ZSL

Institute of Zoology

LIVING CONSERVATION

Science for Conservation

Annual Report of the Institute of Zoology 2002/03

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MISSION:
TO IDENTIFY, UNDERTAKE, AND COMMUNICATE HIGH-QUALITY RESEARCH TO BENEFIT THE CONSERVATION OF ANIMAL SPECIES AND THEIR HABITATS

Contents

FOREWORD

Many years ago, Lord Zuckerman told me that there were three reasons for having a research Institute within ZSL. First, it took scientific advantage of the great diversity of animal species held in the Society's collections. Second, it allowed us to develop better ways of keeping and breeding wild animals. Third, our research should enhance conservation in the wild.

Nowadays our emphasis in ZSL and the Institute is overwhelmingly on the third of these – on how to develop the knowledge that will improve field conservation programmes. The urgency of action to save shrinking habitats and dwindling animal populations is emphasized in innumerable reports and press articles – but if public concern is to be converted into effective action, we need proper understanding of the biology and ecology of the species concerned, and the nature of the threats they face. Disease is one threat – and this Report explains ZSL's research on the outbreak of distemper virus among seals in the North Sea, on the diseases affecting amphibians in many places, and on the causes of the startling decline in the vulture population of India. But the fragmentation of populations and their habitats brings need for deeper understanding of population genetics and critical ecological limits, and these, too, are studied by the Institute.

The Institute of Zoology is not large. It needs to work in partnership with other centres of expertise, so that 'critical mass' is achieved. Our close ties with the Department of Zoology at Cambridge are central, but this Report demonstrates our wider network of cooperation, and the effort ZSL devotes to communicating the latest scientific knowledge about animal conservation through meetings, symposia, journals and books.

I commend this fascinating and encouraging Report to animal conservationists everywhere.

Sir Martin Holdgate

President, The Zoological Society of London

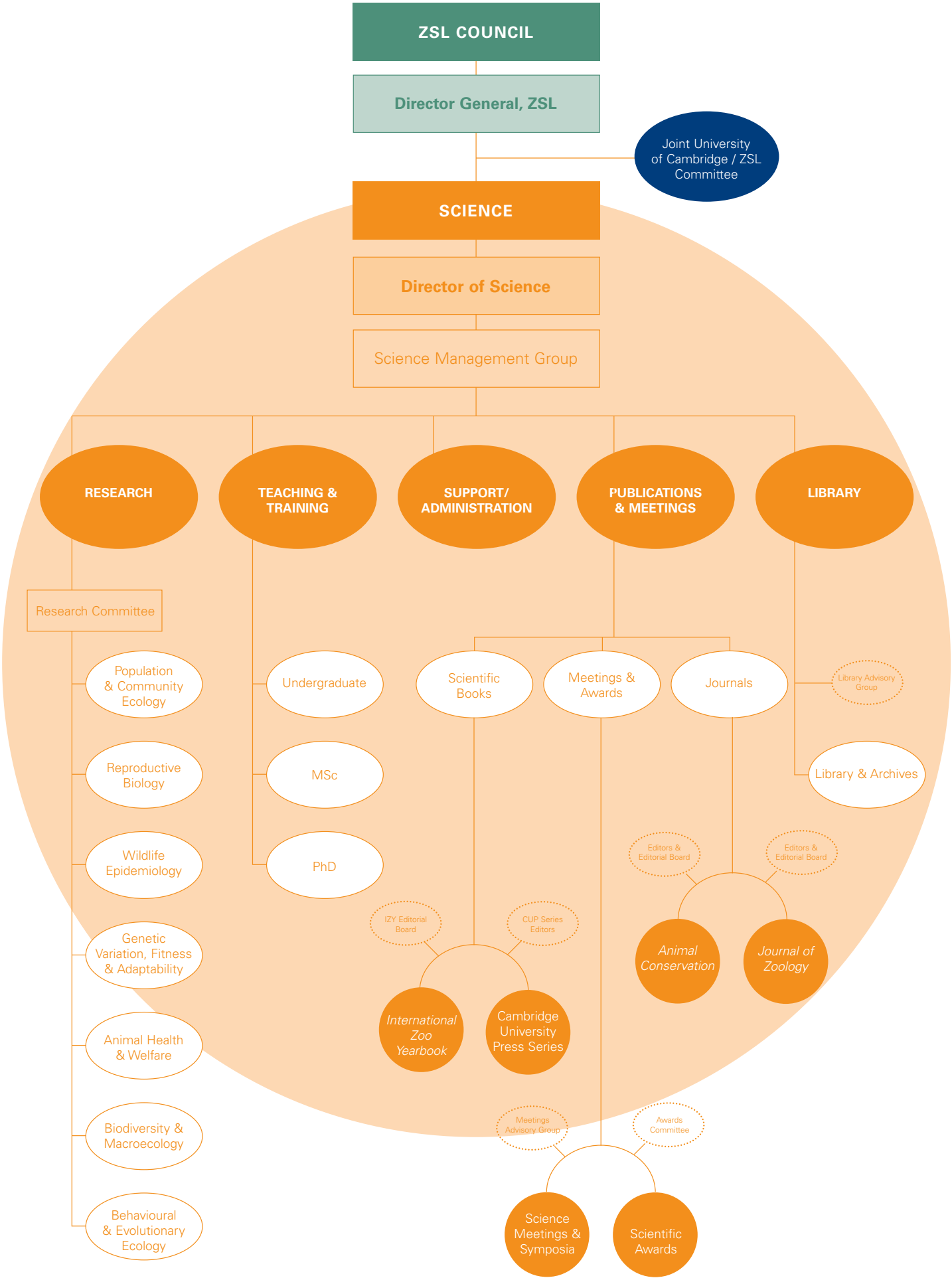
DIRECTOR'S INTRODUCTION

This has been a busy year with many changes and new projects started. While we have been working to review our research strategy and determine longer term strategies for science funding, animal populations in the UK and overseas have encountered fresh threats, leading to some urgent new projects and initiatives for us; a continuing reminder that the work we do must also be responsive and reactive to real issues and challenges.

Following the formal signing of our partnership with Cambridge University in 2001, new plans have begun to come into effect. In ZSL also, an altered emphasis for the work in the zoos and in the field has generated new opportunities for the Institute. These various parties have helped us to review our current research and to develop a coherent strategy for the coming years. The work of the Institute is overseen by a joint University of Cambridge/Zoological Society of London Committee. Chaired by Professor Pat Bateson FRS, this Committee is now meeting twice-yearly and provides invaluable guidance and support on staffing, scientific and strategic issues. Our work is also a major contributor to ZSL's mission-related activities in conservation and the zoos, overseen by ZSL's Strategy Committee. Chaired by Professor Paul Harvey FRS, this Committee has guided us through a process of developing realistic goals and designing strategies to achieve them. Dr Glyn Davies, Director of Conservation Programmes, and Professor Chris West, Director of Zoos, have worked with me and the Director General, Dr Michael Dixon, to set goals and targets for ZSL, and develop ways that we can achieve them through effective collaborations across the Society. Finally, senior Institute staff have worked with me to adjust our earlier research strategy into a slightly new form, summarized on page 33. My thanks go to all those involved over the year for their help in charting a clear way ahead. The figure opposite clarifies the structure and governance of the Institute – our revised research strategy mirrors this structure.

There has been sadness too this year. Daisy Balogh, a third-year PhD student, died suddenly in October 2002. Daisy had worked with us for over four years, and was well-known and liked by all. She is greatly missed by friends and colleagues. A further piece of bad news came earlier this year when we heard of the death of Conrad Scofield. Conrad was a long-time volunteer at the Institute, most recently supporting our field projects in Namibia. Our thoughts are with both their families and friends as we remember the ways in which they enlivened the work of the Institute.

Georgina Mace
Director of Science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NEWS & EVENTS

In October 2002 a new research staff structure was introduced. This includes criteria for different grades of research staff, a career path and a process for staff to gain promotion. Drs Andrew Bourke and Bill Holt were both promoted to Reader during the year, and Drs Sarah Durant and Jinliang Wang were promoted to Senior Research Fellow. Bill Holt was also appointed to visiting professorships at both the Royal Veterinary College and the University of Luton. Dr Andy Fenton joined us on a NERC postdoctoral fellowship working with Dr Andrew Cunningham and Dr Bryan Grenfell of the University of Cambridge.

At the same time we reviewed our Honorary Research Fellows scheme to provide recognition for external scientists who have had long-running and successful collaborations with the Institute. We are delighted to have appointed the first group to the new scheme – they are listed on page 27.

International collaborations are important for our work and one significant new link came to fruition during the year. The analogies between the ZSL and the Wildlife Conservation Society in New York are self-evident. Both are established zoological societies in major cities, running zoos, international field conservation programmes, and undertaking research. We have had a number of informal collaborations with WCS over the years and during 2002 senior WCS and ZSL staff reviewed these links and drew up a formal Memorandum of Understanding for future collaborations. The MoU covers all aspects of our work and provides new opportunities in research, the zoos and in overseas fieldwork. The MoU was endorsed by the governing bodies of both organisations and we have generated new projects as a result. The partnership was highlighted at this year's Stamford Raffles Lecture, delivered by WCS' President, Steve Sanderson (opposite page, a) and celebrated at the Reception on the same evening (opposite page, b).

As usual we held our annual research conference in October – this year attended by over 100 staff and external collaborators. The annual Institute of Zoology student conference held in January included 13 talks from PhD students and we were pleased to welcome a number of colleagues and supervisors from university partners. The prize for the best talk was awarded to Peter Wandeler, with Simon Rees and Roselle Chapman as runners-up. Gina Caplen was awarded the prize for the best student talk at the Silsoe Research Institute student conference.

Terry Dennett retired at the end of February after close to 40 years of providing photographic services to the IoZ staff.

During the year Institute staff have continued to undertake challenging, interesting and important projects. The outbreak of Phocine Distemper Virus (PDV) posed a potentially devastating threat to seals in the North Sea (opposite page, c). We were pleased to be given the responsibility by DEFRA for coordinating the investigation into the spread of the disease and its impact on wild populations. As it turned out, the disease waned as it moved northwards, and the effects in Scotland were not as severe as in the Wash, providing further avenues for investigation.

At much the same time our Darwin Initiative funded project investigating the causes of catastrophic declines in vulture

(from left)
Dr Andrew Bourke,
Peter Wandeler, Terry Dennett,
Dr Andy Fenton

species in the Indian sub-continent was in full swing. Elliot Morley, then Minister for Fisheries, Water and Nature Protection, now Minister of State, Department for Environment, Food and Rural Affairs, opened the Vulture Care Centre near Chandigarh, north of New Delhi (d), and spent a day with our project staff and collaborators from the Bombay Natural History Society, RSPB and representatives from the state of Haryana. All this led to a very hectic period for our wildlife epidemiology staff who coped admirably with the workload and associated publicity.

The Darwin Initiative grants programme run by DEFRA has been running for 10 years, and the vulture project was selected as one of those to be used in the publicity associated with the anniversary. We were invited to present a display of our recent Darwin Initiative projects at a reception hosted by DEFRA following the 2003 Darwin Lecture. At this event we were able to include our two latest awards: for tackling disease threats to Galápagos wildlife and for rhino monitoring in Kenya.

Other publicity during the year was associated with ZSL's participation in the bushmeat campaign. ZSL hosted a significant policy meeting on the subject attended by Clare Short, Secretary of State for International Development. At the meeting, research on bushmeat undertaken by Institute scientists was one item for discussion. This topic was pursued also at a special meeting at the Society for Conservation Biology meeting, which has now been published in the specialist literature, and continues to attract publicity.

(top to bottom) a, b, c, d

FUNDING

We receive our annual core funding from HEFCE via the University of Cambridge and in the period under review this totalled £1,803,720. Additional funding totalled £1,588,664 from many sources including science funding bodies, conservation organisations and government departments.

We received several new grants from DEFRA this year. As well as continuing to support the long-term cetacean strandings project via the Natural History Musem, DEFRA awarded us a grant of £261,461 to monitor the Phocine Distemper Virus outbreak among UK seal populations that commenced during the Autumn of 2002.

We were again pleased to receive several new grants from the Natural Environment Research Council. Drs Matthew Fisher and Andrew Cunningham were successful in their proposal for a study on disease emergence in European amphibians (£193,173) and Dr Jon Bridle won £51,000 for a study on adaptation at the edge of butterfly distributional ranges. A NERC grant was also awarded to us in collaboration with the Universities of St Andrews and Cambridge for spatial modelling of the Phocine Distemper Virus outbreak, running alongside the DEFRA-funded monitoring project.

We were awarded two new Darwin Initiative grants. Drs Simon Goodman and Andrew Cunningham received £75,469 for building capacity and determining disease threats to the endemic fauna of the Galápagos Islands. This project has commenced with a successful visit to build collaborations with other academic and conservation organisations working in the area. Drs Rajan Amin and Richard Pettifor were awarded a Darwin Initiative grant for technical assistance in monitoring rhino populations in Kenya, in collaboration with the Kenya Wildlife Service. We were please to be invited to present our Darwin projects at a special 10th Anniversary meeting of the Darwin Initiative held in March, which was attended by Elliot Morley MP.

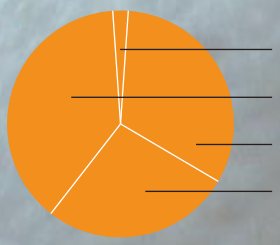
In collaboration with IUCN, we also received funding from the Rufford Foundation for analyses related to the 2003 and 2004 IUCN Red Lists of Threatened Species. While the compilation and production of these lists is undertaken by the IUCN office in Cambridge, we will be working closely with them and other partners to provide analyses of trends and indicators of overall biodiversity status that can be gleaned from these data.

We were also pleased to receive continued funding from both the RSPB and English Nature towards veterinary and disease monitoring projects for endangered wildlife in the UK and overseas.

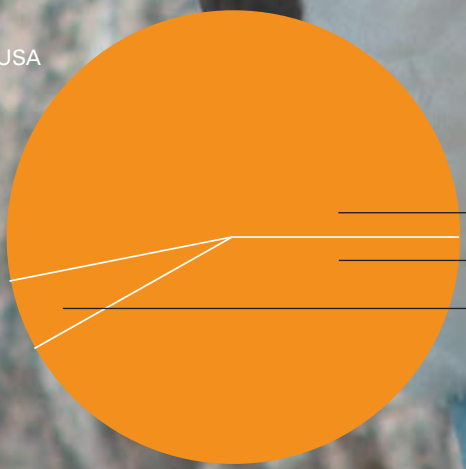
Funding organisations

British High Commission, India
Central Science Laboratory
Darwin Initiative (DEFRA)
Department for Environment, Food and Rural Affairs
English Nature
Fisheries Society of the British Isles
Frankfurt Zoological Society, Germany
Greater London Authority and Save the Trafalgar Square Pigeons Group
Hobson Vision Ltd
IUCN (World Conservation Union), Switzerland
National Birds of Prey Trust
National Institutes of Health, USA
Natural Environment Research Council
Queen Mary and Westfield College
Royal Irish Academy
Royal Society
Royal Society for the Protection of Birds
Rufford Foundation
Saint Louis Zoological Park, USA
Sygen International
University of California at Berkeley, USA
University College London

Research Grants & Contracts



European Union £31,030
Government Bodies £546,543
Research Councils £460,822
Other Organisations £382,169



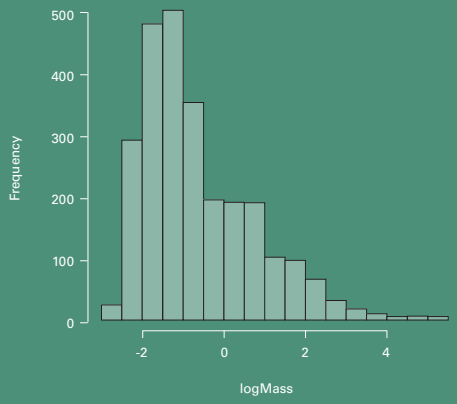
Institute of Zoology Income 2002/03
12 months, 1 August 2002 - 31 July 2003

Core Grant £1,803,720
Research Grants & Contracts £1,420,564
Other Income £168,100

Total Income £3,392,384

BIODIVERSITY & MACROECOLOGY

Frequency distribution of log body mass for 2600 mammal species. In spite of the fact that the overwhelming majority of mammal species are small, we find no evidence that diversification rates are correlated with size. In fact, most species are small because they are either rodents or bats. Other small-bodied orders, such as the elephant shrews and flying squirrels, contain very few species.



Documenting and preserving biodiversity is the primary goal of conservation. However, it is also important to understand the processes which produce patterns of biodiversity. Why, for example, does the mammalian order Rodentia (rodents) contain over 1600 species, while the order Dermoptera (flying lemurs) contains only two species? Variation in species numbers between different groups can arise simply by chance, or because some groups are older than others and so have had more time for new species to accumulate. However, a third possibility has generated a great deal of interest in recent years: that some groups possess ecological or life-history traits which might promote faster species diversification. Because the rate of diversification is equal to the difference between the rates of speciation and extinction, any trait which increases the chance of speciation, or decreases the chance of extinction, could lead to faster diversification. Two pieces of research have addressed this issue:

Correlates of species richness

Several recent studies have used sister-clade comparisons to test hypotheses linking variable biological traits, such as body size, with diversity. Evaluating the findings of these studies is complicated because they differ in the index of species-richness difference used, the way in which trait differences were treated, and in the statistical tests employed. We used simulations to compare the statistical performance of four species-richness indices under a range of conditions. All four indices returned appropriate rates of false positives when the assumptions of the method were met. However, only two of the indices were robust to the different evolutionary models and under all analysis options. These robust indices had comparable power under one non-null model scenario. As far as statistical testing goes, regression through the origin consistently outperformed the *t*-test. Additionally, the choice of branch lengths exerted a strong effect on both the validity and power. Our investigations then enabled us to re-evaluate the findings of previous sister-clade comparisons. Surprisingly, we found no evidence that diversification in animals is fastest at small body size. We provide a set of simple guidelines for others to use to maximize the performance of this method in tests of putative correlates of species richness.

Isaac, N. J. B., Agapow, P. M., Harvey, P. H. & Purvis, A. (2003). Phylogenetically nested comparisons for testing correlates of species richness: a simulation study of continuous variables. *Evolution* **57**: 18–26.

Patterns of biodiversity in Australian mammals

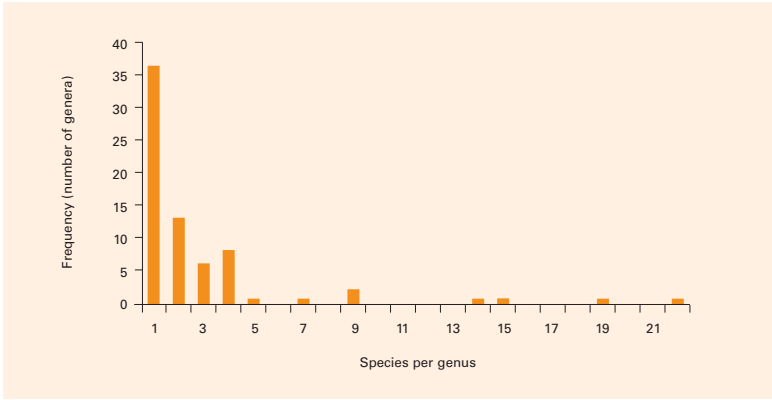
Another study explores some of the traits (size of geographic ranges and speed of life history) which may influence diversification rates in Australian mammals. The first step was to test whether variation in species numbers could simply be explained by chance. Comparing patterns to two null models (Geometric and Poisson distributions) suggested that this was not the case – the number of species was distributed non-randomly among genera. If species richness patterns are non-random, could they be associated with geographic range size or life-history turnover rate? This was tested using the phylogenetic method of sister-clade

comparisons. Sister clades are the same age and have had equal time to diversify, so it follows that a clade which has more species than its sister has diversified faster. Using multiple comparisons of sister genera, it was found that faster diversification in Australian mammals was associated with larger geographic ranges and larger litters, although there were no associations with body size or age at first breeding. Larger geographic ranges may elevate diversification rates by allowing larger populations to be maintained, protecting species from extinction, or by increasing the chance of speciation by allopatric subdivision. Larger litters promote faster population growth, which may reduce the rate of extinction.

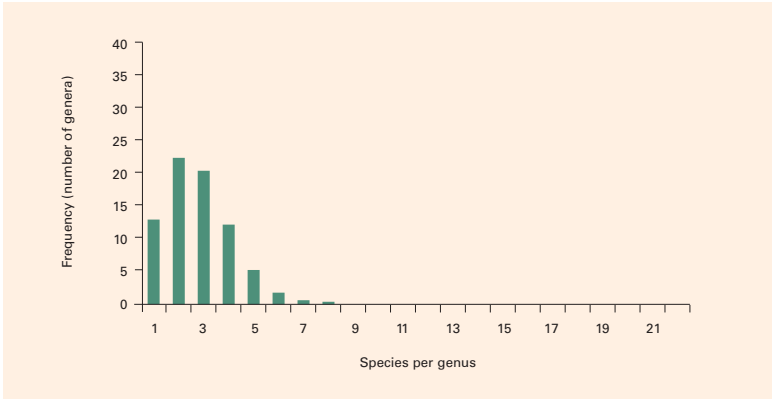
An intriguing question is whether the processes which determine extinction of contemporary species and extinction risk of extant species can be scaled up to influence extinction rates (and hence diversification rates) on macroevolutionary timescales. Our findings provide some evidence that they might: litter size is one factor determining the likelihood of population extinctions, and geographic range size has a strong influence on current extinction risk in some groups of mammals. More work is needed to fully explore the biological drivers of extinction at different scales.

Cardillo, M., Huxtable, J. S. & Bromham, L. (2003). Geographic range size, life history and rates of diversification in Australian mammals. *Journal of Evolutionary Biology* **16**: 282–288.

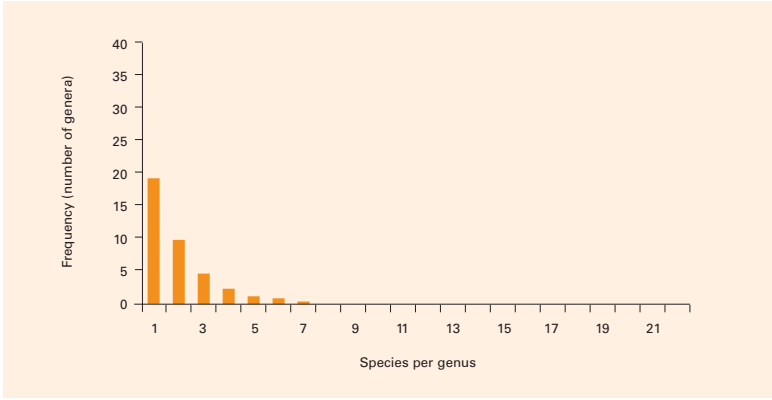
(a) Actual distribution



(b) Poisson distribution

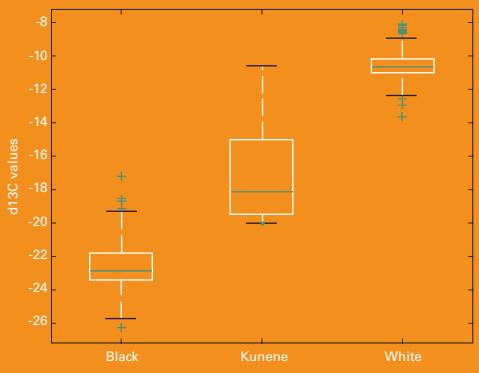


(c) Geometric distribution



Frequency distributions of 210 species of Australian mammals among 76 genera: (a) the observed distribution; (b) the random distribution expected under a Poisson model; (c) the random distribution expected under a geometric model.

POPULATION & COMMUNITY ECOLOGY



Social foraging in primates

When an animal hunts for food, it has to make decisions, such as when and where to forage or how much to eat. These decisions are influenced by how likely the animal is to be predated if it visits a certain place or conducts a particular behaviour. Evolution has shaped the behaviour of animals so that they balance the benefits of foraging against costs such as starvation or predation. Predicting what an animal should do is more complicated if it forages in a group. Other group members can influence its chances of finding food (through sharing or stealing), or its predation risk (a group may detect a predator better than an individual, or may be a more obvious target). If there are advantages to foraging as a group, then it is beneficial for all the members to decide when and where they forage together. But how do they reach a consensus?

We considered how a pair of animals reach decisions about foraging. At any moment, an animal can either rest (using energy and suffering a low risk of predation) or forage (gaining energy, but facing a greater risk). Foraging at the same time as a colleague is beneficial, as it reduces the risk of predation.

Our simple model yielded interesting results. We found that foraging becomes highly synchronized as animals appear to forage or rest at the same time. Pairs appear to separate into one individual that has high energy stores, and one that has low. These 'fat' and 'thin' roles are maintained over a long period of time. Furthermore, the 'thin' individual decides when the pair forages, and acts as a leader for the foraging pair. Interestingly, this provides a mechanism for leadership to exist without any member of a group having special properties, such as dominance.

Our findings also suggest that the rules predicted by the model can be reduced to a simple rule-of-thumb for an animal to follow: 'if I'm hungry, I should forage; if I'm not, then I should copy what my colleague is doing.' This rule and further studies have implications for emergent group behaviour (where individuals following simple sets of rules lead to larger, complex patterns, such as the movement of shoals of fish, where all the animals seem to turn at once). These investigations may help to give us a deeper insight into how groups evolve and organise themselves.

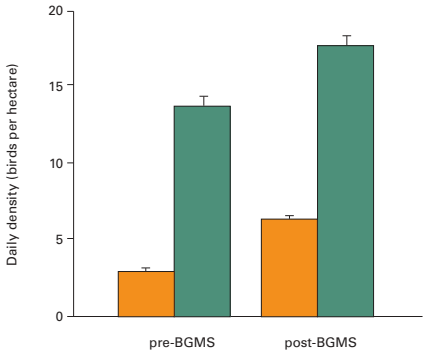
Rands, S. A., Cowlishaw, G., Pettifor, R. A., Rowcliffe, J. M. & Johnstone, R. A. (2003). Spontaneous emergence of leaders and followers in foraging pairs. *Nature* **423**: 432–434.

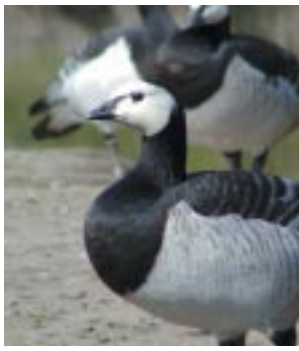
Rhino horn fingerprinting

Although rhino horn is made of bone, it is in fact compacted hair, so its chemical composition reflects what the animals have eaten throughout their lives. The chemical properties of their food are absorbed into the horn through digestive processes. Furthermore, the chemistry of this food varies in response to an area's underlying geology, geomorphological history, and climate. Different types of plants (succulents, tropical grasses, herbs, and trees) also have different biochemical pathways for fixing carbon during photosynthesis, further affecting their chemical composition. A chemical analysis of rhino horn offers the potential of determining both the probable geographical source of the horn as well as the species of rhino from which it comes. Such a rhino horn fingerprinting tool would assist investigators and trade researchers to

(left) Distribution of d13C by species distinguishing between 'desert' black rhino from Kunene and all other populations of black and white rhino. A strong relationship exists between d13C values in black rhino horn and rainfall with highest d13C values being recorded in very arid areas with high coefficients of variation. The low erratic rainfall in Kunene is therefore related to the unusually high d13C values recorded for the 'desert' black rhinos in this area.

(right) Mean daily densities (± standard errors) of barnacle geese on the reserve (magenta) and non-reserve (orange), pre- and post-BGMS. Densities were higher on the reserve both pre- and post-BGMS, and non-reserve densities are higher post-BGMS than pre-BGMS.





learn more about illegal horn trading routes, assist law enforcement efforts, as well as provide forensic evidence that can be used in court. A further benefit is that data on element abundances in horns could be useful in identifying possible mineral toxicities or deficiencies in some areas. For these reasons, the IUCN Species Survival Commission's African Rhino Specialist Group (AfRSG) has rated the development of such a tool as a *Continentally Important* project.

An initial continental African rhino horn fingerprinting database was set up by obtaining samples from South Africa, Namibia, Kenya, Swaziland and Zimbabwe for the two African species of rhino. A total of 361 samples was obtained from 27 black rhino populations and 22 white rhino populations. The horn samples were analysed in three different laboratories, each using a different technique: carbon and nitrogen analysis using mass spectrometry, common and trace element analysis using inductively-coupled-plasma optical-emission-spectroscopy and heavier isotope analysis using laser ablation inductively-coupled-plasma mass spectrometry.

The chemical analysis to date has confirmed horn fingerprinting can reliably classify horn samples at a species and regional level, but that in order to successfully classify samples down to the finer scale of parks, or areas within parks level, more samples will need to be collected (than the current 3–6 per park). Advanced modelling techniques based on non-linear Neural Network and Rule Induction methods provided significant performance improvements over the classical methods such as Canonical Variates Analysis / Discriminant Function Analysis. Neural networks have the advantage that they provide an estimate of the likelihood of a sample belonging to a certain class. A decision can then be made based on these posterior probability estimates. Novelty filters based on neural networks were also successfully developed to detect samples that come from areas not yet covered in the database. Rule Induction gives an explicit representation of the decision process in the form of rules as well as having a natural graphical representation as flowcharts. This is particularly useful for presentation as evidence in a court of law.

Amin, R., Bramer, M. A. & Emslie, R. (2003). Intelligent data analysis for conservation: experiments with rhino horn fingerprint identification. In *Applications and innovations in intelligent systems*: 207–222. MacIntosh, A., Ellis, R. & Coenen, F. (Eds). London: Springer-Verlag.

Integrated farming and wildlife conservation

The successful conservation of any species not only requires information on the species' ecology and distribution, but also a willingness on the part of people who may come into contact with that species to conserve it. Recent work has addressed both these issues for the Svalbard barnacle goose which spends over half the year (September to May) around the shores of the Solway Firth, UK.

We investigated the environmental correlates of foraging behaviour of barnacle geese on improved pasture. We found that geese accumulated fat reserves at the start and end of their time in the UK, but that fat accumulation stopped for 50 days in the middle of winter. Foraging effort was highest at the same time as fat accumulation was zero. This coincided with the time of year when the days were the shortest and food supplies were at a low level, thus even with increased foraging effort fat stores were not improved.

Barnacle geese feed largely on pasture fields and compete with livestock for food, constituting a conflict of interest between farming and conservation objectives. In the early 1990s farmers regularly scared geese from their fields, which restricted the food supply available to the geese, and potentially damaged their ability to accumulate fat stores. In 1994 the Barnacle Goose Management Scheme (BGMS) was implemented around the Solway Firth to encourage farmers to tolerate the geese on their pastures. Farmers were paid to farm sympathetically to the needs of the geese by reducing scaring, keeping livestock off the pastures to avoid competition for food, and fertilizing the pastures to improve the food supply for geese. Our study aimed to assess the efficacy of the scheme in increasing goose use of those fields that were within the scheme. We found that goose densities doubled in fields where 'goose-friendly' farming practices had been implemented. However, goose density on a neighbouring reserve was twice as high as the surrounding fields, even after the introduction of the management scheme. These results provide useful information for conservation management where the interests of farmers and reserve managers are in conflict.

Cope, D. R. (2003). Variation in daily and seasonal foraging routines of non-breeding barnacle geese (*Branta leucopsis*): working harder does not overcome environmental constraints. *Journal of Zoology (London)* **260**: 65–71.

Cope, D. R., Pettifor, R. A., Griffin, L. R. & Rowcliffe, J.M. (2003). Integrating farming and wildlife conservation: the Barnacle Goose Management Scheme. *Biological Conservation* **110**: 113–122.

BEHAVIOURAL & EVOLUTIONARY ECOLOGY

Mating strategies of topi bulls

In some species, males use several different mating tactics to maximize their reproductive output. It is often not obvious what logic determines who does what: Do certain tactics confer higher mating benefits? Do individuals switch between tactics, either in the short term or according to their life-history stage? Are some individuals superior competitors? In our study of African topi antelopes in the Serengeti-Mara region of East Africa, we investigated why some bulls aggregate on minimal territories on mating arenas, so-called leks, whilst others defend large resource-based territories.

We found that although individual males occasionally do swap between lekking and resource defence, such switches are infrequent. Males who succeed in establishing themselves on leks not only benefit from high instantaneous mating rates whilst lekking, but they also appear to obtain higher lifetime reproductive success. Most successful are the central lek males who tend to be larger than other males. In contrast, males who adopt the resource-defending tactic throughout life seem to be doing the best of a bad job. The fact that some individuals contribute disproportionately to breeding suggests that inbreeding is more likely to become a concern than previously thought. This finding has implications for developing conservation measures for the species.

Although topi antelopes are still relatively common, far from all populations mate on leks, and due to human encroachment on wilderness areas, lek-breeding in topi is now a behaviour under increasing threat. In order to understand where leks develop and why lekking is rare, we studied the ecological characteristics of topi leks. Our results indicate that lekking is associated with high population density, suggesting that lek formation may be triggered when high-quality males cluster in areas of maximum female density. Under such circumstances females benefit from using male clustering as a mate choice cue. In turn males benefit from clustering further and a positive feedback between benefits to males and females of mating in clusters may lead to the extreme contraction of the territorial network, which is characteristic of leks.

Bro-Jørgensen, J. (2003). The significance of hotspots to lekking topi antelopes (*Damaliscus lunatus*). *Behavioral Ecology and Sociobiology* **53**: 324–331.

Bro-Jørgensen, J., Durant, S. M. (2003). Mating strategies of topi bulls: getting in the centre of attention. *Animal Behaviour* **65**: 585–594.

Male parentage in ant colonies

The evolution of social behaviour represents a major topic in behavioural and evolutionary ecology. Kin selection theory aims to explain social evolution as a function of the genetic structure of animal societies. As part of our research on basic evolutionary processes, we have been testing kin selection theory using social insects as model systems. One of our favourite organisms for this purpose is the ant, *Leptothorax acervorum*. This ant has a social system in which some colonies are headed by a single queen and others by several, coexisting queens. As in many social insects, the workers are not totally sterile and can lay eggs yielding male offspring. The variation in queen number causes the genetic structure of colonies to vary, a fact that we have exploited to test the predictions of kin selection theory regarding which caste – the queen or the

workers – should produce males. It turns out that, in colonies with a single queen, workers are more closely related to worker-produced males, whereas in colonies with multiple queens workers are equally related to worker- and queen-produced males. Therefore, kin selection theory predicts relatively high levels of worker egg-laying in single-queen colonies and relatively low levels of worker egg-laying in multiple-queen colonies. We tested this prediction by using microsatellite DNA marker loci to assess the parentage of males. We found that the frequency of worker-produced males was very low (2–5% of all males) and did not differ significantly between single- and multiple-queen colonies. This was true for males at both the egg and the adult stage. This finding was therefore not as predicted by kin selection theory. It seems that, even though they are capable of laying male eggs, and should be selected to do so at a high rate in single-queen colonies, workers in all colonies refrain from laying many such eggs. We do not know the reason for this, but one possible explanation is that worker reproduction is selected against because it reduces the overall productivity of colonies. Clearly kin selection theory, although successful in many of its predictions, cannot explain some of the reproductive patterns found in animal societies.

Hammond, R. L., Bruford, M. W. & Bourke, A. F. G. (2003). Male parentage does not vary with colony kin structure in a multiple-queen ant. *Journal of Evolutionary Biology* **16**: 446–455.

Non-lethal DNA sampling in bumble bees

Non-lethal sampling of DNA is valuable for behavioural studies because it means the genetic relationships of individuals can be known in advance of observing their behaviour. In addition, even among invertebrates, non-lethal sampling of DNA from individuals in wild populations will often be required for studies of conservation genetics, since it avoids destroying members of scarce or declining species. Bumble bees represent useful organisms for behavioural studies because they are relatively easy to keep in captivity for the whole of their colony cycle, which, since they are annual insects, lasts only a few months. The conservation biology of bumble bees is also an important area of study, since about one-third of the 19 British bumble bee species have undergone severe declines or become extinct in recent decades.

We investigated the efficacy and consequences of methods of non-lethal sampling of DNA from bumble bee workers. An experiment with two captive and confined *Bombus terrestris* colonies established that, unlike sampling haemolymph, sampling the terminal portion of the tarsus of a mid-leg of a worker both reliably yielded amplifiable microsatellite DNA and did not significantly reduce worker survivorship. In a further experiment with non-confined colonies, workers of four *B. terrestris* colonies were marked and either non-lethally sampled for DNA by tarsal sampling or handled as controls. All workers were then allowed to forage freely at flowers in the external environment. We found that tarsal sampling of either a mid-leg or a hind-leg had no significant effects on worker survivorship, the mean body mass of foraging workers, the frequency or duration of foraging trips, mass of pollen loads or mass of nectar loads. There were no significant differences between the effects of sampling a mid-leg and those of sampling a hind-leg, or, in the hind-leg trials, between sampling a left leg or a right leg. These results showed that tarsal sampling of either a mid-leg or a hind-leg is an effective and acceptable means of non-lethally sampling DNA from bumble bee workers, because effects on individual and colony performance are likely to be absent or minimal. In future, we hope to employ this method of DNA sampling in our studies of both the behaviour and conservation genetics of bumble bees.

Bourke, A. F. G. & Holehouse, K. A. (2002). Non-lethal sampling of DNA from free-foraging bumble bees. Report for the RSPB, October 2002.

GENETIC VARIATION, FITNESS & ADAPTABILITY

Effects of urban colonization and rabies on the genetic structure of Swiss red fox populations

Red foxes are one of the most widely distributed mammals and are ecologically extremely flexible. They utilize a wide range of habitat types and have successfully colonized cities and their suburbs in the British Isles, continental Europe, North America and Australia during the last century. However, as a vector of rabies and other diseases, foxes are of concern for human and animal health. The Swiss city of Zurich was colonized by foxes around 1985 and the number of individuals has increased steadily. We studied whether the fox population in Zurich is isolated from rural populations or whether the urban habitat acts as a constant sink for rural dispersers using microsatellite DNA markers. Genetic variation was lower for foxes within the city compared to their rural conspecifics, whilst genetic differentiation was lower between rural populations than between rural and urban populations. Our results indicate two colonization events by small numbers of individuals from adjacent rural areas resulting in genetic drift and genetic differentiation between rural and urban fox populations. Observed levels of migration between urban and rural habitat will probably erode genetic differentiation over time.

We are investigating the impact of rabies epidemics on the genetic structure and dispersal patterns in selected Swiss study sites. Since 1969, fox carcasses from across Switzerland have been collected at the University of Berne for the surveillance of the latest rabies epidemics, which lasted from 1967 to 1996. Samples of teeth were collected from these foxes for aging purposes, along with data on sex, geographic origin and the results of the rabies virus tests. Using the teeth samples as a source for historic DNA along with recent tissue samples we aim to describe genetic variation within and between rabies-affected and unaffected Swiss fox populations before, during and after the rabies epidemic. In addition, the genetic data gathered will be paired with individual-based demographic data by complementary aging of the tooth samples. This study should help to give an insight into general processes affecting host genetic diversity, migration patterns and demography in relation to epidemics.

Wandeler, P., Funk, S. M., Largiadèr, C. R., Gloor, S. & Breitenmoser, U. (2003). The city-fox phenomenon: genetic consequences of a recent colonization of urban habitat. *Molecular Ecology* **12**: 647–656.

Wandeler, P., Smith, S., Morin, P. A., Pettifor, R. A. & Funk, S. M. (2003). Patterns of nuclear DNA degeneration over time - a case study in historic teeth samples. *Molecular Ecology* **12**: 1087–1093.

Conservation genetics of Iberian Atlantic salmon

The post-glacial expansion of southern biota into northern habitats following the retreat of the polar front some 16,000 years ago has been well studied. Less well understood, however, are the evolutionary and adaptive responses of fauna to global warming in former glacial refugia. Post-glacial warming may have constituted a strong selective force for refugial populations, and one that is likely to intensify in the near future. Investigating the molecular evolution of refugial populations in response to global warming may help us to understand the long-term effects of environmental change and population declines. In this context, new molecular techniques for analysing ancient DNA have revolutionized phylogeography and

conservation genetics, making it now possible to examine the origin and adaptive response of species and populations.

At present, some of the most endangered Atlantic salmon populations are those found in Iberia and other southerly former glacial refugia, located on the margins of the species' geographic range. The archaeological sites of northern Spain are particularly rich in animal bones, including Atlantic salmon from the Late Pleistocene, that have allowed us to test hypotheses on the post-glacial evolution of Atlantic salmon. We sequenced a small fragment of mitochondrial DNA from salmon vertebrae from the Upper Palaeolithic and compared the results with modern samples from Iberia and other regions in Europe. The analysis confirmed the Iberian ancestry of European salmon and indicated a post-glacial expansion. Despite their small population size, the haplotype diversity of modern Iberian populations is still high compared to that of northern European populations, as one would expect if there had been a post-glacial colonization of northern rivers by a limited number of founders originating from southern glacial refugia. Analysis of the ancient vertebrae also suggested the existence of important genetic changes in the refugial populations since the last glacial maximum. An ancient Iberian haplotype, apparently common during the Late Pleistocene, is now rare or absent from modern Iberian populations.

Subsequent analyses of mitochondrial DNA and microsatellite loci from archival scale samples (1950–2000) revealed significant changes in gene frequencies in one of the populations, coincident with a reduction in population size. Although the reasons for the genetic change are not yet clear, several hypotheses can be put forward: (1) random genetic drift due to severe population bottlenecks, (2) input of novel genetic material from stocking with non-native fish, or (3) climatic change, as there is evidence of an increase of approximately 0.5°C per decade in water temperature in the rivers studied. More extensive genetic analysis of ancient and modern samples from a range of Iberian Atlantic salmon populations should help to elucidate these issues.

Consuegra, S., Garcia de Leaniz, C., Serdio, A., Gonzalez Morales, M., Straus, L. G., Knox, D. & Verspoor, E. (2002). Mitochondrial DNA variation in Pleistocene and modern Atlantic salmon from the Iberian glacial refugium. *Molecular Ecology* **11**: 2037–2048.

Gene flow and adaptation in Galápagos lava lizards

Understanding the process of adaptation of populations to local environmental conditions is important to conservation management practices, such as translocations, reintroductions and supplementation of populations. To have any ability to predict the possible consequences of such actions we need to know the degree, rate and spatial scale on which adaptation can occur.

The Galápagos Islands have traditionally provided many examples of adaptation, perhaps most famously in the case of the adaptive radiation of Darwin's finches. Galápagos lava lizards (*Microlophus* spp.) are small- to medium-sized lizards (13–15 cm) which are distributed across the archipelago and are generally common where they occur. On the small island of Isla Plaza Sur lava lizards inhabit two contrasting environments: one half of the island has almost no vegetation while the other half is heavily vegetated, with a sharp transition between habitats. Lava lizards from the unvegetated side of the island have increased sprint speed, running endurance, and wariness over that seen in individuals from the vegetated habitat. These physiological, morphological and behavioural differences are believed to be adaptations to high levels of bird predation in the unvegetated habitat. If so, this would represent an extreme case of micro-adaptation as the island is only around 1 km long.

In collaboration with colleagues from the Charles Darwin Research Station (Galápagos) and Purdue University (USA) we have used genetic markers to examine the population structure of lava lizards on Isla Plaza Sur. We investigated whether gene flow is restricted between vegetated and unvegetated areas. Although there are no physical barriers to dispersal, environmental differences across the island may act as a barrier to gene flow, for example, lizards moving from one habitat to the other may survive or reproduce less well than resident individuals. However, we found little evidence for genetic differentiation between these areas, suggesting that gene flow does not constrain adaptation in this situation. Further analysis indicated that levels of inbreeding among lizards from different areas were similar and therefore different levels of inbreeding depression could not account for the observed performance differences. If natural selection is indeed driving the observed phenotypic differences among lizards, then this selection must be very strong to counter the apparently high rates of gene flow and act on an incredibly fine spatial scale.

Jordan, M. A., Hammond, R. L., Snell, H. L., Snell, H. M. & Jordan, W. C. (2002). Isolation and characterization of microsatellite loci from Galápagos lava lizards (*Microlophus* spp.) *Molecular Ecology Notes* **2**: 349–351.

WILDLIFE EPIDEMIOLOGY

(right) Vulture exhibiting neck-drooping syndrome

Declines of griffon vultures in India

Griffon vultures are declining in Asia at a rate that is unprecedented for birds and that may lead to the extinction of at least three species. Although widespread, the cause of the declines is currently unknown. In 2000, in collaboration with the RSPB and the Bombay Natural History Society, we conducted a survey to quantify the declines in the populations of *Gyps bengalensis* and *G. indicus* across India since 1990–1993. Directly comparable data for the two periods were obtained from over 6000 km of road transect surveys carried out in protected areas, the regions around protected areas and linking highways across the country. An additional 5000 km were covered in 2000 in previously unsurveyed areas. Further data were collected from questionnaires circulated to ornithologists, wildlife experts and forestry officials. Massive declines in the populations of both species were apparent from all parts of the country, and exceeded 92% overall. Our data suggest that the extent of declines did not differ between protected areas and non-protected areas. Sick birds, with drooping neck syndrome, were observed in all regions, and dead adult and juvenile vultures were frequently observed. The availability of food for the vultures did not decline greatly over this period, thus the patterns of declines and the presence of sick and dead birds indicate epidemic disease as a possible cause. If so, this is likely to be an agent to which the population is naive, e.g. an introduced agent or one from which the species were previously isolated. If infectious disease proves to be the primary cause of these declines it could spread to all griffon vultures across Asia, the Middle East, Europe and Africa. In addition to the loss of vultures, there are likely to be many repercussions both to humans and to biodiversity. The increase in uneaten cattle carcasses in India poses a direct health threat and has resulted in an explosion in the stray dog population, which has increased the threat of dog attacks and diseases such as rabies. Our research highlights the need for additional research to confirm the causative agent and to identify measures that can be taken to stem the problem. The British High Commission, New Delhi, is now funding a collaborative pilot project to identify the most likely routes of disease spread.

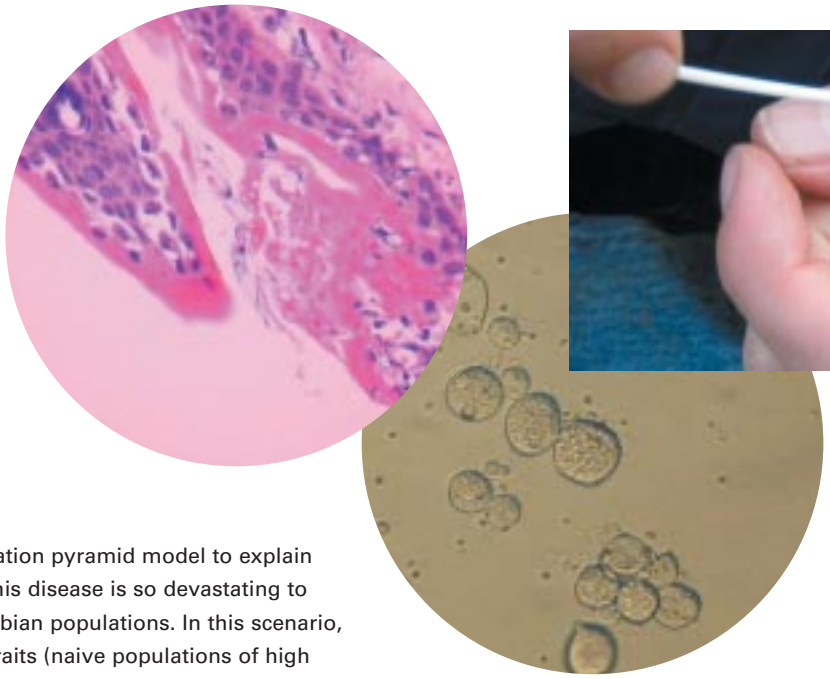
Prakash, V., Pain, D. J., Cunningham, A. A., Donald, P. F., Prakash, N., Verma, A., Gargi, R., Sivakumar, S. & Rahmani, A. R. (2003). Catastrophic collapse of Indian white-backed *Gyps bengalensis* and long-billed *Gyps indicus* vulture populations. *Biological Conservation* **109**: 381–390.

Cunningham, A. A., Pain, D. & Prakash, V. (2002). Catastrophic declines of griffon vultures in India. *Falco* **20**: 10–11.

Infectious disease and amphibian population declines

There has been growing interest in infectious diseases and their role in global amphibian declines. In particular, chytridiomycosis, ranavirus disease, saprolegniosis and *Ribeiroia* sp. infection have been implicated as the cause of heightened mortality leading to these population declines. We have reviewed evidence for the link between population declines and these infectious diseases. Our findings suggest that the clearest link so far exists for amphibian chytridiomycosis, which has caused widespread population declines, particularly in temperate and tropical montane species, and at least one extinction (*Taudactylus acutirostris*).

We have proposed a simple



(left) Histological section of midwife toad skin showing Batrachochytrium sporangia

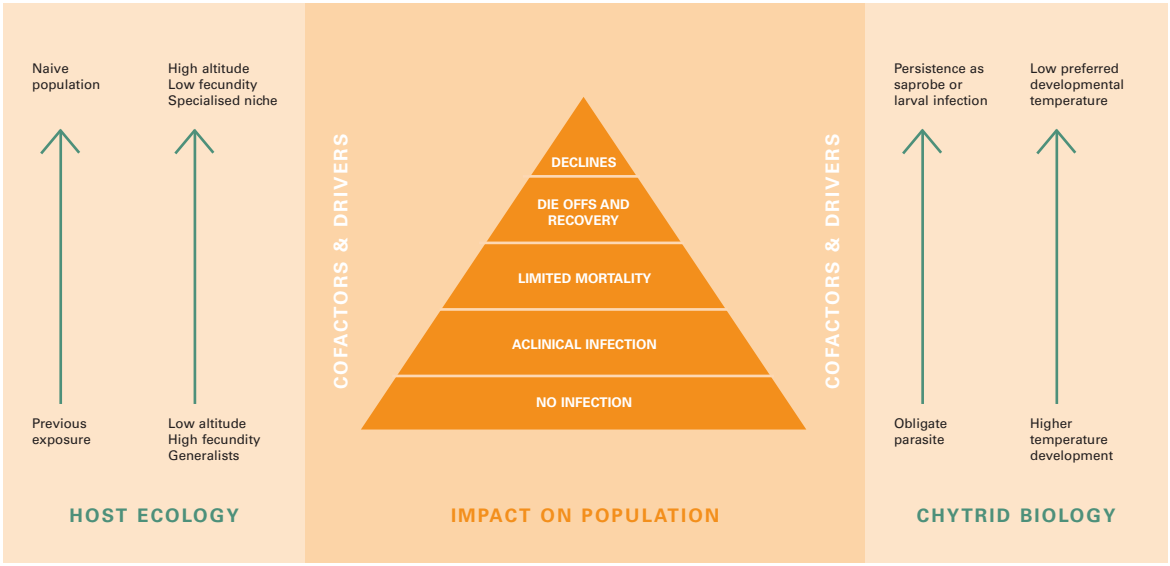
(right) Batrachochytrium dendrobatidis in culture

population pyramid model to explain why this disease is so devastating to amphibian populations. In this scenario, host traits (naive populations of high altitude, stream breeding, low fecundity, habitat specialist amphibians) and pathogen traits (more rapid growth in cool temperatures, wide host range, high virulence, inapparent infection in larvae, potential ability to survive outside host in the wild) combine to produce local extinctions in a proportion of amphibian species that are susceptible. This hypothetical scenario was based partly on a few studies of the fungal parasite that causes chytridiomycosis, *Batrachochytrium dendrobatidis*, and on ecological studies of sympatric, declining and non-declining species. Data collected in the last 2 years have begun to provide support for our pyramid model.

Chytridiomycosis appears to cause declines and extinctions in a select group of amphibians predisposed to heightened impact by certain life-history traits. Disease outbreaks appear to be caused by a range of cofactors and drivers. These include disease introduction (pathogen pollution) and climate change, both of which are supported by some data. Hypothesized cofactors include stress, pollution and increased levels of UV-B light. We propose that ecologically predisposed species are more severely impacted by chytridiomycosis, as it appears that a large number of populations are not significantly affected by this pathogen.

Daszak, P., Cunningham, A. A. & Hyatt, A. D. (2003). Infectious disease and amphibian population declines. *Diversity and Distributions* **9**: 141–150.

(below) A diagrammatic model describing hypotheses on the impact of chytridiomycosis on amphibian populations. Host ecological traits (left) and biological characters of the pathogen (right) are likely to produce a range of effects on different amphibian species and populations (centre). The range of outcomes progresses from: no infection in the presence of the pathogen (resistant species); through to presence of infected animals but no disease (aclinical infection); disease presence resulting in limited mortality; populations in which infection causes mass mortality, local extinctions and species extinctions. Following this model, chytridiomycosis appears to cause declines and extinctions in a select group of amphibians predisposed to heightened impact by certain life-history traits.



REPRODUCTIVE BIOLOGY

Spermatozoa from an Idmi gazelle; collected at KKWRC, Saudi Arabia

Genetic resource banking for gazelles

Freezing and storing spermatozoa with the aim of using it to combat inbreeding depression is growing in popularity, and a number of centres around the world have engaged in establishing Genetic Resource Banks (GRBs) for this purpose. However, to be useful the GRBs must be integrated into genetic management programmes.

Since 1994 we have been developing an integrated GRB programme for the Mohor gazelle in association with the Estación Experimental de Zonas Aridas, Almeria, south eastern Spain. This species has been extinct in its native environment, the western Sahara desert, since about 1971. The last 17 individuals were taken to the breeding and research centre in Almeria where they have been bred successfully. Some reintroduction has been also undertaken into protected areas in North Africa. However, the small number of founders from which this population was derived means that the risk of inbreeding depression is considerable.

Initially there was no information about semen collection, sperm structure or cryopreservation. This situation has now improved and we have begun to set up a bank of frozen semen that could be integrated into future breeding plans.

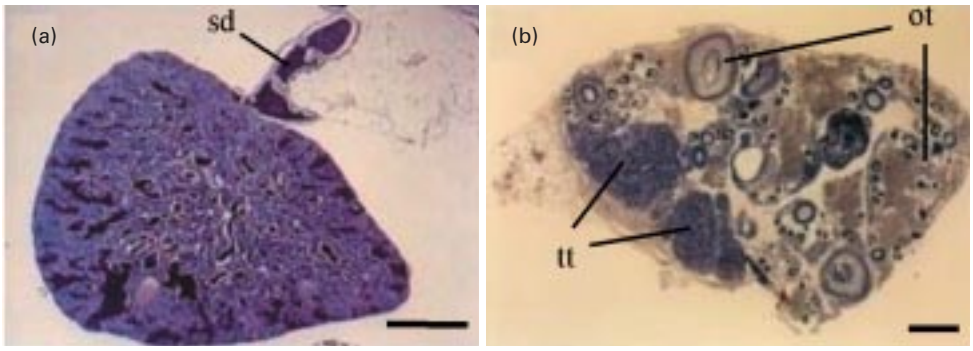
Developing robust insemination protocols presents a challenge and studying the endocrinology of such wild and highly nervous animals is difficult. Regular blood sampling is impossible, and therefore identifying oestrus or detecting pregnancy, become major problems. The experience gained with this species emphasized the need for integrated approaches to such projects, and the solutions are now being applied to similar projects aimed at supporting captive and reintroduced gazelle populations in Saudi Arabia at the King Khalid Wildlife Research Centre in Saudi Arabia.

Holt, W. V., Pickard, A. R., Abaigar, T. & Cano, M. (2002). Integrated approaches to the establishment of genetic resource banks for endangered gazelles. In the *Proceedings of 9th International Symposium on Spermatology*: 127–132. Van der Horst, G., Franken, D., Bornman, R., Bornman, T. & Dyer, S. (Eds). Bologna: Monduzzi Editore.

Sperm survival in the mammalian oviduct

The mammalian female reproductive tract possesses the ability to nurture and protect spermatozoa so that they can remain alive for several hours, days or even months. This ability ensures the presence of competent spermatozoa to meet the egg. In elucidating the dialogue between the oviduct and spermatozoa it might be possible to harness the mechanisms by which sperm are kept alive, thus enabling them to be stored and transported without freezing.

Our research on boars revealed that spermatozoa survived longer in the presence of cells cultured from the oviduct epithelium than those incubated with other cell types. This information indicated the presence of a factor associated with the oviductal epithelial cells, either secreted or forming part of the cell outer membrane, which interacted in some way with populations of spermatozoa. We isolated the plasma membranes of oviductal cells (that would normally be exposed to spermatozoa) and incubated them with spermatozoa. Sperm survival significantly improved. This effect was repeated regardless of the stage of reproductive cycle of donor sows from which the cells were harvested. As the stage of the cycle influences the type



(left) Histological (transverse) sections of (a) normal testis and (b) an intersex gonad from the wild freshwater gudgeon. Sd - sperm duct, ot - ovarian tissue and tt - testicular tissue. Bar represents 500 µm.

*(below) Percentage of motile sperm (a) and curvilinear velocity of sperm at various times after activation in water from male and intersex roach (b). Error bars represent SEM and *** (P<0.001) denotes significant differences between normal males and the intersex group. Group size was between 18 and 40 fish, except for the severely feminized group, which contained three fish.*

and level of hormonal secretions our findings suggest that the factor contributing to the maintenance of sperm viability forms part of the plasma membrane protein/lipid milieu. Further work suggested the factor to be protein in nature anchored to the cell surface. We previously found that the oviduct selectively binds only a subset of sperm by initiating a signalling dialogue, leading to the modulation of gene expression in the oviduct cells.

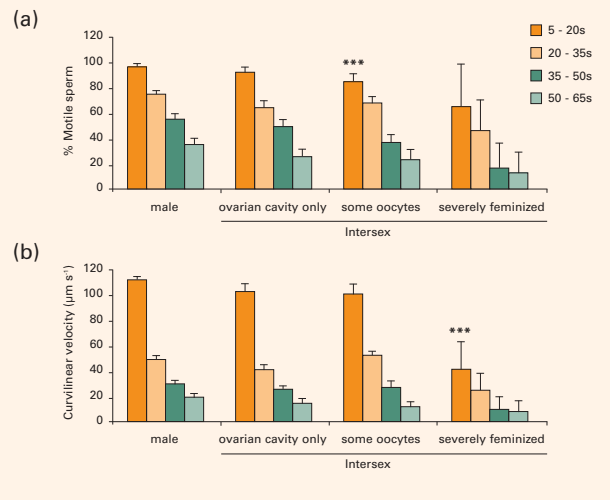
Whether the activity of the anchored protein(s) is directly linked to the gene expression seen or involved during the initial stages of sperm transport is yet to be determined. It is probable that the fertilizing spermatozoon is dependent upon binding to the isthmus of the oviduct for maintaining its viability and it is likely that the isthmic reservoir is the 'waiting room' where it will receive the signal to begin the journey towards the ovulated oocyte.

Fazeli, A., Elliott, R. M., Duncan, A. E., Moore, A., Watson, P. F. & Holt, W. V. (2003). In vitro maintenance of boar sperm viability by a soluble fraction obtained from oviductal apical plasma membrane preparations *Reproduction* **125**: 509–517.

Endocrine disrupting chemicals and fertility in intersex fish

Environmental contamination is posing an ever increasing threat. Of particular concern are endocrine disrupting chemicals (EDCs), which interfere with the reproductive endocrine system of animals. EDCs are believed to be responsible for a decrease in semen quality and increased incidences of testicular cancer and urogenital abnormalities in humans, inhibited reproductive potential of many species of fish, early foetal death in ring seals in Baltic waters and genital abnormalities in polar bears. As yet, however, there is limited evidence that endocrine disruption is the direct cause of reduced fertility in animals.

The majority of contaminants ultimately end up in rivers, lakes and oceans, and since fish may be continuously exposed, they are good indicators of toxicant levels in the environment. The reproductive endocrine system of fish is similar to that of other vertebrate species, and so effects of EDCs observed in fish may be extrapolated to other vertebrates and humans. In collaboration with Brunel, Exeter and Sri Krishnadevaraya (India) Universities, we have been researching the effect of endocrine disruption on roach.



In freshwater and estuarine fish species exposed to EDCs, a widespread incidence of intersex (the presence of an ovarian cavity or eggs within the testes) has been reported. In a previous study with Brunel University we examined the reproductive condition (analysing milt characteristics, fertilization success and numbers of viable offspring) of wild intersex roach in rivers receiving sewage treatment effluents around the UK. The roach is a good model species as they are one of the most widespread freshwater fish in the UK. The results of the study clearly demonstrated that gamete quality in intersex roach is significantly decreased compared to normal roach. Feminized (intersex) fish were less able to release milt than normal males from polluted rivers and intersex fish that did produce milt produced up to 50% less (volume per gram of testes weight) than normal males. Sperm motility (percentage of motile sperm and curvilinear velocity as analysed by computer-assisted sperm analysis on a Hobson sperm tracker) was significantly decreased in intersex roach and the intersex fish also had significantly reduced fertilization success and produced fewer viable offspring than normal fish.

Our study illustrates a direct relationship between morphological effects (intersex) of endocrine disruption and the reproductive capabilities of a vertebrate species. We are continuing to work on collaborative projects addressing the impacts of EDCs on reproduction, specifically sperm quality, and genetic damage in fish.

Jobling, S., Coey, S., Whitmore, J. G., Kime, D. E., Van Look, K. J. W., McAllister, B. G., Beresford, N., Henshaw, A. C., Brighty, G., Tyler, C. R. & Sumpter, J. P. (2002). Wild intersex roach (*Rutilus rutilus*) have reduced fertility. *Biology of Reproduction* **67**: 515–524.

WILD ANIMAL HEALTH & WELFARE

Gamma herpesviruses of artiodactyls

There is great interest in the ability of viruses to cause severe disease and death in certain species, whilst being carried without causing any clinical signs in other, related species. Herpes B virus is an example which may be fatal in humans, but causes few, if any, clinical signs in macaques. A similar example among hoofstock is malignant catarrhal fever (MCF), caused by one of two gamma herpesviruses: alcelaphine herpesvirus-1 (AlHV-1) of wildebeest or ovine herpesvirus-2 (OvHV-2) of domestic sheep. Infection with either virus causes severe illness with high mortality in cattle, deer and many species of exotic ruminants, but is carried sub-clinically by wildebeest and sheep.

Between 1998 and 2000, 103 individuals of 19 artiodactyl species at Whipsnade Wild Animal Park were tested for infection with gamma herpesviruses in order to distinguish between species which are susceptible to MCF, and species which carry related viruses sub-clinically. Gamma herpesvirus DNA was detected by a polymerase chain reaction in the known, or suspected, carrier species: roan antelope, scimitar-horned oryx, gemsbok, musk ox and mouflon. In six other species (lowland anoa, yak, sitatunga, greater kudu, waterbuck and Nile lechwe) it was present in some newborn calves and over 30% of adults, strongly suggesting a carrier state. In contrast five Père David's deer and two swamp deer died of MCF during the study.

Flach, E. J., Reid, H., Pow, I. & Klemt, A. (2002). Gamma herpesvirus carrier status of captive artiodactyls. *Research in Veterinary Science* **73**: 93–99.

Veterinary monitoring of scimitar-horned oryx for reintroduction

Formerly widespread throughout the arid grassland of the Sahel, the scimitar-horned oryx population has declined rapidly due to over-hunting, habitat loss and competition with domestic livestock. The species has been listed in CITES Appendix 1 since 1983 and is recognized as Extinct in the Wild (EW) in the IUCN Red List. A captive-breeding programme, started in the 1960s, has been highly successful, resulting in a secure captive population spread across several countries.

In March 1999, as part of the implementation of the Action Plan for the recovery programme of Sahelo-Saharan antelopes, 14 scimitar-horned oryx were sent from six participating European zoos to Sidi Toui National Park, in Southern Tunisia. We provided veterinary monitoring for the reintroduction with the aim of preventing disease transmission to and from the reintroduced animals and safeguarding the animals' welfare at all stages. This entailed directing and co-ordinating pre-export health assessments, monitoring the animals' health and welfare during transportation from Europe to Tunisia and the pre-release quarantine period, sedating animals for the fitting of radio-collars and performing post-release health checks.

All of the oryx were transported successfully and came through the quarantine period without significant problems. To date there have been no major health problems.

D'Altero, G. L., Flach, E. J. & Zahrah, K. (2002). Veterinary monitoring for re-introduction project scimitar-horned oryx (*Oryx dammah*) in Southern Tunisia. World Veterinary Congress. September 2002, Tunisia.

ZSL CONSERVATION PROGRAMMES

As we move forward with implementing ZSL's conservation mission it becomes important to develop collaborations among activities in the zoos, scientific research and field research to mutual benefit. The evidence is clear that the sum of this work is greater than the total of the individual parts. While different areas of ZSL's mission-driven work have different priorities, goals and customers, together we can achieve skill-sets and solve problems that few other organisations can tackle. During the year we have worked at developing the synergies across ZSL, and here we outline some current projects which contribute to ZSL's six field conservation programmes (see page 33).

(a) *The long-term demography of the Serengeti cheetah population.* The Serengeti Cheetah Project has monitored cheetah populations for over 25 years. As the only long-term project on wild cheetahs, it has made an invaluable contribution to our understanding of cheetah ecology. Cheetahs in the Serengeti occur at very low densities, range over large areas and suffer high mortality rates. The Serengeti ecosystem (over 25,000 sq. km) contains only around 250 adult cheetahs, compared to some 3000 lions and 9000 hyaenas.

(left to right) a, b, c, d, e, f

(b) *Rio Muni: evaluating incentives for sustainable hunting in tropical forests.* The hunting of wild animals for meat (bushmeat) is causing dramatic declines in many tropical species, such as gorillas. We are working in Equatorial Guinea to understand why overexploitation occurs, and to identify how it can most effectively be controlled.

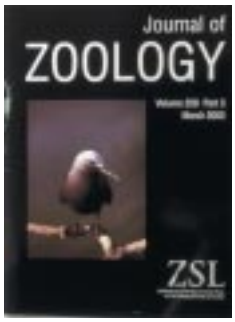
(c) *Development of a monitoring and training unit for the World Heritage Sites of the Democratic Republic of Congo (DRC).* DRC is one of the most biologically rich countries in the world, but its national parks are currently under threat from illegal poaching. We are studying the interaction between poachers and anti-poaching patrols, and the bushmeat trade which drives illegal poaching, in order to gain a better understanding of how to optimize park protection.

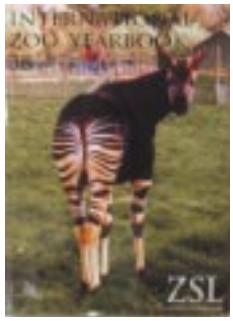
(d) *Epidemiology of parapoxvirus in squirrels.* The red squirrel population in the UK has suffered a severe decline over the last 100 years. There is increasing evidence that a parapoxvirus disease has played a role in the red squirrel's demise and that the introduced grey squirrel transmits the parapoxvirus to the red species. We are working with local conservation organisations to implement management plans to reduce this threat to its survival.

(e) *Darwin Initiative project on tackling disease risks to Galápagos wildlife.* Worldwide, endemic island fauna are at increasing risk from introduced diseases. We are working with several organisations to set up a wildlife pathology laboratory in the Galápagos to help identify and manage disease threats to the unique endemic biodiversity of the islands.

(f) *Conserving Darwin's fox on Chiloé Island, Chile.* This Darwin Initiative project aims to assist with the conservation of biodiversity in Chile, in particular, the critically endangered Darwin's fox. To this end we are assessing fox abundance, distribution and population substructure on Chiloé Island, and monitoring the threat to the species by feral dogs. We are establishing a long-term mammal monitoring programme using ecological and epidemiological methodology, and non-invasive population genetic techniques that can be applied to biodiversity monitoring across Chile.

COMMUNICATING SCIENCE



An essential part of ZSL's work is facilitating the communication of information between professional zoologists, researchers and the general public. We achieve this through a varied programme of meetings, which are open to the public and members of staff, and the publication of scientific journals and books.

Meetings

Our 2003 Stamford Raffles Lecture, *The contemporary experience of wild nature and its implications for conservation*, was given by Professor Steven Sanderson, President and Chief Executive Office of the Wildlife Conservation Society, New York, USA. This event was generously sponsored by the Singapore Tourism Board and Singapore Airlines, and we are grateful for their continuing support.

Regular Scientific Meetings were held throughout the year. At each one three speakers provide an overview of important research within a particular field. Meetings held covered a wide range of subjects, such as *India's vulture crisis*, *Marine predators and the wow factor: new technology, new insights* and *National Parks in the sea*.

In December we held a two-day international symposium with the Wildlife Conservation Society, on *People and wildlife: conflict or co-existence*. The event was organised by Rosie Woodroffe, Simon Thirgood and Alan Rabinowitz. Speakers gave examples of the impact of endangered species on human livelihoods and discussed possible management solutions to conserve these species. A second symposium held by ZSL, the Center for Applied Biodiversity and Conservation International, *Phylogeny and conservation*, was organised by Andy Purvis, John Gittleman and Thomas Brooks. With speakers from five continents, and case studies from a wide range of taxa and regions, this meeting was the first attempt to bring together the different uses of phylogenies in conservation. The Science for Conservation seminars comprised talks by invited speakers on subjects relevant to our research; for example, *Phylogenetic supertrees: new uses for old phylogenies*, *Information flow and foraging decisions in a bumble bee society* and *Challenges for forest conservation in Gabon, central Africa*.

Publications

The *Journal of Zoology*, ZSL's pre-eminent international journal dedicated to academic zoology, continues to receive increasing numbers of high-quality papers from top researchers. The journal promotes hypothesis-driven studies that are of interest to all readers of zoology, and provides comprehensive coverage of the latest research and developments.

ZSL's quarterly journal, *Animal Conservation*, provides a forum for rapid publication of rigorous empirical or theoretical studies relating to species and population biology. The journal brings together innovative research and ideas from evolutionary biology and ecology that contribute to the scientific basis of conservation biology.

The *Conservation Biology* book series, published in association with Cambridge University Press, includes internationally

significant advances in the science that underpins conservation biology. We aim to produce timely books which reflect our research interests and provide an important contribution to a particular field. The eighth book in the series, *Reproductive Science and Integrated Conservation*, edited by William Holt, Amanda Pickard, John Rodger and David Wildt, was published in 2003.

Volume 38 of the *International Zoo Yearbook* was published. The special section, Zoo Challenges: Past, Present and Future, includes 15 articles that address the changing role of zoos, concentrating on the fundamental responsibilities and problems facing modern zoological institutions. Areas covered include zoo-related genetic studies, reproductive technologies, education, environmental enrichment, welfare, husbandry and veterinary care. Section 2 comprises articles on a diverse range of topics, such as the birth of koalas following artificial insemination and food consumption, growth and food passage times in Pacific walrus. The reference section contains a list of Zoos and Aquariums of the World, a list of national and regional zoo associations and a register of international studbooks.

The *Zoological Record*, published jointly with BIOSIS, is the oldest continuous information service for the life sciences. As a record of all aspects of zoological research, it is considered the foremost publication in its field. The continued generous support of various institutions, principally the British Library Document Supply Centre at Boston Spa and the Natural History Museum, London, in providing access to material for indexing is gratefully acknowledged.

Scientific Awards

Outstanding achievements in scientific research and conservation are recognized through our annual presentation of awards. For 2002 the following awards were presented:

The ZSL Frink Medal for British Zoologists
Professor Michael Hassell, FRS, Imperial College of Science, Technology and Medicine, in recognition of his contribution to our understanding of insect population dynamics

The Scientific Medal
Dr Per Erik Ahlberg, Natural History Museum, for his work in the field of palaeontology and to Professor Laurence Daniel Hurst, University of Bath, for his contribution to our understanding of genomic conflict

The ZSL Marsh Award for Conservation Biology
Professor Callum Roberts, University of York, for his contribution to conservation biology

The Stamford Raffles Award
Dr Thomas Jones Roberts, for his contribution to our understanding of wildlife and conservation in South East Asia

The Thomas Henry Huxley Award
Dr Andrea Manica, University of Cambridge, for his thesis *Filial cannibalism in a sergeant damselfish*

The Prince Philip Prize
Kate Louise Honeybill, Ryeish Green School, Reading, for her essay *Do gerbils learn?*

Honorary Fellowship
Professor Robert McNeill Alexander, CBE, FRS, University of Leeds, in recognition of his contributions to zoological research and his longstanding support of ZSL and to Dr William Conway for his contribution to zoology and conservation

(above left) Scientific awards winners 2002

(above right) Speakers at the Phylogeny and conservation *symposium*

LIBRARY

An example of Brian Houghton Hodgson's drawings and notes held in the Library

Containing an estimated 200,000 volumes, ZSL's Wolfson Library continues to maintain its pre-eminence as the largest collection of books and serials on the subject of zoology and animal conservation in private ownership in the world.

The collections include books dating from the present back to the sixteenth century, 6,000 plus serial titles, archives of ZSL and historical photographs.

During 2002 the loans system was computerized and the number of loans increased, greatly enhancing our services. Details of almost all the pre-1860 books have been added to the computerized catalogue. The catalogue, now containing over 12,000 records, can be searched by Library visitors in the Reading Room and by staff via the intranet. Access to a number of online journals has also been provided for staff and visitors.

Interest in ZSL's archives has continued to increase with a variety of researchers visiting the Library, mainly to consult the Daily Occurrence books, the 19th century Council Minutes, Minutes of Scientific Meetings and correspondence collection. These vast archive collections are now being added to our computerized catalogue. There has been a steady stream of historical and genealogical enquiries throughout the year.

The Library continued to provide reference use to Friends of ZSL and members of the public. A special Behind the Scenes tour was held for library staff from the University of London and introductory tours are held for ZSL staff to enable them to make effective use of the Library's resources. Each month a list of newly acquired books is circulated by e-mail to ZSL staff and anyone expressing an interest. From 2003 lists of newly acquired books can be viewed on our website www.zsl.org

A display of Brian Houghton Hodgson's collection of drawings and notes on the animals of Nepal and India attracted a great deal of interest and gave us an opportunity to display some of the beautiful historical material held in the Library.

The Library staff participate in the wider world of libraries and archives by attending meetings and conferences of ASLIB Biosciences, Charity Archivists and Record Managers (CHARM), GLAS User Group and learned society librarians.

Michael Palmer, Archivist, was awarded the Michael Brambell Travel Award 2003 and intends to use this to visit the library and archives of the Wildlife Conservation Society, other archives and libraries in New York and to attend the conference of American Zoos Association in Columbus, Ohio.

EDUCATION & TRAINING

(from left) Paul Eden receiving the award for the student who obtained the highest marks on the MSc in Wild Animal Health course from Dr Michael Dixon, ZSL Director General; Catherine Gatome examining a white-backed vulture in Kenya

(right) Daisy Balogh

Education and training are central to the Institute's activities, with PhD studentships representing our principal means of teaching. However, this year also saw an increase in our commitment to Masters and undergraduate level education with the development of a new MSc course in Wild Animal Biology (in collaboration with the Royal Veterinary College) and an undergraduate course in Conservation Biology (in collaboration with University College London), both to be given for the first time in the 2003–2004 academic year.

In the 2002–2003 academic year 19 PhD students were registered in the Institute, of which seven started their course, and three were awarded PhD degrees (see page 32).

Our annual Student Conference was held in January and 13 students gave presentations on their work. Student projects span a wide range of taxonomic groups (from ants to elephants) and topics (from reproductive biology to the impact of CITES legislation on conservation efforts). The conference represents an opportunity for students to present their work in a relatively informal atmosphere, for them to gauge their progress against others in the same cohort, and for members of staff and university supervisors to learn about the diverse research undertaken by our students.

Our one hundredth graduate of the MSc course in Wild Animal Health passed in 2002 and the course continues to attract more applicants than we can cater for. Our graduates often take up key posts; last year graduates took positions as zoo veterinarians in Perth, Australia; Zurich, Switzerland, and Toronto, Canada. An important part of the course is a 4-month research project. Andrew Breed visited Australia to develop a laboratory test for hendra virus in flying foxes to determine how widespread exposure to the virus is in these species of bats. Hendra virus is known to infect and cause disease and mortality in humans and horses, and is one of a number of newly emerging paramyxoviruses associated with wildlife and of danger to humans. Gracia Vila Garcia worked with the marine mammal research group at the Institute to investigate the hypothesis that mammary development and pathology in harbour porpoises may be influenced by exposure to polychlorinated biphenyls (PCBs) with oestrogen mimetic properties. Catherine Wairimu Gatome visited Kenya to study free-living white backed vultures and to collect data on normal health parameters as an important first stage to monitoring the health status of this species.

It was with great sadness that we learned of the death of Daisy Balogh while attending a conference in Finland in September 2002. Daisy was a bright and able PhD student, a popular colleague and a treasured friend to many in the Institute. As a memorial, the best presentation at our Student Conference will be awarded the Daisy Balogh Prize. Our deepest sympathy is extended to her family and many friends.

GOVERNANCE, STAFF & STUDENTS

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Professor Michael Hassell FRS, Imperial College London
Professor Margaret Stanley PhD, University of Cambridge

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Peter Bennett PhD (Senior Research Fellow) Biodiversity and macroecology
Andrew Cunningham BVMS PhD MRCVS (Senior Research Fellow) Wildlife epidemiology
William Holt PhD (Senior Research Fellow) Reproductive biology
William Jordan PhD (Senior Research Fellow) Genetic variation, fitness and adaptability
Richard Pettifor DPhil (Senior Research Fellow) Population and community ecology

Postdoctoral Research Staff and Lecturers
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Marcel Cardillo PhD (Postdoctoral Research Assistant)
Sofia Consuegra del Olmo PhD (Postdoctoral Research Assistant)
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Zjef Pereboom PhD (Research Fellow) •
Amanda Pickard PhD (Research Fellow)
Sean Rands PhD (Postdoctoral Research Assistant)
Marcus Rowcliffe PhD (Research Fellow Teaching & Training)
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Stuart Semple PhD (Research Fellow) •
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Jinliang Wang PhD (Research Fellow)

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Becki Lawson MSc
Jackie Savery BSc MRes
Joanne Waller BA •

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Elizabeth Boakes MSc
Gina Caplen MSc
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Roselle Chapman MSc
Thomas Charman BA
Ben Collen MRes
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Rob Deaville BSc (Senior Technician)
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Katherine Holehouse BSc (Technician) •
Tracy Howard BSc (Senior Pathology Technician)
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Shaheed MacGregor Htec MSc FIBMS (Pathology Technician)
Neil McCulloch BSc (Technician) •
Matthew Perkins BSc (Pathology Technician)
Anna Randall MSc (Technician)
Lucy Warrell BSc (Technician) •
Laura Whyte BSc (Technician) •
Rod Zamora BSc (Technician) •

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Michael Bruford PhD
Roger Butlin PhD
Peter Daszak PhD
John Gittleman PhD
Rhys Green PhD
Rufus Johnstone PhD
Andy Purvis DPhil
Robert Simmons PhD
Paul Watson PhD BVetMed DSc MRCVS

SCIENTIFIC PUBLICATIONS AND MEETINGS

Scientific Books
Fiona Fisken BSc (Editor)
Peter Olney BSc DipEd CBiol FIBiol FLS (Editor)
Catherine Morris BA (Editorial Assistant)

Journals, Meetings and Scientific Awards
Linda DaVolls BA (Production Editor)
Patricia Manly (Senior Editorial Assistant)
Deborah Body MSc (Scientific Meetings and Awards Co-ordinator)

EDITORS *Journal of Zoology*
Ian Boyd PhD DSc
Juliet Clutton-Brock PhD DSc
Robert Elwood PhD
John Gittleman PhD
Tim Halliday MA DPhil
Philip Rainbow PhD DSc

EDITORS *Animal Conservation*
Michael Bruford PhD
Keith Crandall PhD
John Gittleman PhD
John Reynolds PhD
Robert Wayne PhD •

LIBRARY

Ann Sylph MSc MCLIP (Librarian)
Michael Palmer MA (Archivist)
Marie Monaghan BA (Assistant Librarian
Karen Nevard BA (Library Assistant)

Honorary Research Fellows 2002
Jonathan Baillie PhD
Sultana Bashir PhD MPhil
Mark Blackett PhD
George du Boulay CBE MB BSM FRCP DMRD
Julie Garnier PhD
Peter Kertesz BDS LDS
James Kirkwood BVSc PhD MRCVS FIBiol
Sean Rands PhD
Amanda Vincent PhD
Tim Wacher PhD
Stuart Williams PhD

Others working at the Institute, including volunteers working on projects in the field
Sophy Allen; Benjamin Alyoshkin; Jonathan Baillie; Sultana Bashir; David Bennett; Simon Bracey; Raffaella Cecchi; Zoe Cokeliss; Christina Connolly; Lyndsey Cox; Laura Crawford; Siobhan de Little; Olivier Devineau; Laura Dowsett; George Du Boulay; Boris Dzyuba; Yedra Feltrer Rambaud; Maria Garcia; Emily Goodman; Clare Haines; Nick Horrocks; Carrie Horton; Aerin Jacob; Mark Jordan; Mike Lawes; Javier Lopez-Vaamonde; Richard Merrill; Charles Mlingwa; Susie Molony; Magda Nassef; Romain Pizzi; Abigail Platt; Vibhu Prakash; Nilendran (Rez) Prathalingam; Eileen Raeside; Oscar Ramos Rodriguez; Janna Rist; Sherrylynn Rowe; Patricia Ruiz; Nana Satake; Ivana Schoepf; Conrad Schofield; Angela Schwarm; Lauren Southcott; Jade Spence; Seirian Sumner; Amber Teacher; Ivna Tomaskovic; Cristobal Urzua; Saskia van Gent; Elizabeth Vasey; Willa Veber; Briony Webb

• departures

The Institute Conference, October 2002

COLLABORATIONS

Anglia Polytechnic University Parasitology, social status and welfare of mara; Reproductive biology of the red panda
Antwerp Zoo (Belgium) Genome Resource Bank for the Okapi EEP
Applied Biomathematics (USA) Developing, assessing and using criteria for threatened species assessment

Babraham Institute Analysis of functionally distinct subpopulations in porcine ejaculates
BirdLife International Global biodiversity hotspots; Threatened species assessment
Bombay Natural History Society (India) Conservation of *Gyps* sp. vultures in India
Brigham Young University (USA) Species concepts and the selection of units for conservation management
British Trust for Ornithology Migration of Brent geese and management of goose conflict issues
Brunel University COMPRENDO Comparative Research on Endocrine Disruptors. Phylogenetic Approach and Common Principles focusing on Androgenic/Antiandrogenic Compounds; Reproductive biology of the red panda

Centre for Applied Biodiversity Sciences, Conservation International (USA) Global biodiversity hotspots; Developing, assessing and using criteria for threatened species assessment
Centre for Environment, Fisheries and Aquaculture Science (CEFAS) Cetacean strandings investigation; Endocrine disruption in harbour porpoise
Chinese Academy of Sciences (China) Phylogeography of giant pandas
CNRS, Gif sur Yvette (France) *Drosophila* Gabon project
Conservation Breeding Specialist Group (South Africa) Cheetah censusing
CSIRO Australian Animal Health Laboratory (Australia) Conservation of *Gyps* sp. vultures in India; Anthropogenic change and emerging zoonotic paramyxovirus

Department of Agriculture and Rural Development, Stormont Impact of the 2002 Phocine Distemper Virus epizootic on the UK seal population
Department of Agriculture for Northern Ireland, Veterinary Sciences Division Adenovirus infections of rodents
Department of Fisheries and Wildlife Habitat use of tigers in altered landscapes and monitoring of cryptic mammals
Desert Research Foundation of Namibia (Namibia) Tsaobis Baboon Project
Division of Natural Resources Feeding performance of African wild dog in relation to hunting group size and kleptoparasitism from spotted hyaenas
Durrell Wildlife Conservation Trust Spatial modelling of bushmeat in central Africa

Ecoscope Applied Ecologists Feeding performance of African wild dog in relation to hunting group size and kleptoparasitism from spotted hyaenas
English Nature Health surveillance for species recovery programmes
Estacion experimental de Zonas Aridas (Spain) Reproductive studies in gazelles
European Zoo Association (EAZA) Genetic management of group bred populations in conservation

Fauna and Flora International Habitat use of tigers in altered landscapes and monitoring of cryptic mammals
Fisheries Research Services MEP-2* locus in Atlantic salmon
Frankfurt Zoological Society (Germany) Demography of the cheetahs in the Serengeti; Serengeti Carnivore Census; Cheetah censusing

Harvard Medical School (USA) Anthropogenic change and emerging zoonotic paramyxovirus
Hungarian Academy of Sciences, Budapest (Hungary) Adenovirus infections of rodents

Institut Congolais pour la Conservation de la Nature (Democratic Republic of Congo) Darwin Initiative Congo World Heritage Sites Project
Institute for Animal Health, Pirbright Impact of the 2002 Phocine Distemper Virus epizootic on the UK seal population
Institute of Ecology Anthropogenic change and emerging zoonotic paramyxovirus
Institute of Vertebrate Biology, Academy of Sciences of the Czech Republic (Czech Republic) Genetic analysis and sperm competition in bitterling
IUCN (Switzerland) Developing criteria for threatened species assessment
IUCN African Rhino Specialist Group (AfRSG) (South Africa) Rhino horn fingerprinting

Kenya Wildlife Service (Kenya) Maasai Mara cheetah conservation programme; Black rhino monitoring and conservation
King Khalid Wildlife Research Centre (Saudi Arabia) Reproduction in Saudi Arabian gazelles

Leuser Development Programme (Indonesia) Habitat use of tigers in altered landscapes and monitoring of cryptic mammals

Macaulay Institute, Aberdeen Energetic constraints on animal ecology; Feeding performance of African wild dog in relation to hunting group size and kleptoparasitism from spotted hyaenas
Mammal Research Institute (South Africa) Feeding performance of African wild dog in relation to hunting group size and kleptoparasitism from spotted hyaenas
Marine Environmental Monitoring Impact of the 2002 Phocine Distemper Virus epizootic on the UK seal population; Cetacean strandings investigation
Marine Institute, Salmon Management Services Immune response genes of salmonid populations
Michigan State University (USA) Reproductive success in male hyenas
Moredun Research Institute, Edinburgh Parapox infections of squirrels

National Birds of Prey Trust Conservation of *Gyps* sp. vultures in India
National University of Ireland (Ireland) Immune response genes of salmonid populations
Natural History Museum Impact of the 2002 Phocine Distemper Virus epizootic on the UK seal population; Cetacean strandings investigation
NERC Centre for Ecology and Hydrology MEP-2* locus in Atlantic salmon
New South Wales Zoological Parks Board (Australia) Semen freezing in macropods
Norwegian Institute for Nature Research (Norway) Immune response genes of salmonid populations

Poultry and Diagnostic Research Centre (India) Conservation of *Gyps* sp. vultures in India
Princeton University (USA) Energetic constraints on animal ecology; Anthropogenic change and emerging zoonotic paramyxovirus; Developing criteria for threatened species assessment

Queensland Department of Environment and Heritage (Australia) Susceptibilities of species to human disturbance
Queensland Department of Primary Industries (Australia) Anthropogenic change and emerging zoonotic paramyxovirus

Rotterdam Zoo (The Netherlands) Reproductive biology of the red panda
Royal Society for the Prevention of Cruelty to Animals Wildlife Hospital, Norfolk Impact of the 2002 Phocine Distemper Virus epizootic on the UK seal population
Royal Society for the Protection of Birds Ecology and conservation of the great yellow bumble bee; Conservation of *Gyps* sp. vultures in India
Royal Veterinary College Enhancement of sperm cell survival by epididymal and oviduct epithelial cells; Cetacean strandings investigation; Investigating sperm survival after cryopreservation

Scottish Agricultural College Impact of the 2002 Phocine Distemper Virus epizootic on the UK seal population; Cetacean strandings investigation
Sea Mammal Research Unit, St Andrews Impact of the 2002 Phocine Distemper Virus epizootic on the UK seal population; Cetacean strandings investigation
Sheffield University Global biodiversity hotspots
Silsoe Research Institute Correlates of reproductive fitness in the short-tailed field vole; Ovulation prediction for pigs
Smithsonian Institution (USA) Habitat use of tigers in altered landscapes and monitoring of cryptic mammals
Smithsonian Tropical Research Institution (USA) Measuring abundance of tropical butterflies
Southern African Development Community Regional Programme for Rhino Conservation Bayesian mark-recapture population estimation

Sri Krishnadevaraya University (India) Effects of the pesticide, cypermethrin, on gametogenesis and gamete quality in zebrafish
Station d'Etudes des Gorilles et Chimpanzis, Lope Reserve (Gabon) Adaptive divergence in *Drosophila* along environmental gradients in Gabon
Sumatran Tiger Project Habitat use of tigers in altered landscapes and monitoring of cryptic mammals

Tanzania National Parks (Tanzania) Long term demography of the Serengeti cheetah population; Tanzania Carnivore Conservation Program; Serengeti Carnivore Census; Cheetah censusing
Tanzania Wildlife Research Institute (Tanzania) Long term demography of the Serengeti cheetah population; Tanzania Carnivore Conservation Program; Cheetah censusing
Tarangire Elephant Project (Tanzania) The Tanzania Carnivore Atlas Project
The Technikon, Pretoria (South Africa) Spoor counting methodologies for censusing carnivores in the Serengeti
Tiger Tops (Nepal) Habitat use of tigers in altered landscapes and monitoring of cryptic mammals
Trinity College Dublin (Ireland) Conservation genetics of island populations of bumble bee
Tsaobis Leopard Nature Park (Namibia) Tsaobis Baboon Project

UNESCO 'Conservation in Crisis' Programme Darwin Initiative Congo World Heritage Sites Project
Universidade de Vigo (Spain) Survival tools for endangered breeds of livestock
Universities Federation for Animal Welfare (UFAW) Cetacean strandings investigation
University of Bath Conservation management and ecological genetics of the black bog ant
University of Bergen (Norway) Assessment of gamete quality in Atlantic cod reared under different photoperiods
University of Berne (Switzerland) Microsatellite analysis of rabies affected Swiss red fox population in a fragmented landscape
University of Birmingham Global biodiversity hotspots
University of California at Berkeley (USA) Phylogeography and conservation genetics of Asian sika deer
University of California at Los Angeles (USA) Species concepts and the selection of units for conservation management; Phylogeography and conservation genetics of Asian sika deer
University of Cambridge Species concepts and the selection of units for conservation management; Genetic variation in UK harbour porpoises and their parasites; Habitat use of tigers in altered landscapes and monitoring of cryptic mammals; Energetic constraints on animal ecology; Tsaobis Baboon Project; Phylogeography and conservation genetics of Asian sika deer; Genetic analysis and management of captive breeding population; Optimisation and social constraints in group-living vertebrates; Ecology and conservation of the great yellow bumble bee; Sexual selection and signalling in chacma baboons; Epidemiological modelling of Phocine Distemper Virus; Predicting the susceptibilities of species to human disturbances; Functional response mechanisms in social foragers
University of Cambridge Veterinary School Reproductive biology of the red panda
University of Cardiff Conservation management and ecological genetics of the black bog ant; Phylogeography of giant pandas; Adaptive divergence in Drosophila in Gabon; Colony dynamics and the evolution of policing and reproductive skew in multiple-queen ants
University of Cork (Ireland) Cetacean strandings investigation
University of East Anglia Coexistence and sex ratios in a tropical ant-plant symbiosis; Harvesting, demography and dynamics of Malagasy chameleon populations
University of Edinburgh The role of domestic dogs and jackals for the disease transmission to endangered carnivores in southern Africa; Genetic analysis of hybridisation between red deer and sika deer in Argyll, Scotland; Polygenetic variation and response to directional selection; Adaptive divergence in *Drosophila* in Gabon; Infectious parasites in wild cheetahs
University of Exeter Xenobiotic-induced alterations in gene expression in the brain and gonad; Effects of the pesticide cypermethrin in gametognensis and gamete quality in zebrafish
University of Florida (USA) Habitat use of tigers in altered landscapes and monitoring of cryptic mammals; Modelling prey selection by cheetahs in the Serengeti
University of Ishinomaki (Japan) Phylogeography and conservation genetics of Asian sika deer
University of Kent, Durrell Institute for Conservation and Ecology Malagasy chameleon populations
University of Lausanne (Switzerland) Primary and secondary sex ratios in slave-making ants
University of Leeds Natural selection, assortative mating and gene flow in a grasshopper hybrid zone in northern Spain; Simulations of parapatric and marginal species boundaries
University of Liverpool Impact of the 2002 Phocine Distemper Virus epizootic on the UK seal population; Cetacean strandings investigation
University of London, Imperial College Threatening processes and the conservation status of contemporary mammals; Species and populations as units for conservation assessment and management; Global biodiversity hotspots; Evaluating incentives for the sustainable hunting of bushmeat; Predicting the susceptibilities of species to human disturbances
University of London, Queen Mary and Westfield College Genetic analysis and sperm competition in bitterling; Non-invasive monitoring of the reproductive cycle of fossa; Parapox infections in squirrels
University of London, University College Genetics of quantitative trait variation in *Drosophila*; *Drosophila* Gabon project; Conservation and foraging ecology of bumble bees; Demography and reproduction of elephants in Myanmar; Metapopulation dynamics of black and white colobus monkeys; Bushmeat in Democratic Republic of Congo; Dynamics of species extinctions
University of Malaya (Malaysia) Anthropogenic change and emerging zoonotic paramyxovirus
University of Minnesota (USA) Biocomplexity in the Serengeti ecosystem
University of Natal (South Africa) Costs of vigilance in a social forager
University of Oxford Influence of energetic constraints on animal ecology; Habitat use of tigers in altered landscapes and monitoring of cryptic mammals
University of Queensland (Australia) Semen freezing in macropods
University of Redlands (USA) Feeding performance of African wild dog in relation to hunting group size and kleptoparasitism from spotted hyaenas
University of Regensburg (Germany) Comparison of primary and secondary sex ratios in slave-making ants
University of Saskatchewan (Canada) Cetacean strandings investigation
University of St Andrews Disease and carnivore coexistence; Epidemiological modelling of Phocine Distemper Virus
University of Sussex Communication networks in African elephants
University of Tohoku (Japan) Simulations of parapatric and marginal species boundaries
University of Virginia (USA) Influence of energetic constraints on animal ecology; Threatening processes and the conservation status of contemporary mammals
University of Washington (USA) The Serengeti Carnivore Census
University of West of England Automatic ovulation prediction for pigs
University of York Habitat use of tigers in altered landscapes and monitoring of cryptic mammals

Veterinary Laboratories Agency Cetacean strandings investigation

Wageningen University (The Netherlands) Impact of aquaculture on the immune response genes of salmonid populations
White Oak Conservation Center (USA) Genome Resource Bank for the Okapi EEP
Wildfowl and Wetlands Trust Population viability analysis of Scottish geese
Wildlife Conservation Society (USA) Feeding performance of African wild dog in relation to hunting group size and kleptoparasitism from spotted hyaenas; Habitat use of tigers in altered landscapes and monitoring of cryptic mammals; Long-term demography of Serengeti cheetahs; Cheetah censusing

STAFF REPRESENTATION & PUBLICATIONS

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Animal Health Information Specialists (UK and Ireland) Ann Sylph (Member)
Animal Reproduction Science William Holt (Member, Editorial Board)
ASLIB Biosciences Group Ann Sylph (Newsletter Editor)

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British Veterinary Zoological Society Edmund Flach (Council Member)
Bushmeat Working Group Guy Cowlishaw (Member); Marcus Rowcliffe (Member)

Centre for Ecology and Evolution Georgina Mace (Member, Steering Committee); Jon Bridle (Member, Steering Committee; Co-editor, CEE Newsletter)
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Charity Archivists and Records Managers Group Michael Palmer (Member)
Cheetah Conservation Fund Sarah Durant (Member, International Scientific Advisory Board)
Consortium for Conservation Medicine, USA Andrew Cunningham (Associate Member)
CUP/ ZSL *Conservation Biology* book series Guy Cowlishaw (Series Editor)

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International Union for the Study of Social Insects Andrew Bourke (Member, WD Hamilton Award Committee; Treasurer, British Section)
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Journal of Zoology William Jordan (Consultant Editor)

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Reproduction William Holt (Member, Editorial Board)
Royal Society for the Protection of Birds Georgina Mace (Council Member)
Royal Society, Working Group on Biodiversity Georgina Mace (Member)

Society for Reproduction and Fertility Amanda Pickard (General Secretary)

The Sheep Trust William Holt (Trustee)

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Research strategy During 2003 we reviewed the research strategy. The earlier version, which was developed at the end of 2000, formed a sound basis for our work, but many internally and externally driven changes had rendered parts of it redundant. At the same time new opportunities had arisen, changes had occurred and successes had been achieved which needed to be reflected in a revised strategy.

A full version of the strategy is available on request. This table summarizes the main aspects of the strategy, and the way in which it is to be implemented with our partners and collaborators.

	Objective 1 To undertake relevant, high quality biological research and research training	Objective 2 To anticipate and respond to conservation research priorities identified by conservation organisations	Objective 3 To communicate outcomes and results to scientists, conservation practitioners and the wider community
Activities at the IoZ	HEFCE funded programme We undertake research and research training. Current themes are: • Behavioural ecology and evolution • Biodiversity and macroecology • Genetic variation, fitness and adaptability • Population and community ecology • Reproductive adaptation and management • Wildlife disease and epidemiology We provide training through MSc and PhD programmes		We run a programme of meetings and publications: • Conservation biology book series co-published with CUP • *Journal of Zoology* and *Animal Conservation* co-published with CUP • Annual programme of evening scientific meetings • Biannual international symposia on topical themes in conservation biology • Technical publications to support best practice in zoos (*International Zoo Yearbook*) and in field conservation (Conservation Reports)
with ZSL	We respond to research questions and contribute to ZSL's Conservation Programmes: • Bushmeat and forests • Carnivores and people • Deserts and Rangeland • Marine and Freshwater • UK Native species • Island ecosystems We respond to research questions and contribute to ZSL's living animal collection: • Animal Health and Welfare research • Reproductive monitoring		
with Cambridge University	We maintain and develop research links with Zoology and other relevant departments	Our research is influenced by organisations in the Cambridge Conservation Forum	We contribution to the Tropical Biology Association programme and Cambridge Student Conference
with institutions in London	We maintain and develop research links with academic bodies, especially the Centre for Ecology and Evolution We run MSc in Wild Animal Health and Wild Animal Biology with the Royal Veterinary College	Our research is influenced by London-based conservation issues	Our meetings facilities and programme of talks communicate science and conservation
with other organisations	Collaboration with most relevant outside bodies for core research interests	Research questions are influenced by our formal links with the Wildlife Conservation Society and English Nature	Our meetings facilities and programme of talks communicate science and conservation

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