Proceedings Of The Seventh Annual Symposium On Zoo Research

7th & 8th July 2005 at Twycross Zoo, Warwickshire, England
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Preface

Over the last few years the symposium has proved to be an important date in the BIAZA calendar and offers a great opportunity for staff and students from members and associated academic institutions to meet and deliver posters and presentations on the many research projects carried out within their collections. Thanks must go to Twycross for holding the seventh symposium that continued in the trend of increasing excellence.

It was fitting therefore that the opening presentation involved a study carried out at Twycross. An investigation of the response of adult and adolescent chimpanzees to novel foods found that adolescents spent significantly longer eating and manipulating the novel food items than the adults. Presentations topics over the two days varied as usual, but covered studies of cognitive abilities of animals, osteopathy, behaviour and diet. It was good to see several studies on the effect of visitors and ambient noise on animal behaviour, given that the BIAZA Research Group has produced guidelines on research of this type following last year’s symposia.

Possibly for the first time, there was a presentation on in situ research being carried out within a zoological collection. Paul Crow, from Kadoorie Farm and Botanic Garden, Hong Kong gave a riveting presentation on the ecological monitoring of the big-headed terrapin (*Platysternon megacephalum*). They survive in the upper reaches of a rocky mountain stream encompassed within the property and the research constitutes the first, long-term, in-situ data collected on this montane species. In the year of the EAZA tortoise and turtle conservation campaign it was pertinent that this presentation reminded us of the threats faced by this and many other species of turtle and tortoise in South East Asia.

Together with the big-headed terrapin study, there were two other in situ zoo-based research projects presented: butterfly diversity in Devon chalkland and exploring measuring the impact of conservation project. The three constitute an increase in zoo-based in situ research presented at the symposium.

However, the most entertaining presentation and most innovative enrichment for zoo animals was the development of the “Lionrover”. A devise built to stimulate hunting behaviour in the lions at Blair Drummond Safari Park by Mark Kingston Jones at the University of Sterling.

The introduction of a new record keeping system, ZIMS, in 2006 and the subsequent data cleaning up process opens up more opportunities to use zoo records as research data. Thanks go to Andrea Fidgett (Chester Zoo) for organising the session and workshops and Dave Brunger (Chester Zoo), Ross Snipp (BIAZA) and Kirsten Pullen (Paignton Zoo) for informative presentations on what data was available and how it could be used to investigate areas of animal management. Hopefully the guidelines that will result from these workshops will be put to extensive use once ZIMS and clean datasets are up and running in 2006.

The ongoing support of several academic institutions must be noted. BIAZA is very grateful for the continuing support of Anglia Polytechnic University, Sterling University, University of Edinburgh, University of Manchester, Liverpool University, Liverpool John
Moores University, Trinity College Dublin, Lincoln University, University of Antwerp, University of College Chester, Plymouth University and University of Exeter. I sincerely hope that such co-operations are strengthened and extended to other academic institutions in the future.

On behalf of BIAZA, I would like to thank Twycross Zoo again for hosting and organising this successful, seventh Annual Zoo Research Symposium and hope that research topics have been prompted both within and in connection with our member collections.

Dr. Miranda Stevenson
Director, BIAZA
Acknowledgements

Thanks to East Midland Zoological Society at Twycross Zoo for hosting the event and in particular to John Ray and Amy Nicklin for event co-ordination.

Thanks also goes out to the BIAZA Research Group for running the workshop and for their support before and during the symposium and to all the people who chaired the presentation sessions.

Finally, many thanks to all the presentors for kindly sharing their research with us.
## Delegate List

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Part 1
Oral Presentation Papers
Response of adolescent and adult captive chimpanzees to novel foods.
Lara Bezzina & Jo Martin Moulton College

Introduction

Two main mechanisms affect food habits in primates. Firstly, there is individual learning. This implies risk as the animal has no previous experience or information on the item, therefore includes testing potentially harmful foods. Secondly, social learning, this is learning by watching and interacting with others. Primates will usually learn from dominant or related individuals, peers or sometimes just experienced individuals (Gosset and Roeder, 2001).

There are ways in which animals can reduce the risk from poisonous and harmful foods. Neophobia is the fear of new or novel items, this seems to be present in some species, and variable within species. Aversion learning is when an animal eats a food, experiences negative side effects and avoids that food after recovery (Visalberghi, 1994).

There has been various research into primates, age differences and food choice, including novel foods. However much of this research has been carried out on smaller primates, mainly monkeys, and little has been conducted on apes.

The study on common marmosets by Vitale and Queyras (1997) was concerned with the effect of older ‘food experienced’ individuals on younger ‘food naive’ individuals, especially concerning novel foods. The young marmosets did eat and share the novel foods more when experienced group members were present than when the young pairs were alone. This was only evident in the case of novel foods and not foods they were used to. They also found no notable difference in the response behaviour of the young as well as the older marmosets to novel and familiar foods (Vitale and Queyras 1997).

Other studies have found marked differences in the reactions to novel and familiar foods. In rhesus macaques for example discrimination was seen between familiar and novel foods when given together and even when the familiar diet was suspended. Neophobia can be so strong in some animals that they will starve rather than eat a novel food. The macaques showed a certain level of food-neophobia, however this was lower when the novel food was given directly by a human keeper (Johnson, 2000). In a chimpanzee novel food study the demonstration of a familiar or unfamiliar human eating the same food did not effect the acceptance of the novel food by the chimpanzees (Visalberghi et al, 2002). These studies found conflicting results on human influence, this may indicate a species difference or that another environmental or procedural difference caused the difference.

Infant and juvenile primates are constantly learning and encountering new things, therefore it is understandable that they are not fearful of novel foods. Infant capuchin monkeys were found to be highly curious of novel foods and even preferred to manipulate and eat them compared to foods they were used to. If group adults were present or not, did not effect the infants behaviour towards the novel food (Fragaszy et al, 1997).

Juvenile primates are thought to be more exploratory and curious of new situations and objects than adults (Joebert and Vauclair, 1986, Menzel and Menzel, 1979). Concerning age in vervet monkeys, a pattern was found showing they are quickest to approach novel objects and situations at around 2 years of age. This time to approach gradually increases until 5 years, then steadily declines in adolescence and adulthood (Fairbanks, 1993). Another study regarding behavioural responses of young chimpanzees to a novel environment, found that infant chimpanzees showed signs of distress such as rocking, in a new environment. Young juveniles assessed the environment visually remaining close to the entrance and older juveniles (5yrs) explored the environment with the hands and moved freely throughout the area (Miller et al, 1986). Mayeaux and Mason (1998) also found strong effects of age toward novel objects in new world titi monkeys (Callicebus). In the study juveniles were fastest to approach novel objects and spent longer manipulating them than adults. Younger adult
gorillas (gorilla gorilla gorilla) (under 10 yrs) have been found to be more active in solitary play behaviour, than older adults (above 10 yrs) (Rooney and Sleeman, 1998). These studies suggest there are differences in the behaviour of young and old adult primates.

It is widely accepted that younger primates are more exploratory and take more risks and adults are quite rigid and less adaptable to change, however the studies pre mentioned seem to contradict this point as well as each other. Until primates reach adulthood, they are more at risk from starvation, predation and therefore mortality rates of juvenile and sub adult individuals is higher than fully matured adults (Janson and Van Schaik, 2001). They are more likely to starve due to competition from larger adults, less competent foraging techniques as well as difficulty in eating larger fruits. Large or tough fruits eaten by adults contribute largely to the total energy required from the daily diet. This is due to the higher proportion of pulp in larger fruits and the comparatively small amount of energy required to extract this (Malenky, 1990). Therefore, younger primates are more likely to take risks with the diet as they are more restricted than adults. They are required to find ways to expand the diet in order to survive to adulthood, where finding sufficient food and avoiding predation will be easier due to their size, experience and dominance.

Research on captive chimpanzees and novel foods has been carried out, but this did not concern age of the individuals. As well as obvious primate species differences, there are also interindividual differences within species, as seen in chimpanzees, even with a small sample number of eight. Some chimpanzees completely refused novel foods, showing neophobia, others accepting almost all foods (Visalberghi et al, 2002). Variable reactions and levels of neophobia have also been seen in wild chimpanzees (Matsuzawa et al, 2001). This study used just eight chimpanzees and is the only relevant study on captive chimpanzees and novel foods. As the study also focused on acceptance in accordance to whether the food giver was familiar or not, no information has been gained in acceptance of novel foods if they appear in the environment i.e. are not seen to be given by a human. Johnson (2000) found an increase in acceptance of novel foods in rhesus macaques when given by a human.

In 2001 Port Lympne rehabilitated and released two captive bred gorillas to Gabon in Africa. They both coped well at first and established positions within a wild group, however, after two to three years in the wild both individuals had died. Head gorilla keeper Colin Angus felt that the two most important factors in the gorillas’ survival and transition to the wild were acclimatization and a different diet (Angus 2003, personal communication). It may therefore be important to give chimpanzees a more natural diet in captivity. Novelty in the diet can also be sensory stimulating and highly enriching especially in a routine diet. Choice in a captive environment can also be stimulating, empowering the animals to make their own decisions (Markowitz, 1997). Snyder (1996) stated that young chimpanzees adapt better than older chimpanzees to change, but in the case of separation and reintroduction to the wild may need emotional support, which they would normally get from their mothers.

A study concerning wild chimpanzees feeding behaviour at Bossou (Republic of Guinea, West Africa), found that they fed on 246 items, from 200 different plant species of 664 plant species available (Sugiyama and Koman, 1992). Such a large number of items are maintained through social transmission as well as individual risk taking and learning (Laland, 1999). Although chimpanzee diets in captivity vary widely, it is common for them to have a staple or regular diet of simple fruits and vegetables such as oranges, bananas, apples, pears, carrots and parsnips.

The purpose of this research was to compare adolescent to adult captive chimpanzees in their reactions to and treatment of novel foods. This was done in order to establish whether a difference between the age groups exists in captivity and if this has any implications for captive breeding programmes. Novel foods were used in order to look at their reactions toward newness (environments, objects, individuals etc). It is important that individuals within captive breeding programmes retain behavioural characteristics that are required for survival in the wild (Markowitz, 1997).

Many daily routines and procedures in captive environments do not encourage natural behaviours concerned with feeding and exploring i.e. giving daily food in one go, hand
feeding, predictable feeding times/ routines, food prepared so it does not require manipulation, lack of new and different foods/ tastes, giving what the chimpanzees 'like'. Ideally, captive chimpanzees should be cautious of new things but willing to explore further. Neophobia has been reported in wild chimpanzees and been stated to be stronger than in captive chimpanzees (Matsuzawa 1999), it may be less likely to occur in captivity due to a lack of experience with harmful foods (objects), and no opportunity for food aversion learning.

Method

Subjects:
The study used nineteen captive chimpanzees, which were housed at Twycross Zoo, Warwickshire, Great Britain. The chimpanzees were housed in small groups of 2, 3 and 4 with an indoor and sleeping area and an outdoor run. The chimpanzees ranged from 8 years to 38 years of age, 11 female and 8 male, and were kept in seven separate enclosures. The setup was the current groupings at the zoo. The chimpanzees were given their normal diet throughout the experiment.

Procedure:
The study took place over three months from April to June 2004, and the trials took place once a week during this time on various days and different times appropriate for the keepers schedule. This was done so that the chimpanzees did not get used to a set schedule and know when to expect the trial and therefore the novel food. The groups were tested in their own enclosures, and were shut outside while the novel food was placed in various places on the inside area of the enclosure by the experimenter. This was done so the food didn’t smell of the keeper and to allow equal access to all chimpanzees within the group. The chimpanzees were then let back in and filming with a Canon x21d digital camera commenced. Filming subsided when all traces of the food had been consumed or after 30 minutes, the maximum filming time allowed for the study. The maximum filming time allowed was decided after watching the chimpanzees at their regular feeding time.

The six food items were chosen by discussions with the keepers as to what the chimpanzees had and had not eaten. The foods were also kept within a similar food group of fruits, vegetables and roots. As novel foods were limited due to the chimpanzees experience of a wide range of foods as well as supermarket donations, availability of items was also important in the foods chosen.

Novel foods, and the allowance per chimpanzee used in the study

<table>
<thead>
<tr>
<th>Week</th>
<th>Food</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Black olives</td>
<td>25g</td>
</tr>
<tr>
<td>2</td>
<td>Nisperos</td>
<td>80g</td>
</tr>
<tr>
<td>3</td>
<td>Chicoos</td>
<td>80g</td>
</tr>
<tr>
<td>4</td>
<td>Mangosteen</td>
<td>100g</td>
</tr>
<tr>
<td>5</td>
<td>Whole baby beetroot</td>
<td>100g</td>
</tr>
<tr>
<td>6</td>
<td>Fresh figs</td>
<td>160g</td>
</tr>
</tbody>
</table>

All trials were video recorded and watched back so that each individual chimpanzee could be watched for the whole time, with its behaviours recorded by use of an ethogram. This meant that continuous sampling was possible, so that no important behaviours were missed. The ethogram was concerned with eating related behaviours only, allowing one column for non-food related behaviour. There were nine food related behaviours on the ethogram decided after watching the chimpanzees eat and researching their eating habits.
The behaviour categories used and their descriptions

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approach</td>
<td>To turn toward the direction of the food/ piece of food and move towards it.</td>
</tr>
<tr>
<td>Watch/ Beg other</td>
<td>To look in the direction of another individual that has possession of the food, to watch the individual or perform begging behaviour toward the individual with food. Begging consists of holding out hands, approaching face, mouth or hand of individual with food, touching food that other has possession of.</td>
</tr>
<tr>
<td>Take from other</td>
<td>To gain food from other individual that has possession of food, including taking from hand, mouth or immediate proximity. Individual that has possession of the food can be willing or unwilling to give the food.</td>
</tr>
<tr>
<td>Give to other</td>
<td>To give food to another individual willingly, including from hand, mouth or immediate proximity.</td>
</tr>
<tr>
<td>Approach other with food</td>
<td>To turn toward the direction and move toward an individual that has possession of food</td>
</tr>
<tr>
<td>Touch/ Pick up</td>
<td>To touch or pick up the food with any part of the body.</td>
</tr>
<tr>
<td>Smell</td>
<td>To hold the food to the nostrils, or bring the nostrils toward the food.</td>
</tr>
<tr>
<td>Manipulate/ Wadge</td>
<td>To play with the food in the mouth, hand or on any surface. To move the food in any manner. To form a pulp of the food in the mouth, squeezing out the juices and taking out skins or seeds.</td>
</tr>
<tr>
<td>Chew/ Eat</td>
<td>To consume the food, by chewing it in the mouth without forming a wadge and swallowing the food.</td>
</tr>
<tr>
<td>Other</td>
<td>Any behaviour which is non food related.</td>
</tr>
</tbody>
</table>

Data Analysis

The frequency and total time in seconds for each behaviour per individual per day were calculated and entered into spreadsheets, the totals were then used in order to calculate the mean for each chimpanzee for each behaviour and the frequency of that behaviour over the six days of trials. The data was also split into the two relevant age categories of adolescents 8-15 years and adults 16+ (Goodall, 1986), in order to compare these age groups. This work was carried out on Microsoft Excel on windows 2000.

The data was carried over into the statistical package, Minitab release version 13.20, in order to carry out all statistical tests as well as normality tests on the data. A chi square test of association was carried out on categorised data, as there were two conditions and the data was nominal. The normality test Kolmogorov-Smirnov was used in order to check for normality of each set of data (i.e. for each behaviour). The abnormal data was taken back into Microsoft Excel and log 10 was used in order to normalise the data. A Mann-Whitney test was carried out if data was not normally distributed, and an Independent two sample T-test was carried out if the data was normally distributed. This was done as the Mann-Whitney is a non-parametric test, which can only be used on non normally distributed data. The two tests were chosen as their conditions suit my experimental design. Both tests look for a difference, require two conditions, independent subjects and interval or ratio data.

Results

Acceptance of novel foods

No food was eaten by all chimpanzees in the study, however all foods were eaten by the majority. The least popular foods were baby beetroot and black olives. The beetroot was not eaten by 4 individuals, and 3 individuals tasted but did not eat the beetroot and the olives. This is the highest number of individuals that tasted and rejected the food. The most popular foods were figs, chicos and nisperos, all sweet fruits of similar size. The food consumed
most by the adolescents was niseros (eaten by all), and figs for the adults (eaten by all but one). In 84% of trials foods were eaten by adolescents, in 73% of trials foods were eaten by adults.

### Acceptance of Novel Foods by all Chimpanzees

<table>
<thead>
<tr>
<th>Food</th>
<th>Number of individuals</th>
<th>Number of adolescents</th>
<th>Number of adults</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olives</td>
<td>12</td>
<td>37</td>
<td>48</td>
<td>85</td>
</tr>
<tr>
<td>Nisperos</td>
<td>18</td>
<td>2</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>Chicoos</td>
<td>12</td>
<td>5</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>Mangosteen</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baby beetroot</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Figs</td>
<td>18</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The data from the number of individuals that eat, tasted or did not eat the foods was split into adolescents and adults. A chi-square test of association found a significant association (chi-square=6.390, DF=2, p=0.041). It is likely that this association lies between the age category and the number of foods not eaten. The adults did not eat in a higher number of trials than expected. Therefore, there is a strong association between the age category and the number of foods consumed over all trials.

### Number of adolescent and adult chimpanzees that ate, did not eat or tasted but did not eat the foods over the total number of trials.

<table>
<thead>
<tr>
<th></th>
<th>Eaten</th>
<th>Not eaten</th>
<th>Tasted/not eaten</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of adolescents</td>
<td>37</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Number of adults</td>
<td>48</td>
<td>14</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>85</td>
<td>16</td>
<td>9</td>
</tr>
</tbody>
</table>

### Latency to approach, taste and eat novel foods

Adolescents and adults on average took similar times to approach the foods, but the adults tasted and ate the foods twice as fast on average than the adolescents. The adolescents were observed to play with (roll on the floor, wedge/ manipulate, smear on windows, hold in hand, pass out through bars) the foods frequently. These behaviours were quite common in adolescents yet rare in the adults. A highly significant difference was found between the adolescent and adult times to eat the foods, this was highly significant at 0.05 level of significance.
Mean times taken to perform certain behaviours by adolescent and adult chimpanzees

<table>
<thead>
<tr>
<th></th>
<th>Mean (SD)</th>
<th>Mean (SD)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adolescents</td>
<td>Adults</td>
<td></td>
</tr>
<tr>
<td>Time to Approach</td>
<td>17.22 (18.86)</td>
<td>22.86 (27.21)</td>
<td>T=1.77, DF=13, p=0.101 Non sig</td>
</tr>
<tr>
<td>Time to Taste</td>
<td>50.2 (42.0)</td>
<td>21.42 (20.72)</td>
<td>T=1.77, DF=13, p=0.101 Non sig</td>
</tr>
<tr>
<td>Time to Eat</td>
<td>256.6 (127.5)</td>
<td>126.4 (77.1)</td>
<td>T=2.57, DF=10, p=0.028 Sig</td>
</tr>
</tbody>
</table>

On the first day of trials both adolescents and adults took longer to approach the food, than on the last day, day six. The average time to approach decreased from 40+ seconds on the first day to just 9 seconds on the last day, therefore they may have become used to the procedure of the trials even though trials were a week or more apart, and at different times.

The biggest difference between times spent performing behaviours was the adolescents spent significantly longer eating and chewing the foods than the adults, this was significant at 0.05 level of significance. The average time that an adolescent spent eating a novel food was 171 seconds (2:51 minutes), and just 82 seconds for an adult (1:22 minutes). The adolescents also spent significantly longer wadging and manipulating the foods than the adults, this was also significant at 0.05 level of significance. The average wadging time for an adolescent was 39 seconds, and just 4 seconds for an adult. There was a trend toward the adolescents spending more time approaching the foods. There was also a trend toward the adults spending longer performing other non-food related behaviours; however, these trends did not reach significance. The adults spent longer watching and begging others, however this difference was not significant. The adolescents approached, picked up, smelt, wadged and ate the foods more frequently than the adults.
Time Spent Performing Behaviours by Adolescent and Adult Chimpanzees

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Mean (SD) Adolescents</th>
<th>Mean (SD) Adults</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approach</td>
<td>5.96 (1.25)</td>
<td>4.77 (1.47)</td>
<td>T=1.90, DF=16, p=0.075 Non sig/Trend</td>
</tr>
<tr>
<td>Watch/Beg</td>
<td>10.03 (11.52)</td>
<td>17.27 (24.75)</td>
<td>T=-0.47, DF=1, p=0.642 Non sig</td>
</tr>
<tr>
<td>Take from other</td>
<td>1.75 (3.62)</td>
<td>0.20 (0.35)</td>
<td>T=1.19, DF=7, p=0.271 Non sig</td>
</tr>
<tr>
<td>Give to other</td>
<td>1.25 (2.82)</td>
<td>0.32 (0.71)</td>
<td>T=0.71, DF=9, p=0.498 Non sig</td>
</tr>
<tr>
<td>Approach other</td>
<td>3.14 (4.16)</td>
<td>2.41 (3.56)</td>
<td>T=0.33, DF=13, p=0.744 Non sig/Trend</td>
</tr>
<tr>
<td>Pick up</td>
<td>4.06 (1.86)</td>
<td>3.24 (1.71)</td>
<td>T=0.98, DF=14, p=0.344 Non sig</td>
</tr>
<tr>
<td>Smell</td>
<td>3.68 (2.32)</td>
<td>2.24 (2.19)</td>
<td>T=1.37, DF=14, p=0.192 Non sig</td>
</tr>
<tr>
<td>Wadge/Manipulate</td>
<td>38.80 (50.6)</td>
<td>3.65 (8.17)</td>
<td>T=2.52, DF=10, p=0.030 Sig</td>
</tr>
<tr>
<td>Eat</td>
<td>171.10 (98.1)</td>
<td>82.00 (48.1)</td>
<td>T=2.37, DF=9, p=0.042 Sig</td>
</tr>
<tr>
<td>Other</td>
<td>123.70 (107.6)</td>
<td>222.9 (129.5)</td>
<td>T=-1.82, DF=1, p=0.088 Non sig/Trend</td>
</tr>
</tbody>
</table>
Discussion

The adults in this study on average tasted and ate the foods twice as fast as the adolescents. The study predicted that the adolescents would eat the foods faster than the adults and would be more likely to eat more of the foods than the adults. Therefore the result is the opposite of what may have been expected due to previous research (Johnson 2000, Fragaszy 1997, Menzel and Menzel 1979, Rooney et al, 1998). However the adolescents did eat the foods in more of the trials, the adults were more likely not to eat the foods given.

Younger chimpanzees are known to be more playful, adaptable and exploratory than their elders. The results show that adolescents took a lot longer to eat the foods than adults, this may show a reluctance to eat the foods, although this is unlikely due to a higher percentage of foods completely consumed by the adolescents over all trials (84% adolescents, 73% adults). The adolescents also performed some eating related behaviours significantly more frequently (wadge/manipulate, pick food up, approach food), showing they took their time consuming the foods, stopping to smell, play with and manipulate the foods. This was different to the adults whom often performed a limited number and sequence of behaviours during the trials and consumption of the foods. This may have been due to the adults being accustomed to eating everything they are given without caution because of a foods novelty. This may be an effect of long-term captivity. The adults frequently tasted a food then took it out of the mouth to smell it. The adults have been in captivity longer and have had little opportunity to encounter harmful objects and foods, meaning they ate the novel foods more like they would eat their usual diet, quickly. Remis (2002) found that captive chimpanzees quickly ate foods that they least preferred in food preference trials.

Adolescents may have taken longer to consume the food due to their exploratory and playful behavioural tendencies. They spent significantly more time wadgeing and manipulating the foods than the adults did. Time to eat was the amount of time it took each individual to entirely consume the food, therefore wadgeing, playing with and manipulating were all included in the time to eat total. The adults manipulated and played with the foods less than the adolescents, meaning they ate the foods a lot quicker. Wadgeing is thought to be a cultural practice of wild chimpanzees usually using leaves with a softer fruit/ together (Whitten, 1999). Wadgeing may be useful to chimpanzees for various reasons, it is thought to reduce fibre intake when eating fruits, it may prevent biting into potentially toxic seeds of some fruits (especially novel ones, sometimes spitting out the seeds) and it prevents the loss of fruit juices especially from overripe fruits (Nicholson, 1998). This is therefore a useful behaviour in wild chimpanzees, the results may provide evidence that captive chimpanzees are born with certain behavioural sequences, which may prevent them from harm. These behaviours may be lost after a long period in captivity, as they are not required and are no longer useful to the animals’ survival.

The number of generations that a chimpanzee has been bred in captivity may also affect the extinction of these behaviours. The behaviour of many captive species change over generations of captive breeding and management (Markowitz, 1997). Fear, anxiety and unwillingness to try new foods and interact with new objects or situations would not be a very desirable characteristic for the ease of care and management of captive chimpanzees. No fear or neophobia was seen towards the foods during the trials. Neophobia has been reported in wild (Matsuzawa et al, 2001) and captive chimpanzees (Visalberghi et al, 2002), however not to a great extent. The foods used in this study, although novel, may not have been unusual enough to get a fear or neophobic reaction. The foods used were all types of food which the chimpanzees would be likely to include in their diet if they had the opportunity to in the wild. Four of the foods given were sweet or very sweet fruits, which were favoured overall by the chimpanzees (adolescents: nisperos, adults: figs). Some fruits also look, taste and smell similar. Gosset and Roeder (2001) found that the main factor influencing lemurs’ reactions toward novel foods was the quality of the food. In a study of captive chimpanzee food preferences, high sugar and low fibre fruits were preferred over other fruits and vegetables. Bananas, which were the overall favourite and familiar to the chimpanzees, were only fractionally more popular than novel figs (Remis, 2002). Therefore, the popularity of the novel fruits in the current study may have been due to their quality and preference for this type of food, which overpowered a reaction of fear or suspicion. The olives and beetroot were
the least popular foods, and were the only non-fruits used. The sampling of new fruits also presents fewer risks than many other types of foods, such as leaves (Milton, 1993). Chimpanzees may be neophobic in certain situations but it would possibly take a highly novel situation, object or food to provoke this. Novel foods very different to their normal captive diet may have provoked more neophobic reactions within the group.

No abnormal behaviour was seen during any of the food trails, this was likely to be due to the chimpanzees interest in the novel foods. The foods were enriching for the chimpanzees, giving them new smells and tastes to investigate. Bloomsmith et al (1988) found that a short feeding length and limited variety in the diet of captive chimpanzees resulted in the development of various abnormal behaviours, mainly oral related (e.g. copography, regurgitation). One individual, Mwekundu (10) was often seen sitting in one of the enclosure windows alone, and followed human visitors as they moved around the enclosure. She did this for very long periods of time. During the food trials she only did this a few times whilst eating the food, but was more interested in the food. On two occasions she took ten minutes to eat the small amount of food given.

The opportunity to interact with new situations, foods, individuals and objects should be a part of captive routines, encouraging exploratory behaviours. The novel foods also promoted some wild specific behaviours such as wadgeing mainly in the adolescents. The extent to which this is part of the groups’ normal feeding repertoire was not investigated but may be interesting to investigate in the future. The foods did not promote natural wild behaviours in the adults, as they ate the foods in a similar way to their normal diet.

**Conclusion**

Adolescent chimpanzees spent significantly longer manipulating and eating novel foods. In comparison adult chimpanzees ate the novel foods in a similar way to their normal diet. No neophobia was seen during the food trials and only the oldest individual refused to approach the foods in most of the trials.

This study contributes to the limited research on adolescent and adult captive chimpanzee differences in behaviour, as well as the impact that captivity may have on their behaviour. Many captive environments do not promote the wild specific behaviours that are important to captive breeding programmes and the future of the species. It is clear from the study that the adolescents would be more suitable to breeding programmes and possible reintroduction programmes. Using genes from captive populations is also a reason described for carrying out captive breeding programmes. The adult chimpanzees in this study may not be suitable for this due to their loss of appropriate behaviour, which can contribute to survival in the wild. It has been suggested that eventually the only solution to this problem will be to maintain two populations of a species, one for reintroduction and one for exhibition, (Markowitz, 1997) as different characteristics are desirable for the different environments.

The study shows that something as simple and easy as novelty as enrichment has positive effects, and no abnormal behaviour was seen throughout the food trials. Giving the chimpanzees more choice and variance in captivity is important and empowers them to make their own decisions.

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Ecological survey & monitoring of Platysternon megacephalum (Testudines: Platysternidae) at Kadoorie Farm & Botanic Garden
Paul Crow, Kadoorie Farm & Botanic Garden (KFBG), Fauna Conservation Department, Lam Kam Road, Tai Po, N.T., Hong Kong

Kadoorie Farm & Botanic Garden (KFBG) is incorporated under Hong Kong law as an area for conservation and education and whilst not a zoological garden it incorporates many of the same features and functions including live animal educational exhibits, captive breeding programmes for endangered and critically endangered species and an environmental education program. KFBG also resides in a unique location being placed in a 148-hectare plot, which is managed as a miniature nature reserve. The property encompasses the origin and upper reaches of a rocky mountain stream, which is home to Platysternon megacephalum, The Big Headed terrapin. At this site the species can prosper free from the threats placed on it elsewhere in the region (collection for both the food and pet trade industry).

Given the pressure on all Asian species of chelonian and the mission of KFBG it was a logical step to investigate the population of this extremely understudied species. The knowledge gained from this survey will represent the first long-term, in-situ data collected about this montane turtle species. The monitoring programme will improve global knowledge of some aspects of the ecology of this endangered species and may assist in providing answers to some of the questions about the turtles captive management.

To date, the study is unpublished and ongoing. Data is gathered from individually identified specimens including morphometrics, habitat parameters and range movements via radio-telemetry. Data logging of microhabitat conditions (mini loggers affixed to large specimens) also adds to the data set. GPS and photographic survey of stream sections and capture locations, collection of blood and or shell clippings for potential future DNA analysis and faecal samples for dietary studies are also essential components of the study.

The inception of this study was in conjunction with staff of the Savannah River Ecology Laboratories, USA who provided initial training in field study techniques and remain advisors to the project. Additional support is also provided by local and International volunteers.
Study of self-control in Californian sea lions using reverse-reward task
E. Genty¹, J.J Roeder, C.Salomé² & V. Roy¹,
¹CEPE UPR/CNRS 9010, Ethologie et biologie comportementale des primates, ²Nausicaa Boulogne sur mer, France

Abstract:

Four California sea lions have been tested under reverse-reward task, described to study self-control capacities in primates, to reveal if they could inhibit their natural impulsivity for food. When sea lions were presented with the choice between two different quantities of fish, as opposed to primates, they were spontaneously able to select the smaller quantity of fish to receive the larger one as reward according to the reverse reward task.

Self-control is defined as the ability to inhibit impulsive responses in favour of a more appropriate alternative. This ability has first been studied in human children and it has been demonstrated that self-control does not emerge before the age of 4 years old and that it seems related to other cognitive skills as self-awareness (essential for achieving effective actions in the sake of their later outcomes). The 4 years old children that expressed self-control under experimental conditions developed into more cognitively and socially competent adolescents. Therefore, in a comparative perspective, it appeared of best interest to reveal whether this ability of self-control was related to advanced cognitive abilities that are unique to humans or whether it was related to more general cognitive abilities and could therefore be shared by several primate species.

To assess self-control in nonhuman primates the following experimental protocol was widely used: subjects were presented with the choice between two different quantities of the same food item (i.e. 1 raisin versus 4 raisins) under a reverse-reward contingency, which consisted of rewarding the subject with the quantity of food other than the one it selected. That is to say that if the subject chose the larger quantity of food (4 raisins), it was rewarded with the smaller quantity (1 raisin), and vice-versa. These studies have largely reported that when they are presented with the choice between two different quantities of food in an experimental situation involving a reverse-reward contingency, primates have difficulty in controlling their impulsive gesture toward the larger quantity. But the reverse-reward contingency should be helping for the subject to inhibit their impulsive choice for the larger quantity and to learn to reliably choose the smaller quantity in order to maximize their reward intakes. Boysen and Berntson (1995) reported that chimpanzees’ selections were biased towards the larger quantity of food and that it was the incentive effect of the high-appetitive value of the food that interfered with their ability to master the task. The same bias for choosing the larger quantity was reported in Japanese macaques (Silberberg and Fujita, 1996), squirrel monkeys (Anderson et al., 2000), cottontop tamarins (Kralik et al., 2002), brown and black lemur (Genty et al., 2004) and rhesus macaques (Murray et al., 2005). As opposed to the primate species cited above, the two orang-utans tested by Shumaker et al. (2001) were the only primates that spontaneously expressed self-control by rapidly showing significant selections of the smaller quantity of food under the reverse-reward contingency.

Silberberg and Fujita (1996) demonstrated that a large-or-none contingency, in which the subjects were rewarded only following selections of the smaller quantity, could lead to the inhibition of the bias toward the larger quantity. This training was useful to Japanese macaques (Silberberg and Fujita, 1996), squirrel monkeys (Anderson et al., 2000) and lemur (Genty et al., 2004) as they learned to significantly choose the smaller quantity to maximize their rewards. Furthermore, squirrel monkeys (Anderson et al., 2000) and lemurs (Genty et al., 2004) were able to maintain their significant bias for the smaller quantity when the original reverse-reward contingency was rerun and when novel array-size combinations were presented. Thus, they expressed self-control abilities in a fashion similar to human children over 4 years old. Once acquired, this ability seems very robust as squirrel monkeys and lemurs maintained their performances when they were tested again further months after the end of the study.
To reveal whether this self-control ability was unique to the primate order, we decided to conduct a complementary study to assess this ability in another animal order. The study of marine mammals appeared of particular interest as their brain is broadly comparable to that of primates and because there are few studies that have assessed extend of marine mammals’ cognitive abilities. We therefore decided to conduct a study of self-control abilities in California sea lion (Zalophus californianus).

Nausicaa, the French National Sea Life Center, located in Boulogne sur mer in the north of France displays 6 males california sea lions in an exhibit with a pool of one thousand cubic meters of natural sea water with an underwater observatory.

At Nausicaa, the main goal of the trainers is to take care of the animals’ health. So we have developed medical trainings. We have desensitized sea lions to:
- X-rays
- Ultrasound exam
- Blood sampling
- To breath in and out
- To brush and rinse the teeth

During other training sessions the trainers learn each sea lion to recognize one shape. This differential shape discrimination is very useful for a large range of trainings. A cognitive study showed that our sea lions are able to discriminate their own shape among several. They had to push down a lever placed in front of their shape to indicate their choice. This training allowed the staff to develop the device of the study of self-control.

Four California sea lions were presented with the choice between two different quantities of fish (1 versus 5) under a reverse-reward contingency. The sea lions first showed, as the primate species tested, an initial and impulsive preference for the larger quantity of fish but, as opposed to the majority of primates but as orang-utans (Schumaker et al., 2002), they spontaneously learned to significantly choose the smaller quantity of fish to maximize their rewards. One of the subject was not able to show a significant choice of the smaller quantity and showed performances that did not differ significantly from chance. This performance was due to the establishment of a position bias. Indeed, this subject always chose on the same side of the apparatus. The application of a large-or-none contingency was useful for this subject as it permitted it to overcome its position bias and to learn to significantly choose the smaller quantity of fish to maximize its food-intakes. All the subjects were then able to generalize their performance to novel array-size combinations (2 versus 3, 2 versus 4, 5 versus 7, 1 versus 0). Thus California sea lions were, like orang-utans, spontaneously able to express self-control without prior training.

One possible explanation for orangutans and sea lions performances is based on the social organization of these species. Orang-utan is the least social of all the primate species and they forage alone as do sea lions. The solitary foraging activity implies little competition for resources access which competition should enhance impulsivity among social individuals. Therefore this lack of competition should promote self-control.
Environmental enrichment: does it enrich zoo visitors?
Lizanne Byrne, University of Lincoln

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Lizanne Byrne University of Lincoln (lizanne_byrne@yahoo.co.uk)

Abstract

Research on environmental enrichment of zoo animals continues to grow and several welfare benefits have been indicated (increased range of natural behaviours, improved reproductive success and reduction of stereotypic behaviours). However, the effect of environmental enrichment on zoo visitors has received limited attention.

This study investigated whether the enrichment of a bird enclosure affected zoo visitors in terms of their interest and enjoyment of the exhibit, time spent at the exhibit, impressions of the exhibit, its perceived educational value and their overall perceptions of the zoo.

Interviews were conducted with 200 visitors to the Striated Caracara (Phalcoboenus australis) exhibit at Birdworld, UK. 100 visitors were interviewed in the control group (pre-enriched) and 100 visitors were interviewed in the experimental group (enriched with habitat and food enrichment with explanatory signs). Time spent at the exhibit was also recorded.

The enriched enclosure gained significantly higher ratings on visitor interest, visitor learning and impressions of the exhibit. Viewing time was significantly longer for the enriched enclosure and this may indicate an increased level of visitor interest and enjoyment. Impressions of the zoo were significantly more positive within the enriched group.

The study suggests that enrichment, supported with signs, may enrich zoo visitors by creating a more interesting, enjoyable and educational experience. Furthermore it suggests that enrichment may improve visitor perceptions of animal welfare. Consequently, it is suggested that enrichment has the potential to drive repeat visits to zoos and reduce criticism that zoos continue to face over animal welfare. Such potential benefits of enrichment should be cited alongside animal welfare benefits to help justify the costs, time and resources required for enrichment.

Introduction

Enrichment research has indicated several welfare benefits; reduction in abnormal behaviours such as feather picking in birds (VanHoek and King 1997), reduction in stress (Roy et al 2001), increased range of natural behaviours (Nicol and Pope 1993) and improved reproductive success (Millam et al 1988). Enrichment may also provide additional benefits to the zoo. Enrichment in the form of naturalistic habitats can increase visitors’ perceptions of animal happiness (McPhee et al 1998). Enrichment often serves to increase activity levels and research has indicated that active animals increase visitor stay times at exhibits (Bitgood et al 1988). Furthermore, it appears that visitors may understand the importance of enrichment as 96% of zoo visitors claimed that the provision of apparatus for play/work is very important for animal welfare (Reade and Waran 1996).

It is possible that enrichment may provide additional benefits that have not previously been documented through research. Enrichment may increase visitor interest and enjoyment e.g. if it increases the activity level of an animal or encourages it to access food in novel ways. Enrichment may also serve to educate visitors on several levels. It could teach visitors about animals’ natural behaviour in the wild, their natural habitat, their feeding methods and their social behaviour. In addition, enrichment could help to drive positive perceptions of zoos if it helps to demonstrate to visitors that zoos care about their animals’ welfare. Alternatively, if enrichment helps to make the zoo visit more interesting, enjoyable or educational, visitors may leave the zoo with positive perceptions. This in turn may help to drive repeat visits to zoos or recommendations to others to visit the zoo. In addition, if visitors connect enrichment with improved animal welfare, it could serve to reduce the criticism that zoos continue to face over the welfare of their collection.
Research on the impact of enrichment on zoo visitors is currently very limited. This study investigated whether the enrichment of zoo birds affected the viewing public in terms of their:

- Interest in the exhibit
- Enjoyment of the exhibit
- Impressions of the exhibit
- Perceived learning
- Overall perceptions of the zoo
- Time spent at the exhibit (this could provide an objective measure of interest/enjoyment)

**Method**

The research was conducted at Birdworld Park and Gardens, Surrey, UK. The control group consisted of a pre enriched enclosure containing a pair of Striated Caracara (*Phalacrocorax australis*) which were fed once a day with dead chicks. The experimental group was conducted after the control group and consisted of the same birds housed in the same enclosure which was enriched through several means. The habitat was enriched with areas of sand and gravel bordered by rocks, two additional perches were provided, several plants were distributed throughout the enclosure (a large bamboo, five grasses and three willow plants) and a rock pool was provided (see Figure 1 and Figure 2). These enrichments were devised to provide the birds with miniature replications of the different environments they would experience in the wild. Striated Caracara populate the Falkland Islands and islands such as Navarino and Cape Horn below South America which typically consist of rocky coasts and open grassland (del Hoyo et al 1994).
Feeding enrichment was also implemented twice a day in the experimental (enriched) group and consisted of four types of feeding methods to encourage foraging/working for food (see Figure 3).

- **Hessian Chick** - A dead chick was wrapped in square of hessian. The hessian was tied with one metre of natural rope and the rope was attached to a log in the enclosure at ground level. The birds had to rip into the hessian to access the meat. This feeding method aimed to replicate the carcass feeding which Striated Caracara exhibit in the wild where they feed on dead penguins, sheep and seals (del Hoyo et al 1994).

- **Forage Tray** - A large rectangular plastic tray was sunk into ground at ground level. The tray was half filled with a mixture of bark chippings and straw. Various food (one dead chick, a handful of mealworms and two mussels) were added to the tray twice daily and hidden under the bark and straw. The birds had to scrape through the tray to obtain food. This enrichment encouraged the foraging behaviour observed in wild Striated Caracara that search along the coastline to obtain food such as crabs, mussels and dead penguin chicks (del Hoyo et al 1994).

- **Kerplunk Box** - A freestanding rectangular box made from marine plywood was used as frame to hold 1cm square wire mesh. The bottom of the box was left open while the top of box was covered with a hinged lid of marine plywood that contained a catch to shut the lid down. The wood was sealed with *Ronseal outdoor wood varnish* (non
toxic). Four aluminium 'L' shaped posts were used as a frame for the box and they also functioned as poles to push the Kerplunk into the ground. A hacksaw was used to sharpen the bottom of the aluminium posts to a point to help insertion into ground. Bolts were used to attach the wood frame to the aluminium posts and to sandwich the mesh into the frame. About ten straight twigs were stuck through the mesh holes at various angles to create a holding place for the dead chick which was placed on top of the twigs. The birds had to pull out the twigs to make the chick fall out the bottom of the box to the ground where they could retrieve it. This device was designed to employ the birds’ cognitive abilities to access food.

- Cabbage Feeder – Three holes were made in a whole cabbage. One hole was stuffed with a dead chick, the other two holes were stuffed with mussels. The cabbage was left on the ground in the enclosure and the birds had to roll the cabbage around and peck it to access the food. This form of feeding was also designed to employ the birds’ cognitive abilities to access food.

Three signs explaining the enrichments were displayed in the experimental group (see Figure 3).

![Where do Caracara live in the Wild?](Where%20do%20Caracara%20live%20in%20the%20Wild.jpg)

![Feeding Time for Caracaras!](Feeding%20Time%20for%20Caracaras.jpg)

Where do Caracara live in the Wild?

These pictures of the Falkland Islands show they live along rocky coasts and open grassland. Their enclosure at Birdworld contains rocks, gravel, a pool and sand to give the birds variety in their habitat.

Feeding Time for Caracaras!

In the wild, these birds would spend time scavenging for food such as penguin chicks, grubs, crabs or mussels. We encourage this scavenging behaviour at Birdworld by presenting food in interesting ways...

300 records of visitor time spent at the enclosure were made for both the control and experimental group (150 timings were taken in each group). Records were made covertly as far as possible to minimise any influence of the researcher on visitor behaviour. Visitors were selected on a random, every third person basis and their viewing time was recorded by timing their length of stay within a predefined boundary (right hand post of enclosure to left hand post of enclosure).

200 of the visitors (100 in control and 100 in experimental) were also intercepted to fill in a questionnaire once they had walked outside of the time recording boundary. A brief, three minute long, attitudinal questionnaire was conducted by an interviewer once the visitors agreed to participate. The questionnaire consisted of seven point rating scales developed around opposing adjectives on overall opinion of enclosure (poor to excellent), interest in enclosure (very boring to very interesting), level of learning (learned nothing to learned lots),
impressions of birds (poorly kept to well kept, look bored to look occupied, look sad to look happy) and what impression the exhibit would give about the birdpark overall (bad zoo to excellent zoo, doesn’t care about its birds to really cares about its birds). Two open ended questions were also employed to allow visitors to give spontaneous comments on any exhibit likes or dislikes.

Information on age, gender, sign readership, weather and level of crowding was also collected.

Fieldwork was conducted between 1st April and 12th June 2005 during weekdays and weekends.

Results

Visitors spent significantly longer viewing the enriched enclosure than the control enclosure. Mean viewing time was 49.8 seconds for enriched enclosure compared with 27.9 seconds for control enclosure, \( P < 0.001 \).

The enriched enclosure received significantly higher ratings on overall opinion of exhibit \( P < 0.001 \), level of interest \( P < 0.001 \) and claimed learning \( P < 0.001 \). Figure 4 illustrates the distribution of ratings for claimed interest levels for both enclosures. This distribution pattern was typical across all the rating scale data collected (i.e. the mode rating was typically a couple points higher for the enriched enclosure than the control enclosure).

![Figure 4 – Ratings of visitors’ claimed interest in Control and Enriched Enclosure](image)

The birds were rated significantly more ‘well kept’, significantly more ‘occupied’ and significantly more ‘happy’ in the enriched enclosure than in the control enclosure (\( P < 0.001 \) across all three measures).

Visitors were asked to provide any spontaneous likes and dislikes of the exhibit. The enriched enclosure received significantly more stated likes (71% of enriched group visitors stated a like vs. 50% of the control group visitors, \( P < 0.004 \)). The enriched group also received significantly fewer stated dislikes (68%) than the control group (90%), \( P < 0.001 \).

Key spontaneous likes for the control enclosure included the large size, the naturalness of the enclosure and the birds (Table 1). These likes were expressed at a similar level for the enriched enclosure. However, the enriched enclosure gained additional likes which ranged from the birds having things to occupy them, the signs, the kerplunk device and the pool. Table 2 shows the key dislikes of the control enclosure included the appearance (looking run down or drab) and the size (too small for the birds). These dislikes were also expressed for
the enriched enclosure although the appearance comments received a lower level of mention. Statements of the enclosure appearing too small for the birds gained a slightly higher level of mention for the enriched enclosure. However, the enriched enclosure received fewer comments than the control enclosure that it looked boring.

<table>
<thead>
<tr>
<th>Stated Likes</th>
<th>Control % Visitors</th>
<th>Enriched % Visitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large enclosure</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>Looks natural</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Birds</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Well layed out</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Things to occupy birds/feeding methods</td>
<td>-</td>
<td>15</td>
</tr>
<tr>
<td>Signs</td>
<td>-</td>
<td>8</td>
</tr>
<tr>
<td>Kerplunk Device</td>
<td>-</td>
<td>6</td>
</tr>
<tr>
<td>Pool</td>
<td>-</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 1 – Stated Exhibit Likes

<table>
<thead>
<tr>
<th>Stated Dislikes</th>
<th>Control % Visitors</th>
<th>Enriched % Visitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Looks run down</td>
<td>32</td>
<td>16</td>
</tr>
<tr>
<td>Looks drab/dark</td>
<td>21</td>
<td>7</td>
</tr>
<tr>
<td>Too small</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>Looks boring</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>Too low for birds to fly</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Not much inside</td>
<td>8</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 2 – Stated Exhibit Dislikes

Impressions of Birdworld overall, as judged by the test enclosures, were significantly higher for the enriched enclosure than the control enclosure \( P < 0.001 \) (see Figure 5). Birdworld was also given significantly higher ratings for caring about its birds by visitors of the enriched enclosure \( P < 0.001 \).

![Figure 5 – Ratings of Birdworld overall as judged by test enclosures](image)

**Discussion & Conclusions**

The findings indicate that environmental enrichment (supported with explanatory signs) may

- Increase visitor interest as claimed interest levels were significantly higher for the enriched enclosure than the control enclosure. Furthermore, the significantly longer viewing time for the enriched enclosure might also suggest increased visitor
enjoyment/interest (under the assumption that longer viewing times reflect increased enjoyment/interest). Several factors may account for the increased interest in the enriched enclosure. The spontaneous likes expressed by visitors of the enriched enclosure suggest that the feeding methods and the enrichment signs were appealing and hence may have driven interest. The overall habitat, including the presence of the pool may also have driven interest. Furthermore, past research suggests active animals increase visitor stay times at exhibits (Bilgood et al 1988). Whilst this study did not monitor the activity levels of the birds, observation of their behaviour would suggest they were more active in the enriched enclosure as a result of the alternative feeding methods. Hence the enrichment may have increased the activity levels of the birds and this in turn may have generated greater visitor interest.

The study also suggests enrichment may

- Improve visitor impressions of animal welfare (the birds were perceived to be significantly more well kept, more occupied and happier in the enriched enclosure). Positive perceptions of animal welfare may have been driven by presence of habitat enrichment that provided the birds with a more varied, less barren landscape than the control enclosure. The feeding enrichment may have served to occupy the birds and visitors might perceive this to be a welfare indicator. Previous research suggests this may be the case. Reade and Waran (1996) suggested zoo visitors believe the provision of apparatus for play/work is very important for animal welfare. The enrichment signs may also have played a role to communicate to visitors how the zoo had actively thought about the birds’ habitat and feeding needs.

- Increase visitor learning (claimed learning was significantly higher in the enriched enclosure). Enrichment may have acted as a source of education for several reasons. The feeding enrichments may have served to communicate how the birds feed in the wild (e.g. how they forage for food) and demonstrated the birds’ ‘intelligence’ e.g. through use of the ‘Kerplunk device’. The habitat enrichment may have illustrated the birds’ natural habitat. It is also possible that the enrichment signs played a significant role, either on their own or in addition to visitor observation of the exhibit, to help educate visitors. The signs were designed to provide information on the birds’ natural habitat, feeding behaviour and cognitive abilities as well as communicate the purpose of the feeding enrichments.

- Drive positive impressions of exhibits (overall opinion of the exhibits was significantly higher for the enriched enclosure). The spontaneous visitor comments on enclosure dislikes suggest that negative impressions may be driven by a variety of factors including perceived small enclosure size, unattractive appearance (i.e. looks drabs/run down/boring) and lack of enclosure contents. Enrichment can serve to address these negatives as this research has indicated. The only criticism it did not serve to reduce was the overall enclosure size which remained unchanged between the control and enriched group. In addition to addressing perceived enclosure negatives, enrichment may drive positive visitor impressions. This study indicates positive impressions can be created through large enclosures, natural looking enclosures, well layed out enclosures, signage and feeding devices that occupy animals. Enrichment can serve to provide all of the above.

- Drive positive impressions of the zoo overall (the zoo was rated significantly higher at an overall level and in terms of caring about its birds by visitors of the enriched enclosure). Positive impressions of zoos are likely to be driven by many factors including overall visitor enjoyment, quality of facilities (e.g. catering), staff service levels, interesting collection of animals, interesting keeper talks/shows and presence of children’s play areas. This study suggests that enrichment may also play a role in driving positive impressions, perhaps because it made the visitor experience more interesting or educational or because it demonstrated that the zoo was thinking about how to occupy the birds and provide them with a natural habitat.

The benefits of enrichment may extend further than those already stated. It is possible that enrichment could drive repeat visits to zoos or visitor recommendations (to visit the zoo) because it helps to create an interesting, enjoyable and educational experience. Furthermore it might reduce criticism that zoos continue to receive over the welfare of their animals as
enrichment may improve visitor perceptions of animal welfare. These factors, alongside the potential welfare benefits to animals, should be used to justify the costs, time and resources required for enrichment. The practice of enrichment in zoos is often restricted by these factors (Byrne, 2004) but these should be weighed up against the benefits of enrichment from the point of view of visitors, the zoo overall and the animal welfare benefits.

A further recommendation from this study is to use enrichment signs to visualise the enrichment in practice and communicate the purpose of the enrichment. The signs appeared to help drive visitor interest, enjoyment and education. Furthermore, they functioned to illustrate enrichment in action for those visitors who viewed the enclosure when the birds were not using the enrichment.

Acknowledgements

Many thanks to all the staff at Birdworld, particularly Kerry Banks, who patiently helped with all my requests. I would also like to thank my tutor, Professor Stephen J.G. Hall (Lincoln University) for giving advice on the study and its analysis. Thanks also to Jamie Robinson for giving up his days off work to help shift sand, gravel and build the Kerplunk box. A final thanks to J.S. Nicol for supplying pictures of Striated Caracara in the wild which provided useful information on their habitat and feeding behaviour and were used in the enrichment signs.

References


Noise in the Environment of a Range of Captive Primate Species: How does it Affect Behaviour?
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Abstract

Noise is an uncontrollable stimulus in the environment of captive zoo animals. To date it has received very little attention in order to determine the effects in may have on animal behaviour and welfare. However, human studies have shown that stress-related health issues are associated with long-term noise exposure, especially where sound levels exceed 65dB. This study investigated the behavioural responses of six separate species of primates (black-and-white ruffed lemur, emperor tamarin, silvery marmoset, Javan leaf monkey, variegated Columbian spider monkey and Diana monkey) to environmental sounds. The behaviours of twenty-seven animals at Twycross Zoo were recorded using scan sampling along with the coinciding sound levels in decibels. Mean sound levels ranged from 61.5 to 75.4dB, with sounds peaking often up to or above 90dB. Average sound levels were found to have a varying effect depending on species. Increased levels of sound were found to correlate with a reduction in locomotion and grooming and an increase in feeding and sound-directed behaviour in the black and white ruffed lemur. In the silvery marmoset and emperor tamarin resting was reduced, and in the variegated Columbian spider monkey frequency of aggression increased with higher sound levels. In addition to sound levels the affect of varying sound levels were also investigated. It was found that the impact of sound range was again most apparent in the black and white ruffed lemur, with increased range producing a higher frequency of locomotion and grooming and a decrease in resting and sound-directed behaviour. This study indicates that noise is a problem within zoo environments and does affect primate behaviour and that efforts must be made to consider this stimulus when housing captive animals. Further research is needed in order to fully understand this effect and the consequences for animal welfare.

Introduction

The captive environment has long been a resource for the maintenance of wild animal species and as a source of education and entertainment for the British public. In recent years a great deal of time has been committed to the study of the effects of the captive environment on the welfare of animals that reside within it, and from this many changes have been made in order to improve the environment for the benefit of the animals. Zoo visitors have been recognised to influence animal behaviour, both positively and negatively (Nimon and Dalziel, 1992; Cook and Hosey, 1995; Kreger and Mench, 1995; Wood, 1998; Hosey, 2000). However, most studies have concentrated on the impact of visual rather than aural stimuli.

The environment of captive animals is filled with a great many auditory stimuli that may have an impact on the psychological and physical health of the animal. One of the main sources of noise within the enclosures of zoo animals is from visitors, although they may also be subjected to noises from other animals, keepers and other everyday sounds. The effects of noise have been recognised to be potential stressors in humans and the effects are taken very seriously due to the implications on health (Stranks, 1995). It is therefore appropriate to consider noise as a potential cause of stress within captive animals’ environments. There has been no noise exposure criteria created for animals as has been formulated for humans (HSE, 2002), and it is worth remembering that many animals have a far greater range of hearing than humans (Sales et al, 1999).

Previous studies have shown that noise may cause aversive responses in zoo animals, although research is very limited. In a study of orangutans (Pongo pygmaeus pygmaeus/abelii), visitors were manipulated to create a noisy environment that prompted the adult animals to stare at the stimuli and infants to grab onto their parents in a fear response (Birke, 2002). The impact of noise may go further than affecting immediate behaviour and may affect the breeding and reproduction of animals, which has implications for captive breeding programmes (Owen, 2004).
The aim of this research was to measure sound levels within the zoo environment and to make preliminary investigation into the effects of noise on the behaviour of a number of primate species.

**Methods**

The study was carried out on six primate species at Twycross Zoo (N=24), black and white ruffed lemur (n = 10), emperor tamarin (n = 3), silvery marmoset (n = 3), variegated Columbian spider monkey (n = 4), Javan leaf monkey (n = 5) and Diana monkey (n = 2). The animals were housed in large enclosures with access to indoor and outdoor areas. Viewing access was available to visitors.

Behavioural observations were made of each individual using 10-minute samples with 1 minute scans. A total of 90 minutes of observations was collected per animal. Eight behaviours were recorded: locomotion, feeding, resting, sound directed behaviour, grooming, aggression, play and not visible. At the same time as recording behavioural data the sound level was also noted using a sound recorder (Castle GA 107 sound level meter – octave band analyser and calibrator). The equipment was calibrated before each sample to ensure accuracy. Noise was measured in decibels and both the mean and range of the sound was calculated per sample.

**Results**

There was a range of maximum mean sound levels and sound ranges experienced by the different species, with the black and white ruffed lemurs being subjected to the highest maximum sound levels (Figure 1).

**Figure 1: Maximum Mean Sound Levels and Sound Level Ranges for the Different Species**

<table>
<thead>
<tr>
<th>Species</th>
<th>Max Mean Sound Levels (dB)</th>
<th>Max Sound Level Range (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B&amp;W lemur</td>
<td>75.4</td>
<td>69</td>
</tr>
<tr>
<td>Javan leaf monkey</td>
<td>72.3</td>
<td>62</td>
</tr>
<tr>
<td>Silvery marmoset</td>
<td>68.7</td>
<td>50</td>
</tr>
<tr>
<td>Emperor tamarin</td>
<td>64.1</td>
<td>57</td>
</tr>
<tr>
<td>Diana monkey</td>
<td>61.6</td>
<td>62</td>
</tr>
<tr>
<td>Spider monkey</td>
<td>61.6</td>
<td>50</td>
</tr>
</tbody>
</table>

Correlations between mean sound levels and behaviours were carried out (Figure 2). Increased sound levels related in the following changes in behaviours: for the black and white ruffed lemurs and Javan leaf monkeys it corresponded to a decrease in locomotion and an increase in feeding and sound directed behaviour, with the lemurs also showing a decrease in grooming; for silvery marmosets and emperor tamarins it related to a decrease in resting; and for spider monkeys it related to an increase in aggression. Diana monkeys showed no correlations between sound and behaviour.
Correlations between sound level range and behaviour resulted in a number of relationships for black and white ruffed lemurs, silvery marmosets and Diana monkeys (Figure 3). The other three species showed no relationships. With increased range of sound black and white ruffed lemurs increased locomotion and grooming and decreased sound directed behaviours and resting. Both silvery marmosets and Diana monkeys increased grooming with increased range of sound.

**Figure 3: Spearman’s Rank Correlations between Sound Level Ranges and Behaviours**

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Lemur</th>
<th>Marmoset</th>
<th>Diana monkey</th>
</tr>
</thead>
</table>
| Locomotion| $r_s = 0.497$  
$ p = 0.000$  | ns       | ns           |
| Grooming  | $r_s = 0.245$  
$ p = 0.016$  | $r_s = 0.480$  
$ p = 0.011$  | $r_s = 0.732$  
$ p = 0.001$  |
| Feeding   | ns         | ns       | ns           |
| Resting   | $r_s = -0.228$  
$ p = 0.031$  | ns       | ns           |
| Sound     | $r_s = -0.222$  
$ p = 0.036$  | ns       | ns           |

Discussion

Sound levels within the primate environments observed were generally high, often peaking up to or above 90dB and produced by screams of children or other animals in park producing high volume but generally short in length noises. Anthony (1963) stated that background levels of sound for laboratory animal housing should be between 55 and 60 dB. In this study three of the species were subjected to average sound levels in excess of this. In humans, it has been found that health effects are associated with long-term noise exposure related to stress when exposed to sound levels exceeding 65dB (Ising and Kruppa, 2004); a level that was exceeded frequently in the course of this study.

Those species that were subjected to the highest levels of sound showed the highest number of correlations between sound and behaviour patterns. This was most evident in the black and white lemur whose maximum average sound level was 10-15 dB higher than that advised by Anthony (1963), whereas the Diana monkeys who were subjected to sound levels within the advised range showed no correlations between behaviour and mean sound levels.

There was some evidence that sound level and range of sound level had some effect on the behaviour of the primate species studied. High sound levels appeared to have some
influence on increasing aggression and decreasing resting behaviours and variable sound levels may cause an increase in grooming. These responses to noise and its variation may be indicative of stress. The positive correlation between feeding and average sound levels is likely to be due to a greater interest in the animals at feeding times by human audiences rather than a motivation to feed in noisier environments.

Unlike visual stimuli, zoo animals have no control over the extent of their exposure to noise. The aural system is continuously open in all mammalian species and cannot be closed even during sleep. Sound has the potential to be a stressor which the animal perceives it cannot influence and, therefore, may reduce the animals welfare. Further research needs to be carried out in this area to ascertain the implications of this factor within captive environments, including zoos. This needs to be coupled with management practices which consider ways to protect animals from the effects of excessive levels of uncontrollable noise.

References

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Acknowledgements

The authors are grateful to Twycross Zoo for allowing this study to take place and to David Symons, University College of Northampton, for the loan of the sound recorder. Thanks also go to Katie Brooks for helping with the sound recording observations.
Investigation into inbreeding in the European Zoo jaguar population
Hannah J Drury¹, Sonya P Hill², Ilik J Saccheri¹
¹The University of Liverpool, ²Chester Zoo

Introduction

Introduction to Captive breeding

Records of the jaguar (*Panthera onca*) in European Zoos date back to 1920 (SPARKS, 2001), but it is likely that they were bred in European collections far before this date. The present captive breeding of jaguars has little conservation value as they are classified in the relatively low risk, near-threatened category by the International Union for the Conservation of Nature (IUCN) (IUCN, 1990).

Space is often a constraint in captive breeding, and population management can maintain variation using the smallest possible population size. Inbreeding can be controlled by careful choice and the recording of breeding pairs, and modern technology has provided zoos with efficient tools for recording breeding information.

Studbooks

Studbooks are databases containing the records of a defined species. They should contain identification, the sex, parental identification, birth date, death date and transaction history (Thompson and Earnhardt, 1996). Studbooks allow informed breeding decisions to be made, in order to maintain the highest possible variation of a population.

Traditionally studbooks were kept in index files. This system has huge potential for error in data filing and retrieval. This is a big problem with the jaguar studbook where much of the information has not come from birth locations but from locations where each individual resided later in its life. This second-hand data is susceptible to change as it passes through different institutions. Modern studbooks are computerised, allowing efficient data storage and also identification of population trends.

Jaguars in European Zoos

The jaguar is the only American member of the Genus *Panthera* (family Felidae, class Mammalia) (Burton and Pearson, 1987). Although not in immediate danger, the geographical range of today’s jaguars is one third to half of its historical range. Limited conservation efforts are currently aimed towards the jaguar as a result of its near-threatened status but it is likely that in the future a large conservation effort will be required to ensure the continuation of the species in the wild.

Although jaguars have been bred in European zoos for many years, there are few records of the extent of inbreeding in the zoo population. Although some of the historic breeding records involving jaguars do exist, they are scattered around collections of the world. Most extant information remains basic, identifying just the sire and dam and occasionally the birth date. The first studbook for the European jaguar was collated in 2001. However, this has many gaps and most individuals alive today can only be traced back one or two generations. Clearly it is desirable to trace individuals back further than this if inbreeding is to be avoided. This study aims to address some of the gaps in the studbook.

As the first studbook for the jaguar was only compiled recently, it is likely that the European jaguar population has not been managed as effectively as possible. It is hypothesised that novel genetic material supplied by wild introductions, will not have been used to the full potential. It is also expected that there will have been a comparatively high level of kinship in the European jaguar, resulting in a high level of inbreeding. Finally, it is expected that this
elevated level of inbreeding will have had a detrimental effect on the European jaguar population.

Materials and Methods

Each living jaguar was traced back to a point where a parent was either wild or unknown. The birth location of this individual was contacted, and records on the individual were requested. If the birth location was unknown, records were requested from the first recorded location. Forty-two locations were contacted, (Appendix 1) and a deadline of the 7th February 2005 set for replies. Reminder correspondence was sent out to all locations on the 28th December 2004. After the 14th February 2005 it was assumed that no further information would be received.

The inbreeding coefficient (F) for each jaguar was exported directly from SPARKS to a Microsoft Excel file. Any animals with unknown parentage were discarded from analysis. It is not possible to calculate the actual inbreeding levels from the studbook, as the level of inbreeding in the wild animals used in the European jaguar population is not known. Instead, the increase in inbreeding from the unknown base level was calculated. Any animals with unknown birth dates were assumed to have had the average lifespan for the species, and their birth dates estimated using the average age calculated. The birth date for any animals with unknown birth and death dates was estimated by calculating the average age for first reproduction. It was assumed that all individuals reproduced for the first time at the average age for the species. The individuals were split into five-year periods, using their birth date as the parameter to determine the interval to which they belonged. This meant that the average increase in inbreeding calculated was not of the population, but of the animals born in each interval. Wild animals were also included, as the current study looks at inbreeding in the population not just in captive born individuals. Wild individuals were assumed to have no kinship to the captive jaguar population. The proportion of wild introductions to the population in each five-year interval was calculated to demonstrate the contribution of novel genetic material.

Table 1: Felid species downloaded from the ISIS studbook library CD-ROM.

<table>
<thead>
<tr>
<th>Species (Latin Name)</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Felis silvestris lybica</td>
<td>African Wildcat</td>
</tr>
<tr>
<td>Panthera pardus orientalis</td>
<td>Amur Leopard</td>
</tr>
<tr>
<td>Panthera pardus nimr</td>
<td>Arabian Leopard</td>
</tr>
<tr>
<td>Panthera leo persicus</td>
<td>Asiatic Lion</td>
</tr>
<tr>
<td>Felis nigripes</td>
<td>Black-footed Cat</td>
</tr>
<tr>
<td>Panthera pardus japonensis</td>
<td>Chinese Leopard</td>
</tr>
<tr>
<td>Neofelis nebulosa</td>
<td>Clouded Leopard</td>
</tr>
<tr>
<td>Prionailurus viverrinus</td>
<td>Fishing Cat</td>
</tr>
<tr>
<td>Felis silvestris gordoni</td>
<td>Gordons Cat</td>
</tr>
<tr>
<td>Felis margarita</td>
<td>Sand Cat</td>
</tr>
<tr>
<td>Otocolobus manul</td>
<td>Pallas Cat</td>
</tr>
<tr>
<td>Panthera pardus kotiya</td>
<td>Sri Lankan Leopard</td>
</tr>
<tr>
<td>Panthera tigris sumatrae</td>
<td>Sumatran Tiger</td>
</tr>
<tr>
<td>Panthera pardus saxicolor</td>
<td>Persian Leopard</td>
</tr>
</tbody>
</table>

Fourteen different Felid studbooks were downloaded from the ISIS studbook library CD-ROM, (ISIS, 2001) (Table 1), and these were subjected to the same analysis as the jaguar.

Any individuals older the oldest reproducing individual for each species were assumed to have no reproductive potential and were excluded from the current population. The average increase in inbreeding in the current populations (those that still have reproductive potential), was calculated. Any animals listed as lost to follow up (LTF), that is no longer in the last recorded location, were assumed to be dead. The correction factor was found by calculating the proportion of animals with unknown parentage in each species studbook. The average
increase in inbreeding found in each species was multiplied by the correction factor to take account of the studbook completeness.

A mean kinship value (MK) was calculated for each living individual with reproductive potential. This value is the average relatedness of that particular individual to the entire living population, regardless of sex. Once again animals with unknown parentage were excluded from analysis, and the correction factor was used to take in to account the studbook completeness. A report was carried out in PM2000 to obtain the studbook identification for the jaguars for whom it was possible to calculate a MK value. A kinship coefficient matrix of potential pairings for these individuals was then calculated.

The proportion of individuals that died prior to the earliest recorded breeding age was calculated to indicate the effect of inbreeding on each species. Any animals with an unknown death date were assumed either to still be living or to have died at the average age for the respective species. Any animals listed as LTF were assumed to have lived beyond the juvenile period.

The genetic contribution of each wild jaguar introduced to the current population was calculated using PM2000. The genetic contribution is the number of copies of a gene an individual donates to its descendants, (for example an individual donates 0.5 copies of its genes to its offspring).

Results

Sixteen email replies were received from the forty-two locations contacted (Table 2). Twenty-six locations supplied no information.

Table 2: Correspondence sent out to the different locations and responses received.

<table>
<thead>
<tr>
<th>INSTITUTION</th>
<th>TYPE OF CORRESPONDENCE</th>
<th>REPLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barcelona Zoo</td>
<td>Email</td>
<td>No</td>
</tr>
<tr>
<td>Berlin Zoo</td>
<td>Email</td>
<td>No</td>
</tr>
<tr>
<td>Zooloski vrt Zagreb</td>
<td>Email</td>
<td>No</td>
</tr>
<tr>
<td>Rome Zoo</td>
<td>Email</td>
<td>Yes</td>
</tr>
<tr>
<td>Rostov on Don Zoo</td>
<td>Email</td>
<td>No</td>
</tr>
<tr>
<td>Rotterdam Zoo</td>
<td>Email</td>
<td>No</td>
</tr>
<tr>
<td>Leningrad Zoo</td>
<td>Email</td>
<td>No</td>
</tr>
<tr>
<td>Tierpark Hamburg</td>
<td>Email</td>
<td>Yes</td>
</tr>
<tr>
<td>Hodonin Zoo</td>
<td>Email</td>
<td>No</td>
</tr>
<tr>
<td>De Belo Horizonte</td>
<td>Email</td>
<td>Yes</td>
</tr>
<tr>
<td>Thiory Animal Park</td>
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<td>No</td>
</tr>
<tr>
<td>Zoologicka Zahrrada Plzne</td>
<td>Email</td>
<td>No</td>
</tr>
<tr>
<td>Zoologicka Zahrrada Ostrava</td>
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<td>Yes</td>
</tr>
<tr>
<td>Munich Zoo</td>
<td>Email</td>
<td>No</td>
</tr>
<tr>
<td>Ouwehand Zoo</td>
<td>Email</td>
<td>No</td>
</tr>
<tr>
<td>Noorder Dierenpark Zoo</td>
<td>Email</td>
<td>No</td>
</tr>
<tr>
<td>Wuppertal Zoologicka Garten</td>
<td>Email</td>
<td>Yes</td>
</tr>
<tr>
<td>Tilburg Dierenpark</td>
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<td>Yes</td>
</tr>
<tr>
<td>Lincoln Park Zoo</td>
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<tr>
<td>Zoologicka Zahrrada Mesta Brna</td>
<td>Email</td>
<td>No</td>
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<tr>
<td>London Zoo</td>
<td>Email</td>
<td>Yes</td>
</tr>
<tr>
<td>Whipsnade Zoo</td>
<td>Email</td>
<td>Yes</td>
</tr>
<tr>
<td>Moscow Zoo Centre</td>
<td>Email</td>
<td>No</td>
</tr>
<tr>
<td>Karlsruhe Zoologischer Garten</td>
<td>Email</td>
<td>Yes</td>
</tr>
<tr>
<td>Berlin Tierpark</td>
<td>Email</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Figure 1: The proportion of wild individuals introduced into the captive European jaguar population in each 5-year time interval and the average increase in inbreeding in the individuals born in each 5-year interval with standard error bars.

Data analysed using a one-way ANOVA, showed that the average increase in inbreeding in the jaguar population has changed significantly over time, $F(13,738) = 3.931$, $p < 0.001$ (Figure 1) with a rapid rise seen after 1970. Post hoc tests revealed the increase in inbreeding to be significantly lower between 2000-2004 than the levels seen between 1980-1984, ($p = 0.022$) and 1985-1989, ($p = 0.016$). Figure 1 also shows that the proportion of wild individuals introduced into the captive population has varied, with 0.3 of the jaguar population wild in 1950-1955, and peaks of 0.05 in 1960-1965 and 0.04 in 1970-1975.
The actual increase in inbreeding in the jaguar population per se was found to be slightly higher than the increase in inbreeding when the influence of wild introductions after 1970 are excluded. This difference was not found to be significant, $t(1013) = -0.66, p = 0.509$ (Figure 2).

Figure 3: The average increase in inbreeding in the populations with reproductive potential, including standard error bars.
After correction, the average increase in inbreeding in the jaguar population with reproductive potential increases, \( \mu(F) = 0.054, n = 115 \). This value significantly differs between the investigated species, \( F(14, 1645) = 30.898, p < 0.001 \) (Figure 3). Post hoc tests showed that the corrected average increase in inbreeding in the jaguar population with reproductive potential, was significantly lower than that of the Amur leopard, the Chinese leopard, the Gordons cat, the Persian leopard and the Sumatran tiger, (all at \( p < 0.01 \)), but significantly higher than that of the Pallas cat, (\( p = 0.045 \)) and the African wildcat, (\( p = 0.47 \)).

Figure 4: Graph to show the average mean kinship, \( (MK) \) in the populations with reproductive potential, including standard error bars.

The average mean kinship (MK), in the current jaguar population was found to be \( \mu(MK) = 0.238, (n = 30) \). A significant difference was found between the MK values in the different species, \( F(14, 1795) = 160.436, p < 0.001 \). Post hoc tests showed that the jaguar has a significantly higher average MK than all the other species, except for the Chinese leopard and the clouded leopard, (Gordons cat, \( p = 0.015 \), all others \( p < 0.001 \)) (Figure 4).
Table 3: Male jaguars Capable of Reproduction for Whom the Mean Kinship (MK) can be Calculated. \( \Box = MK < \) that the 0.1002 average for all species with significantly lower MK than the jaguar.

<table>
<thead>
<tr>
<th>Studbook Number</th>
<th>Mean Kinship</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1926</td>
<td>0.2665</td>
<td>LTF</td>
</tr>
<tr>
<td>T1783</td>
<td>0.2665</td>
<td>LTF</td>
</tr>
<tr>
<td>T1784</td>
<td>0.2665</td>
<td>LTF</td>
</tr>
<tr>
<td>T2013</td>
<td>0.2665</td>
<td>LTF</td>
</tr>
<tr>
<td>T1785</td>
<td>0.2665</td>
<td>Krakow Zoo, Poland</td>
</tr>
<tr>
<td>T1732</td>
<td>0.2665</td>
<td>Cyrk Buka</td>
</tr>
<tr>
<td>T1541</td>
<td>0.2665</td>
<td>Moscow Zoo Centre</td>
</tr>
<tr>
<td>T1979</td>
<td>0.2665</td>
<td>Wroclawiu, Poland</td>
</tr>
<tr>
<td>T1600</td>
<td>0.2665</td>
<td>Leningrad Zoo, Russia</td>
</tr>
<tr>
<td>T1978</td>
<td>0.2665</td>
<td>Krakow, Poland</td>
</tr>
<tr>
<td>T1335</td>
<td>0.2665</td>
<td>LTF</td>
</tr>
<tr>
<td>T1720</td>
<td>0.2665</td>
<td>LTF</td>
</tr>
<tr>
<td>T1638</td>
<td>0.0081</td>
<td>Barcelona Zoo</td>
</tr>
</tbody>
</table>

Table 4: Female jaguars Capable of Reproduction for Whom the Mean Kinship (MK) can be Calculated. \( \Box = MK < \) that the 0.1002 average for all species with significantly lower MK than the jaguar.

<table>
<thead>
<tr>
<th>Studbook Number</th>
<th>Mean Kinship</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1925</td>
<td>0.2665</td>
<td>LTF</td>
</tr>
<tr>
<td>T2012</td>
<td>0.2665</td>
<td>LTF</td>
</tr>
<tr>
<td>T1782</td>
<td>0.2665</td>
<td>LTF</td>
</tr>
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<td>T1453</td>
<td>0.2665</td>
<td>LTF</td>
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<tr>
<td>T1776</td>
<td>0.2665</td>
<td>Krakow Zoo, Poland</td>
</tr>
<tr>
<td>T1465</td>
<td>0.2665</td>
<td>LFT</td>
</tr>
<tr>
<td>T1470</td>
<td>0.2665</td>
<td>Olomouc, Czech Rep.</td>
</tr>
<tr>
<td>T1548</td>
<td>0.2665</td>
<td>Katowice, Poland</td>
</tr>
<tr>
<td>T1717</td>
<td>0.2665</td>
<td>LTF</td>
</tr>
<tr>
<td>T1981</td>
<td>0.2665</td>
<td>Olomouc, Czech Rep.</td>
</tr>
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<td>T1336</td>
<td>0.2665</td>
<td>LTF</td>
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<tr>
<td>T1389</td>
<td>0.2467</td>
<td>LTF</td>
</tr>
<tr>
<td>T1477</td>
<td>0.2467</td>
<td>LTF</td>
</tr>
<tr>
<td>T1478</td>
<td>0.2467</td>
<td>LTF</td>
</tr>
<tr>
<td>T1508</td>
<td>0.2467</td>
<td>Stuttgart, Germany</td>
</tr>
<tr>
<td>T1539</td>
<td>0.0162</td>
<td>Horizonte, Brazil</td>
</tr>
<tr>
<td>T1639</td>
<td>0.0000</td>
<td>Zoosafari, Italy</td>
</tr>
</tbody>
</table>

Table 3 and Table 4 show the living jaguars with reproductive potential for whom the MK value could be calculated. The locations of these individuals are also reported where known. LTF indicates that the animals are no longer in the last recorded location in the studbook. Also shown are the individuals for whom the MK is lower than the average value for all species with significantly lower average MK than the jaguar. There are only 3 individuals with reproductive potential for whom the MK can be calculated and is lower than the 0.1002 average.

The kinship matrix, (Appendix 2) shows that of the potential pairings calculated, 34.4% have a kinship coefficient of 0, 22.2% have a kinship coefficient of 0.5 and 43.4% have a kinship coefficient of 1. The kinship coefficient of 1 indicates that both sets of parents have identical lineage.
Seventeen wild introductions were recorded in the jaguar studbook. Figure 5 also shows the founder contribution to the living population, a contribution which is shown to vary widely, from 0 to 13.6. Eight wild individuals are recorded as contributing nothing to the current population. Studbook numbers T1638 and T1639 are recorded as having reproductive potential, and have contributed 0.5 and 0 respectively to the current jaguar population.

Figure 6: Proportion of individuals that died before 1 year of age in relation inbreeding in each 5-year interval.
A correlation was found between the proportion of juvenile jaguars that died prior to 1 year of age and the average level of inbreeding in each of the 5-year intervals, \( r = 0.554, n = 14, p = 0.040 \) (Figure 6). This suggests that the higher the level of inbreeding, the greater the proportion of recorded deaths.

![Figure 6: Proportion of individuals that died before reaching sexual maturity, including standard error bars.](image)

The proportion of jaguars that died before sexual maturity was found to be 0.200 and this appears to be lower than the proportions found in all other species except the Asiatic lion. However no significant difference was found in the proportion of individuals that died before sexual maturity between any of the 15 species investigated, \( F(14,107) = 1.020, p = 0.439 \) (Figure 7).

**Discussion**

Although sixteen replies were received from the forty-two correspondences sent out (Table 2), a high number of individuals with unknown parentage are still recorded in the jaguar studbook. These gaps can be accounted for by the correction factor when looking at population trends, but they cause a problem when looking at actual jaguars to use for breeding, as there is often no reliable indication of the kinship of a chosen pair. This must be taken into account when drawing conclusions, because any values for kinship and inbreeding are a minimum level and assumptions are made that the distribution of inbreeding and kinship in the unknown jaguars is equal to that of the known jaguars.

No increase in inbreeding is reported until 1970 (Figure 1). This is unlikely to be a reliable reflection, as much of the information before 1970 is unknown. The average increase in inbreeding in the interval 2000-2004 is significantly lower than in 1980-1990. This could be a result of wild introductions during this period. The largest introduction was seen between 1945-1950, and this may have helped to retain the low levels of inbreeding during this period. The level of inbreeding rises in 1970-1975, peaks in 1985-1990 and then falls to the levels seen in 2000-2004. Figure 2 shows that this fall is not due to the wild introductions during this period, as the population levels not influenced by these jaguars are slightly (although not significantly) lower than the levels observed. This indicates that these introduced jaguars
were poorly managed, with related pairs reproducing. As the fall in the increase in inbreeding cannot be attributed to wild introductions, it must therefore be due to other factors such as the creation of the first studbook during the interval 2000-2004.

In comparison to other captive felid populations, the corrected level of inbreeding in the jaguar is not unacceptable, and is only significantly higher than the levels seen in the Pallas cat and the African wildcat. Once again it has been assumed that the distribution of inbreeding in the unknown jaguars is equal to that of those with known inbreeding coefficients.

The mean kinship (MK), which gives a good indication of future potential to reduce inbreeding, was investigated. It was found that the MK value in the jaguar population was significantly higher than that found in all other populations, except for the Chinese leopard and the clouded leopard. However, very few MK values can be calculated (Table 3, Table 4), which is reflected both in the large correction factor, and in the relatively large standard error from the mean. As the correction factor is so large, the actual MK may significantly differ from the calculated levels.

The high MK levels observed in the jaguar may have implications for the future. CITES legislation now restricts the exportation of jaguars, thus the future potential for the addition of novel genetic material supplied by wild introductions is substantially reduced. However, a possible source of wild jaguars could be those that infringe on human areas, and are captured from the wild. The possibility for the exportation of some of these problem jaguars to European zoos may need to be considered.

The kinship coefficient matrix (Appendix 2), shows that of the pairs for whom the kinship coefficients could be calculated, 43.4% have a kinship coefficient of 1. This means that both sets of parents have identical lineage, and therefore these pairs are likely to produce offspring with low heterozygosity. The relatively large amount of pairs for whom the kinship coefficient is 1 suggests that there are a large number of related breeding pairs recorded in the studbook. 34.4% of pairs have kinship coefficients of 0 (indicated in red in Appendix 2). These unrelated pairings should be those used for breeding in the European jaguar population.

As illustrated in Figure 5, the use of wild introduced jaguars is far from ideal, and there is huge variation in the contribution of each individual to the current population. Eight wild introductions have had no contribution to the current population. These individuals may have reproduced, but none of their descendants are alive today.

It can also be seen in Figure 5 that two wild introductions (studbook numbers T1638 and T1639), have reproductive potential, and have contributed only 0.5 and 0 respectively to the living population. These individuals must surely have an important role in the future jaguar breeding program, particularly as they are two of the three identified jaguars for whom the MK value lies below the average.

It has been established that there is a certain extent of inbreeding in the European jaguar, but is this level detrimental? When inbreeding is correlated with deaths prior to 1 year of age (Figure 6), a positive correlation is found. However, given that there are significant differences in inbreeding seen across the investigated species, no significant difference was observed in the proportion of juvenile deaths (Figure 7). This suggests that factors other than inbreeding, (for instance captive pressures) are acting on the proportion of juvenile deaths, as all species are presumably exposed to similar levels. Several studies have concluded that carnivorous mammals can manage with low levels of genetic variation, showing little signs of inbreeding depression (Andron, 1996; Kelly et al., 1998). One study concluded that the proportion of juvenile deaths observed in a captive cheetah population was actually attributed to the pressures of captivity and was not in fact related to inbreeding (Merola, 1994).

Although the average increase in inbreeding in the living jaguar population is not unacceptably high (and has significantly decreased since 1980), the high MK value leads to concern over the future increase in inbreeding. In line with other studies on carnivorous mammals, the jaguar does not appear to be expressing any immediate signs of inbreeding
depression but it must be remembered that in this study only recorded neonatal deaths were used as the proportion of juvenile deaths. The wild introduced jaguars have not been used to their full potential and only two of these, T1639 and T1638 are capable of future reproduction. These jaguars along with T1539, for whom the MK level is relatively low, should be key jaguars in the future breeding program, especially as both T1639 and T1638 are located in Europe. The pairings for whom the calculated kinship coefficient is 0 should also be prioritised for future breeding. The possibility of exporting problem wild jaguars captured from native areas should be considered as these jaguars could provide useful genetic material to the future jaguar population.

Although there are many limitations using studbook data as a resource for population analysis, this study illustrates that if sufficient studbook data are known then useful information can be extracted on topics such as inbreeding and its effects, kinship, the contribution of unrelated individuals and future breeding programs. We have also shown how species comparisons can help to put analysis results into context.

Acknowledgments

Many thanks to Dr I.J. Saccheri (The University of Liverpool), Dr P.J. Lunt (The University of Liverpool), Mark Pilgrim (Chester Zoo), Barbara Kingsley (Roehampton University), and all the zoos that responded to our survey for their help with this project.

References

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## Appendix 1

### Locations Contacted

The locations contacted and their addresses. The same addresses were used both for initial and reminder correspondence.

<table>
<thead>
<tr>
<th>Location</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barcelona Zoo</td>
<td><a href="mailto:zoobarna@mail.cinet.es">zoobarna@mail.cinet.es</a></td>
</tr>
<tr>
<td>Berlin Zoo</td>
<td><a href="mailto:presse@zoo-berlin.de">presse@zoo-berlin.de</a></td>
</tr>
<tr>
<td>Zooloski vrt Zagreb</td>
<td><a href="mailto:biolog.zoog@zg.htnet.hr">biolog.zoog@zg.htnet.hr</a></td>
</tr>
<tr>
<td>Rome Zoo</td>
<td><a href="mailto:info@bioparco.it">info@bioparco.it</a></td>
</tr>
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<td>Rostov on Don Zoo</td>
<td><a href="mailto:zoo@rostov.don.sitnik">zoo@rostov.don.sitnik</a></td>
</tr>
<tr>
<td>Rotterdam Zoo</td>
<td><a href="mailto:Rob.beltman@rotterdamzonn.nl">Rob.beltman@rotterdamzonn.nl</a></td>
</tr>
<tr>
<td>Leningrad Zoo</td>
<td><a href="mailto:info@spbzuoo.ru">info@spbzuoo.ru</a></td>
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<td><a href="mailto:info@hagenbeck.de">info@hagenbeck.de</a></td>
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## Appendix 5

### Kinship Coefficient Matrix

Kinship coefficient matrix for potential jaguar pairs, the numbers in red indicate those pairs who are unrelated and thus have a kinship of 0.

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A long term study of *Trichuris trichiura* in zoo-housed Abyssinian colobus (*Colobus guereza kikuyuensis*)

Jacqui Caine¹,² and Vicky Melfi¹, ¹Paignton Zoo Environmental Park, Totnes Road, Paignton, Devon TQ4 7EU, ²School of Biological Sciences, Manchester University, Manchester M13 9PT

Routine faecal screening of Abyssinian colobus monkeys (*Colobus guereza*) at Paignton Zoo confirmed the presence of one principal parasite, *Trichuris trichiura*; this host-parasite relationship has been studied for the past 3 years. *Trichuris trichiura* is a major zoonosis and although light infections are often asymptomatic, uncontrolled infections can result in anaemia, stunted growth and rectal prolapse (Cooper & Bundy, 1988). This study has investigated two main topics: i) the evaluation of methods used to monitor and manage *T. trichiura* burdens in the study group (6.2), and ii) the variation of individual *T. trichiura* and whether they are affected by season, dominance rank, reproductive status etc.

Individually identified faecal samples were collected from all animals and analysed via the McMaster’s technique to establish the prevalence and intensity of *T. trichiura* burden through mean egg counts per gram of faeces (EGF) per animal. Mean individual EGF values declined over the time of the study for all colobus (between September 2002 and April 2004); these negative correlations were significant for five out of eight animals (p< 0.05). This may be due to changes in social status (see below), or husbandry changes; notably antihelmintic administration to individuals now occurs rather than to the group. A higher mean dose of antihelmintic per animal is consumed when fed individually (75%) rather than when presented to the group socially (46%).

Individual variation in parasite load is affected by season. Re-infestation of *T. trichiura* in colobus occurs more rapidly in the colder, wetter autumn months (1.9 months) compared to spring (>3.5 months). Previously, male dominance rank was found to be positively correlated with mean EGF (whereby the most dominant had the highest worm burden; Poyser & Melfi, in press). However, it would appear from further investigation that social hierarchy can be dynamic and not necessarily linear, and thus makes the interpretation of social status and parasite load more problematic; a situation also seen in ring-tailed lemurs (McCuskar in prep). Data from one female demonstrated her mean EGF declined from baseline (1600 EGF) whilst pregnant and lactating (310 EGF), rather than elevating as we might expect if she were immunocompromised.

This project successfully demonstrates and suggests causal factors that may be responsible for individual differences in parasite load. Further studies will continue at Paignton, where changes in group structure and housing have opened up new opportunities for research. Data from multiple zoos are also being collected which will enable us to further explore individual as well as group differences in parasite burden and hopefully enable us to quantify the reliability of using parasite burden as a non-invasive welfare indicator.

**Introduction**

*Trichuris trichiura* and Non Human Primates

*Trichuris spp.* are parasitic nematodes that infect the caecum and colon of many mammal species. The species that infects simians is believed to be *Trichuris trichiura*, which has been identified in *Macaca fascicularis* (Dihn Son, 2002), *Macaca mulatta* (Taylor et al., 1994) and other old and new world primate species. *T. trichiura* is easily transmitted between humans and nonhuman primates and infects an estimated 1049 million people worldwide making it an important zoonosis (Stephenson et al., 2000). The threat of cross species contamination is further exacerbated by the escalating human population, causing communities and wild non-human primates (NHPs) to live in closer proximity (Legesse & Erko 2004, Muriuki et al., 1998).

*T. trichiura*, the *Trichuris* sub-species found in simians, has a simple, direct life cycle (Urquhart et al., 1988). After copulation, each female *Trichuris* lays between 2,000 and
10,000 eggs per day which are passed in the host’s faeces, these eggs can be counted to give a relative *Trichuris* burden (egg count per gram faeces, EGF). Re-infection occurs by ingestion of embryonated eggs, the larvae then migrate to the intestine. Once mature the anterior of the worm burrows into the intestinal mucosa where it ingests cellular secretions. Blood loss due to damage caused to the intestinal epithelium may cause a variety of symptoms including anaemia, colitis and growth retardation (Schmidt & Roberts, 1985). Deaths due to severe *Trichuris* burdens have been reported in Abyssinian colobus monkeys, *Colobus guereza*, and olive baboons, *Papio anubis* (Emikpe et al., 2002; Loomis & Wright, 1986).

The relationship between *Trichuris* spp. and NHP species has been extensively studied (*Pan paniscus*, Hasegawa et al. 1983; *Papio anubis*, Ayoade et al. 2002, Emikpe et al. 2002; *Macaca mulatta*, Phillipi and Clarke 1992, Kessler et al. 1984, Karr et al. 1979; *Macaca fascicularis*, Janagi, 1981; *Colobus guereza*, Loomis & Wright, 1986), as has it’s relationship with humans (Chan et al., 1994; Bundy et al., 1991 and 1987; Wakelin, 1986; Jung & Beaver, 1951). NHP-*Trichuris* spp. studies usually take a brief “snap shot” of parasite incidence, but do not usually explore dynamic changes in this relationship (Stuart et al., 1998). Previous research has almost universally concentrated on the incidence of parasite burden whilst ignoring parasite intensity.

**Factors affecting parasite prevalence and intensity**

Many internal and external factors influence the prevalence and intensity of *Trichuris* burdens; these may influence the whole group (e.g. climate, nutrition and general environmental variables) or individuals (e.g. age, health, reproductive status and/or stress).

Climate and seasonal variation are important variables that affect survival and transmission rate of parasitic eggs. For example, it has been reported *Ascaris suum* oocyst deposits survive better in autumn months (September-October in Denmark) and degrade faster in summer months (July- August; Roepstorff et al. 2001; Larsen & Roepstorff, 1999). In addition, data from Zimbabwe showed that the intensity of *Trichuris* spp. burdens in goats was at its lowest at the end of the dry season and increased gradually throughout the rainy season (Pandey et al., 1994). Stuart et al. (1998) also found moist conditions to be conducive to higher parasite prevalence amongst wild howler monkeys (*Alouatta* spp.). During warmer seasons, oocysts may degrade faster due to greater exposure and desiccation, whereas increased moisture and greater sequestration of eggs in the soil by rain and earthworms in colder seasons helps the oocyst to survive and develop (Roepstorff et al., 2001).

Environmental variables whether captive or wild can grossly affect species’ behaviour and welfare, and as such indices of health (Carlstead et al., 1999). Gastro-intestinal parasite loads in wild Abyssinian colobus have been shown to vary relative to habitat type; colobus living in fragmented areas of the Kibale National Park, Uganda have higher prevalence and intensity of *Trichuris* spp. compared to those living within intact forest areas (Gillespie & Chapman 2004). In captive situations, good hygiene can be facilitated through enclosure design, for example, slatted floors, rather than solid or partially slatted floors in piggeries, provide better protection against parasitic infection (Beloell et al., 2003). The animals’ behaviour within it’s environment can also affect parasite burden; there was a inverse relationship between the intensity of *Ascaris suum* eggs in pasture and distance to the pig house, a pattern which mimicked the pig enclosure use (Roepstorff et al., 2001).

One of the most important factors that affects individual parasite burden is immune function; which is influenced by multiple variables. Age, reproductive status and stress can all lead to impaired immune function. As animals age, there is a reduction in naturally occurring antibodies, which results in a higher susceptibility to parasitic infection (Aspinall, 2000; Yung, 2000; Makinodan, 1998). Deerenberg *et al.*, (1997), noted that parasite prevalence and intensity often increase during mating, pregnancy and lactation due to immunosuppression and/or intensified transmission rate of parasites between animals during reproduction (Priddy 1997; Barger, 1993).

During periods of stress, the body releases Adrenocorticotrophic hormone from the anterior pituitary, stimulating the adrenal cortex to release cortisol into the blood stream (Roth 1985).
During chronic stress, the prolonged secretion of these corticosteroids cause involution of the thymus gland and suppress the secretion of interferons, prostaglandins, leukotrienes and histamines (Fleming 1997), thus resulting in immunosuppression. Raberg et al., (1998) suggest that the adaptive significance of decreased immuno-competence during stress is to counteract the risk of an autoimmune response, such as that seen in pregnant women. In this situation the maternal immune system is suppressed so that an autoimmune response is not launched on the growing foetus (Wegmann et al., 1993). While high parasitic burdens can represent a chronic stressor (Fleming 1997), they may also manifest as a consequence of stress induced by some other means, as stress would have lead to diminished resistance (Gracenea et al., 2002). Hausfater and Watson (1976) found that animals with higher cortisol levels were most heavily parasitized; dominant male and mid ranked female olive baboons, dominant male spider monkey (Phillippi & Clarke 1992). This is an important discovery, since in male spider monkeys, it is the younger of the species that are more dominant, and so the confounding variable of age can be ruled out.

**Aims**

This study explores the factors which affect *Trichuris spp.* infection at a group and individual level for Abyssinian colobus monkeys; for which few previous studies have been conducted (Brown et al., 2001; Loomis & Wright, 1984). It aims to highlight how a greater understanding of the aetiology of *Trichuris spp.* within zoo-housed primates can enable us to better monitor and manage *Trichuris spp.*, but also facilitate further study and understanding of the multifactorial implications of host-parasite interactions.

**Methods**

**Subjects and Housing**

A group (6.2) of Abyssinian colobus monkeys (*Colobus guereza kikuyuensis*) were maintained at Paignton Zoo Environmental Park, Devon, UK; ages ranged from 1 1/2 to 20 years. The group had twenty-four hour access between a sheltered indoor area (10.0 x 5.0 x 2.5 m) and enclosed outside area (10.0 x 5.0 x 5.0 m). Bark was provided as a deep litter flooring substrate outside and the inside cement floor was covered with a thin layer of shavings. Both inside and outside areas had wooden perches and there were two Perspex feeding tables inside.

**Animal Management**

The enclosure was cleaned every morning at 0830 hrs, when the animals were locked outside. Inside floor shavings were replaced and feeding tables and surfaces wiped with Annihilate A.C.R.® (Hydra International LTD, Milton Keynes). The outside enclosure was spot cleaned and the bark was replaced as necessary (approximately monthly).

**Sample collection and analyses**

All data were collected between October 2002 and April 2005. Individual faecal samples were collected; a researcher observed the colobus between 1400 and 1500 hrs, noting the individual and location of faeces voided on a map on the enclosure. Samples, faeces which did not touch other faeces, were collected at 1505hrs and stored in labelled (monkey’s name and date) plastic pots at -5 °C.

Faecal samples were analysed using McMaster’s technique (Urquhart et al., 1988). Two McMaster’s slides were made up for each faecal sample. *Trichuris spp.* eggs in the slide’s chamber were counted under the microscope; an estimation of egg count/gram faeces (EGF) was calculated by multiplying the number of eggs observed by 50 (Urquhart et al., 1988). The two EGF values were averaged to give the mean EGF; this value was used throughout data analysis as a representation of *Trichuris spp.* burden.
Results

Study 1 ~ Season

Data were collected during four conditions, which represented two autumn (October-February) and two spring (March-July) seasons (table 1). Data were collected immediately after anthelmintic administration and continued until the individual mean EGF values were back to baseline levels or 3 months had elapsed (Poyser and Melfi, submitted). Due to the inevitable opportunistic nature of sampling, i.e. when faeces were voided, the number of samples collected varied between conditions (table 1).

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Table 1. A summary of the data collected across conditions.

Repeated measures ANOVA was used to compare the number of days it took for the individual mean EGF to return to baseline levels, across the four conditions.

Results

There was a significant difference in the rates of re-infection between conditions (λ=0.043, F_{7,3}= 66.050, p<0.001, figure 1). Re-infestation of the group was faster in autumn compared to spring; during the spring condition sampling ceased after 3 months which was before mean individual EGF levels returned to baseline levels (table 1).
Study 2 ~ Antihelmintic method of administration

The efficacy of two different antihelmintic administration techniques was compared by investigating the amount of antihelmintic consumed and the number of Trichuris spp. eggs shed post antihelmintic administration. Antihelmintic was administered over three days; either socially, when the total dose required for each individual was mixed with food and fed to the group, and individually, when antihelmintic was delivered to individuals via syringe (table 1). Individual dosing was made possible due to the implementation of a training programme (Melfi & Thomas, submitted).

The amount of antihelmintic consumed was estimated according to the method of administration: i) when social worming, the number of antihelmintic-soaked bread pieces consumed by each colobus was noted; bread was cut into 1 inch squares and a known quantity of antihelmintic applied to each square; ii) during individual worming, the amount of antihelmintic fruit juice solution observed to go directly into the colobus’ mouths (via syringe) was estimated.

Results

<table>
<thead>
<tr>
<th>Group</th>
<th>Erroll</th>
<th>Frasier</th>
<th>Milo</th>
<th>Fergus</th>
<th>Kabul</th>
<th>Hope</th>
<th>Lou</th>
<th>Deanna</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social</td>
<td>82.9</td>
<td>38.99</td>
<td>17.54</td>
<td>38.99</td>
<td>40.94</td>
<td>68.25</td>
<td>&gt;100</td>
<td>7.8</td>
</tr>
<tr>
<td>Individual</td>
<td>75.0</td>
<td>80.0</td>
<td>85.0</td>
<td>60.0</td>
<td>60.0</td>
<td>70.0</td>
<td>90.0</td>
<td>80.0</td>
</tr>
</tbody>
</table>

Table 2. An estimation of the percentage of antihelmintic consumed when administered socially or individually.

The amount of antihelmintic consumed varied by individual and administration method, however consumed levels of antihelmintic were greatest when individually administered (table 2). Mean individual EGF values, for all colobus, were negatively correlated with time i.e. worm burden declined over the course of the study (between September 2002 and April 2004). This correlation was significant for five out of eight animals (p< 0.05, figure 2).

Figure 2 Individual mean EGF values (+/- SE) across conditions.

There was a significant difference in baseline mean individual EGF values, when antihelmintic administration was delivered socially (Autumn 2002, Spring 2003) versus to each individual (Spring 2004, Autumn 2004a, Autumn 2004b; figure 2). The mean number of eggs shed post
antihelmintic administration (relative to the mean individual EGF) was greater after individual antihelmintic administration (matched pairs t-test, $t_{[7]} = 3.033$, $p<0.05$, figure 3).

![Figure 3. Mean percentage of eggs shed (EGF) post-antihelmintic, relative to the baseline EGF values.](image)

**Study 3 ~ Individual variation, social status**

Each male was observed using continuous focal animal sampling (Martin & Bateson, 1994) for 15 min ($n=6$ animals, 12 sessions/animal). All displacement behaviours were noted, where displacement was defined as “movement of one animal (displacer) towards another stationary animal, causing the stationary animal (displacee) to move away”. Females were excluded from this data collection, as they were reported to not form dominance hierarchies; also two females would not be sufficient to investigate dominance rank (Grunau & Kuester, 2001). Observations were undertaken in Autumn 2002 and Autumn 2004.

Behavioural data were arranged into two matrices to create two dominance hierarchies according to the number of individuals each male could displace; the individual at the top of matrix was never supplanted at the top (ranked 1) and the individual that was always supplanted was at the bottom (ranked 6). The strength of each hierarchy ($h$) was calculated using a modified version of the basic Landau equation (Singh et al., 1992), whereby $0>h>1$, such that $h = 0$ indicates a total absence of a ranking system of hierarchy whereas $h = 1$ denotes a perfectly linear order (Singh et al., 2003).

**Results**

The hierarchy created from data collected in Autumn 2002 was more linear than that created from data collected in Autumn 2004 ($h=0.69$ and $h=0.28$ respectively; figures 4 & 5) Significant correlations were found between male EGF values and male dominance rank, weight in kg and actual age in years for the Autumn 2002 data (Spearmans: rank: $r_{[5]} = -0.94$, $P<0.01$; weight: $r_{[5]} = 0.93$, $P<0.01$; age: $r_{[5]} = 0.89$, $P<0.05$, Poyser and Melfi, submitted). Greatest parasite burdens were found in dominant, heavy and older animals. Similar analyses performed with the dataset collected in Autumn 2004 showed similar patterns, but yielded fewer significant results (Spearmans: rank: $r_{[5]} = -0.60$, $P=0.208$; weight: $r_{[5]} = 0.35$, $P=0.49$; age: $r_{[5]} = 0.94$, $P<0.05$).
Discussion

The longitudinal investigation of multiple factors known to influence parasite burden using this study group has proved that certain factors impress a greater influence on the establishment, reproductive success and re-infestation of *T. trichiura* than others. A ‘hierarchy’ of sorts can be created to illustrate which factors remain most influential, and thus be targeted for preventative health measures.

Initially, data analyses showed the mean EGF for each subject was seen to decrease over time, showing a significant negative correlation for five out of eight colobus. While several factors may be at work here, the most convincing seems to be the manner in which antihelmintic is now administered. A higher mean dose of antihelmintic per animal is consumed when fed individually (75%) rather than when presented to the group socially (46%), and as such, greater antihelmintic efficacy is expected as preventative health
measures improve. Certainly six out of eight animals showed a significant decrease in EGF values after individual administration was incorporated, and with each successive trial of antihelmintic, the number of prolific *T. trichiura* worms is expected to decrease further due to the possible accumulative affects of the drug. Further investigation of antihelmintic administration method shows that individual worming results in the shedding of more *T. trichiura* eggs immediately after antihelmintic is given, compared to when the drug is given socially.

While administration of antihelmintic influences the elimination of parasite from each subject, the re-infestation of eggs is most convincingly affected by the external factor of season. Data show clearly that re-infestation of *T. trichiura* occurs more rapidly in the colder, wetter autumn months (mean 1.9 months to re-infestation), while in both spring trials, no subject’s mean EGF reached baseline value before data analysis ceased (mean 3.5 months). As mentioned in the introduction, the influence of weather on parasite prevalence and intensity has been previously documented and support this data that colder, wetter conditions favour nematode oocyst survival, while desiccation of oocysts in the warmer, drier spring months make re-infestation a much slower process (Pandey *et al*., 1994; Roepstorff *et al*., 2001).

Finally individual subject variables such as dominance rank, weight and age were investigated. The autumn 2002- spring 2003 trials proved such factors significantly correlated with *T. trichiura* burden, whereby the most dominant animals had the highest parasite burden, thought to be due to the stress of maintaining a high social rank resulting in immunosuppression. Recent data show that social structure has changed so that the dominance hierarchy is more dynamic, and as such EGF values have become more variable. Dominance rank and baseline EGF no longer correlate, however since group structure is by no means stable, such a result is not surprising. Age does correlate with worm burden, and so may have a greater influence on *T. trichiura* burden than social status. The effect of reproductive status was also investigated for the study group breeding female Lou. The longitudinal nature of the study enables brief analysis of parasite burden whilst she was pregnant and lactating, pregnant and not lactating (due to a still birth) and cycling. Although no statistical analysis was possible, anecdotal analysis showed that her baseline EGF value did not increase with the immunocompromise of pregnancy as expected. Since pregnancy occurred both times during the latter half of the study, it seems her worm burden was more affected by the group trend of a decrease in baseline EGF in the 2004 spring and autumn trials due to improved preventative health. It is also worth considering that some kind of behavioural change due to pregnancy may affect worm burden, i.e. more time spent resting and less time allo-grooming may slow the faecal-oral transmission of oocysts. Some kind of overcompensation of the immune system due to pregnancy may also be at work so that maximum health is maintained for parturition, resulting in the lower baseline EGF seen at pregnancy. A more detailed analysis of pregnant primates and parasite burden is needed to substantiate any of these theories.

**Conclusion**

A hierarchy of factors influencing the prevalence, intensity and re-infestation of *T. trichiura* can be established for this study group. Seasonality being the most influential factor, proves that re-infestation of oocysts occurs more rapidly in the colder wetter autumn months than warmer, drier spring months where oocysts are at risk of desiccation. Preventative health measures follow in this hierarchy, more specifically the manner in which antihelmintic is administered to the group. Individually administered drug ensures that more animals get a higher dosage of wormer than would do via social administration, and as a result, mean EGF values decline after re-infestation. It would seem that social structure and individual variables such as age and reproductive status remain at the bottom of this hierarchy. A now dynamic group structure has proved that the initial assumption of immunosuppression due to the stress of maintaining a high social status may not be as clear cut as once thought, with age becoming a more important factor. This is further substantiated by the immunocompromisation anticipated due to pregnancy not influencing worm burden as expected.
Acknowledgements

The authors would like to thank other members of zoo staff for facilitating this study, notably: Amy Plowman, Ghislaine Sayers, Sheona McGovern, Neil Bemment, Julian Chapman, Lisa Doran, Tony Dobbs, Kelly Elford, Andrew Fry, Lucy Manning and Nicky Jeggo.

References


The use of Thermography as a diagnostic tool in assessing musculo-skeletal problems in the Asian elephant, and as a gauge to the effectiveness of osteopathic treatment of such structures, Twycross Zoo
Dr. Chris Colles, BVSc, Avonvale Veterinary Practice Ltd.

An over view of Thermography

A brief history of its’ use in equine medicine over the last 15+ years, how it works, what it is capable of achieving, along with the advantages of being non invasive, and very portable.

Subjects

2 adult female Burmese elephants housed at Twycross Zoo

Assessment methodology

Prior to scanning, the elephants were kept in the elephant house for at least 30 minutes, and were also unwashed. Each session took place late morning at roughly monthly intervals for the first year, extending to every six weeks during the second year. Scans were taken before, during, and post osteopathic treatment, and recorded.

Conclusion

Thermography has, for the first time, shown that osteopathic treatment does affect a measurable change within the musculo-skeletal systems of these subject elephants.
Using Osteopathy to treat musculo-skeletal problems in 2 Burmese elephants, Twycross Zoo.
Tony Nevin, D.O., Registered Osteopath, Zoo Ost Limited.
29 Alstone Croft, Cheltenham, Glos. GL51 8HB.
Tel : 01242 221153 E-mail : zooostltd@blueyonder.co.uk

A brief outline about osteopathy, and it’s uses.

Osteopathy is a form of manual medicine. That is it requires direct, physical contact between patient and practitioner. Its’ origins date back to the late 19th century, when Scots born Dr Andrew Taylor Still adapted ancient North American Indian medical manipulation into what we now call osteopathy. Throughout its’ inception, and right up to today, osteopathy has been successfully used to treat musculo-skeletal problems in people and animals.

By referring to the musculo-skeletal system in its’ entirety, we need to remember that it is made up of muscles, tendons, ligaments, ligamentous joint capsules, fascia, connective tissue, cartilage, and bone. As osteopaths, we are concerned with the intricate functioning of all of these structures individually, and as a whole system.

Fundamentally osteopaths deal with physical problems affecting these structures. However there are many instances when the emotional state, or psyche of a patient causes physical symptoms to show in the musculo-skeletal system.

For the past 15 years I have split my clinic time between treating people and treating animals and birds, using osteopathy. During this time I have worked on over 20 elephants, both Asian, and African.

The subjects

2 adult (23 year old) female Burmese elephants. Each having successfully reared 1x calf. Both animals were brought into the UK from logging camps in Burma (as it was then). Both were showing signs of stiffness in their backs, and one was lame on the front left limb.

Both of these elephants had received osteopathic treatment prior to them being successfully mated on their first attempt. Treatment was performed with the animals unsedated, although they were on loose chains secured to floor rings. Treatment was performed by myself to both animals. Treatment was then suspended once they had been mated, and was only resumed again in 2003 at the start of this project.

Assessment methodology

Prior to any hands on osteopathic treatment each subject was viewed using an infra red thermal imaging camera operated by Dr Chris Colles, BVSc., and independent veterinary surgeon.

For each visit, the elephants would be kept inside their house, remain dry, and were brushed clean of any debris.

Thermal images were then taken with each animal standing, then lying on their sides. Images would then continue to be taken during the treatment phase.

Images were stored on computer and compared with those taken on each and every subsequent visit.

Osteopathic treatment

Hands on osteopathic treatment was performed with each animal lying on its’ side, whilst it was fully conscious. Each treatment involved the subject lying on both sides to facilitate easy
access to the structures needing attention. Treatment itself involved the use of soft tissue massage, lateral springing of each vertebral spinous process, rocking to each ilia, traction via the tail, and gentle cranio-sacral work accessing the movement inherent within the meninges. Each treatment was performed by myself to help maintain continuity. My physical findings were then compared with those seen on the thermal images. Treatment frequency was at roughly monthly intervals over a 21 month period. Feedback was encouraged from the zoo vet, and elephant keepers.

Conclusion

Through the passive use of infra red thermal imaging we were able to show that osteopathic treatment can, and does, change the physiology to the musculo-skeletal system. Over a period of time, regular osteopathic treatment improved the functioning of these 2 animals physical bodies, and as the nerves that supply these more external structures also supply organs within, it is not difficult to see that osteopathic intervention can work on these structures as well. Although these 2 subjects were treated whilst being fully conscious, it is equally possible to treat whilst the animal is sedated, or fully anaesthetised.

Acknowledgements

My sincere thanks for helping with this ground-breaking project, to

Dr Chris Colles, BVSc.,
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John Ray, Deputy Director, Twycross Zoo
The Elephant House staff, Twycross Zoo
Solutions to a trap-table task: do gibbons (*Hylobatidae*) use simple associative rules for success?
Clare L. Cunningham and James R. Anderson, Scottish Primate Research Group, University of Stirling, Stirling, FK9 4LA
Email: clc1@stir.ac.uk

Abstract

The cognitive abilities of gibbons, taxonomically apes, have been rarely studied. This research assessed gibbons’ understanding of the causal relationships between a goal object, an object to be manipulated and a salient environmental feature. Fourteen gibbons were presented with two rakes placed on tables outside their enclosures that could be pulled in to draw objects towards them. The testing phase introduced a trap along the surface of one table, into which the reward could be lost. Both sets of apparatus were baited and the ape had to select a rake to pull in. Nine subjects effectively learnt to avoid the trap. Further experiments tested a number of associative rules the gibbons may have employed to complete the task. Subjects were not avoiding what they may have perceived as an obstacle in the path of the reward once they had experience of its neutrality, however they did not adapt previous knowledge gained to new situations.

Introduction

The ability to use tools is considered cognitively complex as it is an indirect means of goal attainment (Tomasello & Call 1997). Amongst the primates, chimpanzees (*Pan troglodytes*) and specific populations of orangutans (*Pongo Pygmeaus*) habitually use tools in food processing (van Schaik et al. 2003; Whiten et al. 2001; McGrew 1992; Boesch & Boesch 1990) and in captivity, all species of great ape have shown the capacity for tool use (Boysen et al. 1999; Fontaine et al. 1999; Nakamichi 1999, 2003; Toth et al. 1993). Of the monkeys, capuchins are the most proficient tool users, showing considerable abilities in captivity and recent reports emerging of their tool using skills in their natural habitat (de Moura & Lee 2004, Fragaszy et al. 2004a).

However, being able to use tools does not necessarily imply understanding of the causal relationships between objects. In their extensive work with capuchins (*Cebus* spp.), Visalberghi and colleagues developed a trap-tube task to assess the monkeys understanding of the consequences of their actions on a tool, the action of the tool on a reward and the effect of a salient environmental feature on the reward (Visalberghi & Limongelli 1994). In this task, subjects were required to insert a stick into a clear plastic tube to push out a food reward, avoiding a trap along the tubes length into which the food could be lost. To be successful, the monkeys had to perform two mental operations before interacting with the apparatus: 1) decide which end of the tube to insert the tool and 2) consider the outcome of that first decision. Of the four capuchins used in this task, only one successfully learnt to avoid the trap, seemingly using trial and error to develop a simple distance-based rule (insert stick into end farthest from reward), without showing any apparent predetermination of the causal relationships involved.

While studying chimpanzees (*P. troglodytes*), Reaux and Povinelli (2000) reported that their subjects had similar difficulties resolving the spatial relationships involved in the trap-tube task. Only one of four apes performed significantly above chance, and only in the latter 50 of 100 trials, suggesting that this chimpanzee was using trial and error to determine the correct response. Further analysis of this successful apes’ behaviour revealed that she too was using a distance-based rule to attain the reward.

Povinelli and Reaux (2000) went on to present their apes with a less complicated choice that did not require them to mentally represent both the placement of the tool and the outcome of manipulating it in that location, thus reducing the true tool use task used by Visalberghi and Limongelli (1994) to a more simple zero-order object manipulation task (Fragaszy et al 2004b). Six chimpanzees were given a choice of pulling one of two rakes, presented on a flat
surface, one of which would lead to successful retrieval of the reward and one that would result in the reward being lost into a trap. In this simplified task, only one ape consistently avoided the trap on first presentation of the task, selecting the correct rake from the first trial and maintaining an error rate of less that 20% overall.

In the present experiment, gibbons were given a choice between a rake that offered the chance of reinforcement, and another that if pulled, would result in the reward being lost in a trap along the tables’ surface. Failure to avoid the trap would suggest that gibbons too lack the cognitive underpinnings required to understand three-way causality whereas success would show them to have at least a rudimentary understanding of how the introduction of a trap can change the outcome of an action.

**Experiment 1-Training Phase**

**Methods**

**Study subjects**

The subjects were 14 gibbons (*Hylobatidae*), nine housed at the Gibbon Conservation Center (GCC), California, USA, and five at Twycross Zoo, West Midlands, UK (Table 1.1). All subjects had previously learnt to use a rake to pull in an out of reach food item. At GCC, the apes were housed in outdoor enclosures 10 x 3 x 4 m, with an adjacent smaller area 4 x 3 x 2.5 m in size that was generally available at all times but could be closed off to separate individuals as required (see Mootnick 1997b for more details of enclosure design). At Twycross, subjects had a large outdoor area of the same dimensions as the larger area at GCC, and an indoor area that they had access to at all times except for during cleaning.

Gibbons at GCC are fed four times a day, beginning with breakfast of fruits and primate biscuits, a main feed of fruits and vegetables and two further feeds of apples, bananas and greens (Mootnick 1997a). At Twycross, a small meal of primate pellets, bread or eggs and celery or lettuce was provided in the morning between 8.00 and 10.00am, with the main feed of fruits and vegetables being given in the evening to encourage the apes into their indoor quarters for the night. Water is available at both institutions *ad libitum*.

**Test apparatus and experimental procedure**

The basic task involved pulling in a rake-like rod to obtain a food reward. Two wooden tables (110 x 27 x 12 cm) were placed outside the main outdoor enclosure at floor level, adjacent to the gibbons’ feeding area. The rakes consisted of an aluminium rectangle (25 x 12 cm) fixed to one end of a 115 cm handle with the free end protruding through the chain link fence approximately 5 cm into the enclosure. This elevated the end of the rake to facilitate grasping by the gibbons’ elongated hands (see Beck (1967) for a similar arrangement with a string pulling task).

Trials at GCC were conducted from July 2003 to November 2004, between 0700 and 1030 hours, after the gibbons had received their first feed. Data from the gibbons at Twycross were collected in March to May 2005, with trials undertaken in the afternoon (1400 -1530 hours); subjects were more motivated to attend to the tasks at this facility in the later part of the day.

The first stage was a training phase in which the apes had to choose between two rakes, one that would offer the chance of a reward and one that would not, but without the added complication of the trap. Red grapes were used as the food reward, an item that was only rarely given to the gibbons at both institutions but highly palatable to all. Subjects were tested individually, with cage mates isolated in the smaller adjacent area with the exception of one pair, Chester and Drew, who became distressed when separated and so were left together during testing. In most cases only one ape from each enclosure took part in testing and the arrangement of the enclosures made it unlikely that any individual was able to observe another taking part in the tasks.
Prior to commencing, the gibbon was given a taste of the food reward. Each subject was given a minimum of 20 trials and a maximum of 50, presented in blocks of 10 trials with up to three blocks being presented on each of consecutive days dependent on the individuals’ willingness to participate. Rewards were placed in equal proportions on each table in a randomly predetermined order. During the baiting procedure, the experimenter motioned as if food was being placed on each table; however only one was baited in each trial. The subject then chose which rake to pull in. No training was given. A correct response was scored if the gibbon pulled in the baited rake without first pulling in the unbaited tool. Only one choice was permitted in each trial. If an incorrect rake was chosen, the reward was quickly removed from the table and taken away.

Table 1.1: Subjects used in training phase and trap-table tasks, Experiments 1-4.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Genus</th>
<th>Species</th>
<th>Sex</th>
<th>Age at testing (yrs)</th>
<th>Rearing</th>
<th>Housing</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maung</td>
<td>Bunopithecus</td>
<td>hoolock</td>
<td>M</td>
<td>4</td>
<td>unknown</td>
<td>solitary</td>
<td>GCC</td>
</tr>
<tr>
<td>Chester</td>
<td>Bunopithecus</td>
<td>hoolock</td>
<td>M</td>
<td>5</td>
<td>peer</td>
<td>M/F pair</td>
<td>GCC</td>
</tr>
<tr>
<td>Betty</td>
<td>Bunopithecus</td>
<td>hoolock</td>
<td>F</td>
<td>5</td>
<td>peer</td>
<td>M/F pair</td>
<td>GCC</td>
</tr>
<tr>
<td>Arthur</td>
<td>Bunopithecus</td>
<td>hoolock</td>
<td>M</td>
<td>9</td>
<td>peer</td>
<td>M/F pair</td>
<td>GCC</td>
</tr>
<tr>
<td>Sasha</td>
<td>Nomascus</td>
<td>leucogenys</td>
<td>M</td>
<td>27</td>
<td>unknown</td>
<td>solitary</td>
<td>GCC</td>
</tr>
<tr>
<td>Ricky</td>
<td>Nomascus</td>
<td>leucogenys</td>
<td>F</td>
<td>15</td>
<td>parent</td>
<td>family group</td>
<td>GCC</td>
</tr>
<tr>
<td>Vok</td>
<td>Nomascus</td>
<td>leucogenys</td>
<td>M</td>
<td>17</td>
<td>parent</td>
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<td>GCC</td>
</tr>
<tr>
<td>Kino</td>
<td>Symphalangus</td>
<td>syndactylus</td>
<td>M</td>
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<td>solitary</td>
<td>GCC</td>
</tr>
<tr>
<td>Dudlee</td>
<td>Symphalangus</td>
<td>syndactylus</td>
<td>F</td>
<td>9</td>
<td>parent</td>
<td>F/F sib pair</td>
<td>GCC</td>
</tr>
<tr>
<td>Kimbo</td>
<td>Symphalangus</td>
<td>syndactylus</td>
<td>F</td>
<td>5</td>
<td>parent</td>
<td>F/F sib pair</td>
<td>GCC</td>
</tr>
<tr>
<td>Chloe</td>
<td>Hylobates</td>
<td>moloch</td>
<td>F</td>
<td>13</td>
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<td>family group</td>
<td>GCC</td>
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<tr>
<td>Valentina</td>
<td>Hylobates</td>
<td>pileatus</td>
<td>F</td>
<td>7</td>
<td>parent</td>
<td>M/F pair</td>
<td>Twycross*</td>
</tr>
<tr>
<td>Jason</td>
<td>Hylobates</td>
<td>pileatus</td>
<td>M</td>
<td>33</td>
<td>hand</td>
<td>family group</td>
<td>Twycross</td>
</tr>
<tr>
<td>Jay</td>
<td>Hylobates</td>
<td>pileatus</td>
<td>M</td>
<td>2</td>
<td>hand</td>
<td>M/M sib pair</td>
<td>Twycross</td>
</tr>
</tbody>
</table>

* born and reared at GCC then moved to Twycross at age 6 to form a breeding pair. Tested at Twycross Zoo.

Subjects reached criterion if they achieved 85% correct responses. If they attained this level within the minimum of 20 trials, testing was halted. However, if they did not perform at criterion, further trials were given to a maximum of 50. If after these additional trials an error rate of less than 15% was not achieved, subjects were considered to have been unsuccessful at this task. Individuals’ performances were analysed using binomial tests.

Results and Discussion

Of the 14 gibbons tested, 10 reached criterion performance within 20 trials, while one white-cheeked male (*N. leucogenys*) required 40 trials to achieve 85% correct responses and three individuals from the lar group (*Hylobates spp.*) failed to perform above chance across the maximum of 50 trials (Table 1.2). Collectively, those subjects that attained the required level of performance made only 16 incorrect responses in 260 trials (94% correct), with all individuals choosing correctly from the first trial (Table 1.2). This is comparable to the performance of chimpanzees that achieved an average of 99% correct responses over 20 trials on a similar task (Povinelli & Reaux, 2000).

For those subjects that did not meet criteria, performance in the first 10 trials was compared to that in the last 10, with no evidence of an improvement in the number of correct responses given (Table 1.2). Failure by these apes was largely due to the presence of a significant side bias, with all individuals selecting the right-hand rake on the majority of trials (Chloe: 76%
right side choices - binomial test, n = 50, p < 0.001; Jason: 94% right side choices - binomial test, n = 50, p < 0.001; Jay: 74% right side choices - binomial test, n = 50, p < 0.01).

Table 1.2: Number of correct responses for each subject in training phase; p values are based on binomial tests.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Genus</th>
<th>No. correct (%</th>
<th>p value (all trials)</th>
<th>No. correct trials 1-10 (p value)</th>
<th>No. correct trials 41-50 (p value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maung</td>
<td>Bunopithecus</td>
<td>20/20 (100%)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Chester</td>
<td>Bunopithecus</td>
<td>20/20 (100%)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Betty</td>
<td>Bunopithecus</td>
<td>18/20 (90%)</td>
<td>0.000**</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Arthur</td>
<td>Bunopithecus</td>
<td>20/20 (100%)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sasha</td>
<td>Nomascus</td>
<td>34/40 (85%)</td>
<td>0.000**</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ricky</td>
<td>Nomascus</td>
<td>19/20 (95%)</td>
<td>0.000**</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Vok</td>
<td>Nomascus</td>
<td>17/20 (85%)</td>
<td>0.003*</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Kino</td>
<td>Symphalangus</td>
<td>19/20 (95%)</td>
<td>0.000**</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Dudlee</td>
<td>Symphalangus</td>
<td>18/20 (90%)</td>
<td>0.000**</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Kimbo</td>
<td>Symphalangus</td>
<td>18/20 (90%)</td>
<td>0.000**</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Chloe*</td>
<td>Hylobates</td>
<td>31/50 (62%)</td>
<td>0.120</td>
<td>5/10 (1.000)</td>
<td>6/10 (0.754)</td>
</tr>
<tr>
<td>Valentina</td>
<td>Hylobates</td>
<td>19/20 (95%)</td>
<td>0.000**</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Jason*</td>
<td>Hylobates</td>
<td>28/50 (56%)</td>
<td>0.480</td>
<td>5/10 (1.000)</td>
<td>6/10 (0.754)</td>
</tr>
<tr>
<td>Jay*</td>
<td>Hylobates</td>
<td>23/50 (46%)</td>
<td>0.671</td>
<td>6/10 (0.754)</td>
<td>6/10 (0.754)</td>
</tr>
</tbody>
</table>

* did not reach criterion performance
* significant at the 0.01 level
** significant at the 0.001 level

The hoolock gibbons (Bunopithecus) were the most attentive to the task, coming immediately to the apparatus in all trials and performing with a high level of accuracy (Table 1.2). However, in 15% of trials, these subjects would place a hand, or make a short pull (less than 2cm movement forward), on the incorrect rake, thus contacting both tools before committing to make a choice, suggesting that the hoolocks were not always using a representational strategy, mentally planning the outcome of their actions. By contacting the rake, or manipulating it slightly, before executing a response, the physical connections between the rake, goal object and their own actions may become more salient, allowing the gibbon to perceive the relationships in the visual domain.

Experiment 2

Once they had successfully completed the training phase, additional cognitive elements were added to the basic raking-in task. The gibbons were given a choice between a rake that offered a chance of reinforcement and another that if pulled, would result in the reward being lost in a trap along the tables’ surface.

Methods

Study subjects were as described for training phase (Table 1.1) with the exception of those individuals that did not reach criterion and two siamang females (Dudlee and Kimbo), that were unavailable for testing at this time. General methods and apparatus were as described for the training task, however one continuous table surface was replaced with one that had a trap, in the form of a 4 cm wide slot, 25 cm from the far end that spanned almost the width of the table. Two sets of apparatus were presented, as in the training phase, and the side of the trap was alternated in a randomised schedule. A food reward was placed on both tables in front of the rake but behind the trap. The subject then had to choose a rake to pull in.

Gibbons received trials in blocks of 10 with no more than 3 blocks being given on any day, dependent on the motivation of the subject. To be successful, the apes had to complete 8/10 correct responses on 3 consecutive blocks. The number of trials each subject received was determined by how quickly they achieved criterion performance. A maximum of 200 trials were presented to any individual. Only one choice was permitted in any trial. If the ape chose
the correct rake, leading to reward, they were also given an additional reinforcement in the form of another grape handed to them. If they selected the incorrect rake and the food was lost into the trap, the remaining reward was quickly removed from the apparatus and the gibbon received nothing.

Results and Discussion

Seven of the nine subjects tested achieved reached criterion, however the number of trials needed to accomplish 8/10 correct responses on 3 consecutive blocks varied between apes (Table 2.1). Analysis of performance in the first two blocks (20 trials) compared to the last two (20 trials) shows that all apes with the exception of one, were selecting the correct rake as would be predicted by chance initially, only later biasing their choices towards the attainable reward-rake-trap configuration (Table 2.1). This suggests that they were not immediately able to understand the causal relationships between the three factors, but adopted a trial-and-error strategy, learning through experience that the trap would prevent them obtaining the food. One hoolock gibbon (Maung) performed above chance levels from the beginning, suggesting that the inter-relations between the elements involved in this task may have been more salient to this individual.

Two subjects, one white-cheeked male, Vok (N. leuconedys), and the only remaining Hylobates subject, Valentina (H. pileatus), failed to reach criteria. Further analysis of their results shows that they did not realise more than chance levels in either the first or last two blocks (Table 2.1), indicating that there was no improvement in performance as trials progressed. Both unsuccessful subjects developed a significant side bias that had not been present in the training phase. For Valentina, a bias for the right side tool was evident from the first blocks (Trials 1-20: right side choices 95%, binomial; n = 20, p = 0.000), and persisted throughout (Trials 180-200: right side choices 85%, binomial; n = 20, p = 0.003). For Vok, the bias was again for the right side, however, this time did not emerge until the later trials (Trials 1-20: right side choices 65%, binomial; n = 20, p = 0.263, Trials 180-200: right side choices 75%, binomial; n = 20, p = 0.041). This suggests that when the gibbons can readily discern the requirements for success, no bias is evident. However, once the necessary response to gain reinforcement becomes confused, they adopt a side bias, thus ensuring that they obtain the reward in 50% of trials.

Table 2.1: Number of correct responses in test 2 (trap/no trap) condition showing first 20 trials compared to last 20 for each subject.

<table>
<thead>
<tr>
<th>Subject</th>
<th>No. of trials to criterion</th>
<th>Performance 1st two blocks</th>
<th>(p-value†)</th>
<th>Performance last two blocks</th>
<th>(p-value†)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maung (Bunopithecus)</td>
<td>60</td>
<td>*17/20</td>
<td>(p=0.003)**</td>
<td>*17/20</td>
<td>(p=0.003)**</td>
</tr>
<tr>
<td>Chester (Bunopithecus)</td>
<td>130</td>
<td>13/20</td>
<td>(p=0.263)</td>
<td>*18/20</td>
<td>(p=0.000)**</td>
</tr>
<tr>
<td>Betty (Bunopithecus)</td>
<td>90</td>
<td>9/20</td>
<td>(p=0.824)</td>
<td>*18/20</td>
<td>(p=0.000)**</td>
</tr>
<tr>
<td>Arthur (Bunopithecus)</td>
<td>80</td>
<td>9/20</td>
<td>(p=0.824)</td>
<td>*18/20</td>
<td>(p=0.000)**</td>
</tr>
<tr>
<td>Sasha (Nomascus)</td>
<td>120</td>
<td>11/20</td>
<td>(p=0.824)</td>
<td>*17/20</td>
<td>(p=0.003)**</td>
</tr>
<tr>
<td>Ricky (Nomascus)</td>
<td>120</td>
<td>10/10</td>
<td>(p=1.000)</td>
<td>*17/20</td>
<td>(p=0.003)**</td>
</tr>
<tr>
<td>Vok (Nomascus)</td>
<td>200ª</td>
<td>13/20</td>
<td>(p=0.263)</td>
<td>9/20</td>
<td>(p=0.824)</td>
</tr>
<tr>
<td>Kino (Symphalangus)</td>
<td>150</td>
<td>13/20</td>
<td>(p=0.263)</td>
<td>*16/20</td>
<td>(p=0.012)*</td>
</tr>
<tr>
<td>Valentina (Hylobates)</td>
<td>200ª</td>
<td>11/20</td>
<td>(p=0.824)</td>
<td>13/20</td>
<td>(p=0.263)</td>
</tr>
</tbody>
</table>

† p values based on binomial tests ( * significant at the 0.05 level, ** significant at the 0.01 level, *** significant at the 0.001 level).

a criterion level performance
ª did not reach criterion level performance; 200 represents the maximum number of trials given
Experiment 3

Learning to avoid the trap does not automatically imply an understanding of the properties of the trap itself. The gibbons may simply have adopted an associative rule such as ‘avoid the side with an obstruction in the path of the reward’. To assess the strategy used by the apes, the trap was replaced by a painted red stripe that would present an apparent obstacle but would have no functional significance. If the gibbons were making a choice based on what they perceived to be an obstacle in the path of the reward, they should bias their choices in favour of the ‘no stripe’ side.

Results and Discussion

Collectively, subjects showed a significant bias away from the stripe side in the first block (stripe side choices = 24%, binomial; n = 70, p = 0.000) (Figure 1). By block 2, the gibbons were selecting both stripe and no stripe choices equally (stripe side choices = 41%, binomial; n = 70, p = 0.188), with no significant avoidance of the stripe side in any of the following blocks. Therefore, gibbons were avoiding what they perceived to be an obstacle in the path of the reward until they had experience of its inefficacy.

![Figure 1: Number of stripe-side choices made by each subject in block 1 and block 5 of experiment 3. Dashed line represents chance performance.](image)

Experiment 4

From the results in experiment 3, it would appear that the apes were using a simple associative rule to solve the trap-table task, avoiding what they perceived to be a potential impediment to the progress of the reward. However, avoidance of the ineffective stripe does not repudiate the possibility that they do understand the concept of holes in surfaces; they may have been ‘playing it safe’ by not selecting the rake on the stripe side as the other surface was obviously clear of any obstacle. This experiment reintroduced the trap alongside painted stripes. If the gibbons understand something more about the effect of a hole, they should return to their levels of performance seen in experiment 2, avoiding the trap and not being distracted by the ineffective stripes.
Methods

Study subjects and methods were consistent with those described for experiment 3 with only the apparatus being modified. The trapping hole was reintroduced on one table surface, presented with a red painted stripe of the same dimensions directly below it. The second table had a continuous surface with two painted, red stripes aligned with the trap and stripe on the other.

Results and Discussion

![Bar chart showing number of correct responses for each subject in Trials 1-20 and Trials 30-50.]

**Figure 2: Number of correct responses in the first two blocks compared to the last two blocks for each subject in experiment 4. The dashed line represents chance performance.**

In the first 20 trials, only one individual avoided the trap significantly above chance (Maung; 16/20, binomial; n = 20, p = 0.012), consistently shunning the trap on all blocks. All but one gibbon did show a marked improvement as trials progressed (Figure 2), however, only one other subject was selecting the correct rake significantly more by the last 20 trials (Kino; 15/20, binomial; n = 20, p = 0.041). Therefore, with the exception of one individual, the gibbons did not use their prior learning experience with the trap to reach solution, but appeared to be relearning the correct behaviour within these new parameters. Their tendency to choose both rakes equally in the first trials suggests that they do not have an innate understanding of the properties of a hole that make it effective at preventing goal attainment.

Summary

Gibbons can understand the relationships between a goal object, a tool-like object and a salient environmental feature that impedes retrieval of an out of reach food item. However, the cause and effects have to be learned through experience. They do not appear to understand the distinct properties of a trapping hole that makes it effective. Rather they employ a simple associative rule (pull the rake with no obvious impediment in its path) until they have had experience of its insignificance in food recovery. When ineffective (stripes), and effective (traps) ‘obstacles’ are presented concurrently, they do not readily adapt their previous knowledge, seemingly relearning the correct response required for reinforcement.
One individual, Maung (B. hoolock), was exceptionally attentive and the most proficient at all tasks, ostensibly comprehending the salience of the trap or stripe on the outcome of the task. This suggests that, although not displayed by all tested gibbons, understanding the properties of a trap and how it interacts with a goal object and an object to be manipulated may be within these species potential.

Acknowledgements

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References


Innovation and social learning in the hamadryas baboon (Papio hamadryas)
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Abstract

This study explored innovation and the existence of social learning in the hamadryas baboon (Papio hamadryas) troop at Paignton Zoo Environmental Park using a novel puzzle feeder. Extraction of food from the feeder required a new behaviour (“stick dipping”). It aimed to test two hypotheses: 1) innovation will be affected by age, sex and social network (i.e. harem member or lone individual); 2) Pairs of individuals with high levels of association will take a similar length of time to learn a new skill. Juveniles had more overall contact with the puzzle feeder. However, no evidence of social learning has been witnessed to date. This might be attributed to the social structure of the hamadryas baboon being ordered in such a way that it limits the chances of the social learning of a novel behaviour when the innovator is a lone juvenile male.

Keywords: Papio hamadryas, puzzle feeder, novel behaviour, social learning

Introduction

For the purposes of this study innovation will be defined as:

“The discovery of novel information, the creation of new behaviour patterns, or the performance of established behaviour patterns in a novel context” (Reader and Laland, 2001).

Social learning will be defined as:

“An instance in which the acquisition of behaviour is influenced by observation of or interaction with another animal or its products” (Heyes, 1994).

One of the first recorded incidences of innovation of a novel behaviour and the transmission of that behaviour through a social group via the process of social learning was the case of sweet-potato washing (SPW, the act of washing sweet-potatoes in the sea to remove sand), in Japanese macaques (Macaca fuscata) documented by Kawai (1965). In the SPW example and for a similar wheat washing (WW) behaviour the innovator was Imo, a juvenile female. Such reports sparked great interest into animal innovation and the factors, by which it is affected, of which age; sex and social rank are thought to play a critical role. In an extensive overview of the literature Reader and Laland (2001) reported contradicting findings to Kawai’s (1965) and indeed to their own prediction that in relation to foraging, more instances of innovation would be displayed by low-ranking, juvenile females. This prediction was based on the theory that such individuals have restricted access to major food provisions in comparison to larger or more dominant animals and therefore have greater motivation to source novel supplies. However, results showed significantly more instances of innovation in adult males rather than juvenile females. The authors suggest that innovation is perhaps less costly or more beneficial to males than females. Males are often larger than females and can therefore displace them during feeding competition; they may also have the physical strength that may be required to access novel foods. Furthermore their greater size may decrease their ability to access certain foods (e.g. by climbing trees) while at the same time it means that they require a larger amount of food, increasing their motivation to innovate. However, Reader and Laland are also wary of a bias in the data of more attention being paid to males and therefore more cases of male innovation being reported.
Animal social learning is a rapidly growing field and has developed into a very hot topic in recent years. As a result the definitions of exactly what constitutes social learning are as extensive as they are varied (Whiten (2000) offers a detailed overview of the numerous aspects of social learning). In captive situations imitation is often used as evidence for social learning. The artificial fruit experiment designed by Whiten et al (1996), which tests for imitation of a human demonstrator by primates, has been widely used. To date significant results have been reported for social learning in human children (Whiten et al, 1996) and the western lowland gorilla (Gorilla gorilla gorilla) (Stoinski et al, 2003). Furthermore, Voelkl and Huber (2000) reported imitation of a trained animal demonstrator in marmosets (Callithrix). Animals that watched a demonstrator open a film canister, containing a food reward, with their mouth also preceded to open it with their mouth, while those who witnessed a demonstrator using their hands consistently used their hands.

In field studies the emphasis for studies on social learning tends to be on behavioural variants between field sites. Whiten et al (1999) compiled data from 7 chimpanzee (Pan troglodytes) field sites. They found 39 different behavioural patterns including tool usage, grooming and courtship behaviours that were customary or habitual in some communities but absent in others. In all cases ecological explanations were discounted. In addition Panger et al (2002) investigated cross-site differences in the forging behaviour of the white-faced capuchin (Cebus capucinus). It was found that 20 out of the 61 food substances which were present at all field sites were processed or manipulated differently by at least one individual at one of the sites compared to another. Moreover, Panger et al (2002) were able to collect proximity scores for one of the study groups. This revealed that pairs of animals who exhibited the same food processing behaviours had higher proximity scores than animals with no recorded behaviours in common.

Some studies have tracked the transmission of a novel behaviour demonstrated by a juvenile innovator through a social group. In such instances the trend is for the behaviour to spread between juvenile associates and then to their adult female kin (Kawai, 1965; Perry et al., 2003).

Numerous factors have been proposed to affect social learning, amongst them age, dominance and social rank. In regard to the propagation of SPW and WW behaviour in Japanese macaques (Kawai, 1965) it was found that juveniles aged 1-2.5 years and 2-4 years respectively were the most competent at acquiring the behaviour. For example in relation to kinship it is the mother that would learn from the child, the older sibling that would learn from the younger. Acquisition of both behaviours was shown to be very poor in adults, especially in males over four. It has been suggested that the reason for this gender difference is the close social relationships that females maintain throughout their life (as they are the phylopatric sex in this species) whereas, males of this age tend to move to the more isolated periphery of the group or to transfer to new groups.

Dominance may affect the number of opportunities for social learning, by directly influencing access to apparatus (Fragaszy and Visalberghi, 1989). Moreover, it may mean that the expression of a behaviour that is present in an animals repertoire is suppressed when it is in the company of a more dominant individual (Tokida et al., 1994), possibly to avoid aggression. This has the additional result that the more dominant animal cannot observe the behaviour and cannot therefore learn it through social learning.

There is the possibility that the use of deception could impede social learning. An animal may deliberately inhibit a behaviour when other individuals, not necessarily of higher rank, are present, possibly to avoid drawing attention to a new food source. This deception would have the same effect on social learning as the suppression of a behaviour, as previously discussed. In an overview of the literature Byrne and Whiten (1992) found significantly higher levels of tactical deception in the papio genus than in a wide range of other primate species. However, the idea of deception or the suppression of a behaviour is only relevant when social learning is associated to some valuable or limited resource.
The hamadryas baboon can be found in the arid scrublands and deserts of Ethiopia, Sudan, Somalia and on the southern coasts of Arabia. They have a very varied diet including fruit, leaves, seeds, gum and insects. Furthermore, they are adept foragers and will dig up roots, bulbs and corms during the dry season. They are a sexually dimorphic species, with the males being much larger than the females and also possessing long grey mantles around their heads and shoulders. They also have one of the most complex social structures of the primate order. Unlike other sub-species of savannah baboon which predominantly have matriarchal societies of related females the hamadryas have a patriarchal society, with adult males forming the centre of a harem. Each harem also consists of 1-10 adult females. This number is usually at the lower end of the scale in the wild but increases in captivity. These females will only breed with their dominant males, with the exception of a few sneak matings. Juvenile males will leave the harem and become lone juveniles until they reach sexual maturity, at which time they will attempt to steal juvenile females from existing harems in order to form their own (Barrett, 2000). Males guard their females and ensure that they maintain a close proximity to them at all times. Kummer and Kurt (1963) recorded the distance each female hamadryas strayed from her dominant male in a field situation. The mean distance was found to be 0.65 ± 0.04m. One female was observed to stray to a distance of 5m but was physically attacked by the male immediately afterwards. In a continuation of this study it was revealed that infants’ playing with non-harem members were tolerated to a greater extent than adult females mixing with non-harem members. It is precisely this complex social structure that makes the hamadryas baboon such an exciting candidate for social learning experiments.

**Aim**

Broad definitions of innovation and social learning (see above) have been specifically selected for this study. Hamadryas baboons have been somewhat neglected in this area and so a preliminary investigation into the existence of social learning within the species was the primary purpose of this study, rather than examining the more detailed underlying mechanisms of the process.

The aim of this study was therefore to investigate the innovation and social learning of a novel behaviour in the hamadryas baboon.

**Hypotheses**

1) Innovation will be affected by age, sex and social status.

2) Pairs of individuals with high levels of association will take a similar length of time to learn a skill.

**Method**

**Subjects and housing**

The study animals were 24 individuals including 2 complete harems consisting of; 1 adult male, 3 adult females and 1 juvenile male; 1 adult male, 4 adult females, 1 juvenile male and 2 juvenile females and a further 11 juveniles; 7 males and 4 females. All 4 females were members of other harems while all 7 males were lone juveniles. The animals were housed with an additional 2 adult males, 11 adult females and 8 juveniles. Unfortunately due to time constraints these animals could not be included in the study.

The group were held in a large outdoor enclosure (approximately 35m x 15m), known as “Baboon Rock”. This was styled as a rocky mountain (13m high) and surrounded by a dry moat (3m deep). The baboons had access to “Baboon Rock” and an adjoining off-show indoor area (approximately 3m x 3m x 3m) throughout the day and night except between the hours of 8:15- 10:45am. During this time they were confined to the indoor and an additional outdoor off-show enclosure (approximately 6m x 10m) whilst the “Rock” was cleaned. The baboons were fed a small feed in the off-show area at 8.15am of soft fruits and seeds, their
main feed of vegetables and fruit on their return to the “Rock” at 10:45am and a further smaller feed of "Primate Pellet" and bread at 1.30pm.

Procedure

Two identical novel puzzle feeders were presented to the participants. The feeders were made out of sections of log into which four holes had been drilled. Two of these holes were connected to a central reservoir, which contained a food reward. The remaining two holes were dummy holes and offered no reward. Four steel “stick” tools were also attached to each feeder by wire cables, these tools fitted neatly into the holes. To successfully access the food reward subjects were required to select a “correct hole” and to demonstrate a novel “stick dipping” behaviour. A pear and apple fruit spread was used as the food reward.

The puzzle feeders were presented in the outdoor off-show enclosure; they were securely attached to the wire mesh at set positions within the enclosure, 6 m apart. This was done from 8:15-10:45am when the baboons were brought in for husbandry purposes and fed. As well as recording which subject was the first to interact with the feeders on each occasion instantaneous sampling was used to record the behaviour of the subjects observing or in contact with the puzzle feeders every 20 seconds. This was done for 2½ hours at a time, on 17 occasions over a 12 week period. Behaviours were coded using a pre-established ethogram (Fig. 1) and ranged from basic “contact” with the feeders to “successful manipulation”. “Successful manipulation” was considered to have occurred when an individual used a novel “stick dipping” behaviour to insert a tool into a hole which contained a food reward (“correct hole”) and then proceeded to eat the food reward. Observations were coded in relation to distance from the puzzle feeders namely, <0.5m, 0.5<1m and 1<1.5m. Interaction with the second feeder was recorded using a video camera and was coded in the same way immediately after each session.

<table>
<thead>
<tr>
<th>Behaviour Codes</th>
<th>Behaviour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contact</td>
<td>Touching apparatus (no innovative tool use)</td>
</tr>
<tr>
<td>Chew</td>
<td>Chewing the apparatus</td>
</tr>
<tr>
<td>Correct tool; incorrect hole</td>
<td>Use of a tool for &quot;stick dipping&quot; in an incorrect hole</td>
</tr>
<tr>
<td>Correct tool; correct hole</td>
<td>Use of a tool for &quot;stick dipping&quot; in a correct hole</td>
</tr>
<tr>
<td>Successful manipulation</td>
<td>Eating the food reward after using a tool for &quot;stick dipping&quot; in a correct hole</td>
</tr>
</tbody>
</table>

Figure. 1 Ethogram of analysed behaviours.

Index of Association

Throughout the same data collection period weekly index of association score were also taken, recording which participants were in 0.5m of each Individual participant, at ½ hour intervals on 8 occasions throughout 1 day.

Index of association = NAB/(NA+NB+NAB)

Where NAB is the number of occasions A and B are seen together; NA is the number of occasions A is seen without B; and NB is the number of occasions B is seen without A. All scores are distributed between 0 (no association) and 1.0 (complete association) (Martin and Bateson, 1994).

Data analysis

A Chi square test was conducted to examine the number of times the innovator selected the “correct hole” over the “incorrect hole”.

A Spearman’s rho correlation was carried out on the data relating to the number of times the innovator selected the “correct hole” and the session number (i.e. over time).
Linear regressions were run for each behaviour in the ethogram with age, sex and social network as independent variables. A further linear regression was performed, using the same independent variables, on the mean Index of Association score of each subject.

**Results**
Trends suggest that juvenile males made initial contact with the puzzle feeders on more occasions than any other age/gender group.

**Figure. 2:** Number of initial contacts with the puzzle feeder for each age/gender group (the number of animals in each group has been controlled for).
Furthermore linear regressions found there to be a significant difference in the total number of manipulations of the puzzle feeder per session when the independent variables were age, sex and social network ($R^2=0.369$; $F(3,23)=3.894; p<0.05$). Specifically there was a significant difference between adults and juveniles, with juveniles having more contact than adults ($t(3,23)=2.652; p<0.05$). There was no significant difference in relation to sex ($t(3,23)=-0.169; n.s.$) or social network ($t(3,23)=0.5; n.s.$).

![Figure 3: Mean number of total manipulations per session for adults and juveniles. (*p<0.05) (Mean ± standard error)](imageurl)
Juveniles were also shown to perform specific manipulations namely “contact” (R²=0.395; F(3,23)=4.347; p<0.05) and “chew” (R²=0.366; F(3,23)=3.844; p<0.005) more often per session than adults. However, sex (“contact” t(3,23)=0.334; n.s.) (“chew” t(3,23)=-0.719; n.s.) and social network (“contact” t(3,23)=0.281; n.s.) (“chew” t(3,23)=-0.934; n.s.) did not have a significant affect on either of these behaviours.

Figure. 4: Mean number of “contact” and “chew” manipulations per session for adults and juveniles. (*p<0.05) (Mean ± standard error)

After 5 sessions subject HJ, a 3 ½ yr-old lone male, demonstrated “successful manipulation” of the puzzle feeders. He continued to display this behaviour in all subsequent sessions. A chi squared test indicated that HJ selected the “correct hole” significantly more often than the “incorrect hole” throughout the data collection period (X²(1) = 64.93; p<0.001). Moreover, a Spearman’s Rho correlation revealed a significant positive correlation between the session number and the percentage of time that HJ selected the “correct hole” (rₛ = 0.657; p<0.05).
During the data collection period no other participants “successfully manipulated” the puzzle feeder.

A linear regression was used in order to analyse the mean Index of Association scores with age, sex and social network as independent variables ($R^2=0.37; F(3,23)=3.907; p<0.05$). It was found that adults had significantly higher mean Index of Association scores than juveniles ($t(3,23)=-2.108; p<0.05$). However, sex ($t(3,23)=-1.446; n.s.$) and social network ($t(3,23)=1.93; n.s.$) were not shown to have a significant effect.
An additional linear regression confirmed that lone juveniles spend significantly more time alone than individuals who are members of a harem ($R^2=0.44; F(3,23)=5.243; p<0.01$) ($t(3,23)=2.682; p<0.05$). Sex ($t(3,23)=0.291; n.s.$) and age ($t(3,23)=0.579; n.s.$) had no significant effect on time spent alone.

Figure 6: Mean Index of Association scores for adults and juveniles. (*p<0.05) (Mean ± standard error)
Discussion

Although results were insignificant trends suggest juvenile males have more initial contact with the puzzle feeder (Fig. 2), that juveniles are responsible for significantly more manipulations of the feeder per session than adults (Fig. 3) and that juveniles perform significantly more “contact” and “chew” manipulations per session than adults (Fig. 4). If a higher level of interaction with the puzzle feeder increased the likelihood of innovation then in this situation a juvenile male would be the most likely innovator. This was indeed the outcome. Subject HJ was a lone 3½ yr-old male. This finding is in contrast with that of Kawai (1965) who reported juvenile female innovators and with that of Reader and Laland (2001) who found more instances of innovation in adult males. However, when discussing this data it should be noted that the baboons were fed simultaneously to the puzzle feeders being presented. In a captive situation such as this the adult subjects, adult males in particular, have primary access to a plentiful amount of food, this may decrease their motivation to interact with the puzzle feeders. Indeed the lower number of incidences of initial contact and the significantly lower number of interactions with the feeders, combined with the fact that the more dominant adult subjects could easily have displaced juveniles to gain access to the feeders, would suggest that subjects to not contra freeload, that is work for food when there is simultaneously food freely available. The structure of the hamadryas society is such that lone juvenile males, with no harem to facilitate them in accessing food unlike juvenile females, may have the highest motivation for detecting novel food sources and would therefore be the most likely innovators. Supporting the old adage that “necessity is the mother of invention”.

Examining HJ’s manipulation of the puzzle feeders in more detail it can be seen that he selected “correct holes” over “incorrect holes” significantly more often than would be expected by chance. Indicating that he was able to distinguish which hole would provide a food reward and which would not. Moreover there is a significant positive correlation between the session number and the percentage of time that HJ selected the “correct hole” (Fig. 5). That is the more time HJ had to interact with the feeders the more competent he became at manipulating them.

As no other animal successfully manipulated the puzzle feeders during the data collection period the ability to test hypotheses 2 (Pairs of individuals with high levels of association will take a similar length of time to learn a skill) is severely compromised. Never-the-less, results do show that adults had significantly higher mean Index of Association scores than juveniles (Fig. 6) and perhaps unsurprisingly that lone juveniles spent significantly more time alone than individuals who are members of a harem. These findings are perhaps what one might expect when the social structure of the hamadryas baboon is taken into account. Kummer and Kurt (1963) found that in the wild adult females would only stray a mean distance of 0.65 ± 0.04m from their dominant male, those who strayed further suffered threats or attacks from the male. However, infants were given a freer rein and were aloud to mix and play with juveniles from other harems.

The difference in Index of Association scores due to the social structure of the hamadryas baboon may have had a definitive effect on why no evidence of social learning was observed. For social learning to occur others must first observe the behaviour being carried out by a demonstrator. HJ being a lone juvenile male, that is, an individual who spends significantly more time alone than those who are members of a harem and also an individual who has a lower mean Index of Association score than adults offers few opportunities for this. Furthermore past studies (Kawai, 1965 and Perry, 2003) documented that novel behaviours spread first amongst associated juveniles and then to their adult female kin. With juveniles having lower Index of Association scores than adults opportunities for social learning are again reduced. It would be extremely interesting to witness what effect a juvenile female innovator, who theoretically would have stronger links with female kin or harem members, would have on the social learning of a novel behaviour.

However, there are other factors that must be addressed to as to why no social learning was witnessed during this study. Firstly, as previously discussed, the lack of motivation to use the puzzle feeders due to the subjects receiving food simultaneously to the feeders being presented. Unfortunately this feeding is unavoidable, as without these provisions subjects
would be unlikely to enter the back holding area and furthermore levels of aggression surrounding the puzzle feeders would be expected to increase dramatically.

Baboons as a species are not well documented as being adept tool users. Whilst this may simply be because those studies are yet to be conducted it should be considered that perhaps the puzzle feeders were too much of a challenge to their dexterity to successfully manipulate, with one acceptance. This was difficult to avoid as the feeders had to be novel and offer a level of difficulty that would require innovation and learning rather than the food reward being accessible to all subjects from the outset.

It is also worth remembering that an animal may not necessarily display a behaviour even though it is present in their repertoire. As documented by Tokida (1994) an animal may suppress a behaviour when observed by a more dominant animal. In a similar vein the possibility of deception should also be considered. It would therefore be interesting to examine if HJ inhibits his demonstration of the "stick dipping" behaviour when he is being observed by other individuals. Whether it be suppressing it possibly to avoid aggression from a more dominant animal, or through deception to avoid others accessing the food reward. The later would require a high level of cognitive ability to be able to interpret another individual's point-of-view however, Byrne and Whiten (1992) did find significantly higher levels of tactical deception in the 

Finally it should be noted that in field studies the spread of a behaviour through social learning occurred remarkably slowly. For example in the case of SPW in the Japanese macaque (Kawai, 1965) it took 3 years for 11 subjects to demonstrate the behaviour. While this study was conducted in a captive rather than a field environment the comparative time that was available for data collection was considerably less. Further data collection would be required to clarify if time was a significant factor as to why no social learning was witnessed throughout the duration of the study.

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Novel Feeding and Hunting Enrichment for Large Captive Felids: The Lionrover and Responsive Hanging Prey.
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Abstract

As the feeding of live vertebrate prey to captive carnivores in the UK is neither ethical nor legal, over the years many attempts at providing realistic alternatives have been investigated. These alternatives range from simple feeding poles to more complex counterweight feeders, which aim to stimulate the physical exertion experienced in the capture and consumption of prey species. Whilst this research has proved to be successful, there are potential problems inherent in these devices that reduce the impact of this enrichment. Two projects where conducted at Blair Drummond Safari Park, Scotland, that sought to remedy these problems in providing feeding and hunting enrichment to large felids.

The first project utilised a purpose built remote controlled device dubbed the Lionrover, the movements of which could be fully controlled by the keepers in an attempt to provide captive carnivores with a continually unpredictable form of hunting enrichment. This pilot device was trialed with the park’s resident pride of 20 (5:15) African lions (Panthera leo). Whilst the device suffered several technical difficulties due to budget and design restrictions species typical behaviours were observed during the device presentations and significant increases in hunting behaviour, social rubbing, scanning and sniffing were reported between data collected on baseline and intermittent days. These results seem to suggest that this is a successful technique in achieving an increased expression of natural behaviours outwith the presentation of the device.

The second project was conducted with the same pride. Designed to resemble prey targets through height, texture, and in one instance appearance, two devices (one hessian (burlap) and one cow hide) known as the responsive hanging prey, were placed individually into the enclosures of the felids. Following the introduction of the devices, significant sex differences where observed in the amount of time females spent interacting with the device in relation to the males, and outwith presentations significant increases where found in social rubbing and social grooming.

Both of these projects seemed to be successful in increasing species typical behaviours both during and after the presentation of the enrichment devices supporting the claim that enrichment of this kind provides more than simple temporary effects. In addition the use of the enrichment allowed the public the chance to see these natural predatory behaviours first hand increasing the educational value of their visit to the park.

Introduction

The goals of enrichment are: ‘(1) increase behavioural diversity; (2) reduce the frequencies of abnormal behaviour; (3) increase the range or number of normal (i.e. wild) behaviour patterns; (4) increase positive utilisation of environment; (5) increase ability to cope with challenges in a more normal way.’ (Young 2003, p. 02). The second aim might be better worded as preventing the occurrence of these abnormal behaviours developing in the first place. This is a goal that is particularly important for carnivores as they are prone to developing stereotypies and once they develop they are difficult (if not impossible) to extinguish completely. This then is a form of proactive enhancement of welfare.

As the feeding of live vertebrate prey to captive carnivores has many obvious ethical issues for the prey animals involved, as well as being either illegal as is the case in the UK or publicly unacceptable (Ings et al, 1997), many researchers have attempted to provide realistic alternatives through the introduction of some ingenious enrichment devices.
Feeding poles are an example of such a device whereby meat is placed at the top of a tall vertical pole requiring the felid to climb the pole in order to retrieve the meat (Law, MacDonald and Reid, 1998). This type of enrichment is excellent in stimulating the physical exertion required in the capture and consumption of prey. However it may not be as appropriate for older animals, as one or two cases have occurred where animals have fallen from these devices and risked injury to themselves.

Counterweight feeders are a fantastic example of an enrichment device that aims to stimulate the hunting repertoire of captive carnivores. One device used by Williams et al (1996) employed a baited pulley system, which sent a rabbit carcass sailing across a cheetah (Acinonyx jubatus) enclosure promoting the high speed chasing behaviours of these carnivores. This device promoted positive natural behaviours both during and outside of device presentation. By its design, however, the device is always run along the same path and so there may be a potential risk of a rapid habituation to the predictability of this type of device.

Finally a device used by Markowitz, Aday and Gavazzi (1995) utilised a speaker system twinned with motion detectors in order to promote the entire hunting repertoire of a solitary African leopard (Panthera pardus). Vocalisations of prey species where played through the speakers, and the arrival of the leopard within a time limit would trigger the motion detectors which in turn triggered a speaker at another location. If the leopard followed the path of the vocalisations within the set time frame it would receive a food reward at the end. This device system seems perfect due to its adaptability and its potential for long term utilisation as the device was still being used successfully 16 months later. However it is unclear whether it is limited to enclosures housing solitary animals.

The aims of both studies reported here were therefore an attempt to provide solutions to these potential limitations in the form of two devices, dubbed the Lionrover, and the responsive hanging prey. Whilst the Lionrover attempts to mimic the stalk/chase/capture aspect of hunting the responsive hanging prey simulates the capture and struggle of the prey species resulting in the killing bite to the neck. In providing these forms of enrichment the aims of both studies where to promote species typical (and species appropriate) behaviours through providing realistic alternatives to live prey and to encourage positive social and predatory behaviours outwith device presentations.

Methods

Study animals

The same pride of (5:15) African lions (Panthera leo) were studied in each of the projects (see Table 1). All lions were parent-reared. All five of the males have undergone vasectomies. The lions were housed in a drive though enclosure (L215m by W118m) consisting of a grassy central reservation encircled by road, which was in turn surrounded by a further grassy area. The lions were surrounded on two sides by enclosures containing potential prey species including Grants zebra (Equus burchelli boehmi) and Lechwe antelope (Kobus leche kafuensis). A visitor area and walkway were situated on a third side, and on the fourth side was an enclosure containing Amur tigers (Panthera tigris altaica). A keeper’s jeep was present in the enclosure at all times when the lions were on exhibit and was employed to watch both visitors and lions. The jeep was used to patrol a borderline, which lay approximately 120m down the enclosure, which the lions were not permitted to cross and seemed to treat as an invisible territory line (MKJ, personal obs.). On rare occasions when extreme cases of aggression occurred (usually related to mating behaviour) the jeep broke these up. All of the lions were in general submissive to the jeep, suggesting it holds the dominant status within the group. Cars passing through the enclosure on the road were ignored.
Table 1. Details of the Blair Drummond Safari Park lion pride (ages in years at time of data collection).

<table>
<thead>
<tr>
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<th>Sex</th>
<th>Age</th>
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<tr>
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<td>M</td>
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</tr>
<tr>
<td>Mungo</td>
<td>M</td>
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</tr>
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<td>7</td>
</tr>
<tr>
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<td>5</td>
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<td>F</td>
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</tr>
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</tr>
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</tr>
<tr>
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<td>F</td>
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<tr>
<td>Teekay</td>
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</table>

Study 1

Apparatus

The Lionrover is essentially a remote controlled vehicle designed and built from scratch by Adam Gershel-Clarke of Brighton University. It weighed 15kg allowing it to be carried by a single person and the dimensions (L60cm by W49cm by H20cm) allowed it to fit underneath the keepers’ jeep should this have been required, for example if the device needed to be retrieved. A lightweight aluminium outer shell supported by an internal steel frame protects the internal mechanisms and allowed the lions to do cosmetic damage to the device without risking injury themselves. Two 18v drill motors, batteries, speed controls and gearboxes, powered the Lionrover, however due to the cheap nature of these parts they caused technical difficulties throughout the study. A Futaba Skyport6 remote control, kindly loaned to the research team by the University of Brighton controlled the Lionrover. The external shell of the KCD was painted white with black stripes to remove the unnatural effect of the shiny metal shell. The Lionrover had a potential top speed of around 15-20mph. However due to the technical difficulties with the motors it never reached this full potential. For more details about the design and for photos and video footage of both devices in use, please see [www.lionrover.co.uk](http://www.lionrover.co.uk).

Experimental design and procedure

Two types of data collection took place. The first was conducted during test trials using 1/0 focal object sampling with a thirty-second interval (Martin and Bateson, 1993). This was conducted in order to provide some measure of the range of behaviours displayed during device presentations. The device was used in conjunction with olfactory enrichment and initially 3 trial runs without data collection took place to assess the use of the device and the lions’ reaction to it under close supervision. Following these successful trial runs, data collection took place during three test trials. More presentations were originally scheduled however these were not possible due to technical difficulties. These began at the point at
which the device entered the enclosure and continued until the device was flipped over by one of the study animals. At this point it was necessary to remove the Lionrover from the study animals, as due to budget restrictions the tires, which were made of rubber, could not be adequately protected and therefore posed a choking hazard. The Lionrover was removed by driving the jeep to scatter the pride. As previously mentioned the lions are submissive to the jeep suggesting that it holds a dominant status within the pride, and so this action could be analogous to a dominant male removing a kill. The olfactory sack was left with the study animals however.

The second type of collection consisted of focal animal sampling using all occurrences and point sampling with an interval of thirty seconds (Martin and Bateson, 1993). This was separated into a baseline condition prior to the introduction of the device and an intermittent condition, which started after the first test trial and continued on and in-between device presentations. Data were collected for 120 minutes in the baseline, and 70 minutes in the intermittent days per focal animal. Intermittent data collection allowed the assessment of any behavioural changes that took place after the introduction of the device outwith presentation times.

Study 2

Apparatus

Two variations of the responsive hanging prey were used, both of which attempted to replicate an item of prey in height, texture and in one instance appearance, that could be ‘hunted’ and ‘killed’ by the subjects. A piece of either hessian (burlap, 1m x 1m) or cowhide (1m x 1m) was wrapped tightly around a calf’s leg and sewn up using binding twine. The calf’s leg was angled so that the anklebone faced the top of the device, mainly so that it resembled the neck of the prey when being attacked by the felid. A large metal chain (1 ½ m approx.) was threaded through the hessian/hide and ankle joint of the calf’s leg. In the lion condition the chain was simply attached to a strong branch of a tree by a deshackle where it was left to swing freely. The device was hung 1 ½ m off the ground, creating a height where all subjects must rise onto their hind legs in order to grip the device with their claws and teeth. The cowhide was fresh and was delivered from the local abattoir along with the subjects’ usual supply of food; hessian is widely available.

Experimental design and procedure

Two types of data collection took place. The first was conducted during test trials using one/zero focal object sampling with a thirty-second interval. This was conducted in order to assess any differences in natural behaviours between the two device types. This condition began upon the lions being let out of their overnight quarters and continued until the anklebone became detached from the chain.

The second type was collected in an ABA format with baseline, experimental and post experimental conditions. This consisted of focal animal sampling using all occurrences and point sampling with an interval of thirty seconds. Forty minutes of data were collected per focal animal in each condition. This again was conducted to assess whether any behavioural changes occurred after the introduction of the enrichment device and whether these changes diminished after its removal in the post experimental condition.

Results

Study 1.

Upon the Lionrover entering the enclosure the pride members usually stopped what they were doing and watched the device moving slowly at first. It was then usual for 2 to 5 lionesses to slowly stalk the device from several sides before the device would increase in speed stimulating a chase. The lionesses caught the device by surrounding it and placing their body weight upon it and biting at the shell effectively immobilising it. As was predicted species
typical behaviour was witnessed during most of the presentations of the Lionrover, as the females were generally the first to interact with the Lionrover, chasing and catching it like a prey species with the males moving in to investigate once it became immobile. The majority of the pride settled around the device displaying similar behaviours to those witnessed at communal kills. This continued until one of the lions flipped the device on its back at which point the jeep drove in to remove it.

Figure 1. Comparison of the number of 30-second intervals spent interacting with the Lionrover by sex and trial, in relation to the total time (in minutes) that the device was in the enclosure.

The second type of data collection was focal animal sampling. Changes in the study animals’ overall activity budgets between the baseline and intermittent days are displayed in Figure 2. Paired samples t-tests (2-tailed) using a significance level of <0.05 where used in the analysis of the behavioural states and events that were predicted would alter after the presentation of the Lionrover. Significant differences were found between the percentage of time spent scanning in the baseline and intermittent days (t (19) = -4.26, p = <0.001) as well as in the time spent watching conspecifics (t (19) = -3.70, p = 0.002).
Of the seven behavioural events that were analysed three significant differences were found. The rate per hour of hunting behaviour rose significantly between the baseline and the intermittent days ($t(19) = -2.21, p = 0.039$). There was also a significantly higher rate per hour of social rubbing in the intermittent days than in baseline ($t(19) = 2.41, p = 0.026$). The rate per hour of sniffing behaviour on the intermittent days was also higher than baseline ($t(19) = -2.84, p = 0.010$; Figure 3).
Study 2.

Figure 4. Comparison of the number of 30-second intervals spent interacting with device by sex and trial, in relation to the total time (in minutes) that the device was in the enclosure.

The level of interaction on the part of males and females during each of the test trials is shown in Figure 4. The bars represent the total time the device remained hanging from the chain with the mean number of thirty-second intervals spent interacting with the device by the study animals in hashed. The results show that the females spent significantly more time interacting with the device than males did in the hessian (t (14) = 5.909, p = 0.001) and hide (t (18) = 6.421, p = 0.001) conditions.
Figure 5. Comparisons of mean rates per hour of social behaviours during experimental hessian and hide conditions. Of these behaviours only chasing behaviour was found to be significantly higher in the hide condition than it was in the hessian condition (t (19) = -2.236, p = 0.038).

Figure 6. Comparison of the mean rates per hour of the social behaviours observed between baseline, experimental and post-experimental conditions. Figure 6 shows the comparisons in the social behaviours observed between the baseline, experimental and post experimental conditions. Repeated measures ANOVA’s revealed significant differences in both social rubbing (F (2,38) = 19.666, p = 0.001) and social grooming (F (2,38) = 8.90, p = 0.001) which decrease again post experimentally suggesting that these differences are short-term and a result of the enrichment. A significant difference in copulation was also found (F (2,38) = 3.41, p = 0.043).
Discussion

Both types of enrichment were successful in promoting species typical behaviours during device presentations, as well as encouraging positive behaviours outside of device presentations. This conforms to the findings of Williams et al (1995) that the effects of hunting enrichment are not simply immediate benefits.

The increases in the rate per hour of social rubbing in both studies, as well as in social grooming in the hanging prey study are important ones, in terms of increased species typical affiliative behaviours that may improve welfare. Schaller (1972) describes head rubbing and social grooming as the two most frequent behavioural patterns, which actively encourage social cohesion more than any other interactions between individuals. He suggests that head rubbing in particular, functions not only as a welcome after a period of separation and as a means of maintaining amicable relations, but also as a function of preserving social cohesion before embarking upon group efforts such as hunting (Schaller, 1972).

The increases in the predatory behaviours of hunting, scanning and sniffing found between baseline and intermittent days in the Lionrover study suggest that this form of enrichment may actively encourage these forms of positive natural behaviour. This may be particularly important as Schaller (1972) made the observation that whilst lions are not always hunting they are however always on the look out for a potential meal. These are however only preliminary findings and further work is required to confirm these results.

As the only significant difference in the behaviours observed between the hanging prey device conditions was in chasing behaviour it appears that the hessian and hide do not impact differentially on behaviour. The best enrichment schedule would therefore seem to be a continuation in the alternation of the device types for variety and to avoid habituation.

The significant sex difference observed in the hanging prey study, which is supported qualitatively from the Lionrover observations, is that these enrichments encourage captive lions to behave like their wild counterparts. These findings therefore support the idea that by studying the behaviour of captive animals, a greater store of information and understanding may be built up about their wild counterparts (Law et al, 1998). Finally as both types of enrichment were used during opening times they proved both engaging and educational to the public allowing them to witness these natural behaviours that they might not otherwise get an opportunity to see.

Returning to the goals of enrichment (Young, 2003) it is possible to say that there was an increase in the number of positive and natural behaviours such as predatory behaviours of hunting and scanning and the social behaviours of rubbing and grooming. No data were recorded on the utilisation of the captive environment, however there is scope for doing this in future projects. Similarly no data were collected on the ability to cope with challenges in a more normal way, however it is possible to speculate that through introducing new and novel objects into a captive animals environment this is achieved. Finally as no instances of abnormal behaviours were observed in either study, these behaviours could not decrease and it is only possible to speculate that these forms of enrichment aid in the prevention of such stereotypies developing.

A Lionrover MkII is now under construction implementing the information that has been acquired throughout this study. Design improvements will include the use of wheelchair parts in order to increase the reliability of internal mechanisms of the device, wooden wheels and improvements to the aerial design. This will mean that the device can be left in the enclosure until the study animals move to their overnight quarters without the need to remove it from them. Plans for future research use include testing its applications in a number of enclosure types with a range of carnivores, potentially both large and small. Use of the Lionrover is undoubtedly going to be restricted by the space and terrain present within the enclosure, with the large area within a safari park setting obviously allowing a greater freedom of movement than a more three-dimensional zoo enclosure. It is hoped that the changes in design made to
the MkII will allow a greater adaptability between enclosure types however, allowing it to be successfully utilised within both safari park and zoo type settings.

Young (2003) states that enrichment devices should be as simple as possible to run and maintain and that cost should be an important deciding factor in designing an enrichment device. Whilst this certainly seems to be true and whilst a much simpler device such as the responsive hanging prey might not have suffered the same problems, feeding enrichment for captive carnivores is a notoriously difficult challenge in animal welfare (Ings et al, 1997). Several authors have suggested that cost is too much of a restriction on enrichment techniques and that for such engineered techniques of enrichment the long-term benefits that might be provided should be considered an investment (Lindburg, 1988; McPhee, 2002).

The devices described above are at either end of the spectrum in terms of cost and simplicity and the hanging prey certainly seems more appealing in terms of price and simplicity, added to this is the fact that there is much greater scope for utilisation in a wider range of enclosure types. If a reliable model of the Lionrover can be built however it has the capacity to be continually dynamic in its presentation. Not only can it be used in conjunction with olfactory enrichment, but also it has the potential to be used with feeding and auditory enrichment or as a combination. By enabling the keepers to continually make the device unpredictable and by frequently coming up with new escape tactics in response to the captive carnivores' attempts to capture it, this device might remain a source of innovative enrichment as it is continually used in different and fresh ways.

For captive carnivores, which habituate quite quickly to one particular type of enrichment, techniques must be original and continually adapted to provide sustained positive results (Mellen, Hayes and Sheperdson, 1998). A combination of enrichment techniques ranging from the simple to the complex, which stimulate different behaviours and exercise different parts of a carnivore’s muscular system therefore seems appropriate in order to make up for a behavioural repertoire that carnivores may appear to have no use for in captivity.

Acknowledgments

We would both like to thank the staff and keepers at Blair Drummond Safari Park and in particular; Gary Gilmour, Brian Reid, Gordon Hill, John Correri, David Booth and Gavin Hughes. Thanks also to Graham Law for his useful comments on the both project designs.

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References


Sexual swelling cycles in the Sulawesi crested black macaque (Macaca nigra)
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Abstract
Females of many catarrhine primate species exhibit exaggerated swellings of the perineal skin at certain points of the oestrus cycle. Several hypotheses as to the physical and behavioural significance of sexual swellings have been proposed. Changes can be observed in the size, shape, turgidity and colour of these swellings over the course of the oestrous cycle and there are substantial inter-individual differences. This study aimed to quantify various characteristics of sexual swellings in a group of Macaca nigra housed at Paignton Zoo Environmental Park (1.5.1) over a five month study period, whilst simultaneously observing behaviour to test the following hypotheses:

1) Male mate choice is affected by sexual swelling characteristics, in particular maximally swollen females will receive the highest frequency of mating attempts and levels of affiliation from the adult male; and 2) female social status is affected by sexual swelling characteristics, in particular females, when maximally swollen, will receive the lowest levels of affiliation and highest levels of aggression from other females.

Three females cycled during the study period and the mean horizontal swelling length of the maximum swelling was 21.88±0.54cm. The maximum number of cycles achieved by an individual female was two, therefore relatively little data were suitable for statistical analysis. However, it was clear that there were intra- and inter- behavioural changes within the group, which will be discussed further. It appeared that females were in closer proximity to the male when maximally swollen (females spent a mean 16.88% time with the adult male when maximally swollen, compared to a mean 6.88% when flat. These data were not amenable to statistical analysis owing to too few data points; however, there are clear trends. This study established a sound methodology to quantify various characteristics of sexual swellings, suitable for use in a continuation of research at this zoo, and other EEP institutions housing M.nigra.

Keywords: Sexual swelling, Sulawesi crested back macaque

Introduction

Sexual swellings

Changes in the size, shape, turgidity and colour of female sexual (perineal) skin over the course of the oestrous cycle can be observed in many catarrhine primates, including the Sulawesi crested macaque, Macaca nigra. In this study, sexual skin that is maximally swollen, increasing, or decreasing in size will be defined as ‘sexual swelling’, and at other times it will be referred to as ‘sexual skin’. It has been well documented that sexual swellings reach maximum size around the time of ovulation (Gillman and Gilbert 1946; Graham 1981), and size is hormonally controlled (Thomson et al. 1992; Bettinger 1997; Reichert et al. 2002).

Functional significance

The functional significance of sexual swellings has been the subject of much discussion. The Reliable Indicator hypothesis (Pagel 1994) suggests that sexual swellings are a reliable indicator of differences in female reproductive quality, thus predicts most fertile females exhibit the largest swellings. In support of this prediction, maximally tumescent females have been found to receive the most male mating interest (Dixson 1983; Reichert et al. 2002). However, several studies have demonstrated that sexual swellings may occur in least fertile females, for example females that never conceive (Rowell 1970), are gestating (Wallis 1982), or lactating (Zinner and Deschner 2000).
Research aims and hypotheses

The current study aimed to establish a suitable methodology for the quantification of sexual swellings in *M. nigra* housed at Paignton Zoo, whilst simultaneously studying their behavioural significance within the social group. Literature reviewed prior to the study highlighted two main points 1) there is a lack of behavioural research regarding the role of sexual swellings in inter- female social behaviour; and 2) there is a lack of suitable standardised methodology to accurately quantify sexual swelling characteristics over time. In addition, large variation in sexual swelling patterns in *M. nigra* has been noted between EEP institutions (Vicky Melfi, pers. comment).

**Aim 1.** To reliably quantify sexual swelling characteristics, and describe their variability within and between females over the oestrus cycle. This will lead to the establishment of standardised methodology for application at other EEP institutions.

**Aim 2.** To study behavioural changes within the group in relation to changes in sexual swelling characteristics.

Hypothesis 1. Male mate choice is affected by sexual swelling characteristics; in particular maximally swollen females will receive the highest frequency of mating attempts and levels of affiliation from the adult male.

Hypothesis 2. Female social status is affected by sexual swelling characteristics, in particular females, when maximally swollen, will receive the lowest levels of affiliation and highest levels of aggression from other females.

Methods and materials

**Data collection and test subjects**

Data were collected from December 2004 to April 2005. The group consisted of five adult females; three of which exhibited oestrus cycling, one was sterilised, and one was pregnant. The group also consisted of one adult male, one juvenile male, and one infant.

**Quantification of sexual skin/swelling**

Quantification of sexual skin/swelling occurred on a daily basis where possible. Non-invasive methods of quantification were chosen because daily capture of females was impractical. The horizontal length, vertical height, and outward thickness of sexual skin/swelling were estimated using photographic capture, using an object in the same shot of known dimension and depth to allow scaling. To facilitate this procedure, a wooden climbing structure with marked scale bars was erected in the enclosure, so that photographic capture could occur *ad hoc* when a female used the structure. If an animal backed-up towards an enclosure window, an acetate grid was used to measure the dimensions of the sexual skin/swelling.

Sexual skin/swelling was scored on a scale of 1-3:
1. Flat, pale perineal skin, wrinkles may be apparent
2. Sexual swelling increasing or decreasing in size
3. Maximally swollen, shiny, brightly coloured with few or no wrinkles

The colour of sexual skin/swelling was coded against paint sample colour cards, which were later standardized. The overall condition of the sexual swelling was also noted, although data will not be presented in this paper.
**Behavioural observations**

Data were collected in eight observation blocks, each block lasting five days with a seven-day gap between each block. Behavioural observations recorded social behaviour and proximity between individuals (table 1). Daily, each female was sampled using the focal follow method (Martin and Bateson 2001) for 20 min am between 0900 and 1200 hrs, and 20 min pm between the hours of 1300 and 1600 hrs. Each female was sampled once during am and once during pm, in random order.

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Sampling method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broad state behaviours</td>
<td>Instantaneous sampling at 1 min intervals</td>
</tr>
<tr>
<td>(social, resting, locomotion,</td>
<td></td>
</tr>
<tr>
<td>foraging/feeding, out of sight,</td>
<td></td>
</tr>
<tr>
<td>other)</td>
<td></td>
</tr>
<tr>
<td>Mating</td>
<td>Frequency and success of copulation. All occurrence</td>
</tr>
<tr>
<td></td>
<td>sampling at 1 min intervals</td>
</tr>
<tr>
<td>Grooming and aggression</td>
<td>Initiator, receiver or mutual. One-zero sampling at 1</td>
</tr>
<tr>
<td></td>
<td>min intervals</td>
</tr>
<tr>
<td>Nearest neighbour</td>
<td>First male and female nearest neighbour.</td>
</tr>
<tr>
<td></td>
<td>Instantaneous sampling at 1 min intervals</td>
</tr>
<tr>
<td>Self-directed behaviour</td>
<td>Hair plucking, scratching, other behaviours observed.</td>
</tr>
<tr>
<td></td>
<td>All occurrence sampling</td>
</tr>
</tbody>
</table>

*Table 1. Behavioural observations*

**Calculation of dominance hierarchies**

**Method 1.**

Dominance hierarchies and their strengths were calculated using the method of presenting the proportion of aggressive dyadic interactions won by both cycling and non-cycling females in a matrix (Singh et al. 1992, 2003). One matrix was produced using data from each of the following: 1. The total number of days where all females were flat (eleven days); and 2. The total number of days when a) female A, b) female H, and c) female S were maximally swollen (these were the three cycling females in the study). This produced four dominance matrices for comparison.

The calculation for the strength of a hierarchy $h$:

$$h = [12/(n^3-n)] \sum_{a=1}^{n} [d_a - (n - 1)/2]^2$$

where $d_a = \sum_{a=1}^{n} P_a$

A $h$ value of 1 represents perfect linearity; the strongest possible hierarchy. Each dominance score ($d_a$) was converted to produce an interval scale to rank the dominance of individuals. In addition, dominance hierarchies were calculated using three other methods in order to ascertain if conflicting hierarchies would be achieved depending on the method used.
Method 2.
The dominance index, $X$ (Pardi 1948)

$$X = \frac{\text{number of aggressive dyadic interactions won}}{\sum \text{number of aggressive dyadic interactions}}$$

An $X$ value of 1 means that an individual won all dyadic interactions, an $X$ value of 0 means that all dyadic interactions were lost.

Method 3.
The dominant-subordinate matrix (Martin and Bateson 2001). An individual is ranked in terms of the number of different individuals defeated in dyadic aggressive interactions.

Method 4.
A modified version of the dominant-subordinate matrix (Martin and Bateson 2001). An individual is ranked in terms of the total number of aggressive dyadic interactions won.

Results
Sexual swelling cycling
Three females cycled during the study period: female A, female H and female S (fig.1). The mean maximum horizontal swelling length was 21.88 ±1 SE 0.54cm. Female A had the largest maximum horizontal swelling length of 23.4 cm.

Female A cycled once during the study, and resumed cycling approximately one week after data collection was completed. It is not known if female A was pregnant during her non-cycling period. Female H and female S both cycled twice, and their first and second cycles overlapped by seven and nine days respectively. The length between the onset of the first cycle to the onset of the second cycle was 41 days for Female H, and 46 days for female S. The length between the onset of swelling to the onset of flatness for female A was considerably longer (35 days) than that of Female H and S (female H: 24 days cycle one, 21 days cycle two; female S: 21 days cycle one, 17 days cycle two).

Only one female was maximally swollen at any one time, and the cycles of Female H and Female S appeared to be closely synchronised; as Female S began to increase in swelling size as Female H began to decrease in swelling size. This trend is observed in both the first and second cycles.
Figure 1. Sexual skin/swelling scores of three cycling female *Macaca nigra*

**Key:** Female A, Female H, Female S

**Broad state behaviours**

Figures 2 to 5 show changes in social, resting, locomotory and feeding behaviour with sexual skin/swelling score, abbreviated to ‘flat’ (flat sexual skin, scored 1), ‘inc’ (increasing sexual swelling, scored 2), ‘max’ (maximally swollen sexual swelling, scored 3), and ‘dec’ (decreasing sexual swelling, scored 2).

There was a general overall increase in social behaviour when maximally swollen compared to when sexual skin was flat (Fig. 2, female A increase 5.1%, female H increase 36.3%, female S increase 9.2%). All females showed an increase in resting behaviour with decreasing sexual swelling size, compared to when sexual skin was flat (Fig. 3, female A increase 13.4%, female H increase 27.7%, female S increase 3.6%). When maximally swollen, locomotion for female H was a minimum of zero, whilst locomotion for female S was a maximum 18.8% (Fig. 4). Feeding and foraging were lowest when females were maximally swollen, and generally maximum with increasing sexual swelling size (Fig. 5)
Key: female A, female H, female S

Proximity and affiliation
The daily percentage of time the adult male was the nearest neighbour, and how much of this time was spent resting and being social, was superimposed onto the daily sexual skin/swelling graph for comparison (fig.6). In the same manner, the daily percentage of time a female was the nearest neighbour, and how much of this time was spent resting and being social was superimposed (fig.7). Only data for female H is shown. Due to data being suitable for trend analysis only, no axes are given for these trendlines.

Figure 6. Female H daily sexual swelling/skin score and trendlines to show percentage

Key: Daily percentage of total time spent with adult male nearest neighbour
Daily percentage time spent resting with adult male nearest neighbour
Daily percentage time spent socialising with adult male nearest neighbour
Resting, socialising and total time spent with the adult male nearest neighbour peaked at times of maximum swelling, and were lowest when sexual skin was flat (fig.6). The highest percentage of time spent with the male when maximally swollen was 72.5% and levels of social behaviour were consistently low throughout the cycle, peaking at 4%. It appeared that females were in closer proximity to the male when maximally swollen (females spent a mean 16.88% time with the adult male when maximally swollen, compared to a mean 6.88% when flat).

Resting, being social, and total time spent with female nearest neighbours peaked when the sexual skin was flat (fig.7). The highest proportion of time spent with females when the sexual skin was flat was 57.5%. Socialising with females was consistently low throughout the study. Grooming initiated by the adult male did not appear to show a trend with swelling condition. Grooming initiated by other females peaked when the swelling was flat. These data are not shown.

Figure 7. Female H daily sexual swelling/skin score and trendlines to show percentage time female was the nearest neighbour.

Key:
Daily percentage of total time spent with female nearest neighbour
Daily percentage time spent resting with female nearest neighbour
Daily percentage time spent socialising with female nearest neighbour

Aggression and dominance

When all females had flat sexual skin, the three females that cycled during the study occupied the lowest ranking three positions in the dominance hierarchy (table 2). This hierarchy was also the weakest. Female H was higher in dominance rank when maximally swollen, compared to when sexual skin was flat. In contrast, dominance ranks of female A and S were lower when maximally swollen, compared to when sexual skin was flat. Plotting the daily percentage of aggression initiated and received from the adult male and females demonstrated that cycling females received most aggression when maximally swollen. The data is not presented in the current study, as it only shows trends and was not analysed. The strongest (most linear) hierarchy obtained was when female S when maximally swollen.
Maximally swollen female | Hierarchy rank and strength (h) | Effect on female dominance
---|---|---
(All females flat) | I,W,S,A,H | h=0.401 |
Female H | A,I,W,H,S | h=0.704 | H ↑ dominance |
Female A | W,I,H,S,A | h=0.551 | A ↓ dominance |
Female S | W,H,I,A,S | h=0.732 | S ↓ dominance |

Table 2. Overview of dominance calculations using method 1. Female I was sterilised and female W was pregnant during the study.

Results from the three alternate methods of calculating dominance hierarchies are summarised below (table 3). All methods agreed with dominance shifts calculated by the methods of Singh et al. (1992, 2003). The 3 cycling females always occupied the three lowest ranking positions of the hierarchy when flat.

<table>
<thead>
<tr>
<th>Dominance method</th>
<th>Maximally swollen female</th>
<th>Hierarchy rank</th>
<th>Effect on female dominance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method 2. Dominance index</td>
<td>(All females flat)</td>
<td>I,W,A/S,H</td>
<td>-</td>
</tr>
<tr>
<td>Female H</td>
<td>I/A,W,H,S</td>
<td>H ↑ dominance</td>
<td></td>
</tr>
<tr>
<td>Female A</td>
<td>W,S,H,I,A</td>
<td>A ↓ dominance</td>
<td></td>
</tr>
<tr>
<td>Female S</td>
<td>I,H,W,A,S</td>
<td>S ↓ dominance</td>
<td></td>
</tr>
<tr>
<td>Method 3. No. different animals defeated</td>
<td>(All females flat)</td>
<td>I,W,S,H,A</td>
<td>-</td>
</tr>
<tr>
<td>Female H</td>
<td>A,W,H,I,S</td>
<td>H ↑ dominance</td>
<td></td>
</tr>
<tr>
<td>Female A</td>
<td>I,H,W,S,A</td>
<td>A ↓ dominance</td>
<td></td>
</tr>
<tr>
<td>Female S</td>
<td>W,H,I,A,S</td>
<td>S ↓ dominance</td>
<td></td>
</tr>
<tr>
<td>Method 4. No. aggressive interactions won</td>
<td>(All females flat)</td>
<td>I,W,A,S,H</td>
<td>-</td>
</tr>
<tr>
<td>Female H</td>
<td>W,I,H/A,S</td>
<td>H ↑ dominance</td>
<td></td>
</tr>
<tr>
<td>Female A</td>
<td>I,S,H,W,A</td>
<td>A ↓ dominance</td>
<td></td>
</tr>
<tr>
<td>Female S</td>
<td>W,H,I,A,S</td>
<td>S ↓ dominance</td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Overview of dominance calculations using methods 2-4. A/S means that Female A and Female S were of equal rank

Conclusion

Sexual swelling characteristics and cycling

The mean maximum horizontal swelling length of 21.88cm obtained from the three cycling females is larger than the mean maximum horizontal swelling length reported in a previous study of captive M.nigra swelling characteristics and cycling (Dixson 1977), 16.42cm (n=three females, each cycling twice). The current study had the disadvantage of a relatively small sample size and number of cycles. The mean cycle length in the current study was 43.5 days (n=three females, distance between two consecutive cycles measured) However, Dixson reported a mean cycle length of 33.5 days (n=two females, each cycling twice) and Thomson et al. reported a mean cycle length of 39.8 days (n=five females, each cycling twice) in captive M.nigra.
The duration of maximum sexual swelling appeared to be one day, and only one female was maximally swollen at any one time. This is not comparable to previous studies in M.nigra due to a lack of previous data.

**Male-female behaviour**

It was hypothesised that male mate choice is affected by sexual swelling characteristics, and that maximally swollen females will receive the highest frequency of mating attempts and affiliation from the adult male. Only four mating attempts were observed throughout the study, therefore, not enough data were available to test this aspect of the hypothesis. When a female was maximally swollen, the total time, time resting and being social was spent with the adult male nearest neighbour was greater compared to when the sexual skin was flat. It is also interesting to note from the broad state behaviour graphs (fig. 2-5) across sexual skin/swelling score, that social behaviour was generally higher when a female was maximally swollen compared to when the sexual skin was flat. This appears to lend support to the reliable indicator hypothesis (Pagel 1994), which states that a female should exhibit a maximally swollen sexual swelling at times of maximum fertility, and therefore receive the most adult male attention. However, low levels of social behaviour with the adult male nearest neighbour, in comparison to time spent resting, were surprising. The data can only reveal trends at this stage owing to too few data points. As behaviour was categorized into broad states only, the ‘social’ behavioural state includes being engaged in both affiliative (ie. grooming) and aggressive behaviours. As frequencies of affiliative and aggressive events have not been analysed, it cannot be concluded from the current study whether an increase in social behaviour when maximally swollen was a result on increased levels of affiliation, and/or aggression. Individual differences between females were highlighted by differences in broad state behaviours across sexual skin/swelling score, and suggest that behavioural changes over time may be affected by other factors as well as sexual skin/swelling score, such as age, health, and previous reproductive success.

An increase in resting behaviour when sexual swelling size was decreasing may have been due to a carry-over effect of high levels of locomotion when maximally swollen (except in the case of female H), as supported by Matsumoto-Oda and Oda (1998), who stated that locomotion in female chimpanzees (Pan troglodytes) was highest at times of maximum swelling. Decreased levels of foraging and feeding were most likely to be due to increases in locomotion and social behaviour.

**Female-female behaviour**

It was hypothesised that female social status is affected by sexual swelling characteristics, and when maximally swollen, a female will receive the lowest levels of affiliation from other females. In support of this hypothesis, the proportion of time that the nearest neighbour of female H was female was lowest when maximally swollen. This finding is supported by the study of Aujard et al. (1998), where female-female proximity and grooming was lowest at times of maximum swelling in Tonkean macaques (Macaca tonkeana). As behaviour was categorized into broad states only, it is hard to determine if females were being more or less affiliative or aggressive with changes in overall social behaviour.

Dominance hierarchy data demonstrates that the cycling females appeared to occupy the lowest dominance positions, and for female A and S their dominance decreased when maximally swollen. However, female H increased in dominance when maximally swollen, which once again highlights the existence of individual differences between females. Only small shifts by one rank position indicate that sexual swelling characteristics may not have a large effect on dominance. By achieving the same results by using four different methods of calculating dominance hierarchy, these dominance shifts are further validated. Dominance rank is likely to be affected by several factors including reproductive status, health and age.
**Evaluation**

The current study has successfully established a standardized methodology. It is anticipated that this will form the basis of a longer-term study of sexual swelling cycles in *M. nigra* at Paignton Zoo, and at other EEP institutions. Anecdotal evidence suggests that females at the same zoo may have swelling characteristics more similar to each other than those at different zoos, which would make interesting comparison. Data collected over a relatively short time scale, considering that cycle lengths appear to be in the range of 41-46 days for this group, did not allow statistical analysis. It is anticipated to collect more data from more cycles to increase the data set.

**Acknowledgements**

We would like to acknowledge both the Science Department, and the Mammal Department at Paignton Zoo.

**References**


Is conservation a waste of time? Evaluating the impact of conservation projects
Olivia Walter, Durrell Institute of Conservation Biology, University of Kent

This project comes from work done by a group of zoo professionals and interested academics to evaluate zoo’s contribution to conservation (Mace et al., in press). The group devised a questionnaire, a part of which looked at the impact conservation projects that zoos supported or ran had on the target audience (species, habitat, people). It is this part of the questionnaire that is being tested.

So for example, take these Asian cheetah – or rather Iranian as they are the only place outside Africa that they exist. WCS and Iranian Wildlife Service have mapped the range and looked at the density of prey. They are using this data to ensure protection in areas where the range and protected areas are overlapping, to mitigate human/animal conflict and start some community based projects with the overall aim of conserving cheetah and their prey. The question we are asking here is have these activities had any effect on the population numbers of the cheetahs and their prey (the project goals).

To begin a process of evaluation, we have to decide what we mean by ‘evaluation’, and then what it is that we are evaluating. Evaluation has become a buzz word and I am not sure everyone is using it for the same meaning.

For effective conservation, decision makers need to make decisions on what actions to take based on what works and what does not work. Pullin et al. (2004) asked 141 managers of British natural habitats on what they based management decisions. They found practitioners tended to rely on their own experience and those of their colleagues. These experience-based decisions relied heavily on traditional land management practices (Saterson et al. 2004). Little research was carried out to find out whether these practices the right effect.

The same research also looked at the reality of managers looking for the information when faced with day-to-day pressures and insufficient time and concluded that the little information that was available on the impact of various management was difficult to find. The few long term monitoring projects are not written up in papers accessible to managers nor in a format whereby managers can use the information quickly (Fazey et al. 2005). Most evaluation tends to be retained within managers heads and subject to bias, peer pressure and is not systematically carried out. Sacket et al. (2000) emphasises the need for concise reviews as it is impossible for practitioners to read all articles that might be relevant and come up with reliable conclusions while Fazey et al. (2004) points out that reviews are highly valued in the publications. They go on to point out that it is not clear how research may be useful to managers and practitioners and suggests mainstream conservation biology journals include a short section in the abstract and discussion on the relevance to management and policy as is seen in the British Medical Journal and has been demonstrated to be effective in the Journal of Applied Ecology (Ormerod et al. 2002). Groups such as the IUCN/SSC Invasive Species Specialist Group (www.issg.org/database/welcome/) and the Centre for Evidence Based Conservation (www.cebc.bham.ac.uk) are addressing this situation by building online databases for practitioners to put their experiences.

Approaches to conservation processes tend to be either static, in terms of traditional management methods or go through fashions. Claims that past approaches (e.g. community based conservation) don’t work and that new approaches (like direct payments) are the only way forward are a matter of experienced-based opinions. We can not actually say that one method is better than the other because neither approach has been fully evaluated (Saterson et al. 2004).

It is very rare to find detailed evaluation of conservation projects across the board (Kleimen et al. 2000) and current methods biology tend to be focused within a process, for example integrated conservation and development programmes (Wells et al. ????), protected area management (e.g. Hockings 2003) and reintroductions (XXX). But no evaluation to date has compared one process with another. Therefore Mace et al. (in press) evaluated projects
against a definition of ‘conservation’. “Actions that directly enhance the persistence of wild habitats and wild species” immediately puts the focus on conservation in the wild. It has been formulated in such a way as to define IMPACT rather than input or output as is common in other evaluative methods (c.f. Darwin Initiative). It is difficult to define and measure but holds much more weight and means that we can compare across projects of different foci.

The following questions are then asked: Do our actions or conservation ‘effort’ have an impact on the target biodiversity? Does this impact actually lead to enhancing the persistence of biodiversity in the wild? For example, a project jointly run by WCS and I.R of Iran Department of Environment to secure the remnant population of Asiatic cheetah in Iran and their prey set up a camera trap programme to determine the population of cheetah and other animals in the national parks and research to determine the threats while other organisations ran community programmes to reduce the conflict between the herders, their livestock, cheetah prey and water sources (www.wcs.org/international/asia/asiaticcheetah.org). This evaluation process would therefore ask whether these activities had succeeded in reducing the decline in, maintaining or increasing the cheetah and prey populations.

The holy grail

Given that in depth research is a luxury that conservation can not afford neither in terms of finance nor time, an ideal method that:

- Evaluates projects of any size, shape or form
- Produces data from across organisations that is comparable
- Is quick and easy to use by anyone
- Uses information that is available
- Can be used at any time in the project cycle to benchmark the project and to adapt management accordingly
- Allows benchmarks and targets to be determined
- Encourages best practice

By formulating a method to effectively evaluate conservation projects and comparing across project types, objective decisions could then be made as to where to put the limited funds available for conservation.

Testing a holy grail

In order to test Mace et al.’s method, data was collected on projects using a standardised data collection sheet. Data was collected from published papers, information on organisation’s websites and fact sheets, project reports and from the ‘project leaders’. More often than not, data was accumulated from a mixture of these sources. The ‘project leader’ is someone who knows the project well, but is not necessarily the ‘leader’ as such.

The project data was then scored by the project leaders and by five other conservation biologists who do not know the project in hand. This data was used to test whether the method is robust between scorers, irrespective of whether they know the project well or not.

To score the project, the focus of the project or focus of the different project components had to be determined. Taking in to consideration that conservation projects have a number of different dimensions from zoo to wild, from initiation to completion, from indirect to direct actions, from large to small, with different foci, in different countries, projects (or components) were defined as the following for the purposes of this evaluation exercise:
Table 1: Project description

<table>
<thead>
<tr>
<th>Project foci</th>
<th>Foci description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training</td>
<td>Enhancing the capacity of people who are in a position to change legislation or behaviour</td>
</tr>
<tr>
<td>Research</td>
<td>Undertaking research and monitoring related to species and habitats</td>
</tr>
<tr>
<td>Species/Taxa</td>
<td>Undertaking direct action to enhance species viability and persistence</td>
</tr>
<tr>
<td>Habitat</td>
<td>Undertaking direct action to enhance habitat quality, viability and persistence</td>
</tr>
<tr>
<td>Education</td>
<td>Enhancing public education and awareness; changing attitudes</td>
</tr>
</tbody>
</table>

Each project foci was given an IMPACT score where:

\[
\text{IMPACT} = \text{Importance} \times \text{Volume} \times \text{Effect}.
\]

Where **Importance** is how significant or influential the target (people, taxa, habitat, policy) are for conservation, **Volume** is how many of the target (people, taxa, habitat, policy) that were addressed by the project and **Effect** is how the project affects the conservation outcome. See Table 2 of the scoring system for Taxa as an example of the scoring system.

These scores were converted to numbers using a simple weighting system where A=1, B=2, C=3, D=4, E=5 and N=1. N being awarded to projects where it was too early to tell the effect.

Where projects had more than one component of different foci, each foci was scored and the scores proportionally represented in relation to the proportion of effort spent on each focus. These were added up to give a single final score or a measurable index of success (see Table 3 for an example).

Table 2: Scoring for Taxa

<table>
<thead>
<tr>
<th>Importance</th>
<th>Volume</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endangerment of the target*: A: not threatened B: nationally/regionally threatened (e.g. UK or EU) C: Lower risk (NT, DD) D: Globally extinct in the wild, critical, endangered or vulnerable (EW, CR, EN or VU)</td>
<td>The proportion of the global population targeted by the project: A: 0-1% B: 2-10% C: 11-50% D: 50%+</td>
<td>Effect of the project on the status of the species in the wild compared with not activity/project in the area of project focus: A: no discernible effect B: marginal improvements C: Improvement/stable D: substantial improvement/increase in numbers N: in it’s first phase</td>
</tr>
</tbody>
</table>


Table 3: Component scores

<table>
<thead>
<tr>
<th>Component focus</th>
<th>% effort</th>
<th>Component score</th>
<th>Proportional score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taxa</td>
<td>60%</td>
<td>60</td>
<td>35</td>
</tr>
<tr>
<td>Habitat</td>
<td>20%</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Training</td>
<td>20%</td>
<td>80</td>
<td>16</td>
</tr>
</tbody>
</table>

Total score = 57

From these scores the following hypotheses will be tested:

1) There is no bias between assessors scores
2) There is no bias between assessors score and those of the project leader
3) Scores are comparable between projects of different sizes and foci
4) Project size, foci and geography have not baring on the score
5) Type of organisation (i.e. Zoo based or non-zoo based) has no bearing on the success of a project
6) Type of organisation has not baring on the focus of the project

**Summary Statistics**

Table 4: Summary statistics for Impact scores of project leaders and the total cost of the project

<table>
<thead>
<tr>
<th></th>
<th>Impact score</th>
<th>Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>4</td>
<td>3,077</td>
</tr>
<tr>
<td>Maximum</td>
<td>67</td>
<td>12,000,000</td>
</tr>
<tr>
<td>Mean</td>
<td>35.75</td>
<td>1,488,120</td>
</tr>
<tr>
<td>St deviation</td>
<td>19.12</td>
<td>3,136,198</td>
</tr>
<tr>
<td>Median</td>
<td>36.4</td>
<td>159,649</td>
</tr>
</tbody>
</table>

For 33 projects that were analysed, Impact scores ranged from four to 67, with one being the lowest possible score and 80 the highest. The variety of projects analysed is demonstrated by the range in the cost; from three thousand to twelve million dollars. Although the mean cost is $1.5 million, most projects are around the $150,000 mark.

In order to determine whether there was a relationship between the cost and Impact score, a regression was carried out on the data (see Figure 1). In order to make the data normally distributed and therefore the relationship linear, the cost data was logged (log10).

![Figure 1: linear regression of Impact score and cost.](image)

The linear regression shows a very slight but significant relationship between cost and Impact score; the bigger the project budget, the more likely it is that the project is going to work. However, the cost of the project has not been adjusted for local economics nor for the effect of governance (see O-Connor *et al.*, 2003 and Smith & Walpole 2005). Adjusting for these variables may bring about a different result.
Summary of findings

1. Can conservation projects be scored? I have managed to score 66 projects from different organisations, of different types, of different ideas. However, whether this scoring truly reflects the project needs to be investigated further.

2. How consistent were scores between scorers irrespective of their previous knowledge? To date, not enough data has been collected so this answer can not be tested. Mace et al. (in press) shows the results from a pilot study where scores were significantly significant over four independent scorers and the project leader. However, there was indications that this relationship was a bit more complicated.

3. What do the Impact scores tell us about ‘successful’ and ‘less successful’ projects? From data presented here, an even spread of impact scores has shown a significant relationship with project cost although the cost has not been adjusted for how much it costs to run a project in the various countries. The data must be looked at more closely to see if the projects with low or high impact scores have anything in common or correlate with any other variables.

Comments on the method

- The depth of data given for each project is different depending on the time and care project leaders took to fill in the datasheets or how in-depth project reports were. The fact that the project leaders varied in their knowledge of the project. They varied from the people who actually ran the project on a day to day basis to programme managers who in some cases acted more like sponsors.

- Much of the evaluation of effect was subjective. Often the data was the gut feeling from project leaders rather than proven study. Independent scorers would then decide whether the project had an effect, and if it did, how large was this effect. This again was subjective.

- Volume scores were often best guesses, particularly for proportion of species the project targets

- Dividing project effort between the project components may have been done on different basis for each project. For example most practitioners used time or man-hours spent on each component, others used project budget.

- The method appears to be biased towards big is better; the more endangered the taxa/habitat or important the people and the more of them a project will instantly be awarded a importance x score of 16 irrespective of whether the project has had any impact. This score would be higher than a project that is looking at training a few park rangers (importance x volume score of 2) which may change the behaviour of the park rangers immediately stopping and reducing a threat to a minimum immediately. The maximum impact score of this possibly highly effective conservation tool would therefore be 8, less than the first project described before this project had been running for long enough to discern an impact.

- ‘No discernable effect’ may be due to the project being badly planned or run, funds embezzled, project staff not getting on or natural disaster. Or it might have been a very well planned and run and the threats they were addressing were in fact negligible to other threats or that all threats need to be addressed together but there is neither the resources nor the capacity to achieve this.

- The method does not take in to account the process – Kleiman et al., (2000) state evaluation should include both the process (how effectively and efficiently the project functioned) and the substance (what the project accomplished) of the project. Further investigation of the results will lead to further discussion of this point.

- What happens when the project appears to have a negative effect that is due to a factor outside the control of the project. For example when ebola wiped out 95% of the great ape population (NEED REF AND DATE) or coral bleaching occurs due to the effects of the El Niño (REF and date).

- When collecting data, the ‘effect’ part was very difficult to obtain. Few project reports had this kind of information and when asked, project leaders had to look at their project in a different way. It appeared that while project leaders my lead successful projects on the ground, few of them thought about their projects in terms of the planet as a whole, possibly because it therefore makes the project seem very insignificant. Conversely, programme
leaders (those coordinating from the office), had little detailed information on the individual projects but could see where each project fitted in to a regional programme or something similar.

- The method does not accommodate for negative effect.
- It is very difficult to evaluate indirect conservation actions such as lobbying government for policy change or educating school local children. The effects of these actions tend to be take some time to filter down to the actual biodiversity and are often difficult to extract the cause and effect.
- It is almost impossible to extrapolate cause and effect of most conservation projects. It is therefore difficult to say that an effect is the direct consequence of conservation actions and not a factor outside the project control (such as rainfall).

Conclusion

Mace et al., have produced a method of evaluating the impact conservation that goes some way to being the holy grail. This is a first attempt and it aims to promote discussion on what impact projects have. Work to date indicates that projects of all shapes and sizes are able to be scored using this method. Investigation as to what these impact scores mean look to provoke some interesting discussion. Robustness between scorers has yet to be analysed.

Acknowledgements

Thank you to Mace et al., for coming up with a method for me to test for my MSc project. Thank you to everyone who was asked, coerced or bullied in to giving data. Thank you to Bob Smith (DICE) for general moral and statistical support and thank you to Miranda Stevenson for giving me the time off work.

References


Validation and Measurement of faecal glucocorticoid metabolite concentrations in western lowland gorillas (Gorilla gorilla gorilla)
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Abstract
In mammals it is well documented that stress or disturbance increases the production of adrenal glucocorticoids, as well as other hormones, including adrenocorticotrophic hormone or corticotrophin (ACTH), catecholamines and prolactin. There is only limited information available on the welfare of western lowland gorillas (Gorilla gorilla gorilla) and the evaluation of this, both in the wild and in captivity, can be aided by the non-invasive measurement of faecal glucocorticoid metabolites, in conjunction with behavioural assessments. One of the aims in this four-part study was to validate a technique for the non-invasive measurement of glucocorticoid metabolites in gorilla faeces, using recently-established enzyme immunoassays (EIAs) with biotinylated labels. Further aims were to test whether being relocated to a new enclosure is a disturbing- or enriching-enough event to have a significant effect on metabolite concentrations, and whether environmental enrichment efforts, in a previously under-stimulating enclosure, have a significant effect also. An experiment was also conducted to determine the effects of storage of faecal samples at environmental temperature, over a 24-hour period, on metabolite concentration. The results of the validation procedure showed which EIA is likely to have practical applications for this purpose. Gorillas’ adrenal responses to the housing changes suggested that there was an enriching effect overall. Results of the storage experiment have provided information about the length of time that gorilla faecal samples can be left at environmental temperature for, without significant effect of bacterial enzymes on metabolite concentrations.

Introduction
In mammals it is well documented that stress or disturbance can increase the production of adrenal glucocorticoids, and so this measure is used widely today as a welfare indicator, especially for short-term problems (Möstl and Palme, 2002). Glucocorticoid metabolite concentrations that are measured in faeces reflect the cumulative secretion and elimination of hormones over a number of hours (Palme et al., 1999) and do not represent a single sample point like blood samples do (Touma, 2003). Thus, the concentration of faecal glucocorticoids or their metabolites is likely to be a more accurate and more practicable means of measurement, as well as being non-invasive, and is favoured for the assessment of the welfare of wild animals, both in situ and ex situ, in conjunction with behavioural measures. In this four-part study, we 1) undertake a validation of an enzyme immunoassay (EIA) suitable for measuring faecal glucocorticoid metabolite concentrations in zoo-housed western lowland gorillas (Gorilla gorilla gorilla), 2) relate such concentrations to welfare following manipulations to housing that were hoped to be positive, namely relocations to new enclosures, 3) relate such concentrations to welfare following feeding-related environmental enrichment efforts in existing enclosures, and 4) undertake a storage experiment to assess the effects of bacterial enzymes on metabolite concentrations over time, at environmental temperature.
Methods

Sample collection and storage

None of the gorillas in this study had received any formal training for medical or other purposes. All faecal samples were freshly-voided and collected opportunistically, and care was taken to avoid any obvious contamination with urine or other liquids; each sample was homogenised carefully prior to storage. Samples were collected as follows:

Part 2: multiple samples collected from a family group (2.7.0) before and after they were moved to a new enclosure at Howletts and Port Lympne Wild Animal Parks, Kent, UK. Time periods: baseline (i.e. before relocation) and each of Months 1-4 (i.e. after relocation). All samples were frozen at -20 °C shortly after defecation.

Part 3: multiple samples collected from a pair (1.1.0) at Zoo Duisburg, Germany, before, during and after they received experimental feeding-related environmental enrichment efforts in their previously under-stimulating enclosure (see Hill and Broom (2003) for a description of the efforts used). Time periods: baseline (i.e. before enrichment efforts), experimental enrichment (i.e. during provision of enrichment efforts) and baseline 2 (i.e. after the enrichment efforts were stopped and there was a return to the conditions in the baseline period). All samples were frozen at -20 °C shortly after defecation.

Part 4: one sample collected from a female at Port Lympne, and stored at environmental temperature; sub-samples of it were subsequently frozen at -20 °C at 0 h, 1 h, 2 h, 4 h, 8 h and 24 h after defecation.

Data analyses

All samples were shipped on dry ice to the Institute of Biochemistry, Vienna, prior to analysis by S.P.H. Biological validations using radiometabolism or adrenocorticotropic hormone (ACTH) studies were not practicable in this research, due to their invasive nature. Thus, another type of biological validation was performed for Part 1 of the study, whereby samples collected from a female gorilla from Part 2 and another female from Part 3 (both of whom were known to have shown behavioural responses to the manipulations to their housing) were analysed to validate the EIA most suitable for this species, using the Kruskal-Wallis one-way analysis of variance by ranks (Siegel and Castellan, 1988). 7/15 available EIAs, developed by the working group at the Institute of Biochemistry, were tested in the validation.

In Part 2, samples were compared month–by-month after the relocation with the baseline, using the Kruskal-Wallis analysis. In Part 3, samples from the experimental enrichment and baseline 2 periods were compared with those collected during the baseline, using the Kruskal-Wallis analysis. In Part 4, the sub-samples frozen at each of 1 h, 2 h, 4 h, 8 h and 24 h after defecation were compared with the one frozen at 0 h, using the Friedman two-way analysis of variance by ranks (Siegel and Castellan, 1988). The procedure for measuring faecal steroid metabolites with enzyme immunoassays (EIAs) on microtitre plates (MTPs), using biotinylated steroids as labels, is based upon the procedure developed and described by Palme and Möstl (1997).

The actual time delay for peak faecal glucocorticoid excretion for gorillas has not yet been established, but is estimated as being 24 hours, based upon the known time delay in a chimpanzee (Bahr et al., 2000). Thus, samples in my study were labelled to correspond with either “normal” or “disturbing” days, based on the experimental time periods and the behaviour that had been observed in the 24-hour period preceding the sample collection, i.e. samples were labelled to reflect observed events from one day prior to the faeces being voided.

The data for each of Parts 2 and 3 have been pooled, because of the small number of samples for most individuals in some time periods, rendering it impracticable to conduct statistical analyses on most individuals.
Results

The results presented in this paper are taken from Hill et al. (in prep.) and thus are only briefly summarised here.

Parts 1 and 4 (validation and storage experiments, respectively)
The results obtained in the validation experiment were used to identify the EIA likely to be the most suitable for western lowland gorillas; for ease of reference, its lab code is 69a. The results of the storage experiment have also shown that the 69a-EIA is more robust to the effects of bacterial enzymes on faecal matter left at environmental temperature over a 24-hour period. The 69-EIA is thus used in the subsequent analyses.

Part 2 (relocation)
The Kruskal-Wallis analysis has shown a significant difference between relocation periods in glucocorticoid metabolite concentration, although post hoc tests, comparing results for each month in the post-relocation period with the baseline, have not been declared significant, reflecting a decrease in power in the tests. Behavioural data, collected in conjunction with the faecal samples, showed that after the relocation only one gorilla had significantly higher levels of behaviour that indicated poorer welfare (Hill, 2004).

Part 3 (enrichment efforts)
Behavioural data, collected in conjunction with the faecal samples, showed that experimental enrichment efforts had a highly significant effect in improving gorilla welfare (Hill, 2004), but in spite of a tendency for metabolite levels to drop during the experimental enrichment and baseline 2 compared with the baseline, the Kruskal-Wallis analysis has not shown a significant difference between these periods in the concentrations of glucocorticoid metabolites.

Discussion and conclusions

Whilst there was an insufficient number of faecal samples to test statistically the changes in glucocorticoid metabolite concentration for individual gorillas in Parts 2 and 3, due to sampling difficulties, the pooled data for each of those investigations have revealed several things. The adrenal response of gorillas in Part 2 suggests that the new enclosure had an enriching effect overall, as there was a significant reduction in metabolite concentration in the post-relocation period compared with the baseline. The adrenal response of gorillas in Part 3 suggests that the provision of feeding-related enrichment efforts may have improved welfare, as glucocorticoid metabolite concentration tended to be lower during this time, although not significantly so, and behavioural data obtained during that study confirm an improvement in welfare, in association with the enrichment efforts (Hill, 2004). It is possible that the relocation and enrichment efforts were not meaningful enough to the particular gorillas in this study to cause larger changes in their adrenal response; other individuals may respond in different ways to the same procedures, as welfare is the state of an individual in attempting to cope with its environment.

Acknowledgements

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References


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Introduction

South American fur seals, *Arctocephalus australis*, are carnivorous mammals, belonging to the Otarid (fur seal & sea lion) family (Riedman 1990; Swolgaard 2002). They are distinguished from Phocids (true seals) mainly by the presence of externally visible ear pinnae, external scrotal testes and hairless hind-flippers that can be turned under the body for terrestrial locomotion (Riedman 1990). In addition, their hind-flippers are equipped with claws that are used to groom their thick fur coat (Riedman 1990).

It is thought that approximately 400,000 individuals (Seal Conservation Society 2005; Riedman 1990) inhabit remote rocky shores of South America from Cape Horn northwards to Peru on the Pacific coast and Southern Brazil on the Atlantic coast (Swolgaard 2002). South American fur seals are terrestrial breeders (Riedman 1990) and breeding occurs during springtime; October to December in their natural habitat (Swolgaard 2002). Sexual maturity in these animals is reached at 3 years for females and approximately 7 years for males (Swolgaard 2002; Seal Conservation Society 2005). Bulls, weighing up to a mass of 200kg, compete to establish breeding territories and create harems of females with which to mate in a polygynous manner. Little is known about the movement of bulls and sub-adult males, but the smaller cows, of up to 60kg mass, remain in rookeries year-round, and so there exists a social system that is influenced by the breeding season (Swolgaard 2002; Seal Conservation Society 2005).

Since South American fur seals are fairly social mammals, they exhibit aggression to other members of their species. Aggression occurs during territorial competition in the wild, during which the bulls will push, lunge and slash at the flippers, chest and hindquarters of their opponent (Riedman 1990). Additionally, Cassini’s studies focus on the behaviour of South American Fur Seals in wild colonies. One study found that they responded strongly to close tourist approaches (less than 10m), and/or if disturbance was severe; tourist attitude was observed, and intense tourist behaviour, e.g. running, shouting and or hand movements elicited a strong response (Cassini 2001b). Another study concluded that the most common type of aggression was “open-mouth”, and aggression exhibited by females increased at midday (Cassini 2001a).

Aggression and related behaviour has been studied in other social animals, such as primates, and has led to the description of stereotypic and self-directed behaviours (Maestripieri, Schino et al. 1992). A study on captive Baikal seals (*Phoca sibirica*) at Twycross conducted by Jones and Whitehead (1993) found that the seals would retain their individual space whilst basking and would bite, snort, scratch or lunge if this was transgressed. Also, Hunter, Bay et al. (2002) studied the effects of enrichment on captive harbour (*Phoca vitulina concolor*) and gray (*Halichoerus grypus*) seals and found that it increases random swimming and exploration whilst decreasing stereotypic swimming.

However, little research has been conducted on the behaviour of fur seals, particularly on stress-related behaviour in these animals. But, previous observations and research (Natalie Garret, unpublished), conducted on four South American fur seals, *Arctocephalus australis*, at the Living Coasts attraction in Torquay, suggested the possibility that they engage in self-directed behaviour.
Introduction to stress-related behaviour and previous research.

Both self-directed behaviour (SDB) and stereotyping can be forms of displacement behaviour, and both have been observed in several species of birds and mammals. Stereotypic behaviours are defined as a repetitive movement of the body that seems to be irrelevant to the situation and serve no apparent function (Mason 1991a; Mason 1991b; Shepherdson 1989). Mason (1991a) highlights that animals in captive environments may respond in a more pro-active, rather than an inactive, manner and exhibit stress-related behaviour, since they spend less time on general maintenance and are subjected to aversive situations. Self-directed behaviour has also been described as a stress-related behaviour, and has been defined by Hall and DeVore (1965), amongst others, as easily observable self-maintenance actions that are often desultory, jerky and of short duration (Hall and DeVore 1965). Such behaviour has previously been observed in several mammal species, most notably, primates (Maestripieri et al. 1992).

Self-directed behaviours observed in primates include autogrooming (Troisi and Schino 1987), scratching (Diezinger and Anderson 1986; Easley, Coelho et al. 1987; Pavani, Maestripieri et al. 1991), yawning (Hadidian 1980; Hall and DeVore 1965), body-shaking (Castles, Whiten et al. 1999) and muzzle wiping (Hall and DeVore 1965). Such activity has particularly been observed in primates when subjected to stressful situations, both in both laboratory and field studies (Rowell and Hinde 1963), and thus are known as stress–related behaviours. However, a proportion of SDB exhibited by any animal is self-maintenance (Castles, Whiten et al. 1999), and both Pavani, Maestripieri et al. (1991) and Easley, Coelho et al. (1987) agree that scratching is a body care activity, but that tension and arousal lead to rousing of pelage, which requires scratching. Thus causal factors of scratching are linked to primitive body care function.

Rowell and Hinde (1963) suggested that a potentially dangerous or uncertain situation results in the animal becoming anxious or stressed. Such situations may arise through conflict (Troisi and Schino 1987) or through failure to meet the individuals needs, such as lack of stimulation by enrichment or lack of space etc, thus resulting in fear and frustration of the animal (Diezinger and Anderson 1986; Mason 1991a; Mason 1991b; Shepherdson 1989). For example, conflict situations are thought to provoke fear and uncertainty, and such situations seem to have been studied extensively. In primates, increased scratching has been observed in both the aggressor and aggressee during the immediate minutes following a conflict, and this impacts on ‘reconciliation’ (Aureli 1997; Das, Penke et al. 1998). Castles and Whiten (1998) concluded that baboons have a clear response following a conflict; exhibiting elevated levels of scratching, autogrooming, body-shaking and yawning.

Hall and DeVore (1965) noted that yawning functions primarily as a displacement activity when it is not preceded, or followed by, any expression of attack or threat (but functions secondarily as a threat), and Hadidian (1980) described yawning as highly stereotypic, occurring in stressful situations. The function of scratching has also been noted as a displacement activity (Easley, Coelho et al. 1987), since it is expressed more in higher-ranking individuals (with perceived high tension).

In addition, increased scratching has been observed in subordinate individuals when proximate to a dominant male, i.e. within 5m (Castles, Whiten et al. 1999; Pavani, Maestripieri et al. 1991; Troisi and Schino 1987). However, it has also been observed that the absence of neighbours also resulted in increased levels of SDB above that expressed when subordinates were in close proximity (Castles, Whiten et al. 1999). Additionally, Rowell and Hinde (1963) reported that an isolated undisturbed animal exhibited some differences from the usual behaviour, but that on exposure to stress, the changes became even more pronounced.

Although increased levels of SDB are linked to the presence of stress, other factors have been found to affect expression of SDB. Climatic factors and time of day have been found to affect autogrooming (Troisi and Schino 1987) and scratching (Pavani, Maestripieri et al. 1991); it affects pelage and thus both increase in frequency with an increase in temperature. In addition, enclosure characteristics have also been found to affect behaviour, with more
ecologically representative exhibits reducing the frequency of stereotypic behaviour (Chang, Forthman et al. 1999).

To conclude, previous research suggests that anxiety increases arousal and alertness, which physiologically prepares the animal for a rapid response in an uncertain situation and is exhibited through the expression of self-directed behaviours (Castles, Whiten et al. 1999; Maestripieri, Schino et al. 1992). Thus scratching behaviour, amongst others, may be used as a simple behavioural measure of anxiety and suggest the presence of stress or social tension (Troisi, Schino et al. 1991). Maestripieri, Schino et al. (1992) comments that this allows insight into their emotions and their perception of relationships and may explain why the magnitude and intensity of SDB observed varies between individuals.

Since SDB has been observed in primates, it is possible that South American fur seals also express this behaviour, as they, like primates, have a defined social system that is dependent on social interactions, and SDB can play a crucial role in the regulation of this.

**Aims & Hypothesis**

The aim of this investigation was to ascertain whether South American fur seals exhibit SDB by comparing the frequency of possible stress-related behaviours exhibited, to those exhibited during an assumed less-stressful period. Husbandry management events coincided with the study period and so it was possible to test the effect of this on a group of South American fur seals.

**Method**

**Study subjects.**

Data was collected on a group of South American fur seals located at the Living Coasts attraction in Torquay (figure 1). The group consisted of four young individuals at the beginning of the study, however this changed over the duration. Individuals are summarised below (Table 1).

![Figure 1. Study Subjects.](image)

<table>
<thead>
<tr>
<th>Name</th>
<th>European Studbook number</th>
<th>Gender</th>
<th>Date of Birth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grace</td>
<td>T0106</td>
<td>Female</td>
<td>26/05/01</td>
</tr>
<tr>
<td>Otari</td>
<td>T0108</td>
<td>Male</td>
<td>11/06/01</td>
</tr>
<tr>
<td>Frodo</td>
<td>T0113</td>
<td>Male</td>
<td>12/06/02</td>
</tr>
<tr>
<td>Bella</td>
<td>T0115</td>
<td>Female</td>
<td>22/06/02</td>
</tr>
</tbody>
</table>

All four individuals are half siblings, being born at Bristol Zoo Gardens. All were moved to Living Coasts on 9th June 2003, into an enclosure holding approximately 504 cubic metres of natural seawater.
Methodology.

Data was collected during three distinct periods between January and June of 2005, and incorporated two zoo management events; enclosure and group variation. Data was collected between January and June 2005, as indicated below (Table 2).

Table 2. Periods of data collection.

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan ’05</td>
<td>Observe 4 seals at Living Coasts (LC) to give baseline levels (Condition 1).</td>
</tr>
<tr>
<td>Feb – Mar ’05</td>
<td>• Seals removed to holding area while maintenance work carried out.</td>
</tr>
<tr>
<td></td>
<td>• Also, Otari relocated to Bristol Zoo.</td>
</tr>
<tr>
<td></td>
<td>• Seals released into modified pool.</td>
</tr>
<tr>
<td>Mar ’05</td>
<td>Observe 3 seals at LC in perceived stressful/new situation (Condition 2).</td>
</tr>
<tr>
<td>Apr ’05</td>
<td>Observe Otari at Bristol (Condition 2b).</td>
</tr>
<tr>
<td>May ’05</td>
<td>Further follow up observations on 3 seals at LC (Condition 3).</td>
</tr>
</tbody>
</table>

Data was collected for 10 days in each of the 3 periods. 30-minute observation sessions were carried out every hour between 10am and 4.30pm and alternated on a daily basis. During each 30-minute session, instantaneous scan sampling was carried out at 1-minute intervals to obtain general activity for each seal. Also, within each session, all occurrence sampling of possible self-directed behaviours was conducted for a focal seal. The proposed SDBs that were being recorded were body-shake, scratch and yawn, all of which have been noted in primate studies, in addition to flipper-rub, head-body rub, nuzzle and rock scratch, which were defined as being possible SDBs following preliminary observations. Separate bouts of these behaviours were identified if there was a pause in behaviour for greater than 5 seconds, or if the behaviour changed. The table below (Table 3) is drawn from the original ethogram used in the study and describes the possible SDBs that were being recorded.

Table 3. Proposed SDBs

<table>
<thead>
<tr>
<th>Self-directed behaviours</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body shake</td>
<td>Rapid shakes of the body; similar to that of a dog, as though to rid fur of excess water.</td>
</tr>
<tr>
<td>Flipper rub</td>
<td>Using fore flipper to rub face or body. May be carried out on land or in the water.</td>
</tr>
<tr>
<td>Head-body rub</td>
<td>Twist so head is used to rub lower part of body.</td>
</tr>
<tr>
<td>Nuzzle</td>
<td>Twist so that head is touching tail to groom</td>
</tr>
<tr>
<td>Rock scratch</td>
<td>Rubbing part of the body on the rock to scratch the particular area</td>
</tr>
<tr>
<td>Scratch</td>
<td>Using hind flipper claws to scratch face and body, by repeatedly drawing them back &amp; forth across their fur</td>
</tr>
<tr>
<td>Yawn</td>
<td>Opening jaws to full gape</td>
</tr>
</tbody>
</table>

Since the exhibition of SDB may be affected by a multitude of confounding variables, such as climate, wave activity in the enclosure, interindividual proximity and the occurrence of aggression, these were also noted. The state of their thick pelage may also be an important factor, since this requires regular grooming; there is likely to be periods when the fur requires more care than at other times e.g. body-shake on exiting water, rubbing when wet etc. Since self-maintenance behaviours were recorded as SDB, it is necessary to consider this factor...
and consequently a code was devised to note the state of their pelage. Hence, it is necessary to use each animal as their own control and record confounding variables where possible.

**Results & Analysis**

A total of 250h of scan data, and approximately 50h per subject observing possible SDBs, were collected over the course of the study. Mean values and standard errors were calculated for each behaviour in each condition for each seal, this included both self-directed behaviours noted during the all occurrence sampling, and general activity obtained from the scan sampling. The results were graphed and are presented for each seal (Figures 2-9). In addition, significance testing was carried out using SPSS ® to determine whether there were any significant variations in the levels of behaviour expressed.

**Results for Otari**

Otari, the elder male seal of the subject group was relocated to Bristol, and hence there are 2 sets of behaviour recordings; one in January before he left Living Coasts, and another following his move, in April.

![Activity of Otari](image)

**Figure 2.** General activity of Otari
There were no significant variations in either general activity levels or frequency of possible SDBs, according to the chi-squared test for difference. However, there was an observable decrease in his stereotypic swimming and an increase in his play behaviour from condition 1 to condition 2b (Figure 2). In addition, the rate of SDB expression seems to have decreased, with the exception of body shake and yawn (Figure 3).

**Results for Frodo**

Frodo is the younger male seal remaining at Living Coasts; three sets of data was collected on his behaviour, the means are presented in the figures below.

**Activity of Frodo**
There were no significant variations in either general activity levels or frequency of possible SDBs, according to the Friedmans test. However, there seems to be large variations in the resting out of, locomotion in water and stereotypic swimming between condition 1 and condition 2 (Figure 4), which may be affected by the enclosure modification. In addition, his play behaviour has increased over the latter two conditions. Frequency of possible SDB appears to generally increase across the three conditions, with the exception of rock scratch and yawn (Figure 5).

Results for Grace.

Grace is the elder female seal at Living Coasts, and so three sets of behaviour data have been collected, and the means are presented below.
SDB rates expressed by Grace

<table>
<thead>
<tr>
<th>Type of Self-Directed Behaviour</th>
<th>Condition 1</th>
<th>Condition 2</th>
<th>Condition 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body shake</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flipper rub</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head-body rub</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuzzle</td>
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<td>Rock scratch</td>
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<td>Scratch</td>
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<td>Yawn</td>
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Figure 7. SDB expression of Grace

Again, no significant variations were detected using the Friedmans test. However, there was an increase in resting out of water and a decrease in locomotion in water and stereotypic swimming between conditions 1 and 2 (Figure 6). With respect to proposed SDBs; there seemed to be a general decrease in the frequency expressed, with the exception of rock scratch and body-shake. The majority of these show a sharp decrease followed by a small increase (Figure 7).

Results for Bella.

Bella, the youngest female seal at Living Coasts, also has 3 sets of behaviour recordings and these again these are presented below.

Activity of Bella

Figure 8. General behaviour of Bella.
Likewise here, the mean behaviour levels yielded no significant results when subjected to the Friedmans test. But, background activity recordings do reveal that her water use and play has generally increased over the experimental period (Figure 8). There is a general decrease in the expressed proposed SDBs, with the exception of rock scratch, yawn and body-shake (Figure 9). However, similarly to Grace, inconsistent fluctuations suggest a less clear effect of the two management events.

Results summary.

All results have been analysed for significance, using Friedmans test for those seals for which 3 data collections were carried out, and using chi-squared for Otari, as there are only 2 sets of data on his behaviour. However, these all yielded non-significant results at the 95% confidence level. Even so, activity graphs show some large differences in their locomotory and resting behaviours, in addition to, and perhaps more importantly, play and stereotypic behaviour, since this can also be indicative of stress. Also, all fur seals show general trends in SDB rates, but with inconsistencies in body-shake, rock-scratch and yawn categories; Otari, Grace and Bella show decreasing trends, while Frodo shows a general increase in the rates of proposed SDBs.

Discussion

The results of this study seem to suggest general trends in variation of behaviour in *A. australis*, and it may be that this reflects the social tension that they are experiencing. Previous studies suggest that similar behaviours in primates are indicative of stressful situations (Rowell and Hinde 1963). Thus it may be that Otari, Grace and Bella, who all show a general decrease in their SDBs, are experiencing decreased stress between condition 1 and 3, whilst Frodo may be experiencing increased stress, as demonstrated by the increasing trend in frequency of SDBs. Since stereotypic swimming also seems to indicate the presence of stress (Mason 1991a; Mason 1991b; Shepherdson 1989, Hunter, Bay *et al.* 2002) this behaviour too can be examined in order to assess the individuals perception of the environment. In this study, it is interesting to note that those showing decreased trends in proposed SDB expression also show a decrease in the proportion of time spent engaged in stereotypic behaviour, whilst Frodo, with his increased proposed SBD expression, displays an increased occurrence of stereotyping.

There are also some interesting points to note from the results. The variation in Otari’s stereotypic swimming and play behaviour may be influenced by the changes in both group and enclosure characteristics, since following his move to Bristol he was placed with four other females of various breeding ages, and the increase in play suggests he is building affiliations. In addition, the increase of play behaviour observed in Frodo may have occurred
as a result of Otaris departure; Frodo is now the only male thus affecting his manner of interaction and affiliation with the females. The fluctuations in the proposed SDB exhibited by Grace perhaps suggests an initial decrease perhaps suggesting an initial decrease in the stress she is experiencing, but increasing over a long-term period.

Although body-shake has proved a reliable SDB indicator of stress in primate studies (Castles, Whiten et al. 1999), it appears to be an undependable measure in *A. australis*. In this species, and other fur seals, it is likely to prove a more necessary maintenance function and be used as a drying procedure following water use. It can be observed from the results that frequency of body-shake in these study subjects seems to correspond with incidence of water use.

It is important mention that the zoo management events are perceived periods of stress, and it may be that neither actually induce stress in the study group of *A. australis*. Wild seals have adapted to cope with arduous times (Riedman 1990; Swolgaard 2002) and it may be questionable as to whether assumed stressful situations prove a good trial in captive animals. Additionally, it is difficult to distinguish between the effects of the two separate zoo management events; as each event may counter-act the behavioural effect produced from the other event, and therefore responses to each condition may be masked. This point is highlighted by the results for Grace and Bella, which show inconsistent fluctuations and thus the zoo management events have a less clear effect on them. It is also possible that individuals may differ in the levels and types of behaviour expressed when subject to stressful situations.

Finally, however, these preliminary observations reveal trends, and further targeted research is required to test the validity of these actions as self-directed behaviours in *A. australis*. Following this study, it would seem that scratch and flipper-rub might be the most reliable behaviours on which to conduct further research to determine whether South American fur seals exhibit self-directed behaviour.

**Acknowledgements**

This study has been conducted in association with the Whitley Wildlife Conservation Trust and special thanks go to Paignton Zoo science department, and Tony Durkin and the animal keepers at Living Coasts. I would also like to thank the education team and Glenn Frost at Living Coasts for sharing their knowledge, and Sue Dow and keepers at Bristol Zoo for their co-operation and participation.

**References**


Effect of visitor numbers on the behaviour of captive Capachins (Cebus xanthosternos)
Elizabeth Hague, University of Wales

It has been argued that visitor presence effects captive animal behaviour. The aim of this investigation was to examine the impact of visitor number in the behaviour of captive Cebus xanthosternos housed at Chester zoo. The results were then used to determine whether changes to the capuchin enclosure had been beneficial to the groups’ welfare. The hours in which the zoo was open each day were separated into six sampling periods. The behaviour of three group members was scan sampled and visitor number recorded, every two minutes within eighty-minute periods. Statistical analysis indicated that the group showed significantly less social interaction and more locomotory behaviour correlating with increased visitor number. The results supported the stressful response theory of Charmoye et al., (1988). The group showed a stressful response to increased visitor number. It was concluded that changes to the capuchin enclosure had not prevented a visitor response, and that animal welfare was impacted despite enclosure modifications.
Kinkajou environmental enrichment and activity levels
Simone Johnson1, 2, Kirsten Pullen2, and Adam Robbins1
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2Liverpool John Moores University, Liverpool

Abstract

A non-breeding pair of kinkajou (Potos flavus) housed at Newquay zoo was thought to be overweight due to inactivity, in addition to which the male performed a large amount of stereotypic pacing. Previous research has shown that environmental enrichment can promote welfare and encourage species-appropriate behaviour that otherwise might not be seen in captivity. Food and scent enrichment were used to discover which was the most effective at reducing stereotypies and increasing natural behaviours and activity. Instantaneous scan sampling was used to collect data for three environmental conditions, baseline, food enrichment and scent enrichment. The location of each kinkajou was also recorded to evaluate the use of space. Although neither food nor scent enrichment gave a significant decrease in pacing behaviour positive trends were seen. The food enrichment did encourage a weekly significant increase in the male’s foraging behaviour (Kruskal Wallis H = 6.53, d.f. = 2, p = 0.038), whereas the scent enrichment encouraged a significant increase in feeding (H = 7.28, d.f. = 2, p = 0.026) and a significant decrease in affiliative interactions (H = 9.96, d.f. =2, p = 0.007). The female’s behaviours were only significantly affected by the scent enrichment, with a decrease in both affiliative interactions (H = 9.18, d.f. = 2, p = 0.010) and locomotion (H = 6.21, d.f. = 2, p = 0.045).

Overall, scent enrichment produced a more significant variation in behaviour levels than food enrichment. However, as neither significantly reduced the levels of pacing behaviours observed, further work is required concentrating on a range of enrichment techniques and their effect over time.

Background

The kinkajou is a medium sized nocturnal, neotropical mammal found in the forests of South America (Ford, 1988). Previously thought to be solitary, new research has found that they regularly congregate whilst feeding and sleep together in day dens of up to five individuals (Kays, 2000). Further research shows that the kinkajou’s social feeding groups generally consist of one adult female, two males, one sub adult and one juvenile. However, breeding females are often solitary. Fighting has been observed within groups and a dominance relationship has been suggested on the basis of these observations. It is also evident that kinkajous’ have distinct home ranges, which may overlap and are marked with scent (Kays, 2001).

Their diet consists mostly of fruit and they are known to exploit large, highly productive canopy trees (Julien-Laferriere, 1993) and the most important fruit in the diet of the wild kinkajous is the fig (Kays, 1999). Dietary adaptations include an extendable extra long tongue. It is believed that the long tongue is used to lick nectar from flowers and to obtain honey (Poglayen-Neuwall 1967). The name ‘honey bear’ an alternative name for the kinkajou, originates from its apparent love of honey. It is also suggested that wild small vertebrates and bird eggs form part of their natural diet (Kays 1999). While there is no direct evidence of this, eggs are often used to supplement the diet of captive Kinkajou’s.

Isidors eagle (Oroactus isidora), harpy eagles (Harpia harpyja) and jaguars (Panthera onca) are known predators of kinkajous although the most effective predators are humans. Humans hunt kinkajou for meat, fur and to supply the global pet trade. Hunting and habitat destruction have reduced the kinkajou’s home range but they are not yet classified as threatened (Ford 1988).

Kinkajous have many specialised adaptations to life in the tropics including, a resting body temperature more than 2°C lower and a 65-70% lower metabolic rate, than in other mammals. Other arboreal adaptations include prehensile tail and opposable rear feet, which enable them to hang upside down (Julien-Laferriere 1993).
A non-breeding pair of captive kinkajou housed together in the “Wildlife At Night” building at Newquay zoo was thought to be overweight primarily due to low levels of activity, in addition to which the male performed a large amount of stereotypic pacing. Environmental enrichment is known to reduce stereotypic behaviour and encourage natural behaviours that otherwise might not be seen in captivity. There are many different types of enrichment including food, scent, auditory, tactile and visual (Young 2003). Previous studies have shown positive changes in behaviour after simple forms of feeding enrichment are introduced (Shepherdson, 1989). As one of the concerns with the captive kinkajou was their weight, food and scent enrichment were used to discover which was more effective at reducing stereotypies and encouraging natural behaviours and activity.

**Aims**
The aims of the project were to increase natural behaviours such as foraging and scent marking, and to reduce stereotypic behaviour and increasing activity levels. Two specific hypotheses were made:

a) The introduction of enrichment will reduce stereotypic behaviour  
b) The introduction of enrichment will increase enclosure use and activity

**Methods**

**Subject animals**
The adult male, approximately 3 years old at the time of study and adult female, approximately 24½ years old at the time of study were held together in the ‘Wildlife At Night’ building. Their enclosure was entirely indoors and measured 5.4m x 4.3m x 2.85m high. It had a constant temperature of 24ºC maintained by a wall mounted heater and the lighting regime was reversed where 9.00 until 21.00hr was dimly lit artificial moonlight and 21.00-9.00hr was brightly lit artificial daylight.

**Enrichment devices**
An ethogram of behaviours and a tick sheet were constructed. Also two enrichment devices were constructed, a hanging feeder and a scent bottle. The feeding device was made out of two hanging baskets held together with cable ties. It was filled with fresh hay and fresh food hidden in the hay each time it was used. Rope was attached to one of the hanging baskets to allow it to be hung from a log in the kinkajou enclosure. The scent bottle was made out of a plastic bottle that had holes cut out of it. A few drops of peppermint oil were put onto each of five pieces of paper towel. These were then rolled up tightly and put into the bottle. The remainder of the bottle was filled with hay before being hung by string in the kinkajous’ enclosure.

**Spread of participation index**
To evaluate the use of space, the enclosure was drawn and divided into zones following the guidelines set out for the spread of participation index (SPI) in Plowman, 2003. An SPI value of 0 would indicate that all areas of enclosure were used equally and an SPI of 1 would indicate that only 1 area was used exclusively.

**Data collection**

Instantaneous scan sampling was then used with each kinkajou’s behaviour and location being recorded every minute over a 30-minute session. Each session was spaced apart from the next one by an hour and 2½ hours of data were collected each day. Data collection roughly followed an enrichment timetable. This involved a three-day rota and was designed to prevent habituation of the objects used. The timetable comprised three environmental conditions;

Condition 1. Baseline. Feeding followed the normal procedure and was put into hanging buckets around the enclosure once per day.
Condition 2. Food Enrichment. All food was divided into two hanging feeders, which were introduced into enclosure in the morning whilst the kinkajous were in their nest boxes.

Condition 3. Scent Enrichment. The scent bottle was put into the enclosure in the morning whilst the Kinkajous were in their nest boxes.

Once 5 days of data collection per condition had been collected, the data was entered into Excel spreadsheets, charts were constructed and data was analysed using Kruskal Wallis tests and post hoc comparisons.

Results

![Figure 1 Male behavioural activity](image)

Figure 1 shows the behavioural categories on the x-axis. These are feeding, foraging, grooming, aggressive, affiliative, locomotion, pacing, inactive alert, not alert and out of sight.

An increase in foraging behaviour is clearly visible when food enrichment is used. It is a weakly significant increase (Kruskal Wallis $H = 6.53$, d.f. = 2, $p = 0.038$), whereas the scent enrichment encouraged a significant increase in feeding ($H = 7.28$, d.f. = 2, $p = 0.026$) and a significant decrease in affiliative interactions ($H = 9.96$, d.f. = 2, $p = 0.007$). Positive trends can also be seen in pacing behaviour, not alert and out of sight which appear to decrease with both scent enrichment and food enrichment. Grooming also appears to increase slightly with scent enrichment.
Figure 2, with behavioural categories as before, feeding, foraging, grooming, aggressive, affiliative, locomotion, pacing, inactive alert, not alert and out of sight, shows the female's behavioural activity. Positive trends can be seen in feeding, foraging and grooming behaviour with both types of enrichment. However, Kruskal Wallis tests showed that the female's behaviours were only significantly affected by the scent enrichment, with a decrease in both affiliative interactions ($H = 9.18$, d.f. = 2, $p = 0.010$) and locomotion ($H = 6.21$, d.f. = 2, $p = 0.045$).

Figure 3 shows the mean SPI value for the male and female kinkajou under the three conditions. As mentioned earlier, an SPI value close to 0 indicates that all zones in the enclosure were used equally. A decrease in SPI value is clearly visible from baseline to food enrichment for the male and the Kruskal wallis test confirmed that the decrease was significant ($H=8.36; df=2; p=0.015$). It can be seen that the females SPI value increased from baseline to food enrichment and again from food enrichment to scent enrichment.
Discussion

Food enrichment

Food increased foraging in the male significantly, and in the female slightly. This is a positive change as it is a natural behaviour. Trends were seen in the males pacing behaviour, which decreased with the addition of both types of enrichment.

Scent enrichment

Scent enrichment increased the amount of time the male spent feeding although it is not clear why this would happen. Peppermint was used in the scent bottle and this perhaps stimulated his senses to feel hunger. Grooming increased slightly with scent enrichment for both the male and female kinkajou. Affiliative interactions reduced significantly when scent enrichment was used. This is an important finding as it could have implications for breeding. Affiliative interactions could have decreased with the use of scent as only one scent bottle was placed in the enclosure. Through visual observations it was obvious that the male was controlling access to the bottle and would not let the female approach it. This highlights the need for multiple enrichment devices to be used so all animals in the enclosure have access to them and they cannot be controlled.

Use of space

The male’s use of space increased with food enrichment, which was probably due to the increased levels of foraging, he exhibited. Two hanging feeders were used on food enrichment days and were hung in different parts of the enclosure so he would have to move around to investigate them.

The female's use of space decreased slightly with food enrichment and more prominently with scent enrichment. This again may have been due to the male controlling the devices.

Conclusions

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Male</th>
<th>Female</th>
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<tr>
<td>Hypothesis 1. Reduce stereotypic behaviour</td>
<td>✓ Food ✓ Scent</td>
<td>✗</td>
</tr>
<tr>
<td>Hypothesis 2. Increase enclosure use</td>
<td>✓ Food ✓ Scent</td>
<td>✗</td>
</tr>
<tr>
<td>Hypothesis 2. Increase activity</td>
<td>✓</td>
<td>✓</td>
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Table one shows whether the original hypotheses have been accepted indicated by a tick or rejected, indicted by a cross.

Recommendations

At least one enrichment device per animal and an extra one should be used to prevent any animal from controlling them.

Further research

No research on kinkajous has yet discussed the function of scent marking. If this was known it may be easier to encourage the natural behaviour of scent marking in captive kinkajous. It would also be interesting to discover why eating increases when scent enrichment is used and if certain scents (such as predator scents) increase affiliative behaviour.
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Comparisons of butterfly diversity at three calcareous grasslands within Torbay.

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Abstract

Torbay is home to the majority of calcareous grasslands within Devon. There are a number of important sites including Clennon Hill (Paignton) which is within the grounds of Paignton Zoo Environmental Park. The site is owned and managed by the Zoo’s parent organisation the Whitley Wildlife Conservation Trust. This study compares the vegetation and butterfly diversity between Clennon Hill and two other calcareous grasslands in Torbay: Berryhead and the Grove.

All sites were found to be CG3b communities within the National Vegetation Classification (Rodwell 1992), however detrended correspondence analysis shows that each site is floristically distinct. Clennon Hill has significantly greater plant species richness but plant diversity is similar across the three sites. Negative correlations were found between plant diversity and butterfly diversity at the Grove: also the abundance of the larval food-plant, Festuca ovina was negatively correlated with the abundance of adult meadow brown and gatekeeper butterflies. Personal observation shows that these two butterfly species use adjacent bramble as a nectar source. Bramble is likely to outcompete the calcareous grassland species (including Festuca ovina) so areas with abundant bramble may have lower plant diversity. If this is the case it shows the importance of a mosaic of habitat types for butterflies, containing both their larval food-plants along with areas of scrub for shelter and nectar. This is currently being investigated.

Introduction

Calcareous grasslands are plagioclimax plant communities in which lime-loving plants are characteristic (pH 7.0 – 8.4). Calcareous grasslands are generally low-nutrient areas with exceptionally high plant diversity. The area of the UK covered by calcareous grassland has been declining rapidly in recent decades. The greatest threat to calcareous grasslands in the UK and Europe is fragmentation and destruction caused by under-grazing, over-grazing, agricultural intensification and urban and industrial intensification (Steffan-Dewenter, 2002). Many calcareous grasslands are now granted protection by a SSSI, NNR, AONB or CWR status, however a great deal of damage has been done. It is estimated there are 40,000-50,000 ha of calcareous grasslands remaining in the UK (ukbap.org.uk). According to Berkshire HAP (2001) between 1930 and 1984 97% of unimproved grasslands in England and Wales were lost. Furthermore in Worcestershire alone between 1980 and 1991/2 28% of the remaining unimproved grasslands were damaged and 37% lost. The loss of these grasslands has had an effect on the associated wildlife; particularly butterflies. Bourn (2002) found that butterflies are more greatly affected by habitat changes than any other order of insects. There are 59 butterfly species native to the UK, 27 of these are associated with calcareous grasslands, including 3 of conservation concern (JNCC 1992).

There are very few calcareous grasslands within Devon, they are only found in isolated areas in southern parts of the county including Plymouth and Torbay (Torbay Local BAP, 1998). Torbay is a borough of south Devon and the home of Paignton Zoo Environmental Park. Within the zoo grounds is an area of calcareous grassland which is considered to be the second most important in the borough. The site is owned and managed by the zoos parent company the Whitley Wildlife Conservation Trust (WWCT). Members of the WWCT are active members of the steering group for the local Biodiversity Action Plan which considers calcareous grasslands to be a priority habitat.
Aims and objectives

- Classify vegetation composition of three calcareous grassland sites.
- Compare butterfly and plant species richness, diversity and abundance both within and between sites.
- Relate vegetation composition to butterfly abundance, richness and diversity within and between sites.
- Recommend possible methods of improving butterfly abundance and diversity through vegetation management.

Methodology

Site descriptions

Clennon Hill is an unimproved west-facing calcareous grassland covering approximately 4500m$^2$. It is surrounded by scrub and young trees, predominately ash (*Fraxinus excelsior*). The site is grazed by pygmy goats.

Berryhead is located on top of a steep sea-cliff and contains a large area of calcareous grassland. An area of approximately 2400m$^2$ was sampled for the current study. It is surrounded by stone walls and has very little scrub.

The Grove site is composed of two woodland glades separated by approximately 80m of woodland. The first is approximately 104m$^2$, the second covers approximately 750m$^2$. Like Clennon Hill it is surrounded by scrub and young trees predominately ash (*Fraxinus excelsior*).

Vegetation Survey

As two of the three grassland sites are essentially woodland clearings they are surrounded by scrub; this edge habitat was surveyed separately from the grassland proper. Each site was divided into 8 equal-sized sections. The 8 sections of the sites correspond to the division of the site for butterfly monitoring (figure 1). This allows within and between site comparisons of butterfly presence and vegetation. Within each section 10 quadrats were placed randomly; 5 50x50cm quadrats have been surveyed in the grassland during August 2004 and 5 2x2m will be surveyed in the edge habitat during August 2005. All plant species within the quadrats and their percentage cover were recorded.

Butterfly Survey

Data was gathered using two methods; set transects (or Pollard Walk technique) and timed counts. The transects are approximately 400m long in total, the same length at each site. These were walked weekly and the number of butterfly species and individuals within a 5m radius counted. Timed counts involve standing at set points on a site (in this case one point per section) again noting all butterflies that come within a 5m radius. The routes are divided into 8 sections in order to find out if any particular areas of the sites are particularly species rich or poor (figure 1).
The data collection was split between two years. The first half was collected between 19th July until 27th September 2004. In 2005 the collection began 4th April until the 12th of July. This will give a complete set of data for the 26 weeks of the butterfly season and follows the recommendations of the Butterfly Monitoring Scheme (http://bms.ceh.ac.uk).

The criteria for carrying out transect and timed count surveys are:
- Conduct between 10.30am and 16.00pm.
- Temperature at least 13°C with less than 60% cloud cover, or at least 17°C if there is 100% cloud cover.
- The wind speed must not be greater than F4 on the Beaufort Scale and it must not be raining.
- Butterflies, caterpillars and pupae seen within 5m ahead, left or right of the observer are counted.

Data analysis
- Rodwell (1992) and MAVIS Plot Analyser v.1 (Smart 2000) were used to assign sites to National Vegetation Classification communities. In order to see how these sites were related to each other detrended correspondence analysis was used to produce an ordination plot. The program DECORANA (default settings) was used within the package Community Analysis 2.15 (Pisces Conservation 2003).
- The plant and butterfly species diversity were calculated using Simpson’s Index. The similarity of the sites to each other in terms of both species richness and diversity was tested with One-Way ANOVA and post-hoc Bonferroni tests; both conducted in SPSS v12.
- To investigate a possible relationship between butterfly and plant abundance and diversity within sites Pearson correlation analysis was conducted in SPSS v12.

Results

Plants

All three sites correspond with the same National Vegetation Classification (NVC) community CG3b Bromus erectus with Centaurea nigra (Rodwell 1992). No Bromus erectus was found however in any of the sites. This may indicate that the calcareous grasslands in Torbay do not closely conform to those in other areas of the country.

Figure 2 shows an ordination plot for all three sites with each point representing one section within the grassland. It shows that although the sites correspond to the same NVC community they are none the less distinct from each other. The ordination plot shows that the Grove and Berryhead form discrete clusters suggesting relatively homogenous but distinct vegetation within each. Clennon Hill on the other hand has greater heterogeneity between the sections.
Figure 2: Detrended correspondence analysis plot of vegetation for each site section within the Grove Berryhead and Clennon Hill.

Figures 3 and 4 show the difference in plant species richness (figure 3) and diversity (figure 4) between the three sites. Clennon Hill has significantly higher plant species richness ($F = 10.365$, $P = 0.02$) but there is no significant difference between the three sites in terms of species diversity ($F = 0.555$, $P = 0.582$). This may be due to higher levels of variation in diversity within each site.

Figure 3: Mean plant species richness between sites, Grove, Berryhead and Clennon Hill.

Figure 4: Mean plant diversity between three sites: Grove, Berryhead and Clennon Hill.
Butterfly results

Figures 5 and 6 show butterfly richness (figure 5) and diversity (figure 6) between the three sites. The Grove has the greatest species richness, significantly higher than that of Berryhead ($F = 5.693$, $P = 0.01$). The Grove also has the highest butterfly diversity which is significantly greater than Clennon ($F = 4.975$, $P = 0.015$).

**Figure 5: Mean butterfly species richness between sites; Grove, Berryhead and Clennon Hill.**

**Figure 6: Mean butterfly species diversity of sites July-September 2004. Grove, Berryhead and Clennon Hill.**

Butterflies and Plants

To investigate any relationships between plant and butterfly diversity Pearson correlation analysis was conducted for each site. Unexpectedly a significant negative correlation was found between plant diversity and butterfly diversity within the Grove (figure 7).

To investigate this result further all butterflies and their foodplants were tested for a relationship using Pearson correlation and negative correlations were found between both the gatekeeper and meadow brown butterflies and their food-plant *Festuca ovina* (Figure 8 and 9).
Figure 7: Relationship between plant diversity and butterfly diversity in each section of the Grove.

![Figure 7: Relationship between plant diversity and butterfly diversity in each section of the Grove](image)

Figure 8: Scatterplot showing mean % cover Festuca ovina against mean number of Gatekeepers seen in each section of the Grove.

![Figure 8: Scatterplot showing mean % cover Festuca ovina against mean number of Gatekeepers seen in each section of the Grove](image)
Figure 9: scatterplot showing mean % cover Festuca ovina against mean number of meadow browns seen in each section of the Grove.

Discussion

Berryhead, Clennon Hill and the Grove have similar vegetation types (both have CG3b communities within the National Vegetation Classification (Rodwell 1992). Clennon Hill has a greater species richness but plant diversity is similar across the three sites. Nevertheless detrended correspondence analysis shows that each site is floristically distinct. All three sites are therefore unique examples of calcareous grasslands within Torbay. All three have high butterfly species richness and diversity. It is therefore important that all three sites are conserved effectively for the plant and butterfly species they contain. Unexpected relationships were found between plant diversity and food-plants and the diversity and abundance of butterflies within the Grove. Plant diversity was negatively correlated with butterfly diversity and the abundance of the food-plant, *Festuca ovina* was negatively associated with the abundance of adult meadow browns and gatekeepers. This result may relate to the vegetation surrounding the grassland at the Grove site. Personal observation shows that these two butterfly species use adjacent bramble as a nectar source. Bramble is likely to outcompete the calcareous grassland species so areas with abundant bramble may have lower plant diversity and foodplants. If this is the case it shows the importance of a mosaic of habitat types for butterflies, containing both their larval foodplants along with areas of scrub for shelter and nectar.

The quadrats surveying the surrounding vegetation will enable this hypothesis to be investigated further.

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• Southwest Biodiversity Action Plan website. - www.swbiodiversity.org.uk


• UK Biodiversity Action Plan website. - www.ukbap.org.uk/habitats.asp
Intra and inter-variability in lemur diets across UK zoos.

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¹School of Biosciences, Cardiff University, ²Paignton Zoo Environmental Park, & ³Faculty of Life Sciences, University of Manchester

The provision of diets that meet the nutritional needs of captive primates is an essential part of good husbandry, contributing towards preventative health and the promotion of good animal welfare. Kaumanns et al. (2000) found considerable variation in the type and amount of foodstuffs provided to primates in European zoos; both intra- and inter-species. The extent of this variation may indicate that nutrition is poorly understood, or practised within zoos. In recent years the incidence of iron storage disease (haemosiderosis) in lemurs has become a topical issue, and so the nutritional monitoring of these species has generated particular attention.

In this study, empirical data were collected from zoo-housed lemurs in the UK to compare i) feeding practices, ii) intra- and inter-species differences in estimated nutritional content of consumed diets, using Zootrition (WCS, 1999), iii) the estimated dietary iron intake for these consumed diets. Several groups of lemurs were studied in different UK zoos (ring-tailed N=4, red ruffed N=3, black and white ruffed N=3, red fronted N=3). An intake study was conducted to estimate the total daily amount of food consumed, each trial gathered data during 5 consecutive days; 3 trials were undertaken with each lemur group. For each trial a representative sample of each food type fed was dried (N=3). The iron content of the dried food samples was measured using atomic adsorption spectroscopy and compared with published data.

The results collected demonstrated many differences between institutions. Feeding style varied, from providing food in dishes, to scatter feeding on the ground. Both intra- and inter species differences were observed with regards to the number and type of food items presented to the lemurs, the amount consumed and, therefore nutritional intake. Indeed, there appeared to be greater differences in the diets fed lemurs between zoos, relative to the different diets fed to different species within a zoo.

Interestingly, the iron levels in the food consumed diet appeared to be lower than that excreted by the lemurs. This suggested that there was a degree of sample contamination, either in the collection and analyses of the samples, or due to current husbandry techniques; this latter topic is currently being investigated.
The effect of playback of conspecific calls on the howling and affiliative behavior of a pair of black howler monkeys (Alouatta caraya) at Paignton Zoo
Elizabeth Carroll1,2, Kirsten Pullen1 & Andrew Priest1
1Paignton Zoo Environmental Park (Whitley Wildlife Conservation), 2Department of Biosciences, Cardiff University

Abstract
Paignton Zoo is home to a pair of black howler monkeys. Despite both being of reproductive age, they have never bred and are heard howling only extremely rarely. It has been suggested that their lack of howling could mean that, or be a result of the fact that they have not bonded properly as a pair.

We used the playback of recorded howler monkey calls to attempt to stimulate howling in the pair, and investigate any other behavioral changes. The calls used had previously been recorded from a past howler male at Paignton Zoo. When they were recorded, these calls were separated into social and territorial calls based on the behavior shown by the monkeys immediately before, during and after the call was given. Both types of call were played back from a laptop with speakers to the current pair of howler monkeys.

Playback was conducted in ten 3-day blocks of no playback (baseline), social call playback and territorial call playback. Calls were played back twice each day, in the morning and early afternoon. Instantaneous scan sampling in six 30-minute sessions per day was used to collect data on behavior and proximity. Key behaviors were recorded using all-occurrence sampling during the same sessions. The first and fourth sessions of each day immediately followed call playback.

Unfortunately, due to several factors that will be discussed, no statistically significant differences were found in behavior between baseline, social call playback and territorial call playback days. However clear indications of some effects were apparent. Although it was rarely heard, howling only occurred on playback days, and not on baseline days. Allogrooming by both animals was observed to occur substantially more during playback days than baseline, suggesting that playback might increase social bonding. Autogrooming by both monkeys was also higher on playback days, suggesting a possible increase in social tension in response to playback. Additionally, the pair were seen mating for the first time at the Zoo on one of the call playback days. As a first attempt to conduct call playback at Paignton Zoo this study successfully overcame technical difficulties and has shown that behavior is likely to be altered in a positive direction. However to make firm conclusions further studies are needed, minimizing data confounds and using better quality recordings, preferably of a range of different howls from proven breeders.

Introduction
Black howler monkeys are found in the forests of South America. (Wolfheim 1983). They are a sexually dimorphic species and their diet consists mainly of leaves, which are laden with secondary compounds. They spend between 62 and 80% of the day resting, digesting their bulky diet. (Kitchen 2004).

They live in groups of several males, females and young. Thorington, Ruiz and Eisenberg (1984) studied a wild Alouatta caraya population. Adult males of the same age were never found in a troop, suggesting that a dominance hierarchy exists (Thorington et al., 1984).

They are so called thanks to their characteristic howls, or roars, which are resonated and amplified by an enlarged hyoid bone in the throat (Kitchen 2004). Both males and females are known to howl. While making their most intense roars, howler monkeys exhibit a characteristic posture and head movements (Whitehead, 1995). Troop members may touch or even embrace one another at this time (Sekulic, 1982).

Howler monkeys are often heard to roar in the early morning. This ‘dawn chorus’ is thought to act as a possible positional cue, informing neighbouring troops of their whereabouts (Sekulic 1982).
Howling is also thought to play a role in territorial demarcation. It is stimulated by the detection of other troops or individuals nearby (Crockett & Eisenberg 1987; Sekulic & Chivers 1986). It can also provide information on troop composition, in particular the minimum number of males present in a troop. It cannot reliably convey the maximum number of males present because not all of the males participate in howling bouts at any one time (Crockett & Eisenberg 1987). Vocal rates and inter- or intra-display durations may allow individuals to assess their opponents (Clutton-Brock & Albon, 1979; Sekulic, 1982; Haimoff, 1983 cited in Sekulic & Chivers, 1986). High roaring rates might be costly therefore indicating a high fighting ability, and a low probability of intruders successfully invading the troop (Sekulic, 1982).

Howling is also less costly than physical fighting and is therefore usually used instead.

Paignton Zoo is home to a pair of black howler monkeys. The female, Millie was born the 26th January at Twycross Zoo, and has been at Paignton since the 18th May 2001. The male, Dunlin was born at Port Lympne Zoo Park on the 24th August 1999 and arrived at Paignton Zoo on the 19th December 2003.

Both of the pair were parent reared and should therefore possess the necessary social skills, and they are both of reproductive age. However since being together the pair have never bred and are rarely heard to howl either. It has been suggested that their lack of howling may mean that, or be a result of the fact that they have not properly bonded.

The howlers are housed in the centre of the zoo. They have both an indoor ‘house’ and an outdoor island, which is reached from the house by a rope bridge. Pileated and Lar gibbons are housed either side of the howler monkeys.

Another species in which vocalisation is important is the gibbon. Gibbon song is thought to function in territorial advertisement, mate attraction and the formation and maintenance of pair and family bonds (Geissmann 2002).

In an experiment at London Zoo, gibbon song was played back and used as enrichment for Lar gibbons (Hylobates lar) (Shepherdson et al 1989). It was found that the gibbons reacted to the playback and often responded with a duet of their own (Shepherdson et al 1989).

Aims

This experiment aimed to test whether, in a similar way to the gibbon playback enrichment, the playback of howler monkey calls would stimulate howling in the Paignton Zoo pair. It was hoped that this would cause increased bonding between the pair and so result in breeding. We also wanted to investigate whether playback has any other effects on behaviour, particularly affiliative behaviour which could indicate increased bonding, and possible ‘social tension’ behaviours which could be indicators of stress.

This is the first time that a playback experiment has been conducted at Paignton Zoo therefore was a chance to develop and test out the methodology which could then be improved and repeated in the future.

The Calls

The calls used were recorded in the summer of 2003 from the previous Paignton male, Aikei.

When the calls were recorded they were separated into social calls and territorial calls based on the behaviour displayed by the monkeys immediately before and after the call was given. One of each call type was chosen based on call quality, and was cleaned up and amplified tenfold using Adobe Audition.

The calls were played from a laptop with speakers, which were placed out of sight of the monkeys.
Hypotheses

We hypothesized that there would be differences in behavioural responses to the social call, the territorial call and no call (baseline).

It was predicted that the social call would cause an increase in social bonding behaviour such as allogrooming and social resting, and that the distance between the monkeys would decrease as they sought closer contact with one another.

It was predicted that the territorial howl would cause an increase in the monkeys' locomotion due to increased territorial patrolling behaviour. It was also thought that the distance between the monkeys would increase and that possible 'social tension' behaviours such as yawning, scratching and scent marking would also increase.

Finally, it was predicted that vocalisation would increase in response to both calls.

Method

Data collection took place over a 30-day period, between the 24th Jan and the 4th Mar 2005. The calls were played back at the start of the first and fourth 30-minute data collection sessions, so was played once in the morning and once early in the afternoon. Playback was conducted in 3-day 'blocks' of no call, social call and territorial call. The social and territorial call days were alternated to avoid a routine becoming established.

Every minute in 30-minute sessions, instantaneous scan sampling was used to record the monkeys' behaviour and their proximity to each other. There were six 30-minute sessions each day, each separated by 30-minute rest periods.

During these 30-minute sessions, all-occurrence sampling was used for key behaviours including howl bouts, scratching and yawning.

Notes were also made on weather conditions, the approximate number of public around the enclosure and whether or not a keeper was present.
Results

Female Behaviour.

Figure 1: A bar chart showing the percentage of time the female howler monkey (Millie) spent in each behaviour on days with no playback, social playback and territorial playback, sampled by instantaneous scan sampling.

Male Behaviour.

Figure 2: Bar chart showing the percentage of time the male howler monkey (Dunlin) spent in each behaviour on days with no playback, social call playback and territorial call playback, sampled using instantaneous scan sampling.
As we can see from figure 1 Millie’s locomotion increased on playback days, particularly social playback days. Her allogrooming also increased with playback, again with the largest increase being on social playback days. Autogrooming was seen to increase on playback days, this time with the largest increase being observed on territorial playback days. Howling was only ever observed on playback days but was a rare event, hence the large error bars.

Figure 2 shows that in Dunlin’s case locomotion actually decreased with playback. However, as predicted his allogrooming and autogrooming were both higher on playback days. Allogrooming in this case increases most on territorial playback days. Again, as with Millie, howling was only seen infrequently hence the large error bars.

Female Event Behaviour:

Figure 3: Bar charts showing the rate per hour of certain ‘key’ behaviours shown by the female howler monkey (Millie) on days with no playback, social call playback and territorial call playback, sampled by all-occurrence sampling. The data is split into two graphs because of scale differences.

Male Event Behaviour:

Figure 4: Bar charts showing the rate per hour of certain ‘key’ behaviours shown by the male howler monkey (Dunlin) on days with no playback, social call playback and territorial call playback, sampled by all-occurrence sampling. The data is split into two graphs due to scale differences.

As we can see from figure 3, Millie’s howl bouts were only ever observed on playback days, but were not seen very frequently so the error bars are very large. Millie was never seen to throat rub or body rub. While her scratching was seen to increase on playback days, another possible social tension
behaviour, yawning, was actually seen to decrease on social playback days, and remained about the same level as baseline on territorial playback days. Stretching, which was identified as a possible display behaviour, was seen to increase on playback days. However this behaviour was identified late and was open to interpretation with sunbathing so is inconclusive.

From the equivalent graph for Dunlin in figure 4, it can be seen once again that although howl bouts were only ever observed on playback days their infrequency of occurrence means that the error bars are extremely large. Throat rubbing and body rubbing were also seen fairly infrequently so the error bars here are quite large too. Scratching was seen to increase with both playback calls, while yawning saw a slight decrease with social playback and only a fairly slight increase on territorial playback days. As with Millie, stretching increased with playback but as this behaviour was identified late and is open to interpretation with sunbathing, these results are inconclusive.

**Statistical Analysis**

As the data was non-parametric, a Kruskal Wallis test was used to look for statistically significant differences in behaviour and proximity between the different playback calls.

Unfortunately despite apparent trends both observationally and graphically, the results were found to be no-significant (apart from male stretching behaviour, but the results for this behaviour were found to be inconclusive for reasons discussed above).

**Discussion.**

However there were several confounds affecting my data collection, which could account for this non-significant result. During my data collection period, the miniature railway track that runs directly past the howler monkey enclosure was being re-laid. This involved a lot of people being around and the use of heavy, noisy machinery at times. On at least one occasion the monkeys howled in response to this machinery.

In order for the calls to be loud enough for the monkeys to be able to hear it, it was necessary for them to be amplified. However with the equipment we were using this caused a significant amount of distortion to the calls. There were also a couple of occasions when the monkeys were at the back of the island and the wind was blowing in the wrong direction when it was not clear that the monkeys had actually heard the playback at all.

Aikei, the male whose call was used, was not a not a proven breeder. In fact he was Millie’s previous mate and when they were together they never bred. He was wild-caught when he was very young so it is possible that he never learnt to howl properly and that therefore there was something abnormal about his howl.

Sound windows are times of day during which a species is most likely to vocalize. This was not determined experimentally in this case. Anecdotal evidence alone was used to determine when the calls should be played.

Observationally and graphically, differences in behaviour were seen between the responses to the social call, the territorial call and no call, despite statistical non-significance.

The allogrooming did appear to increase on social call playback days, particularly in the female, suggesting that the social call does promote social behaviour. Allogrooming by the male, while it did increase in response to the social call from baseline, seemed to increase more when the territorial howl was played. This could be because he felt threatened by the possibility of a territorial male nearby so sought to strengthen the bond he had with Millie.
On territorial playback days, Millie’s locomotion was found to increase, although not as much as on social playback days. Dunlin’s locomotion actually decreased on playback days. It could have been that he was already in a key part of his territory when playback began and therefore did not want to move from that position.

We also saw a possible increase in social tension behaviours in response to playback, particularly of the territorial howl. Autogrooming, which included scratching was found to increase in both of the monkeys in response to playback. Scratching was one of the key behaviours observed using all-occurrence sampling, and it was found to increase the most in both animals in response to the territorial call, which is in line with our hypothesis. However yawning- another possible social tension behaviour- did not follow the same pattern. In fact it was found that yawning actually decreased on social playback days, increasing just slightly or remaining at about the same level as baseline in response to the territorial call. However work has not been done on social tension and self directed behaviours in this particular species so we cannot say which behaviours would be used in ‘preference’.

An increase in vocalisation behaviour was seen in response to playback. In fact howling was only seen on days when playback was used. However, howling was a rare event, hence the extremely large error bars so conclusions cannot really be drawn here.

Conclusions

Despite the fact that our results were non-significant, trends do indicate clear differences in behaviour between no call, social call and territorial call results.

Despite a lack of significant results, this was a successful first attempt at playback for Paignton Zoo, as technical difficulties were overcome and the monkeys did appear to show a reaction to the calls.

On one occasion, an attempted mating was seen just outside of a sample period on a social playback day. This was the first time mating has been observed between the pair and is therefore very exciting.

Future Work

The experiment needs to be repeated using a call of better quality preferably using better quality equipment. It would also be useful to use the howl from a proven breeder, in case there was anything abnormal about Aikei’s howl.

It would also be interesting to look at the effect of playback on the position of the howlers on the island, as this was not investigated in this experiment.

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References


Visitor Impact on the captive felid behaviour at Edinburgh Zoo
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Introduction

Zoo research in the past has focussed on the effects of the environment or feeding management on the behaviour and welfare of captive animals. Recent research has included assessments of the ‘visitor effect’ on captive animals. It is not known whether visitors affect behaviour of captive felids and, should an effect be shown, whether this has a negative or positive impact on captive felid welfare.

Hosey (2000, cited by Chamove, Hosey and Schaetzel, 1988) declared that it is often difficult to determine causality i.e. do zoo animals alter behaviour in response to active visitors or are zoo visitors accumulating at enclosures where animals are more active? This bi-directional relationship is known as the ‘visitor attraction model’. Primates have been seen to respond strongly, with aggressive displays, to human visitor presence. Chamove et al (1988) assessed the effects of zoo visitors on the social behaviour of 15 different primate species, concluding that visitors were a source of excitement to the primates, initiating great levels of activity and resulting in less intra-conspecific amicable/affiliative behaviour and higher levels of aggressive behaviour. It was concluded that visitors altered primate behaviour. In a study by Wood (1998), results showed that in the presence of higher weekend crowds behaviour such as foraging, object-use, grooming and play decreased (Wood, 1998).

It was suggested that buffering the animals from the sights, sounds and smells of humans might help reduce the ‘visitor effect’. Birke (2002, cited by Blaney and Wells, 2004) observed adult orang-utans using paper sacks to cover their heads more often during periods of high visitor density. It was concluded that both abnormal behaviour and aggression remained at a consistently lower level during all four weeks of the barrier condition; a positive result. The public received the camouflage net barrier positively; general perception was that the animals looked more exciting and less aggressive when the net was in place, plus highlighting to the visitors the importance of seeing the gorillas as wild animals rather than a faceless exhibit (Blaney and Wells, 2004).

It has been thought that cats are relatively slow in response to visitor activity, causing visitors to quickly lose interest when a response is not immediate. A paper by Margulis et al (2003) suggested that zoo animal activities influence zoo visitor reaction, not vice versa. This study found no effect of visitor presence/absence on felid activity levels and also concluded that visitor numbers and visitor interest were related to the level of activity seen in cat exhibits (Margulis et al, 2003).

Methods

This study was designed to identify the effect of visitor numbers and noise levels on the behaviour and enclosure use of five felids at Edinburgh Zoo (two Persian leopards, two snow leopards and a jaguar, all housed individually (Table 1)). The enclosures consisted of three concrete walled sides with a viewing window on the fourth side; visitors to the zoo were able to view the felid exhibits between 0900-1800 h each day through a glass window. The enclosures contained a substrate of vegetation and natural climbing structures such as logs, trees and raised platforms, plus various enrichment items including hanging ropes and inflatable balls. Observations of felid position within the enclosure, behaviour exhibited (using an ethogram, shown in Table 2), the number of visitors at the enclosure window and visitor noise levels (using an ordinal scale) were taken using an instantaneous scan sampling method at 30 second intervals over a period of four weeks. A timetable ensured that observations were spread across the day, ensuring that all individual felids were observed at intervals throughout the day.
TABLE 1: Edinburgh Zoo felids observed in this study (Edinburgh Zoo, 2004)

<table>
<thead>
<tr>
<th>Common name</th>
<th>Latin name</th>
<th>ARK ID</th>
<th>Sex</th>
<th>Age / years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persian leopard 1 (P1)</td>
<td>Panthera pardus saxicolor</td>
<td>870206</td>
<td>F</td>
<td>17</td>
</tr>
<tr>
<td>Persian leopard 2 (P2)</td>
<td>Panthera pardus saxicolor</td>
<td>98EB03</td>
<td>M</td>
<td>5</td>
</tr>
<tr>
<td>Jaguar (J)</td>
<td>Panthera onca</td>
<td>89KB05</td>
<td>M</td>
<td>14</td>
</tr>
<tr>
<td>Snow leopard 1 (S1)</td>
<td>Uncia uncia</td>
<td>91KA03</td>
<td>M</td>
<td>13</td>
</tr>
<tr>
<td>Snow leopard 2 (S2)</td>
<td>Uncia uncia</td>
<td>93BA01</td>
<td>F</td>
<td>13</td>
</tr>
</tbody>
</table>

TABLE 2: Ethogram of felid behaviour

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locomotion</td>
<td>Walking/running, not stereotypical behaviour</td>
</tr>
<tr>
<td>Feed/Forage</td>
<td>Eats food or drinks water</td>
</tr>
<tr>
<td>Stereotypy</td>
<td>Repetitive pacing along same path</td>
</tr>
<tr>
<td>Vocalisation</td>
<td>Animal makes sound with larynx</td>
</tr>
<tr>
<td>Grooming</td>
<td>Uses tongue to clean him/herself</td>
</tr>
<tr>
<td>Rest</td>
<td>Lying or sitting with eyes closed</td>
</tr>
<tr>
<td>Alert</td>
<td>Stands, sits or lays immobile with eyes open, showing no other behaviour</td>
</tr>
<tr>
<td>Not Visible</td>
<td>Observer cannot see animal</td>
</tr>
</tbody>
</table>

Observations were taken for five days, incorporating a weekend to ensure the study included both busy and quiet periods. A camouflage net was placed across enclosure windows on alternate weeks with two days adjustment period before observations continued (Figure 1). This net was used as a ‘buffer’ between visitors and felids, and results were analysed to determine whether this had an effect on any felid response to visitor numbers and noise (i.e. ‘visitor effect’).

Data was analysed using SPSS. Chi square tests were carried out to discover whether visitor numbers and visitor noise levels affected felid position in the enclosure and overall felid behaviour for both conditions (net/no net). Logistic regression analysis was then carried out to determine which of the variables camouflage net, visitor numbers and visitor noise had an impact on the most prevalent felid behaviours; stereotypy, rest and alert behaviour.
Figure 1: Photograph showing camouflage net in place over the window of a felid enclosure at Edinburgh Zoo (photograph by author, 2004).

Results

Visitor Numbers

It was determined that visitor numbers had a significant effect \((p<0.05)\) on \(P2, J, S1\) and \(S2\) and that the presence of camouflage netting made no difference to this effect. Rest/alert behaviours increased significantly with increasing visitor numbers at the enclosure window for \(S2\) and \(S1\).
- Rest \(S2\) \(Exp(B)=1.29, p=0.048\)
- Alert \(S1\) \(Exp(B)=1.40, p=0.035\)

Visitor numbers had a significant effect \((p<0.05)\) on overall felid behaviour in all felids, with camouflage netting making no difference to the effect on \(J, P2\) and \(S1\) but in contrast causing a change in the effect for \(P1\) and \(S2\). When investigated it was seen that with net present \(P1\) and \(S2\) showed no reaction to visitor numbers but when net was absent there was a significant change in overall behaviour of these individuals. This suggested that the net decreased the reaction of these individual felids to visitor numbers.

Visitor Noise Levels

Results showed that visitor noise levels had a significant effect \((p<0.05)\) on felid enclosure position of four out of the five felids \((J, P2, S1\) and \(S2\)). The presence of camouflage netting did not alter the reaction of \(P2\) and \(S1\) to visitor noise levels, however did affect the response of \(S2\).
- Net absent = significant change in enclosure position \((p=0.00)\)
- Net present = enclosure position unaffected \((p=0.178)\)

This implied that presence of a camouflage net decreased the effect of visitor noise levels on \(S2\) enclosure position.

It was determined that visitor noise levels had a significant effect \((p<0.05)\) on overall behaviour of all five felids and camouflage net altered this effect in \(P1\) and \(S2\).
- Net absent = significant change in overall behaviour \((p=0.00/0.00)\)
- Net present = overall behaviour unaffected \((p=0.328/0.151)\)

This implied that the presence of a camouflage net decreased the effect of visitor noise levels on overall behaviour of \(P1\) and \(S2\).
Camouflage Net

Results showed that the presence of camouflage net had a significant effect on P2 stereotypical behaviour (Exp(B)=0.441, \( p=0.028 \)), whereas all other felid stereotypical behaviour was unaffected by presence or absence of net. P1 and S1 rest behaviour was overall unaffected by net presence or absence. When net was present this also had a significant effect on rest behaviour of P2, J and S2:
- P2 decreased rest with net (Exp(B)=0.369, \( p=0.00 \))
- J, S2 increased rest with net (Exp(B)=1.664/7.664, \( p=0.00 \))

Alert behaviour was unaffected by net presence in P1, P2, J and S1, however the presence of camouflage netting did have a significant effect on S2 alert behaviour (Exp(B)=0.217, \( p=0.00 \)).

Discussion

The overall behaviour of felids at Edinburgh Zoo altered with increased visitor noise/numbers, an important result, proving that visitors do impact on captive felids at Edinburgh Zoo. It is important however to determine exactly the reaction visitors had on the individual animals in order to determine whether visitors had a negative or positive impact with respect to animal welfare.

Four out of five felids significantly changed their enclosure position in response to increased visitor noise/numbers. There could be several explanations for this – if the animals were moving away from the enclosure window, i.e. the area occupied by visitors, this could be through fear of the visitors, a perceived threat. Alternatively if the change in enclosure position is towards the enclosure window, this could be either due interest in the visitors or an attempt to threaten. If enclosure position was changing regularly this was often due to stereotypical pacing behaviour, which is a sign of stress in captive felids. Further studies carried out should determine exactly how the felids changed their enclosure position in response to visitors, therefore enabling a decision to be made as to whether visitors were acting as an interest factor or stressor.

Rest and alert behaviours significantly altered with visitor numbers, however again it is important to determine whether ‘rest’ and ‘alert’ are positive or negative behaviours. If rest is construed as a relaxed, and therefore positive, behaviour then a decrease in rest would be a negative reaction to visitors. It has been suggested, however, that rest could also be a defence mechanism shown by the felids. By ‘playing dead’ they are demonstrating submissive behaviour in presence of a perceived threat. It is necessary to investigate this further, in conjunction with other behaviours, in order to determine whether felids in this situation were reacting in fear or were simply relaxed with visitor presence. The same can be said for alert behaviour, which could be taken as a response of fear i.e. becoming alert to a threat/stressor, or as interested behaviour, simply watching visitors at the enclosure window. It is important to take into account the age of the individual animals, plus the length of time they have been in captivity, as an animal that has been in the same enclosure for ten years is quite likely to have become acclimatised to noise and visitor presence.

Visitors did not significantly affect stereotypical behaviour, which therefore means there is another reason why the felids displayed this particular behaviour. In order to improve the welfare of these individuals and reduce stereotypical pacing, it will be necessary to determine the cause of this.

The presence or absence of camouflage netting across the enclosure windows had a significant effect on felid behaviour and enclosure position. With no netting across the enclosure windows, there was a significant effect of visitors on felid behaviour and enclosure position however when net was in place there was no significant effect. Again it would need to be determined whether the behaviours displayed by the individual felids were positive or negative reactions to visitors before it can be determined whether camouflage net presence had a positive or negative effect. If rest behaviour is seen as a relaxed (therefore positive) behaviour then a decrease in this as a result of camouflage netting presence could mean that the netting is acting as a stressor. In the case of the jaguar, it appeared that visitor presence at the enclosure window was an interest factor, therefore preventing a clear view could cause stress in form of frustration to the individual.

In some cases it was clear that the presence of a camouflage net over the enclosure window had a positive effect. When camouflage netting was in place the young Persian leopard (P2) decreased display of stereotypical pacing behaviour. As this is a proven stress-related behaviour shown in captive felids, the presence of camouflage netting was a positive addition to the enclosure.
As always there were problems with this investigation which hopefully could be avoided in future studies. It was important to take into account that Edinburgh Zoo relies on the public for income. The big cats are an important attraction therefore it was decided that it would be best to only cover half of the enclosure window with the camouflage net. This could result in bias if an animal had a preferred sleeping spot which happened to fall behind the camouflage netting, however taking observations when netting was absent and comparing these with observations taken when netting was in place should have erased this bias as it was still possible to note changes in behaviour. There were concerns also that this concentration of netting on one side of the enclosure window would result in a concentration of visitors at the non-net side of the enclosure window, which could be stressful for the animals. This was not the case as visitors soon realised that it was still possible to see through the netting so spaced themselves out along the entire enclosure window.

Disturbance of the camouflage netting by the public was a recurring problem. In excitement to spot the animals inside the enclosures, the netting often became detached from the window or was lifted up by children to see more clearly. There were concerns that regular disturbance of the netting could enhance any stress related to visitors at the enclosure window and that the netting would be perceived by the animals as an object to be feared. Recommendation for future studies would be to ensure that netting is secured at both top and bottom of the enclosure window and cannot be detached or pulled down by the public.

Future studies on this topic could explore visitor impact on captive felids by investigating visitor behaviour (e.g. eating), appearance/dress, also whether various species’ react differently and whether being captive or wild-born affects response to visitors.

Until it is determined whether visitors have a negative or positive impact on captive felids there are a number of management practices which could be implemented to lessen any potential negative impact by visitors. As a camouflage net buffer lessened frequency of stereotypical behaviour in at least one of the individual animals, it may be beneficial to erect this on a permanent basis. This particular felid, the young Persian leopard (P2), already has an enclosure featuring high amounts of vegetation, deliberately planted by managers and a wooden barrier prevents visitor contact with the enclosure window. This enclosure adaptation demonstrates an understanding of this individual animal’s needs. As each species/individual is unique it could be necessary in the future to adapt enclosures to suit a particular need following behavioural study. This is time consuming and costly, however, therefore may be impractical.

Signs asking the public to please refrain from knocking on the enclosure window should be posted next to enclosures, posing as a reminder to the public. Most visitors understand that animals may become frightened as a result of their actions, however it is sometimes necessary to explain in a sign why knocking can be distressing to an animal. Over-excited children act without thinking but a well-placed attractive sign can help small children to learn not to knock on the glass.

The visitor attraction model implies that in many cases visitors are attracted to enclosures where animals are active. Visitors to large cat enclosures are often disappointed at felid inactivity and questions were asked such as “are they bored?” and misconceptions made such as “they are bored because the enclosure is too small”. Educational material placed next to the enclosure, explaining the natural inactivity of felids throughout the day, plus an explanation of current enrichment methods implemented to prevent boredom, could increase visitor satisfaction that a zoo understands the needs of the animals and prevent visitors from knocking on the glass in order to promote activity.

In summary, the conclusion was made that visitors affected the behaviour of all five felids at Edinburgh Zoo and that presence of a camouflage net barrier across enclosure windows mitigated the felids’ responses to both visitor numbers and noise levels. It is important to stress that this investigation does not determine whether the impact of visitors on captive felids has a negative or positive effect on the animals, with respect to animal welfare. This would need further investigation and time in this case did not allow for this amount of detail.

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References


The successful integration of an adult male chimpanzee in a multi-male, multi-female group.
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Abstract

We successfully introduced a 23-year-old male chimpanzee in an existing group within 68 days. We used a stepwise approach instead of direct introduction into the group. After the introduction, the new male clearly behaved as the alpha-male. During the six months following the introduction, only three serious fights occurred and involved the oldest resident male and the newcomer. Two hand-reared males showed few positive interactions with the new male, but all other animals showed various levels of acceptance. We discuss introduction procedures and factors that may have contributed to the success of this introduction. We suggest the introduction of adult surplus chimpanzee males into social groups should be considered a manageable alternative to a solitary life or euthanasia.

Introduction

The problem of surplus animals in captive populations has become increasingly important in the past decades, as breeding successes increase, while holding space is limited [Lindburg, 1991; Glatston, 1996]. Chimpanzees pose a very specific case in the surplus problem. Although the captive population consists of about as many males as females [Seal & Flesness, 1986], most institutions keep only one or two males per group, in order to minimize intra-group aggression. Therefore, many chimpanzee males are considered surplus. As chimpanzees have a long life span, adequate solutions for these males are needed, especially as ever more surplus animals are available from circuses, labs and private owners [Brent, 1998]. Some authors have suggested euthanasia as a reasonable and necessary animal management tool [Glatston, 1996; Graham, 1996; Lacy, 1991]. Yet, euthanasia is a “minefield from both ethical and political standpoints”, especially when great apes are involved [Glatston, 1996]. Since chimpanzees are very social animals, a solitary life is no option. The alternative is to place these animals into existing groups, or forming new ones.

However, the introduction of chimpanzees is a complex process that can often result in serious wounding, and in some cases even death [Adang et al., 1987; McDonald, 1994; Alford et al., 1995]. This is especially true for the introduction of male chimpanzees. In the wild, male chimpanzees are philopatric and behave hostile towards strange males, while females transfer between groups [Goodall, 1986]. The problems of hostility towards strange males and the confinements of captive environments make the introduction of male chimpanzees in groups that already contain males potentially dangerous [McNary, 1992; Brent et al., 1997].

The aim of this paper is to report on the successful integration of a fully adult male in a complex chimpanzee group that already contained four younger males. Various studies have evaluated introduction procedures, including adult males [Strachan, 1995; Brent et al., 1997; Fritz & Howell, 2001]. However, none deals specifically with the integration of a fully-grown, adult male in an existing multi-male, multi-female group. We feel that the publication of this case study contributes to the management and welfare of individual chimpanzees in captivity and that introducing an adult male chimpanzee in an existing group is, under certain circumstances at least, a feasible alternative to a solitary life or euthanasia.

Methodology

Background of the study Animals In 1987 the Royal Zoological Society of Antwerp (RZSA) started with the formation of a group of chimpanzees [Dupain, 1987]. Despite the various social backgrounds of the individuals the initial socialization went well. In 1992 an adult male killed one of the newborn infants during a moment of group excitement. It was then decided to move both resident adult males, Tony and Arnold, to the RSZA’s Wild Animal Park Planckendael, where they were housed together with a pair of older adult males. After Tony could be placed in another zoo and the two older males had died, Arnold remained alone in 2001. It was then decided to try to reintegrate this male back into the chimpanzee-group at Antwerp Zoo. The risk of infanticide was not longer considered important,
since breeding was no longer a goal in the Antwerp colony and all females were on oral contraceptives.

The composition of the group (Table 1) had changed considerably since Arnold’s departure nine years earlier. Four females had known Arnold (Shirley, Khaky, Judi, Maaike). The other group members were infants when Arnold left the group (Tambuzi, Tuma) or were added after Arnold’s departure (Chita, Jaimie, Siri). The situation of the main group was complex because many of the animals were hand-reared and some of them had been kept as ‘pets’ for many years. They were in some ways less sociable or less socially skilled than the others [see also Bloomsmith and Baker, 2001]. Especially the group’s two oldest males, Chita and Jaimie, were more focused on humans than on conspecifics. Unlike most chimpanzee males, they did not form close male-male coalitions and neither of the two males was able to dominate the females. Instead Shirley, a female that showed many masculine characteristics, had claimed the alpha position. As in other zoos with dominant females, there often was tension [e.g. de Waal, 1982] and we felt the introduction of a male that could take up the leading position would benefit to all animals. During the initial group formation and in the early years of the colony Arnold was a very socially skilled male [Dupain, 1987] and therefore seemed ideal to fulfill the role of alpha-male.

(See Table 1)

**Housing conditions**

The chimpanzee-section of the great ape house in the Antwerp Zoo consists of five indoor cages (two cages of 68m³ and three of 86m³), linked in series, that all have direct access to a 825m³ outside run (see figure 1). Inside and outside exhibits are bordered by glass. The top of the outside area is covered with wire mesh. In all enclosures climbing structures provide escape routes in case of conflicts. Except for when the outside enclosure was cleaned, or in case of illness of an animal, the nine chimpanzees were housed together continuously.

(See Figure 1)

**Introduction procedures**

Based on analysis of a large number of cases, Brent et al. [1997] concluded that in general introducing new animals directly into a group yields the highest success. They also noted however, that chances of success are lower when adult males are involved. Therefore we decided to apply a more gradual approach and to give each group member time to get acquainted with Arnold. We followed the sequence of phases advised in the Chimpanzee Husbandry Manual [McNary, 1992] and other publications [Fritz & Howell, 2001; Watts & Meder, 1996]. Even though all animals were housed together permanently, the keepers distinguished three subgroups when handling them (see table 1). We decided to take advantage of this information in the introduction process. It is important to keep in mind that our initial goal was to introduce an adult male in the group to perform the role of alpha-male. Therefore we provided Arnold with many bluffing materials, such as empty canisters and branches, in all phases. If possible, we did not give such materials to the group members. All of the apes were given displacement materials (Watts & Meder, 1996) such as scattered food and small branches and leaves, to distract attention and divert tensions.

Each phase was thoroughly evaluated and discussed - involving curators, ethologists, keepers, and veterinarians – to decide which steps should be taken next.

**Phase 1: Visual access.**

In this phase, the animals were given distal visual contact to get used to each other’s presence. Initially we planned to confront the chimpanzees individually, but it proved nearly impossible to separate some animals. Therefore we worked with combinations of animals, based on the knowledge of the different subgroups (see table 1). Arnold was in cage 5 while the other animals were given access to cage 3. Cage 4 remained empty during this phase. A removable screen was placed in this cage, which prevented the apes to see each other in between visual contact sessions and at night.
Phase 2: Limited tactile contact

Arnold was given free entrance from cage 3 to cage 4 adjacent to the group members in cage 5. Only a grille through which the chimpanzees could touch each other, separated Arnold from the other chimpanzees. Each day, five to seven 30-minute trials were performed in succession, depending on the opportunities to shift animals between enclosures in balanced combinations.

Phase 3: Physical introduction

Prior to this phase we gave Arnold plenty of opportunity to explore the outside area on his own. During physical introductions, the animals involved had access to the outside area and two cages (3 and 4), so that a single ‘loop’ was created, which gave animals the possibility to retreat, and keepers a chance to intervene more easily, if necessary. The animals that were not involved in introduction sessions were kept in cages 1 and 2 so that they could be split up in two smaller groups when tensions arose among them. When all animals were brought together in the final stage, the group had access to the outside enclosure and all inside rooms.

Based on experiences in the previous phases, one individual of each subgroup was chosen as a ‘starter’. When affiliative behaviors between Arnold and the chimpanzee ‘starter’ occurred regularly, the other animals from the subgroup were added in about three day intervals (see figure 2). Each day before a new physical introduction, the animal involved was given the chance to see through a grille how Arnold interacted with introduction partners. In this way we could also monitor this animal’s reactions. Only three dyadic introductions took place (three ‘starters’ of a subgroup). We deliberately limited this number, as we felt these animals were very nervous when separated and confronted with the new male on their own. The presence of a (calm) familiar individual facilitated introduction. As some authors have reported that violent attacks mostly occur at night [de Waal, 1996; Strachan, 1998], Arnold initially spent the nights alone, and the introduction partners remained with him from about 08.00 hours until 14.00 hours. As soon as an affiliative bond with a female was formed, this female stayed as his companion for the night, and joined the other introduction partners the next day.

Observation protocol

The first author monitored all distal visual contact sessions and all close visual contact sessions (see below), as well as each new physical introduction. Observations were based on a standard observation protocol and consisted of a combination of focal animal sampling [Altmann, 1974] of the new male Arnold, and all occurrence sampling [Altmann, 1974] of all agonistic and affiliative behaviors in the introduction partners. Observations were limited to three sessions of 30 minutes per day as soon as the same combination of animals remained together for consecutive days without animals being added, and five days after all animals were put together. In between these sessions, the keepers monitored the animals regularly.

Results

Phase 1: Visual access (day 2- day 4)

Arnold arrived in the great ape house on June 11, 2001 (day 1). From day 2 on, we gave animals in smaller subgroups visual access. All animals remained remarkably calm and were interested in Arnold, especially the females that had known him before. Arnold showed much positive interest as well, looking at the other chimpanzees intensively.

Phase 2: Limited tactile contact (day 4-day 16)

From day 4 on, we gave Arnold the possibility to enter cage 4, while small subgroups in various combinations were separated in cage 5. The provided enrichment proved very efficient. All animals enjoyed the scattered food, the more hesitant animals pretending to eat while peering at Arnold. Various animals used small sticks or wood wool to poke or touch Arnold. Generally, the sub-adults responded by quasi-aggressive behavior (as defined by Adang [1986]). All three adult males performed mutual displays. Again, three of the females that had been housed together with Arnold before showed affiliative behavior. Especially Judi and Maaike initiated play, grooming and copulations through the grille. Khaky also seemed interested, but as soon as she initiated contact, either Shirley or Khaky’s son Tambuzi reacted by attacking Arnold and/or Khaky. Shirley showed most aggressive behavior and was supported by Khaky. On day 11 and 12, we gave the whole group access to cages.
1, 2 and 3, as well as the outside area. All animals except Maaike joined in a group attack on Arnold through the grille. Arnold reacted fearful at first, then regained his confidence and displayed. After three sessions involving the whole group, in which Arnold not only showed increasing self-confidence and bluffing behavior, but also eagerness to maintain contact with several group members, we decided not to postpone the actual physical introduction any longer.

Phase 3: Physical introductions (day 16 – day 68)

Figure 2 gives an overview of the physical introduction phases and occurrences of aggression. As can be seen from this figure, on some days Arnold was left on his own. This was because animals could not be shifted in the desired combinations.

(See Figure 2)

We started on day 16 with the introduction of Chita's subgroup, since these animals had subdominant positions in the main group, and there were no strong social ties between them. Also, we wanted the group's oldest male Chita to be introduced first, as this encounter was potentially a dangerous one and was considered the most crucial step of the introduction. Although during previous phases there had been many ritualized aggressions between the two males, on the very first day Chita and Arnold played gently. On day 17 it became clear that Arnold was dominant over Chita, as Chita yielded when the two males were being fed. As mutual interest decreased rapidly, we decided to add Maaike to the two males as a social catalyst. She showed strong positive response to Arnold, expressed as playing, grooming and mounting, which confirmed her attitude in the earlier phases. Jaimie and Siri were then added on day 22 and day 25 respectively, without any problems. Jaimie avoided all contact with Arnold and stayed at great distance. Siri also kept her distance, although Arnold was very interested in her and tried to approach her. Given the positive reactions of all members of Chita's subgroup, it was decided to leave the animals in this combination for two weeks and then proceed with the introduction of Judi and her son Tuma.

On day 38, a few hours after the introduction of Judi, the first aggression occurred when we let Chita's subgroup join Arnold and Judi. Both Maaike and Judi, very docile before, now attacked Arnold and bit him several times in toes, fingers and head. Chita and Jaimie displayed in the vicinity. At first, Arnold behaved very submissive to all animals (yield, flee, grin and scream), but started a bluff display within an hour after the attack. We planned to give him some more time alone with Maaike and Judi. It was however necessary to add Tuma to this trio on day 39, because he showed signs of distress when separated from his mother. On day 44, when the rest of Chita's subgroup was added again, another conflict occurred. This time Arnold regained self-confidence sooner and started to display before the group attack was over. After this incidence we did not add any other individuals for another week, during which Arnold spent most mornings with these six individuals. Tuma preferred to stay with Shirley's subgroup on some days, and was thus not always present. In the afternoon, when Arnold was separated and the other animals rejoined the main group, Arnold tried to restore contact with the introduction partners. Therefore we let Maaike or Judi spend the nights with him. On day 49 a fight occurred that was not witnessed by observers. The keepers found Arnold grappling with Chita. Apparently the whole group then joined forces and attacked Arnold. Afterwards, several canine marks and scratches could be noticed on Chita's back, while Arnold showed only minor, superficial wounds. While Chita seemed uncomfortable, Arnold's self-assured attitude seemed untouched.

Next, we started to introduce Arnold to Shirley's subgroup. Given her strong, positive reactions in visual contact phases, Khaky was used as 'starter' on day 58. Khaky showed the highest level of affiliative behavior of all animals introduced to Arnold, but at the same time also attacked Arnold 'single-handedly' on several occasions, biting his hands and wrists. On day 60, Shirley and Khaky were placed with Arnold together. Corresponding to her behavior in earlier phases, Shirley's reaction to Arnold was aggressive at first, but she gained little support from Khaky. The next day (day 61) Tambuzi and Khaky were placed together with Arnold. Tambuzi provoked Arnold several times but, like Shirley, did not get any support from Khaky. We decided to introduce Maaike as a companion for Tambuzi, but she did not interact with Tambuzi, Khaky or Arnold. The next 7 days we started introducing several animals from the other subgroups to Arnold and Khaky, including Chita and Jaimie, in various combinations. Since the relationship between Shirley and Arnold was still rather tense, and given the problems between Shirley and Chita in the past, only the combination Shirley and Chita with Arnold was postponed. Then for three days, all animals except Jaimie and Chita formed a group together with Arnold, without any problems.
Finally, on day 68, Jaimie and Chita were added so that all ten chimpanzees were together for the first time. This caused a conflict, with many animals chasing Arnold, but no physical harm was done. It was clear that the group attacks were initiated by Siri and Shirley and were joined by Tambuzi. Chita and Jaimie kept their distance. The animals that had shown most positive interactions with Arnold in previous phases (Khaky, Judi, Tuma, and Maaike) did not join the attack, or only provided vocal support. Judi, who had a maximal genital swelling at the time, embraced Arnold several times during the attack. All calmed down very soon and after three days no more group violence occurred. During the following week all chimpanzees were allowed together from about 09.00 hours until 15.00 hours. While the rest of the group stayed together in the outdoor area, Arnold spent the rest of the afternoon and night with one of the females, most often Khaky or Judi, when they were in estrus. As all went well for a week, we no longer separated Arnold from the group and all animals spent day and night together without any problems.

Post introduction phase

In the 6-month period after day 68, Arnold clearly behaved as the new alpha-male and every individual currently shows submissive behavior (pant grunts, yielding) towards Arnold.

There have been some minor fights, and three more serious conflicts this period. The minor incidents usually start when Arnold, during one of his bluff-displays slaps or chases another chimpanzee. The enclosure provides enough escape routes however, and Arnold never shows signs of much distress. Usually, the whole group then chases Arnold and everything calms down very soon. Khaky, Judi and/or Maaike quickly present to Arnold as soon as the conflict has ended. The three more serious fights all involved the oldest resident male, Chita. Unfortunately keepers or ethologists did only witness one. On day 92 the first serious fight took place. Between 07.30 hours and 08.00 hours Shirley and Arnold sustained minor wounds on hands and in the face. Chita suffered the most serious wounding as he lost the digit of his middle finger on the right hand. When he rejoined the group at 16.00 hours, he immediately showed very submissive behavior towards Arnold (pant grunting, bobbing), which suggested that Arnold probably was at least partially responsible for Chita’s wounds.

A second serious fight occurred on day 165. This time Chita sustained a cut on his left hand. The third serious fight again involved Chita and Arnold on day 221 and was witnessed by the keepers. Arnold attacked Chita without any warning, whereupon the whole group gathered around the two fighting males. When Shirley joined in, the fight ended. Chita had cuts on his right hand, and the wounds on his left hand had reopened. After this third fight serious aggression generally ceased.

Discussion

We consider the integration of the adult male Arnold successful for the following reasons. Aggression was extremely low during the whole introduction process. Only six cases of contact-aggression occurred during the initial stepwise introduction, and three more serious fights broke out in the following six months. Most aggression resulted in minor wounds on fingers, toes and face. The most serious aggressive incidents occurred after the introduction had been completed and all animals spent day and night together. Although only one actual fight was witnessed it is suspected that Arnold was involved in the other two fights as well, given Chita’s subsequent fearful reactions to Arnold. These fights occurred infrequently and never truly escalated we did not feel this as a failure of the introduction process, as aggression is a truly integrated part of chimpanzee social life [Baker and Bloomsmith, 2001].

It is difficult to make general conclusions about the ‘secret of success’ in this introduction. Much depends of course on the individual characteristics of the chimpanzees involved [Fritz, 1994]. We feel however that a number of specific factors may have contributed. First, Arnold was not a complete stranger to the adult females of the group. In the wild, male chimpanzees often react violently to unknown adult females and have been known to kill them [Goodall, 1986]. The only female that had never seen Arnold before was Siri, a young adult. In the wild these females generally evoke less aggression from males [Goodall, 1986]. Moreover, all females were of high reproductive value for Arnold, since none of them had dependent offspring and all but one showed regular menstrual cycles. Secondly, none of the group’s males had had contact with Arnold before. It has been found that reintroduction of males to former male cage-mates after lengthy separations, often results in serious wounding [Strachan, 1995]. The third and probably most important factor is the age and character of all males involved. All resident males were younger than Arnold. Moreover, the group’s oldest resident males, Jaimie and Chita, seem to lack social ambition and did not have dominant positions in the
The two other males in our group, Tuma and Tambuzi are adolescents and probably young enough to accept the new leadership of Arnold. Arnold himself showed some remarkable social skills that, to our opinion, were helpful in the introduction. Arnold never showed violent behavior in the first contacts. On the contrary, he often behaved playful or even submissive. This was surprising, since it has been stated that when the new male behaves submissively during the first interactions, introductions are often less successful [Brent et al., 1997].

Although in general we followed introduction procedures as recommended by the species’ Husbandry Manual [McNary, 1992], we made alternative decisions on a number of points. First, we limited the number of one-to-one introductions, as we felt this caused stress in many animals. We rather worked with animals that affiliated with Arnold as social catalysts for introduction partners. In retrospect, the distal visual contact and restricted tactile contact phase proved to be very useful to monitor individual reactions to the newcomer. This also takes into account the findings of Brent et al. [1997], who found that there is less aggression among introduction partners when animals are introduced into small groups instead of one individual at a time. We were also cautious not to place too strong individuals or coalitions opposed to Arnold, before he had been able to assert his dominance and positive social relationships had been formed [see also Adang et al., 1987]. A second way in which we deviated from the general approach is that our tempo was fairly high. It has been suggested that prolonged visual and auditory contact of potential group members benefits group formation [Alford et al., 1995]. We did not want to habituate the chimpanzees to each other with grilles in between them, as we felt this would create a false idea of security. Looking back this interpretation seems to have been correct, as the animals that displayed most aggressive behavior to the new male during the close visual contact-phase, were also the most timid and frightened without the safety of the grille.

Conclusions

1. We were able to introduce the new male to all chimpanzees successively in a fairly short time, while first giving them at least some distal and close visual contact.
2. Given the necessary precautions and time, an adult male can successfully be integrated in an existing, complex group. This provides future prospects for at least a few ‘surplus’ chimpanzee males that in this way can still have a chance to an enriched social life, instead of spending their time alone behind the scenes or in some cases even facing euthanasia.

Acknowledgements

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Literature


Table 1: Chimpanzees at Antwerp Zoo

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Name</th>
<th>Gender</th>
<th>Year of birth (estimate)</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shirley’s subgroup</td>
<td>Shirley</td>
<td>f</td>
<td>(1978)</td>
<td>Lab²</td>
</tr>
<tr>
<td></td>
<td>Khaky</td>
<td>f</td>
<td>(1978)</td>
<td>Lab²</td>
</tr>
<tr>
<td></td>
<td>Tambuzi</td>
<td>m</td>
<td>1992</td>
<td>Zoo, mother reared (Khaky)</td>
</tr>
<tr>
<td>Judi’s subgroup</td>
<td>Judi</td>
<td>f</td>
<td>(1977)</td>
<td>Ex-pet</td>
</tr>
<tr>
<td></td>
<td>Tuma</td>
<td>m</td>
<td>1992</td>
<td>Zoo, mother reared (Judi)</td>
</tr>
<tr>
<td>Chita’s subgroup</td>
<td>Chita</td>
<td>m</td>
<td>(1986)</td>
<td>Ex-pet</td>
</tr>
<tr>
<td></td>
<td>Jaimie</td>
<td>m</td>
<td>1990</td>
<td>Zoo, hand-reared (Dublin)</td>
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<td></td>
<td>Maaike</td>
<td>f</td>
<td>(1985)</td>
<td>Wild</td>
</tr>
<tr>
<td></td>
<td>Siri</td>
<td>f</td>
<td>1991</td>
<td>Zoo, hand-reared (Antwerp)</td>
</tr>
<tr>
<td>New male</td>
<td>Arnold</td>
<td>m</td>
<td>(1978)</td>
<td>Lab²</td>
</tr>
</tbody>
</table>

1: individual had been housed together with Arnold until 1992.
2: individuals had been housed together at former facility
Figure 1: Schematic overview of the chimpanzee exhibit (outside enclosure and inside cages) at Antwerp Zoo.

Arrows mark passages. Barred areas are not accessible to the apes.

- : glass
- : wall
Figure 2: Overview of physical introductions.
Black boxes show individuals present with the new male.
White boxes show individuals not housed together with the new male.
White crosses mark individuals involved in contact aggression.
Stereotypical Surface Breaking Behaviour in Captive Rays (Genus: *Raja*) at the London Aquarium

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Abstract

Captive rays are often seen lifting the front of their bodies above the surface of the water in public aquaria. Some believe this behaviour is an expression of curiosity, and this view is exploited in ray touch pools. The converse view is that “surface breaking behaviour” (SBB) is a stereotypy, i.e. a repetitive, invariant behaviour with no obvious function, and therefore poses welfare implications. It has been proposed that the behaviour is an adaptation to an unnatural surface feeding method. The aim of this study was to question both views. I investigated whether SBB in five species of *Raja* rays at the London Aquarium correlated with time of day and number of human visitors present, and how SBB performance differed between two tanks. Frequency, total duration and mean duration of SBB were investigated, as well as the proportion of rays in the tank performing the behaviour. My data did not support the feeding hypothesis, because the time of day patterns did not relate to feeding times, and the rays were fed from the bottom of the tank. The time of day patterns may have been due to circadian rhythms, possibly relating to a behaviour in the wild. SBB occurrence was independent of the presence of human visitors. The behaviour was more prevalent in the small ray touch pool than in the large Atlantic tank; this may reflect differences in enrichment. Thus predispositions and environment seem to interact in SBB development. Further work is needed to study SBB ontogeny, to investigate its performance in wild rays, and to analyse the welfare implications of this behaviour.

Introduction

Stereotypies are diverse behaviour patterns that are repetitive and invariant, with no obvious function (Mason 1991a). Performance of stereotypical behaviour is associated with captivity, restraint, lack of stimulation, and unavoidable stress. Stereotypies are thought to develop when animals are faced with insoluble problems (Stolba *et al.* 1983). Thus, stereotypies can be considered measures of poor animal welfare (Broom 1983). Mason and Latham (2004) found that 68% of the situations that caused stereotypies also decreased welfare. They concluded that, although more research is needed, stereotypies should always be taken as warning signs of potential suffering, but not as the sole index of welfare.

Casamitjana (2004) conducted an independent study of public aquaria in the United Kingdom, and the welfare of their captive fish. He proposed a “unified theory of fish stereotypy”, wherein different types of stereotypical behaviour are simply different manifestations of similar problems. He identified seven types of fish stereotypy, of which the most prevalent form in United Kingdom public aquaria in 2004 was surface breaking behaviour (Figure 1). This behaviour is most common in *Raja* rays (Figure 2).
Relative frequency of types of abnormal behaviour found in UK public aquaria in 2004

- SBB (33%)
- ITB (20%)
- Pacing (20%)
- Flashing (18%)
- Circling (6%)
- Spiralling (2%)
- Other (1%)

Figure 10 Relative frequency of types of stereotypical behaviour found in United Kingdom public aquaria during 2004. SBB = surface breaking behaviour, ITB = interaction with transparent boundaries. N = 320. Data from Casamitjana (2004).

Relative frequency of observed SBB in UK public aquaria

- Raja rays (60%)
- Dogfish (20%)
- Smooth hound (7%)
- Spurdog (1%)
- Sole (1%)
- Leopard shark (1%)
- Hornsharks (2%)
- Skates (2%)
- Plaice (3%)
- Stingrays (3%)

Figure 11 Relative frequency of observed surface breaking behaviour (SBB) in UK public aquaria in 2004, per type of fish. SBB occurs in 71% of UK public aquaria. N = 107. Data from Casamitjana (2004).

Surface breaking behaviour (SBB) was defined by Scott et al. (1999a) as: “lifting of the front of the body so that the snout, eyes and sometimes the respiratory spiracles are raised above the level of the water”. It is the repetitive and invariant nature of the behaviour that defines it as a stereotypy; an individual ray often repeats SBB in a single bout of behaviour.

Contention exists concerning the reasons for SBB performance. Some believe that it is an expression of “curiosity”, and that the rays seek attention from human visitors. Ray touch pools exploit this view by allowing visitors to touch the animals (Figure 3). These tanks are found in 16% of UK public aquaria (Casamitjana 2004). The converse view is that SBB is “abnormal” and associated with captivity, and thus any welfare implications should be determined.

Scott et al. (1999a) investigated whether SBB occurrence in the ray touch pool at the Scarborough Sealife Centre correlated temporally with the feeding schedule of captive rays fed from the water surface. They found that SBB incidence peaked around the feeding period. They subsequently added a feeding stimulant one hour prior to the usual feeding time, which led to an increase in the incidence of SBB. The authors concluded that SBB was a non-random, appetitive behaviour, related to foraging. They hypothesised that SBB developed as an adaptation to the unnatural surface feeding method.
In a further experiment, Scott et al. (1999b) modified the rays’ feeding regime, so that food was delivered to the tank floor. They found that rays reduced the frequency of SBB, and fed more from the bottom of the tank, following this modification, but the behaviour did not disappear completely.

Figure 12 A child being encouraged to touch a thornback ray performing surface breaking behaviour (ray pool, London Aquarium).

The aim of this study was to investigate the views discussed above: the effect of human visitors on SBB performance, and how the behaviour correlates with time of day and time in relation to feeding. Scott et al. (1999a) performed their study within a relatively narrow time window (10:45 to 15:15). To investigate diurnal patterns more fully, I collected data during a wider time window (09:30 to 18:00). From my preliminary observations, the rays appeared to perform SBB more in the morning and late afternoon.

I also compared SBB performance in two different tank environments: the small ray touch pool and the large, staff-restricted Atlantic tank. It seemed that SBB was performed more in the ray pool than in the Atlantic tank, and I wished to investigate this further, as enclosure environment has been shown to affect performance of stereotypies in other species (Ödberg 1987; Wiedenmayer 1996).

Method

Study area

All observations were performed at the London Aquarium. The first study location was the ray touch pool, a display tank where people were encouraged to touch the animals (Figure 3). It had an approximate depth and volume of one metre and 40,000 litres, respectively. Data were collected every day between 14/12/2004 and 17/12/2004, inclusive. The animals were fed daily by staff at 11:30, using a pole with a grasping end to deliver chopped squid and sand eels to the bottom of the tank.

The second study location was a staff-restricted platform above the Atlantic tank. The animals were only exposed to the public through windows. The tank had a depth of 16 metres and a volume of 1,500,000 litres, approximately. Data were collected every day between 09/01/2005 and 13/01/2005, inclusive. The animals were fed by SCUBA divers at the bottom of the tank on Mondays, Wednesday and Fridays, at 12:10, with an additional surface feed on Sundays. The numbers of different ray species are shown in Table 1. Also present were eagle rays, lesser spotted dogfish, and many species of teleost fish.

The subjects were aged approximately 5 years old or higher. They had been bred and raised in captivity, in a small tank in the Quarantine room of the London Aquarium, and had then been transferred either to the ray pool or to the Atlantic tank.
Table 3 Numbers of individual rays of different species and sex present in each tank.

<table>
<thead>
<tr>
<th>Ray species</th>
<th>Number of individuals</th>
<th>Ray pool</th>
<th>Atlantic tank</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Thornback, Raja clavata</td>
<td>4</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Spotted, Raja montagui</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Undulate, Raja undulata</td>
<td>-</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Painted, Raja microcellata</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Blonde, Raja brachyura</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>10</td>
<td>22</td>
<td></td>
</tr>
</tbody>
</table>

Focal watches and scans

Two-minute focal watches were performed (425 in the ray pool, 426 in the Atlantic tank). To avoid bias, a random order of focal individuals was chosen before a set of focal watches was performed. The people around the ray pool were counted immediately before each observation; this was not applicable to the Atlantic tank.

Surface breaking behaviour (SBB) was defined as having occurred when the ray lifted its snout clear above the water surface (Scott et al. 1999a), as in Figure 4. The duration of each SBB occurrence was noted. The numbers of occurrences were added together to give the frequency, and the durations of each occurrence were added together to give the total duration. The total duration was divided by the frequency to give the mean duration of SBB occurrence (focal watches with frequencies of zero were discounted).

Scans were performed at 15 minute intervals (97 in the ray pool, 87 in the Atlantic tank). The rays performing SBB were counted; these values were divided by the total number of rays in the tank to give the proportions of rays performing SBB. Proportions were normalised by arcsin square root transformations.

Statistical analysis

Two sets of general linear models were performed using Minitab 13.32; first, using the ray pool data, and the predictors time of day and number of people, and second, using the data from both tanks, and the predictors time of day and tank. Four different responses were studied:

1. Frequency
2. Total duration
3. Mean duration
4. Proportions of rays performing SBB
The data of the first three responses were from the focal watches, and the fourth from the scans. A linear mixed model was initially fitted on the ray pool data using GenStat 6.1, with fish identity incorporated as a random factor, but it was not significant (p > 0.5). Therefore identity was not incorporated into the subsequent general linear models. Species and sex were incorporated when analysing the focal watch data, but not the scan data, from which only the overall proportion of rays performing SBB was of interest.

All significant interactions from the general linear models were presented, along with all the factors that were not involved in the significant interactions. Regression lines were plotted to illustrate the effects of time of day and number of people, and box-plots were plotted to illustrate significant effects of tank and species. Where interactions occurred, separate graphs were plotted for the different factors.

Results

Frequency

There was a significant interaction between the effects of species and squared time of day on the frequency of SBB occurrence, and there was a significant tank effect (Table 2). Overall, frequency was higher in the ray pool (mean 1.41 ± 0.12) than in the Atlantic tank (mean 0.61 ± 0.10). Thornback rays exhibited a pronounced pattern with time of day in the ray pool, with peaks occurring in the morning; in contrast, while there was a similar, significant pattern in the Atlantic tank, it was much less marked (Figure 6). Thornback rays had higher frequencies than any other species. Tank environment had no effect on spotted rays or the undulate ray, and neither species showed a relationship between frequency and time of day. The ray pool painted ray had higher frequencies in the morning than in the evening. In contrast, only one SBB occurrence was detected in the Atlantic tank painted ray. No SBB was detected in the blonde ray. There was no effect of sex, or of the number of people present around the ray pool (Figure 5).

<table>
<thead>
<tr>
<th>Source</th>
<th>Results of general linear model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ray pool</td>
</tr>
<tr>
<td>Species – time squared interaction</td>
<td>F_{3,408} = 5.39, p = 0.001</td>
</tr>
<tr>
<td>Number of people</td>
<td>F_{1,408} = 2.27, p = 0.132</td>
</tr>
<tr>
<td>Tank</td>
<td>-</td>
</tr>
<tr>
<td>Sex</td>
<td>F_{1,408} = 2.07, p = 0.151</td>
</tr>
</tbody>
</table>

**Bold** value indicates a significant result.

Figure 14 Regression line showing the non-significant relationship between the number of people present around the ray pool and frequency of surface breaking behaviour (SBB) for all species; F_{1,423} = 2.01, p = 0.157, R-Sq(adj) = 0.2%.
Figure 6 Regression lines showing the quadratic relationships between time of day and frequency of surface breaking behaviour (SBB) for: (a) ray pool thornback rays, $F_{2,212} = 10.66, p < 0.001, \text{R-Sq(adj)} = 8.3\%$; (b) Atlantic tank thornback rays, $F_{2,250} = 3.77, p = 0.024, \text{R-Sq(adj)} = 2.2\%$; (c) ray pool spotted rays, $F_{2,121} = 0.27, p = 0.764, \text{R-Sq(adj)} = 0.0\%$; (d) Atlantic tank spotted rays, $F_{2,94} = 1.16, p = 0.318, \text{R-Sq(adj)} = 0.3\%$; (e) ray pool undulate ray, $F_{2,39} = 1.48, p = 0.240, \text{R-Sq(adj)} = 2.3\%$; (f) Atlantic tank undulate rays, $F_{2,45} = 0.32, p = 0.726, \text{R-Sq(adj)} = 0.0\%$; (g) ray pool painted ray, $F_{2,41} = 5.12, p = 0.010, \text{R-Sq(adj)} = 16.1\%$; (h) Atlantic tank painted ray, $F_{2,21} = 0.41, p = 0.671, \text{R-Sq(adj)} = 0.0\%$. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. 
Total duration

There was a significant interaction between the effects of species and squared time of day on total duration of SBB, and there was a significant tank effect (Table 3). Overall, total duration of SBB was longer in the ray pool (mean 11.99 s ± 1.22) than in the Atlantic tank (mean 4.67 s ± 0.74). Thornback rays were the only species whose total duration of SBB was significantly affected by time of day and by tank (Figure 6). They spent more time breaking the surface in the morning, and this pattern was more pronounced in the ray pool.

The number of people around the tank had no effect on total SBB duration. There was a weak effect of sex in the ray pool (means of males 13.32 s ± 1.90, and females 10.65 s ± 1.54), probably because four out of the five thornback rays were male, and this species had the longest total durations of SBB.

<table>
<thead>
<tr>
<th>Source</th>
<th>Results of general linear model</th>
<th>Ray pool</th>
<th>Both tanks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species - time squared interaction</td>
<td>$F_{3,408} = 4.70, p = 0.003$</td>
<td>$F_{4,835} = 4.58, p = 0.001$</td>
<td></td>
</tr>
<tr>
<td>Number of people</td>
<td>$F_{1,408} = 2.30, p = 0.130$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tank</td>
<td>$F_{1,835} = 11.25, p = 0.001$</td>
<td>$F_{1,835} = 2.65, p = 0.104$</td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td>$F_{1,408} = 4.73, p = 0.030$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Bold** value indicates a significant result.
Mean duration

There was a weak effect of time of day on the mean duration of SBB occurrence in the ray pool, independent of species (Table 4). Slight peaks occurred in the morning and late afternoon (Figure 7). There were no significant effects of time of day or of tank when the data from both tanks were analysed together. There were no effects of sex, or of the number of people. Species effect was not significant in the ray pool, but it was significant when the data from both tanks were analysed together (Figure 8). Mean duration was longest for thornback rays (mean 10.61 s ± 0.88).

Table 6 Results of the general linear models for mean duration of an occurrence of surface breaking behaviour.

<table>
<thead>
<tr>
<th>Source</th>
<th>Ray pool</th>
<th>Both tanks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time squared (hours²)</td>
<td>F₁,₁₃₆ = 4.35, p = 0.039</td>
<td>F₁,₁₉₉ = 3.53, p = 0.062</td>
</tr>
<tr>
<td>Number of people</td>
<td>F₁,₁₃₆ = 0.79, p = 0.376</td>
<td>-</td>
</tr>
<tr>
<td>Tank</td>
<td>-</td>
<td>F₁,₁₉₉ = 0.01, p = 0.940</td>
</tr>
<tr>
<td>Species</td>
<td>F₃,₁₃₆ = 0.97, p = 0.410</td>
<td>F₃,₁₉₉ = 3.25, p = 0.023</td>
</tr>
<tr>
<td>Sex</td>
<td>F₁,₁₃₆ = 0.26, p = 0.614</td>
<td>F₁,₁₉₉ = 0.09, p = 0.767</td>
</tr>
</tbody>
</table>

**Bold value** indicates a significant result.
Figure 16 Regression line showing the significant quadratic relationship between time of day and mean duration of an occurrence of surface breaking behaviour (SBB) in the ray pool, for all species; $F_{2,150} = 2.57$, $p = 0.080$, $R^2(\text{adj}) = 2.0\%$.

Figure 17 Box-plots showing how ray species (both tanks) differed in mean duration of an occurrence of surface breaking behaviour (SBB). B = blonde ray ($n = 0$), P = painted ray ($n = 27$), S = spotted ray ($n = 36$), T = thornback ray ($n = 138$), U = undulate ray ($n = 9$). The box represents the middle half of the data, the whiskers extend to the extreme values and the line inside the box represents the median. Individual points with values outside these limits (outliers) are plotted with asterisks.
Proportion of rays

The proportion of rays performing SBB was highest in the morning, decreased in the early afternoon and increased in the late afternoon (Figure 9). There was no relationship between proportion of rays and number of people around the ray pool (Table 5). There were no interactions between the factors. There was a significant tank effect (Figure 10), with the ray pool (mean 0.15 ± 0.01) having a greater proportion of rays performing SBB than the Atlantic tank (mean 0.06 ± 0.01).

Table 7 Results of the general linear models for the proportions of rays performing surface breaking behaviour. Proportions were normalised by arcsin square root transformations.

<table>
<thead>
<tr>
<th>Source</th>
<th>Ray pool</th>
<th>Both tanks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time squared (hours^2)</td>
<td>F_{1,92} = 5.30, p = 0.024</td>
<td>F_{1,180} = 5.66, p = 0.018</td>
</tr>
<tr>
<td>Number of people</td>
<td>F_{1,92} = 0.68, p = 0.411</td>
<td>-</td>
</tr>
<tr>
<td>Tank</td>
<td>-</td>
<td>F_{1,180} = 20.31, p &lt; 0.001</td>
</tr>
</tbody>
</table>

**Bold value** indicates a significant result.

Figure 18 Regression line showing the significant quadratic relationship between time of day and the proportion of rays in the ray pool performing surface breaking behaviour (SBB) for all species; F_{2,94} = 4.85, p = 0.010, R-Sq(adj) = 7.4%. Proportions were normalised by arcsin square root transformations.

Figure 19 Box-plots showing the difference between the ray pool (n = 97) and Atlantic tank (n = 87) in proportions of rays performing surface breaking behaviour (SBB). Proportions were normalised by arcsin square root transformations.
Discussion

Time of day and feeding regime

Surface breaking behaviour (SBB) frequency and total duration were highest in the morning, 1.5 hours before feeding time, then decreased almost exponentially. Mean duration of SBB and proportion of rays performing SBB increased again in the late afternoon. Thus feeding time and peak SBB incidence did not coincide, and the patterns I found in relation to feeding time did not match those of Scott et al. (1999a). Our studies also differed in the feeding method: the rays at the Scarborough Sealife Centre were fed from the surface, whereas the rays in the London Aquarium were fed from the bottom.

That Scott et al. (1999b) managed to reduce SBB performance by altering the feeding method is not conclusive evidence that surface feeding causes SBB. The authors did not eradicate the behaviour fully. Feeding method may only have been a confounding variable, which exacerbated the stereotypy once developed. Controlled comparisons are needed between tanks where the rays are surface-fed and ones where they are bottom-fed. It is probable that any differences would simply be a matter of degree, which would implicate other factors. In addition, feeding time should be varied experimentally.

Scott et al. (1999a) were correct in concluding that the stereotypical temporal patterns suggest SBB is a non-random behaviour. These patterns may be explained by an innate circadian rhythm, independent of feeding time. This could be tested by light/dark cycle shift experiments. The rhythm may relate to a natural behaviour from which the stereotypy was derived, or could be associated with a stimulus, other than feeding, that contributed to its development. Circadian rhythms in stereotypes have been noted in other species, e.g. apomorphine-induced stereotypes of Wistar rats (Nakano et al. 1980), and stereotypies associated with mental retardation in humans (Brusca 1985).

It is not inconceivable that circadian patterns of SBB reflect natural arousal and activity levels. Unfortunately it was not possible to control for these factors, but they were cancelled by calculating the mean duration of SBB. Interestingly, its relationship with time of day reflected that of the proportion of rays performing SBB. It is also possible that Scott et al.’s results (1999a) reflected levels of activity; they did not control for this.

Tank environment and presence of human visitors

The fact that the same temporal patterns were seen in the Atlantic tank as in the ray pool, but to a smaller degree, suggests two possibilities. First, the ontogeny of the stereotypy is innate, possibly relating to a behaviour in the wild. The fact that SBB is so widespread among aquarium rays supports this idea (Casamitjana 2004); in addition, my data showed that certain species were predisposed to perform SBB. Second, the eliciting stimulus was experienced in both tanks, but less so in the Atlantic tank. These ideas are not mutually exclusive. Thus it is probable that there was an interaction between environment and predispositions.

It seems unlikely that the differences between the two tanks were caused by simple differences in volume-induced probability of being near the surface. Personal observations revealed that certain individuals seemed to consistently spend more time at the surface of the Atlantic tank than would be expected; also, when not surfacing, the rays tended to stay at the bottom of the tank.

In an under-stimulating environment, the sensory input provided by stereotypical behaviour may be rewarding (Mason 1991a). Paradoxically, stereotypies are also performed in over-stimulating environments, indicating that they may sometimes be used to reduce arousal (Delius 1967). As the number of people present around the ray pool had no effect on SBB occurrence, the behaviour was not a manifestation of the rays’ reactions to visitors and thus not a response to such over-stimulation.

Therefore it is either the effect of enrichment, in terms of interaction with other fish and with objects, or of enclosure size, that may explain the differences between the tanks. The Atlantic tank had a much larger volume than the ray pool, and contained more species of fish and a more diverse range of objects. Experiments with bank voles, Clethrionomys glareolus (Ödberg 1987), and gerbils, Meriones unguiculatus (Wiedenmayer 1996), have shown that enrichment has a greater effect than enclosure size on the development of stereotypies in these animals. It is plausible that the same is true for the ontogeny of surface breaking behaviour, and that under-stimulation is an eliciting factor. This is also supported by the fact that enrichment has been shown to improve welfare in captive octopuses (Wood and Wood 1999).
Conclusions

It is unknown whether SBB occurs in wild Raja rays; however, studies of migratory behaviour of thornback rays in the southern North Sea have shown that rays tend to occupy very shallow water during the spring, sometimes within one metre of the surface (Hunter, personal communication; Hunter et al. 2004). It is therefore possible that SBB is performed in the wild. If SBB is associated with migratory behaviour, it may be involved in activities such as mating or parturition. Breaching of the water surface has been observed in wild manta rays (Manta birostris). Theories regarding this behaviour have included parturition, parasite removal, and social behaviour (Ishihara and Homma 1995), but these have largely been based on anecdotal evidence (Vas 2005). Clearly, further research into the behaviour of wild rays is needed.

It is inevitable that, in an observational study such as this, the results will not be unambiguous. However, two facts are strikingly clear: my data did not support Scott et al.’s foraging hypothesis (1999a), and SBB occurrence was independent of the presence of human visitors and therefore not an expression of curiosity towards people. Instead, the eliciting factors for SBB appear to be heterogeneous. First, some species seem to be predisposed to performing the behaviour. Second, temporal patterns of SBB may follow an innate circadian rhythm. Third, manifestation of the behaviour seems dependent on enclosure enrichment. These eliciting factors may relate to a behaviour in wild rays. Further experiments are needed to confirm their effects on SBB development. In addition, physiological measurements such as heart rate and glucocorticoid levels should be investigated to determine whether SBB is associated with stress, and to gain further insight into the welfare of captive rays.

Acknowledgments

I am very grateful to my project supervisor, Andrea Manica, Dept. of Zoology, University of Cambridge. I also thank Liz Downey and the rest of the Education staff at the London Aquarium. All photographs were taken by the author.

References


Can Environmental enrichment compensate for not providing carcasses or live prey?
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¹Mammal Department and ²Science Department, Paignton Environmental Park (Whitley Wildlife Conservation Trust)
Contact correspondence vicky.melfi@paigntonzoo.org.uk

Abstract

This study aimed to evaluate the use of both carcass feeding and environmental enrichment for captive carnivores, and evaluate the effectiveness of both methods in eliciting natural feeding behaviours. A review of all published papers on carnivore enrichment or the use of carcass provision was completed. Information gained included the species, type of enrichment/carcass provision, and behaviour elicited.

The results showed that environmental enrichment and carcass provision alone could not encourage all feeding behaviours but together they could. The results also showed that there is a paucity of research in this area, as only 22 published papers were found, and research that does exist is biased towards felids, 18 of the 22 papers concerned felids.

In conclusion it is suggested that the optimum feeding regime for captive carnivores would comprise both carcass provision and environmental enrichment. However there is still need for further research especially concerning the carnivore species for which little data exists, such as the canids and viverrids.

Introduction

The provisioning of captive animals is an extremely important part of animal husbandry as in the wild animals will spend a large amount of their time budget involved in feeding and foraging behaviours and it is the responsibility of animal managers to replicate these behaviours in the captive situation.

Carnivores are defined as any animal that is flesh eating, and many will catch live prey while others scavenge. Lindburg (1998) defined four main feeding behaviours that are exhibited by carnivores these are;

- Locating
- capturing
- killing
- consumption

\{ \text{Foraging} \}
\{ \text{Processing} \}

For the purposes of this study we have also split these categories further into specific common behaviours that are exhibited by carnivores (Table 1).
Table 1. Common feeding behaviours exhibited by carnivores

<table>
<thead>
<tr>
<th>Locating</th>
<th>Capturing</th>
<th>Killing</th>
<th>Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stalking</td>
<td>Chasing</td>
<td>Killing bite</td>
<td>Preparing e.g. plucking</td>
</tr>
<tr>
<td>Crouching</td>
<td>Swiping</td>
<td>Dragging</td>
<td>Caching</td>
</tr>
<tr>
<td>Pouncing</td>
<td>Biting</td>
<td>Carrying</td>
<td>Possessiveness</td>
</tr>
<tr>
<td>Sniffing</td>
<td>Holding</td>
<td>Licking</td>
<td>Eating</td>
</tr>
<tr>
<td>Flehmen</td>
<td>Pushing*</td>
<td>Eating</td>
<td>Preparing e.g. plucking</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
*Clawing/striking prey  
Mounting prey*

*These behaviours were observed in the tigers at Paignton zoo environmental park*

The ‘killing’ behaviours cannot be replicated in captivity as we cannot provide live prey due to legal obligations. The Secretary of States Standards on Modern Zoo Practice (DEFRA 200) states that:

‘Although the Protection of Animals Acts 1911 to 1964 **do not prohibit the feeding of animals with live prey**, the live feeding of vertebrate prey should be **avoided save in exceptional circumstances**, and then only under veterinary advice. Where any live prey must be used, its welfare must be considered as well as any potential injury which might be caused to the predator’

Therefore in the captive situation there is more opportunity to encourage the other foraging and feeding behaviours. Providing carcasses has been used in some studies to elicit these behaviours, and has met with a good degree of success (Houts, 1999). However there is still some controversy over using carcasses due to the possible health risks it may incur, therefore until these issues are resolved we must investigate all possible ways of increasing these feeding behaviours including enrichment methods.

This study aimed to review all investigations to date, where carcasses or environmental enrichment was used to elicit any of the feeding behaviours mentioned in table 1. On the basis of findings it was hoped that an evaluation of the effectiveness of both methods for encouraging natural feeding behaviours could be made.

**Methods**

Data was gathered from published papers where the main topic was carnivore environmental enrichment and/or carcass feeding. The journals used included, Applied Animal Behaviour Science, Animal Welfare, Shape of Enrichment, and Zoo Biology. The information gained from each paper included, the species, type of environmental enrichment and/or carcass provision, and the feeding behaviours stimulated.

Environmental enrichment was defined as – The provision/addition of novel stimulus to elicit a change in behaviour. Examples of this include, novel scents and objects, and novel feeding methods.

Carcass feeding was defined as – The provision of whole/partial animals with/without, fur, feathers and appendages. Carcasses could range from pinkies and chicks to a whole horse.
Carcass feeding was considered separate from environmental enrichment and all carnivore taxa were included in the study.

**Results**

22 papers in total were found, 8 of these documented the effect of carcass feeding while 14 concentrated on environmental enrichment.

Both carcass provision and environmental enrichment elicited many feeding behaviours (fig 1.) however only carcass fed animals exhibited stalking, killing bite, caching, and species specific feeding behaviours (fig1). Conversely there were some behaviours that were only exhibited by animals provided with environmental enrichment, these were crouching, flehmen, chasing, swiping, and pushing and mounting prey (fig 1.)

All the studies that were found were heavily biased towards felids. 18 of the 22 studies found predominantly featured felids, and of these 6 concentrated on tigers (fig 2.). There was a paucity of data on other carnivore species and there were no representative species from the canid, procyonid, mustidlid, viverrid and hyenid groups in any study.

The most common enrichments that were used in studies were; barrels, suspended hessian sacks, scents, feeder balls, ice blocks, tug of war rope, and imitation prey.

**Discussion**

All the identified feeding behaviours could be stimulated by either carcass feeding and/or environmental enrichment. However neither method could stimulate all the
feeding behaviours, as there appears to be specific behaviours that are stimulated by only one or the other method.

Together environmental enrichment and carcass feeding could result in an optimum feeding regime for captive carnivores. However we must consider that carnivores readily habituate to enrichment (Clubb, 2004), and this must be taken into account by providing a complex environmental enrichment programme (Melfi, et al in press)

Few studies have been published in this area and those that have been are biased towards felids. Therefore there needs to be more research into the effects of both carcass provision and environmental enrichment generally, but there is a specific need for research on the species that are under represented in the literature.

Conclusions

Carcass feeding and a complex environmental enrichment programme can stimulate the expression of many feeding behaviours, and the optimum feeding regime would need to include aspects of both methods.

Both carcass feeding and environmental enrichment pose other problems when considering their implementation these include;
- practicalities of use
- health concerns
- visitor education/attitude
- nutrition
- social interactions

Acknowledgments

We are grateful to Kathy Knight and Ruth Pearson for helping with this research and extremely thankful for Kathy’s help in writing the paper.

We would like to acknowledge the funding provided by the ‘keeper for a day’ programme and the support provided by the staff and management at Paignton zoo, especially, Jason Knight, Andy Meek, Julian Chapman and Neil Bemment.

Also a big hand goes to the big cats!!!!

References


DEFRA. 2000. Section 2, 1.1.6, Secretary of States Standards on Modern Zoo Practise.

Melfi, V. In press
Tony Warburton established the World Owl Trust 40 years ago after rescuing 2 orphaned barn owl chicks. From the outset research was the primary focus of the organisation (then called the British Owl Breeding and Release Scheme) and in it’s early days produced pioneering work on the ecology of the barn owl.

The main focus was field studies, captive breeding and release of Tyto alba alba. This culminated with the publication of the ‘Barn Owl’ by Bunn, Warburton and Wilson

BOBARS gradually expanded its work to include Little Owls, Short-eared Owls and various diurnal raptors. BOBARS also undertook wildlife rehabilitation work, which has expanded through the years. BOBARS first worked with non-native species in 1982, breeding the European Eagle Owl (Bubo bubo bubo) for the European captive breeding and release program.

In 1985 BOBARS was offered aviary space at Muncaster Castle. The Trust became one of the first specialist owl centres in the world and transformed into The World Owl Trust with a new mission of ‘working to save the world’s owls and their habitats.’

Over the years a number of small research projects investigating the genetics and taxonomy of owl species have been carried out at the centre. The publication of this work resulted in the reclassification of several owl species.

Veterinary investigations on blood protozoa of owls have also been published.

The World Owl Trust has supported overseas conservation programmes for several years. The major ongoing project is the Philippine Eagle Owl Conservation Initiative in conjunction with Flora and Fauna International. The trust has funded the building of aviaries, veterinary assistance, island bird surveys and technician training courses and has sent staff to the Philippines to assist in the endangered species breeding centres.

Smaller projects include funding a field survey in Indonesia, which rediscovered the previously presumed extinct Flores scops owl, and in 2003 a field survey of Kelsar National Park in India, which described 12 species of owl.

The trust is now developing a strategic plan and conservation and research are a core area of future development. There will be four programmes:

1. UK Conservation and Field Programmes
2. Overseas Conservation and Research Programmes
3. Veterinary Research

The UK conservation program is the most developed program and the trust employs a full time UK conservation officer. Our main project is ‘Operation Barn Owl’ which includes habitat assessment and protection, an advisory service for farmers and builders, next box and nest site provision and public education. In addition research is undertaken on food, diets and nutrition. Population fluctuations are assessed using owlet-ringling techniques.

In 2005 WOT began the Long-eared owl project which currently involves survey work, public education and nest basket schemes. We hope that this project will be expanded in the future. We are also currently planning a similar program for the short-eared owl.

Smaller projects that we contribute to include the red squirrel monitoring and collecting blood samples from grey squirrels for parapox surveillance, natterjack toad surveys and heron surveys. The World Owl Centre is one of the few places in the country where yellow balsam grows, this plant is the exclusive food plant for the netted carpet moth and so we are working to conserve this population. WOT also participates in the Harvest mouse program and has bred animals which have been released into the wild.
Our habitat conservation work started close to home as our first wildflower meadow project occupied former animal paddocks at Muncaster. The meadow projects have now expanded, our conservation officer advises on habitat protection and creation through Cumbria. Further habitat preservation and restoration program is undertaken through our farm stewardship scheme, which culminated in a major project on a local farm. This is used by many local schools and groups for community involvement work and will be expanded into an eco-tourism venture in the future to include activities such as badger watching and guided bird watching.

Overseas conservation work will be expanded with a further 5-year commitment to the Philippine Eagle Owl project including a veterinary support visit by the trust's vet in 2006.

Asian fish owl species are declining through rainforest destruction and the trust intends to establish an ecological study using rehabilitated, radio-tracked animals to investigate feeding behaviour, reproduction and habitat usage.

The trust was successfully bred the endangered Ashy-faced owl for a number of years and is hoping to support conservation initiatives in Dominican Republic where this cave dwelling owl is being out-competed by the introduced American barn owl.

Today the World Owl Centre is one of the biggest owl collections in the world holding around 250 birds of 52 species and subspecies. This is an important resource for conservation research.

The current amenities include a veterinary hospital, quarantine unit, artificial incubation and handraising facilities. We intend to build a purpose built research centre with wet and dry labs, accommodation and post-mortem facilities. In addition 40 C.C.T.V. and Internet cameras will be installed to allow observation of breeding behaviour and chick rearing. These will be connected to our web site to allow off-site usage for approved students.

We hope that this will encourage the establishment of a range of veterinary, nutritional and reproductive based researched projects in collaboration with academic institutions.
Does the provision of carcasses compromise the health of zoo-housed carnivores? Preliminary report
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²Paignton Zoo

Abstract
The provisioning of carnivores in captivity with carcasses is a topic of much debate within the zoo community. The argument stems from a number of proposed benefits and risks associated with its use; however the main objections to its use are generally related to health risks. Past research into the provision of carcasses has focused on its use as an enrichment tool for large felids, either to alleviate feeding related stereotypies or promote natural foraging and feeding behaviours. There is a paucity of data on other carnivores. The aims of this study were to investigate feeding regimes for a wide range of carnivore taxa, we wished to; establish what feeding regimes are being implemented world wide; investigate any associations between feeding regime and health and on the basis of our findings make husbandry recommendations for the species involved in the study.

Preliminary findings indicate that carcass feeding is a widely practiced feeding method, although its use varies with different species. There appears to be a clear divide between geographical regions with Europe and other regions feeding predominantly carcass diets and USA feeding predominantly commercial diets. Health problems do not appear to be elevated in carcass fed animals, in fact there is some evidence to suggest that they are in fact experiencing less health problems, however this cannot be confirmed until further analysis is completed.

Statistical analysis will be carried out on the data to see if any relationships between feeding method and health indices exist. Details of these and further analysis are discussed.

Introduction
The question of whether to provide zoo-housed carnivores with carcasses is a topic of much debate within the zoo community. While some zoos regularly provide their carnivores with carcasses i.e. either the whole animal (with or without fur, feathers, appendages etc) or smaller pieces of meat on the bone, others prefer to feed nutritionally balanced commercial diets, and many feed a combination of food types. The debate between the methods of feeding stems from a number of proposed advantages and risks associated with the provision of carcasses.

The main advantages of carcass provision would appear to be the associated behavioural benefits either by promoting natural foraging and feeding behaviours or by reducing feeding related stereotypies such as pacing. McPhee (2002), found that providing large felids with calf carcasses reduced off-exhibit stereotypic behaviours; Bashaw et al (2003) found that the presentation of horse leg bones increased the frequency of feeding behaviours; and Bond and Lindburg’s (1990) study found that cheetahs fed carcasses had improved appetites, longer feeding bouts and a greater possessiveness of food than those fed commercial diets.

Other related benefits of carcass provision are thought to include improved muscle and body condition (Houts, 1999), and improved oral health (Bond and Lindburg, 1990, Fitch and Fagan, 1982). Providing social groups with carcasses may also be advantageous when trying to establish a stable social group. When animals all feed from one carcass dominant animals will gain priority access and dominance hierarchy will be maintained. While there has been no study on the possible social benefits of carcass provision there is anecdotal evidence that carcass provision may strengthen social bonds in captive wolves (Houts, 1999; Ziegler, 1995) and Bush dogs (MacDonald, 1996).

The main objections to carcass feeding are related to the health risks it may incur. Possible problems that have been suggested are; risk of contamination of the carcass before presentation; increased risk of conferred parasites; impaction/perforation or obstruction by bones, fur and feathers; and increased aggression when presented to social groups. So far there has been no scientific evidence that any of these problems are directly related to feeding method and any evidence of their occurrence comes from anecdotal sources (Houts, 1999).
All studies into the provision of carcasses that were found when researching this paper were mainly concerned with its use as an enrichment tool for large felids and there is a paucity of data on other carnivores. While not all non-felid species may be strict carnivores, some proportion of their diet is made up of animal prey. Therefore the presentation of this portion of their diet in captivity is still an important issue, and they too could benefit from the behavioural advantages of carcass provision that have been suggested for felids.

Therefore the main aims of this study were to:
- Establish what feeding regimes are practiced in zoos worldwide for a range of carnivore species, and in particular:
  - To what extent carcasses are fed i.e. whole animal, or partial meat on the bone
  - How often these types of food are presented i.e. as regular food or occasional enrichment.
- Establish whether there are increased, decreased or negligible health risks associated with feeding carcasses
- On the basis of findings make recommendations regarding the provisioning of captive carnivores

Methods

Materials and data collection

Felid species studied – Lion, tiger, jaguar, leopard, ocelot, caracal, fishing cat, pallas’ cat.
Non-felid species studied – Polar bear, brown bear, grey wolf, African wild dog, bush dog, fennec fox, fossa, binturong, kinkajou

Surveys were mailed and e-mailed to zoos that contained the species to be studied. A total of 192 zoos worldwide were surveyed, and these were all accredited with their respective continents institutions; EAZA (European Association of Zoos and Aquaria), AZA (American Zoo and Aquarium Association), PAAZAB (African Association of Zoological Gardens and Aquaria), and ARAZPA (Australian Regional Association of Zoological parks/aquaria inc). Endorsement letters were obtained from the BIAZA (British and Irish Association of Zoos and Aquaria) research committee and the small carnivore and felid TAGs (Taxon Advisory Groups), and these were sent with the surveys.

The survey included sections on health problems and feeding method, but also included sections on other environmental variables that could affect health, so these could be accounted for in the analysis. The independent variables (IVs) that were eventually analysed were: (1) Feeding method, (2) species, (3) enclosure size, (4) enclosure complexity, (5) amount of non-food enrichment, (6) frequency of keeper observations, (7) frequency of vet observations, (8) frequency of parasite testing, (9) wild prey caught, and (10), sourcing, (11) screening and (12) storage of carcasses and meat. The Dependant Variables (IVs) i.e. the health problems were split into (1) Parasite occurrence (2) disease occurrence and (3) death/injury directly due to feeding method. For the purpose of the preliminary report all health problems were combined.

For the purpose of this preliminary analysis feeding method was split into three different categories;
1. **Carcass** - An animal with or without fur/feathers/innards/appendages (can range from horse to pinkies and chicks)
2. **Meat** - Unprocessed meat i.e. meat on the bone
3. **Commercial** - A formulated meat based diet

Some species were fed with a variety of methods, in these cases the most common diet i.e. that fed weekly was taken as the predominant diet. If animals received any carcasses on a weekly basis they were classed as being carcass fed.

Data analysis

The results of statistical analysis are not included in this report, but the following information gives and overview of the analysis that will be carried out.
To determine which of the independent variables (IV's) will best predict the presence or absence of the three health problems, data will be analysed using a forward stepwise binary logistic regression model (Tabachnick and Fidell, 2001). Each survey reply will be classed as a separate data set. Binary logistic regression was chosen as the data is varied in its form, i.e. some variables are categorical while others are continuous. Three separate regression models will be created, one to predict the presence or absence of disease, one to predict the presence or absence of parasites, and one to predict the presence or absence of injury or death due to feeding.

Results

Of the 192 zoos surveyed, 51 responded (26.5%). 171 separate data sets were obtained, due to some zoos having more than one species involved in the study.

Species feeding regimes

Figure 1 shows the total survey responses received for each of the carnivore species included in the study and what each species is fed, in terms of carcass, meat or commercial diets. The most popular feeding method for felids appears to be carcass feeding, as for all species the majority of survey results reported carcass provision as their predominant feeding method. Although some of the large felids receive almost as much meat in their diets as carcasses. The provisioning of the non-felid carnivores was much more varied, polar bears, African wild dogs, bush dogs, fennec foxes and fossas were mainly carcass fed, the kinkajou was the only species to be predominantly fed on a commercial diet, and the grey wolf the only species predominantly fed on a meat diet. There were equal responses from zoos holding Binturongs that fed carcass and commercial diets.

Regional variations

Data from USA, European, and the Rest of the World (ROTW) surveys were compared to see if there were any differences in feeding regime. (Fig 2). Data for the Australasia, Africa and Asia survey responses were combined due to a lack of data from these geographical regions. Carcass provision was the predominant feeding method for Europe and other geographical regions. Commercial diets were predominantly used in USA and scarcely used in Europe and not at all in other regions. The USA and other regions, survey responses reported similar numbers for meat provision as the dominant feeding method, while European regions used meat at a slightly higher level.

![Figure 1. Total survey responses indicating most common feeding method for each carnivore species](image-url)
Figure 2 Regional variations in the feeding methods implemented for the carnivores surveyed

Health problems

The percentage of returns that had experienced a health problem were calculated for each separate feeding method (Fig 3.) Species that received commercial diets showed more health problems (57% of returns). Half the meat fed species experienced health problems (50%), and only 39% of carcass fed animals experienced health problems.

Figure 3 Total number of responses and incidences of health problems reported

Discussion

Species feeding regimes

From the preliminary analysis it appears that all the species involved in the study are receiving carcasses in their diets to some degree. The provisioning of carnivores seems to be dependant on species, with a bias of carcass feeding for the felids, while the other species receive more varied diets. This is probably due to the differing degrees of carnivory seen in these species. However we also have to consider the fact that we have received less survey responses for these non-felid species, for example only three surveys have been returned for both the brown bear and polar bear. Therefore at this time it is felt that we have not gained an accurate representation of the predominant feeding regimes for these species.
Feeding regime also seems to be ‘region’ dependant, with a clear division between the USA and other continents. This agrees with the evidence that at three of the International Conferences on Environmental Enrichment, the opposing sides of the ‘carcass feeding debate’ were Europe; advocating the use of carcasses for improved health and behaviour, and the USA; tending to oppose its use due to the possible health problems that may result (Houts, 1999). There may be other factors, apart from the perceived health risks that are influencing this divide, these are likely to include, public perception of carcass feeding, different priorities when formulating a diet, and possibly cost factors of diet.

**Health indices**

From the preliminary data it appears that carcass fed animals are not experiencing any increased health risks. In fact commercial fed animals are experiencing more health problems in terms of the percentage of surveys we have received. Again caution must be taken when interpreting these results. We have received many more surveys for carcass fed animals than we have for meat or commercial fed animals, and therefore maybe getting a more accurate result for carcass feeding than the other two methods. It is also necessary to carry out the statistical analysis (section 2.2.) before any firm conclusions about associations between feed method and health indices can be drawn.

**Further analysis**

1. Health problems split into parasite occurrence, disease occurrence, and direct injury/death due to feeding. Separate analysis will be performed to see if any of the three health problems can be predicted by environmental variables
2. Felid and non-felid carnivores will be split, and separate analysis will be performed for each group
3. If enough data is obtained separate species analysis will be performed.
4. If enough data is obtained separate analysis for different diseases will be performed to see if there are any that are particularly relate to feeding method e.g. oral disease.

**Acknowledgements**

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All the zoos that have taken the time to respond to our surveys

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Part 2
Poster Presentations
Social organisation in a captive Gelada baboon group (Theropithecus gelada) at Colchester Zoo
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Abstract

Eight Gelada baboons (Theropithecus gelada) were studied to analyse the social organisation of the group. The baboons were studied daily for three weeks, starting on the 5th July 2004, for a total of 45 hours. This involved focal sampling of a single individual or dyad for a period of 3 hours. During focal samples, every activity that the individual or pair undertook and the amount of time recorded, with a particular focus on grooming behaviour. Displacement was also recorded during focal sampling, i.e. any instance when one individual supplanted another. The results indicated that a dominance hierarchy was present and was found to be strongly linear (Landau's index of linearity = 0.9722). Based on occasions when individuals displaced others, the adult male is most dominant, followed by the adult females and then the juveniles and infants. There was no correlation between age and dominance ($r = 0.617, n = 8, p > 0.05$), but a positive correlation between grooming and dominance (excluding infants: $r = 0.951, n = 6, p < 0.001$; including infants: $r = 0.866, n = 8, p < 0.01$). There did appear to be a linear relationship between age and dominance when excluding the elderly female from the analysis, who perhaps had a lower dominance rating due to her age and condition. The Geladas appeared to exhibit reciprocal grooming which probably serves to maintain strong relationships. It appeared that males did significantly less grooming than females but this is inconclusive because two of the males were juveniles. The alpha female did significantly less grooming than the others, while the adult male received more grooming than the other individuals. These trends are thought to be explained by their status. The Geladas appeared to form grooming dyads. The related adult females formed the strongest grooming dyad, in support of previous research on Gelada baboons. This dyad included the alpha female suggesting that she formed a grooming dyad with a related female in preference to a grooming dyad with the alpha male.

Introduction

The species, Theropithecus gelada, commonly known as the gelada baboon, originates from the central and Northern rocky regions of Ethiopia (Primate Specialist Group 1996). They are naturally found at high altitudes and are terrestrial primates that rarely climb trees. Unusually, they spend much of their day grazing and their diet mainly consists of grasses, bulbs and small insects. In Ethiopia, Geladas are found in large herds of up to 600 individuals, made up of multiple harems and bachelor groups (Barrett 2000). Their basic social unit is a harem, with one male, between 3-8 adult females and their offspring (Napier & Napier 1967). In the wild, the females in the harems are closely related, and tend to interact with each other more than with the male.

The social structure and interactions are key aspects to understanding primate systems. Dominance appears to play an important role in Gelada society. For example, lower-ranking females take 4-5 months longer to conceive than high-ranking females (Barrett 2000). The Gelada baboon social structure differs from many other systems in their complex multi-layered society (Barrett 2000). There has been limited research on this species, particularly with respect to captive behaviour. This study looks at a one-male unit of Geladas in captivity consisting of entirely captive-born individuals some of
whom are related. The main objective of the study was to determine the social structure of a group of captive Gelada baboons and investigate the social dynamics with a particular focus on allogrooming.

Materials and Methods

Study subjects

A breeding group of eight Gelada baboons were observed during this study. The group consisted of one adult male, three adult females, two juvenile males and two infants (one male and one female; see Table 1). The group were studied at Colchester Zoo where they were kept in a large naturalistic outdoor enclosure. This enclosure had a central tri-level platform with tree trunks for access. The substrate was grass and there was a gentle slope to the terrain at the rear. The baboons also had open access to a small indoor enclosure with a large bar in the centre for perching. Hay was scattered on the floor of the indoor area.

Table 1. Individuals in the study group

<table>
<thead>
<tr>
<th>Identification letter</th>
<th>Name</th>
<th>Sex</th>
<th>Age (on the 5th July 2004)</th>
<th>Sampled as</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Junior</td>
<td>M</td>
<td>12Y, 5M, 24D</td>
<td>An individual</td>
</tr>
<tr>
<td>B</td>
<td>Gimira</td>
<td>F</td>
<td>24Y, 6M, 23D</td>
<td>An individual</td>
</tr>
<tr>
<td>C</td>
<td>Sereba</td>
<td>F</td>
<td>9Y, 6M, 6D</td>
<td>A dyad with infant G</td>
</tr>
<tr>
<td>D</td>
<td>Mena</td>
<td>F</td>
<td>IOY, 10M, 5D</td>
<td>A dyad with infant H</td>
</tr>
<tr>
<td>E (mother is C)</td>
<td>Bako</td>
<td>M</td>
<td>3Y, 8M, 16D</td>
<td>A dyad with juvenile F</td>
</tr>
<tr>
<td>F (mother is D)</td>
<td>Malachi</td>
<td>M</td>
<td>2Y, OM, 25D</td>
<td>A dyad with juvenile E</td>
</tr>
<tr>
<td>G (mother is C)</td>
<td>Jamah</td>
<td>M</td>
<td>OY7M, 15D</td>
<td>A dyad with mother C</td>
</tr>
<tr>
<td>H (mother is D)</td>
<td>Malaika</td>
<td>F</td>
<td>OY6M, 1ID</td>
<td>A dyad with mother D</td>
</tr>
</tbody>
</table>

Data collection

The baboons were studied daily for three weeks, starting on the 5th July 2004, for a total of 45 hours (including preliminary observations). Preliminary observations were conducted to allow the observer to become familiar with the individuals and their behavioural repertoire. Following this, a day of Ad Libitum sampling (Martin & Bateson 1993) was done on the group. This gave an indication of the most conspicuous and frequent behaviours that take place within the group.

Data collection consisted of focal sampling between 09:00-12:00 and 13:00-16:00 (Martin & Bateson 1993). This involved observing a single individual or dyad (e.g. mother with infant). During this time every activity that the individual or pair undertook was noted. Behaviours were classified as:

- Feeding (which included drinking and foraging)
- Resting (lying or sitting)
- Locomotion
- Autogrooming
- Allogrooming
- Ventro-ventral contact between mother and infant

Displacement was also recorded during focal sampling, i.e. any instance when one individual supplants another. This was defined as when one individual removes food from another or simply when an individual's presence or behaviour causes another to move away. Individuals who backed down or behaved submissively during aggressive interactions with another were considered to have been supplanted.

A very obvious display is the lip-flip which reveals the teeth and gums of the upper jaw. It is thought to be a defensive aggressive threat (Bernstein 1975) but as it was often seen accompanied with a chase and responded to with a submissive response it was taken at face value as an aggressive display for
the purposes of this study. Aggressive behaviours included eyebrow raising, chasing, mouth fencing, jumping towards, pushing, pulling, biting and hitting. However, physical encounters of an aggressive nature (e.g. the final four on the list) were rarely observed if at all and were more readily observed during juvenile play. It is also worth noting that geladas are known to be very vocal creatures (Bernstein 1975) but defining which vocalisations are aggressive is beyond the scope of this study.

Submissive behaviours are less easy to define. Lip-smacking, moving the lips apart and together rapidly (often accompanied by a soft chattering vocalisation) was a very obvious and frequent one. This response is often seen in other contexts such as grooming and therefore is not purely submissive (Bernstein 1975). Others include, moving away, running away and in rare instances hiding (behind or beneath objects or individuals) or flattening oneself to the ground.

**Analytical methods**

**Dominance**

The dominance hierarchy was calculated by noting the number of occasions an individual was supplanted and who supplanted them. This data was put into a dominance matrix to present it clearly (Martin & Bateson 1993). From this, Landau's index of linearity ($h$) was calculated:

$$h = \frac{12}{(n^3-n)} \sum [va-(n-1)/2]^2$$

The number of animals in the group is represented by $n$ and $va$ is the number of individuals who are subordinate to animal $a$. It was deemed appropriate to exclude the infants from the equation and count the number of individuals who are subordinate to `animal a` rather than the number of individuals `animal a` has dominated in order to achieve a figure that fell within the specified range 0-1 (Rho et al, 2004). A value of $h>0.9$ indicates a strongly linear hierarchy.

Analyses were conducted using statistical tests on the computer program SPSS 9.0. The total number of times an individual has supplanted any other was used to test for a correlation between age and dominance (with age displayed to the nearest year). In addition to this, a correlation between grooming and dominance was also tested for. Two different analyses were conducted for this, firstly using the total amount of time each individual was groomed excluding grooming on infants by mothers and secondly, the total amount of time each individual was groomed including grooming on infants by mothers. All data sets had a normal distribution according to a Kolmogorov-Smirnov (k-s) test, therefore, Pearson's product-moment correlation coefficient was used to analyse the pairs of data.

**Grooming**

A test was conducted to identify if there was a significant difference between the total lengths of time (in seconds) each individual was groomed for and the total length of time (in seconds) each individual groomed others. The infants were excluded from this analysis because any grooming they carried out was rare and not recorded. This left only 6 pairs of data and so the non-parametric Wilcoxon matched pairs test was conducted.

The total length of time spent grooming by male Geladas was compared to that by females. This was done using a Chi-squared "goodness of fit" test (Fowler et al 1998) with "Yates's correction". The equation for this being:

$$X^2 = \sum (|O-E|-0.5)^2 / E$$

The results suggested that the alpha female, D, groomed less than the other individuals, while the adult male appeared to receive more grooming attention than any other individual. A Chi-squared "goodness of fit" test with Yates's correction was used to determine whether these differences were significant.

Grooming interactions between the adult Geladas were compared using Chi-squared tests for "goodness of fit" with the following equation:

$$X^2 = \sum (O-E)^2 / E$$
Results

Dominance

Landau’s index of linearity resulted in a figure of 0.9722. This indicates that the hierarchy in the group is strongly linear (see Table 2).

<table>
<thead>
<tr>
<th>Number of occasions when individual is displaced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of occasions when individual displaces another</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>C</td>
</tr>
<tr>
<td>E</td>
</tr>
<tr>
<td>F</td>
</tr>
<tr>
<td>G</td>
</tr>
<tr>
<td>H</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td>RANK</td>
</tr>
</tbody>
</table>

Table 2 Final dominance matrix

Based on occasions when individuals displaced others, the dominance hierarchy is ADBCEFGH (from most dominant to least dominant). In contrast, based on occasions when individuals are displaced, the dominance hierarchy is GAHBDFCE. When excluding the infants, the dominance hierarchy is ABDFCE (which is more similar to that based on occasions when individuals displaced others). The adult male supplanted the two juvenile males more frequently than he supplanted other individuals.

There was no correlation between age and dominance (r = 0.617, n = 8, p > 0.05). However, there appeared to be a linear relationship when excluding B. There was a strong correlation between grooming and dominance (excluding infants: r = 0.951, n = 6, p < 0.001; including infants: r = 0.866, n = 8, p < 0.01).

Grooming patterns

Females spent more time grooming than males (X² = 297.32, df = 1, p = 0.01, see Figure 1). The alpha female, D, groomed significantly less than other individuals (X² = 933.388, df = 1, p < 0.01). The alpha male received significantly more grooming than other individuals (X² = 430.054, df = 1, p < 0.01).

Figure 1. Total amount of time spent grooming by males and females
No significant relationship was found between amount of time spent grooming and amount of time being groomed ($z = 0.734$, $n = 6$, $p > 0.05$) despite apparent differences (see Figure 2).

The adult geladas appeared to form grooming dyads. There was a significant difference between the grooming interactions between the three adult females ($X^2 = 1419.438$, $df = 2$, $p < 0.01$) and between the dominant male and each of the adult females ($X^2 = 337.328$, $df = 2$, $p < 0.01$). Females C and D formed a strong grooming dyad. The alpha male, A, was the main grooming partner of B. A also groomed C relatively frequently.

**Discussion**

**Dominance**

Despite showing a strongly linear dominance hierarchy, it is difficult to interpret because there appear to be dominance reversals. The total number of occasions each individual was supplanted gives a different hierarchy to the total number of occasions each individual supplanted others. Based on occasions when individuals displaced others, the adult male is most dominant, followed by the adult females and then the juveniles and infants. In contrast, based on occasions when individuals are displaced, the infants, G and H, were placed in high-ranking positions. The main reason for this seems to be due to the presence of the infants in the analysis. There weren’t many occasions on which the infants supplanted others, which seems appropriate. However, there weren’t many occasions when the infants were supplanted by others, which is thought to be because they were generally ignored by most of the adults and appeared to avoid confrontation with them. Therefore, the hierarchy is felt to be more representative when excluding the infants and so the final hierarchy was based on the number of occasions each individual supplanted others (which included the infants in the analysis).

The lack of correlation between age and dominance is surprising and may be explained by the eldest female B. This individual appeared to be an outlier, and when excluding her from the analysis, there did appear to be a linear relationship. There is some evidence to suggest that a female’s status can depend on her weight and condition (Dunbar 1982). Although the weights of the animals are not known the female B appeared to be slighter and in poorer bodily condition than the other females. She was also thought to be post-reproductivity as she no longer went into a visible oestrus. During this study, it was observed that although she regularly presented herself to the adult male he rarely mounted her. This, combined with her age and lack of offspring, strengthened the probability that she was no longer in a reproductive condition. These factors may explain why her rating was lower than expected (Dunbar 1984). When excluding this individual, there does appear to be a linear relationship. Therefore, these results are consistent with the trend of increasing dominance with age and also that post-reproductivity the animal may fall in its dominance rating.

The strong correlation between grooming and dominance would be expected as it indicates that the higher an individual is ranked in the hierarchy the more grooming it receives. This pattern was less
significant when including the infants. This is thought to be due to the high frequency of mother-infant grooming, which is related to rearing rather than dominance.

Grooming patterns

In general, the Geladas appeared to exhibit reciprocal grooming. This was evident in that there was no significant difference between the amount individual’s groomed and the amount that they were groomed. In addition to this, when observing the baboons grooming interactions, they usually groomed in pairs and each individual in the dyad played a role as both “groomer” and “groomee” during a grooming bout. This reciprocal grooming probably serves to maintain strong relationships.

Females groomed more than males. This variation may have been due to the females being related or because two of the males were juveniles, who spent less time grooming than other individuals (except for the infants) and more time playing (Nathan 1973, Mori 1979a). However, this pattern has been observed in another captive study of Gelada baboons (Bernstein 1975). Therefore, the results may indicate a true difference in grooming behaviour between the sexes, which supports evidence from the wild that the females interact with each other more than the males (Barrett 2000).

Analysis indicated that the adult female, D, groomed significantly less than other individuals. This is thought to be due to her high-ranking status. The number of occasions she supplanted others is twice that of both the other adult females and observations indicated that she strongly influenced interactions within the group (e.g. a flash of the eyelids appeared to separate other grooming dyads). This suggests that she is stable in her dominant position. In addition to this, her subordinates would frequently groom her without reciprocation, often following dominant-subordinate interactions. This is a well-documented way of reconciliation in the primate world (Swedell 1997).

In contrast, the alpha male, A, groomed others relatively frequently. This may be to reinforce relationships with the females for reproductive reasons. In addition to this, dominant male Geladas are noted for using solicitation and reassurance rather than aggression in many situations (Mori 1979a). Male in their mid-prime, which A can be described as, have been cited as being even less aggressive with the females in their group than early-prime males (Dunbar & Dunbar 1975). Male A did not groom the juveniles or infants, which has been identified in dominant males in wild studies (Mori 1979a).

Grooming dyads

Studies have shown that Geladas form grooming dyads determined by the females (Dunbar 1982). Bonds with other females increase fitness, while those with the alpha male are less likely to affect fitness or dominance. Females C and D formed a strong grooming dyad. They are full-siblings, which explains their close interactions. The alpha male, A, was the main grooming partner of B, which may have developed as they are the only other adults in the group. The relatively high grooming interactions between A and C may have been because C was in oestrus during data collection. The alpha female, D, formed a grooming dyad with the alpha male, A, least frequently of all the 3 adult females. This is in contrast with research that suggests that the alpha female usually establishes a close relationship with the alpha male (Mori 1979b). However, evidence suggests that the right for the alpha female to monopolise the alpha male is not always enforced. For example, Dunbar (1982) found that grooming dyads in Gelada baboons are usually matrilineal and that forming kin dyads can be more profitable than a strong bond with the dominant male (and the results from this study would be consistent with this as C and D are full siblings). Furthermore, the female which interacts with the alpha male most is usually the female without an adult female grooming partner and that this has no bearing on dominance (Dunbar 1982).

Conclusion

The results from this study indicate that there is a dominance hierarchy present in the Gelada baboon group. In addition to this, there appear to be a number of patterns in the grooming exhibited by the group. These findings indicate that a number of aspects influence dominance and grooming patterns, such as age and relatedness respectively. While the results provide an insight into the social organisation of a captive Gelada baboon group, additional research focussing on groups with a different social structure (e.g. multi-male groups or bachelor groups) would be an interesting comparison. In addition to this, further studies on the development of the offspring within the group, in
particular the juvenile males, or following changes to the group composition would be of interest in terms of influencing captive animal management of this species.

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An investigation of the cooperative strategies employed by spider monkeys (Ateles fusciceps robustus) during allogrooming
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Introduction

Primates can devote up to twenty percent of their daily time budgets to grooming one another (Dunbar 1991), an investment which, for the groomee at least, would appear prudent. Being groomed serves both valuable hygienic and hedonistic functions; while ridding an individual of ectoparasites (Saunders 1988), it also triggers the release of beta-endorphins (Keverne et al 1989) and decreases the heart rate (Feh and de Mazieres 1993), resulting in a highly pleasurable, stress-reducing experience. For a groomee therefore, it is certainly a beneficial activity in which to partake. Groomers, on the other hand, appear burdened with a far worse deal. They must forgo pursuing activities for their own gain, a potentially weighty sacrifice considering the stringent time budgets of many primate groups (Dunbar 1992). Additionally, groomers expose themselves to danger due to a decrease in vigilance (Maestripieri 1993). Such altruism on their part would clearly contradict what is now considered a central premise of evolution. Namely, in the struggle for survival, only individuals who behave in ways that are self beneficial will succeed and pass on their genes to future generations (Darwin 1859).

Hamilton (1964) developed a credible explanation as to how cooperation in the natural world might operate. His theory of inclusive fitness proposes that selection actually acts at the level of the gene. As replicas of an individual’s genes exist in those of common descent, when two animals are sufficiently related, altruism can benefit the gene. However, altruism will only spread by inclusive fitness if a helper increases the survival of his shared genes more than he decreases the survival of his own genes. There is strong evidence to suggest that inclusive fitness accounts for a lot of the altruism seen in primate groups. For example, Kapsalis and Berman (1996a) found that rhesus macaques groom and support close kin to a greater extent than distant relatives. Similarly, Silk et al (1999) found that female baboons preferentially groom kin. However, kin selection cannot be the only force driving the evolution of cooperation within primate societies. Allogrooming can also be common among non-kin (Sade 1972).

The theory of reciprocal altruism (Trivers 1971) states that both the recipient and the provider of a cooperative act benefit if, at a later date, the roles are reversed and the favour returned. Trivers emphasised that the evolution of such arrangements would require that the benefits received by the recipient are greater than the costs incurred by the giver.

Quite literally then for primates, allogrooming could well be a case of ‘you scratch my back, I’ll scratch yours’. However, Trivers’ theory does not fully explain the subtleties of how reciprocation may arise and be maintained within a population. A crucial consideration regarding the time-delay between favours being received and returned is the question of how animals avoid being cheated out of their anticipated rewards. Evidently, for reciprocal altruism to evolve, animals must adopt some behavioural strategy whereby they avoid interacting with individuals who fail to return favours. This essentially requires making decisions on the basis of what others do, a type of behavioural strategy which can be modelled using a technique known as game theory.

Game theory is a method of modelling decision making processes, which has become a fundamental tool in determining the most advantageous strategies available to an individual in a social context. Essentially, game theory models recognise that, in an interactive environment, the success of a behavioural tactic employed by any particular individual is dependent on the tactics that are being used by others. Therefore, in order to attain the highest possible payoff from an interaction, an animal must know or correctly anticipate the strategies that those around them will adopt.

Advances in evolutionary game theory throughout the 1970s allowed for Trivers’ (1971) original ideas on reciprocal altruism to be further developed. The Prisoner’s Dilemma (PD), a classical paradigm within game theory, was the first game used to address the matter of animal cooperation (Axelrod and Hamilton 1981). The game models an interaction between two individuals whereby both would benefit from mutual cooperation but each would further profit by cheating and exploiting the help given to them by their partner.
Strategies in the conventional Prisoner's Dilemma game consist of a combination of only two moves; cooperate and defect. Such a discrete choice of moves, it can be argued, lacks ecological validity because cooperation in the natural world is seldom an all or nothing endeavour (Roberts and Sherratt 1998). When considering the fact that varying degrees of cooperation can be reciprocated, a new problem arises: How does an animal avoid being short-changed?

Roberts and Sherratt (1998) revealed that in a computer simulation when opportunities exist for variable investment, cooperation can flourish if a strategy of ‘Raise the Stakes’ (RTS) is played. An individual playing RTS will begin a cooperative partnership by investing very little. If his partner then matches this initial amount of cooperation, the player will raise his investment slightly on the next move, and so forth.

Another strategy which takes into account the size of a cooperative act is Connor's (1992) parcelling model of reciprocity. Connor devised his theory from directly observing reciprocation in the natural world (specifically, egg-trading in simultaneous hermaphrodite sea-basses) and therefore, it has the immediate advantage of reflecting at least one form of naturally occurring cooperation. The parcelling model of reciprocity predicts that if a resource is divisible it will pay for an individual to split it up into small parcels which are then offered out one at a time, providing that a parcel is received in return. By doing this an animal can manipulate its opponent’s optimal strategy as in order to receive a sufficient amount of benefits from a cooperative act, an individual will have to accumulate several packages but this can only be achieved by returning the favours.

Like-for-like reciprocation is not the only form of cooperation to occur between unrelated individuals. Animals often exchange one type of favour for a completely different sort in return. This process, known as interchange, is distinct from reciprocity in which the same kind of aid is received as is given (Hemelrijk and Ek 1991). This involves different processes to reciprocity, for example, being able to assess the values of two separate commodities relative to one another.

Evidence would suggest that interchange is a particularly prevalent form of cooperation in primate societies. Seyfarth (1977) argued that grooming between primates is exchanged for subsequent coalition support during aggressive encounters. Seyfarth claimed that as dominant individuals make the most effective coalition partners, competition will arise between lower ranking individuals to be grooming partners with those higher up the hierarchy. Since Seyfarth (1977) suggested that primates trade grooming for support, evidence to suggest the interchange of grooming for other commodities has become plentiful. It would appear that grooming can be traded for tolerance, in the form of reduced aggression from dominant animals towards subordinates (Silk et al 1981) and for consent to join a new group (Hauser et al 1986). Grooming can also be exchanged for access to tangible resources, for example, food and water (de Waal and Lutterell 1989), mates (Smuts 1985) and infants (Muroyama 1994).

A general framework for how interchange may operate across species has only recently been developed. The biological markets model of cooperation (Noë and Hammerstein 1995) asserts that cooperative exchanges in the natural world are similar to those in an economic market whereby two classes of traders exchange commodities to their mutual benefit. Competition for attractive trading partners should take the form of outbidding, in which those with the more common commodity will try to offer more of their product than other members of their class, in order to make themselves more favourable trading partners. The idea that individuals can choose who to trade with significantly lessens the threat of being cheated which is so central to Prisoner’s Dilemma models. Having a choice of partners means that the costs of ending a cooperative relationship are reduced because instead of it resulting in no interaction at all, an individual can simply find someone else with whom to interact. Therefore, it will pay for individuals to be as desirable a trader as possible as they will attract partners. Barrett et al (1999) have found convincing evidence that baboons adopt a biological market strategy when subordinate animals trade grooming for access to monopolisable resources from dominant individuals.

To date, research on cooperation in primates has mainly focussed on the strategies adopted by Old World species. Although recently efforts have been made to rectify this inequality (for example, Parr et al 1997; Pastor-Nieto 2001), there is currently insufficient knowledge about cooperation across the diverse array of social systems found in platyrrhines. Therefore, it was decided that the study species for this project should originate from the New World and owing to their complex social system, spider monkeys were chosen. *Ateles*, in the wild, live in clans of between eighteen and thirty-five individuals. Their social structures seem to have evolved in accordance with the species' food specialisation.
Spider monkeys consistently prefer to eat ripe fruit which, by its nature, is patchy in distribution. It appears that in order to optimally access their favourite foods, they have developed a system whereby clans fission into smaller subgroups which travel and feed together during the day (van Roosmalen and Klein 1988). Unlike the fission-fusion organisations seen in some catarrhines, such as baboons, however, *Ateles* subgroups are fluid, regularly changing in both size and composition (Symington 1990). The only other primate species to have adopted such a social structure is the chimpanzee. Indeed, the social organisation of spider monkey and chimpanzee communities are strikingly similar (Chapman et al 1995); both are frugivorous species, living in fission-fusion social systems in which males are philopatric and females most likely disperse. It therefore, stands to reason that parallels will exist in the structures of the two species’ societies.

The fluidity of spider monkey groups means that some clan members may not come into direct contact with others for several days. It has been suggested that, in order for individuals to recognise clan members which they may not have seen for some time, spider monkeys must have evolved good memories (Dunbar 1992b). This may have implications for the techniques involved in reciprocation. Therefore, it is interesting to question whether or not their unique social system has given rise to any distinct processes of cooperation.

The social organisation of spider monkeys further differs from patterns seen in Old World monkeys in that males are the philopatric sex. As the majority of what is known about primate allogrooming derives from studies of philopatric, female monkeys (for example, Seyfarth 1977; Barrett et al 1999), it will be interesting to see whether grooming relationships differ among females which traditionally disperse into non-natal groups.

**Method**

Data were collected from a group of eight Columbian black spider monkeys (*Ateles fusciceps robustus*) at Colchester zoo. The group comprised of five females and three males, all between the ages of 2 years 2 months and >21 years 11 months.

One hundred hours of data collection were carried out over twenty-one days. Research commenced at 9.00 every morning. In order that an accurate account of the spider monkeys’ daily activity patterns could be obtained, for the first week, observations continued until 5pm each day. At this time the monkeys were locked inside for the night and the lights were switched off. It became clear, however, that allogrooming seldom occurred in the afternoons, thus, after dedicating two hours after lunch each day to determining the group’s dominance hierarchy, observations would terminate at 3.30pm.

An all occurrence sampling technique (Altmann 1974) was employed in the collection of grooming data. This involves watching the whole group and recording instances of a particular behaviour (in this case grooming) as they occur. The method was deemed appropriate due to the fact that allogrooming primarily occurred in the mornings when the group remained indoors and it was possible to simultaneously keep track of all individuals via the glass panel which stretched the length of all three rooms.

Allogrooming was defined as the act of one individual using its hands to search through another’s hair and pick out foreign entities, either with its hands or mouth. The information recorded for each bout consisted of the time, the identity of both individuals involved, the length of time each groomed the other (in seconds), the location of where the bout took place, the reason the bout ended and the identity of any others that were present. Following the methods of Henzi and Barrett (2002), bouts were considered to have ended if grooming ceased for 10 or more seconds.

Information relating to the group’s dominance hierarchy was gathered in the afternoons. Individuals were generally more dispersed at this time of day, therefore focal sampling was used. Each animal was monitored for a period of fifteen minutes and within this time every instance of dominance behaviour which they displayed was recorded, along with the identity of individuals to whom the behaviour was directed. Dominant behaviours were construed as any actions of outright aggression, provocation of submissive behaviours or avoidance in other animals. If dominance was directed towards the focal animal this was not recorded. This directional bias ensured that each animal was equally represented in the dominance matrix. The order in which individuals were observed changed daily in order to make sure that the time of day did not confound results.
Results & Discussion

The results obtained suggest that, although a rare behaviour within the group, allogrooming did occur, it was undoubtedly influenced by highly developed and complex cooperative strategies. It seems likely that a substantial proportion of the group’s allogrooming can be explained in terms of inclusive fitness benefits (Hamilton 1964). Related group members were found to allocate higher percentages of their allogrooming to one another than would be expected if grooming were equally distributed among all eight individuals. Furthermore, different trends were evident in the grooming performed by kin as opposed to non-kin. A degree of delayed reciprocation was found to occur for non-kin dyads after a period of nineteen days. Conversely, when kin dyads were included in the analysis, a significant level of time-matching was never achieved across the whole study period. This suggests that a certain amount of reciprocation is essential to sustain grooming relationships between unrelated individuals but is not, however, necessary when partners are kin.

The fact that reciprocation between unrelated individuals was delayed implies that spider monkeys may possess sophisticated cognitive abilities. Memory constraints are likely to have an impact on the length of the time delay that is possible between receiving and returning a favour. Memories decay over time which will inevitably make delayed reciprocity harder, as will the fact that new interactions will occur in the meanwhile, increasing the computational load of tracking who owes you what and what you owe to whom (Stevens et al 2005). Spider monkeys may, however, be equipped with such neural complexity. As fruit eating primates, *Ateles* have larger brains than leaf-eating species, which have presumably evolved to track variations in fruit distribution through space and time (Milton 1981). It is perhaps possible that these advanced memory functions have become generalised to be also capable of monitoring the spatial and temporal distribution of grooming partners and their contributions. This view is supported by studies of fruit-eating *Brachyteles* whereby group members have demonstrated the ability to recognise one another after temporary periods of dispersion (Strier 1990).

The group members were found to fall into one of two categories which were defined not only by their dominance ranking but also by the style of allogrooming which they adopted. With kin dyads excluded from the analysis, the ‘dominant group’ generally engaged in a lot more social grooming than the ‘subordinate group’. Dominant individuals were also found to distribute more grooming than they received per day, while the subordinate group, on the other hand, received more grooming than they gave per day. Furthermore, when a member of the dominant group and a member of the subordinate group groomed one another, significantly more grooming was directed to the lower-ranking individual of the two. These results imply that there are alternative benefits to be obtained from providing fellow group members with grooming for dominant individuals, particularly when their partners are members of the subordinate group. The question, thus, arises as to what exactly it is that the dominant group gains from contributing more grooming to the subordinates than they receive. The dominant group consisted of one male and two females. Therefore, the preference observed, for grooming down the hierarchy is just as likely, if not more likely, to exist in females as it does in males.

A possible explanation as to why spider monkey allogrooming might have evolved in such a way, based on the notion that females disperse is concerned with the extent to which lower-ranking group members will profit from group living. The costs and benefits of aggregation determine the size and composition of groups (Clutton-Brock and Harvey 1977; Chapman et al 1995). Primates can benefit from living in large groups in terms of inter-group competition and infanticide and predation avoidance but at the same time must face the consequences of within group competition for food, a cost which is likely to most affect subordinate individuals. When the costs of living in one group become too great for low-ranking females in non-female-bonded societies, there is nothing to stop them leaving in search of a better deal elsewhere. In the case of spider monkeys, this could mean simply joining another subgroup or transferring to a different clan altogether. If, for some reason, however, it is important to the dominant individuals that lower-ranking group members remain in close proximity, they will presumably make membership of their group as attractive an option as possible, for example, by offering unidirectional allogrooming. Indeed, dominant females have been found to manipulate the number of individuals in their sub-groups suggesting that group size is important to them. Certain females within spider monkey clans can be recognised as ‘leaders’, showing a superior knowledge of food source. They choose the daily travel routes of subgroups, as well as determining precise activity patterns. Leading females also consistently dominate all other females within a group (van Roosmalen and Klein 1988). Van Roosmalen and Klein (1988) have reported that whenever food patch size and distribution permit it, leading females will merge subgroups together which suggests that, whenever possible, larger group sizes are preferable.
The size and composition of subgroups vary in accordance with food distribution, suggesting that the benefits for dominant individuals to have subordinate members by their side do not always outweigh the costs. Therefore, rather than allogrooming being given as an incentive to permanently remain within one subgroup, it is likely that grooming is offered to keep animals in the clan, in which case they will be available if needed. Allogrooming from dominant individuals to subordinate members, could however, be a means by which subordinates choose which subgroup to join when needs be.

One reason why it might be important to dominant group members that their subordinate counterparts remain close by is so that they can join subgroups to help with predation defence. Generally, large groups are considered advantageous in both reducing the chance of predation and the cost of vigilance (van Schaik 1983). In support of this, Shimooka (2003) claims that although threats from birds of prey appear minimal, several attacks on adult spider monkeys by large cats have been observed. Furthermore, infant mortality as a result of predation is described as being extremely high. In a group of *Ateles belzebuth belzebuth*, Shimooka concluded that sixty-four percent of newborns became victims of predation. It is, thus, plausible to reason that group size is important in minimising predation risks and, in societies where female emigration is possible, dominant individuals may maintain group cohesion by distributing unidirectional allogrooming to subordinate individuals.

The study has highlighted some surprising results concerning the cooperative strategies used by spider monkeys during allogrooming and it is particularly interesting that the findings here are in direct contrast with patterns of allogrooming seen in Old World primates. Unlike the study group, a preference for grooming up the hierarchy appears to be a robust phenomenon in species such as baboons (Barrett et al 1999) and macaques (Sade 1972).

**References**


Social interaction and enclosure use by Western Lowland Gorillas (Gorilla gorilla gorilla)
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Introduction
The aim of this study was to compare the social interactions and enclosure use by a group of captive Western lowland gorillas (Gorilla gorilla gorilla) within the first year following the introduction of a new adult male and a later follow-up period.

Background
The adult gorillas had been mixed together in the Gorilla Island complex at Bristol Zoo Gardens. The group consisted of an adult female who had been at the zoo since 1998, a second adult female who arrived in November 2001 along with an adult male. The second female had cataracts in both eyes that were removed successfully in 2002. In the summer of 2003 adult males were exchanged with London Zoo and a period of introduction followed. The incoming male had a history of aggressive behaviour resulting in injury to females. Veterinary intervention was required to modify the behaviour of the male but he has now settled and has mated with both females.

Gorillas

<table>
<thead>
<tr>
<th>Gorilla</th>
<th>Female</th>
<th>Age</th>
<th>Arrived in Bristol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Romina</td>
<td>Female</td>
<td>25</td>
<td>Nov 2001</td>
</tr>
<tr>
<td>Salome</td>
<td>Female</td>
<td>29</td>
<td>Nov 1998</td>
</tr>
<tr>
<td>Jock</td>
<td>Male</td>
<td>22</td>
<td>Jun 2003</td>
</tr>
</tbody>
</table>

Behaviour studies
Behavioural observations of the gorillas were made at different times after following the introductions. Activity, location and nearest neighbour were recorded at one-minute intervals using a scan-sampling technique. Data were recorded over 20 minute periods with session at various times during the day, providing a minimum of 900 minutes data for each animal. During the follow-up period data were also recorded using focal animal sampling.

The total observations of behaviours were grouped in to the following categories:
- locomotion: walking, climbing, running
- rest: sitting or lying down, not obviously performing other activities
- alert: standing, sitting or lying down but alert or watching
- feeding: eating, or other food directed activities
- self care: grooming or body care
- interactions: chasing, threatening, playing, courting, fighting, allogrooming.
Scans when an animal was out of sight have been omitted from these results. Data presented here were recorded 9, 12 and 16 months after the introduction of the male to the group. The nearest neighbour for each animal was recorded and distance apart was estimated as less than 2m, between 2 and 5m, more than 5m and “alone” (outside when the others inside or vice versa). The gorilla enclosure consists of an indoor area on two levels with a high level link between the two ends and dens that can be isolated on one side. Large steel baskets are provided in several locations and levels with wood-wool as nests. There are 3 doors that give access to a 1250 m² outdoor area bounded on three sides by a water filled moat with electric fence. The location of the gorillas was recorded in the sections as illustrated below.

**Figure 1. layout of Gorilla Island and**

**Results**
Cumulative frequency plots showed that most categories of behaviour had levelled off by 900 minutes.

**Behaviour** There were differences in the proportion of the time spent in various activities between the studies as illustrated in Figure 2. In the summer study the gorillas spent more time moving around and less time resting. Jock and Salome spent more time alert while Romina spent less time resting and more time feeding.

**Figure 2. Gorilla activities**
**Enclosure use** The enclosure use by the gorillas is shown in Figure 3. The gorillas do not use each area equally but the most frequented areas vary between individual and season.

Jock spent between 2 and 31% of his time on the higher levels. Romina spent between 12 and 34% of her time on the higher level and Salome between 40 and 68% of her time.

**Nearest neighbour** There has been a shift in the social dynamics of the group as illustrated by the nearest neighbour results (Figure 4). In the first study Salome was most likely to be nearer Jock and spent 50.1% of her time within 5m of him. Romina spent 31.9% of her time away from the other two. In the summer study Romina was more likely to be nearer Jock, spending 40.5% of her time with in 5m of him while Salome spent more time away from the other two, often outside. In the November-December study Jock spent most time nearer Salome, 59.4% of it within 2m of her. However, Salome spent most time away from the other two (24%).

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**Figure 3. Gorilla enclosure**

<table>
<thead>
<tr>
<th>Proportion of time spent indoors</th>
<th>Jock</th>
<th>Romina</th>
<th>Salome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar - Apr</td>
<td>.99</td>
<td>.66</td>
<td>.99</td>
</tr>
<tr>
<td>Jul - Jul</td>
<td>.75</td>
<td>.38</td>
<td>.57</td>
</tr>
<tr>
<td>Nov - Dec</td>
<td>.98</td>
<td>1.00</td>
<td>.77</td>
</tr>
</tbody>
</table>

Jock spent between 2 and 31% of his time on the higher levels. Romina spent between 12 and 34% of her time on the higher level and Salome between 40 and 68% of her time.
Discussion

Time spent in locomotion was significantly different for each animal but resting, feeding and self-care were not. Feeding is under-represented as the gorillas were separated for their main feeds and thus not recorded in the study reported here. The time spent alert was different for each animal but only reached statistical significance between Jock and Salome. The number of interactions is low but included play, affiliative behaviour, courtship, mating and chastisement.

In an earlier study with the previous male Romina spent more of her time near the male, while Salome spent most of her time away from the others, although she was more likely to be nearer Romina than the male (Dow et al, 2004). In the current study the group dynamics have changed and Romina was more likely to be away from the others while Jock and Salome spent more time within 5m of each other. The preferred locations reflect the furniture within the enclosure with the females preferring areas containing nest baskets that were used particularly in the middle part of the day. Jock’s preference was for the two areas in front of the public viewing area and the doorway between the two.

During the warmer weather all gorillas spent time outside. The females used the outside shelter more than the male and if away from the others were most likely to be there. The main user of the shelter changed from Romina in the spring to Salome during the summer. All three were more active in the summer study largely as a result of moving around the outside enclosure.
Conclusions

After his initial aggressiveness the male has modified his behaviour towards the females and includes mating, socializing and playing with the females. He initially formed strong affiliative bonds with the younger female and was more likely to be near her while the older female spent more time away from the other two. This was reversed in the follow-up study with the younger female more likely to be on her own. The shift in the social dynamics within the group may reflect a maturing of the relationships within the group and sexual receptiveness of the females. Romina, the younger female, became pregnant in August so was no longer coming into oestrus during the November-December study. The baby was born in May 2005.

References

Does zoo visitor noise affect primate behaviour?
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Introduction

Many variables associated with the presence or behaviour of zoo visitors, such as visitor noise, have been hypothesised to have negative effects on non-human primate behaviour and welfare. However, data to support the visitor noise hypothesis are limited. We examined the relationship between visitor noise and behaviour in three primate groups: golden lion tamarin (*Leontopithecus rosalia*, 1.1), western lowland gorilla (*Gorilla gorilla gorilla*, 1.4), and Sumatran orangutan (*Pongo pygmaeus abelii*, 2.4).

Methods

The three study groups were housed at the Toronto Zoo (Canada). Ten minute continuous focal animal samples (Martin and Bateson 1986) were used to collect 15 hours of data. Simultaneously, visitor noise was measured (in decibels) from the visitor viewing areas every minute using a sound level meter (Velleman DVM1326). Although visitor noise was treated as the independent variable, experimental manipulations were not carried out because the natural levels of visitor noise were deemed to be the more appropriate stimuli.

Statistical Procedure

The commencement of behavioural states or the occurrence of behavioural events were included in this analysis if they followed a noise level reading by sixty seconds or less. This ensured that behavioural states which began prior to the noise level measurement were not included in the analysis.

Results

Spearman’s rank order correlations were calculated to determine if there was a relationship between visitor noise and the commencement of states or the occurrence of events for solitary, affiliative, aggressive, abnormal, or visitor-oriented behaviours. The only significant correlation was a negative one between visitor noise and the initiation of social play in the gorilla group ($r = -.228$, $N=138$, $p < .05$).

Conclusion

All bouts of social play were performed by the two immature females (<22 months) in the gorilla group, indicating that the decrease in the initiation of social play as visitor noise increased may represent a particular sensitivity of immature gorillas to visitor behaviour. Although there was no relationship between visitor noise and the commencement of behaviour in our orangutan group, previous research
on zoo-housed orangutans (Birke 2002) reported increased looking at visitors by infants and adults, approaching and holding by infants, and sitting by adults, which suggests that some adult and immature orangutans are sensitive to visitor noise. However, Birke’s results are not directly comparable to ours due to the lack of an objective measurement of noisy visitor groups and an experimental manipulation of visitor noise which is probably less reflective of typical visitor behaviour.

Although the initiation of social play between gorilla youngsters decreased as visitor noise increased in our study, the general results suggest that visitor noise, as a discrete variable, did not affect the behaviour of the study animals. The mixed results of the few visitor noise studies on primates indicates further research on this issue is necessary for two reasons: 1) Animal welfare 2) The potential impact visitor-related variables may have on zoo-based behavioural, cognitive, and physiological research.

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Suzanne Hayes
Blackpool Zoo & Liverpool John Moores University

The nest building and other behaviours of several bird species within a free flight enclosure at Blackpool Zoo was studied during the nesting season March to June 2005. The species of particular interest were African Spoonbill, Waldrapp Ibis and Sacred Ibis, all of which were showing nesting behaviours at the time of the observation period. This study builds on many previous studies focussing on nest architecture in particular on their function. Nests within the enclosure were compared with known information relating to the species nest in the wild, their use and the behaviours associated with their use were monitored to gain an understanding of how practical the design of the nests are for the specified species. It was found that only 3 species within the enclosure were showing nesting behaviours from March to June 2005. There was no significant difference in aggressive behaviours between all nesting and non nesting species except for the Demoiselle Crane, which showed a high occurrence of flight-escape behaviours over the study period. There was a significant difference in the time spent foraging between nesting and non-nesting individuals. From this study it is suggested that the nesting areas for the Demoiselle cranes, Black crowned Night Herons, White Stork and Little egret could be improved upon.
Preliminary findings of the prevalence of diseases in captive Western Lowland Gorillas (Gorilla gorilla gorilla) in the United Kingdom and Ireland (1896-2005)

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Research ongoing
Gorillas mentioned in the text refer to western lowland gorillas unless otherwise specified.
Table and figures referred to in the text are displayed in the appendix.

Introduction

The western lowland gorilla (Gorilla gorilla gorilla) is a subspecies of the western gorilla (Gorilla gorilla) and is found in West Africa (Meder 2004). Population declines resulting from habitat loss and hunting for bush meat have led to the classification of the western lowland gorilla as an ‘endangered species’ (Butynski 2000). Gorillas have been kept in zoological collections since 1855 (Willoughby 1978). There are currently 839 western lowland gorillas recorded in the International Gorilla Studbook (2004) in 146 collections worldwide. This includes 381 gorillas in Europe, with 126 currently in captivity in twelve zoos in the United Kingdom and Ireland (Hilsberg-Merz 2005). The causes of disease and mortality cited in the literature on gorillas in captivity include a wide range of infectious and non-infectious diseases incorporating all body systems. Previous retrospective studies have recorded numbers of gorillas and their causes of death (Benirschke and Adams 1980, Cousins 1983, Meehan and Lowenstine 1994). The purpose of this study was to provide an overview of the causes of death of captive gorillas, in the United Kingdom and Ireland, since records began and compare the results with previous surveys of gorilla mortality.

Materials and Methods

Data

British and Irish zoological collections that are currently keeping or have kept gorillas were approached for inclusion in this study by letter to the zoological director and the responsible veterinary surgeon. Twelve institutions accepted and visits were made to nine zoos to collect data and interview the veterinary and keeping staff. Post-mortem reports and clinical records were viewed, either in paper form or in the MedARKS computer database. These records dated from 1896 until 2005. Where available, the clinical history, including events leading to death, gross pathological details with any further ancillary diagnostic information, was noted.

Data processing

Each gorilla was classified according to gender and origin (wild or captive bred). Individual gorillas were then categorised according to their age at death (see Table 1). The cause of death was also categorised (see Table 2). Disease categories were classified according to body system. In each case, the category was chosen to depict the major contributing factor to death. Age and disease categories were modelled on previous studies for ease of comparison of data (Benirschke and Adams 1980, Meehan and Lowenstine 1994). The circumstances surrounding the deaths were classified (see Table 3). The zoological collections supplying data were kept anonymous throughout the analysis and presentation of results.

Statistical analysis

Data was analysed using the SPSS statistical package (Gerber and Voelkl 1997). After completion of descriptive statistics, logistical regression analyses were carried out with selected variables. Variables including age group, gender and origin were added to the model with the status of specific disease categories (0=absence, 1=presence) as the dependent variable.
Results

109 gorillas were included in the study. Figure 1 shows the percentage of males and females in the study and Figure 2 shows the origins of the population. Figure 3 shows the proportions of males and females from both wild and captive-bred origins. For each of the gorillas, a minimum dataset including gender, origin and age at death was collected, where this information was available. The cause of death and further pathological information were ascertained for 81 of the 109 gorillas. The numbers of gorillas in each category of disease are displayed in Table 4. Table 5 shows the numbers of gorillas in each age group within each disease category. Figure 4 shows the overall numbers of gorillas in each disease category. The number of gorillas of each gender is displayed in Table 6 in relation to the circumstances of death. Logistical regression analyses were run against the presence of multi-systemic disease, cardiovascular disease, respiratory disease and gastrointestinal disease in relation to age group, gender and origin. No significant relationship was found between any of these variables (P<0.05) (Petrie and Watson 1999).

Multiple Organ System Involvement

This category contains 21 gorillas in which the cause of death could be attributed to more than one body system. Six cases of presumed sepsis were recorded. Four further cases involved both the cardiovascular and respiratory systems. All were male gorillas aged between 10 and 27 years old. One case involving the cardiovascular, respiratory, and gastrointestinal systems was seen in an adult female gorilla with evidence of interstitial pneumonia, gastroenteritis, hepatopathy and cardiomyopathy. The respiratory and gastrointestinal systems were responsible for seven cases in the multi-systemic category. Five cases involved pneumonia, with enteritis. In one case Balantidium coli was identified and thought to be the cause of the enteritis. The gastrointestinal and haemolymphatic systems were both involved in the death of an adult female gorilla that had colitis and tuberculosis of the spleen. The only case of chronic renal failure recorded in this study occurred in an aged female gorilla also affected by diarrhoea. A period of stress led to diarrhoea, with excessive fluid and mineral loss prior to death. One case of multiple abdominal tumours, affecting many organs, was recorded in an aged, wild-caught, female gorilla which had a prolonged period of illness prior to death. Unfortunately, no histopathology was performed therefore the nature of the masses was not confirmed.

Respiratory System

22 deaths due to respiratory disease were recorded. Two gorillas, under one day of age, were included in this group. One died of acute purulent bronchopneumonia and the second was a case of lung collapse. Four neonatal gorillas succumbed to respiratory disease with two cases of aspiration pneumonia and two cases of atelectasis. Four infants included two cases of bacterial pneumonia and two cases of viral pneumonia. Four juvenile gorillas died from pneumonia. Bacteria were the causative agents in two cases. Five adult gorillas were in this category which included two cases of acute respiratory failure. Two gorillas of unknown age died due to haemorrhage of the lungs and acute bronchitis respectively. These animals were wild-caught and died in 1904 and 1908. No further information was available for these gorillas.

Gastrointestinal

Twelve deaths caused by gastrointestinal disease have been recorded in this study. These include a neonate with acute gastritis; three neonates with enteritis and one infant affected by Shigella spp. infection. Two juveniles were included: one wild-caught male had a heavy worm burden and a 15 month old female which died following infection with Shigella spp. Ulcerative colitis was diagnosed in a wild-caught adult gorilla. One aged wild-caught female died following repeated bouts of diarrhoea and bloat and a second aged wild-caught female died following a large intestinal obstruction. Two wild-caught gorillas were reported to have died of gastrointestinal diseases but their ages were not recorded. One of these, which was heavily parasitized, died in 1896, whereas the second gorilla, which had diarrhoea, died in 1904.

Still/Premature/Aborted

Nine stillborn, aborted or premature infant gorillas were recorded. Seven gorillas were classed as stillborn. These were full-term foetuses that had been born dead. As most gorilla births occur overnight or early morning so that the infant is not immediately observed (Aspinall 1980), and as post-mortem examination of dead infants have not always been performed, stillbirth has sometimes been difficult to confirm. Various factors associated with stillbirth included strangulation by the umbilical cord, dystocia due to foetal oversize, assisted delivery and caesarean section. One baby was known
to be premature, based on firm gestation dates, and lived for only fifteen hours. One aborted foetus was reported and suspected to have had an infectious cause.

Miscellaneous
Nine cases were classified as miscellaneous. This category included cases of traumatic, accidental death and maternal abandonment. Two cases of trauma and one case of the baby being lain on by the mother were noted in gorillas less than one day old. Neonatal cases included trauma, abandonment and idiopathic haemorrhage. One case of traumatic death and one case of ‘sudden infant death syndrome’ were recorded in infant gorillas. The only adult in this category was a 15-year-old male gorilla. After being kept inside for seven weeks, he was let into a moated outside enclosure. The following morning, the male was found to have drowned.

Cardiovascular System
This category contained seven gorillas. One stillborn baby had an unspecified septal defect. A 3-day-old gorilla was examined following unexpected death and the presence of a patent ductus arteriosus and a foramen ovale were noted. These can be present in neonatal animals for a number of days after birth (Kumar, Cotran and Robbins 1992) and might have been significant enough in this case to cause cardiac failure. Other cases include two adult males which died suddenly due to acute heart failure and a myocardial infarct. Of three aged animals, one had an aortic aneurysm, one had cardiac ischaemia associated with a general anaesthetic and one died following chronic cardiac failure.

Musculoskeletal
One case of death due to a musculoskeletal disease was recorded in this study. This gorilla was born without a diaphragm and took only a few breaths.

Other body systems
No animals were classified in the endocrine, haemopoietic and lymphoid, urogenital or neurological categories in this study.

Circumstances of death
Information regarding circumstance was known in 82 gorillas. Illness, the most common category (39 cases), was defined as a problem that had been identified prior to death, for which treatment had commenced. Sudden deaths (20 cases) included animals that had shown no signs of illness prior to death (see Table 8). Anaesthetic related deaths comprised seven cases and were defined as death during an anaesthetic or during the expected recovery period. Five cases were gorillas with underlying risk factors e.g. long-term respiratory or cardiac disease, or presumed sepsis. All four traumatic cases were below one month of age. The stillbirths’ included aborted foetuses, premature and full term gorillas. Three gorillas were euthanased due to debilitating diseases. These included a case of parasite overload, in 1940; a case of presumed sepsis following gangrenous skin infection, in 1939, and a case of terminal tuberculosis, in 2001.

Discussion
The gorillas in the multi-systemic category account for 25.9% of deaths (21 out of 81 gorillas). Three cases of systemic infections were noted in Meehan and Lowenstein’s 1994 study and Cousins (1983) reported six cases of septicemia. Benirschke and Adams (1980) recorded eight gorillas, with multi-system involvement out of 48 deaths. These included five cases of pneumonia with gastrointestinal disease; one case of pyelonephritis with gastrointestinal Shigellosis and Salmonellosis; one case of coccidiomycosis and pneumonia, and a further case of coccidiomycosis with meningitis and renal infarcts.

Two cases of tuberculosis (2.5% of total population) were reported here compared with previous studies, which found 4.0% of the population had confirmed tuberculosis (nine out of 226 gorillas) (Cousins 1983). No cases were reported in other studies (Benirschke and Adams 1980, Meehan and Lowenstein 1994). This shows no significant change in the overall prevalence of tuberculosis.

The cases in the respiratory category account for 27.1% of all classified deaths (22 out of 81 gorillas). This compares to one case in Meehan and Lowenstein’s study of 74 gorilla deaths in 1994: a case of viral infection in an infant. Four cases out of 48 gorillas (8.3%) were reported to have respiratory disease as a primary factor leading to death in Benirschke and Adam’s 1980 study. These gorillas ranged from 17 months to 23 years old and all had pneumonia. This data can also be compared to a further survey where the author showed a 14.6% (33 out of 226 gorillas) prevalence of
respiratory disease (Cousins 1983). Nine cases of tuberculosis were not noted to be limited to the respiratory system. Cousins reported four deaths due to the *Coccidioides immitis*. This fungal disease, generally restricted to the western United States, can affect the respiratory system (Cousins 1983). Not surprisingly, no cases were seen in this study of British and Irish captive gorillas.

The deaths in the gastrointestinal category account for 14.8% of the classified population in this study (12 out of 81 gorillas). Meehan and Lowenstine reported a 20.3% prevalence of gastrointestinal disease (15 out of 74 gorillas) including seven cases caused by parasites, six bacterial infections, one case of mixed bacterial and parasitic disease, and a ruptured appendix in an adult male. Cousins (1983) reported a prevalence of 39.4% of gastrointestinal disease in his study of 226 gorillas. Fifty-five cases of bacterial disease were recorded, 27 gorillas were affected by high parasite burdens and seven gorillas had viral disease associated with hepatitis. He commented that parasitism was the greatest single morbidity and mortality factor in captive gorillas. Benirschke and Adams (1980) reported that the majority of the gorillas in their study had some form of gastrointestinal disease including those caused by *Shigella* spp., *Salmonella* spp., *Balantidium* spp. and *Strongyloides* spp. There were 15 cases of gastrointestinal disease, with or without parasites that accounted for 31.3% of all the deaths in their study population of 48 gorillas.

In this study, only two gorilla deaths were caused by parasitism. They were both wild-caught and were recorded in 1896 and 1940. Two further cases had the presence of parasites as incidental findings. It would be difficult to draw firm conclusions regarding the prevalence of parasites in the captive population of gorillas, in the United Kingdom and Ireland, from this data, as there are 28 cases with unclassified causes of death. Nevertheless, the overall prevalence in this study population does seem to show that there has been a decrease in the prevalence of gastrointestinal disease, at death, in captive gorillas. The decreasing numbers of wild-caught gorillas in zoos, seen from the studbook, could also partly account for this statistic. It is well known that wild gorillas carry a number of different parasites as commensal organisms within their gastrointestinal tracts (Sléeman, Meader, Mudakikwa, Foster and Patton 2000). Cousins (1972) commented that at one time, 80% of captive gorillas up to the age of ten years old died of *Oesophagostomum stephanostomum* infection. Most zoos now conduct regular faecal analysis and have routine worming regimes, which will help to prevent the occurrence of parasitic diseases such as strongyloidiasis. Despite this, cases are still seen of diarrhoea caused by the protozoan *Balantidium coli*, which is believed to be a commensal organism of the large intestine of gorillas (Munson and Montali 1990). This organism can cause recurring problems as it can be shed intermittently by carrier gorillas during times of stress (Loomis 2003). Three animals, in this study, had evidence of *Balantidium coli* infection within the large intestine, with no signs of clinical disease.

Stillbirths accounted for 8.6% of this study population (seven out of 81 gorillas) and abortion for 1.2% (one case). This can be compared to Benirschke and Adam’s study where 2.1% were stillborn (one case), 6.3% (three cases) were abortions and 6.3% (three cases) were premature. Meehan and Lowenstine (1994) recorded six cases of foetal deaths due to infection-related illnesses, three cases of dystocia, two cases of intra-uterine hypoxia and one case of prematurity due to hyaline membrane disease. It should not be assumed that these were still births as they might have lived for a few hours. Cousins (1983) did not include the figures for this group but commented that their inclusion would have greatly increased the percentage of early deaths.

In the miscellaneous category, trauma accounts for 4.9% of the total number of classified deaths (four out of 81 gorillas). All were under six months the age. This can be compared to Meehan and Lowenstine’s study where 12.2% of the study population had trauma-related deaths (nine out of 74 gorillas). Six infants died due to trauma, prompting the authors to suggest a review of the husbandry conditions of family groups (Meehan and Lowenstine 1994). Twelve cases of killings were recorded by Cousins (1983), which accounted for 5.3% of the total population. He also reported five cases of drowning (2.2%) which compares to 1.2% of this study (one case in 81 gorillas). Great apes are thought to respond to water on an individual basis, with some showing no fear of deep water (Cousins 1978). This might explain the case noted in this study.

One case of abandonment, in a neonatal gorilla, was recorded in this study (1.2%). Maternal neglect was seen in three cases in Meehan and Lowenstine’s study (4.1%). Benirschke and Adams (1980) reported one case of rejection (2.1%) whereas Cousins (1983) had five cases in his study of 226 gorilla deaths (2.2%).

The cardiovascular deaths accounted for 8.6% of the study population (seven out of 81 gorillas). This compares to 21.6% (16 out of 74 cases) of Meehan and Lowenstine’s study which were all adult
and aged gorilla. Cousins (1983) reported that 6.2% (14 out of 226 gorillas) of his cases died from cardiovascular disease. Two cases of possible congenital heart abnormalities were noted, there was one case of cardiac failure associated with a general anaesthetic - in a juvenile gorilla, and the remaining unspecified cases were within the adult and aged groups. Benirschke and Adams (1980) reported that 6.5% of their cases were due to cardiac disease. These included an aortic aneurysm, thrombophlebitis and heart failure with arteriosclerosis.

Only one death was due to a musculoskeletal disorder in this study. No other articles reported deaths due to musculoskeletal disorders.

Mortality in Young Gorillas
In this study, there were 56 gorillas under one year of age at the time of death, representing 69.1% of the study population. Meehan and Lowenstine (1994) recorded 27 deaths under one year old (36.5%). Gorillas under one day old account for 22 animals in this study (27.2%) compared with 16.2% in Meehan and Lowenstine’s study (12 out of 74 cases) and 16.6% in Benirschke and Adam’s paper (8 out of 48 cases) (1980). Cousins (1983) included figures for live-born animals less than five years old, which amounted to 51.8% (117 gorillas) of his study population. In this current study population, there were 67 gorillas in the juvenile, infant, neonate and stillbirth/premature/aborted age groups, which accounts for 82.7% of the gorillas. This is a far greater proportion than was seen in Meehan and Lowenstine’s study, which showed 35 gorillas (47.3%) died before reaching adulthood. In this current survey, 82% of young gorillas died in the years following 1980, therefore showing there is still a high level of mortality within these age groups despite advances in care of captive gorillas. Data concerning birth rate was not available when analysing these results but might also have increased over the last 25 years. When comparing the deaths of gorilla’s post 1994, with the Meehan and Lowenstine’s published figures, there remains a high number of young gorillas. 24 out of 45 gorillas were less than one year old at death (53.3%).

Conclusions
This study shows that there continues to be a high proportion of captive gorillas that die in the early stages of life. Causes of death in infant and neonatal gorillas include infectious diseases, congenital abnormalities and trauma. Respiratory disease has been found to be the most common primary cause of mortality and is seen across all age groups. Gastrointestinal disease seems to be on the decline especially in relation to parasitism. This result highlights improvements in the husbandry and preventative health regimes, which are continuing to be developed, in the care of captive gorillas. Less cardiovascular disease was noted compared to previous studies and was seen mostly in older gorillas; however, this relationship was not statistically significant. Only two cases of tuberculosis were confirmed in this survey. Data produced from methodical post-mortem examination and accurate record keeping within zoos can be combined to form large databases useful for many areas of research. Although limited by partial deficiency of early-century raw data, this research has produced large amounts of information which can be used to investigate and prevent diseases in captive gorillas. Development of this study into a worldwide survey, with increased population numbers, might then produce statistically significant conclusions concerning the causes of morbidity and mortality in captive gorillas.

Acknowledgements
I thank all participating institutions for making their records available, without which this study would not have been possible. Directors, administrative staff, veterinary surgeons and keeping staff all gave generously of their time, assisted me in my data collection and informed me about their gorillas. I thank my supervisor Ann Pocknell (Veterinary Pathologist, Zoological Society of London). I also thank the staff at the library of the Zoological Society of London for their assistance whilst researching the archives at London Zoo. I acknowledge Aviva Petrie for her advice on statistics and Tony Sainsbury and Wayne Boardman for their guidance throughout the creation and completion of this study. I also thank Twycross Zoo for their financial support.
References


Appendix

<table>
<thead>
<tr>
<th>AGE GROUP</th>
<th>CLASSIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Still born, premature, aborted (0-1d)</td>
</tr>
<tr>
<td>2</td>
<td>Neonate (1d-1m)</td>
</tr>
<tr>
<td>3</td>
<td>Infant (1m-1yr)</td>
</tr>
<tr>
<td>4</td>
<td>Juvenile (Female 1-7yrs, Male 1-9yrs)</td>
</tr>
<tr>
<td>5</td>
<td>Adult (Female 7-30yrs, Male 9-30yrs)</td>
</tr>
<tr>
<td>6</td>
<td>Aged (over 30yrs)</td>
</tr>
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Table 1: Age group classification for age of death for each individual gorilla.
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<td>2</td>
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</tr>
<tr>
<td>3</td>
<td>Digestive</td>
</tr>
<tr>
<td>4</td>
<td>Musculoskeletal</td>
</tr>
<tr>
<td>5</td>
<td>Aborted</td>
</tr>
<tr>
<td>6</td>
<td>Premature</td>
</tr>
<tr>
<td>7</td>
<td>Still</td>
</tr>
<tr>
<td>8</td>
<td>Multi-Systemic Involvement</td>
</tr>
<tr>
<td>9</td>
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Table 2: Category classification according to cause of death of each individual gorilla.

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<td>Sudden death</td>
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Table 3: Table to show the classifications used for the circumstances surrounding each gorilla death.

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</tr>
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Table 4: Numbers of gorillas, according to gender, in each disease category.

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Table 5: Numbers of gorillas according to age group in each disease category. This does not include gorillas of unknown ages.

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<td>Illness</td>
<td>25</td>
<td>14</td>
<td>0</td>
<td>39</td>
</tr>
<tr>
<td>Stillborn</td>
<td>4</td>
<td>5</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Sudden Death</td>
<td>9</td>
<td>11</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>Trauma</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Unclassified</td>
<td>12</td>
<td>12</td>
<td>3</td>
<td>27</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>58</strong></td>
<td><strong>48</strong></td>
<td><strong>3</strong></td>
<td><strong>109</strong></td>
</tr>
</tbody>
</table>

Table 6: Numbers of gorillas, according to gender, depending upon the circumstances of death.

<table>
<thead>
<tr>
<th>AGE GROUP</th>
<th>CIRCUMSTANCE</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Anaesthetic Related</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>Euthanasia</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Illness</td>
<td>2</td>
<td>7</td>
<td>9</td>
<td>9</td>
<td>6</td>
<td>1</td>
<td>34</td>
</tr>
<tr>
<td>4</td>
<td>Stillborn</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>5</td>
<td>Sudden death</td>
<td>6</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>7</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>6</td>
<td>Trauma</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
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<td>7</td>
<td>Unclassified</td>
<td>8</td>
<td>6</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>28</strong></td>
<td><strong>19</strong></td>
<td><strong>14</strong></td>
<td><strong>19</strong></td>
<td><strong>19</strong></td>
<td><strong>3</strong></td>
<td><strong>102</strong></td>
</tr>
</tbody>
</table>

Table 7: Numbers of gorillas, according to age group, depending on the circumstances of death. This does not include gorillas whose ages are unknown.

<table>
<thead>
<tr>
<th>AGE GROUP</th>
<th>CAUSES OF SUDDEN DEATH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Anoxia, suffocation, prematurity, lack of diaphragm.</td>
</tr>
<tr>
<td>2</td>
<td>Acute gastritis, idiopathic abdominal haemorrhage, aspiration pneumonia, lung collapse.</td>
</tr>
<tr>
<td>3</td>
<td>Acute bronchopneumonia.</td>
</tr>
<tr>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>Cardiac infarct, acute heart failure, emphysema and cardiac failure, chronic bronchitis and cardiac failure, drowning.</td>
</tr>
<tr>
<td>6</td>
<td>Cardiac failure, aortic aneurysm, large intestinal obstruction.</td>
</tr>
</tbody>
</table>

Table 8: Summary of diseases causing sudden death in gorillas according to age group.
Figure 1: Percentage of gorillas within the study population according to gender.

Figure 2: Percentage of gorillas within the study population according to origin.

Figure 3: Number of gorillas within the study population according to gender and origin.
Figure 4: Number of gorillas in each disease category according to cause of death (see table 1 for disease category classification).
Preliminary Investigation on the Effects of Captivity and Implications for Conservation: Using Red Pandas (Ailurus f. fulgens) as a Case Study
Kristen Jule
University of Exeter

Abstract

A preliminary study on captive red pandas (Ailurus f. fulgens) in the UK found that captive red pandas spend approximately 7-8 hours a day active. However, activity levels vary throughout the day. Captive red pandas spend the majority of their active time locomoting, next in non-locomotory behaviours such as grooming, and then in foraging. Diurnal variation in activity levels differed more between enclosures than within subjects and appear to be influenced by aspects of husbandry. Captive pandas also space themselves at a discreet distance from their con-specifics and unrelated individuals engage in little social interaction, this has social housing implications. Red pandas utilise only 35-45% of their provided enclosure space, therefore enrichment should be employed which encourages exploration. Red pandas spend nearly 95% of their time off the ground, and when provided, spend over 50% of their time above 6 metres, so provisioning of climbing structures is important. A behaviour discovery curve shows that 30 hrs of observation provides approximately 75% of the behavioural repertoire that would be observed in 100 hours.

Introduction

Studies on how animals fare in captivity are critical to the future of captive animals. There are several reasons why continued studies are so valuable; most importantly to improve the welfare of captive animals, but also for promoting captive breeding success and ex-situ conservation efforts. This is an endless area for research as the field is ever growing and changing and many species respond to captivity in unique ways. Studies on the effects of captivity are particularly helpful for conservation efforts such as re-introductions; for previous reviews have found that captive-born animals are half as likely to survive as wild-caught animals in a re-introduction (Griffith, 1989; Fischer et al., 2004). This implies that there is an effect of captivity on wild fitness; which needs to be investigated further if re-introduction projects are to improve success rates.

Zoological parks across the world are involved in International breeding programs for a wide range of species, although mostly mammals. Most of these breeding programs involve species which have been designated as threatened or higher by the IUCN (World Conservation Union) Red List. Programs such as SSPs (Species Survival Plan) and EEPs (European Endangered Species Breeding Programme) have been created in order to manage captive breeding efforts for animals have the potential to be released back into the wild (for conservation purposes only).

Red pandas (Ailurus fulgens) have been listed Appendix I, CITES, in 1995 and EN C2a, IUCN Red List, in 1996 and are involved in SSP and EEP breeding programs; their adaptation to captivity is an important aspect to study for conservation purposes. Despite the existence of an international captive breeding programme spanning nearly thirty years, there has been very little behavioural investigation on captive red pandas. They are a unique species both taxonomically and phylogenetically and in need of further study. A recent study by Clubb & Mason (2003), revealed that carnivores are particularly sensitive to captivity; and even though red panda are primarily herbivorous, they are in the order Carnivora.

An initial study was carried out at two zoos in the United Kingdom primarily to investigate the following: 1) To catalogue an extensive ethogram of captive behaviours; since no ethogram has previously been reported for either captive or wild red pandas. 2) To identify behavioural and environmental variables for use in future study. 3) To assess an optimum behavioural observation period that will be sufficient to identify a broad array of behaviours for future study.

Methods

Four subjects (3 female, 4 male), ranging in age from 4-9 years, were observed for a total of 66 hours. Subjects were housed in two separate enclosures and the zoological institutions included in the study were Paignton Zoo Environmental Park and Newquay Zoo, both located in the United Kingdom. Data were collected in 2005, from March through June, using instantaneous point sampling every minute for
thirty minutes, as well as all occurrence sampling in order to record frequency of event behaviours, such as scent marking. Individual behaviours, distance from one another, and location in the enclosure were recorded for each data point. Observation times ranged between the hours of 09:00 and 16:00 (zoo opening hours).

Behaviours were categorized into either active or inactive. Inactive behaviours were classified as sleeping, resting but alert, or out of sight for greater than 10 minutes. Active behaviours included 1) locomotion throughout the enclosure, 2) foraging, including consumption of food or drink, 3) Non-locomotory behaviours: such as sitting and grooming, 4) performance of stereotypies, and 5) social interaction (see Table 1 for a condensed ethogram). In this study, pacing was the only form of stereotypical behaviour observed.

Analyses were calculated on Excel and SPSS v.11.5.

<table>
<thead>
<tr>
<th>Category</th>
<th>Behaviours within Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inactive</td>
<td></td>
</tr>
<tr>
<td>Resting</td>
<td>Sleeping (lying down)</td>
</tr>
<tr>
<td>Resting alert</td>
<td>Resting while alert (lying down)</td>
</tr>
<tr>
<td>Active</td>
<td></td>
</tr>
<tr>
<td>Locomoting</td>
<td>Climbing, walking, running</td>
</tr>
<tr>
<td>Non-locomoting</td>
<td>Sitting, standing, grooming, other</td>
</tr>
<tr>
<td>Foraging</td>
<td>Foraging, consumption of food/water</td>
</tr>
<tr>
<td>Territorial</td>
<td>Exploring, scent-marking, vigilance</td>
</tr>
<tr>
<td>Social</td>
<td>Engaging in social behaviours (e.g. play, fight)</td>
</tr>
<tr>
<td>Stereotypies</td>
<td>Performing stereotypical behaviours (e.g. pacing)</td>
</tr>
</tbody>
</table>

Table 1. Condensed Ethogram

Results

For the purpose of initial assessment of activity budgets, data from all subjects were combined as there were no significant differences between subjects. It was found that captive red pandas spend approximately 31% of their time active (see Figure 1). It is difficult to say how this corresponds with red pandas in the wild, as pandas are elusive in the wild (Pradhan, 1999); but one study suggests that they spend approximately 56% of their time active throughout the day and night (Yonzon & Hunter, 1989). This would suggest that captive red pandas are less active than their wild counterparts.

Figure 1. Activity Budget
As can be seen in Figure 2, the majority of red panda's active time is spent locomoting and next in non-locomotory behaviours, such as grooming. There is very little data on the activity budgets of wild red pandas, due to their location and elusive nature in the wild; but like giant pandas, red pandas are herbivorous carnivores; and since pandas are not biologically adapted to digesting plant material, they must have a lot of food intake in order to receive the nutrients they require; therefore, it is reasonably safe to assume that they would need to spend more time foraging in the wild. Also, similar to many other animals held in captivity, home ranges of wild pandas (1.02-9.62 km²) extend much farther than the edges of their captive cousins' enclosures (0.06-0.2 km²); therefore the time required to travel around the home range, whether for territorial purposes or foraging, would also be greater for wild individuals.

Stereotyping consisted of approximately 10% of the red pandas activity budget (Figure 2). Red pandas tend to have rather complex stereotypical pacing patterns. Although complex seems contradictory to the nature of stereotypies in general, which are defined as repetitive movements or behaviours with no obvious goal or function (Mason, 1991); it should be noted because there is a risk of classifying territorial or exploratory behaviour with stereotypy, and vice versa. Therefore, determining amounts of stereotypies is subjective and in the case of this study, I decided to err on the side of caution, and thus believe that the amount of stereotypy reported here is an under-representation.

Figure 2 also shows that red pandas have a very limited amount of social interaction in captivity. The amount of limited social contact between captive red pandas is also supported by analysis of social spacing. This was done by using the Clark & Evans (1954) formula for spatial distribution, which calculates nearest neighbour distances in relation to a predicted mean random distance. Results found that red pandas spend their active time spaced at a greater distance from each other than mean random distance would predict, Paignton R=1.49, p<0.05 and Newquay R=1.11, p<0.05. It is therefore reasonable to assume that pandas employ avoidance measures in order to decrease contact, or potential contact, with fellow housed con-specifies. Previous studies on captive red pandas have also found that adult pandas maintain a discrete distance (Keller, R. 1990). This is consistent with their behaviour in the wild, as red pandas are primarily solitary animals and adult males and females tend only to meet during the breeding seasons (January and February) (Pradhan ; Pralad & Yonzon, 1989).

Captive red pandas' activity levels vary throughout the day (see Figure 3). Figure 3 shows that the pandas at Paignton Zoo have peak activity levels around 09:00 and again at 14:00; feeding times varied, however and they spent most of their time nesting resting higher up in the trees. Red pandas at
Newquay Zoo tended to increase their activity level as the day progressed; their shared nest box was cleaned out in the mornings, which appeared to stimulate activity. Pralad & Yonzon (1989) found that the activity patterns of wild red pandas peaked throughout the day, around 06:00, 15:00, and again at around 18:00, they also report that rest periods lasted between .25 and 5.5 hours long. This suggests that their natural daily activity pattern tends to vary throughout the course of the day. Studies on captive giant pandas at a reserve in China, shows activity peaks at 09:00-10:00 and again from 15:00 to 16:00; these activity levels were highly correlated with feeding times (Mainka & Zhang, 1994). It appears that husbandry and feeding regime does have a large effect on daily variation of captive red pandas, and care should be given to how and when husbandry regimes are carried out.

**Figure 3.** Captive activity levels plotted against time of day.

**Figure 4.** Captive time spent different elevations above the ground

Figure 4 shows that captive pandas spend nearly 95% of their time above the ground and, when provided, they spend over 50% of their time above 6 metres. Therefore, provisioning of three dimensional climbing structures with nesting areas is of particular importance to the welfare of red pandas.
pandas. Providing opportunities to climb are also important for the development of physical abilities, as wild red pandas tend to spend a majority of their time in high bamboo canopies (Pradhan et al., 2001). Therefore, for some species, including the red panda, climbing is an essential ability for survival in the wild; Stoinski et al. (2003) reported that fatalities and injuries sustained in relation to falls was a large factor in the re-introduction of captive-born golden lion tamarins.

Figure 5. Behaviour Discovery Curve.

The behaviour discovery curve is a plotted logarithmic model that predicts how many behaviours will be observed in any given length of observation time for an individual animal. It is obtained from running a linear regression, with the natural log of observation hours (+1, as no behaviours are seen at 0 hours) as the independent variable and the number of cumulative behaviours observed at each hour for the individual as the dependant variable. The un-standardised B coefficients from the model are then used in an equation to provide the data points for the curve:

\[ = B \text{(constant)} + B \text{(variable)} \times \ln(\text{hour} + 1) \]

From these calculations, predicted numbers of behaviours observed for any given time observation can be extrapolated, these are then plotted onto a graph. Depending on the purpose of study (i.e. how accurate a time budget is needed), length of observation time can be approximated. For the purpose of future study, I determined that I wanted to record no less than 70% of the possible behaviours recorded from 100 hours of observation. This model estimates that 30 hours of observation per animal will provide me with approximately 70% of the potential behaviours that would be observed in 100 hours.

Conclusions

This report is on preliminary work that will be used in further studies researching effects of environmental variables (such as enclosure size) on behaviours (such as activity budgets) in order to improve current housing conditions and enrichment procedures. The basis for this study is to continue on to look at behavioural similarities in related individuals (located both in similar (same zoo) or different (other zoo) housing conditions) in order to investigate the long-term effects of captivity on red pandas; in particular, in relation to losses in behavioural repertoire. Further studies will include personality profiling, with respect to relatedness, effects of keeper contact, effects of environment enrichment and behavioural elasticity in the captive red pandas.

References


The effect of visitor impacts on behavioural repertoires and use of enclosure captive red-necked wallabies, *Macropus rufogriseus fruticus* at Chester Zoological Gardens

Daniel Lockley & Juliet Leadbeater
University College Chester

ABSTRACT

The effects of visitors upon captive animals in zoos, is still an area under-researched, and the majority of work conducted has been based on primate species. As little work has been published on non primate species, it was decided that a non primate species would be the subject of a visitor effects study. Twelve female captive red-necked wallabies were observed at Chester Zoological Gardens, Cheshire, in the presence and absence of visitors to see if visitors influenced how the wallabies behaved and made use of their enclosure. Subjects were observed throughout the morning from 10:00-12:00 and during the afternoon from 13:00-15:00, using scan sampling. The behaviour of each individual wallaby was recorded along with the type of surface the wallaby was standing on and their location within the enclosure, both in the presence of “visitors” (more than twenty people) and “no visitors” (nobody present except the observer), with a gap of three minutes or longer between each observation so that the last result did not influence the next. A chi square analysis showed that visitors significantly affected wallabies' behaviour, and this behaviour differed from morning to afternoon. It also showed that visitors influenced how the wallabies used their enclosure, as less time was spent near to the viewing platform, and had an effect on the types of surface used within the enclosure. Although grass was the preferred surface, ditches were significantly used more when visitors were present, compared to when no visitors were present. The analysis was able to show an association between subjects and visitors, but was unable to determine the ways in which wallabies were affected. As some animals have shown increased stereotypies, stress and aggressive behaviour towards visitors, it is crucial to determine the true effects visitors have upon animals, so further studies are needed for wallabies and zoo animals in general.

Aim of study

The aim of the study was to observe the effects of visitors on Red Necked Wallabies’ behaviour at Chester Zoological Gardens. It was decided that a non-primate species would be chosen as there are numerous examples of visitor effect studies on primate species, but very few published studies on non-primate species. As no studies were found on marsupials and the zoo had a collection of red-necked wallabies (*Macropus rufogriseus fruticicus*) with a reasonable sample size it was decided that wallabies would be the subjects to test.

The Zoo Environment

In recent times zoos have become increasingly aware of the specific needs of animals in captivity. Also, the public's perceptions have changed dramatically during the last couple of decades. The introduction of the Zoo Licensing Act in 1981 led to improved husbandry and care of captive species. Zoos are moving forward in recognising the requirements of animals, and are able to develop enclosures replicating natural environments and encourage species to display natural behaviour including foraging (by scatter feeding), climbing (introducing ropes and other apparatus) and places to rest in privacy (by providing hides and areas where the animal can escape public view and members of the same species). It was suggested by Wilson (1982) that enriching the animal’s enclosure has proved to be positive as studies on captive primates showed this leads to benefits such as decreased aggression, increased activity, decreased abnormal behaviour, improved breeding and health.

Purpose of keeping animals in zoos

Although the main aim of Chester Zoo is to focus on conservation, breeding rare and endangered species and to provide entertainment, the reasoning behind how visitors perceive the role of the zoo, and why they visit animal establishments varies from person to person. Research by Reade (1996) shows people perceived the most important role of the zoo to be conservation, followed by research, education and entertainment respectively. However previous research by Kellert and Dunlap (1989) showed the main reasons for visiting zoos were family enjoyment, aesthetic appeal of animals and for education.
purposes. Although reasons why people visit zoos have no direct effects on the species, for all the reasons mentioned above, the effect of visitors should not be harmful for animals.

**Visitors affecting animal behaviour**

Previous studies of zoo animals show that human visitor presence has affected the behaviour of several mammalian species, but does not always cause stress to the animal. On the other hand, evidence from other studies, including Margulis et al (2003), suggests that it is not the reactions of zoo visitors that influence animals but the other way round. However, Hosey (2000) suggests the amount of data published on visitor effects was sparse, so there is little information available to draw solid conclusions.

Studies are also variable because conditions vary from zoo to zoo in ways that species are housed and displayed, variables are not kept the same in all studies and visitor number, ages, sexes and amount of noise varies. Therefore the findings from research carried out at one zoo may contradict the findings from another. Of the published research, Mitchell and Hosey (2005) state the majority of studies focus on interactions of non-human primates. As far as non-primate species is concerned, there are few published studies on visitor effects.

As well as recognizing the effects visitors have on the general behaviours displayed by animals, it is also important to recognize whether they influence the ways in which animals use their enclosure, for example, areas near viewing platforms, and whether the tested animals are influenced to use certain surfaces or areas within the enclosure. This approach has been used in many studies, including Hosey and Druck (1986), which looked at time spent by primates in front of viewing windows, and O’Donovan et al (1993) who looked at whether a female cheetah with cubs spent more time near to, or away from, the viewing platform.

It is also vitally important to establish whether behaviours are being shown as a reaction to stimuli and whether they are part of the animals’ everyday behavioural repertoire.

Although previous visitor studies differ in their designs and the aims they want to achieve, a common outcome reported by Hosey (2000) is animals are either affected positively or negatively.

**Negative effects upon behaviour by visitors.**

Hediger found that there were many associations between stress and the zoo environment. However, the first zoo visitor studies were not published until the 1980’s (Mitchell and Hosey, 2005). A common cause of chronic stress described by Hediger (1964, as cited in Moberg, 2000) is when wild animals in confined spaces are unable to avoid fearful situations and display natural escape response, unlike the same species in natural habitats, as there is a restriction to enclosure size.

After looking at the zoo environment and how humans and animal interacted, Hediger (1970) suggested that animals perceive humans as being significant as five possible types. These are an enemy, a prey, a symbiont, a piece of inanimate environment or member of their own species. This was different from the views of Snyder (1975, as cited in Hosey, 2000) whose opinion was animals become habituated to the public and are mostly unaffected by their presence.

Research by Carlstead (1991) shows other stressors include the use of machinery near to enclosures, which has caused stereotypical behaviour in the form of pacing in species including the fennec fox (Fennecus zerda), and Carlstead et al (1999) found enclosures with greater public access have seen higher mortality rates in a number of species including black rhinos (Diceros bicornis).

**Positive affects upon behaviour by visitors.**

Morris (1964, as cited in Hosey, 2000) suggested visitors act as a form of enrichment because in the wild and captivity, animals have to adapt their behaviour in uncertain circumstances, such as encountering unfamiliar species (thus, for animals in captivity, humans represent an unfamiliar species).

However Chamove et al (1988) disagreed that humans are enriching to animals and believed humans have negative effects on behaviour as it caused increased aggression and stereotypes in their study.

Positive animal and visitor interactions have been observed in a number of species. It was found by Cook and Hosey (1995), that chimpanzees (Pan troglodytes) can discriminate between who they
respond to and who they choose not to respond to. Chimps showed interest in male visitors and paid particular interest to those holding objects and were less likely to respond to females who were not holding objects. This is positive, as it lowers the chance of them showing increased aggressive behaviour as previously observed by Maki et al (1987). The chimps also showed begging behaviour when visitors were observed eating food. Although this may be providing a distraction for the chimp, some researchers studying chimp behaviour could disagree, and perceive it as not beneficial, suggesting it is stressful in other ways, as it is not natural.

**Hypothesis**

The study allowed the following hypothesis to be answered:

<table>
<thead>
<tr>
<th>Hypothesis One</th>
<th>Null Hypothesis One</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visitors influence how wallabies make use of their enclosure. (For example, it is expected that more time will be spent in sections away from the viewing platform in visitor present conditions compared to visitor absent conditions).</td>
<td>Visitors have no influence on how wallabies make use of their enclosure.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hypothesis Two</th>
<th>Null Hypothesis Two</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visitors influence the use of surfaces used by wallabies within their enclosure. (For example, if visitors do influence how wallabies use surfaces within their enclosure, there is likely to be increased use of ditches, the house and stoned area in visitor present conditions as they help conceal the wallabies.)</td>
<td>Visitors have no influence on the surfaces used by wallabies within their enclosure.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hypothesis Three</th>
<th>Null Hypothesis Three</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visitors affect how wallabies behave during observations. (For example, it is expected that wallabies will move around more and show more signs of vigilance when visitors are present as they will be more wary of danger.)</td>
<td>Visitors have no effect on how wallabies behave during observations.</td>
</tr>
</tbody>
</table>

**METHOD**

**Subjects**

The subjects that were used throughout the study were all twelve of Chester Zoo's female red-necked wallabies. All of the subjects were born in captivity and parent-reared, apart from one, which was hand-reared. Subjects were aged between four months and eight years at the beginning of the study.

**Determining Procedure**

A pilot study was conducted in September 2004. Subjects were observed four times over a period of four days for two hours, to determine the methodology for the study. Previous to this wallabies were observed to determine behaviours that would be included on the ethogram.

The main focus of this study was the effects of visitors on the behaviour of wallabies. Determining how many people would be present for observations labelled “visitors” needed to be established. As the wallabies are not a main attraction of the zoo, visitor numbers at the enclosure at any one time are much lower than popular species such as the elephants. When observations took place in September, the highest number of people around the enclosure ranged between thirty and forty maximum. As visitor figures for the zoo decrease each month after the summer period due to weather deterioration and children returning to school, it was likely that the number of people visiting the enclosure would also decrease. It was therefore decided that the maximum number seen throughout the pilot study would be halved, so a high number of visitors was defined as being twenty people. For absent conditions the wallabies would be observed when nobody was around the enclosure apart from the observer.

Throughout the pilot study it was extremely difficult to judge where the wallabies were situated within the enclosure and to individually identify them. From looking at various methods of recording behaviour in Martin and Bateson (1996) it was decided that, as twelve wallabies were being observed, scan sampling would be the most appropriate method of recording behaviour, as the individual behaviour of each wallaby is recorded without having to identify each subject individually. To prevent bias, it was therefore
decided that the behaviour of the wallaby furthest away was recorded first each time, moving from left to right across the enclosure.

**Recording position within enclosure**

As the enclosure measures 2050m² it would be impossible to locate positions without sectioning the enclosure into smaller grids (an idea previously used by Blasetti et al (1988)). The number of sections cannot be too high as the observer only has a short amount of time to record the location within the enclosure and record the behaviour of each individual wallaby. It was decided that the enclosure would be divided into twelve sections. This was done using visual objects so that the observer could determine where the wallabies were located within the enclosure. Objects were out of reach of the wallabies and it is unlikely that they would have influenced their behaviour.

**Procedure**

The study was conducted at Chester Zoological Gardens, Cheshire, from the 29th October to 13th November 2004: but did not occur on a daily basis due to observer availability. On observation days the wallabies were observed between the hours of 10 am and 12pm and 1 pm and 3pm. The observer arrived at the enclosure at least fifteen minutes prior to testing, allowing the wallabies to habituate to the observer’s presence.

Data was collected for the effect of “visitors” when there were twenty people or more at the viewing point or on the path adjacent to the enclosure. Data was collected for the effect “no visitors” when nobody was present on the path or viewing platform, apart from the observer using a data collection sheet.

Behaviour was recorded from the viewing platform using scan sampling. On each occasion in “visitor” present and “no visitors” the behaviour (as listed in table 2.4.2) shown by each individual wallaby was recorded, as was the grid number the wallaby was located in and the type of surface the wallaby was standing on.

Once all the data was collected, a chi squared statistical analysis was performed to see if there was an association between how wallabies behaved and “visitor” and “no visitor” conditions. Although the analyses enable us to observe associations, they would provide no information regarding ways in which the subjects were being affected.

**Table 2. 4.2 Ethogram used for determining behaviours being displayed by wallabies in the absence or presence of visitors.**

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeding or drinking (F)</td>
<td>The consumption of food from grazing or foraging or the consumption of water. (<em>If the wallaby was feeding in a stationary or resting position but food was being consumed the behaviour was defined as feeding</em>)</td>
</tr>
<tr>
<td>Grooming (G)</td>
<td>The preening of own body for periods of five seconds or longer incorporating licking or scratching. (<em>If the wallaby was in a stationary or resting position but showing signs of grooming behaviour then the behaviour was defined as grooming</em>)</td>
</tr>
<tr>
<td>Movement (M)</td>
<td>Either sustained quadrupedal or bipedal movement or hopping using hind legs, and tail as a balance.</td>
</tr>
<tr>
<td>Resting (lying down) (R)</td>
<td>Lying on side or front and taking part in no other activity. (<em>The behaviour was only classed as resting if the wallaby was not grooming, feeding or in a vigilant state</em>)</td>
</tr>
<tr>
<td>Social Behaviour (So)</td>
<td>A range of behaviours including allo-grooming, nose to nose or nose to body sniffing and any interaction between wallabies. (<em>If the wallaby was in a stationary or resting position, these behaviour were ignored and social behaviour was recorded</em>)</td>
</tr>
<tr>
<td>Stationary (upright before resting)(S)</td>
<td>Standing on hind legs with tail behind, or in a crouched position with front legs and hind legs in contact with the ground. (<em>Classed as stationary as long as wallaby is not grooming, social behaviour, vigilant or feeding</em>)</td>
</tr>
<tr>
<td>Vigilance (V)</td>
<td>Head held high with wallaby looking around and movement of ears to locate distraction in either a resting or stationary position. (<em>Only vigilant if wallabies looking around and moving ears to locate distraction</em>)</td>
</tr>
</tbody>
</table>
RESULTS

Visitors influence how wallabies make use of their enclosure.

A comparison between visitors and location of subjects within the enclosure gave a significant result (chi square = 607.350, DOF = 11, P < .000), meaning that the result was not down to chance and that visitors influenced how wallabies used the enclosure. Therefore the null hypothesis can be rejected and the hypothesis accepted.

Figure 3.1 Bar chart showing the number of times that subjects used individual grids within the enclosure in the presence of “visitors” and “no visitors”.

![Bar chart](image-url)
Visitors influence the use of surfaces used by wallabies within their enclosure.

Surfaces used by subjects within the enclosure, were significantly influenced by visitors’ (\text{chi square} = 195.879, \text{DOF} = 3, P = .000). The null hypothesis could therefore be rejected, allowing the hypothesis to be accepted.

Figure. 3.2.1 Bar chart showing the number of times subjects used surfaces within the enclosure when observed by visitors or no visitors.
Visitors affect how wallabies behave during observations.

Wallaby behaviour was significantly affected by visitor presence (chi square = 274.644, DOF = 6, P = .000). The hypothesis can be accepted and the null hypothesis can be discarded.

**Figure. 3.3.1 Bar chart showing the number of times behaviour was displayed by subjects in visitor present and absent conditions**

**DISCUSSION**

**The influence of visitors on how wallabies make use of their enclosure**

The study found, that subjects were significantly influenced (chi square = 404.687, DOF = 3, P < .000) by visitors in the ways in which they used their enclosure. In the presence of visitors, subjects spent the majority of time located in grids four, six and seven (figure 3.3.1). Grids four and seven were situated away from the public pathway, and down the side of the enclosure. The grids contained a ditch, which helps to conceal wallabies from visitors and visitors are prevented from walking down this side of the enclosure, as a fence runs the length of the enclosure.

Previous studies, including Blasetti et al (1988), support these findings that visitors affect how animals use their enclosure. Blasetti reported that wild boars do not use the whole of their enclosure and use areas situated near viewing platforms and walkways considerably less compared to other areas, and some behaviours were expressed considerably less near the viewing area. A study by Hebert and Bard (2000) found that orang-utans prefer the upper canopy in a naturalistic enclosure and spend little time on the floor or in lower canopy areas, as these are closer to the observing visitors.

In the absence of visitors, wallabies used grids ten, eleven and twelve more and these are situated closest to the viewing platform (figure 3.3.1). When more than 20 people were present, grids eleven and
twelve were used least, clearly demonstrating that visitors influence how they make use of their enclosure, because more time would have been spent nearer to the viewing platform when visitors were present.

Primate studies, including Hosey and Druck (1986) and Mitchell et al (1991b), found that primates like to interact with audiences at the front of the enclosure. However Blasetti’s study showed boars used the back of their enclosure more. The result of the present study showed similar finding to Blasetti, suggesting that non-primate species perceive their viewing audiences differently. However, O’Donavan et al (1993) found that time spent at the front, middle, and the back of the enclosure by cheetahs was not influenced by visitors and similar findings were observed by Margulis et al (2003) in a felid study. This result therefore questions whether they do perceive viewing audiences differently.

**Visitors influence the use of surfaces used by wallabies within their enclosure.**

The study showed that there was a significant association between the type of surface used within the enclosure and the presence and absence of visitors. It was found that wallabies favoured a grass surface in both visitor absence and presence conditions. This is not unexpected, as wallabies are grazing species, and at least two thirds of the enclosure is surfaced with grass. However there was increased usage of ditches and the stoned area when “visitors” were present compared to “no visitors” (figure 3.3.2). This could suggest that the wallabies were trying to conceal themselves from viewing audiences and are wary of larger audiences.

These results show that it is extremely important that zoo enclosures are designed appropriately and take the animals’ behaviour into consideration. If ditches or areas away from visitors were not present the animal could suffer high levels of stress, which have been observed in spider monkeys (*Ateles geoffroyi rufiventris*) observed by visitors (Davis et al, 2003).

The smallest difference between visitor conditions was the use of the emus’ house. The house may not have been used as often as ditches or the stoned area as it is located next to the viewing platform.

**Visitors affect how wallabies behave during observations.**

Visitors significantly affected the wallabies’ behaviour (chi square 274.644, DOF = 6, P < .000), (figure 3.3.1).

Throughout the observation, the behaviour displayed most in the presence and absence of visitors was feeding. The results showed that wallabies fed significantly more when no visitors were around. It could be perceived that wallabies fed more in visitor absent conditions, as they were able to feed without being disturbed. When visitors were around, more time was spent having to respond to visitors by moving around more or displaying increased vigilant behaviour. Similar findings were witnessed by Stanley and Aspey (1984), who found that captive ungulates show less head down behaviour when lions were visible. This is not surprising as lions are a predator of ungulates; however it is not known whether wallabies perceive humans as a predator.

The study found that grooming (Chi square .563, DOF = 1, P < .453), resting (Chi square .292, DOF = 1, P < .589) and social behaviour (Chi square .681, DOF = 1, P < .409) were not significant, meaning that the wallabies are just as likely to show this behaviour in either visitor present or visitor absent conditions. Similar findings have been found in other studies, including that by Stanley and Aspey (1984), who found that feeding, lying down and social behaviour, including sniffing, occurred considerably less in the presence of predators.

Movement around the enclosure was another behaviour that was significantly affected by the presence of visitors (Chi square 86,382, DOF = 1, P < .000). This supports previous findings of Hosey and Druck (1986) and Chang et al (1999) who found that locomotion increases when visitor numbers are higher and decreases as the number of visitors drops. In conditions of no visitors, movement was observed less but increased in the presence of the visitors. When no visitors are present there is little need to move around; however, as people move closer to the animal the situation changes and the animal needs to assess whether it is safe and react accordingly.

Although an association between the number of visitors and increased locomotion behaviour has been found, the study provides no evidence to suggest whether subjects were moving more because they were stressed or whether it was coincidental.
Limitations to the study

The study was limited as the data was only collected from one zoo and there were many uncontrollable variables. Like most zoo-based studies, the sample size used was limited and this is a concern of Hosey (1997). Other factors that are uncontrollable and may affect behaviour include weather, noise control of visitors, neighbouring animal behaviour and visitor activity.

Further suggestions

A more recent technique that has been applied in recent studies, to see whether visitors cause stress to animals in captive environments is to take blood, faecal or urine samples from the animal and see whether cortisol levels have increased (Davis et al, 2005). This technique could be applied to wallabies in the future; however, the study would have limitations, including the amount of samples that can be taken from the animal, the cost, and time and it would need to be determined whether actually collecting the samples is causing stress to the animal.

As discussed earlier, a problem with zoo studies is the methodology used in visitor studies and the variables they test for. To try and overcome this problem, Mitchell and Hosey (2005) have published research guidelines that provide researchers with information on how to set up an ideal visitor effect study. Although this current study has used some of the suggested methods more could be used. Therefore if future studies were to be conducted referring to the new published guidelines could make improvements.

CONCLUSION

Visitor Study

The main findings of the present study show that the red-necked wallabies' behaviour was affected by visitor presence and the design of the enclosure could affect how the wallabies behave. Although the study has provided evidence that visitors affect behaviour, it has emphasized the difficulties that are observed in many zoo-based studies, including the large number of independent variables and lack of information known about non-primate species, as the majority of research is based upon primates. As some areas of zoo research are not fully established and are currently under-researched, it may not always be possible to draw strong conclusions from results.

Although the study has established that visitors have a significant effect upon the behaviour of the wallabies, the results of the study have not determined whether wallabies are stressed by visitors and have raised further questions that need to be answered. Therefore, in order to determine the true effects that visitors have on captive wallabies, further studies need to be carried out.

REFERENCES


Acknowledgements

Firstly I would like to thank Stephanie Wehnelt and the research department at Chester Zoological gardens for allowing me to conduct this research, and the rhino keepers Shane Blake, Helen Boczek, Mark Cleave, Charlie McKenzie and Rosie Scott for their support through out the project.

I am extremely grateful to my supervisor Juliet Leadbeater for all her guidance and encouragement through out the study and to Debbie Scott for help in developing strategies to tackle the project.
Abstract

Adult male chimpanzees are known to form strong bonds amongst themselves both in the wild and in a captive environment. This study examines the changes in relationships between the adult males (n = 5) in a captive group of chimpanzees (Pan troglodytes) at Chester Zoological Park at 3 time points over a four year period; in 2000, 2002 and 2004. Instability was highest during 2002 when a new alpha male became established. Scan, instantaneous sampling was used to collect data on grooming dyads, and rowwise matrix correlations were used to assess stability in relationships across years. Grooming relationships between males changed significantly during the study period. In contrast, grooming relationships between females were highly correlated across years, demonstrating long-term stability. Grooming reciprocity between males was found in all years except 2002, when the male dominance takeover took place, highlighting lack of reciprocity between males during periods of instability in the hierarchy.

Introduction

Adult male chimpanzees (Pan troglodytes) form strong bonds amongst themselves both in the wild and in captivity, whereas adult female chimpanzees are dispersed in the wild and strongly bonded in captivity (de Waal, 1982). Grooming is thought to be one indicator of bond strength and grooming patterns are often used as accurate representations of relationships between individuals (e.g. Newton- Fisher, 2002, Nakamura, 2003). Although males have strong bonds with each other, they seem to show little long-term loyalty in their relationships with other males (Uehara et al., 1994), and are involved in a continuous and intense competition to maintain or increase their standing in the dominance hierarchy (Goodall, 1975 cited in Nishida & Hiraiwa- Hasegawa, 1987). Among females the strong bonds formed in captivity appear to be more long term and stable (de Waal, 1982).

This study investigates the long-term stability and flexibility in the grooming relationships between the adult males and the grooming relationships between the adult females of a captive group of chimpanzees over a four-year period. This period includes a time of social instability, when a new male became the dominant alpha male.

Methods

Subjects were the five adult males, and fourteen of the eighteen sexually mature females, of a well established group of twenty seven chimpanzees housed at Chester Zoological Gardens, UK.

The individual Boris was the dominant alpha male for over a decade before a younger male, Dylan, was considered to be dominant at some point in 2002 (C. Caws, personal communication).

Data were collected from September to December in the years 2000, 2002 and 2004 during park opening times. Identities of grooming partners and directions of grooming were collected during instantaneous scan sampling, every fifteen minutes. The male hierarchy was found to be stable in 2000 and 2004 and unstable in 2002 (C. Caws, personal communication). Rowwise matrix correlations were used to compare grooming interactions between dyads across years to assess stability in relationships. Grooming patterns between members of each sex were analysed. Partial correlations were used for female-female dyads to control for kinship.
Results

<table>
<thead>
<tr>
<th>Grooming Given</th>
<th>Grooming Given</th>
<th>Kr statistic</th>
<th>Significance of Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males 2000</td>
<td>Males 2004</td>
<td>4</td>
<td>0.3297</td>
</tr>
<tr>
<td>Males 2000</td>
<td>Males 2002</td>
<td>16</td>
<td>0.0034</td>
</tr>
<tr>
<td>Males 2002</td>
<td>Males 2004</td>
<td>4</td>
<td>0.1463</td>
</tr>
<tr>
<td>Females 2000</td>
<td>Females 2004</td>
<td>0.201743</td>
<td>0.0009</td>
</tr>
<tr>
<td>Females 2000</td>
<td>Females 2002</td>
<td>0.285815</td>
<td>0.0001</td>
</tr>
<tr>
<td>Females 2002</td>
<td>Females 2004</td>
<td>0.236329</td>
<td>0.0004</td>
</tr>
</tbody>
</table>

Table 1: Results of Pairwise and Partial Matrix Correlation tests for correlations of grooming given between males, and grooming given between females, across study years. Non significant results are emblazoned.

<table>
<thead>
<tr>
<th>Grooming Given</th>
<th>Grooming Given</th>
<th>Kr statistic</th>
<th>Significance of Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males 2000</td>
<td>Males 2000</td>
<td>13</td>
<td>0.0344</td>
</tr>
<tr>
<td>Males 2002</td>
<td>Males 2002</td>
<td>10</td>
<td>0.123</td>
</tr>
<tr>
<td>Males 2004</td>
<td>Males 2004</td>
<td>32</td>
<td>0.0008</td>
</tr>
<tr>
<td>Females 2000</td>
<td>Females 2004</td>
<td>0.219535</td>
<td>0.0009</td>
</tr>
<tr>
<td>Females 2000</td>
<td>Females 2002</td>
<td>0.278178</td>
<td>0.0001</td>
</tr>
<tr>
<td>Females 2002</td>
<td>Females 2004</td>
<td>0.653425</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

Table 2: Results of Pairwise and Partial Matrix Correlation tests for correlations between grooming given and grooming received between males, and between females, in each study year. Non significant correlations are emblazoned.

Differences in grooming amongst males were found between 2000 and 2004, and 2000 and 2002, but not between 2002 and 2004. Grooming between females did not differ across study years (Table 1).

Grooming reciprocity occurred in all three years amongst females. Males also groomed reciprocally in 2000 and 2004, but did not in 2002- the year of the dominance takeover (Table 2).

Discussion

Grooming patterns between the adult male chimpanzees showed significant changes over the years of 2000-2004, during a time of instability in the social dynamics of the male hierarchical system. Grooming given between male grooming partners changed between the years 2000 and 2004; more specifically between 2002 and 2004, but not 2000 and 2002, this change occurred after the new male became alpha- an identical situation occurred in a wild chimpanzee community at Ngogo, Uganda (Watts, unpublished, cited in Watts, 2000). Grooming between males may change as a result of altered investments in relationships (Newton-Fisher, 2002).

Unlike the other study years, male grooming was not reciprocal in 2002- the year of the takeover; highlighting the importance of the take-over period to the male relationships. Grooming reciprocation has been shown previously both in captivity (Helmerijk, 1990 cited in Newton-Fisher, 2002), and in the wild (Watts, 2000, Newton-Fisher, 2002), and represents the great importance given to grooming effort allocation (Newton-Fisher, 2002) and also offers support to the idea that grooming is used as a social tactic (de Waal, 1982). Contrastingly, grooming relationships between females were highly correlated and reciprocation was shown in all study years, demonstrating long-term stability.

Grooming patterns between males may have been affected due to other factors such as oestrous patterns of females and the increases in age of individuals as the study progressed.

To conclude, the grooming relationships between the adult males of a captive group of chimpanzees changed over a period of social instability whereas female grooming relationships were remarkably
stable across the four years. These results highlight the flexibility in male-male relationships and the stability of female-female relationships in captive chimpanzees.

Acknowledgements

We would like to thank Clare Caws of Chester Zoological Park for both her help in data collection and providing invaluable information about the chimpanzees.

References


The length of the 2nd to 4th digit ratio (2D:4D) and its relationship to primate mating strategies and the evolution of human society

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2D:4D and the prenatal environment

The length of the 2nd digit divided by the length of the 4th digit - 2D:4D ratio - is sexually dimorphic in humans, primates and possibly other mammals (Phelps, 1952; Roney et al. 2004; McMechan et al. 2004) and is affected by levels of in utero sex hormones, specifically testosterone, oestrogen and their derivatives (Lutchmaya et al. 2004). Within human populations males have lower mean 2D:4D (shorter index finger compared to ring finger) than females. However, there is overlap between the sexes and variation between populations (Manning et al. 2000) (Figure 1).

![Figure 1. Mean 2D:4D of 9 human populations (Manning, 2002) and 7 non-human primate species; P. papio (m=11; f=21) (Roney et al. 2004); C. jacchus jacchus (m=7; f=2); V. variegata ruba (f=1); P. pygmaus pygmaus (f=1); C. erythrotis (m=3); C. mona (m=1); E. rubriventer (f=1). (F=females, M=males).](image)

2D:4D and human mating strategies

The posterior HOXa and HOXd genes are responsible for growth and patterning of the digits and are also strongly expressed in the developing urogenital system (Kondo et al. 1997). This may go some way to explaining why, in humans at least, 2D:4D correlates with many gender specific traits and behaviours, particularly reproductive and mating abilities (see Manning, 2002 for an overview). For example, human males with low 2D:4D, compared to the population mean, tend to have higher sperm numbers per ejaculate and produce more offspring than males with high 2D:4D (Manning et al. 1998). Low 2D:4D has also been shown to correlate with more successful male-male competition and courtship behaviours.
such as greater levels of sporting ability and musical achievement (Manning and Taylor, 2001; Slumming and Manning 2000). Low 2D:4D has recently been correlated with increased levels of physical aggression in males, but no such relationship was shown in females (Bailey and Hurd, 2004), although a link has been shown between reactive (i.e. verbal) aggression in females with low 2D:4D’s (Benderlioglu and Nelson, 2004).

Variation in 2D:4D has also been linked to behavioural differences between human populations; polygamous societies tending to have more masculinised digit ratios (low 2D:4D) than monogamous groups (Figure 1). Competitiveness in male mating strategies may lead to selection for higher levels of foetal testosterone within a population resulting in lower 2D:4D (Manning et al. 2000).

Non-human primate 2D:4D and human evolution

For over 100 years ago it has been observed that non-human primates have more masculinised 2D:4D than humans (Ecker, 1875). In the 1950’s Schultz also observed this trait, but neither author provided digit data in support of this claim. Non-human primate soft-tissue digit data is rare; one small study of Guinea Baboons (*Papio papio*) (Roney et al. 2004). It is possible that, as in humans, exposure to higher levels of foetal testosterone in non-human primates organises adult male behaviour, allowing them to compete more successfully with other males for access to females and possibly enhancing abilities to defend access to those females. However, lack of comparative primate data makes it impossible to investigate variation in inter- and intra-species 2D:4D and whether specific mating strategies correlate with digit ratios.

It seems that non-humans primates may also be more sensitivity to androgens than humans. The response of the androgen receptor gene to testosterone has been shown to alter its sensitivity from lower mammalian groups through the Primate Order, with humans being the least sensitive (Djian et al, 1996). This led Manning et al (2003) to hypothesise that a ‘feminisation’ may have occurred through human evolution. Again, this hypothesis is impossible to test without non-human primate digit data.

If a ‘feminisation’ with increased foetal oestrogen exposure has taken place in the *Homo* lineage, it is hard to reconcile the mechanisms and timeframes of such an event, or events, with current evolutionary thinking. A late evolutionary change that might be linked to increased *in utero* oestrogen is a reduction in skeletal robusticity (Churchill et al. 1996; Trinkaus, 1997). Conversely a move away from aggressive, male dominated mating strategies is thought to be a more ancient adaptation (Key and Aiello, 1999; Key, 2000). Language and higher levels sociality, generally regarded as feminine characteristics, are estimated to have emerged half a million years ago (Dunbar, 2004) and could have contributed to broadening mating strategies and facilitating the emergence of more complicated societies (Strum & Latour, 1997). These skeletal and social adaptations all point to selection for more feminised traits, which might also be reflected in fossil digit ratios.

2D:4D – an investigative tool?

Mating and social behaviours are central to primate and human group dynamics but prove difficult to trace in the archaeological record. The link between human 2D:4D and human inter-population mating behaviour seems strong, it could be that similar relationships will be found between inter-species mating behaviours in primates and digit ratio. Furthermore, as the wealth of extinct hominin digit remains increase, it may be possible to use digit ratio as a means of tracing changes in mating strategies through the hominin fossil record. For example, it would be interesting to know the 2D:4D of the relatively recently discovered fossilised hand of *Australopithecus* from Sterkfontein, South Africa (Clark, 1999), dated to over 4 million years (Partridge et al, 2003), and how this compares to the digit ratios of other extinct and extant hominoid species.

2D:4D is normally obtained from soft-tissue measurements, but correlation between whole finger length and bony digit length, estimated from x-rays and photocopies, is fairly good (Manning, 2002; p3). If disarticulated archaeological and fossil material is to be interpreted a relationship between total soft-tissue finger length and individual bony components of the digit must be established. It is hypothesised that the proximal phalanx will prove to be a good proxy for whole finger length, and there is some evidence from hand ink print data to support this assumption (Manning pers. comm.). Two studies have been designed to investigate bone and soft-tissue relationships: a human hand x-ray study (Royal Liverpool University Hospital Trust, UK) and a primate hand dissection study (National Museums of Scotland, UK).
This study aims to collect non-human primate digit data to understand the relationships between interspecific mating strategies and 2D:4D and to put this into a wider evolutionary context by asking why humans experience a more oestrogenised foetal environment than other primates and how this may have affected human social evolution? The project also aims to assess the validity of using 2D:4D as a tool to investigate the past and trace changes in mating behaviour through time. Tracking evolutionary change in hominin mating behaviours has to begin with an analysis of non-human primate 2D:4D; a non-human primate digit database will form the to core of this research project.

Hypotheses

Species in which males are under intense pressure to compete for access to females will be exposed to high levels of foetal testosterone and will therefore have the lowest mean 2D:4D. Conversely, species with less competitive mating systems will be exposed to less prenatal testosterone and will have higher mean 2D:4D.

A move away from higher levels of in utero testosterone towards a more oestrogenised foetal environment occurred with a shift to more human-like mating strategies with the evolution of the genus Homo around 2 million years ago (Key and Aiello, 1999; Key, 2000). This was followed by further hormonal changes concomitant with other major social adaptations such as the emergence of language and higher levels of sociality occurring around half a million years ago (Dunbar, 2004).

Study objectives

1. To make a comparative study between humans and non-human primates.
2. To examine the relationships between non-human primate mating strategies and digit ratio using the index on inter-male competition formulated and utilised by Plavican and van Schaik, 1992 and Kay et al. 1988.
3. To understand the relationship between soft-tissue digit length and each individual bony component of the digit in both human and non-human primates.
4. To use the data gathered from human populations and non-human primate species to allow hypotheses to be generated about prehistoric mating behaviour.

Non-human primate digit data collection methods

A request for data has gone out to many zoos in the UK, Canada and US. The response has been good, but more zoos are needed. Access to primate digits can only be gained opportunistically, usually whilst the animal is anaesthetised for a medical procedure.

Data collection is quick, simple and non-invasive; a vet or veterinary nurse is required to measure the lengths of all the fingers (excluding the thumbs) of the anaesthetised primate from the crease at the base to the tip of the finger. Some accompanying information is also required; zoo number, genus, species, sex and age. Data is submitted via an on-line questionnaire on the study web site, www.digitratio.com

Non-human primate digit data - preliminary results

The small amount of data collected so far supports the convention that non-human primates have lower, more masculinised 2D:4D’s than humans (Figure 1). Three curiosities are noted. In the one species with a reasonable amount of data, P. papio (Roney et al. 2004), the sex difference in 2D:4D was opposite to the pattern exhibited in all the other species sampled, including humans. Secondly, the Common Marmoset (Callithrix jacchus jacchus) is described as having a monogamous/polyandrous mating strategy (Kay et al. 1988), but the mean 2D:4D of this species is one of the lowest of all the species sampled. Finally, although only one result for a female Orang-utan (Pongo pygmaeus pygmaeus) has been obtained, it lies within the human range. Clearly, the situation between 2D:4D and mating behaviour is complex, and more data is needed.
Acknowledgements

I would like to thank all the zoo staff who have agreed to help out with digit data collection, particularly Steve Unwin and Steph Sanderson from Chester Zoo. I would also like the thank my supervisors, Dr. A.G.M Sinclair from the University of Liverpool and Prof. J.T Manning from the University of Central Lancashire for providing expert guidance.

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