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Zoo Research News

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News and Views from the Zoo Research Group

BIAZA 8th Annual Symposium on Zoo Research

This symposium took place at Colchester Zoo on 24th and 25th July 2006 and was attended by 102 delegates from zoos and academic institutions. It included an excellent mix of 25 talks and 24 posters on all aspects of research undertaken in zoos including presentations by undergraduate and postgraduate students, keepers and more experienced researchers. Each year the variety of research areas covered at the symposium expands and this was no exception with talks and posters on genetics, reproduction, nutrition, health and conservation. Various aspects of animal behaviour and cognition accounted for 29 presentations but the range of questions within this topic was impressive, with only three presentations on the ever popular topic of environmental enrichment. Although there was still a bias towards research on primates (19 of all presentations) many other mammal taxa, reptiles, birds, invertebrates and even plants were represented. The overall standard of presentations was very high but the prize for best student talk was won by Naomi Fox (Durham University and Paignton Zoo Environmental Park) for her presentation entitled 'Factors affecting *Trichuris trichuria* burden of Abyssinian colobus monkeys (*Colobus guereza kikuyuensis*'. Djamila Hagemans (Van Hall Instituut and Paignton Zoo Environmental Park) was awarded the best student poster prize for her poster 'Nesting material preferences of captive dormice (*Muscardinius avellanarius*)'. Their abstracts are included in Research Snippets. As always the symposium included a methods workshop with the aim of producing an issue of the series Zoo Research Guidelines. This year the topic was zoo research by survey and questionnaire and this issue of the guidelines is likely to be one of the best used in the series. We hope that it will really facilitate the process of production, completion and analysis of questionnaires and make it much simpler and quicker for everyone.

Workshop on how to get zoo research published

This workshop was also held at Colchester Zoo the day before the main symposium, it was attended by Core Group members, other zoo professionals and three journal editors. The main messages that emerged were first, that the perception that zoo research is difficult to publish is just a perception, in reality it is no more difficult than other types of research. Secondly, that the major barriers to publication are finding the opportunity to write the papers and lack of knowledge as to the best places to submit them. And finally, that editors are human! The contribution of the editors on the day was invaluable and they provided much advice as to how and when to approach them in the publication process. The outputs of the workshop will be published as a new volume of the Zoo Research Guidelines. Many thanks to all those involved on the day, especially the three editors.

Congratulations and thanks to Colchester Zoo, especially Fay Clark, for superb organisation which helped make both the above meetings such a success.

BIAZA Research Group Resources

The following resources can be downloaded without charge from the BIAZA website (www.biaza.org.uk):

- Previous issues of Zoo Research News
- Zoo Research Guidelines: Project Planning and Behavioural Observations. Wehnelt, S., Hosie, C., Plowman, A. and Feistner, A. 2003.
- Zoo Research Guidelines: Monitoring Stress in Zoo Animals. Smith, T.E. 2004.
- Zoo Research Guidelines: Studies of the Effects of Human Visitors on Zoo Animal Behaviour. Mitchell, H. and Hosie, G. 2005.
- Zoo Research Guidelines: Sampling Guidelines for Zoos. BIAZA. 2002.
- Zoo Research Guidelines: Statistics for Typical Zoo Datasets. Plowman, A. (ed.) 2006.

The following resources are also available from the BIAZA office (there may be a small charge).

- Abstracts of the 1st Annual Symposium on Zoo Research. Plowman, AB (ed.) 1999
- Proceedings of the 2nd Annual Symposium on Zoo Research. Plowman, AB (ed.) 2000
- Proceedings of the 3rd Annual Symposium on Zoo Research. Wehnelt, S and Hudson, C (eds.) 2001
- Proceedings of the 4th Annual Symposium on Zoo Research. Dow, S (ed.) 2003
- Proceedings of the 5th Annual Symposium on Zoo Research. Gilbert, T (ed.) 2003
- Proceedings of the 6th Annual Symposium on Zoo Research. McDonald, C. (ed.) 2004
- Proceedings of the 7th Annual Symposium on Zoo Research. Nicklin, A. (ed.). 2005
- A database of browse use in British and Irish Zoos and poisonous plants information (CD, 2001). Plowman, A.B. and Turner, I.
- A Bibliography of References to Husbandry and Veterinary Guidelines for Animals in Zoological Collections. Macdonald, A.A. and Charlton, N. (eds.) 2000

Feature Article

Spontaneous numerical representation in three lemur species (*Lemur catta, Varecia variegata variegata, Varecia variegata rubra)*

Claudia Uller and Rosaline Cullen, University of Essex

Introduction

Over the past ten years much research has been developed investigating the cognitive capacities of animals, including numerical abilities, as part of a core knowledge system which may be phylogenetically ancient, predating human cognition. The basic idea is that all animals, humans included, come into life with a set of conceptual structures already in place. Animals use these representations to guide learning throughout life. Numerical abilities are particularly interesting because they are, in a sense, abstract (as opposed to properties such as colour, size or shape). This special representational status provides us with an insight into how minds are structured. Human adults show very sophisticated understanding of number in a variety of tasks. These representations are present even in non-linguistic babies and researchers have suggested that such representations may be found in other primate species that do not possess language. Hauser *et al* (2000) investigated rhesus monkeys in a choice task in which the monkeys selected the larger of two numerosities. The contrasts included 1 v 2 slices of apple, 2 v 3, 3 v 4 and 4 v 6. The monkeys were able to 'go for more' only up to 4, a limit also observed in human infants (Uller *et al.*, 1999). This evidence suggests that a core knowledge system for number may be composed of two complementary numerical systems, one for small numbers (object file mechanism) and one for large numbers (analogue magnitude mechanism).

To generalise the origins and nature of such abilities, one would like to investigate species that have split from the common ancestor of monkeys, apes and humans long before our time, approx. 47-54 million years ago. Two recent papers have started to address these issues in prosimians. Lewis *et al.* (2005) showed that lemurs reliably differentiated between numerosities that differed by a 1:2 ratio, but did not at ratios of 2:3 or 3:4. Using a looking time method, Santos *et al.* (2005) showed that prosimians from four different species looked longer at outcomes of a 1+ operation that differ from 2, namely, 1, 3 or a big 1. Both lines of research suggest that lemurs keep track and search for the exact number of raisins being placed into a bucket in a 1 v 2 case; and lemurs keep track of the visual number of lemons being added behind an occluder when the result of the operation requires an understanding of 'twoness'. These results show that prosimians understand about ones and twos, but not more than that. The present task addressed whether prosimians understand a bit more than ones and twos. We followed a procedure developed for testing babies and nonhuman primates (cf. Hauser et al. 2000) in which subjects 'go for more' when the ratio between the numerosities fall within 2:1 and 2:3 for small numbers. If the small number system, as the core knowledge hypothesis predicts, is phylogenetically ancient, then we would expect prosimians to succeed in the tasks developed for human babies and monkeys.

Methods

<u>Subjects:</u> Thirteen lemurs were tested individually in their own environments at the Colchester Zoo: 7 ring-tailed (*Lemur catta*), 4 black and white (*Varecia variegata variegata)* and 2 red ruffed (*Varecia variegata rubra*). The animals are housed separately according to kind, with the ring-tailed group split in two separate houses due to requirements of the breeding season. Each of the 3 enclosures has an indoor compartment and an outdoor enclosure to which they have *ad libitum* access.

<u>Apparatus:</u> Two opaque containers, white paint kettles, measuring 15cm x 18cm were used for the presentation of number choices. Compounds of raisins of approximately 3cm in diameter were used as stimuli. They were liquefied and pushed into a mould to ensure equal size for all exemplars used as stimuli. The experimental trials were videotaped using a SONY handyman DCR-TRV950 E video camera.

<u>Procedure:</u> The animals were tested in their outside enclosures. The test animal was isolated from the other animals as much as possible. Due to Zoo procedures, animals could not be tested in total isolation. In order for an experimental trial to be valid, the animal had to be distant from other animals at least 1m so that it could watch the display and make a choice without being disrupted by another animal. When the animal was found in those conditions, the experimenter placed the two containers equal distances away from each other and the animal. As the animal was not restrained or controlled, these distances were subject to slight changes. However, the experimenter ensured that the animals were always within 2m of the buckets, but not within reaching distance. At the beginning of a trial, the experimenter showed the animal the empty containers by tilting them towards the animal and showing its inside. The experimenter then placed the containers at equal distance from the animal on the ground. The animal then watched as the experimenter placed the appropriate number of compounds of raisins, one at a time, into the containers. Once the experimenter finished the presentation, she stepped back and allowed the animal to approach and choose one of the two containers. A choice was recorded as successful when the animal approached and touched a selected container. Although the animals were not strictly timed in their approach to the containers, they were clear in their choices: either they showed interest and made a choice instantly, or they did not choose at all. The experimenter made sure to attract the attention of the animal in each trial so that it watched all the steps in which the compounds of raisin were lowered into the containers. There were two experiments. In experiment 1, choices were 2 v 3 compounds; in experiment 2, choices were 1 v 2 compounds. Each animal was tested twice for each experiment. There was a one-month lag between the trials for Experiment 1 and the trials for Experiment 2. In addition, if an animal was unsuccessful in one experimental trial, it was tested once again seven days after the unsuccessful trial. This was meant to ensure that the animal was fit to receive the trial again and not be habituated to the experiment (cf. Uller *et al*. 2001 for a discussion on the habituation issue). Ten trials were discarded due to (1) lack of attention or (2) disruption by other animals. Order of presentation (2 first, 3 first) and side (left first, right first) were counterbalanced across subjects.

Results and Discussion

Experiment 1. 20 lemurs made successful choices. Twelve lemurs selected the container with 3 raisin compounds and eight selected the container with 2 raisin compounds. Although there seems to be a trend in the data, a binomial test revealed no significant effect (p=0.25, one-tailed). Experiment 2. 16 lemurs made successful choices. Twelve lemurs selected the container with 2 raisin compounds and four selected the container with 1 raisin compound. A binomial test revealed a significant effect (p=0.038, one-tailed). The lemurs reliably chose 2 over 1, but did not reliably choose 3 over 2. This result is original and supports the idea sponsored in Lewis *et al.* (2005) that lemurs succeed in discriminations when the ratio is 1:2, but not when the ratio is 2:3.

The capacity to 'go for more' shown previously in monkeys and human babies was here extended to lemurs. Lemurs were able to select the larger of two numerosities when the paired numbers were 1 versus 2, but not 2 versus 3. In order to succeed in the tasks, we infer that, at a minimum, the animals recognized that 2 is more than 1, but these results do not indicate that the lemurs have an understanding of 'more than 2'. We also infer that the animals spontaneously tracked the number of objects, as there was no training involved and therefore no learning could have occurred. Finally, we conclude that the animals made a decision on which 'container' to choose after spontaneously tracking the number of objects being placed into the containers. Just as in the case of monkeys and human infants, lemurs 'went for more' when the numerosities were smaller than 3. Therefore, we suggest that lemurs show a rudimentary ability to 'go for more' that has previously only been shown in monkeys and human infants.

However, it is still unclear what 'kind of number' is being assessed in this series of experiments, and further controls are required to narrow down the kinds of representations that could underlie this capacity. The pattern of successes and failures in the present experiments, and in light of infant and monkey results, indicate that the system underpinning this ability is limited. The rudimentary numerical ability revealed here composes part of a precursory numerical system that can be characterized as follows. (1) This system is limited. The limit on the spontaneous number representation in monkeys and human babies seems to lie between 3, 4. (2) This system is precise. The system precisely tracks exact small numerosities that compose the representations of small sets. It does not involve estimative capacities. (3) This system is spontaneously available. The representations revealed by visual attention and reach/touch methods do not require training and thus are not learned. (4) This system is adaptively powerful. As such, these representations may be widespread in the animal kingdom. (5) This system is 'entity-based'. The representations are constructed on the basis of one-one correspondences. For each entity encoded, one representation is formed and stored in short-term memory.

The nature of this ability, however, remains unclear. For human infants and nonhuman primates, researchers have proposed that an object-file model would be the best candidate to account for such and other results (e.g., Uller *et al.* 1999; Hauser *et al.* 2000). This model is originally adopted from the literature on object-based attention (Trick & Pylyshyn 1994). It assumes that objects are individuated according to principles of object individuation and identification, and then encoded as object files maintaining one-one correspondence. For each object encountered in the world, one file is opened. A maximum of 4 object files can remain open simultaneously. Object files are discrete and precise. They do not rely on a capacity to estimate number. The counterpart of the object file model is an analog magnitude model that operates in concert with the former for number representation in humans and other animals, and is used for larger numerosity encoding and estimation processes (e.g., Whalen *et al.* 1999). Further experiments that probe the lemurs' numerical capacities will help us decide if these abilities are or are not comparable to human and monkey/ape numerical abilities. For example, experiments that address the ratio between two numerosities will help clarify the nature of these abilities as far as a model is concerned. Contrasts between higher numbers in which the ratio is 1:2, namely, 4 versus 8, 5 versus 10, 6 versus 12, 8 versus 16, etc., are useful in this respect. This will assess whether the lemurs 'go for more' when the ratio is larger. Conversely, larger ratios that contrast a small numerosity with a rather large numerosity (e.g., 2 versus 20) will also help tease apart the lemur capacity to go for more. That is, 2 may be an understandable/tangible numerosity within their repertoire, but 20 may be 'far too much', representing not a discernable quantity, but a rather confusing one, in which case the lemurs would 'go for less'? These are all empirical questions. In doing so, we will be on safer grounds to evaluate the kinds of numerical representations being assessed, and their nature.

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Best Student Talk at 8th BIAZA Annual Symposium on Zoo Research, Colchester July 2006

Identification and evaluation of factors affecting *Trichuris trichiura* burden of Abyssinian colobus, *Colobus guereza kikuyuensis* .

Naomi Fox, Durham University/Paignton Zoo Environmental Park and Vicky Melfi, Paignton Zoo Environmental Park

Routine veterinary screening of *Colobus guereza kikuyuensis* faecal samples at Paignton Zoo, Devon, highlighted the presence of one principle parasite *Trichuris trichiura*. A longitudinal study has been carried out and previous results highlighted sex, weight, dominance, season and method of antihelmintic administration as key variables affecting density of infection. This study has involved several additional elements to build on understanding the factors affecting *Trichuris* load and to investigate the use of the level of *Trichuris* infection as a welfare indicator:

1. Parasite density was determined using the McMasters technique to quantify eggs per gram (epg) of faeces but it has become clear that different laboratories practice variations of this technique. Therefore validations of the McMasters technique have been carried out to establish the optimum floatation time within the McMasters chamber to increase the reliability and comparability of results.

2. Due to possible circadian rhythms in egg release, the effects of time of day on epg has been investigated by collecting hourly faecal samples to determine the significance of time of faecal collection.

3. The housing conditions and social composition of the study subjects were altered dramatically in March 2005, when the animals were rehoused as two single sex groups. The new enclosures did not, to our knowledge, have pre-existing egg banks in the soil and all individuals were wormed prior to the move. The time taken for reinfestation after the move/antihelmintic administration was investigated and sex/age mediated differences in infection further explored.

4. Male-male aggression has lead to one male being maintained on his own. The significant psychological effects of isolating a social animal could impair immunological responses. It has also been suggested that subjects encountering affiliative interactions are more resistant to helminth infection.

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Best Student Poster at 8th BIAZA Annual Symposium on Zoo Research, Colchester July 2006

Nesting material preferences for captive dormice (*Muscardinius avellanarius*)

Djamila Hagemans, Van Hall Instituut/Paignton Zoo Environmental Park and Natasha de Vere, Paignton Zoo Environmental Park

The hazel dormouse (*Muscardinius avellanarius*) is an endangered British mammal. Paignton Zoo is part of the breeding and reintroduction programme for this species. Past research has investigated dormouse habitat requirements but less research has been carried out on their nesting behaviour and the plant materials that nests are constructed from. This study aims to establish the type of resources captive dormice prefer for nest-building in relation to the natural materials they use in the wild.

Due to the fact that these animals are nocturnal, cameras are used to observe some behavioural patterns of captive dormice. Fresh nesting materials are provided each day, consisting of willow, conifer needles, hazel, bramble, ivy, clematus, honeysuckle, moss, dead leaves and grasses. These materials are presented to seven dormice and every three days their nests are removed and dismantled.

Preliminary results show that moss and grass are the nesting materials most used by captive dormice, with no use of willow. This could indicate a preference for moss and grasses for nesting material, but may indicate use of the most easily manipulated resource.

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A comparison of husbandry, feed intake and cause of death of captive giraffe *(Giraffa camelopardalis)* in the United Kingdom

Paul Rose, Institute of Zoology and Marcus Clauss, University of Zurich

A combination of hay with compounded feeds does not adequately replicate the wild diet of giraffe in a captive state. Pathological changes can occur in the animal, as a result of substandard nutrition, which may lead to 'peracute mortality syndrome,' particularly when combined with additional stresses. A link between inferior diets in captive giraffe has been stated previously, yet the underlying cause of the disease is still poorly understood. Recent work has shown that a condition termed 'Serous Fat Atrophy' (SFA) is an underlying cause of death in captive giraffe (Potter & Clauss, 2005). Work on dietary energy for captive giraffe is limited and in temperate countries stress and death may be incurred if giraffe cannot meet energy demands in cold weather. In this study the forage and concentrate rations given to the giraffe in seven collections were sampled and analysed for dry matter (DM), crude protein (CP), acid detergent fibre (ADF) and metabolisable energy (ME). The total daily food offered (of all dietary constituents, forage, concentrate, fruit and vegetables) and any left-over food was weighed on site. Total nutrient intake was thus calculated and a compared across collections.

Calculation of basal metabolic rate (BMR) and metabolic body weight (MBW) was undertaken for each animal. Intakes of CP, ADF and ME differ between collections. The relationship between amount of concentrate ingested (DM/$kg^{0.75}$ MBW) and relative amount of ME ingested (MJ ME/$kg^{0.75}$ MBW) was calculated. All diets fed fulfil the basic minimum maintenance requirements of 0.39-0.59 MJ/ME$kg^{0.75}$ (taken from Potter & Clauss, 2005), but some giraffe are borderline cases. Contrastingly, the diets fed at some collections are providing far too much energy and such animals run the risk of obesity. The overall conclusion is that none of the animals in the study seems to be fed on an energy deficient diet. Browse intake was also measured at five of the seven collections that regularly fed tree branches. Fowler (1977) recommends feeding browse at a level of 10-25% of the total daily diet (wet weight). Calculation of 'as fed' percentages of browse show differences between collections ranging from 14.4% to 25.4%. Differences in browse provision are a direct reflection of human resources allocated to giraffe husbandry at each respective zoo.

In conjunction with Clauss *et al.*, (2006), results of a PME survey from 14 collections show that 77% of animals (whose age was known) had died before they were 15 years old. Of these cases 28 showed an absence of reduction of fat or fat in a gelatinous state or SFA in the coronary groove, mesentery or in generalised areas of the body. 48% of animals in the PME reports were said to have been in a poor to emaciated condition at death. However, PME reports from UK collections can yield no definite conclusions as to the prevalence of SFA due to limited records and incomplete reports which make data analysis difficult.

Acknowledgements
I would like to thank all the participating institutions for allowing me to collect intake data and sharing PME reports with me.

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Abundance and habitat requirements of duikers (*Cephalophus* spp.) in the Udzungwa Mountains, Tanzania.

Andrew Bowkett, Paignton Zoo Environmental Park and Francesco Rovero, Trento Museum of Natural Sciences, Italy.

The Udzungwa Mountains are home to an exceptional diversity of threatened and endemic fauna. The area has a rich but little-studied forest antelope community including the seriously threatened but poorly known Tanzanian endemic, Abbott's duiker *Cephalophus spadix*. In order to establish the most effective monitoring method for forest antelope in this area, different relative abundance indices were tested in the Mwanihana Forest, Udzungwa Mountains National Park and the results used to investigate forest antelope habitat requirements.

Relative abundance indices were recorded along two 4 km transects. Transect walk encounter rates were calculated for 0.5 km transect sections (10 replicates each). Other relative abundance indices were sited at the centre of each transect section: tracking strips (n = 16), hair-traps (n = 16) and camera-traps (n = 10). Habitat variables including canopy cover, large tree (>10 cm DBH), medium tree (5-10 cm DBH) and small plant stem (<5 cm diameter at 1 m) density and Shannon diversity, and percentage ground cover were recorded for each of the sampled transect sections. In addition a visibility index was calculated by estimating the proportion of 1 m by 1 m plastic sheet visible at a distance of 20 m for four random bearings for each transect section.

Harvey's duiker *Cephalophus harveyi* was the most commonly encountered forest antelope for all relative abundance indices with camera-trapping having the highest record frequency (Camera-trap mean: 0.16 photos per day). Camera-trapping rates increased significantly with diversity of small stems (r^2 = 0.51, F = 8.17, P = 0.021) and climber ground cover (r^2 = 0.49, F = 7.62, P = 0.025) but decreased significantly with canopy cover (r^2 = 0.64, F = 14.50, P = 0.005) and visibility (r^2 = 0.51, F = 8.31, P = 0.020). However, several of these variables were intercorrelated and none of the results remained significant following sequential Bonferroni correction (Rice 1989). To overcome these problems a Principal Components Analysis was used to generate independent factors. Camera trapping rate increased significantly with a factor representing decreasing canopy cover and visibility, and increasing climber ground cover (r^2 = 0.81, F = 34.31, P = <0.001). These habitat features are characteristic of forest gaps with regenerating vegetation and contradict previous research on closely related red duiker species (e.g. Perrin *et al.* 2003).

Data from a wider geographic area are needed to test the robustness of these results and this work is currently underway. Beyond habitat selection inferences, camera-trapping results need to be calibrated with independently derived density estimates before being used as a measure of population abundance (e.g. O'Brien *et al.* 2003).

No Abbott's duiker sightings or field sign were encountered from line transect counts, tracking strips or hair-traps. However, three camera-trap photos re-confirmed the presence of the species in the area. These results serve to emphasise the difficulty in studying Abbott's duiker. Further research into forest antelope ecology and population status is needed in order to identify management actions pertinent to biodiversity conservation in the Udzungwas.

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Announcements

Keeper Research Workshop at Mammal TWG

At the first annual Mammal Working Group meeting (an amalgamation of all previous mammal TAGs), there will be a workshop on observation, data analysis and how to fit this in to a keeper's day. It is being coordinated by the BIAZA Research Core Group and will be held at Flamingo Land, North Yorkshire on either 26th October or 2nd November (date to be confirmed). Contributions from keepers who have done some research would be welcome. For more information about the meeting please see the BIAZA website's events section or contact the BIAZA office (admin@biaza.org.uk).

BIAZA resources for zoo researchers

The BIAZA website sections on research and conservation are in the process of being updated. The research area will include indications of where students can go to find material already available before writing to the zoos. It will also include details of a new BIAZA support scheme that will shortly be launched. Letters of support may be awarded to students to three different levels to assist zoos in their decision as to whether to become involved with the project. This is due to live by the end of September and should work together with the new guidelines on surveys and questionnaires to make life easier for researchers and zoo staff.

Your contributions are needed

Please send articles, announcements, comments or other feedback for the next issue by the end of Sept. to:

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