulnerable in the IUCN red data book. Its major threats are the loss of habitat through agriculture and commercial forestry and a lack of knowledge about the species and its behaviour, which is needed to start any successful conservation programme.

Methods
The *R. roulroul* populations at Harewood Bird Gardens were observed over a period of two weeks directly and by video cameras. The individual behaviour types were isolated then put in to functional groups, such as feeding and preening, to form an ethogram of the *R. roulroul* behaviour (table 1)(Lehner, 1996).

The two aviaries were divided up into grids by the use of 2ft garden canes placed at the corners of the grid squares. The composition of each square was recorded for both vegetation and substrate. From this information each square was given an index value for the cover present. In this study the level of cover offered by the square was classed as low, medium or high (Gibbons *et al.,* 1994).

The *R. roulroul* were filmed for 45 minute periods at three times during the day 09:00-09:45, 12:00-12:45 and 15:00-15:45. The tape was analysed and the behaviour type, time, duration of the behaviour and at what location within the aviary the behaviour took place were recorded.

Work currently in progress
- From these results I intend to form time budgets of behaviour exhibited by *R. roulroul* for the three time periods. Then using these time budgets statistically determine if there is any variation in the types of behaviour exhibited at different times of the day.

- Habitat preferences will also be determined by investigating if any specific areas of the aviary are utilised more than other areas and for what purpose

- Transition matrixes will be formed to investigate if any of the behaviour types are in any way linked and whether these linkages are altered in any way from one time period to the next.

Conclusion
From this project I hope to give an insight into the behaviour of this little known species. This insight may then be used to help with the holding and the breeding in captivity of this species, thus helping with its conservation. This project will start to answer questions on *R. roulroul* behaviour but it will also elaborate the point that a lot more questions need to be asked to help successfully conserve this species both in captivity and in the wild.

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Feeding		Scratching at substrate then pecking
		Pecking at substrate
		Sifting of beak through substrate
		Movement of larger substrate particles with beak
		Browsing
		Drinking
Preening		Preening chest
		Preening wing
		Preening under wing
		Scratching head with foot
		Preening of back and neck feathers
		Ruffling of body feathers with wings in
		Ruffling of body feathers with wings out
		Stretching wing
		Stretching leg
		Stretching leg and wing
Motion	Stationary/ Observational	Standing
		Lying down
	Resting	Lay, head back
		Lay, head in chest
		Stood, two legs, head back
		Stood, two legs, head in chest
		Stood, one leg, head back
		Stood, one leg, head in chest
		Perched high branch
		Perched low branch
	Mobile	Quick
		Slow
Aggression	Inter-specific	Advance slowly mouth open
		Advance slowly
		Gaping
		Chase opponent
		Being chased
	Intra-specific	Advance slowly mouth open
		Advance slowly
		Gaping
		Chase opponent
		Being chased
Male/Female interactions		Female pecks at males body
		Female pecks at males beak
		Male lies down head on ground, female does the same alongside
		Male as above mouth open, moves beneath stationary female
		Male picks up food, female takes the food
Nesting		Sit in nest site weaving
		Sit in nest site
		Walk around nest site
		Walk through nest site
		Carry material to nest site
		Through nesting material over back to forming pile

Signalling	Vocal	Chirp
		Long low trill
		Tutting
	Visual	Standing upright
		Tail flicking

Table 1. Ethogram of observed behaviour of *R. roulroul* in captivity.

Endocrine determinants of pregnancy in the Nile hippopotamus (*Hippopotamus amphibius*)

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Abstract

*Fecal pregnandiol-3α–glucuronide (PdG) was validated as a reliable tool for monitoring reproductive events, i.e. pregnancy, parturition and abortion in Nile hippopotami (*Hippopotamus amphibius*). The study thus provides the first endocrine evaluation of pregnancy in the Nile hippopotamus.*

Results and discussion

Using an enzyme-immunoassay (EIA), faecal PdG levels were quantified in four adult hippopotami six months (n = 3) and four months (n = 1) prior to and six months (n = 4) following parturition. Mean estimated gestation length $\pm$ SEM, was 235 ± 1 .0 days. Levels of PdG were significantly elevated six months pre-parturition (6.27 ± 1.35 µg/g faeces) compared to corresponding values six months post-parturition (0.27 ± 0.06 µg/g faeces; fig. 1). Analysis of monthly PdG concentrations by one-way ANOVA six months prior to and six months following parturition revealed a significant effect of month ($F_{[11, 45]} = 2.95$; $p < 0.01$; fig. 2).
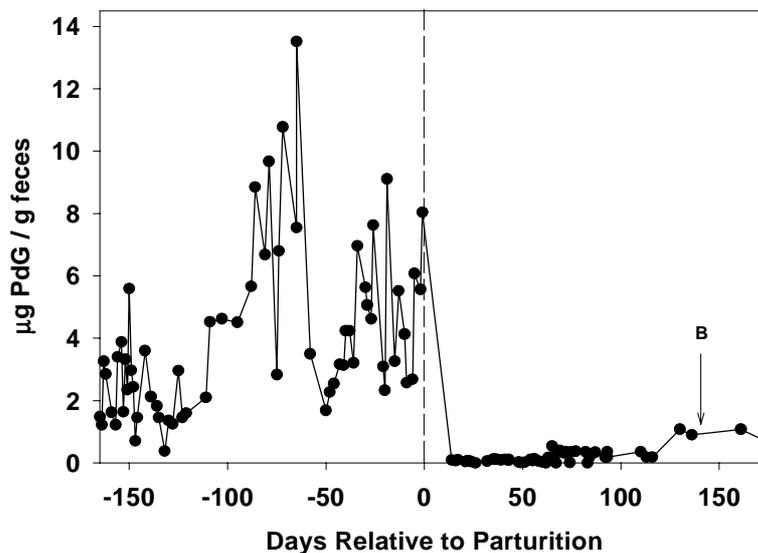

Figure 1. Concentrations of faecal PdG six months prior to and six months following birth for one female (Rosie). Day 0 = parturition, B = observed breeding behaviour.

Concentrations of PdG rose significantly throughout pregnancy to reach a plateau three months prior to parturition. PdG levels returned to baseline values immediately following birth and remained low for at least six months. Female weight did not change significantly over the period six months prior to and three months post-parturition ($F_{[8, 21]} = 0.275$; *NS*; fig. 3). The four females copulated within six months of parturition suggesting that these females experienced a post-partum ovulation. Hormone levels were also quantified for 12.8 months in one female hippopotamus that experienced two abortions. PdG levels were

significantly elevated in this female two weeks immediately prior to each abortion compared to two weeks following the abortions (4.04 $\pm$ 0.71 versus 0.70 $\pm$ 0.27 µg/g faeces respectively; fig. 4).
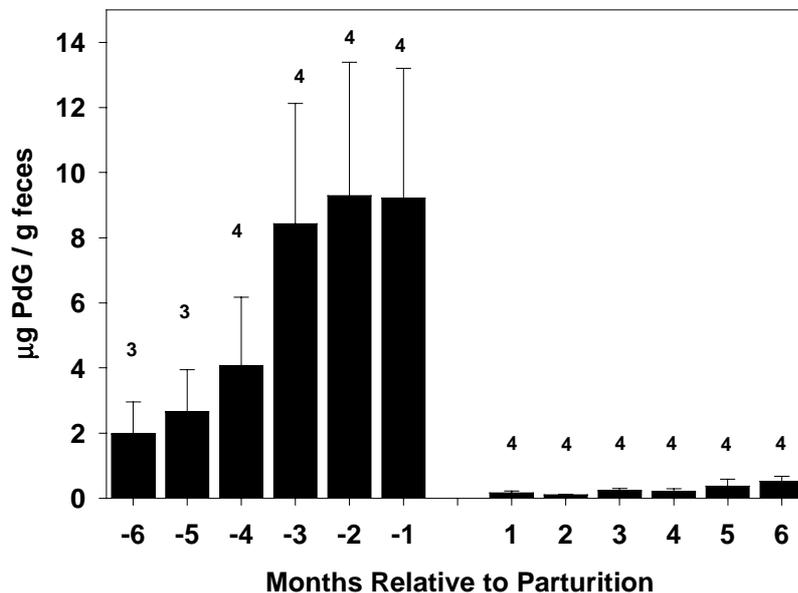

Figure 2. Monthly mean $\pm$ SEM concentrations of faecal PdG six months prior to and six months following parturition. For each month the number of females contributing to the data set is indicated above the bar.
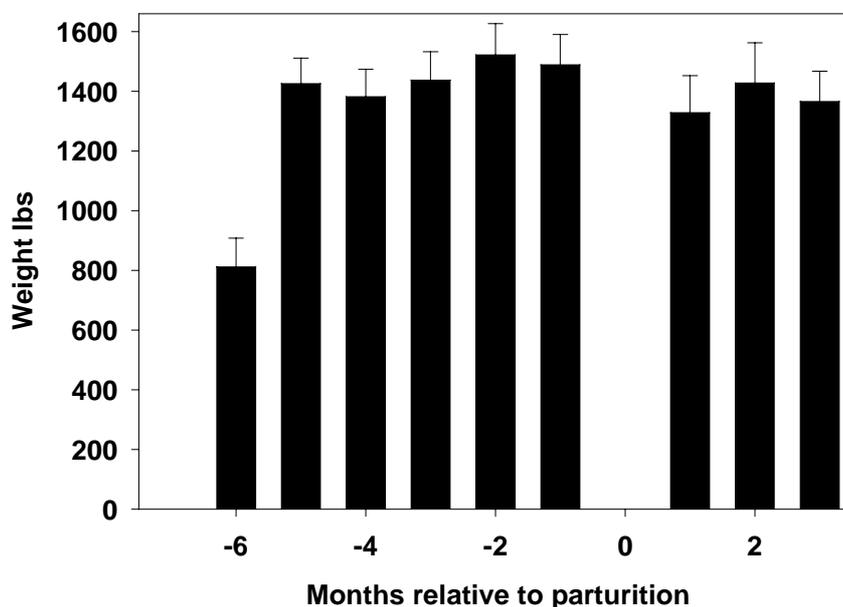

Figure 3. Mean $\pm$ SEM female weights 6 months prior to and 3 months following parturition

A pilot study assessed the utility of sweat PdG as a tool for monitoring reproductive events in female hippopotami. Sweat samples were collected from one adult female six through two months prior to parturition and levels of PdG quantified in (non-extracted) sweat using an EIA developed for analysis of sweat PdG in this species. PdG was detected in all sweat samples. The pattern of PdG excretion in the sweat resembled the pattern of PdG excretion in the faeces (fig. 5).
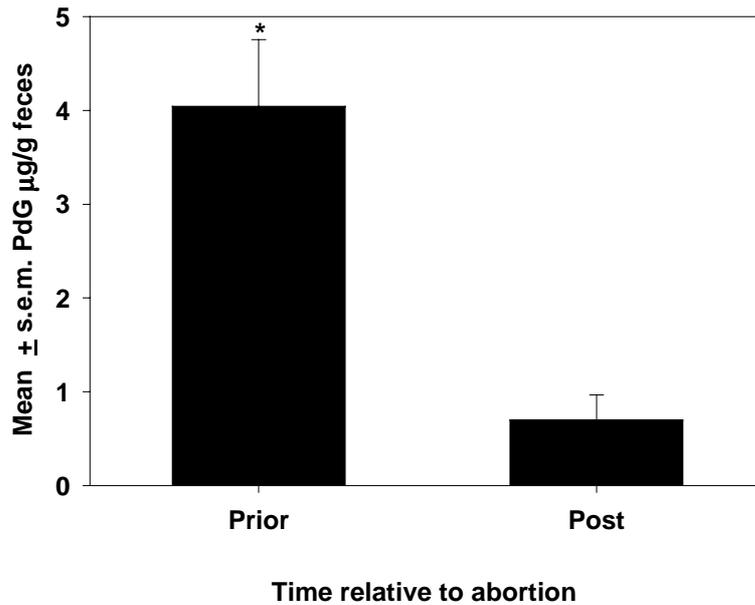
Figure 4.   Mean ± SEM concentrations of faecal PdG excreted two weeks before and two weeks following abortion (n = 2 abortions).
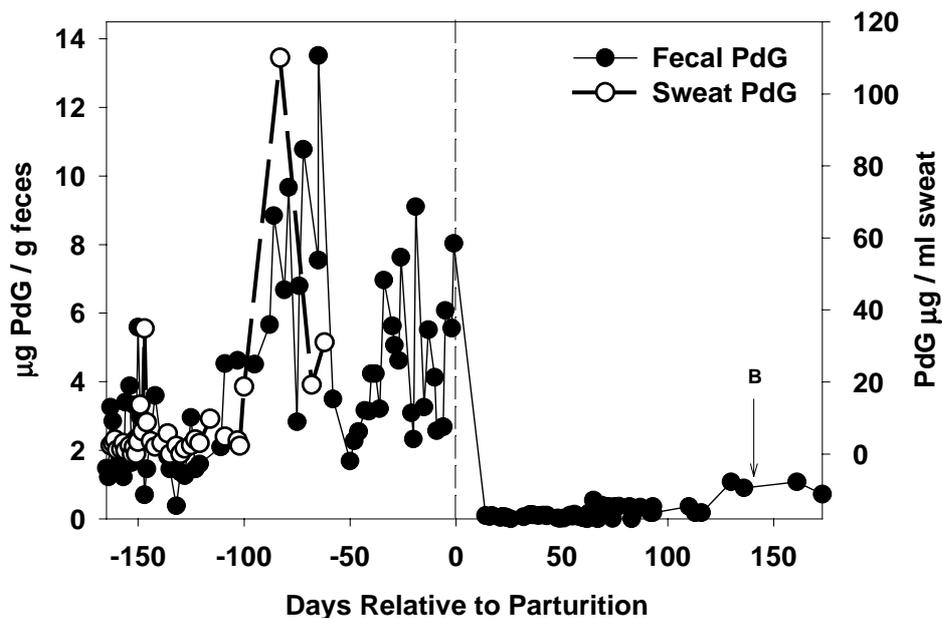

Figure 5.   Concentrations of faecal PdG six months prior to and six months following birth together with sweat PdG six through two months prior to parturition . Day 0 = parturition, B = observed breeding behaviour.

Conclusions

In summary the study achieved several goals. First we successfully developed a non-invasive technique to reliably collect fresh faecal and sweat samples from individual hippopotami for hormone analysis. Second, we validated an EIA to quantify levels of excreted PdG in the faeces and sweat by demonstrating specificity, accuracy, precision and sensitivity for the assay and third, we showed that concentrations of PdG excreted in the faeces (and possibly the sweat) can be used as reliable a tool to monitor pregnancy, parturition and abortion in female Nile hippopotami. The

current study provides the first endocrine data for reproductive events in Nile hippopotami and suggests that concentrations of faecal PdG could serve as a potential tool to monitor and detect reproductive occurrences in this species.

Non-invasive hormone analysis for reproductive monitoring in female southern white rhinoceros (*Ceratotherium simum simum*)

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Abstract

*The reproductive status of captive female southern white rhinoceros (*Ceratotherium simum simum*) was monitored non-invasively using an enzyme-linked immunosorbent assay measuring faecal 4-pregnen-20α-ol-3one (20α-hydroxyprogesterone, 20α-OHP). Matched faecal and plasma or urine samples were collected two to three times per week from eight female animals, housed at three zoological establishments in the UK for six months. The faecal samples were dried, crushed and the steroid hormones extracted with potassium hydroxide and methanol prior to analysis. The data were contrasted with urine or plasma steroid concentrations determined using previously validated assays (Hindle et al., 1992), for confirmation of our findings. Using this method we identified two pregnant, five cyclic and one acyclic animal. In cyclic females, the mean (±SD) faecal immunoreactive 20α-hydroxyprogesterone concentrations varied between 501.2 ± 158.1 ng/g dry faeces during the luteal period and 158.1 ±14.7 ng/g dry faeces in the inter-luteal period, which corresponded with the period when matings were observed. The acyclic female showed no comparable cyclic variation in hormone excretion; sample concentrations remained around 177.3 ± 97.5 ng/g dry faeces. In the pregnant animals, concentrations of faecal progestagens rose significantly above mean luteal levels after the first fifty days of gestation, and remained elevated at an average of 3637.5 ±1192 ng/g dry faeces until the end of the study. One female has produced a live calf 15 months after the predicted conception date. The mean oestrous cycle length was 32 ± 1.85 days, with mean inter-luteal and luteal periods of 7.6 ±1.3 and 25.6 ±1.6 days respectively. These data demonstrate that under appropriate management conditions, this technique provides a valuable asset for reproductive monitoring and herd management in the southern white rhinoceros.*

Introduction

Wild female southern white rhinoceros reproduce regularly, with average inter-calving intervals of 2.5 years (Owen-Smith, 1975). However, reduced reproductive success has been reported in captivity (Patton *et al.,* 1999), and is reflected in the UK population of this species. Of the five extant rhinoceros species, the southern white is currently the least endangered (Foose, 1999), numbering some 8400 free-living animals, and 700 animals in captivity (Göltenboth & Ochs, 1997), but its poor reproductive performance in captivity and the ever-present pressure of poaching on wild populations result in its survival remaining conservation dependant.

Both urinary and faecal analyses have been used to study reproductive events in white rhinoceros (Hindle *et al*., 1992; Radcliffe *et al*., 1997; Schwarzenberger *et al.,* 1998; Patton *et al.,* 1999), but the data available is often conflicting and the hormonal profile of the reproductive cycle and pregnancy has yet to be fully characterised. A number of practical issues contribute to this problem: sample collection for non-invasive endocrine analysis is difficult in group-housed animals; many of the reproductively active females are pregnant most of the time and hence rarely exhibit non-conceptive cycles; the remaining animals available for study are often non-reproductive and exhibit erratic cycles or none at all (Schwarzenberger *et al.,* 1998). The current study aimed to develop a practical method for monitoring reproduction in this species, using faecal hormone metabolite analysis and which was validated through comparison of the data with results obtained from matched urine or plasma samples.

Materials and methods

Animals and study sites

Eight animals of unknown reproductive status from three different zoological collections within the UK were studied (table 1). Diets were consistent between the different groups, although the Paignton Zoo (PZ) animal, had no free access to natural graze during the winter. Approximately 20g – 50g of faeces per animal was collected fresh, two or three times per week, and stored frozen at –20ºC. For the Whipsnade Wild Animal Park (WWAP) animals, venous blood was collected in 20ml heparinised evacuated tubes (Vacutainer, Becton Dickinson Vacutainer Systems, Plymouth, UK) from the dorsal ear vein on the same day as the faecal samples. No restraint was used. Blood samples were centrifuged for two minutes and the plasma separated and stored frozen at –20ºC in 2ml plastic vials. For the remaining individuals either free-flow or floor-drainage urine samples were collected and 10 to 15 ml were stored frozen at –20ºC in plastic universal containers.

Name	Sex	Provenance	Age In Years	Location	Reproductive category after sample analysis
Trio	Female	Captive born	23	WWAP	Pregnant
Mikumi	Female	Captive born	9	WWAP	Pregnant
Clara	Female	Captive born	19	WWAP	Cyclic
Toots	Female	Wild born	7	WMSLP	Cyclic
Mtuba	Female	Wild born	9	WMSLP	Cyclic
Trixie	Female	Wild born	5	WMSLP	Cyclic
Zulu	Female	Wild born	9	WMSLP	Acyclic
Gracie	Female	Captive born	20	PZ	Cyclic

WWAP: Whipsnade Wild Animal Park, Dunstable, Bedforshire, England.
WMSLP: West Midlands Safari and Leisure Park, Bewdley, Worcestershire, England.
PZ: Paignton Zoological and Botanical Gardens, Paignton, Devon, England.

Table 1. Summary of the southern white rhinoceroses used in this study and their reproductive status as determined from the results of the analysis

Assay procedures

Faecal and urine samples were analysed for their 20α-OHP content using the assay procedure previously described by Hindle *et al.* (1992). The sensitivity of the assay was 0.13 ng/ml as determined at 80% B/Bo. The interassay coefficient of variance (CV) was 27.4% (N = 16) for the high (6.4 ng) quality control (QC), 6.4% (N = 16) for the low (0.1 ng) QC and 18.03% (N = 16) for a 1.3 ng QC. Plasma progesterone concentrations was measured by radioimmunoassay (RIA) using a method similar to that described by Shaw *et al.* (1989).

Urine sample steroid concentrations were indexed to their creatinine content (Hodges & Green, 1989) to account for variations in fluid volume. Prior to analysis by 20α-OHP ELISA, the samples were hydrolysed and extracted as described by Hodges *et al.* (1979). Concentrations of urinary 20α-OHP are, therefore, expressed in ng/mg creatinine.

Faecal samples were thawed and dried in a laboratory oven for 18 h at 40°C prior to extraction. The entire sample was then thoroughly mixed, pulverised and sieved through a 1.0 by 1.5mm sieve to separate the faecal powder from the coarse undigested hay. Several potential extraction procedures were evaluated and the optimum method found to be that described by Shaw *et al.* (1995). The extracted faecal material was diluted 1:40 with assay buffer for non-pregnant animals and 1:200 for pregnant animals before analysis. Sample concentrations are expressed as ng/g dried faecal powder.

Data analysis

Faecal hormone concentrations were contrasted with corresponding urine or plasma data. Visual interpretation of the faecal 20α-OHP data suggested inter-luteal phase concentrations <200 ng/g faeces. Based upon this observation, and the work of Plotka *et al.* (1988), Schwarzenberger *et al.* (1998) and Patton *et al.* (1999), the inter-luteal phase was defined as a period of eight to ten days during which a minimum of three samples <200 ng/g faeces could be demonstrated. In cases where sampling was less than three times a week, speculative assumptions were made that these periods equated to inter-luteal phases. The onset of the luteal phase was considered as the first of two consecutive samples of successively increasing concentration, which exceeded the mean + 2SD of the preceding inter-luteal phase. The last inter-luteal phase sample and first luteal phase samples were all collected within a seven-day period. Separate mean ± standard deviation (SD) inter-luteal and luteal phase concentrations were calculated for each cycle. In the same way, a baseline of 2ng/mg creatinine was assumed for urine analysis.

The duration of the oestrous cycle was calculated as the time between the onset of two successive luteal phases. Cycle length was calculated separately for each individual for the faecal, plasma or urinary values, as applicable.

Results

Matched plasma progesterone and faecal 20α-OHP concentrations showed a significant correlation (Pearson's product moment correlation coefficient $r^2 = 0.36$, $p < 0.0001$, N = 38). The correlation between urinary and faecal 20α-OHP concentrations was not as strong ($r^2 = 0.24$) but still significant ($p < 0.0001$, N = 59). Faecal 20α-OHP analysis suggested that two of the eight females sampled were pregnant, five were cyclic and one was acyclic animal.

In the presumed pregnant animals, during the first fifty days of gestation, the mean faecal 20α-OHP concentration was 408.7 ± 45.5 ng/g and not significantly different from the mean luteal concentration in non-pregnant animals (t-test: two-sample assuming unequal variances, $p > 0.1$, N = 2, N = 5). However, after the first fifty days of pregnancy, the faecal concentrations rose to a mean of 3637.5 ± 1192 ng/g, significantly different to the non-pregnant luteal concentration mean (t-test: two-samples assuming unequal variances, $p < 0.05$, N = 2, N = 5). For one pregnant female, Trio, plasma progesterone concentrations rose almost immediately after presumed conception (retrospectively confirmed by parturition occurring 15 months later) and frequently exceeded the upper limit of detection of the assay (>6.0ng/ml, fig 1a.). For the other female (Mikumi; fig 1b.), plasma concentrations showed no significant increase and tended to be similar to those observed in the non-pregnant female which exhibited oestrous cycles (Clara; pregnant mean = 2.31±0.48ng/ml vs 2.18±1.61ng/ml during oestrous). Nevertheless, the diagnosis of pregnancy based on the characteristics of the faecal profile was confirmed by parturition 15 months after the presumed date of conception.

In cyclic animals, the average oestrus cycle length was 32 ± 1.85 days (based on seven complete cycles in five females) with average luteal phases of 25.6 ±1.6 days and inter-luteal periods of 7.6 ± 1.35 days. The mean faecal 20α-OHP concentrations were 158.06 ± 14.7 ng/g during the inter-luteal phase and 501.2 ± 158.1 ng/g during the luteal phase (fig. 2). Urinary 20α-OHP concentrations ranged from 0.018 to 28 ng/mg creatinine, with a mean of 5.2 ± 5.6 ng/mg creatinine. Urinary 20α-OHP profiles did not reveal as many complete oestrous cycles as the faecal profiles. Cycles detected were generally shorter than those determined using faecal profiles (25±1.1 days) with 16 day inter-luteal and 9 to 10 day luteal intervals. The acyclic female had low faecal and urinary 20α-OHP concentrations which showed no cyclic variation.
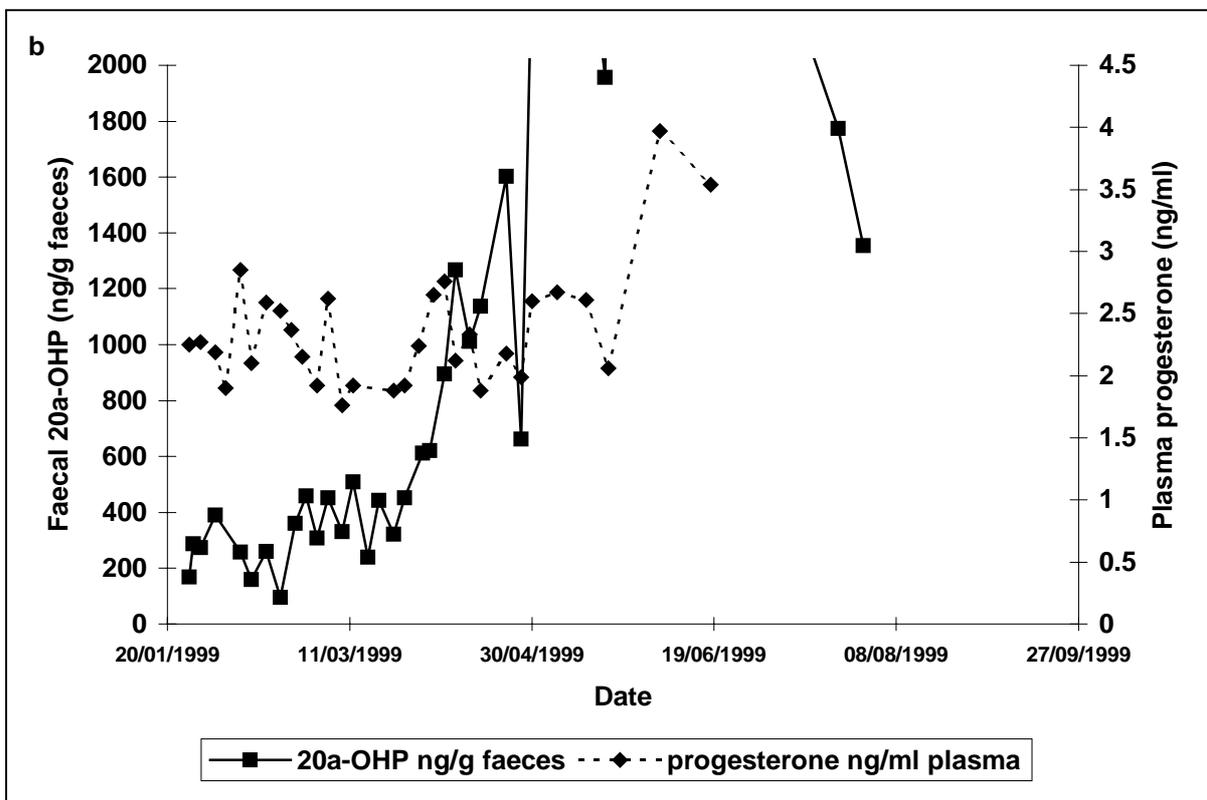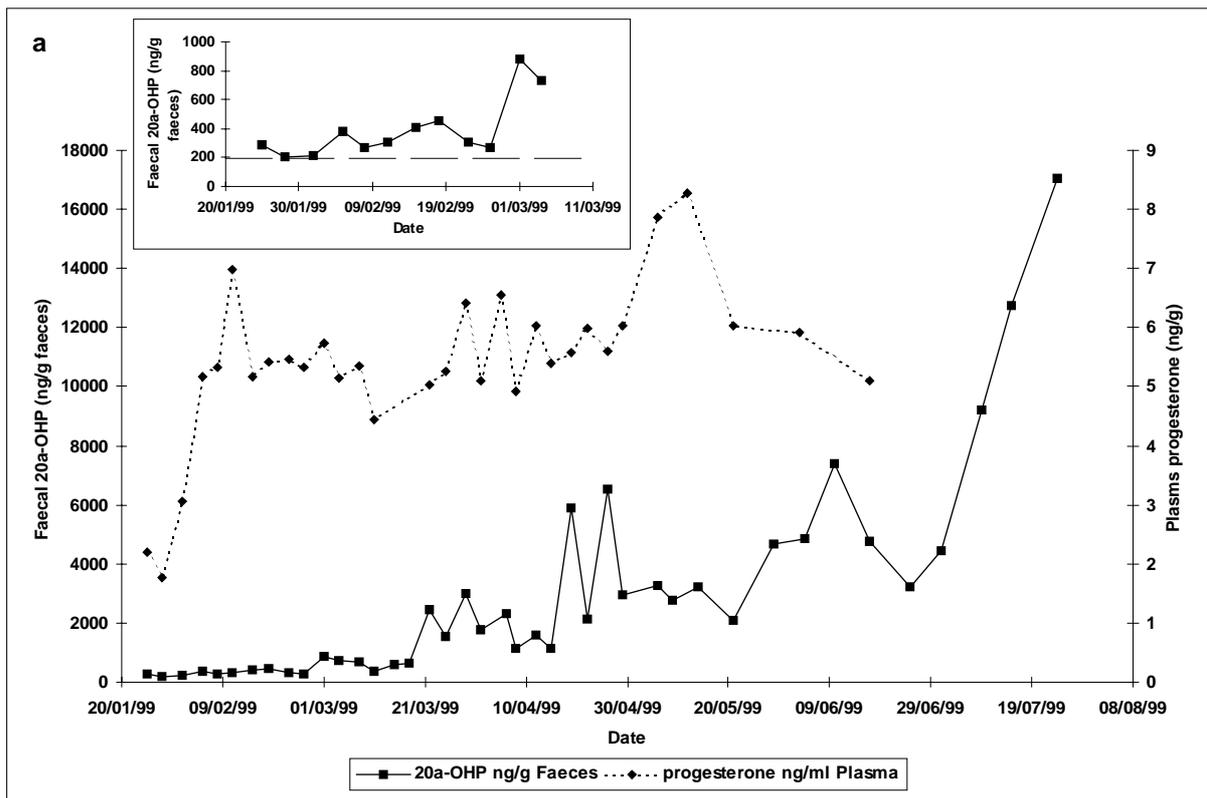
Figure 1. a) Faecal and plasma progestagen concentration in pregnant white rhino "Trio", inset shows the faecal hormone concentrations over a larger scale. b) Comparable profile for pregnant female Mikumi.
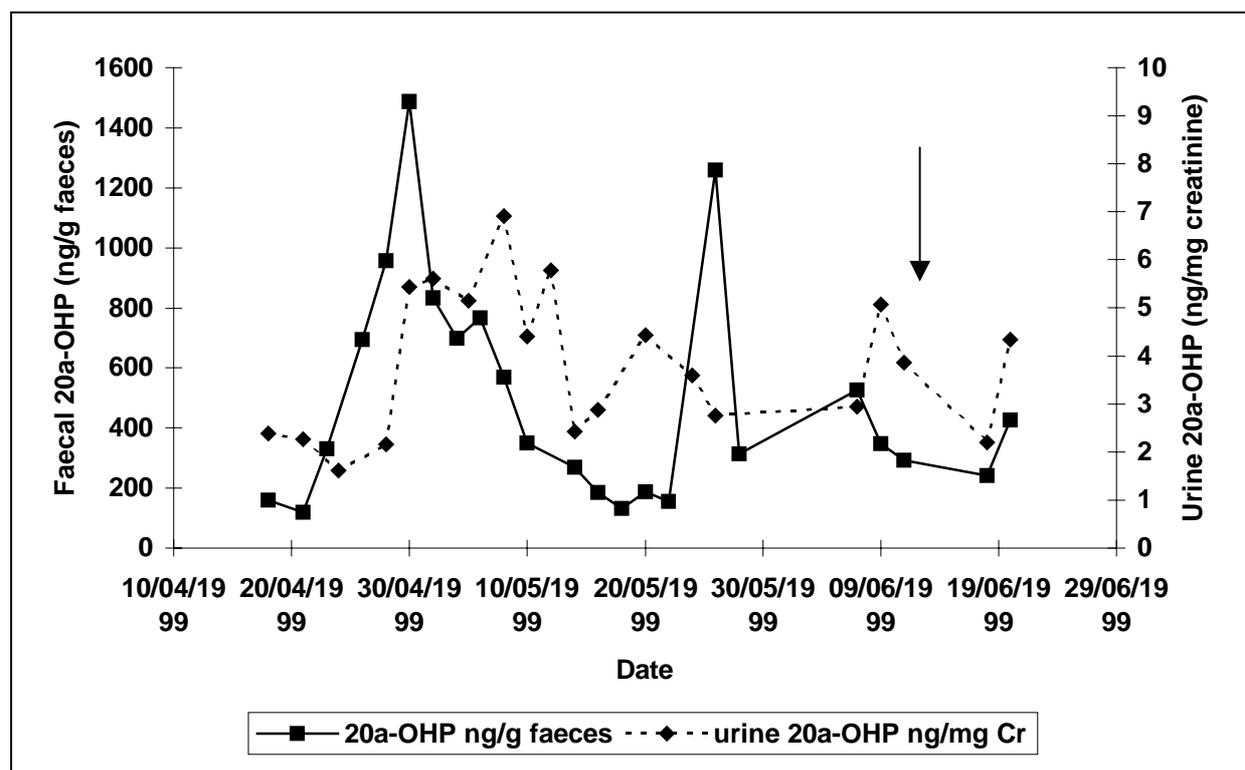
Figure 2. A typical profile from a cyclic female (Toots) showing faecal and urinary hormone concentrations. The arrow indicates observed mating behaviour.

Discussion

Faecal progestagen profiles were used to accurately diagnose pregnancy in two females. From the fiftieth day of gestation both animals showed a rise in faecal progestagen concentrations to levels significantly higher than average luteal concentrations. This finding corresponds with the results of Patton *et al.,* (1999), who noted a rise in faecal progestagen levels between the first and third month of gestation. Levels continued to increase until the seventh month of gestation before remaining at a relatively constant high level until the end of the study period. These observations suggest that pregnancy can be diagnosed in the southern white rhinoceros as early as two months post-conception, but regular, frequent sample collection is vital for accurately interpreting the changes in the longitudinal hormone profile and predicting parturition dates with any degree of accuracy.

Significant differences in the plasma progesterone profiles of the two pregnant females existed during the early stages of gestation, which would have resulted in differential diagnoses in the absence of the faecal data. Trio's plasma progesterone concentration was low for the first three samples collected, presumably around the time of ovulation and conception (categorised as an inter-luteal phase from the faecal data). Plasma concentrations then rose precipitously and remained elevated until the end of sampling. Trio gave birth to a female calf on 1st May 2000, 15 months exactly after her presumed conception at the end of January 1999. Mikumi's plasma progesterone levels were within the normal cyclic range until 70 days after the presumed date of conception, after which they doubled in concentration. The lack of obvious cycles in the faecal data led us to presume that conception had occurred around 21st February 1999, when faecal hormone concentrations were fluctuating about the 200ng/g level, indicative of the inter-luteal phase. This female gave birth on the 19th May 2000, once again 15 months after the presumed date of conception. Both gestations were within the normal range recorded for this species.

Previous studies (Radcliffe *et al.,* 1997; Schwarzenberger *et al.,* 1998; Patton *et al.,* 1999) have suggested the frequent occurrence of extended luteal phases in captive white rhinoceros females, which may be a factor involved in the reduced reproductive rates of this species. One of the five cyclic females studied (Clara) exhibited two periods of elevated progestagen concentrations lasting 49 and 60 days. However, she also exhibited temporal changes which fitted the criteria for a presumed oestrous cycle of approximately 35 days duration. It remains to be determined whether the extended periods of elevated progestagens were due to infrequent sample collection resulting in an absence of inter-luteal samples, or truly aberrant cycles. Aberrant cycles may be caused by pathological conditions such as endometritis or pyometra, but further clinical investigation would be required to confirm this.

Zulu demonstrated erratic, non-cyclical progestagen concentrations persistently below the average luteal concentrations in all of the cyclic animals and has not shown signs of behavioural oestrus for over six months. This is a common observation for captive southern white rhinoceroses (Schwarzenberger *et a.l,* 1998; Patton *et al.,* 1999) and further monitoring would be needed to establish whether she remains acyclic or exhibits periods of normal cyclic activity.

Our findings suggested that differentiation between normal and aberrant cyclic activity was not possible when less than two regularly spaced samples were collected per week. Such intensive monitoring may interfere with management, especially in extensive herd situations, but would be essential for assessing females with poor reproductive records. For early pregnancy diagnosis, the collection of two to three samples per week over an initial three month period is required. Thereafter, pregnancy may be monitored by weekly sampling. Faecal sampling may require the isolation of an animal until it has defecated, or close observation of the animals to ensure sample identification in a herd situation. Nevertheless, it remains a simpler procedure than either urine or plasma collection, and these data suggest that faecal analysis may provide more practical information than either urine or plasma analysis.

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Validation of faecal corticosteroid analysis in rhesus monkeys (*Macaca mulatta*)

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Abstract

The assay of plasma corticosteroid levels is often used to study the stress levels of animals in captivity. However, when using plasma samples, the procedure of blood collection can in itself be stressful for the animal and can produce a rapid cortisol rise, hence affecting the results. In recent years, there has been a rapid development of alternative methodologies such as the measurement of urinary, salivary and faecal corticosteroids. These indicators have the main advantage that results are less likely to be influenced by the sampling collection and that, because of their non-invasive nature, they do not require a Home Office licence. Measurements in faeces have the added advantage that there is a long time lag between plasma and faecal cortisol levels. They are a cumulative measure of the hormone excreted over time, and thus less likely to be affected by short stressful events. This makes it the indicator of choice for assessing long term changes in baseline corticosteroid levels. However, a thorough validation has to be conducted for each species before using this method. This study addressed four key aspects. The first one, extraction efficiency refers to the nature of the samples and in what proportion, and how consistently, steroids can be extracted from faeces in order to produce analysable extracts. We achieved a high efficiency (73.08%) with a low variability (CV= 2.6%) by modifying a methanol extraction protocol. The other three aspects of validation refer to the particular laboratory analysis to be used to detect the cortisol metabolites in faeces (in our analyses we used the ICN ^{125}I corticosterone). These determinations are parallelism, accuracy and challenge. Parallelism measures if serial dilutions of the sample produce a curve parallel to the standard curve of the assay. In other words, if the metabolite to analyse behaves in a similar way to the standard hormone of the kit. This indicates that faecal metabolites are correctly recognised by the antibody without interference. In our analyses, the curve for the rhesus faecal samples was parallel to the standard curve as it was found that their slopes were not significantly different ($F_{3,\ 34} = 1.31615$; p=0.2851). Accuracy was determined by adding different amounts of corticosterone, and demonstrating that the results increase accordingly. The last determination was the challenge, which was done to demonstrate that an increase in cortisol levels can actually be detected in faeces. Faecal samples were collected from six monkeys over six days, at the same time each morning. They were captured, handled and tranquillised for veterinary procedures on the second day of sampling. All but one monkey showed a significant increase of faecal corticosteroids on the third day of sampling, returning to baseline levels on day four. Having completed the validation of this analysis for rhesus monkeys, we now believe this technique is ready for its use in experimental studies.

Workshop: Uses and abuses of non-invasive hormone analysis to monitor stress in zoo animals

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Abstract
This workshop was organised to increase delegates' understanding of non-invasive techniques used to monitor stress in exotic species. Emphasis was placed on the advantages and challenges associated with each technique. Researchers with hands-on experience of various techniques gave presentations focusing on the logistics of the techniques in a zoo setting. This was followed by a series of 'real life' problems for which subgroups of delegates attempted to formulate experimental plans to answer.

Introduction - Non-invasive assessment of stress: an overview
Tessa Ellen Smith

'Stress' has been assessed using a variety of indices including: general health status, cardio-physiological measurements, immune competency, reproductive physiology, behaviour and endocrine parameters, including levels of glucocorticoids, or cortisol. Studies employing cortisol as an index of stress however, need to be aware that baseline cortisol concentrations and HPA responsiveness can be significantly modified by a range of factors including reproductive status of both subject and partner, social status, developmental history, temperament, health status, age, time of day and the social context in which the stressor is experienced. The relationship between stress and cortisol levels is not simple. Exposure to a stressor can produce an increase, a decrease or no change in cortisol levels. Further more, although certain experimental treatments such as cage enrichment might not alter baseline cortisol, they might modify the magnitude of the stress response to a subsequent stressor. When there is significant variation in baseline cortisol levels among subjects, it might be more appropriate to assess percentage change in cortisol in response to a stressor instead of absolute change.

Since procedures associated with collecting blood samples themselves alter HPA activity, non-invasive sampling techniques are advisable for stress related studies to avoid potential masking or augmentation of HPA activity in response to a stressor. Additional advantages of non-invasive assessment include minimizing invasion and discomfort to subjects, increased sampling frequency, large sample quantity, collection by non-specialist, reduced administration (no Home Office license required), samples can be stored at –20ºC as collected (compared to blood which requires plasma separation and often storage at –75ºC) and minimal exposure to blood-born pathogens. Challenges of non-invasive monitoring include, indirect hormone measurement, time lag associated with hormone metabolism and reduced control over the time of sample collection (although this can be overcome by animal training). These advantages and disadvantages may be greater or lesser depending on whether cortisol is quantified in the faeces, saliva or urine.

Faeces - Monitoring stress in mara; preliminary findings of faecal cortisol analysis
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Welfare differences between paired and unpaired (bachelor) male mara (*Dolichotis patagonium*), a socially monogamous species, free-living in the grounds of Whipsnade Wild Animal Park, were

assessed, as previous studies have suggested negative welfare implications for bachelor males. To investigate the possibilities for non-invasively quantifying physiological stress, faecal samples were collected from 30 identifiable males (15 paired, 15 bachelors) for corticosteroid analysis. Additional matched faecal and serum samples collected immediately *post-mortem* from animals culled for management purposes (Dorji, 1999) were also evaluated for validation of our findings. The faecal samples were stored at -20°C until extracted with 80% (v/v) ethanol. After centrifugation, the supernatant was harvested and stored at +4°C for immunoassay. The cortisol content of the faecal extracts and serum samples was measured using a solid phase enzyme immunoassay kit for cortisol (DRG Instruments, Germany) which cross-reacted with cortisol 100%, corticosterone 29% and cortisone 3%, but other corticosteroid metabolites <1.0%. The standard curve ranged between 20 and 800 ng/ml. Serum samples were analysed without extraction according to the manufacturers instructions and were found to contain between 2.53 and 192.85ng/ml cortisol. Faecal samples were serially diluted using phosphate-buffered saline, between 1:20 and 1:2560 (v/v) but all dilutions were below the minimum detectable dose of the assay. Despite efforts to titrate the standard curve to read lower concentrations and modifications to the initial extraction procedure in an attempt to increase the sample concentration, no readings were obtained using faecal extracts from this species. Thus, we conclude that metabolism of cortisol prior to excretion in the mara precludes the assessment of welfare using the cortisol immunoassay kit evaluated in this study. Further investigations of the corticosteroid composition of mara faeces and the validation of alternative immunoassays specifically designed to measure mara faecal corticosteroid metabolites will be necessary before this technique can be used in practice.

Reference: Dorji, T., (1999) MSc. Thesis, University of London.

Saliva - Investigation into the use of salivary cortisol to assess stress levels in rhesus monkeys (*Macaca mulatta*)

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In our experience, there are three key points that need to be solved in order to implement the use of salivary cortisol in captive animals: a) Sample collection, b) Reliability and consistency of results, and c) Time course of sampling. The first point has not been addressed in our work, but the literature reports successful cases of training of animals to chew on suitable materials that can later be centrifuged to obtain the sample. The first part of our study referred to point b: in order to determine the proportion of plasma cortisol that could be found in saliva and the relationship between the two parameters, matched samples of plasma and saliva were obtained from 26 tranquillised subjects. The third issue c: the time lag for an increase in plasma cortisol to be reflected in saliva, was addressed by collecting a series of samples over time. Saliva was collected from 22 rhesus monkeys at five minute intervals after they were tranquillised for routine veterinary procedures. In this way, it was possible to see how the hormone levels were changing over time after the initial stressor (animals needed to be captured before tranquillisation). This allowed us to determine a suitable sampling duration, so that results were unaffected by any stressful procedure.

Samples were taken with cotton buds (although they are probably not suitable to use with conscious animals). They were refrigerated, centrifuged (3000 rpm for 30 minutes) to extract the saliva from the cotton buds, and finally frozen at -20ºC until they were analysed. This was done by a commercial laboratory (SCL Biosciences, Ltd.) using a radioimmunoassay kit (ICN Corti-cote).

Urine - Collecting urine in Colombian black-faced spider monkeys (*Ateles fusciceps robustus*): a non-disruptive approach

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Cortisol has been validated as a reliable measure of stress in a variety of primate species. Although animals maintained in naturalistic captive groups do not face many of the potential dangers of living in the wild, such as predation threats and the need to locate dispersed food sources, they do face other stressors. These events include the removal and introduction of group-mates, intra-group conflict, the birth of new individuals and the presence of large groups of human spectators. We set out to devise an approach to collect urine samples from a group of ten spider monkeys at Chester Zoo, in order to monitor the hormonal impact of such periodic events. Furthermore, we wanted to develop a reinforcement free protocol for collecting urine samples, which minimised the potential for stress in the animals and that did not disrupt the daily routine of the staff. Therefore, our procedure was designed to fit within the daily routine of both the animals and the keeper staff. Although we have yet to develop the assay protocol, we will base the procedure on those protocols already developed for other Neotropical primates, including spider monkeys. Although the cost for collecting urine specimens is low, the cost for developing and running a cortisol assay may run between £1.00 to £2.00 per sample, not including labour and overhead expenses. Funding will be derived from a number of sources including in-house funding from Chester College, and various national and international grant sources. To date our method has been successful with respect to the non-disruptive nature of the urine collection protocol.

Behavioural measures as welfare indicators

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Behavioural measures are relatively easy to collect but their interpretation in relation to welfare is fraught with difficulties. Whilst there is some agreement about measures of poor welfare (such as stereotypies, vacuum and displacement activities, aggression, reduced reproduction, injury and poor health), their absence does not necessarily mean good welfare. Positive welfare indicators may include play, exploration and decreased timidity, but these measures differ among species and individuals. One study that illustrates the points aimed to determine the compatibility of two primate species, the Goeldi's monkey, *Callimico goeldii*, and the pygmy marmoset, *Cebuella pygmaea*, in a mixed exhibit. Mixed species exhibits have the potential to improve psychological well-being by increasing the complexity of the social environment, but must be carefully monitored to determine that welfare is not compromised. Data were collected on to checksheets by a single observer over a one month period. No indicators of poor welfare were observed during the study. The smaller *Cebuella* were submissive to *Callimico* at roost and feeding sites, but there was no overt aggression observed. Species differences in foraging behaviour, locomotion, substrate and height preferences reflected their natural behaviour in the wild. However, the relative inactivity of *Cebuella*, combined with the lack of play by either species, which both contained young individuals, may be indicative of low levels of stress. Ideally the study would have been a pre- and post-mixing study to determine how the presence of the other species affected behaviour. In addition, giving the subordinate *Cebuella* an opportunity to choose to cohabit in the same enclosure as *Callimico* would determine the enriching value of the housing arrangement.

'Real-life' problems considered
1. Assessing the effect of visitors on zoo primates
Geoff Hosey, Biology and Environmental Studies, Bolton Institute

There are two parts to the question: do human crowds cause stress to animals and do the animals habituate to the presence of visitors over time?

The working group decided that the use of hormonal techniques may not be appropriate for assessing the impact of visitors on zoo primates due to the difficulty of interpreting results. A successful study would need to quantify cortisol concentrations in the context of a wide range of behavioural and environmental variables relating to both visitors and animals. If, however, endocrine samples are already being collected from a species for another purpose (e.g. veterinary analyses), the same samples could be assessed for cortisol levels. Crude physiological parameters could be obtained opportunistically in this way on events such as a huge change in visitor numbers (e.g. at Easter weekend).

2.   Assessing the impact of various husbandry techniques on welfare of elephants
Stephanie Wehnelt, Zoological Gardens, Chester.

Elephant husbandry protocols, in particular training methods, have caused much controversy. In light of the large variation in husbandry methods between zoological institutions, it is important to understand the levels of stress caused by different management techniques such as shackling. The group decided that salivary cortisol concentrations might provide a reliable indicator of stress in elephants in response to husbandry procedures. Saliva samples could potentially be collected from elephants in a reliable safe manner. Salivary cortisol closely mirrors circulating plasma cortisol so should give an accurate reflection of changes in cortisol levels during a short-term stressor. Challenges associated with the latter experimental approach include determining (1) the extent to which salivary cortisol concentrations match concentrations of cortisol circulating in the blood and (2) the time lag between an increase in levels of circulating plasma cortisol and corresponding changes in levels of salivary cortisol.

3.   Faecal stress hormone assessment in pied tamarins
Eluned Price and Dominic Wormell, Durrell Wildlife Conservation Trust, Jersey

This project has already been initiated but the group were able to come up with some recommendations to improve the methodology being suggested.   The pied tamarins were housed in proximity to a closely related callitrichid species which is a natural competitor in the wild. Concerns were raised therefore as to whether or not the subject population was already stressed - a potential confound to a cortisol validation study.   To validate faecal cortisol as an index of stress in pied tamarins it was proposed that faecal samples would be collected at least two weeks prior to and at least two weeks following exposure to a presumed stressor that the animals experience as part of their husbandry procedure such as exhibit change or handling.   Emphasis was placed on the importance of collecting faecal samples at the same time each day to control for circadian variation.

4.   Understanding and reducing catatonic states in okapi
Jess Ostler, Marwell Zoological Gardens.

This problem concerned a 14 year old genetically important female okapi who entered a catatonic state every time she was introduced to a male. Administration of a long acting neuroleptic drug (clopixol) did not change her reaction. The group decided that a full history was needed on the female to determine whether or not past traumatic events might have caused this reaction, and if possible an ECG to investigate potential neurophysiological damage. It was proposed that a detailed behavioural and physiological study be conducted on the single female to assess baseline levels of behaviour, hypothalamic pituitary adrenal and hypothalamic pituitary gonadal function. The data would be used to determine the most appropriate time for drug or procedural administration. Subsequent studies might determine the extent to which the behavioural and

physiological response of the subject female to environmental and social factors differs from the response of other female okapi.   Environmental and social variables assessed might include different areas of the enclosure, olfactory contact with the male etc

In practise, this was a rather hypothetical question since Marwell Zoological Gardens had decided that due to the persistent and severe response of the female to the male, they would rather investigate the possibility of artificial insemination than attempt another introduction.

5.   Is there an optimal level of stress for welfare?
Alan McElligott, Department of Zoology, University of Zurich.

Managers, scientists and animal care staff extend extensive effort trying to minimize stress levels in captive animals.   Since animals in the wild experience stressful events with a high regularity, one would assume that animals are physiologically adapted to experience, cope with and survive stress. Therefore, is a stress-free life beneficial to the long-term well-being of captive animals?   Might short periods of acute stress (for which the animal has an adaptive coping behaviour) be beneficial to the long-term well-being of captive animals?

Delegates concluded that we do not know enough about the physiological and behavioural parameters of 'stress' to accurately determine an animal's stress level. In particular, we do not know how to interpret changes in circadian patterns of cortisol excretion. For example, what do qualitative and/or quantitative changes in the circadian pattern of cortisol excretion mean?   In conclusion, we should be very careful about making management decisions and changes based on physiological data that we do not know how to interpret.