ZSL

Institute of Zoology

LIVING CONSERVATION

Science for Conservation

Annual Report of the Institute of Zoology 2001/02

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

Contents

FOREWORD

This report covers work undertaken during the first year in which the Institute of Zoology has been affiliated with the University of Cambridge. Along with other members of the Joint Committee drawn from the University and the Zoological Society of London, I am very pleased to see the scientific successes that have been achieved, and the support that staff have received from funding bodies and collaborators both nationally and internationally.

The Institute is funded by HEFCE through Cambridge to develop as a national centre for conservation biology. This is a relatively new area of science, but one that is becoming of increasing interest and importance both to the public and to politicians. This report gives strong indications of how the unique set of collaborations arising from the new link can bear fruit and is likely to do so. I hope you enjoy the contents and share our view that the science in it is both topical and fascinating.

Professor Patrick Bateson

Chairman, University of Cambridge/Zoological Society of London Joint Committee; Department of Zoology, Cambridge

DIRECTOR'S INTRODUCTION

ZSL's Scientific Awards, left, the Stamford Raffles Award; right, the Scientific Medal

Introducing this report presents me with several challenges. Although we have kept to the same size, this year's report contains substantially more information than past issues have had to include. This is mainly because we present the outcomes from 19 months instead of the usual 12 months. The change of funding partner to the University of Cambridge in January 2001 means that we are now producing our annual reports on an academic rather than a calendar year, so this issue includes our work from January 2001 to July 2002. Next year we will be back on a 12-month cycle.

This has been a period of great change and of great activity in the Institute. In the pages that follow we try to present a synopsis of our work and point to the most exciting and rewarding science that our staff have been involved in. The science reports speak for themselves so here I outline some significant events that will have important consequences for us in the future.

Foremost among these must be our new partnership with Cambridge University. We are extremely fortunate to have the Zoology Department at Cambridge as our academic partners for HEFCE funding. We have enjoyed a stimulating and welcoming series of interactions with them as the partnership has developed. Professor Malcolm Burrows and his department, especially the Conservation Biology Group, have been more than generous with their time and ideas as we have sought to put substance on to the bare bones of the relationship that was agreed at the end of 2000. We now have a growing number of new joint projects, rapid growth in joint studentships and some novel and exciting projects that are now developing, which will I hope come to fruition in the next year.

At the same time, ZSL itself has been going through a period of change. The Director General, Dr Michael Dixon, has overseen a new structure for the Directorate, which clearly reflects the main activities of the Society in running zoos, doing science and undertaking conservation programmes. The new structure has greatly strengthened the synergies between the two zoos, and with the appointment of a new Director for Conservation Programmes, has allowed us to identify cross-cutting conservation activities to which all areas of the Society contribute. These changes have already had major benefits for the way that the Institute interacts with the rest of the Society, and these first positive steps will I believe continue to develop, and will ultimately substantially improve our ability to deliver our mission.

As a result of this reorganisation, other aspects of the Society's work now fall clearly under the science area within the Society. We are delighted to have the Scientific Publications and Meetings Department, the Library, and the Scientific Awards working alongside the research work of the Institute. You will find reports from these departments also in this edition of our annual report.

Amidst all this change, Institute staff have continued to undertake innovative and important scientific work, to publish widely and to participate in a variety of national and international activities. The details follow, and I hope you will enjoy reading about our work, and will contact me for any further information or with any queries or comments.

Georgina Mace

NEWS & EVENTS

Left to right, a, b, c, d

The Higher Education Funding Council for England (HEFCE), from whom we receive core funding, assesses the performance of university departments and research institutes by a periodic Research Assessment Exercise (RAE). The 2001 RAE was similar to that held in 1996, and comprised a systematic review of the research outputs of staff members. We entered voluntarily, as we did in 1996, by submitting our work to the Biological Sciences panel. We were awarded a grade 4, which indicates that the panel considered all the research submitted as being of at least national quality, with some being of international quality. While we were pleased with this result, our goal is to achieve at least a grade 5 in the next similar assessment.

One of the ways that the RAE assesses quality is through the status of individual members of staff, and other external measures of success. So we are pleased to report a number of independent awards and prizes during the period. Georgina Mace was elected to Fellowship of the Royal Society in 2002, in recognition of her work in conservation biology. Her work defining methods of classifying threatened species was also rewarded by the Society for Conservation Biology, who awarded her their Distinguished Service Award for Individuals in Academia, presented at their 2002 Annual Meeting. Two staff were awarded individual research fellowships. Matthew Fisher (a) was awarded a Wellcome Trust Research Training Fellowship for his work on the population genetics and biology of emerging opportunistic pathogens, and Guy Cowlishaw (b) was awarded a NERC Advanced Fellowship for work on the dynamics of species extinction.

Our students have also been successful in external competitions. Susie Paisley won the prize for the best talk at the Cambridge Student Conference in Conservation Science in 2001, and Roselle Chapman won a prize in the poster competition at the same event in 2002. Roselle also won a best talk prize at the Postgraduate Seminar day at University College London. Steven Rossiter, who was a PhD student at the Institute, was the 2001 winner of the ZSL Thomas Henry Huxley Award (c), for the best PhD thesis.

Staff were also responsible for some significant published output. Sarah Durant, Christine Müeller and Chris Carbone all authored papers in *Nature* or *Science* (see pages 31, 32 and 33). Peter Bennett and Ian Owens co-authored a monograph on the *Evolutionary Ecology of Birds* which was published by Oxford University Press to critical acclaim. Several staff also co-edited books in the CUP/ZSL series (see page 22) and Bill Holt's edited volume on *Cryobanking the Genetic Resource* was published in 2001.

As usual there were several VIP visits. Most notable were visits from Sir Dominic Cadbury, Chairman of the Wellcome Trust, who visited the Wellcome Building to see the wildlife disease work, and Professor Abdulaziz Abuzinada (d), head of the National Commission for Wildlife Conservation and Development in Saudi Arabia, who came to see the scientific work that supports ZSL's management of the wildlife centre at Thumamah, Saudi Arabia.

Finally, thanks to some hard work by Simon Goodman we have a comprehensive and regularly updated web site which records research opportunities, news, events and project progress (see **www.zoo.cam.ac.uk/ioz/index.htm**).

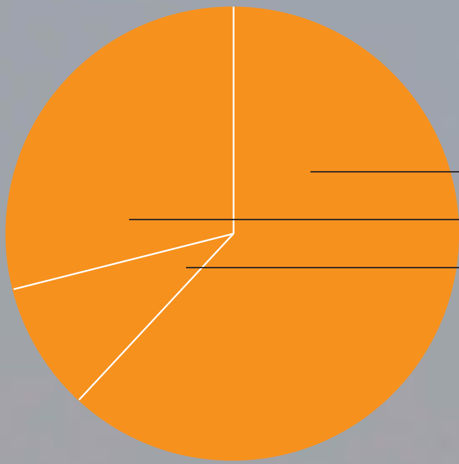
FUNDING

As usual our core funding came from HEFCE, but during the period 29% of our income came from other grants gained in open competition. Overall we received 45 grants with a total value of £1,266,026.

This was a successful period for funding from the Natural Environment Research Council. Andrew Bourke and Bill Jordan were awarded £269,000 for their project on kinship and information in reproductive conflicts on the bumble bee, Georgina Mace and Andy Purvis (Imperial College) were awarded £175,000 for a project to identify causal processes in mammalian threat, and Peter Bennett was a member of a five-institution wide consortium that was awarded £750,000 to study the evolutionary and ecological factors underlying hotspots of global bird diversity.

In both years we were awarded two grants under the government's Darwin Initiative for the Survival of Species (through DEFRA). Andrew Cunningham received funding to investigate and design recovery plans for vulture species undergoing severe declines in India. The project is in collaboration with the Royal Society for the Protection of Birds (RSPB), the Bombay Natural History Society and the National Bird of Prey Centre. Already much work has been done in establishing a diagnostic laboratory in India and holding *in situ* training workshops. Guy Cowlishaw's project was for a monitoring and training programme for the five world heritage sites in the Democratic Republic of Congo. This supports ongoing practical conservation by establishing management systems to maximise protection and developing Congolese staff capacity in this key area for biodiversity.

The Darwin Initiative funded two additional projects in 2002. Sarah Durant received £192,000 over 3 years to create a national plan for carnivore conservation in Tanzania in collaboration with the Tanzania Wildlife Institute. In the final year of the project a carnivore conservation action plan for the country will be produced. Stephan Funk also has funding for carnivore conservation; this time for the Darwin's fox on Chiloe Island, Chile. The project funds collaboration with zoologists at the Universidad Los Lagos, Chile, to undertake ecological and population genetic studies and to investigate the significance of threats such as disease to this poorly known and highly endangered species.



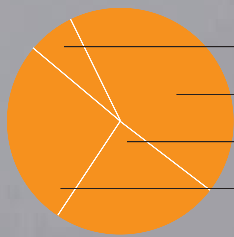
Institute of Zoology Income 2001/02
19 months, 1 January 2001 - 31 July 2002

Core Grant £2,709,567

Research Grants & Contracts £1,266,026

Other Income £399,589

Total Income £4,375,182



Research Grants & Contracts

European Union £83,851

Government bodies £540,240

Research Councils £302,918

Other Organisations £339,017

Funding organisations

Association for the Study of Animal Behaviour
Biotechnological and Biological Sciences Research Council
British Andrology Society
British Council
British Ecological Society
Chester Zoo (North of England Zoological Society)
Conservation International, USA
Darwin Initiative
Department for Environment, Food and Rural Affairs
Department for the Environment, Transport and the Regions
Economic and Social Research Council
English Nature
Estacion Experimental de Zonas Áridas, Spain
European Union
Frankfurt Zoological Society, Germany
Genus ABS
International Cheetah Conservation Foundation, Namibia
Japanese Society for the Promotion of Science, Japan
Joint Nature Conservation Committee
Kings College
Leverhulme Trust
LTS International Limited
Ministry of Agriculture, Fisheries and Food
National Institutes of Health, USA
Natural Environment Research Council
Oxford University Press
Peoples Trust for Endangered Species
Reproduction
Royal Society
Royal Society for the Protection of Birds
Scorer Associates
Smithsonian Institution, USA
Society of Reproduction and Fertility
Swiss Rabies Centre
Sygen International
The Wellcome Trust
University College London
Wild Conservation Society (WCS), USA
World Conservation Union (IUCN)
World Wildlife Fund UK
XY Inc.

RESEARCH STRATEGY

In the following pages our work is presented in the thematic areas in which research is now organised. The development of our research strategy began in 2000, and is a continuing process in which we evaluate our relative strengths, the funding environment, key developments in conservation biology, developments in ZSL and at Cambridge, and the core scientific areas that we must nurture in order to maintain scientific excellence. Over the past 2 years we have been especially influenced by the growth and re-definition of conservation programmes within ZSL, and by projects forged with our academic funding partners in Cambridge.

Each of the seven themes is headed by a Senior Research Fellow, who oversees the area of work within the Institute, and reports on activities to a monthly research committee meeting. Within themes, research is organised in projects, each led by a research fellow. All projects are registered and have stated aims, defined collaborators and funding sources, and start and finish dates. At any time there may be over 80 projects running, with some themes containing many more than others. We have found this system to be effective in stimulating collaboration among staff and between buildings, since many research staff work on projects in two or more thematic areas. Our weekly seminar series and research talk series are also cross-cutting and are aimed at stimulating discussion and providing a learning environment for our students and young postdoctoral staff.

Our strategy is summarised in the following table. Although we are a relatively small research institute we believe that our work is characterised by the collaborative framework in which we operate. We can only achieve our goals by active participation and nurturing of this network which includes our closest colleagues in ZSL, at Cambridge and in London, and extends to the wide variety of national and international collaborators that are detailed on pages 28 and 29.

Scientific work at the Institute of Zoology underpins the design of actions to conserve animal species and their habitats

	Objective 1	Objective 2	Objective 3
	To undertake relevant, high-quality biological research.	To respond to research priorities identified by conservation practitioners	To communicate outcomes to scientists, conservation practitioners and the wider community
Institute of Zoology	We undertake relevant, highest-quality research responding to priorities identified by conservation practitioners in our key thematic areas: • Wild animal health and welfare • Reproductive biology • Genetic variation, fitness and adaptability • Behavioural and evolutionary ecology • Population and community ecology • Wildlife disease and epidemiology • Biodiversity and macroecology		We communicate significant outcomes through scientific publications
with ZSL	We undertake collaborative projects in zoos and our work supports ZSL conservation programmes	We address research questions raised by field projects and conservation breeding programmes	We run a programme of scientific publications and meetings
with Cambridge University	We undertake collaborative research with the University, especially Zoology Department	We develop research links especially through the Cambridge Conservation Forum	We undertake teaching and training, including via the Tropical Biology Association, Cambridge University and other postgraduate students
with London institutions	We undertake collaborative research via the Centre for Ecology and Evolution, the Royal Veterinary College, and others	We work with a network of institutions with interests in conservation biology, including NGOs, media and relevant GOs	We undertake teaching and training at London University (UCL, RVC)

Body size, prey availability and population density in carnivores

Numerous studies have found that the population densities of individual species of carnivores are linked to the densities of their most common prey. However, few studies have examined how different species of carnivores respond to variation in prey abundance across a range of species. We formulated a way of examining carnivore abundance across species by comparing carnivore population density in relation to prey biomass (prey population size x prey weight). Our analysis shows that despite the great diversity among carnivores in size, social structure and prey type, their abundance changes consistently in relation to their body weight and the amount of prey needed to support them. We find that regardless of the species of predator or prey, approximately 10,000 kg of prey supports 90 kg of predator. Thus, this amount of prey could support 90 individual 1kg mongooses or one 90 kg jaguar.

Animal population density is usually associated with body size because energetic needs are related to size - big animals require more resources and so are found at lower density. At the same time it is known from studies on single species, that population density is related to the abundance of food resources and more food-rich habitats support bigger populations. While it is known that size and food availability affect population sizes, this study has been one of the first to examine size and food richness across a range of species.

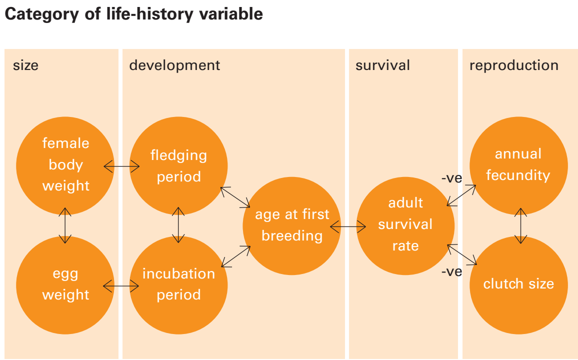
Animal abundance is important for understanding the structure of animal communities, measuring biodiversity and is critical for conservation. An understanding of animal abundance aids the management of both wild and domestic animal populations. Our predictions may help scientists to calculate the population sizes of carnivores and provide vital baseline information on poorly studied, endangered species. This information may also be used to identify suitable areas for re-introduction or to assess the impact of harvesting wildlife on natural predators. This approach could be used to identify other key factors affecting population decline in carnivores. For example, species such as African wild dogs and lynx may have unusually low population densities because of poaching, other forms of persecution or predation.

Carbone C & Gittleman J L (2002). A common rule for the scaling of carnivore density. *Science* 295: 2273-2276.

Carbone C, Christie S, Conforti K, Coulson T, Franklin N, Ginsberg J R, Griffiths M, Holden J, Kawanishi K, Kinnaird M, Laidlaw R, Lynam A, MacDonald D W, Martyr D, McDougal C, Nath L, O'Brien T, Seidensticker J, Smith J L D, Sunquist M, Tilson R & Wan Shahruddin W N (2001). The use of photographic rates to estimate densities of tigers and other cryptic mammals. *Animal Conservation* 4: 75-79.

Immune system evolution in primates

The extent to which inter-specific variation in the immune system reflects evolutionary adaptation to socio-ecological factors remains poorly understood. However, many studies have identified social and ecological correlates of parasite abundance and disease prevalence that would be predicted to play a role in shaping the evolution of the immune system. We examined variation in a key component of the immune system (baseline leucocyte concentration) among 33 anthropoid primate species to test whether immune defences in this clade show adaptation to socio-ecological



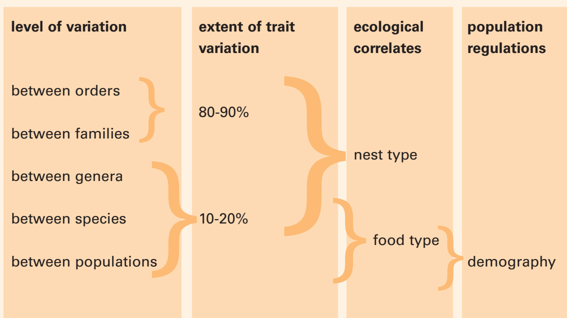
Core life-history inter-relationships among birds. Arrows indicate the presence of significant independent covariance between life-history traits among ancient avian lineages (families and orders) as revealed by multivariate regression analyses. All the associations between measures of size, development and survival are positive. The only significant negative correlations are between measures of reproductive effort and adult survival rate (-ve).

parameters. We found evidence that the risk of disease infection from the environment is important in immune system evolution: concentrations of lymphocytes and phagocytes (which are primarily involved in immune recognition, and defence against micro-organism and macro-parasite infection, respectively) were positively correlated with annual rainfall. This is as would be predicted if interspecific variation in the immune system is related to parasite prevalence since primates suffer higher rates of parasitism in wetter habitats. We also found evidence that the risk of injury and subsequent infection is important in shaping immune defences: concentrations of platelets (the cells primarily involved in blood clotting and inflammation) were negatively related to body mass, as predicted if injury risk affects immune system evolution, since animals with larger body mass have a relatively lower surface area available to injury. In addition, for males, the sex which plays the active role in troop defence and retaliation against predators, concentration of platelets was positively correlated with rate of predation. In conclusion, our analysis suggests that the risk of disease infection from the environment and the risk of injury have played a key role in immune system evolution among anthropoid primates.

Semple S, Cowlishaw G & Bennett P M (2002). Immume system evolution among anthropoid primates: parasites, injury risk and predators. *Proceedings of the Royal Society of London Series B* 269: 1031-1037.

Hierarchical explanations of diversity in birds

Why do life histories and mating systems vary so extensively across bird species? We investigated this question by analysing a database of some 3000 species. We found that the greatest diversity in life-history traits among living birds evolved among their ancient ancestors, probably over 40 million years ago. Furthermore, we found a robust pattern of core inter-related traits that evolved among those ancient lineages. Measures of body size, growth and survival rates are positively correlated with each other, but survival is negatively correlated with measures of fecundity. This variation among ancient avian lineages in the core relationships between life-history traits is correlated with variation in an ecological trait - nesting habit. It is not, however, associated with foraging habits, diet or developmental mode, despite the popularity of these explanations for avian life-history diversity. We show that the evolution of hole- or colony-nesting by ancient birds was associated with greater egg and chick survival, slower growth rates and delayed breeding in comparison to open nesting families. The ecological conditions that favour delayed breeding, and its consequences for increased adult survival and reduced reproductive effort, are those where the chances of nest failure are low. Our hierarchical comparative approach has shown that ancient ecological diversification in nesting habit can explain complex patterns of life-history diversity among living birds. Other explanations, such as food limitation or demographic variation, help to explain the relatively small proportion of life-history variation located at the levels of between species and populations. This hierarchical approach has also helped to demonstrate how variation in mating systems among birds has evolved through a combination of evolutionary predisposition and ecological facilitation. This work shows that to explain the adaptive radiation of birds, we must examine both their evolutionary history and current ecological relations in a hierarchical framework.

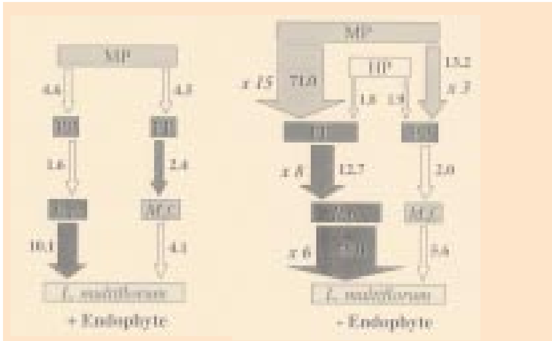


Hierarchical view of life-history variation in birds as revealed by the comparative approach

Bennett P M & Owens I P F (2002). *Evolutionary Ecology of Birds: Life histories, Mating Systems and Extinction.* Oxford: Oxford University Press.

POPULATION & COMMUNITY ECOLOGY

Consumer food chains on infected (left) and uninfected (right) grasses (Lolium multiflorum). *Two species of aphids,* Rhopalosiphon padi *(R.p.) and* Metopolophium festucae *(M.f.) colonised the experimental plots. Numbers refer to the interaction strength between the different components of the food web. PP refers to primary parasitoid; MP to mummy parasitoid and HP to hyperparasitoid. The latter two are secondary parasitoids that consume either the primary parasitoid or each other.*



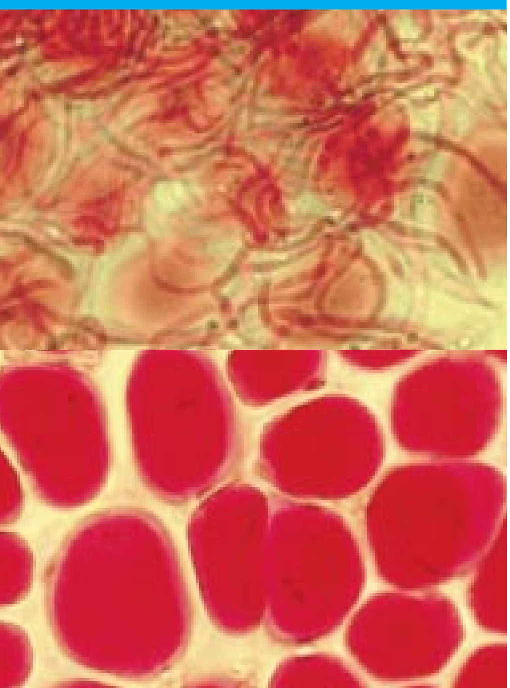
Control of food webs by symbiotic microbes

A central problem in ecology is to understand how animal populations or whole, interacting communities are limited by their food supply and by their natural enemies. There is consensus that an inter-play between the two forces controls the structure of food webs.

We addressed whether symbiotic microbes that live within the food plant could also have community-wide effects on the consumers of such a resource. We used the system of fungal endophytes that form mostly mutualistic associations with a variety of grass species. The fungal hyphae grow between the cells of the host plant tissue, causing asymptomatic infections that are transmitted exclusively through the plant seeds. This is an intimate association in which both parties gain advantages. Endophytic fungi obtain nutrients from their host plants, while infected plants may gain protection from insect herbivores or vertebrate grazers via the toxic and deterrent effects of alkaloids synthesised by the fungus. To study the effects on a whole community living on such plants, we quantified the strength of interaction between aphids that consume such plants and their parasitoid community. These parasitoids consist of primary parasitoids attacking aphids, and secondary parasites consuming primary parasitoids.

In an experiment on small monocultures of either infected or uninfected *Lolium multiflorum* patches, we showed that the grass endophytes limit the energy supply through the insect food chain and thus affect interactions at higher consumer levels as a result of lower plant quality, rather than lower plant productivity. Herbivore-parasitoid webs on endophyte-free grasses showed an enhanced insect abundance, increased parasitoid species richness, higher rates of parasitism, all of which led to uneven trophic links. Symbiotic microbes can exert regulatory structuring forces for food web dynamics but they have been mainly overlooked in the past because of their hidden life style.

Omacini M, Chaneton, E J, Ghersa C M & Müller C B (2001). Symbiotic fungal endophytes control insect host-parasite interaction webs. *Nature* 409: 78-81.



The aleuron cell layer of (top) endophyte infected and (bottom) uninfected grass seeds in the study of symbiotic microbes.

Depletion of algal beds by geese

The depletion and renewal rates of food resources are key determinants of movement patterns in animal populations. If we can understand the drivers of these processes, it becomes possible to build models that allow us to predict the responses of animals to changes in conditions. This study describes the successful application of one such depletion model, describing the interaction between migratory Brent geese, and intertidal green algae on the east coast of England. In order to investigate the determinants of algal availability for the geese, we combined studies of goose behaviour with monitoring of changes in algal biomass in relation to environmental conditions. The results indicated that the food intake rate of the geese was strongly related to

algal availability, that goose grazing had no long-term effect on the algae, and that in the absence of grazing, algal biomass declined over the course of the winter at a rate determined by the strength of onshore winds.

Armed with this understanding, we were able to construct a model simulating patterns of algal depletion over time. Since the geese prefer intertidal habitats, and switch to feeding inland when these are no longer profitable, an accurate simulation of depletion allows us to predict when geese will switch inland for a given set of population and environmental conditions. Geese can cause financial losses to farmers when feeding on crops, and this is locally an important wildlife conflict issue. The ability to predict the duration and intensity of inland feeding is therefore a useful aid in the search for management solutions that minimise the conflict. We found that the depletion model was extremely good at predicting the timing of switches to inland feeding in 6 years for which the information was available. In the 1950s when the goose population was ten times smaller than at present, the switch did not take place until late winter. In contrast, in more recent years the switch occurred between late October and early December, depending on the extent of autumn storms.

Rowcliffe J M, Watkinson A R, Sutherland W J & Vickery J A (2001). The depletion of algal beds by geese: a predictive model and test. *Oecologia* 127: 361-371.

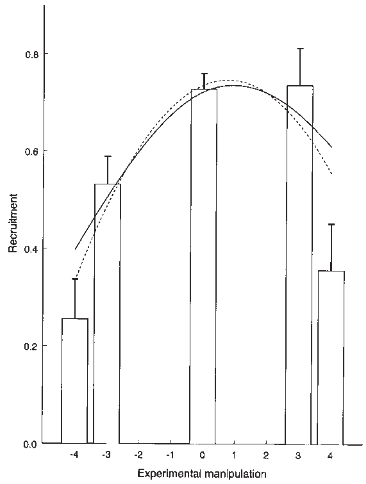
Variation in clutch size in birds

In many bird species there is variation in clutch size among individuals within a population. Females rearing the larger clutches tend to be more successful than those with smaller ones in terms of the number of offspring that survive to breed (recruits). Two hypotheses have been put forward to explain variation in clutch-size between individuals within years, namely the Individual Optimisation Hypothesis (IOH) and the Cost of Reproduction (COR). Earlier papers provided experimental evidence for the IOH; individuals were laying the size of clutch that maximised their fitness. However, the evidence for future survival or fecundity cost amongst parents rearing larger broods was mixed; while such CORs were seen in collared flycatchers, there was no such effect apparent in great tits.

We revisited the original data and added new data from further experimental years. The IOH was supported by our analysis of great tits. In addition, we made use of recent developments in multi-state capture-recapture models, applying this statistical approach to both sets of data to test the predictions of the COR. The manipulation of reproductive effort (e.g. brood size manipulation) may alter not only life-history traits, such as future adult survival rate and future reproductive effort, but also behavioural decisions affecting recapture/resighting and dispersal probabilities. The inclusion of state-dependent decisions can radically alter the conclusions drawn regarding the costs of reproduction on future survival or reproductive investment. We focused on possible changes in four different life-history and behavioural traits following manipulation of current reproductive effort: (1) survival rate, (2) capture probability, (3) future reproductive effort and (4) dispersal rate. We were unable to find any evidence for the existence of costs of reproduction on survival or future reproductive investment, nor did we find a clear effect of clutch/brood size manipulation on capture and dispersal probabilities. Furthermore, in female flycatchers, the previously observed pattern in survival could in fact be explained by differential dispersal probability between females of different groups.

Doligez B, Clobert J, Pettifor R A, Rowcliffe J M, Gustafsson L, Perrins C M & McCleery R H (2002). Costs of reproduction: assessing responses to brood size manipulation on life-history and behavioural traits using multi-state capture-recapture models. *Journal of Applied Statistics* 29: 407-423

Pettifor R A, Perrins C M & McCleery R H (2001). The individual optimisation of fitness: - Variation in reproductive output, including clutch-size, mean nestling mass and offspring recruitment, in manipulated broods of great tits *(Parus major)*. *Journal of Animal Ecology* 70: 1-18.



The means of the observed recruitment per nest in great tits fitted against experimental manipulation (histogram + SE) and the fitted polynomial (dotted line) and a spinal fit to the raw data (dotted line).

BEHAVIOURAL & EVOLUTIONARY ECOLOGY

Lek-breeding topi antelopes

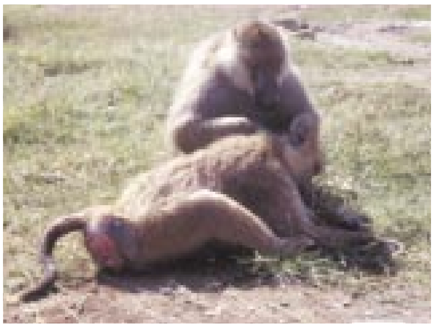
A study on topi antelopes in the Maasai Mara National Reserve, Kenya, investigated their unusual lek-breeding behaviour. Among mammals, the habit of mating in aggregations on traditional arenas or leks, is only found in a few species of antelope and deer. Why this unusual mating system has evolved has been the subject of intense debate. Existing ideas suggest that females visit leks because they benefit directly either from protection by lekking males against harassment by males off the lek, or from low predation risk, or from improved availability of scarce nutrients. However, our study found that female topi compete aggressively for matings with

preferred males on central lek territories. Females even actively interfere with the matings of other females, and this is more likely to happen in the centre of the lek than elsewhere. Levels of harassment and the estimated risks of predation were higher for females on the lek than for those outside it. Food resources on the lek appeared insignificant. These findings failed to support previous hypotheses for lek visits by females. Instead, by showing that females compete for particular males, they demonstrate that females choose among males and derive indirect benefits from being fertilized by their preferred partners. This represents an unusual demonstration of female mate choice for indirect benefits in mammals and suggests that leks evolve for similar reasons in mammals as in birds. The study also highlights potential problems faced by topi in the wild. Even in topi, leks are rare phenomena and the behaviour is increasingly under threat from cattle grazing within the Maasai Mara National Reserve.

Bro-Jørgensen J (2002). Overt female mate competition and preference for central males in a lekking antelope. *Proceedings of the National Academy of Sciences, U.S.A.* 99: 9290-9293.

Social intelligence in elephants

Despite widespread interest in the evolution of social intelligence, little is known about how wild animals acquire and store information about social companions, or whether individuals derive benefits from possessing enhanced social knowledge. Elephants, because of their large brains and complicated social systems, are particularly intriguing in this respect. With scientists from the University of Sussex and the Amboseli Elephant Research Project, we used audio playback experiments on African elephants to examine how well different families recognised individuals that were



not part of their family units. We found that elephant groups reacted differently to playbacks depending on how familiar they were with the calling elephant. When elephants heard complete strangers, the adults clustered around their young; whilst familiar calls were ignored. However there was great variation in responses between different groups; some groups were better at discriminating friend from foe than others. On closer analysis, we found that there was a significant correlation between the age of the oldest female or matriarch and the group's discriminatory ability. Superior discriminatory abilities appeared to contribute to a higher per capita reproductive success experienced by families with older matriarchs during the period of the study.

These results demonstrate that ageing and experience may influence reproductive success through their effect on the acquisition of social knowledge. Furthermore, the possession of enhanced discriminatory abilities by the oldest individual in a group of advanced social mammals, such as elephants, can influence the social knowledge of the group as a whole. These findings have important implications for conservation as well as evolutionary biology. In many mammal societies the oldest individuals are also the largest and these tend to be particular targets of hunters and poachers. If family groups rely on these individuals for their store of social knowledge then whole populations may be affected by the removal of a few key individuals. In elephants in particular, tusk size is related to age and hunters focus their efforts on individuals that have large tusks. In view of these results it is clear that the removal of matriarchs from elephant family units could have serious consequences for the conservation of this endangered species.

McComb K, Moss C, Durant S M, Baker L & Sayialel S (2001). Matriarchs as repositories of social knowledge in African elephants. *Science* 292: 491-494.

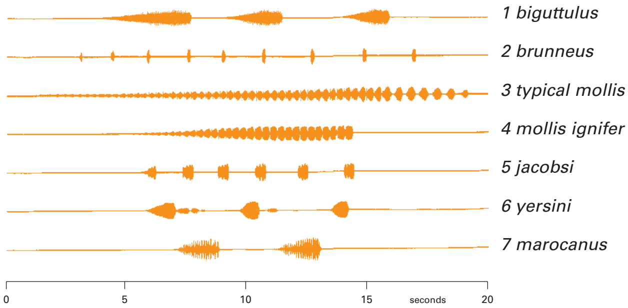
Copulation calls in female yellow baboons

In a wide variety of animal species, females vocalise just before, during or immediately after they mate. These vocalisations, or 'copulation calls', are particularly common among primates and evidence is now accumulating that by calling, a female incites males in her group to compete amongst themselves for the opportunity to mate with her. In a recent study of female copulation calls of yellow baboons in Kenya, we looked in more detail at these calls, in order to examine what sort of information they might contain. Over 500 copulation calls were recorded from seven different females, and their acoustic structure was analysed. Our first finding was that the calls from different females were individually distinct; subsequent playback experiments confirmed that males could distinguish between different females on the basis of these vocal signals. We also found that the structure of calls is affected by the calling female's reproductive state: females closer to ovulation gave calls which contained more component units. Males listening to this signal may therefore be able to judge how likely a copulation with the caller is to result in a successful fertilisation. The analyses also demonstrated for the first time that the dominance rank of the mating male has a direct effect on the nature of female copulation calls: calls were longer and contained more units during matings with higher ranked males. This greater investment of energy in calls when mating with males of higher social status is an interesting contrast to the findings of studies on other species, such as elephant seals and feral fowl, in which females are less, rather than more likely to give calls during copulations with high ranking males. The question of why females should signal information about the relative strength of their mating partner in this way is currently under investigation.

Semple S (2001). Individuality and male discrimination of female copulation calls in the yellow baboon. *Animal Behaviour* 61: 1023-1028.

Semple S, McComb K, Alberts S & Altmann J (2002). Information content of female copulation calls in yellow baboons. *American Journal of Primatology* 56: 43-56.

GENETIC VARIATION, FITNESS & ADAPTABILITY



Variation in male calling song in closely-related Chorthippus *grasshopper species. These songs are used by males to attract females.*

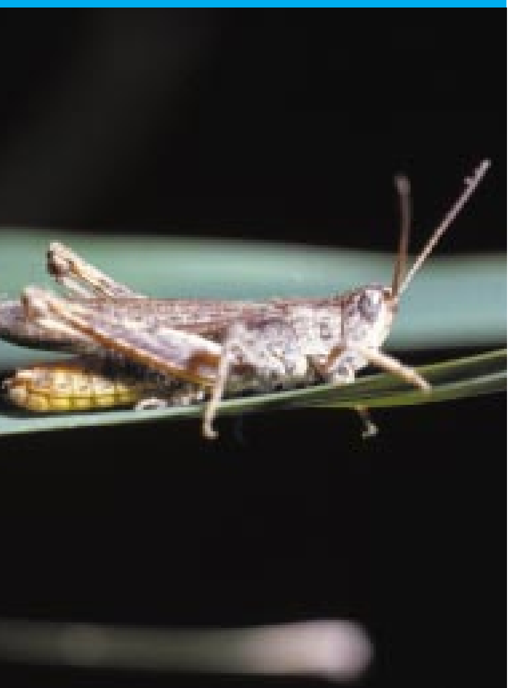
Gene flow and selection in a grasshopper hybrid zone

A key issue in predicting the response of species to environmental change is how the spread of new genes and genotypes is limited by their need to move through different habitats and genetic backgrounds to get to where they are at highest fitness. An understanding of these limits to adaptation is important in determining the long-term sustainability of populations in fragmented and changing habitats.

We have been studying gene flow and selection in two *Chorthippus* grasshopper species, in collaboration with the University of Leeds and the University of Tokyo. Males of these species use highly distinctive calling songs to attract females. These acoustic signals probably diverged while grasshopper populations were isolated in different parts of southern Europe by the advancing ice sheets of the recent ice ages.

Analysis of morphological variation and field recordings of male song have revealed a region south of the Picos de Europa mountains in northern Spain where the two species come into contact and hybridise. In this region, genes affecting song variation are more restricted in their movement through different genetic and ecological backgrounds than those affecting morphology. This suggests that selection is effectively stronger on genes involved in mating signals, possibly because of discrimination by females against hybrid song. There is evidence that some populations have more hybrids than others, which could be the result of continual extinction and recolonisation of populations, making some contacts more recent than others, with less time for hybridisation to occur. This is supported by the ecology of these species, which typically live in habitats created by human disturbance. This kind of population structure may be important in the spread of new adaptations. Alternatively, females could have stronger preferences for their own species' song at some sites than at others, a result which would be of major interest for studies of speciation. These hypotheses are now being used to test female response to different male songs, and experimental crosses to map genes involved in the male signals and female preferences of these grasshoppers.

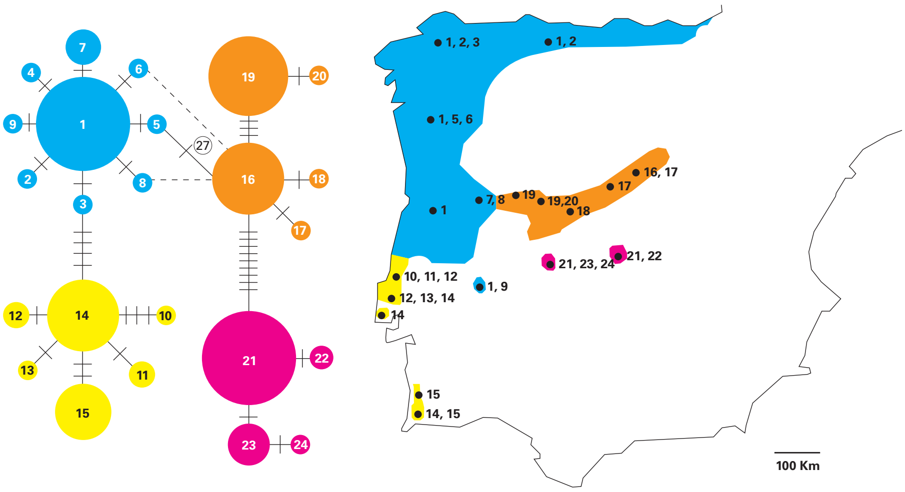
Bridle J R & Butlin R K (2002). Mating signal variation and bimodality in a mosaic hybrid zone between *Chorthippus* grasshopper species. *Evolution* 56: 1184-1198.



Biogeography and genetic diversity in the Iberian Peninsula

Present day patterns of biodiversity are the result of a series of historical and contemporary processes, many of which can overwrite the genetic signature of previous events. For example, the dramatic climatic oscillations of the last ice age (i.e. during the Pleistocene) have been widely regarded as the principal determinant of current levels and patterns of genetic differentiation within and among species, particularly in the Northern Hemisphere. The persistence of temperate habitats in the Iberian Peninsula, even during the most intense glaciations, made this area an important refuge for a variety of animal and plant species during the Pleistocene. However, little is known about the influence of the Pleistocene climatic fluctuations on genetic diversity in Iberian fauna and flora or the detailed pattern of Pleistocene refugia within the Iberian

Map of the Iberian Peninsula with the distribution of the four clades and minimum spanning network of the 24 haplotypes detected. Black dots on the map are sample points. The areas of the circles in the network are proportional to haplotype frequency (range 1-13). Bars on the connecting lines between haplotypes indicate the minimum number of substitutions, with the exception of the connection between the coastal and inland regions where the number is given (27). Dashed lines represent alternative links between these two main clades.



Peninsula. We have examined mitochondrial (mt)DNA sequences from Schreiber's green lizard as a model system to examine biogeographic patterns in this area. This species is endemic to the area with a distribution across the north-west and central mountain systems and some isolated populations in central and southern Spain and Portugal. We found considerable differences among groups of geographically-clustered mtDNA sequences which are consistent with divergence among major sub-groups within the species during the Pliocene, well before the Pleistocene. These major genetic groupings survived the Pleistocene, in what appears to have been at least four isolated refugia. Postglacial expansion of the range of many of the refugial populations has produced contiguous ranges for the morphologically similar, yet genetically highly divergent, groups. Our work suggests that the Iberian Peninsula has a complex biogeography and contains much previously unrecognised intraspecific genetic diversity.

Paulo O S, Dias C, Bruford M W, Jordan W C & Nichols RA (2001). The persistence of Pliocene populations through the Pleistocene climatic cycles: evidence from the phylogeography of an Iberian lizard. *Proceedings of the Royal Society of London Series B* 268: 1625-1630.

Paulo O S, Jordan W C, Bruford M W & Nichols R A (2002). Using nested clade analysis to assess the history of colonization and the persistence of populations of an Iberian lizard. *Molecular Ecology* 11: 809-819.

Reproductive skew in hyenas

Limited observations of wild spotted hyenas suggest that the highest-ranking immigrant males monopolise reproductive success. However, field observations on mating behaviour are rare in this species, so the real extent of reproductive skew among male hyenas remains unknown. We have combined long-term field observations with molecular analyses to examine patterns of reproductive skew among male hyenas, and to test predictions of competing models suggesting alternative relationships between male rank and reproductive success. We used paternity determined from 12 microsatellite markers, together with demographic and behavioural data collected over 10 years, to document relationships among reproductive success, social rank, and dispersal status of male hyenas. Our data suggest that dispersal status and length of residence are the strongest determinants of reproductive success. Natal males comprise over 20% of the adult male population, yet they sire only 3% of cubs, whereas immigrants sire 97%. This reproductive advantage to immigrants accrues despite the fact that immigrants are socially subordinate to all adult natal males, and it provides a compelling ultimate explanation for primary dispersal in this species. High-ranking immigrants do not monopolise reproduction, and tenure accounts for more of the variance in male reproductive success than does social rank. Immigrant male hyenas rarely fight among themselves, so combat between rivals may be a relatively ineffectual mode of sexual selection in this species. Instead, female choice of mates appears to play an important role in determining patterns of paternity in hyenas. Our data support a 'limited control' model of reproductive skew in this species, in which female choice may play a more important role in limiting control by dominant males than do power struggles among males.

Szykman M, Engh A L, Van Horn R C, Funk S M, Scribner K T & Holekamp K E (2001). Association patterns among male and female spotted hyenas (*Crocuta crocuta*) reflect male mate choice. *Behavioral Ecology Sociobiology* 50: 231-238.

WILDLIFE EPIDEMIOLOGY

Environmental pollution and harbour porpoises

Harbour porpoises were once common in the English Channel but their numbers have declined; a detailed survey in the mid-1990s failed to sight any. Environmental pollution has been proposed as one threat to the species, and we investigated whether long-term exposure to heavy metals, including immunosuppressive metals like mercury (Hg), is associated with infectious disease in this species. Post-mortem investigations on 86 harbour porpoises that were found dead along the coasts of England and Wales revealed that 49 of the porpoises were healthy when they died as a consequence of physical

trauma (most frequently entrapment in fishing gear). In contrast, 37 porpoises died of infectious diseases caused by parasitic, bacterial, fungal and viral pathogens (most frequently pneumonia caused by lungworm and bacterial infections). We found that mean liver concentrations of Hg were significantly higher in the porpoises that died of infectious disease, compared to healthy porpoises that died from physical trauma, supporting the idea that environmental pollution contributes to infectious disease mortality in this species.

Bennett P M, Jepson P D, Law R J, Jones B R, Kuiken T, Baker J R, Rogan E & Kirkwood J K (2001). Exposure to heavy metals and infectious disease mortality in harbour porpoises from England and Wales. *Environmental Pollution* 112: 33-40.

Parapoxvirus is pathogenic in red squirrels

Emerging infectious diseases (EIDs) are increasingly cited as the causative agents behind either exclusion or extinction of wildlife populations. A common wildlife EID scenario is where the translocation and establishment of animals into a new geographical region, often through human involvement, introduces novel pathogens to the native fauna. When the introduced host acts as a reservoir population from which infection can spill-over to sympatric wildlife, pathogens which would otherwise fail to persist may cause the extinction of susceptible host populations. Such a scenario is believed to describe the action of parapoxvirus infection in squirrels.

The process by which the red squirrel has been replaced in the UK by the alien introduced grey squirrel is not fully understood but cannot be entirely explained by competition. The hypothesis that parapoxvirus is a component of the replacement mechanism is based on three main lines of evidence: (1) the red squirrel decline has been associated with epidemics of

Parapoxvirus was proven to cause debilitating disease in red squirrels which manifests as skin lesions.

infectious disease and for which similarities in clinical signs suggest parapoxvirus as a causative agent, (2) grey squirrel seroprevalence to parapoxvirus is high in English and Welsh populations, where the red squirrel is almost extinct, but zero in Scottish and Irish populations, where the declines are less marked and parapoxvirus-associated disease has not been recorded, and (3) although infection by parapoxvirus has been demonstrated in red squirrels, only one grey squirrel has been found with signs of infection. However, the hypothesis remains unfounded without evidence that parapoxvirus is pathogenic in red squirrels while having little effect on grey squirrel health.

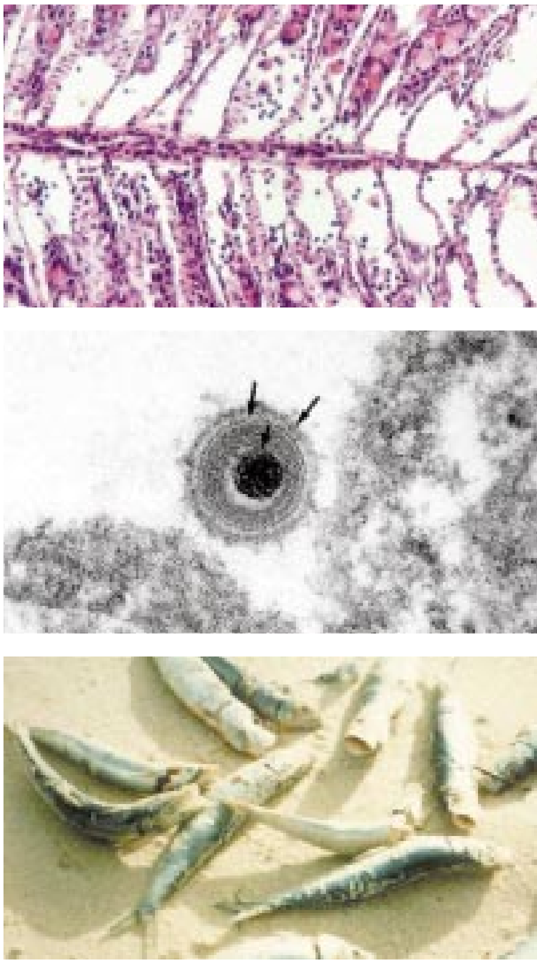
To test this hypothesis, individuals of both species were challenged with material from skin lesions from red squirrels which had died of parapoxvirus-associated disease in the wild. Twelve grey squirrels developed an antibody response post-challenge and showed no signs of disease, while four red squirrels developed skin lesions of parapoxvirus infection, similar to those observed on squirrels found dead in the wild. One red squirrel had exuding inflammatory skin lesions for 6 weeks post-challenge, demonstrating the potential for transmission between red squirrels. The study proved that parapoxvirus produces a debilitating disease in red squirrels while having no apparent impact on challenged grey squirrels, and indicates that parapoxvirus is a probable contributor to the decline of the native red squirrel.

Tompkins D M, Sainsbury A W, Nettleton P, Buxton D & Gurnell J (2001). Parapoxvirus causes a deleterious disease in red squirrels associated with UK population declines. *Proceedings of the Royal Society Series B* 269: 529-533.

Emerging infectious diseases

Emerging infectious diseases (EIDs) are those that have recently increased in incidence or geographic range, that have recently moved into new host populations or that have recently been discovered. EIDs have been recognised as a serious threat to human health for some time, but are only now being recognised as a threat to wildlife conservation. By using the criteria that define EIDs of humans, EIDs of wildlife can be identified. In recent years increasing numbers of wildlife EIDs have been reported, often with important biodiversity or human health consequences. We reviewed a series of important wildlife EIDs. For example, amphibian chytridiomycosis, a disease first reported in 1998 and which is considered to be a fundamental cause of global amphibian declines and extinctions. A series of diseases of marine invertebrates and vertebrates has recently been described, such as pilchard herpesvirus disease which, in 1995, caused mass mortality of pilchards over more than 5000 km of the Australian coastline and seriously affected the associated fishing industry. Human health is directly affected too, as occurred with outbreaks of two recently-emerged viral zoonoses, Nipah virus disease in South East Asia and West Nile virus disease in the U.S.A. We have highlighted the need for an integrated and interdisciplinary effort to investigate EIDs of wildlife and of human beings alike. Although EIDs have varied aetiologies, pathogenesis, zoonotic potential and ecological impact, there often are strikingly similar underlying factors driving their emergence in both human and wildlife populations. These are predominantly ecological and almost entirely the product of anthropogenic influences on ecosystems. Thus, the threats wildlife EIDs pose to biodiversity and human health represent yet another consequence of human environmental change.

Daszak P, Cunningham A A & Hyatt A D (2001) Anthropogenic environmental change and the emergence of infectious diseases in wildlife. *Acta Tropica* 78: 103-116.



Top, diseased gills from a pilchard infected with herpesvirus; middle, electronmicrograph of the causative herpesvirus; bottom, pilchards that died from herpesvirus disease on a beach in Australia.

REPRODUCTIVE BIOLOGY

Non-invasive hormone monitoring

Non-invasive hormone monitoring is a useful tool for evaluating the reproductive status of individual animals, and can easily be used by *ex situ* conservation biologists to assist with population management. However, many people conclude that these techniques have limited application for species conservation or for use in *in situ* conservation programmes. Although a thorough understanding of the changes that occur in the particular species of interest is required before more detailed analyses can be performed, once this has been established, the possibilities for applying non-invasive hormone assessments in conservation biology are vastly increased. Three examples illustrate this. First, our study on the reproductive physiology of the Mohor gazelle identified population characteristics which might limit the success of using assisted reproduction to intensively manage this species. As a result, efforts can be focused on individuals that may be of significant genetic value to the population, but limited in their ability to breed naturally. Second, further observations of wild black rhinoceros indicate seasonal patterns of breeding within the species' natural range. The long gestation and inter-birth intervals of this species make assessments of population demography difficult in the field. Our results provide new data to assist wildlife managers to make decisions about population management. Finally, a new study is integrating measures of population reproductive success with assessments of habitat quality in a rodent, the short-tailed field vole. This species is known to be sensitive to environmental toxicants, which affect its reproductive success.

Our objective is to produce an integrated system by which vole populations can be monitored and alterations in reproductive output investigated. In collaboration with engineers, who are developing an automated non-lethal trap capable of sampling large numbers of the population, our goal is to establish this system as the first mammalian terrestrial biomarker of environment quality.

Caplen G, Mottram T T, Pickard A & Milligan S (2001). Monitoring wild fauna fertility non-invasively. In *Integrated management systems for livestock*: 155-156. Wathes C M, Frost A R, Gordon F & Wood J D (Eds). *British Society of Animal Science Occasional Publication No.28.* Institute of Agricultural Engineers.

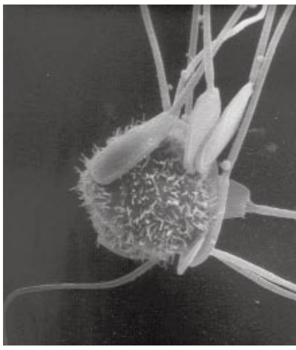
Garnier J N, Holt W V & Watson P F (2002). Non-invasive assessment of oestrous cycles and evaluation of reproductive seasonality in the female wild black rhinoceros (*Diceros bicornis minor*). *Reproduction* 123: 877-889.

Pickard A R, Abaigar T, Green D I, Holt W V & Cano M (2001). Hormonal characterization of the reproductive cycle and pregnancy in the female Mohor Gazelle *(Gazella dama mhorr). Reproduction* 122: 571-580.

Genetic resource banking for gazelles

Semen freezing and storage, coupled with the use of artificial insemination, is increasingly proposed as a useful supporting strategy for the genetic management of wild animals and rare breeds of domestic species. Organised collections of frozen semen, embryos and oocytes (known collectively as Genetic Resource Banks; GRBs) are being set up around the world in support of particular groups of species. For example, there is an overwhelming case for storing semen from rare Australian mammals in case their populations decline further, with concurrent loss of genetic diversity and the consequent exposure of rare and deleterious alleles that accompanies inbreeding. We have been involved with the development of GRBs, concentrating particularly on solving some of the technical problems

Left, sperm–oviduct interaction in the pig; right, gazelle spermatozoa



that limit the success of semen cryopreservation. Using the pig as a model species, and comparing genomic DNA from individuals whose spermatozoa are stable during cryopreservation with DNA from individuals with freeze-sensitive spermatozoa, we recently showed that some determinants of sperm survival might be genetically determined. We are currently aiming to investigate this finding in more detail.

We have also been developing some of the organisational policies and procedures that are essential for setting up GRBs. Current thinking about these issues was brought together and published in 2001, in a book compiled with support from a European Commission grant awarded for this purpose. We have been specifically involved with the integrated development of reproductive technologies for gazelle conservation. This has included a long-term study of semen freezing techniques and short-term sperm storage procedures, with the aim of developing effective GRB and artificial insemination techniques in Mohor gazelle. Recently, we have initiated a study of semen evaluation and freezing in Saudi Arabian gazelles housed at the King Khalid Wildlife Breeding Research Centre in Saudi Arabia, with the eventual aim of establishing GRBs for these species.

Abaigar T, Cano M, Pickard A R & Holt W V (2001). Use of computer-assisted sperm motility assessment and multivariate pattern analysis to characterise ejaculate quality in Mohor gazelles (*Gazella dama mhorr*): effects of body weight, electroejaculation technique and short-term semen storage. *Reproduction* 122: 265-273

Thurston L M, Siggins K, Mileham A J, Watson P F & Holt W V (2002). Identification of amplified restriction fragment length polymorphism markers linked to genes controlling boar sperm viability following cryopreservation. *Biology of Reproduction* 66: 545-554.

Watson P F & Holt W V (2001). *Cryobanking the Genetic Resource.* New York & London: Taylor & Francis.

Sperm storage and oviduct function

Females of many species have become adapted for reproductive strategies that involve some degree of sperm storage. While some species, e.g. bats and some insects, store spermatozoa for months or even years, others store them for a few days. In either case, fertilisation takes place at a time coincident with optimal breeding season, or possibly once several males have mated, thus allowing sperm to compete for their place at the egg surface. The way in which sperm survival is prolonged by the female reproductive tract presents an intriguing puzzle that we have been looking into.

Aside from being of intrinsic interest, knowing how the cells of the mammalian oviduct support sperm viability longer than the best conditions we can provide in the laboratory, may help with the development of better sperm transport and storage media. These media would be useful in genetic management programmes whereby spermatozoa could be sent between widely dispersed locations without having to transport the animals themselves.

Using the pig as a convenient model system we have shown that laboratory cultures of porcine oviduct cells can maintain boar spermatozoa for about 5 days at body temperature. This compares with a maximum of 48 hours in the absence of the cultured cells. We have also shown that if oviduct cell surface membranes are isolated, they can prolong sperm survival when the rest of the cellular machinery is absent. We have previously shown that the oviduct selectively binds only a subset of sperm, and more recently have found that these initiate a signaling dialogue, which leads to the modulation of gene expression in the oviductal cells. We have also shown that subsets of spermatozoa in an ejaculate are differentially activated or repressed by their environment, and thus there is scope for the oviduct to impose a considerable degree of selection over the fate of individual spermatozoa. Oviductal function in mammals is clearly far more complex than a simple conduit that leads sperm towards the egg.

Elliott R M A, Duncan A, Watson P F, Holt W V & Fazeli A (2001). Peripheral bound membrane proteins are involved in the maintenance of boar sperm viability by oviductal apical plasma membrane preparations *in vitro. Molecular Biology of the Cell, Abstracts, 41st American Society for Cell Biology Annual Meeting,* Washington DC.

Green C E, Bredl J, Holt W V, Watson P F & Fazeli A (2001). Carbohydrate mediation of boar sperm binding to oviductal epithelial cells *in vitro. Reproduction* 122: 305-315.

Holt W V & Harrison R A P (2002). Bicarbonate stimulation of boar sperm motility via a protein kinase A-dependent pathway: between-cell and between-ejaculate differences are not due to deficiencies in protein kinase A activation. *Journal of Andrology* 23: 557-565.

Wildlife health surveillance schemes

Wildlife health surveillance schemes are important for several reasons: to gain an understanding of the population dynamics of rare species, to detect harm to the welfare of wild animals caused by human beings, to detect the emergence of new disease entities and to identify new sources of infectious disease for domestic animals and wildlife. Many developed countries have well organized national surveillance programmes for monitoring the health of their wildlife but a coordinated system is absent in the UK. In a paper published in the *Veterinary Record*, the current schemes in the UK were examined and their merits and drawbacks evaluated. National surveillance programmes in three other countries were used as a basis to illustrate how a national programme could be developed in the UK.

Surveillance schemes in the UK can be divided into statutory and non-statutory types. A good example of a statutory system is the Wildlife Incident Investigation Scheme run by the Central Science Laboratory which is responsible for investigating incidents thought to be caused by pesticides in companion and wild animals. Other government agencies, such as the Veterinary Laboratories Agency, are involved in wildlife health monitoring but investigations can only be carried out in specific circumstances. Non-statutory schemes are run by several research institutes, universities and charities. Our work for English Nature's Species Recovery Programmes is a good example. In this work we investigate disease and causes of mortality in species such as the red kite, for which there is a reintroduction programme in England.

In France, there is a cooperative decentralized surveillance venture called the SAGIR network in which a number of government bodies and agencies plus a veterinary school cooperate across the 95 Departements of the country, in a system partly funded by hunting interests. Data are compiled centrally and regular reports are written. In Canada, the national surveillance system differs in that it is based on the cooperation between four veterinary colleges but receives government funding. Detection of disease incidents in Canada is largely reliant on the work of volunteers.

The current approach to the investigation of diseases of wildlife in the UK is fragmented and uncoordinated; it depends upon a small number of limited statutory schemes of restricted scope and other *ad hoc* studies

with limited funding in universities, institutes and rehabilitation centres. As a result important disease occurrences may be missed, there is little knowledge of the range of diseases which occur, or when or where epizootics have occurred or their impact on individual animals or populations. The systems used in other countries should be used as the basis to discuss and develop a coordinated and methodical system for monitoring the health of wildlife.

Sainsbury A W, Kirkwood J K, Bennett P M & Cunningham A A (2001). Status of wild health monitoring in the United Kingdom. *Veterinary Record* 148: 558-563.

Detection of aspergillosis in penguins

Avian aspergillosis is a widespread, common fungal disease which in captive birds occurs particularly at times of stress. The severity of the clinical disease depends on the immune status of the bird and on early detection and treatment. Aspergillosis is a significant cause of mortality in captive penguins and most outbreaks occur in newly introduced penguins, with sporadic cases in established groups. We have developed an indirect ELISA for the detection of *Aspergillus fumigatus*-specific immunoglobulin in penguins which can be used to determine the seropositivity of penguins in captive collections in the UK. The indirect ELISA was standardised by making use of a family-specific antiserum (anti-*Aptenodyptes patagonica patagonicus*). The results were calculated quantitatively as ELISA units, derived from polynomial regression analysis, and semi-quantitatively as end titres. Serum samples from 61 captive penguins were tested with the assay and 57 (93%) were seropositive, but the detection of immunoglobulin did not correlate with clinical disease. The ability to determine the serological profile for a group of penguins would allow the normal background titre to be established for the collection, and would make it possible to monitor individual penguins for the development of clinical disease, and assess their response to treatment.

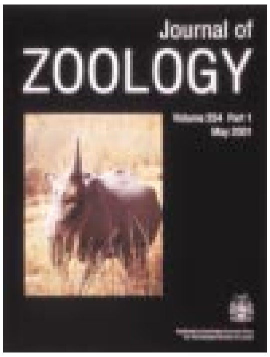
German A C, Shankland G S, Edwards J & Flach E J (2002). Development of an indirect ELISA for the detection of serum antibodies to *Aspergillus fumigatus* in captive penguins. *Veterinary Record* 150: 513-518.

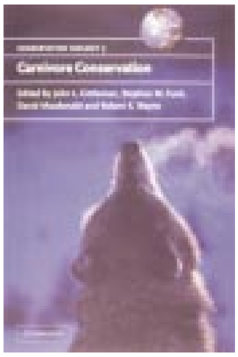
Marker systems for the estimation of digestibility and low food intake in giraffes

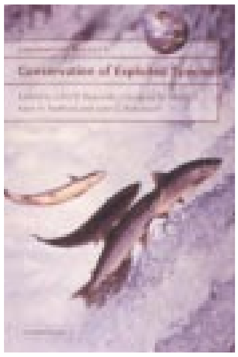
Information on the digestive physiology of giraffes is vital for optimal feeding and management of the species in captivity. High-energy, acidosis-inducing feeds, and diets too high in fibre can cause a range of ruminant-associated problems. Captive giraffes can also suffer from peracute mortality syndrome, a condition in which severe depletion of body fat stores occurs. We determined nutrient digestibility in captive giraffes at Whipsnade Wild Animal Park using four different marker systems. Acid detergent lignin and acid insoluble ash provided useful values on digestibility of dry matter, crude protein, neutral detergent fiber and acid detergent fiber. The results of our study were used to calculate food intake and energy use, and to provide an optimum diet for the giraffes held in the collection.

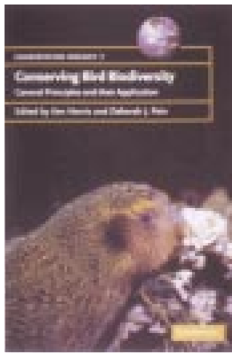
Clauss M, Lechner-Doll M, Flach E J, Tack C & Hatt J-M. (2001). Comparative use of four different marker systems for the estimation of digestibility and low food intake in a group of captive giraffes (*Giraffa camelopardalis*). *Zoo Biology* 20: 315-329.

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.

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 an important forum for the 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. Titles are based on either symposia held at ZSL or other topics which meet these aims. Three new titles have been published: *Carnivore Conservation*, edited by John Gittleman, Stephan Funk, David Macdonald and Robert Wayne; *Conservation of Exploited Species*, edited by John Reynolds, Georgina Mace, Kent Redford and John Robinson and *Conserving Bird Biodiversity*, edited by Ken Norris and Deborah Pain.

Production of Volume 38 of the *International Zoo Yearbook* began. The special section, Zoo Challenges: Past, Present and Future, includes 15 articles that address the historical trends and future aims of zoos in relation to animal management. Articles in Section 2, The Developing Zoo World, range from the artificial insemination of koalas to the development of a computerised avian and veterinary record system

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.

The 2001 Sir Stamford Raffles Lecture, *Embryonic development – from the egg to five fingers*, was presented by Professor Lewis Wolpert CBE, FRS (University College London). The 2002 Stamford Raffles lecture, *The natural history of trilobites*, was given by Professor Richard A. Fortey FRS (Natural History Museum and Oxford University). These events were generously sponsored by the Singapore Tourism Board and Singapore Airlines, and we are most grateful for their continuing support.

The Science and Conservation seminars held by the Institute of Zoology comprised talks by invited speakers on subjects relevant to our research; for example, *Vocal communication and social knowledge in elephants, Consequences of inbreeding in butterfly metapopulations,* and *Sperm competition and the evolution of ejaculates*.

We hold regular Scientific Meetings on Tuesday evenings. At each one three speakers provide an overview of important research within a particular field. The nine meetings held during the period covered a wide range of subjects, such as *Sexual and parental behaviour in animals: what use are comparisons between species?, Population genetics and conservation of wolves in Europe* and *Getting ecotourism right: turning a marketing ploy into a tool for conservation.*

A joint meeting of The Zoological Society of London and The Royal Society of Medicine was held in June 2002. The meeting, *As the zoo vet said to the gynaecologist! Reproduction in Man and Animals*, was very well attended by members of both societies.

Tuesday talks are aimed at a general audience. The thirteen talks included *Marine mammal strandings in the UK: what have we learnt from ten years of Government-funded research, The langur cliffhanger – can south China's forest fauna survive* and *The changing status of British birds. Making Waves*, a lavishly illustrated talk by Martha Holmes, a series producer on BBC1's landmark series on the world's oceans, *The Blue Planet*, was particularly popular.

Scientific Awards

Outstanding achievements in scientific research and conservation are recognised through our annual presentation of awards. During 2001 the following awards were presented:

The ZSL Frink Medal for British Zoologists
Professor Nick Davies, FRS, University of Cambridge, in recognition of his contribution to behavioural ecology

The Scientific Medal
Dr Alan Cooper, University of Oxford, for his research in phylogeography

The ZSL Marsh Award for Conservation Biology
Dr Eleanor J Milner-Gulland, Imperial College of London, for her contribution to conservation biology

The Stamford Raffles Award
Dr Norman Moore for his research on the ecology and behaviour of dragonflies

The Thomas Henry Huxley Award
Dr Stephen Rossiter, University of Bristol, for his thesis 'The causes and consequences of genetic structure in the greater horseshoe bat (*Rhinolophus ferrumequinum*)'

Honorary Fellowship
Professor Patrick Bateson, FRS, Provost of King's College, Cambridge and Biological Secretary of the Royal Society. In recognition of a career as a world leader in ethological research

Top, the 2002 Stamford Raffles lecture; from left to right: Sir Martin Holdgate, Professor Richard Fortey, Christina Nedovich and Gabriel Tseng from the Singapore Tourism Board.

Bottom, the 2001 Scientific Award winners; from left to right: Alan Cooper, Norman Moore, Sir Martin Holdgate, Gill Bell (winner of the Michael Brambell Travel Award for ZSL staff), Brian Marsh, Stephen Rossiter, Eleanor J. Milner-Gulland, Nick Davies.

EDUCATION & TRAINING

The Institute's PhD students continue to be one of our greatest assets. Our partnership with Cambridge University has led to the registration of many new PhD students at Cambridge and these students are benefiting from the wide range of high-quality training opportunities offered at the University.

Between January 2001 and July 2002, 24 students were registered at the Institute and ten were awarded PhD degrees. Studentships were funded by the Natural Environment Research Council (NERC), the Biotechnology and Biological Sciences Research Council (BBSRC), studentship schemes in collaborating universities, and overseas funding agencies. The Institute provides valuable resources and skills, as well as opportunities to collaborate with researchers in the laboratory and in the field. This is reflected in the range of research interests of our PhD students and the approaches that they use in their studies. We have students working primarily on overseas field programmes as well as those who spend all their time in the laboratories working with experimental or analytical approaches. For some studies a range of approaches are used. The success of our PhD students is reflected in the positions they have taken after leaving the Institute, most are now working in renowned research institutions or with significant conservation projects abroad.

Those completing their studies during the period were Saffron Townsend, Andrew Cunningham, Julie Garnier, Octavio Paulo, Juliet Dukes, Jonathan Baillie, Susanna Paisley, Jakob Brø-Jorgensen, Russell Seymour and David Cope. Details of their thesis topics are on the inside back cover.

All our students play an active role in

the academic life of the Institute and are keen to present their work in seminars and discuss recent research topics in journal clubs. Attendance to these internally organised meetings is good and discussions are lively. The Institute's annual Student Conference, open to Institute staff, external supervisors and collaborators, was well attended and presentations were of a very high standard.

Students also have the opportunity to participate in external conferences. In March 2001 and 2002 our students were well represented at the Cambridge Student Conference on Conservation Science. This Conference is attended by around 200 by delegates from over 30 countries. Two of our final year PhD students spoke in 2002, and four spoke at the 2001 meeting.

The link with Cambridge has provided Institute students with additional opportunities to exchange ideas and discuss research topics with Cambridge Zoology postgraduate students, and two informal meetings, one in London and one in Cambridge, have taken place so far.

We also provide project opportunities and host students undertaking independent research for projects for MSc and MRes courses at collaborating universities. Over the spring and summer months especially, our student numbers are increased by visiting postgraduates from University College, Imperial College and Imperial College/Natural History Museum. Within the period we have also hosted visiting students from Cardiff University, York University and the University of Virginia, USA.

We run a Master of Science course in Wild Animal Health with the Royal Veterinary College. The course provides veterinarians and other graduates in biological sciences with advanced training in clinical veterinary techniques, epidemiology, diagnosis, prevention and control of wildlife diseases and management of captive and free-living wild animals. Fifteen veterinarians completed their MSc course in 2001 and several have gone on to take up key posts in zoo and wildlife medicine. One component of the MSc course is a research project and two examples of these illustrate the type of study that can be achieved. Hester van Bolhuis carried out a field comparison of three different methods for the diagnosis of tuberculosis in orang utans, namely an intradermal tuberculin test, a gamma-interferon assay and immunochromatography. Diagnosis of tuberculosis in this species is known to be particularly difficult because orang utans develop non-specific tuberculin reactions. This study provided valuable results which show that the interferon assay has potential as a more specific method of diagnosis. Laura Twedt Zvonar investigated the seroprevalence of falconid herpesvirus in free-living and captive raptors in the UK, and found that 5.4% of captive raptors (n=56) and 10.1% of free-living birds (n=69) were positive for antibodies to the virus. Interestingly there was a higher seroprevalence in falconids than members of the Accipitridae (hawks and eagles) and this is consistent with the greater frequency of herpesvirus disease in falcons. We receive regular news from graduates of the course and were particularly pleased to hear that Dr Fernando Gual-Sil has recently been appointed General Director of Zoological Parks in Mexico City and has three zoological collections under his jurisdiction.

MSc student Laura Twedt Zvonar was presented with the Mazuri Zoo Foods Award by Professor Lance Lanyon, Principal of the Royal Veterinary College.

Mazuri Zoo Foods

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✻ arrivals
• departures

COLLABORATIONS

Babraham Institute Sperm physiology and cell signalling
Birdlife International Technical aspects of *Red Lists of Threatened Species*
Bombay Natural History Society (India) Vulture declines in India
British Trust for Ornithology Migration of Brent geese and management of goose conflict issues

Centre for Environment, Fisheries and Aquaculture Science (Lowestoft-Burnham-on-Crouch) Marine mammal toxicology
Charles Darwin Research Station (Galapagos Islands) Selection and gene flow in lava lizards
CNRS, Gif sur Yvette (France) *Drosophila* Gabon Project
CSIRO Australian Animal Health Laboratory (Australia) Infectious diseases of amphibians, Vulture declines in India

Department of Agriculture and Rural Development for Northern Ireland (Veterinary Sciences Division) Adenoviruses and the diseases of squirrels
Desert Research Foundation of Namibia Tsaobis Baboon Project
Direction Generale de Forets (Tunisia) Scimitar-horned oryx reintroduction
Durrell Wildlife Conservation Trust (Jersey) Spatial modelling of bushmeat in central Africa

ECOFAC Programme (Equatorial Guinea) In-country support during PhD fieldwork
English Nature Veterinary surveillance in Species Recovery Programme
Estacion Experimental de Zonas Aridas (Spain) Gazelle research

Fisheries Research Services (Aberdeen and Pitlochry) Population genetics of Atlantic salmon

Hungarian Academy of Sciences (Hungary) Adenoviruses and the diseases of squirrels

Imperial College, Department of Biology Avian biodiversity, Extinction filters in endemic island birds, Predicting extinction risk in mammals
Institut Congolais pour la Conservation de la Nature (Democratic Republic of Congo) Darwin Initiative Congo World Heritage Sites Project
Institut fur Zoo und Wildtierforschung, Berlin (Germany) Viral monitoring for oryx reintroductions and elephant reproductive monitoring
Institute of Animal Health Evolution of domestic ungulate major histocompatibility complex
Institute of Education, Mathematical Modelling Laboratory Bayesian cross-classified models in ecology and evolution

Ludwig-Maximilians University, Institute of Animal Physiology, Physiological Chemistry and Nutrition (Germany) Animal nutrition

Marine Environmental Monitoring UK-stranded marine mammals and marine turtles
Marine Institute (Republic of Ireland) Impact of aquaculture on natural salmonid populations
Max Planck Institute for Evolutionary Anthropology, Leipzig (Germany) Quantification of nuclear DNA in historic teeth samples
Moredun Research Institute Parapoxviral infections in squirrels, Research into gamma herpesviruses of ungulates

National Bird of Prey Centre Vulture declines in India
National Centre for Ecological Analysis and Synthesis, University of California (USA) Extinction risk, phylogeny and conservation and Host-parasite co-evolution workshops
National Museum of Scotland Taxonomic studies
Natural History Museum Taxonomic studies, UK-stranded cetaceans
Norwegian Institute for Nature Research (Norway) Impact of aquaculture on natural salmonid populations

Poultry Diagnostic and Research Centre (India) Vulture declines in India

Razi University (Iran) Reproduction in bats
Royal Society for the Protection of Birds Population genetics of the great yellow bumble bee, Veterinary support for UK and international conservation projects, Vulture declines in India
Royal Veterinary College Sperm function

Scottish Agricultural College UK-stranded cetaceans
Sea Mammal Research Unit (Cambridge) UK-stranded cetaceans
Silsoe Institute, BBSRC Ecotoxicology/endocrinology of field voles
Smithsonian Tropical Research Institution Measuring abundance of tropical butterflies
Station d'Etudes des Gorilles et Chimpanzis, Lopé Reserve (Gabon) *Drosophila* Gabon Project

Tanzania National Parks Serengeti Cheetah Project, Tanzania Carnivore Conservation Centre
Tanzania Wildlife Research Institute Serengeti Cheetah Project, Tanzania Carnivore Conservation Centre
The Macaulay Institute Management of goose conflict issues
The Wellcome Trust Opportunistic diseases
Tsaobis Leopard Nature Park (Namibia) Tsaobis Baboon Project

UNESCO "Conservation in Crisis" programme Darwin Initiative Congo World Heritage Sites Project
University of Berne (Switzerland) Long-term genetic study of foxes and rabies
University of California at Berkeley (USA) Fungal pathogens of cetaceans and amphibians, Sika deer phylogeography
University of California at Davis (USA) Analysis of long term data on Serengeti cheetahs
University of California at Los Angeles (USA) Sika deer phylogeography
University of Cambridge Conservation priorities, Conservation status of the radiated tortoise, Genomic studies of sperm–oviduct interactions, Modelling of social foraging behaviour in baboons, Population genetics of the great yellow bumble bee, Porpoise population genetics, Sika deer phylogeography, Tsaobis Baboon Project
University of Cardiff Social biology of multiple-queen ants
University of Chiang Mai (Thailand) Human/animal transmission of *Penicillium marneffei*
University of East Anglia Conservation of exploited species, Exploitation of Malagasy chameleons, Sex ratios in ants symbiotic with plants
University of Edinburgh Red-sika deer hybridisation and suid phylogenetics
University of Ireland, Cork (Republic of Ireland) Impact of aquaculture on natural salmonid populations
University of Ishinomaki (Japan) Sika deer phylogeography
University of Lausanne (Switzerland) Sex ratios in slave-making ants
University of Liverpool UK-stranded cetaceans
University of London, Imperial College Structure and impacts of bushmeat trade, Equatorial Guinea bushmeat project
University of London, Kings College Ecotoxicology / endocrinology of field voles
University of London, Queen Mary and Westfield College Endocrinology of fossa, Parapoxviral infections in squirrels, Reproductive tactics in bitterling, Stickleback sperm quality
University of London, University College Conservation ecology of urban bumble bees, Meta-population processes in colobus monkeys, Demography of managed Asian elephants, Genetics of body size variation in *Drosophila*, Evolutionary and veterinary genetics, Life-history variation in birds and mammals
University of Luton Cryopreservation of fish sperm and embryos, Nematode infections of yak
University of Murcia (Spain) Sperm–oviduct interactions and ovulation detection
University of Natal (South Africa) Samango monkey social foraging project
University of Oxford, Depatment of Zoology Ethiopian wolf genetics, Life-history variation in birds and mammals, Reproductive decisions in birds
University of Paris (France) Capture, mark and recapture models
University of Portsmouth Haemoglobin in mammals
University of Regensburg (Germany) Sex ratios in slave-making ants
University of Queensland (Australia) Cryopreservation of macropodid sperm
University of Stirling Parapoxviral infections in squirrels
University of Sussex Analysis of data on communication networks in Africa elephants
University of Tohuku (Japan) Simulation studies of species ranges
University of Tokyo (Japan) QTL analysis of grasshopper song
University of Virginia (USA) Predicting extinction risk in mammals
University of Wageningen (The Netherlands) Impact of aquaculture on natural salmonid populations
University of Washington (USA) Statistical analysis of long term data set on Serengeti cheetahs
University of Zurich (Switzerland) Giraffe nutrition

Veterinary Laboratories Agency Paramyxoviral infections in reptiles, UK-stranded cetaceans

Wildfowl and Wetlands Trust Individual-based population models
Wildlife Conservation Society (USA) Conservation of exploited species, Joint projects with WCS Tanzania, Organisational approaches to conservation priority setting
World Conservation Union (IUCN) Technical aspects of *Red Lists of Threatened Species*

STAFF REPRESENTATION & PUBLICATIONS

Animal Conservation Georgina Mace (Editor); Guy Cowlishaw (Member, Editorial Board)
Animal Reproduction Science Bill Holt (Member, Editorial Board)

Behavioural Ecology Andrew Bourke (Editor)
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Centre for Ecology and Hydrology, NERC Georgina Mace (Member, Biodiversity and Biocontrol Programme Advisory Group)
Cheetah Conservation Fund Sarah Durant (Member, International Scientific Advisory Board)
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Durrell Wildlife Conservation Trust Georgina Mace (Council Member)

European Association of Zoo and Wildlife Veterinarians Edmund Flach (Infectious Diseases Working Group)
European Commission Fifth Framework Programme "Quality of Life and Management of Living Resources" Bill Jordan (Member, Expert Assessment Panel)
European Journal of Entomology Christine Müeller (Member, Editorial Board)

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International Embryo Transfer Society Amanda Pickard (Secretary, Companion Animals, Non-domestic and Endangered Species Advisory Committee), Bill Holt (Co-chair, CANDES Regulatory Committee)
International Union for the Study of Social Insects Andrew Bourke (Member, European Conference Program Committee; Treasurer, British Section)

Journal of Zoology Bill Jordan (Consultant Editor)

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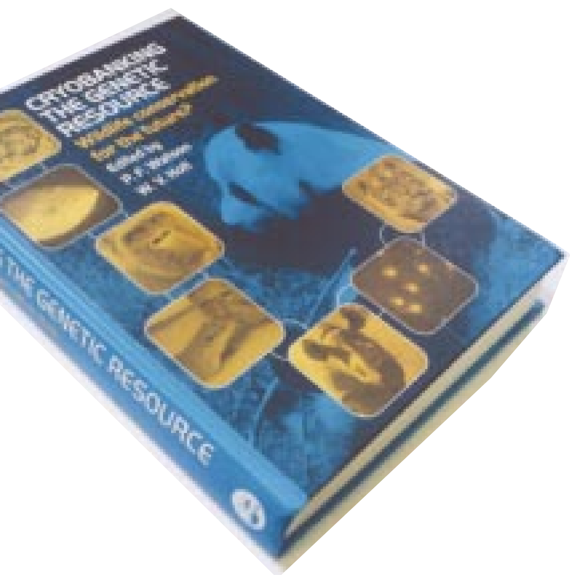

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