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Paper Abstracts

A survey of Humboldt penguin husbandry in British zoos

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The Humboldt penguin (*Spheniscus humboldt*) is an endangered species. Despite this, it is quite frequently kept in zoos world-wide. Comparatively little work has been done on this species.

This project is a survey of the different husbandry regimes of the Humboldt penguin in the 23 British zoos in which it is kept. Sixteen zoos provided information for my survey. From this data, I drew conclusions regarding how the species should be kept in captivity to enable future release into the wild. I collected both population and enclosure data, and related enclosure information to population productivity and success.

The project also compares the effect on population health of hand-rearing penguin chicks or allowing the chicks to be parent-reared.

The recommendations made in this project involve population size and enclosure designs.

**An investigation of breeding behaviour and chick survival in
captive Bali starlings (*Leucopsar rothschildi*)**

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The Bali starling, *Leucopsar rothschildi*, is the only endemic avian species on the island of Bali, Indonesia. *L. rothschildi* is currently listed as critically endangered in the IUCN Red Data Book and is also an Appendix 1 species under CITES. In February 1999, the wild population was estimated to be just 25 individuals; therefore, it is essential that we are able to manage the captive population successfully.

Although there is a large captive population, breeding success has been inconsistent among the various participating institutions. Rearing success has been unpredictable and very varied at Jersey Zoo, but it has been unclear what factors influence this. Therefore, a study was initiated in spring 1998 which would allow 'secretive' viewing of breeding activity. Small cameras, which relay live pictures to television monitors and time-lapse video recorders, were placed inside specially adapted nest-boxes. The aim of the project was to discover reasons for egg and chick losses, by investigating reproductive activity and parental behaviour.

The eventual sample size was 14 clutches from six different pairs. Investigation of parental behaviour found that the starlings shared incubation unequally during the day, the female incubating significantly more (mean 67.8%) than the male (mean 19.2%). Night-time incubation was carried out solely by the female. All chicks were helped to hatch by their parents. The female carried out significantly more brooding, preening and manipulation of the chicks and the male carried out more nest building, significantly more feeding of the chicks and removal of faecal sacks. This study found that egg production and fertility were good (76% fertility) but that there were problems with hatching (68% hatching success) and chick survival (78% mortality). The results implicated diet, feather plucking and ambient temperatures as causes of chick mortality.

**DNA fingerprinting of a family of blue-eyed cockatoos (*Cacatua ophthalmica*)
to assist captive breeding management strategies**

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As with most species, the breeding management of the blue-eyed cockatoo, *Cacatua ophthalmica*, in captivity relies upon the availability of accurate pedigree data. Since captive breeding management to maintain genetically viable populations is relatively recent in origin, such data are not always available, and uncertainty may arise when the records are incomplete. This may be especially relevant for long-lived animals, such as parrots, where changes in housing and even ownership may add further complications to the systematic keeping of records.

In this study, the record of an individual male blue-eyed cockatoo was uncertain; he could have been the progeny of either of two pairs of adults. Since he had reached the age to enter the breeding programme, and one, otherwise appropriate, possible pairing was with a potential sibling, it seemed advisable to clarify his pedigree.

One of the pairs was not available for analysis but, by using standard multi-locus DNA fingerprinting techniques, it was possible to compare his genetic profile with the other pair plus four of their known offspring. Band-sharing coefficients revealed that he was the progeny of this pair, and full sibling to their other offspring, confirming his position within the studbook.

The effective management of Chilean flamingos at Dublin Zoo, with special reference to social organisation and breeding behaviour

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This project aims to determine the social organisation within the flock of Chilean flamingos at Dublin Zoo. The aims will be fulfilled by looking specifically at the inter-relationships between morphology, hierarchical position in the flock and breeding success for adults (taking into account the factors that influence the occurrence and success of breeding). Further studies will examine the stages of integration of juvenile flamingos into the Dublin flock and quantitatively assess the nutritional intake of the flamingos.

The study will use non-invasive observation techniques as much as possible to monitor the behaviour of displaying birds and mate selection. Work will include the identification of the sequences of breeding display, the notation of copulatory pairs (the change, if any, between historic data), the occurrence of extra-pair copulation and the sequence and preference of nest selection. Further work on aggression and nearest neighbours will give additional information on social organisation in the breeding and non-breeding periods.

Conclusions drawn from this study should prove in useful stock management and further the understanding of captive flock behaviour.

The role of Belfast Zoo in understanding the function of tamarin mixed-species troops

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The saddle-backed tamarin (*Saguinus fuscicollis*) forms stable and permanent mixed-species troops with three other tamarin species, with which it lives sympatrically. Since 1992, we have pursued a study of the dynamics of one such association, that between the saddle-backed and red-bellied (*S. Labiatus*) tamarins. Belfast Zoological Gardens, Northern Ireland, has been at the centre of our project.

We have been furnished with an unparalleled situation, which we believe to be a model for the role that zoos can play in the advancement of primate biology. The zoo has provided us with a free-range area and enclosure off-exhibit to the public, for uninterrupted data collection, and a large sample size of both study species which it has maintained for the past 7 years. We have studied the behaviour of both single- and mixed-species troops to answer questions about the relative costs and benefits of forming associations. To date, the main areas of investigation have included free-ranging troops, dominance relations and feeding competition, intra- and inter-specific social learning, optimal foraging, vigilance behaviour and responses to novelty. Our results suggest that the potential costs and benefits of forming such troops differ between the species and may be heavily dependent upon the effects of selection pressures such as predation and efficient foraging.

Apart from the superb facilities and generous support from Belfast Zoo, this project illustrates another vital role that modern zoos can contribute to research, namely the opportunity to test hypotheses in controlled conditions. The nature of the project is cyclic; hypotheses derived from observations in the wild are empirically tested and refined in the controlled captive environment, which allows the generation of more specific hypotheses to be examined in the wild. This dual approach has increased understanding of the function of tamarin mixed-species troops.

Monogamy, cuckoldry and group living in the mara, *Dolichotis patagonum*, at Whipsnade Wild Animal Park

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The mara is a large (8-10kg) caviomorph rodent from the dry, scrub deserts of central and southern Argentina. The social organisation of this species is highly unusual, combining monogamy with the communal denning of the young. This is puzzling. In facultatively monogamous species such as the mara, where males do not provide any direct parental care, female dispersion is assumed to prevent polygyny. But if individuals from the same species show a form of group living, by sharing nursery dens, there are likely to be opportunities for males to mate with more than one female. Why, then, are maras monogamous?

At Whipsnade Wild Animal Park, U.K., where this study was carried out on a free-ranging population of some 120 maras, female dispersion does not appear to be a barrier to polygyny. Females aggregate around shared dens and at localised food sources. For the most part, the strong pair bond in the mara is maintained by the male, but females are not entirely passive partners. Paired males remain closest to their mate when the female is approaching oestrus and guard her both by chasing off strange males and by over-marking female scent marks. Whilst males do provide some indirect paternal care in the form of vigilance, this does not provide an adequate explanation for the evolution of monogamy. In the mara, the close association between pair members in the mara can best be explained in terms of a male mate guarding strategy.

Of ten families of maras for which a genetic analysis of paternity was carried out, one definite and two probable instances of extra-pair fertilisations (EPFs) were found, representing the first EPFs to be documented for a socially monogamous mammal using the technique of DNA fingerprinting. In the Whipsnade mara population at least, strong social monogamy maintained by male mate guarding does not appear to prevent occasional instances of cuckoldry.

Development of behaviour and play in captive ring-tailed lemurs (*Lemur catta*)

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The lemurs of Madagascar may provide us with some insights into the phylogeny of social behaviours such as play. In this study the behaviours of infants in a group of semi-free ranging ring-tailed lemurs at Chester Zoo were observed from birth to 16 weeks of age. By 9 weeks the juveniles, and occasionally the adult males, were interacting playfully with the infants. Allomothering appeared within a few days after birth and grooming of infants, by adult females and juveniles, within hours of birth. Filial relationships and the dominance hierarchy play an important role in these behaviours. Adult males were found to pay particular interest in the infants during the second month.

Much of this preliminary study indicates that the development of behaviour in this group of captive animals is similar, in both type and rate of development, to that of free-living ring-tailed lemurs at Berenty Reserve, Madagascar, hence establishing the ecological validity of this study.

The strength of preference of mink (*Mustela vison*) for different forms of environmental enrichment

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We investigated the importance that captive-reared mink place on different forms of enrichment. We housed 16 animals (raised in fur-farm conditions) in multi-compartment cages which provided 7 potential enrichments (in addition to *ad lib* food, drinking-water and shelter). These included an empty cage, an extra nest-site, novel objects to explore, to chase and chew, and a bath full of water. Each was accessed via an entrance-door which was weighted by 250, 500, 750, 1000 or 1250g for 1 week at a time. Compartment use was automatically recorded 24h/day.

As access costs increased, visits decreased and some enrichments ceased being used altogether. The rate of decline in visits was significantly lower for the swimming bath and extra nest-site than for other resources, and greater for the empty compartment. The rate at which mink ceased visiting altogether was also significantly lower for the swimming bath, and higher for the empty compartment. We then measured the urinary cortisol (a physiological stress indicator) excreted by mink when denied access for 24h to some of the resources; the swimming-bath, extra nest-site and empty cage. For comparison, food was also denied for 24h. Cortisol output increased when the swimming bath was denied and increased very similarly when food was denied, but did not do so for the other two resources.

Over all, these results show that:

- 1) animals born and bred in barren conditions can remain very motivated to perform natural activities;
- 2) they rank some enrichments over others (with behavioural and physiological measures giving a similar ranking);
- 3) this ranking was unrelated to the amount of time spent using the enrichments – swimming was highly valued, even though it took less than 30 minutes a day;
- 4) measuring strength of preference is therefore an important tool when evaluating environmental enrichments

Enrichment, behaviour and visitor attention at Dublin Zoo

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Dublin Zoo and Trinity College have been working in partnership for the past three years on a wide range of research topics. This talk will present results from three of these studies, chosen for their contrasting subject matter and methodologies.

The first study aimed to solve a specific husbandry problem: meerkats digging deep holes in their enclosure. Enrichments which rewarded shallow digging and which made foraging more challenging were implemented. The meerkats responded with a dramatic reduction in the depth to which they dug, but no reduction in the overall digging time, reflecting a more natural pattern of behaviour.

The second study looked at aggression and reconciliation in primates. The hypothesis was that Sulawesi macaques and chimpanzees would show reconciliation behaviour after agonistic encounters, while orang-utans might not, owing to the differences in their social structure in the wild. The study found rather clear results in accordance with this prediction. The orang-utans escalated fights and showed almost no reconciliation behaviour afterwards, while the other species stopped most agonistic encounters after threat displays, and showed extensive reconciliation. These results may suggest that, although orang-utans are apparently able to adjust to living in a social group in zoos, their levels of stress through unresolved aggressive encounters may be a problem.

Finally I will present a study into the response of visitors to the exhibits in the zoo, specifically focusing on the behaviour of the animals at the time. The study showed a very strong correlation between activity of the animal and how long visitors spent at the exhibit. Interestingly it also showed that having more than one individual of some species is also important in maintaining visitor interest. Useful data were also obtained on the amount of time visitors spent reading the signs provided. This indicated that visitors obtained absolutely minimal information from this medium.

Research in zoos is vital if we are to understand the behaviour of zoo animals and stand any chance of conserving their behaviour for effective re-introduction.

Are some Carnivore species pre-disposed to develop stereotypy because of their foraging strategy in the wild?

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It has been suggested (*e.g.* Terlouw *et al.* 1991, Mason & Mendl 1997) that taxonomic differences in the form and timing of abnormal stereotyped behaviour in captivity are related to species differences in foraging strategy in the wild; for example, carnivores tend to display pre-feed locomotory stereotypies whereas ungulates show more post-feed oral stereotypies. To explore this proposition further, we looked at species within the order Carnivora to test for a correlation between natural foraging behaviour and the development of stereotypic pacing in captivity.

Information on pacing stereotypies for 23 carnivore species were taken from studies conducted in zoos, and data on various wild behaviour variables relating to foraging niche were culled from the literature. A Comparative Analysis of Independent Contrasts (CAIC) was carried out on species averages. Pacing frequency was positively correlated with home-range size ($p = 0.007$, $F_{19,1} = 7.05$) and daily distance travelled ($p = 0.027$, $F_{16,1} = 4.70$), but negatively related to time spent active ($p = 0.004$, $F_{11,1} = 13.29$) and foraging ($p = 0.017$, $F_{1,5} = 13.36$) in the wild. The tendency to develop pacing (*i.e.* the proportion of individuals from a given species that showed some degree of pacing) was positively related to home-range size ($p = 0.002$, $F_{1,14} = 12.43$) and negatively related to time spent active in the wild ($p = 0.027$, $F_{16,1} = 4.70$). These results show that behaviour in the wild has a direct bearing on the tendency of a species to develop stereotypy when placed in captivity.

Kinship and rank effects on feeding competition in a captive troop of rhesus monkeys (*Macaca mulatta*), under two feeding regimes

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The feeding behaviour of eight adult females and three juveniles in a captive troop of rhesus monkeys were observed, in two feeding regimes: scattered and clumped. Dominance rank was established using supplant data. All subjects were observed and categorised as belonging in either of two matriline, according to which matriarch they were related. The dominant matriline controlled the food patch and therefore members of the subordinate matriline visited the feeding site less often. The matriarch of the subordinate matriline was more dominant than several members of the higher-ranking matriline, which is unusual in rhesus monkey troops.

It was found that individual rank had a significant effect on feeding behaviour in both scattered and clumped feeding conditions. Higher-ranking females were disturbed less during feeding (in both regimes) than subordinates. High-ranking females had a significantly higher mean percentage time feeding than low-ranking females in clumped conditions. However, in scattered feeding the opposite is true. Rank was only significantly correlated with moving in the clumped regime.

Juvenile behaviour showed variation from the adult females. The three juveniles played during feeding bouts and received less aggression than the lowest ranking females. Year-old offspring (infants) did spend time with their mothers when they were feeding. The mother's rank did appear to affect whether or not she took her infant to the feeding site in the clumped situation.

Seasonality in captive Sulawesi crested black macaques (*Macaca nigra*)

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Previous research on the activity budget of wild Sulawesi crested black macaques shows no seasonal variation. However, when this species is kept in a temperate climate in captivity, there are many factors, *e.g.* rainfall, which are different from those found in the wild and thus may lead to seasonal variation in behavioural expression.

At three zoos in the UK, behavioural data were collected during the winter and summer seasons. This presentation compares the activity budgets between winter and summer for each zoo. It also identifies how access between the inside and outside enclosure may affect the activity budget.

Studies on the social structure of Rodrigues fruit bats (*Pteropus rodricensis*) and the effects of resource distribution on dominance

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Chester Zoo's new 'Twilight Zone' houses a breeding colony of the endangered Rodrigues fruit bat (*Pteropus rodricensis*). The major component of the 'Twilight Zone' is a capacious, indoor, free-flight area which contains a profusion of trees and vegetation. This emulation of a tropical habitat provides a naturalistic environment for the bats, allowing them to display a wide range of natural behaviours.

It is the aim of the International Studbook for this species to maintain healthy, genetically viable populations of Rodrigues fruit bats in captivity. To this end, it is necessary to maximise use of the available gene pool. This is particularly important with this species, as the founder population of these captive colonies numbered only 23 individuals; after successful breeding, numbers now stand at over 500.

Male Rodrigues fruit bats have both feeding and roosting territories that they defend. Control of resources is likely to be of significance to a male's mating potential. The bats reputedly have a harem mating system, with several females utilising one male's roosting territory and mating with that male; however females have also been described as promiscuous; so the mechanisms of the mating system remain unclear. If the dominant males succeed in obtaining the majority of the matings, and if this means that they are siring most of the offspring, there may be a high risk of inbreeding within captive colonies. The longevity of the bats (20-30 years) potentially exacerbates the situation.

These important issues require careful scrutiny and are currently being investigated at Chester Zoo. Practical solutions need to be devised to alleviate this potential problem. The main aims of this research project are to examine the bats' social structure, and to test whether altering the distribution of resources affects the bats' behaviour and, consequently, the involvement of individuals in breeding opportunities.

Zoo visitor effects revisited: who does what to whom?

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It seems intuitively obvious that human visitors to zoos must have an effect on the behaviour of captive animals. The first systematic studies appeared to show that this was indeed the case, at least for primates, and that the effect was an aversive one. However, subsequent studies indicate that the “audience effect”, if any, is more complex than this, in that the direction of causality is not always clear, and also in that not all species respond to the presence of visitors as if they are stressful. This paper reviews the available zoo audience studies and suggests that housing conditions and the natural social organisation of different species are additional variables that influence what response, if any, the animals show to the presence of people.

Poster abstracts

A study of the pharmaceuticals used in the veterinary care of primates at Paignton Zoo

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Veterinary records held on the primates at Paignton Zoo between the years 1971 and 1998 were investigated in order to study pharmaceutical use over this period. The records contain reports on 35 of the 39 species of primate which have been kept at the Zoo. Of the 324 reports available, 107 (33%) were not used. A number of these were transfer reports or laboratory results, but a significant proportion were reports which were considered too difficult to read and interpret. Use of a consistent format for veterinary reports would facilitate access to the information contained within them.

The most common reason for veterinary visits from the 202 analysed was injury to the animals (40%), followed by BCG vaccinations (22%). Pharmaceuticals were used on 311 occasions, 65% of these being on Cercopithecidae and 15% on Cebidae. Ketamine is the most frequently used pharmaceutical (30% of total use). Several show variation in use over time. Ampicillin, chloramphenicol, and streptomycin were all used frequently before 1987: none of these have been used since that date. Ketamine has been in continuous use since 1974. The last BCG vaccination was done in 1981.

Visitor studies at Paignton Zoo: effectiveness of various zoo interpretation materials

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Zoos provide a valuable resource to educate the population about the natural world and conservation issues. To assist visitors with learning, there are several kinds of basic and interactive information sources. Two of these that are utilised at Paignton Zoo are wayside exhibits (WE) and audio-visual posts (AV). Wayside exhibits are found around all enclosure areas and show a picture of the animal and information concerning (i) habitat, diet, breeding and other behaviour, (ii) an interesting fact, and (iii) possible threats to the animal and conservation efforts. Audio-visual posts convey information through the use of three or four video or audio clips. The preferences of zoo visitors for these two resources was examined by comparing usage at three sites (the desert house, the ape house, and the tiger enclosure) on five days between November 1998 and January 1999.

Although there are some variations between sites and between days, only about one third of visitors stop at the information resources. This is in agreement with previous work. There were significant differences in the relative use of either AV or WE information resources. At the ape house AV was used more often, at the desert house AV use and WE use were approximately the same, and at the tiger enclosure WE was used about twice as frequently as

AV. However, there were fluctuations between days in relative use. The amount of time spent at the AV sources varied significantly. The mean time spent listening at the ape house was 58 seconds, followed by 45 seconds at the tiger enclosure, but only 23 seconds at the desert house. Individual visitors spent more time at each of the AV sources than did pairs or larger groups. This is not in agreement with previous work. Reasons for these results concerning AV and WE resources may include factors such as content and relative positioning. Further investigation with larger sample sizes is required to elucidate these results.

The impact of Paignton Zoo Environmental Park on the water quality of the local environment.

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The stream and lake system that forms an integral part of the Paignton Zoo Environmental Park was sampled at a number of sites over the period October 1998 to January 1999 to determine the impact of the Park activities on the bacteriological quality of the water.

Total coliforms and faecal streptococci were determined on a number of samples taken from a number of sites within the Environmental Park.

Using the Microbiological Quality Requirements for Bathing Water Directive as a guide, the water samples often exceeded the guideline value but not the imperative value for total coliforms. Faecal streptococci, in comparison, often exceeded the imperative values.

The initial sample taken close to the point at which the stream enters the Environmental Park showed that the catchment above the Environmental Park was making a significant contribution of these two bacteria to the water. In general the number of total coliforms and faecal streptococci present at each site declined as the stream progressed into the Environmental Park. The number of total coliforms often declining more rapidly than the number of faecal streptococci.

The decline in the number of bacteria as the stream flows through the Environmental Park may reflect the way in which the water flows through a number of lakes and over a number of dams; allowing the bacteria to sediment or be subject to natural die-off as their progress through the Environmental Park is slowed.

The views and opinions of keepers at two British zoos on the subject of environmental enrichment

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Keepers at London Zoo and Marwell Zoological Park were interviewed about the types of environmental enrichment attempted, the practical problems of implementing these and the effect of the public on exhibit design. The freedom of the keepers to make decisions regarding their animals and enclosures varies, depending on communications with zoo management, but is more often limited by constraints on time and money.

In most circumstances, the keepers need to be highly motivated and determined in order to gain the appropriate tools and materials, before they can even start to construct enrichment devices and then be able to judge their success. Enclosure design, particularly regarding night-time areas, was seen as another matter for consideration where the particular knowledge and understanding of keepers would be more useful determinants than the traditionally applied criteria of public aesthetic preferences.

The effects of an environmental enrichment upon the behaviour of hyacinth macaws, *Anodorhynchus hyacinthus*, at Paignton Zoo.

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The effects of a species-specific environmental enrichment upon the behaviour of a young pair of hyacinth macaws, *Anodorhynchus hyacinthinus*, at Paignton Zoo were investigated by supplying appropriate foraging opportunities. The enrichment device consisted of a 1.8m branch with many smaller branches and with 30 holes of various sizes randomly drilled into the surface. Food was placed in the holes in layers consisting of a banana/pineapple outer layer followed by grapes, then nut. Behaviour was observed as follows: a baseline period without enrichment (20 hours), a training period when enrichment was first added (20 hours), enrichment periods after training (2 x 20 hour periods), and post-enrichment periods without enrichment (2 x 20 hour periods). Behaviour was recorded at one minute intervals. Each period consisted of 1200 daytime samples obtained over five days.

Results show that, during enrichment, both parrots spent significantly more time allopreening and significantly less time on aggression than in the baseline or post-enrichment periods. In the baseline period, 4.3% of the samples showed the parrots allopreening. This rose to 9.3% during the training period and 13% during the enrichment periods. In the post-enrichment period, allopreening dropped to 4.8%. Aggressive behaviour was recorded in 18% of the samples during the baseline period, but this decreased to 6% during training and 2.3% during enrichment. Again, the behaviour change was a temporary one: during post-enrichment aggressive behaviour rose to 17.1%. During enrichment, the parrots consumed less 'free' food than in other periods. Instead, they chose to forage for their food on the enrichment device.

The results clearly show that providing environmental enrichment, such as foraging opportunities, can be successfully utilised to minimise certain undesired behaviours (aggression and destructive behaviour) which often occur among hyacinth macaws in captivity.

The mortality of captive non-human primates

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The mortality of primates at Paignton Zoo Environmental Park over the period 1960 to 1999 was investigated by an analysis of post mortem reports. Data collected from post mortem reports were collated with respect to cause of death and age.

225 post mortem reports for the period in question were examined. A major category, 29%, gave no diagnosis. The others could be grouped into related causes but no single major cause could be identified.

Bacterial infections played a significant role with *Escherichia coli*, *Streptococcus* species and *Yersinia pseudotuberculosis* being the most commonly isolated bacteria.

The young and pregnant appear to be a high risk group with physical injuries and eating disorders a common cause of death.

Evidence suggests that the causes of death at Paignton are in general agreement with other published studies.

A statistical analysis revealed that no significant association existed between primate super family, cause of death, age at death and bacterial infections suffered, suggesting that no particular group was more susceptible than any other.