Developing the research potential of zoos and aquaria

The EAZA Research Strategy

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The European Association of Zoos and Aquaria (EAZA: www.eaza.net) was established in 1988 and is the single, unified representative for zoos from 34 European countries, ranging from Spain to Sweden and from Ireland to Kazakhstan. Members exist in other countries including Israel, Kuwait, Turkey, Qatar and the United Arab Emirates.

COVER: Zoo researcher anaesthetising a European dormouse, before its release to the wild. Part of the investigations for a collaborative field conservation project involving zoo, university and wildlife trust staff and volunteers. PHOTO: Stephanie Sanderson

BACK COVER: Komodo dragon hatching in a zoo. European zoo and university researchers, working in close collaboration, have established through DNA testing that female dragons can produce young without mating by means of parthenogenesis or 'virgin birth'. This remarkable fact is of great importance for conservation breeding and release programmes. There was worldwide media interest after the research was published in the prestigious international journal *Nature* (Watts *et al*., 2006). PHOTO: Douglas Sherriff

DESIGN: Jantijn van den Heuvel, Made, the Netherlands

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Dedication and acknowledgements

For his exceptional contributions to the development of science and research within the European and wider zoo community, this publication is respectfully dedicated to Prof. Dr. Günther Nogge, formerly director of Cologne Zoo and a past chair of the European Association of Zoos and Aquaria and its Research Committee.

The editorial team of Prof. Gordon McGregor Reid, Dr. Alastair Macdonald, Dr. Andrea Fidgett, Bart Hiddinga and Dr. Kristin Leus are also immensely grateful to all those who assisted in the production of this Research Strategy in many and various ways over several years.

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Foreword

The research potential of European zoos and aquariums is clearly enormous and it is becoming ever more important to harness this potential to best advantage. A rapidly growing number of animal species are nearly extinct in the wild and require support from zoo and aquarium breeding programmes to help guarantee their continued existence. The conservation and research challenges are everywhere large and daunting, from threatened Black rhinos and Orang-utans to European storks, African cichlid fishes, Caribbean corals and Pacific island land snails. There is a particularly urgent need to prevent the dramatic decline and extinction of a substantial proportion of the 9,000 or so (scientifically described plus undescribed) species of frogs, toads, newts and other amphibians of the world. Effective breeding and the safeguarding of populations of endangered species in zoos and aquariums and in the wild requires considerable knowledge of the biology of each species including reproduction, behaviour, group dynamics, parasitology, husbandry, medical needs and so forth. A vast amount of knowledge on such aspects has already been built up over the past hundred years of zoo and aquarium history, but much more is needed – hence this EAZA Research Strategy.

Zoos, aquariums and their partners are developing as one of the most substantial sources of scientific knowledge and activity, for the ultimate benefit of the survival of biodiversity, individual species and natural ecosystems. Many aspects of the biology of wild animals simply cannot be studied efficiently in their original habitats, especially when the status of many populations and species is in decline and individual animals may only rarely be seen. To ensure survival in the wild, there is a critical importance in gaining a greater understanding of the lives of rare and threatened taxa and building international computerised databases such as the Zoological Information Management System (ISIS-ZIMS).

Zoo staff involved directly in collaborative conservation and education projects in the field, at home and abroad, is a welcome and increasingly familiar contribution. To maximise the research potential of zoos and aquariums in the EAZA realm requires effective cooperation and communication between all of the member institutions, their biological and veterinary scientists, and the many university and other partners they work with. This Europe-wide endeavour, often with colleagues overseas, now requires joint strategic planning for effective delivery. For this purpose the EAZA Research Strategy has been produced by the Research Committee, fully supported by many others affiliated to the EAZA community and under the leadership of its co-chairs Gordon McGregor Reid and Alastair Macdonald.

The Strategy has been fully endorsed by the EAZA Council and we gratefully acknowledge the large efforts made to produce this important publication. I am certain that through its implementation it will greatly contribute to our one and only headline goal: to help save wildlife and nature from further destruction and, by doing so, help ensure the future of humanity. EAZA invites zoos, aquariums, relevant international and regional organisations and national and local government administrations to adopt the Strategy and strongly support it.

Leobert E.M. de Boer
EAZA Chair

Summary

The European Association of Zoos and Aquariums (EAZA) is a large membership organisation bringing together zoos and aquaria in 34 countries, who employ 20,000 staff and welcome more than 125 million paying guests each year, with high economic impact. Successful scientific research and training underpins EAZA member activities in wildlife conservation, education, animal welfare, ecotourism and other areas. There are more than 250,000 animals in EAZA collections and research directly involving them is designed to be benign, non-invasive and non-intrusive and is subject to strict protocols, regulation and legal and ethical scrutiny. The purpose of this Research Strategy is to help to further develop appropriate and excellent research and training within the European zoo and aquarium community and among its many partners. This is the first such strategy to be published and it aims to galvanise collaboration, planning and activity in zoos and aquaria; and seeks to engage other like-minded stakeholders such as national and local governments, development agencies, universities, botanical gardens, gene-banks, wildlife organisations and partners in the habitat countries.

The EAZA Research Strategy sets out a clear and purposeful research vision and mission, establishes primary goals and a detailed action plan with objectives that are specific, measurable, realistic and time-bound. There is a glossary of scientific and technical terms and a set of useful addenda, including: a benchmark survey on the current status of research in EAZA zoos; examples of excellent zoo research projects and programmes; and a guide to the relevant literature. Zoo research is set in the well-established and documented framework of ethics and obligations provided by the European Union Zoos Directive (see Appendix II), the Earth Summit and its Convention on Biodiversity (CBD: see Appendix III) and the World Conservation Union (IUCN: see Appendix V). Also considered in this Strategy are important areas for research and development including veterinary care, legal, social and environmental issues, funding, outreach and the public understanding of science, education and technology.

Conservation of biodiversity is set as a main driver, especially in the context of the World Zoo and Aquarium Conservation Strategy and the Global Strategy for Plant Conservation. Conservation is actions that substantially enhance the survival of species and habitats, whether conducted in nature (*in situ*) or outside the natural habitat (*ex situ*). The EAZA *in situ* Conservation Database already lists 436 zoo and aquarium projects in 94 countries and the need to greatly expand such direct conservation action is stressed. Work with local as well as exotic taxa is important in that, for example, one in six European mammal species is now threatened with extinction. Scientifically managed zoo populations and associated reintroductions have, for instance, brought the European bison back from the brink of extinction to a small, but healthy population of 1,800. Also emphasised is the need to rise to growing research challenges on climate change and its impact on wildlife, emergent infectious diseases, achieving biosecurity, determining efficient methods for sustainability and recycling; and the need to develop and utilise safe and appropriate new technologies and transfer these to conservation partners in the developing world.

Zoos already conduct important *ex situ* work including scientifically managed 'assurance' breeding programmes, affording the potential for reintroduction of species that have become extinct in the wild. Sadly, this long-term 'safety net' role must inevitably expand in response to poaching, pollution, disease, climate change and the rapidly accelerating fragmentation and loss of natural habitats.

While basic scientific data are often available through longstanding study and documentation exercises in zoos and aquaria and in the field, the Strategy emphasises the need to make these widely computer accessible; and notes that in-depth studies are often required to yield information critical to species survival and the maintenance of genetic vigour and viability both *in situ* and *ex situ*. Zoos and

aquariums have the opportunity and responsibility to produce this kind of information, use it in educational interpretation and make it widely available through publications and other media.

It is considered vital that zoos and aquariums build on their central role in gathering, researching and disseminating information on the biology of threatened wildlife at home and abroad. The strategic intention is to everywhere apply that knowledge to the care, husbandry and conservation of species both in nature and in zoo or aquarium conditions.

Basic and advanced biological data on up to two million individual animals and 10,000 taxa have already been gathered and recorded in scientifically sound ways in zoos and aquaria and entered into ISIS-ZIMS – the revolutionary new computerised global Zoo Information Management System – and this process must now be greatly expanded.

All zoos and aquariums are encouraged to plan to develop the necessary resources and facilities and employ researchers. Individual institutions should build research specialisations and engage appropriate research staff to take their development aspirations forward. These staff should, where possible and appropriate, also actively take part in local, regional and national research strategies and contribute to European advisory networks.

The Strategy emphasises the fact that, to develop their own institutional research agenda, zoos and aquariums will often need access to experts in numerous disciplines who may be geographically dispersed. Research potential should be enhanced through the building of strategic partnerships, communications and physical capacity. Furthermore, groups of zoos or aquariums are encouraged to cooperate to fund one or more research positions to provide services to their respective consortia as well as have staff join wider advisory boards and generally promote worthwhile collaboration and information exchange.

Through its Research Committee, EAZA will promote, monitor, evaluate, benchmark and guide research and establish and support regional networks of expert zoo, aquarium, university, museum and wildlife researchers. EAZA will provide effective, broadly accessible means of communication, discussion and collaboration including in the habitat countries and with equitable benefits sharing.

EAZA Research Vision and Mission

Science and research already underpins many of EAZA's functions and a Research Committee was created in 1990 with a specific remit. The EAZA Council has, on the recommendation of this committee, adopted a scientific 'vision' and 'mission' for EAZA.

Vision EAZA has the high aspiration that every European zoo and aquarium will:

- *make a significant contribution to ethical and highly effective research, particularly in the areas of biodiversity conservation and animal welfare;*
- *produce and use excellent science to increase knowledge which improves the quality of decision-making and management of collections, programmes and projects;*
- *engage in and foster scientific education, training and benefit sharing.*

Mission EAZA and its Research Committee will work towards the vision and engage in the mission to ***encourage and support all European zoos and aquariums to adopt a scientific approach and participate in worthwhile and ethical research***.

To pursue the vision and achieve the mission, individual zoos should:

- *provide the necessary facilities, tools and staff to conduct effective research and to develop a thriving scientific culture;*
- *create a meaningful expenditure plan for research purposes;*
- *keep abreast of contemporary research in its widest context and use this to inform and improve zoo programmes and guide future direction;*
- *develop new scientific perspectives, linking basic and applied research and using existing and new methodologies and innovative technologies;*
- *produce and publish high-quality scientific research in increasingly greater measure;*
- *engage in collaborative partnerships with peer institutions and kindred organisations at home and abroad;*
- *share research results and contribute to broad-based education and training and wider communications exercises.*

EAZA Science and Research: Introduction

In the context of zoos and aquaria, this section covers the meaning of science and research, its overall purpose, ethics and obligations, core subject matter, value in management, wider benefits and needs, organised sources of knowledge, scientific products and the public understanding of science, education and technology.

Definitions

'Science' is *a body of knowledge based essentially on observation and experiment*. A great deal of important science has been produced in leading zoos in Europe since the 19th century. Indeed, some large zoos (zoological societies) contain, or are closely associated with, scientific research institutes, e.g. in Antwerp, Berlin, London and Moscow. Also marine biological research stations with a distinguished history often have an aquarium as their 'public face', e.g. in Genoa, Monaco, Naples and Plymouth. With zoos and aquariums in support, these organisations have helped to lay the foundations for contemporary terrestrial and aquatic biology.

A 'zoo' can be defined as *any permanent establishment where living wild animals are kept for exhibition to the public* for seven or more days a year, with or without an admission charge. A zoo may be a charity or operate in the public or private sector. As well as conventional zoological gardens, this encompasses aquariums, safari parks, bird gardens, birds of prey centres, reptile and amphibian centres, butterfly or bug houses and some animal sanctuaries. All of these can be productive venues for scientific activity. The precise nature of the science will vary with the size, resources and policy of the organisation and the statutory licensing arrangements.

'Research' is the *process used to assemble and test knowledge using the scientific method*, i.e. it is the means by which science is created. 'Zoo research' is *any scientific investigation involving a zoo or aquarium, their facilities, resources, programmes and partnerships*.

Zoo research aims to be *benign, non-invasive and non-intrusive* and currently focuses mainly on issues of *conservation of biodiversity* and *animal welfare* and *husbandry*. This includes research in zoo grounds, in partner institutions and in the wild, at home or abroad. Among other criteria, research methods

are characterised by: logical and rational thinking, objectivity, the recognition and establishment of general patterns, the testing of hypotheses (typically 'educated guesses' on cause and effect), the need for evidence, close and critical observation, quantification, precise measurement, test and control comparison, careful analysis, statistical evaluation, correlations, accurate prediction and reproducible results.

Good science is based not on folklore, anecdote, intuition, personally held beliefs, or solitary and statistically insignificant instances. Rather it depends on acquiring and critically evaluating the evidence for hypotheses and making sensible, valid generalisations. This is done using solid, consistent and dependable facts gathered through repeated observation and, as appropriate using rigorous, systematic experimentation in duplicated trials. Scientific terms, methods and philosophy can be difficult to understand and the subject of endless debate. Hence, for clarity, a wide range of specialised terms (each marked *q.v.* in the text) is defined in the glossary (page 53).

Overall purpose Good research produces a well-validated body of knowledge based on internationally accepted principles and suitable for sharing. The research may be performed by a zoo's own staff, and/or by students, trained volunteers or professional research partners. Overall, the

PHOTO:
Nora Schwitzer

most important aspects of the knowledge gained from zoo research concern *conservation of wild species and habitats and the health and welfare of individual wild animals or populations*. 'Conservation' is actions *that substantially enhance the survival of species and habitats*, whether in nature (*in situ*) or outside the natural habitat (*ex situ*).

Research results are particularly valuable in terms of *identifying, characterising and solving problems* and in *prioritisation and decision-making* for conservation, animal welfare or other purposes, including education and public relations. Zoo research can play a vital part in the *expansion of scientific knowledge* on many fronts and be transferable in far wider contexts, including wildlife management in the field. Methods of safely anaesthetising rhinos in natural habitats were, for example, first developed in zoos and safari parks.

Zoo research possibilities are practically endless and can, for example, extend to benign, non-intrusive studies involving concepts in engineering and mathematics, e.g. biomechanical or biomaterials studies of flight (aerodynamics), navigation and migration in bats, birds and insects; or of swimming (hydrodynamics) in mammals, reptiles, frogs, fishes and invertebrates. Not all zoo-based research has to be immediately and obviously 'practical' or driven by prior hypotheses. The major longer-term value of spontaneous, speculative 'blue-sky' research in zoos and aquariums is highlighted in the Strategy.

Ethics and obligations

From the European Union Zoos Directive, the Convention on Biodiversity, the Global Biodiversity Assessment, the United Nations Environment Programme and various documents of the World Conservation Union (IUCN) it is clear that the need for and value of zoo research is widely recognised and that zoos *can and should be actively involved in appropriate research and scientific studies* (see Appendices II, III, IV and V).

When deciding upon the appropriateness of research to be undertaken, *the well-being of individual animals and the preservation of species and other biological diversity should be paramount. The health and safety of staff and visiting researchers must be an equally high priority.*

Scientific research is a public process subject to internal and external audit and evaluation. Hence it must be legal, and abide by international regulations and conventions such as the Convention on Migratory Species (CMS; *q.v.*), Convention on International Trade in Endangered Species (CITES; *q.v.*) and various conventions on the Conservation of Nature and Natural Resources. Research must also be conducted to the highest welfare standards. There should be an *ethical review process* and the results of studies should be distributed to colleagues. It would be unethical to keep potentially valuable research information a secret (refer to Appendix I).

Core subject matter

Basic and applied research programmes in zoos or aquariums can embrace a remarkably large number of topics including: animal care, ageing, assisted reproduction, behaviour, bioinformatics,

bio-materials or 'gene' banking, biotechnology, contraception, database management, diet, disease, DNA analysis, domestication, environmental enrichment, husbandry, identification, life histories, low temperature biology (cryobiology), parasites, population analysis, reproduction, studbooks, human behaviour, visitor studies and wildlife crime.

Research efforts on these topics will, in turn, typically draw on combinations of major scientific disciplines such as anatomy, anthropology, biochemistry, biogeography, bioinformatics, biotechnology, ecology, education, endocrinology, ethnology, ethology, evolution, forensics, genetics, genomics, information technology, nutrition, parasitology, pharmacology, physiology, population biology, psychology, sociology, taxonomy and veterinary medicine.

As well as observational data, a wide variety of materials and methods may – subject to risk assessments, biosecurity and health and safety precautions – be utilised in studies of living zoological collections and associated products (e.g. tissue and blood samples, faeces, urine, bones, eggs, nests and feathers). For example, some substances such as hormones contained in faeces and urine are important in non-invasive studies of stress. All animals die eventually, and post-mortem material can be usefully studied and be deposited in museums and universities for future reference; especially material from threatened species.

Equally important are the computerised records and archives that zoos and aquaria maintain on breeding, e.g. parentage, clutch/litter size, inter-birth interval, infant survival, group composition, behaviour, medical issues etc. Being zoological gardens, there is an increasing engagement with botanical and horticultural research, seed banking and the breeding and management of rare and endangered species of plants, which follows the *Global Strategy for Plant Conservation (q.v.)*.

There is also a growing emphasis on conserving local or indigenous as well as exotic fauna and flora; and some zoos work with or host biological records centres for monitoring local wildlife. This new local aspect is prompted by the growing lists of threatened European species, e.g. one in six European mammals are now under threat according to the IUCN Red List; and Arctic Fox, European Mink and Iberian Lynx are among the large 'charismatic' animals which are 'Critically Endangered' and which are cared for in zoos.

Productive and inventive zoo research is also characterised by the inter-linking or cross-over of disciplines, the application of a wide range of new technologies, such as 'DNA fingerprinting' and electronic micro-chipping for species identification, cryobiology to create a gene-bank or 'frozen zoo', faecal hormonal analysis to determine levels of stress, use of blood-sucking ticks to obtain small blood samples and NMRI scanning (*q.v.*) as a non-invasive means of assessing an animal's health status.

Value in zoo management As emphasised in *Building a Future for Wildlife* (WAZA, 2005): 'Research is a tool to assist in doing any activity better'. Zoos and aquariums provide a unique setting for high quality

investigations in basic and applied science. Research initiatives may often concern conservation but can also produce a wide range of other information on which to base rational management decisions. It is estimated by the International Species Information System, ISIS (*q.v.*), that at least 10,000 animal taxa are maintained in zoological collections worldwide, with species of fish and invertebrates still substantially undercounted. In EAZA collections alone there are at least 250,000 individual animals which constitute a massive and biodiverse resource to care for and study. Collection managers and field-workers frequently identify 'gaps' or shortcomings in essential biological information on species. Research is needed to remedy this situation. Examples of high priority biological research targets are: species extinction crises; management of small threatened populations, both *in situ* and *ex situ*; understanding of human impacts on biodiversity (including through climate change) and how to reduce them; reintroduction programmes; restoration of damaged habitats; education assessments to improve public attitudes – now including studies on 'conservation psychology' (*q.v.*); and new methods for the promotion of awareness of conservation and other scientific issues.

Research allows zoos to identify and characterise problems experienced in the fields of animal husbandry and welfare and to accurately assess and predict conservational impacts of activities. Potential solutions to real problems can result and research also allows for the objective measurement and evaluation of the effects of implementation of management changes.

Zoos benefit directly from research, as results can often be immediately applied in a practical context such as in husbandry, contraception, reproduction, population management, health and ageing; and in assessing the effectiveness of educational tools and methods. Research, in its broadest context, can also be usefully applied to socio-economic aspects of running a zoo such as sustainability (*q.v.*), recycling, visitor attendance and focus, spending patterns, communications, marketing and public relations exercises. Assessing the *effectiveness* (or not) of specific conservation measures is a vital and challenging area of research.

Zoos certainly conduct important *ex situ* work including scientifically managed *'assurance' breeding programmes*, affording the potential for *reintroduction of species* that have become extinct in the wild. While the scale of conservation problems and the research needed can sometimes be overwhelming, it is important to *note and celebrate* success. For example, the European bison has been brought back from the brink of extinction to more than 1,800 animals as a direct result of scientifically managed zoo breeding programmes and reintroductions to eastern Europe (see other research-supported examples, Appendix VII).

Wider needs and benefits

As well as underpinning practical or applied science, zoo research can make a general, perhaps major contribution to fundamental or theoretical knowledge. Often problems or 'symptoms' observed in everyday animal management can only be solved

if basic research is first carried out on several aspects associated with the problem. For example in order for a good diagnostic test to be developed for a particular disease, the basic research on genetics, taxonomy or life cycle of the causal pathogen and its host may be necessary. Again, in order to address a shortage of potential breeders in a breeding programme, basic research into the social dynamics and reproductive strategies of the species may be required.

New research approaches are needed to address other emerging needs in a rapidly changing world. For instance, the Strategy recognises compelling scientific evidence that global climate change is occurring, exacerbating threats in nature and already having deleterious impacts on wildlife. As a necessary strategic consequence, many new species will likely have to be brought into zoological collections for conservation breeding, to add to those already in care and which are being studied. Examples of investigations relevant to addressing the biology of climate change include temperature-dependent sex determination in animals, the effects of changed seasonality on food availability and foraging strategies, health and reproduction and survivability and temperature tolerance in animals and plants. It is also important that zoos help monitor the impact of climate change and other potentially deleterious factors on exotic and indigenous species within their own local environment, in line with the 'Agenda 21 initiative' linked to the Earth Summit and Rio Declaration (*q.v.*) on sustainable development and the conservation of biodiversity.

Research should, for example, also be used to help determine and monitor wildlife diseases, including emergent infectious diseases such as Severe Acute Respiratory Syndrome (SARS) and avian influenza; which may also be zoonotic (communicable to and from humans). Research results should, in addition, be used to derive 'coping strategies' for the appropriate treatment, care and biosecurity of animals threatened with disease. An example here is the current amphibian extinction crisis – evidently caused in large part by the potentially lethal chytrid fungus (*Batrachochytrium dendrobatidis*) – being addressed as part of a global partnership, the Amphibian ARK (*q.v.*).

Fundamental research may be conducted by the zoo or aquarium alone, or done in cooperation with external academic research establishments. Whatever the case, such research often brings added benefits above and beyond the formulation of potential solutions to immediate practical problems in zoos and aquaria.

High-quality research published in international, refereed journals brings credibility to the zoo or aquarium. It will develop a good reputation as a serious institution that makes sound, science-based decisions. Unlike universities, zoos are not typically subject to formal research assessment exercises and the use of citation analysis to help determine the quality of published research output. However, this method of assessment may be brought in at some point under the European Zoos Directive. Funding support for research projects proposed by such zoos may more easily be obtained through external research grants and other science subsidies. Equipment bought and facilities

installed for the research project become physical assets and often bring wider benefits to the zoo's operations above and beyond the research project they were initially obtained for. Zoos that make a substantial general contribution to scientific knowledge will inevitably have a stronger public position.

Organised sources of knowledge

Good research is based on precise data – these can be gathered specifically within the framework of a research project, or can be extracted from repositories or 'store-houses' of routinely gathered information. Zoos and aquariums are distinctive enterprises in that many have specialised libraries and archives and have, for decades, invested in the routine and systematic recording of data on various aspects of animal management including daybooks, animal inventories, studbooks, biomedical records, radiographs, histological slides, biological samples, gene-banks, cryo-banks, museum material and photographs. These data are usually now incorporated in specialised computer programmes such as those operated by ISIS. The EAZA *in situ* Conservation Database focuses on scientifically managed field programmes and currently lists 436 zoo and aquarium projects in 94 countries.

The shared use of data to investigate mutual concerns is hugely beneficial to the zoo community. Scientific analyses of patterns in such databases allows for the identification of trends and problems, the extraction of previously unknown life history parameters on species and accurate biological predictions. Processed data can often provide immediate feedback to meet practical management needs.

PHOTO:
Bruce Adams

Scientific products

At different levels, many kinds of scientific analyses, method statements and reports can be produced by zoo and aquarium staff and associates and be of considerable value. However, peer-reviewed publication is regarded by professional scientists as the 'acid test' of the most rigorous and well-validated research. Not all zoo biologists achieve this high aspiration – but published and unpublished reports by keepers or other staff and visitors should be routinely deposited in libraries and be widely disseminated, including through e-mail groups and websites. University and school students and student keepers may complete very useful studies but rarely have enough skills, time and resources to conduct thorough, in-depth research. However their unpublished reports are 'indicative' for future investigations and are, at least, valuable 'research training exercises'. If well planned and executed, the results of several student or keeper projects over successive years can be combined to achieve peer-reviewed publications. Good base-line or 'pilot' studies and documentation can contribute substantially to future publications.

Public understanding of science

There is an emerging research discipline which focuses on the public understanding of science, education and technology (PUSET). Zoos and aquariums (together with natural history museums) are often the first place to which members of the public, schoolchildren and students direct animal enquiries (in person, by telephone, letter and e-mail). Research results can inform responses and stimulate a far wider appreciation of science. Zoos and aquariums, with their many millions of visitors, form the ideal (in many respects unique) platform where science and the public can meet.

In EAZA institutions alone there are 125 million visitors per annum, creating a mass 'multicultural' audience which embraces people from all ages and socio-economic categories. By bringing science to this wider public, investigators can explore contemporary attitudes to biological science and the conservation psychology. Zoos and aquariums have a role in combating unhelpful, negative public stereotypes of science and scientists and in addressing the widespread decline of classroom science teaching in Europe and the reduction of 'whole organism' content.

Science can also provide 'added value' to a zoo visit and increase appreciation of the benefits of research and its results. This should have positive consequences for future generations. It may well encourage young people to start scientific or medical careers. This is a goal now also often pursued by government ministries for science – and there may be additional public funding opportunities here. For zoos and aquariums themselves, among the most exciting experiences for a visitor is to witness 'research in action' in the zoo grounds, and to learn first hand of the zoo's own projects and results through demonstrations, talks, signage and other interactive and innovative educational interpretation. Research, therefore, should be used to increase the quality of the zoo's operations and form an 'added attraction' to help satisfy visitors. Research can be a superb vehicle for education and training, formal or informal.

EAZA Research Challenges

Working to develop research potential within EAZA is both a challenge and an opportunity in that this organisation unites more than 300 accredited zoos and aquariums who have some 20,000 employees in 34 countries. Each member zoo and country will have its own political, economic, social and cultural history. Factors which limit the growth of scientific research in zoos and aquariums include staff capacity and numbers, language, communication, taxonomic bias, non-standard methods, funding, limited physical space or other resources and institutional isolation.

Many institutions are currently unable to fully develop their research potential because they lack staff trained in research skills (project design, methodology, analysis and scientific writing). From this, there may be the mistaken view that absence of trained research staff means that no research can be undertaken. In fact, it is perfectly possible to engage in basic, worthwhile, low-cost activities in a local context and use trained volunteers to gather data (see examples of model projects, Appendix VII). There is a common taxonomic bias towards large-bodied species and towards mammals and birds versus reptiles, amphibians, fishes and invertebrates. Within mammals, primates are favoured over other taxa. This irrational bias needs to be addressed.

Linked to this is the key issue of resources. Research certainly requires a topic to focus on, time, labour and funds. The necessary level of investment may be comparatively low or high, depending on taxa and needs including equipment (e.g. benches, sinks, microscopes, fume-cabinets, computers) and analytical methods (e.g. hormonal, nutritional, genetic, faecal, electronic). Some institutions may be hampered by 'isolation', not knowing what others are working on or who has already studied what, or what the standard method is.

The EAZA member institutions have already created a substantial body of research information, yet much of it has not so far been widely disseminated. Numerous documents or publications in many different languages and with

a specialised terminology are generated each year within the European zoo community and may be difficult to locate or interpret. Zoo-relevant research articles are sometimes featured in 'obscure' journals, generally inaccessible to colleagues and the wider scientific community. In particular, there is often limited contact and scientific exchange between eastern and western European zoos, a situation which is currently being improved upon (see EARAZA). Scientific translation projects are already being embarked upon as collaborative scientific exercises.

EAZA is resolved to address the issue of research being often a low institutional priority and the associated issues of lack of capacity, isolation, inadequate communication and insufficient resources. EAZA encourages zoos and aquariums to take advantage of unique and substantial opportunities and effectively prioritise, build capacity, initiate partnerships, develop communication networks and work to enhance funding prospects [see following sections].

EAZA Research Survey

Progress made by EAZA and its member zoos in the field of research must be properly monitored and measured against baseline data and key performance indicators. This can be achieved through regular surveys that gather, quantify, analyse and express in summary figures, charts and graphs the various aspects of research. This should include the budgets and staff time that zoos spend on research, which topics are being researched, publications on zoo-based research, relationships with universities and other research institutions and assessments of the ethics, value and effectiveness of research. A basic survey of the status of research in EAZA member zoos was conducted in 2005 and an article summarising the results is provided here (Appendix VII). A research survey has also been conducted in Eurasian zoos (see EARAZA).

EAZA has established Research Goals (see next section) in response to recognised challenges, survey data and the relevant sections of the *World Zoo and Aquarium Conservation Strategy* (WZACS, 2005, *q.v.*) the *Global Strategy for Plant Conservation* and other wider strategies of the World Conservation Union and the Convention on Biodiversity. EAZA considers that the successful pursuit of these goals and formulation and delivery of action plans should mainly relate to research conducted by individual zoos and aquariums or consortia; but often in collaboration with EAZA committees or groups and also external partners, including in the habitat countries.

EAZA Research Action Plans

Outline

This section describes how EAZA will move from research challenges to beneficial opportunities and how it will achieve its goals in outline and in specific detail. It covers the prioritisation of research, the need and means to build capacity and partnerships, to communicate more widely, set a budget and raise funds. The potential partnership role of NGO's (*q.v.*), universities and museums and other educational and training establishments is highlighted.

Identify research priorities

The scope for research is huge, and time and resources are always limited, so it is important to identify research priorities. There are several bases for this. For example:

- degree of threat, where threatened species are high priorities (e.g. IUCN www.redlist.org);
- species that are endemic to biodiversity hotspots (e.g. www.unep-wcmc.org);
- problems identified by EAZA Taxon Advisory Groups, EEP Species Committees and other EAZA Groups;
- biological issues in individual collections;
- specialities and facilities of associated university departments;
- specialities and expertise of staff.

The above list is by no means exhaustive. Irrespective of how research is prioritised, it is vital to communicate in order to maximise opportunities for collaboration and to avoid unnecessary duplication of effort. However, a desirable 'repeatability' of results may involve parallel studies in separate institutions. Whenever possible, the results of research should be published in the most appropriate format, such as peer-reviewed research journals, taxon specialist journals, and other professional publications.

Build research capacity

EAZA zoos and aquariums need to expand their research capacity in order to be taken seriously as scientific institutions. This means that research should not just be 'a minor role' or peripheral aspect, but become an integrated part of organisational strategy – one which fosters a 'learning and innovation culture'. This is an 'evidence-based' culture which queries, tests, records and analyses information as a basis for decision-making.

Zoos and aquariums have in their collections animals and plants about which we may know very little and which may be close to extinction, at least in the wild. The zoological community has an obligation to maximise the opportunities for learning about threatened species to better care for them and ensure the survival of populations and species.

Scientifically trained staff will develop and deliver good quality, worthwhile research. This means having, minimally, at least one trained person with a research remit. More staff can have a synergistic, 'multiplier' effect and eventually build a department. To employ animal care staff with science backgrounds (degrees, diplomas or technical qualifications) is also consistent with an organisational research strategy. In this way, the scientific approach can gradually pervade an organisation and become an internal funding priority.

PHOTO:
Rob Doolaard/IZP

Zoos and aquariums should contribute to building research capacity generally by acting as training grounds for keepers and students at home and abroad. Every year, many undergraduate and graduate students of zoology, biology, environmental science, veterinary medicine, anthropology and psychology gain placements in European zoos as a required part of their course and they conduct research projects. Increasingly, zoos are a major resource underpinning the production of graduates in these and other areas.

Zoos and aquariums are attractive places to study. By making collections available to others to investigate and they provide unique training opportunities. Such an exercise also exposes students directly to conservation issues, and to the challenges of animal management and of shaping human attitudes to wildlife. These experiences can be critical in positively influencing student career choices. Hosting students usually requires input by the zoological institution (e.g. a student coordinator). Professionally organised and focused studies by external students can generate useful research projects.

Build research partnerships

EAZA zoos and aquariums can significantly increase their research potential by developing partnerships. By working together, often through national and regional networks, they can acquire sufficient 'critical mass' to undertake studies with representative sample sizes. Several zoos can also collaborate together to for example fund studies, support a researcher, buy equipment, provide samples, etc. This provides a means for small institutions with limited resources to make a contribution to scientific research.

Engage with science-based organisations and institutions

As well as collaborations within the zoo and aquarium community, partnering with academic or science-based institutions or organisations (wildlife NGO's, research institutes, scientific societies, government agencies, universities and museums (for the latter two see below) is an excellent way for zoos and aquariums to gain access to trained scientists and specialised equipment and to develop cooperative research studies. Research involving the overlap between key disciplines can often yield productive results.

Creating a relationship with or gaining membership of an IUCN-SSC specialist group can be very beneficial. In particular, the IUCN-SSC Conservation Breeding Specialist Group (*q.v.*) and Reintroduction Specialist Group (*q.v.*) are already closely-linked with zoo programmes, the facilitation of strategy development and conservation and research training exercises. There are also numerous IUCN-SSC taxon specialist groups such as for elephants, crocodiles, amphibians and fishes and each one will have its own strategy, priorities and programmes.

Engage with universities

Some zoo staff will be of sufficient calibre to be engaged by a partner university as part-time visiting researchers or lecturers in biological and veterinary science departments. In this capacity these staff can participate in academic life at undergraduate and postgraduate

level including research, refereeing scientific papers, teaching, course evaluation and examination and in the supervision of research students. Similarly, zoo staff should be encouraged and supported to participate in external scientific panels and boards where there is a correspondence in aims. The expertise thus gained will provide beneficial feedback for the zoo and help inform its own programmes and processes.

Zoos can, in turn, invite university staff to become research associates or become members of a working group or board. Zoos can also help organise or host scientific lectures, conferences and seminars and publish the results. They can build up specialist reference libraries and archives on research topics together with material banks (e.g. the Frozen Ark Project; *q.v.*) for use by staff and visitors (see below). Joint field expeditions to conduct research is another promising area.

Engage with nature museums

Taxonomic problems often hamper the management of animal collections and wild animals, and natural history museums may hold preserved examples of variation in what are now fragmented (or extinct) populations. They may also have living zoo or aquarium animals. Zoos can establish their own museum or material can be accessed in external institutions. Zoo, museum and botanical garden collections (both living and preserved) can complement and support each other. Building such partnerships in systematic, comparative and 'whole organism' biology will be mutually advantageous.

Material supplied by zoos and aquaria can be used for research into taxonomy, anatomy, pathology, functional morphology, reproductive biology, ageing studies and many other purposes. Museum specimens such as skulls, eggs, skins, faeces, feathers, cryo-preserved gametes and DNA can be used in research and in scientific education and training. It is important that EAZA institutions keep and share high-quality specimen information through ISIS-ZIMS, especially on threatened taxa.

Foster social science research

While zoos and aquariums have been making ever greater contributions to biological, veterinary and conservation sciences, there has been a relative dearth of social science research. This is puzzling as zoos are social and cultural centres, their 'raison d'etre' to welcome people through their gates to explore and become immersed in the natural world through exhibits and presentations.

There has been limited academic evaluation as to how visitors and the general public perceive the modern zoo, its place in society and its impact on conservation and economies. Given that most zoos rely on public support for their existence they should seek answers to these questions. Some kinds of external funding support may depend on these results (see funding, page 24).

A subject area that should be particularly important to zoos is the better understanding of the effectiveness of education, both formal and informal. One approach to this is observed in the emerging field of conservation psychology: the scientific study of the reciprocal relationships between humans and the rest of nature, with a particular focus on how to encourage conservation of the natural world. It aims to understand two broad outcome areas: how people behave towards nature, and how people care about or value nature. The public motivation to fund conservation (or not) is clearly an important aspect.

EAZA zoos speak to 125 million Europeans a year, but are we speaking to these visitors in the most effective way, are our visitors listening, and most importantly are our messages leading to positive conservation action by our visitors? More research in the thematic area of conservation psychology would assist in improving understanding. Emotional engagement using science is a central aim.

Social sciences and ethnographic research can also be useful in the field when considering, for example, the conflict between people and animals, or exploring alternative livelihoods as a means of minimising habitat destruction and the poaching of animals. Research on the value and impacts of ecotourism is also necessary.

PHOTO:

Rob Doolaard/IZP

Build research communications

EAZA zoos and aquariums need to develop extensive communication networks for discussing research and rapid on-line publication outlets. The EAZA Taxon Advisory Groups, Committees and Working Groups are existing collaborative groups gathered around particular clusters of species, focused on individual species or dealing with specific topics (e.g. genetic management, reintroduction, ethics). Part of their remit is to identify research priorities in terms of generalised problems or issues for particular taxa. These problems frequently need to be turned into specific questions that can be addressed by a scientific investigation. However, such problems provide an important 'to do' list for the improved management of animals and often raise and resolve questions of basic biology.

The EAZA Research Committee is an important forum in this process, but there are many other relevant EAZA Committees and Working Groups (*q.v.*) where research, development and ethical questions arise.

Invest in and fundraise for research

One way of implementing an organisational research strategy is for zoos and aquaria to emulate other successful types of organisations which invest at least 5% of their budget per annum in research and development ('R&D'). Details of individual zoo operations with commercial aspects are included annually in the *International Zoo Yearbook*. The EAZA *in situ* Conservation Database tracks financial contributions made directly to field projects.

The means of funding research can be tackled in different ways. Many research questions only require small sums to be addressed successfully and can be managed on modest internal budgets. Careful and systematic observation and the basic recording of what is seen can generate new understanding. Other studies may involve more significant costs. Where and how these funds can be obtained (and where and how they should be applied) requires commitment, prioritisation, a trained level of competence, time to look, and often a degree of imagination.

The zoo itself should always be prepared to provide 'seed money' to its staff in order to conduct feasibility or pilot studies, and to initiate research contacts between staff, Taxon Advisory Groups and trained researchers. Increasingly, university staff need to have skills in research fundraising – from which zoos with links and attractive research questions may benefit.

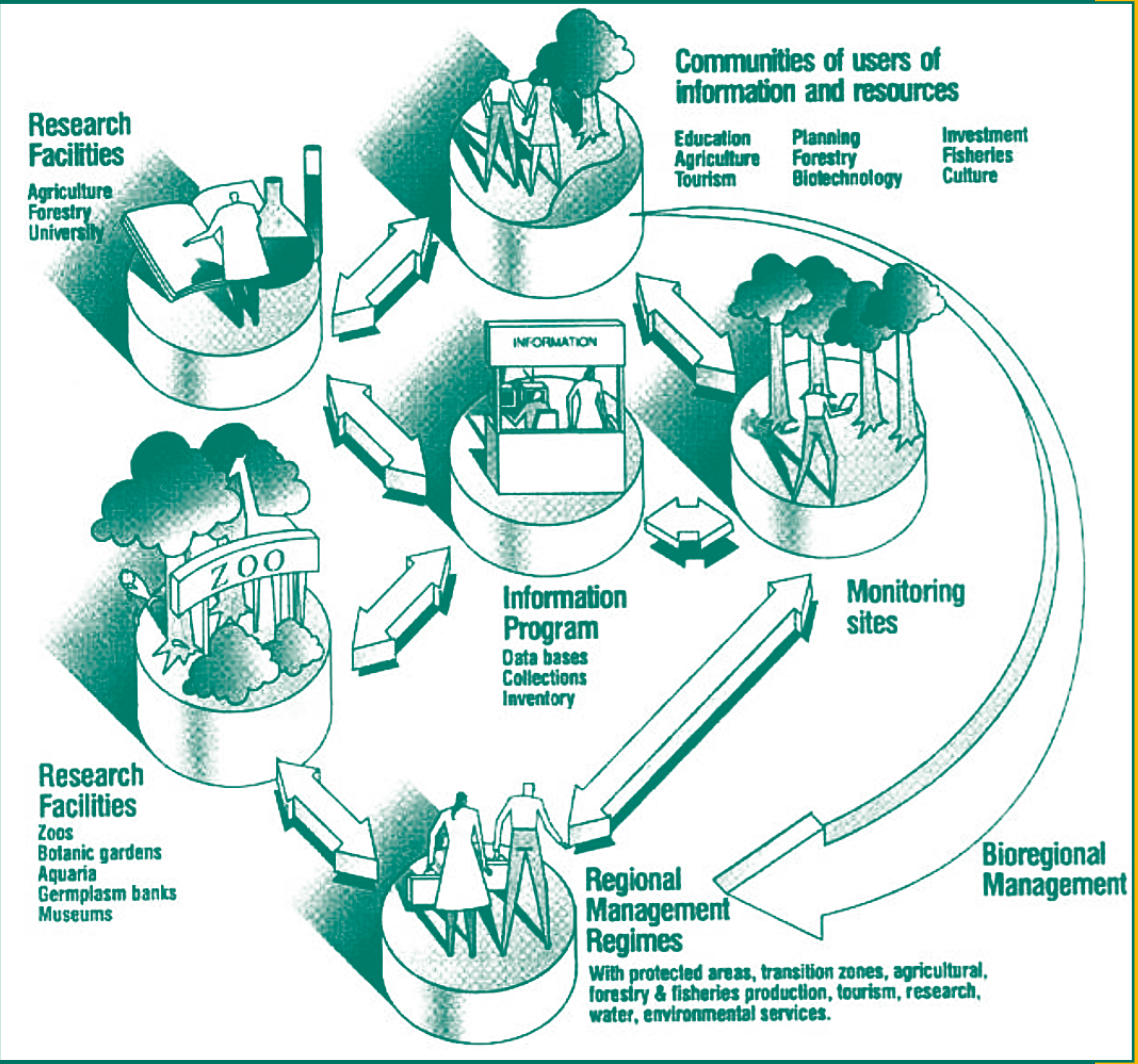
Current external sources of research funding or sponsorship to zoos include individuals, special (often species) interest groups, bequests, grants, trusts, charitable organisations, industry and commerce, local and national research bodies, as well as local and national governments, non-government organisations (NGOs) and major international agencies such as IUCN, World Bank, EU, UN, UNESCO (*q.v.*) and FAO (*q.v.*). Article 20 of the Convention on Biological Diversity deals with financial resources.

Sometimes, the available funding may not be specifically related to the question to be investigated and so the applicant may find it difficult to obtain the 'best fit' to their project. However, such grants may provide some or most of the materials essential to answering the questions relevant to the zoo. Lateral aspects include, for example, funding for laboratory space or equipment for a wide range of veterinary or husbandry studies. These can (as a 'by-product') facilitate the answering of research questions, or perhaps a conference centre could be made available which will provide the venue for discussing how to tackle research questions that emerge, or perhaps a redesigned enclosure can include facilities for animal weighing, measuring and conditioning which were absent in the old enclosure.

It is important to note that there will be times when one area of research is preferred by those providing financial support, and there can appear to be 'fashions' in topics and the availability of research funding. Also note that those who fund research often need to be able to see published output reporting the successful creation of new knowledge (or its successful application) from the money contributed. High-quality and interesting research results attract attention which should be publicised through the zoos public relations machinery. This helps to make subsequent applications for further funds successful and will normally be essential in the case of attracting commercial sponsorship.

It will often be the case that a cluster of organisations with a joint research proposal (especially across Europe) will stand a greater chance of funding success than a stand-alone project offered by a single zoo (see Coral Zoo project, Appendix VII). There is also a presumption in favour of entering into funding partnerships with zoos or conservation bodies in the developing countries.

While small grants may be readily accessible, the application process for large grants can be onerous and take months or years. It is more likely to be successful through consortia and using the expertise of people familiar with the process. Sometimes the recruitment (for a fee) of professional fundraisers ('development managers') will produce results.



Summary diagram to illustrate the information flow and relationships between various stakeholders involved in the conservation of biodiversity, *in situ* and *ex situ*. This includes the research contributions of zoos, botanic gardens, aquariums, germplasm or gene banks and museums. Courtesy of WRI/ IUCN/ UNEP, 1992. *Global Biodiversity Strategy: Guidelines for Action to Save, Study and Use Earth's Biotic Wealth Sustainably and Equitably*. World Resources Institute, Washington DC; The World Conservation Union, Gland, Switzerland; and the United Nations Environment Programme, Nairobi, Kenya.

Research Action Plan

Specifics

Zoo and aquarium research objectives should be 'SMART' i.e. specific, measurable, achievable, realistic and time-bound. Below, a '14 point plan' is provided of specific goals, objectives and actions for EAZA institutions, the EAZA Research Committee, the EAZA Executive Office and EAZA partners. The time-bound elements will be tracked in annual progress meetings and reports of the EAZA Research Committee.

Goals

Each EAZA institution will:

1. *Identify and pursue its own research policies and priorities.*
2. *Participate in research.*
3. *Develop an infrastructure, equipment and allocate sufficient staff time for research, taking into account the policies and priorities of other conservation and research agencies.*
4. *Link research priorities and policies to the regional and institutional animal collection planning process and the relevant activities of others.*
5. *Increase the dissemination of research plans, news and results.*
6. *Identify research priorities and projects in which they can cooperate collectively.*
7. *Ensure that all staff and departments understand the value of and need for research in zoos.*
8. *Integrate research as a component of management decisions into all disciplines within the institution.*
9. *Maximise the use of ZIMS and other zoo-based databases as research tools.*
10. *Measure and evaluate research processes, progress and output.*

EAZA Taxon Advisory Groups, Committees and Working Groups will:

11. *Identify research questions specific to their taxa/expertise.*
12. *Ensure that all members understand the value of and need for research on their taxa or area of expertise.*
13. *Disseminate research plans, news and results.*
14. *Measure, evaluate, recognise and celebrate research progress and the resultant output and success.*

How EAZA plans to pursue these goals in detail is indicated in the next section.

Objectives and actions:

1. *Each Institution will identify and pursue its own research policies and priorities.*
   - 1.1. Each institution (guided by the examples shown on the EAZA website) will write research policies and priorities appropriate to its capacity and report this to the relevant EAZA Annual General Meeting. (Action: All EAZA Members)
   - 1.2. Examples of institutional policies and priorities will be collated that cover the range of capacities and topics of EAZA institutions. (Action: EAZA Executive Office)
   - 1.3. Examples of statements on ethical, legal, social and environmental guidelines will be collated which cover the range of nationalities and capacities of EAZA institutions. (Action: EAZA Research Committee)
   - 1.4. EAZA Research Committee will review the collected material and select appropriate examples selected for the website. (Action: EAZA Research Committee)
   - 1.5. The EAZA website will show and develop examples of policies, priorities and statements which cover the range of capacities and topics of EAZA institutions. (Action: EAZA Executive Office)

2. *Each institution will participate in research.*
   - 2.1. The EAZA Research Committee will ensure documentation is readily available to assist Institutions in undertaking research and, where necessary, stimulate production of other model documents. (Action: EAZA Research Committee; EAZA Executive Office)
   - 2.2. The EAZA Executive Office will develop criteria for and advertise an annual EAZA Research Award. (Action: EAZA Executive Office)
   - 2.3. The EAZA Executive Office will conduct a survey of institutional research activity at least every 3 years. (Action: EAZA Executive Office)

3. *Each institution will develop an infrastructure and allocate staff time for research.*
   - 3.1. Institutions will set aside a percentage of the budget for research and report this to the relevant EAZA Annual General Meeting. (Action: All EAZA members)
   - 3.2. Institutions will allocate space and obtain equipment and materials necessary for research by staff and visitors; possibly eventually including, for example, laboratory benches, sinks, fume cabinets, microscopes, a library, archive, computer database, gene-bank, cryo-bank and museum collection. Any laboratory facilities must be developed to meet relevant safety, health, hygiene, environmental and biosecurity standards. (Action: All EAZA Members)
   - 3.3. Institutions will set a target to employ at least one appropriately trained researcher as an established member of staff or engage a research associate. (Action: All EAZA Members)
   - 3.4. Institutions will set aside a realistic percentage of staff time for research and research training and report this to the relevant EAZA Annual meeting. (Action: All EAZA Members)
   - 3.5. Institutions will consider opportunities to conduct research when new animal accommodation is being developed. (Action: All EAZA Members)

3.6. The EAZA Research Committee will provide guidance to members on how to access sources of research funds and help build partnerships. (Action: EAZA Research Committee)

4. *Each institution will link research priorities and policies to the regional and institutional animal collection planning process.*

4.1. Institutions will take account of recommendations of the EAZA Taxon Advisory Groups, Committees and Working Groups and IUCN/SSC specialist groups when identifying their research priorities and policies. (Action: All EAZA Members)

4.2. EAZA Taxon Advisory Groups, Committees and Working Groups will make their research recommendations and links to relevant web sites readily available on the EAZA website. (Action: EAZA Taxon Advisory Groups, Committees and Working Groups; EAZA Executive Office; EAZA Research Committee)

5. *Each institution will increase the dissemination of research plans, news and results.*

5.1. Institutions and their collaborators will include news of their research activities, results and successes in their annual reports, International Zoo News, EAZA Research Newsletter, EAZA News, zoo magazines, IUCN Specialist Group newsletters, etc. (Action: All EAZA Members)

5.2. Institutions and their collaborators will publish the results of their research activities in the most appropriate form (paper or electronic media), including in refereed research journals, taxon specialist journals and professional publications. They will also collate and make readily accessible unpublished scientific reports by staff, students and other visitors. In all cases appropriate credit and benefit must be given to the contributors of written material, specimens, photographs and other materials. (Action: All EAZA Members)

5.3. The EAZA Research Committee will continue to support the organisation and publication of research symposia, sponsor publications and produce its research newsletter and make it relevant to changing needs. (Action: EAZA Research Committee)

5.4. Institutions to send delegates to attend international zoo research seminars and conferences and host or organise these where possible. (Action: All EAZA Members)

5.5. The EAZA Research Committee will expand the list of periodicals to better indicate the range of periodicals in which articles can be published. (Action: EAZA Research Committee)

5.6. Measuring dissemination of research output will be included in the next EAZA Research Survey. (Action: EAZA Executive Office)

6. *Each institution will identify research priorities and projects in which they can cooperate collectively.*

6.1. EAZA Taxon Advisory Groups, Committees and Working Groups will list the ongoing and intended research in their annual reports, their e-mail groups and websites. (Action: EAZA Taxon Advisory Groups, Committees and Working Groups)

6.2. Where appropriate, each institution should cooperate in a research coordinated by Taxon Advisory Groups, species programmes and/or EAZA Committees/Working Groups. (Action: All EAZA Members)

6.3. Wherever possible, organisations should favour and engage in research projects in partnership with conservation agencies in the habitat country. The equitable sharing of research materials and benefits must be ensured. (Action: All EAZA Members)

7. *Each institution will ensure that all staff and departments understand the value of and need for research in zoos.*

7.1. Institutions will encourage and facilitate all research visitors and collaborators, to present their research results to zoo staff, including the core administration. (Action: All EAZA Members)

7.2. Institutions will make research policies and output available to all zoo personnel. (Action: All EAZA Members)

7.3. Institutions will ensure participation of research staff in other zoo activities. (Action: All EAZA Members)

8. *Each institution will adopt and integrate research as a component of management decisions into all disciplines within the institution.*

8.1. Institutions will ensure participation of research staff in zoo decision-making processes. (Action: All EAZA Members)

9. *Each institution will maximise the use of ZIMS and other zoo-based data bases as research tools.*

9.1. Institutions will enter accurate, consistent and reliable information into ZIMS and other databases. (Action: All EAZA Members)

9.2. ISIS and Institutions will agree upon policies required to define intellectual property rights, data sharing agreements and form of acknowledgements. (Action: ISIS; All EAZA Members)

9.3. Institutions, EAZA Taxon Advisory Groups, Committees and Working Groups will recommend research-related issues to be included in ZIMS. (Action: EAZA Research Committee)

10. *Each institution will measure and evaluate research processes, progress and output.*

10.1. Institutions will incorporate evaluation into their research strategy. (Action: All EAZA Members)

10.2. The EAZA Executive Office will conduct a survey of institutional research activity at least every three years. (Action: EAZA Executive Office)

11. *EAZA Taxon Advisory Groups, Committees and Working Groups will identify research questions specific to their taxa/expertise.*

11.1. EAZA Taxon Advisory Groups, Committees and Working Groups will formulate research questions relevant to their taxa/expertise. (Action: EAZA Taxon Advisory Groups, Committees and Working Groups)

11.2. EAZA Taxon Advisory Groups, Committees and Working Groups will take into account the recommendations of specialist groups, e.g.

IUCN/SSC. (Action: EAZA Taxon Advisory Groups, Committees and Working Groups)

11.3. The EAZA Research Committee will liaise with and assist EAZA Taxon Advisory Groups, Committees and Working Groups in suggesting projects suitable to individual member zoos and other partners. (Action: EAZA Research Committee)

11.4. The EAZA Research Committee will assist EAZA Taxon Advisory Groups, Committees and Working Groups to liaise with universities and other organisations which can help transform the questions into research projects/hypotheses. (Action: EAZA Research Committee)

11.5. The EAZA Research Committee will ensure documentation is readily available to assist EAZA Taxon Advisory Groups, Committees and Working Groups in undertaking research and, where appropriate, stimulate production of model documents. (Action: EAZA Research Committee; EAZA Executive Office)

12. *EAZA Taxon Advisory Groups, Committees and Working Groups will ensure that all members understand the value of and need for research on their taxa.*

12.1. EAZA Taxon Advisory Groups, Committees and Working Groups will present and discuss research reports at their meetings. (Action: EAZA Taxon Advisory Groups, Committees and Working Groups)

12.2. EAZA Taxon Advisory Groups, Committees and Working Groups will invite outside researcher(s) with an interest in the relevant taxa to present information/research results at their meetings. (Action: EAZA Taxon Advisory Groups, Committees and Working Groups)

12.3. EAZA Taxon Advisory Groups, Committees and Working Groups will support and cooperate with appropriate research initiatives from any source. (Action: EAZA Taxon Advisory Groups, Committees and Working Groups)

13. *EAZA Taxon Advisory Groups, Committees and Working Groups will disseminate research plans, news and results.*

13.1. EAZA Taxon Advisory Groups, Committees and Working Groups will share research questions, news and results on the EAZA website and TAG list serves. (Action: EAZA Taxon Advisory Groups, Committees and Working Groups)

13.2. The EAZA Research Committee will continue to produce the EAZA Research Newsletter and sponsor other relevant publications. (Action: EAZA Research Committee)

13.3. The EAZA Research Committee will identify individuals and guidelines to assist in the publication of data. (Action: EAZA Research Committee)

14. *EAZA Taxon Advisory Groups, Committees and Working Groups will measure, evaluate, recognise and celebrate research progress and the resultant output and success.*

14.1. The EEP Committee, in cooperation with the EAZA Research Committee, will evaluate the research activity of the TAGs as part of the routine monitoring of TAG and EEP functions. (Action: EEP Committee, EAZA Research Committee)

Appendix I. Zoo research: ethical guidelines

It is vitally important for all zoos and aquariums that engage in research to be familiar with best practice and to adopt the highest ethical standards. In particular they must abide by national and international legislation and the code of practice set by EAZA and other responsible bodies. All EAZA institutions should, among other things, maintain excellent standards of animal welfare, avoid invasive or intrusive studies, prevent escapes of alien species to nature, abide by legislation covering transport, and follow standardised permit procedures (e.g. CITES) when transferring samples or stock. Details of all the codes are on the EAZA website (www.eaza.net) and are grouped under the EAZA Code of Practice (2004). There is a separate section covering research.

EAZA Code of Practice, Article 4 Research

- Members will facilitate appropriate non-invasive and humane research on animals in their collection by approved researchers.
- Members will encourage and support their staff to collect and record data, to carry out relevant research and to publish and/or present the results of these efforts, recognising the role that the animals in their care could take in furthering scientific knowledge.
- Members must observe the EAZA Research Standards (1997).

www.eaza.net

At all times EAZA members should also act in conformity with the EAZA Code of Ethics and the WAZA Code of Ethics and Animal Welfare: 'Ethical Guidelines for the conduct of research on animals by Zoos and Aquaria' (www.waza.org). There are other international statutes, codes and conventions to follow. For example, the EU Zoos Directive (Appendix II) is primarily concerned to ensure that zoos in the Member States accommodate their animals under conditions which aim to satisfy the biological and conservation requirements of the individual species. By comparison the World Conservation Union (IUCN) (Appendix IV) holds that all research on or affecting a threatened species carries a moral responsibility for the preservation or enhancement of the survival of that species; and the Convention on Biological Diversity (Appendix III) is concerned to see the conservation of biological diversity, the sustainable use of its components (including species) and the fair and equitable sharing of the human benefits deriving from the use of genetic resources. An organisation should not gain an unfair benefit through withholding results, e.g. a new method which allows for the public display of an otherwise difficult to maintain animal. Last, peer-reviewed journals where zoo researchers might publish will have their own guidelines and high ethical standards to meet.

Ethical issues

While conservation may act as a main driver (see above), there are very many other appropriate subject areas for research, some of which concern theoretical questions and others which facilitate practical animal identification and management or relate directly to husbandry and welfare. Whatever the topic there will be ethical issues to consider. Fundamentally, ethics concerns that which is morally correct and is the science of morals, moral principles or codes. In turn, morals is concerned with the distinction between right and wrong (good and bad).

In theology there will often be an absolute and objective distinction between 'good and bad' (based on belief); whereas for many biologists these are subjective and relative values. Nevertheless, commonly agreed moral principles often lead to codes of conduct and laws. That is to say some of the work needed to determine what is 'right and wrong' is already embodied in statutes. For example, the Scientific Procedures Act, 1986, in the UK regulates any experimental or scientific procedure applied to a protected animal which

may cause that animal pain, suffering, distress or lasting harm, and defines a protected animal as any living vertebrate, other than man. This includes mammals, birds and reptiles from halfway through gestation or incubation periods and fish and amphibians from the time that they are capable of independent feeding. There has been a recent focus on pain perception in embryos contained in vertebrate eggs and the associated need in particular circumstances for euthanasia beyond a critical stage in development (see below). Nonetheless, the point at which an embryo needs to be protected is not always clear and invertebrates (including highly complex and sentient cephalopods) do not always have protection in national legislation on scientifically regulated procedures. Hence, before embarking on a programme, zoo researchers should first be guided by their national conservation, animal welfare and scientific procedures legislation but they must also exercise prudent and humane judgement. Here, the term 'bioethics' is sometimes employed. It was first used in 1970 and now represents a major academic discipline for Ethical, Legal, Social and Environmental (ELSE) issues, which are often intertwined.

When considering the ethics of acquiring animals which may be subject to research there are issues concerning purpose and value, i.e. what serves the 'greater good' in conservational and/or welfare terms? In the case of sample size – too small and it will be scientifically invalid, too large and it may be wasteful. If some animals are 'sacrificed' (killed) for critical data that cannot reasonably be obtained by other means, there is the issue of euthanasia (humane killing). In many instances there will be no clear 'right and wrong'. What is 'bad' for an individual animal may be 'good' for a species and vice versa. The impact of research on individual animals (their welfare and survival) will often have to be balanced against the impact on populations (group survival) and attendant conservation implications (species survival). There might even need to be an evaluation of these aspects in relation to any impacts on the ecosystem (environmental sustainability). Independent of arguments in sustainability, zoos and aquariums should not engage in trade in rare animal parts or products such as ivory, tiger skins, shark jaws, preserved butterflies and coral skeletons.

Animal welfare and the 'five freedoms'

Traditional ethics essentially bypass the moral 'status' and moral 'rights' of animals. The intellectual case for 'animal rights' has been strongly made by some authors who typically espouse a philosophy (perhaps not always coherent or consistent) that zoo biologists may find hard to accept. Animal rights groups often focus on the love and care for individual animals (versus the more abstract and general concepts of 'nature conservation' and 'species survival'), and, for them, the negative and morally repugnant impact of management in the confines of a zoo.

The 'five freedoms' of Professor John Webster are often utilised by animal welfare and animal rights organisations. Webster considers that for all animals there should in essence be: 'freedom from hunger, freedom from discomfort, freedom from pain, injury and disease, freedom from fear and distress and freedom to express normal behaviour'.

At first sight these 'freedoms' seem to be rooted in common sense and can serve as useful ethical guiding principles for zoo managers and researchers. But, on closer reflection, just how valid and useful are these welfare principles? Are they fully realistic, definable and measurable – and what are the implications for scientific experimentation? Much of our view must be inferred from the behaviour of the animal or physiological measures – and what is 'normal' and acceptable is not always clear. For example, some stress (including in nature) will be necessary to keep any animal physiologically primed and mentally active. But how much stress is 'appropriate' and when does 'stress' become 'distress'? For example, the 'motivation principle' in well-intentioned 'behavioural enrichment' experiments must depend to a degree on hunger or discomfort but, certainly, this should not be excessive. In many instances there will be no clear 'right' or 'wrong' and researchers must adopt the 'precautionary principle', erring on the side of minimising any prospective harm that might result from the particular investigation or activity.

Appendix II. Zoo research: EU Zoos Directive

European zoos and aquariums within the European Union (EU) have legal and statutory obligations to demonstrate their research activities under zoo licensing inspections and for other external assessments. Zoos and aquariums in member states of the EU are all obliged to interpret the EU Zoos Directive (1999) nationally. The Zoos Directive, now being enacted by many member countries, encourages zoos to participate in research, particularly where conservation benefits accrue to a species. It also endorses training in the relevant research skills and the exchange of information relevant to species conservation, including breeding and reintroduction to the wild.

The European Council Directive 1999/22/EC relating to the keeping of wild animals in zoos (the EU Zoos Directive)

The keeping of animals in zoos must be regulated to ensure the preservation of species while retaining a role in education and scientific research. The Directive requires EU Member States to have in place domestic legislation to protect wild animals and conserve biodiversity through a licensing and inspection regime for zoos.

'Zoos' are defined as all permanent establishments where live animals are kept, with a view to public display for seven days per year or more, with the exception of circuses and pet shops; also those establishments that the Member States exempt from the requirements of this Directive by virtue of the fact that they do not display a significant number of animals or species to the public and that this exemption does not undermine the objectives of this Directive.

The Member States guarantee that all zoos will implement the following conservation measures:

- participating in research from which conservation benefits accrue to the species, and/or training in relevant conservation skills, and/or the exchange of information relating to species conservation and/or, where appropriate, captive breeding, repopulation or reintroduction of species into the wild;
- promoting public education and awareness in relation to the conservation of biodiversity, particularly by providing information about the species exhibited and their natural habitats;
- accommodating their animals under conditions which aim to satisfy the biological and conservation requirements of the individual species, inter alia, by providing species specific enrichment of the enclosures; and maintaining a high standard of animal husbandry with a developed programme of preventive and curative veterinary care and nutrition;
- preventing the escape of animals in order to avoid possible ecological threats to indigenous species and preventing intrusion of outside pests and vermin;
- keeping of up-to-date records of the zoo's collection appropriate to the species recorded.

Appendix III. Zoo research: Convention on Biological Diversity

The Convention on Biological Diversity was adopted by world leaders at the 1992 Earth Summit (*q.v.*) in Rio de Janeiro and establishes three main goals: the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits from the use of genetic resources. Within the convention, specific reference is made to the need for *ex situ* conservation (Article 9) and research and training (Article 12). See the separate entries below for each of these articles and www.biodiv.org for more on Article 16 *(Access to and transfer of technology)*, Article 18 *(Technical and scientific cooperation)* and Article 20 *(Financial resources)*.

Convention on Biological Diversity:

Article 9, *Ex situ* conservation

Each contracting party shall, as far as possible and as appropriate, and predominantly for the purpose of complementing *in situ* measures:

(a) Adopt measures for the *ex situ* conservation of components of biological diversity, preferably in the country of origin of such components;

(b) Establish and maintain facilities for *ex situ* conservation of and research on plants, animals and micro-organisms, preferably in the country of origin of genetic resources;

(c) Adopt measures for the recovery and rehabilitation of threatened species and for their reintroduction into their natural habitats under appropriate conditions;

(d) Regulate and manage collection of biological resources from natural habitats for *ex situ* conservation purposes so as not to threaten ecosystems and *in situ* populations of species, except where special temporary *ex situ* measures are required under subparagraph (c) above; and

(e) Cooperate in providing financial and other support for *ex situ* conservation outlines in subparagraphs (a) to (d) above and in the establishment and maintenance of *ex situ* conservation facilities in developing countries.

Article 12, Research and training

The contracting parties, taking into account the special needs of developing countries, shall:

(a) Establish and maintain programmes for scientific and technical education and training in measures for the identification, conservation and sustainable use of biological diversity and its components and provide support for such education and training for the specific needs of developing countries;

(b) Promote and encourage research which contributes to the conservation and sustainable use of biological diversity, particularly in developing countries, inter alia, in accordance with decisions of the Conference of the Parties taken in consequence of recommendations of the Subsidiary Body on Scientific, Technical and Technological Advice;

(c) And in keeping with the provisions of Articles 16, 18 and 20, promote and cooperate in the use of scientific advances in biological diversity research in developing methods for conservation and sustainable use of biological resources.

Appendix IV. Zoo research: Global Biodiversity Assessment

Published in 1995 and commissioned on behalf of the United Nations Environment Programme (UNEP), the Global Biodiversity Assessment (GBA) is designed to support the Convention on Biodiversity (*q.v.*, Appendix III). It is an independent, peer-reviewed scientific analysis of the current issue, theories and views regarding the main aspects of biodiversity. An essential element is held to be the collection and dissemination of knowledge generated by scientific research.

In the **Summary for Policy Makers** (see References) the GBA considers that: "A wide variety of measures can be used to conserve biodiversity including both *ex situ* and *in situ* methods. ... *Ex situ* conservation centres such as arboreta, aquariums, botanic gardens, seed banks, microbial collections, field gene banks, forest nurseries, propagation units, tissue and cell cultures, zoological gardens and museums can help conserve stocks of both wild and domesticated animals, plants, fungi and micro-organisms but are less able to maintain their populations. ... Enhanced research, inventory and monitoring are important to promote responsible policy-making and management. Research into the uses and applications of biodiversity and its components is important as is further research into ways in which biodiversity contributes to the provision of ecological services, so that those services can be sustained indefinitely. ... [and in terms of building national capacity and expertise] ... Committed and skilled people are the key to successful maintenance and sustainable use of biodiversity. Training must be provided for those involved in managing protected areas, conducting biodiversity inventories, and developing and safe-guarding *ex situ* collections of all kinds. ... National training programmes and international exchange programmes must concentrate on producing more skilled scientists, particularly in developing countries. ... Educating the public and making people aware of the issues involved in biodiversity are essential elements in improving the decision-making process."

Appendix V. Zoo research: World Conservation Union (IUCN)

The IUCN holds that all research on or affecting a threatened species carries a moral responsibility for the preservation or enhancement of the survival of that species. Maintenance and development of the research resource is clearly in the interest of the researchers. Basic and applied research is critically needed on many aspects of the biology of animal and plant species at risk of extinction (e.g. those listed by IUCN as Vulnerable, Endangered, Critically Endangered, or Data Deficient) to provide knowledge vital to their conservation. Other scientific interests may involve the use of threatened species in a wide variety of studies and thus the IUCN has a policy supporting research involving threatened species (www.iucn.org). The Species Survival Commission of IUCN contains science-based specialist groups which are either thematic (e.g. Conservation Breeding Specialist Group; Reintroduction Specialist Group) or taxon based (e.g. groups for elephants, rhinos, small carnivores, parrots, crocodiles, amphibians and fishes). Many of these groups count zoos and aquariums and/or their staff among the membership.

IUCN Policy Statement on Research Involving Species at Risk of Extinction

IUCN encourages basic and applied research on threatened species that contributes to the likelihood of survival of those species.

When a choice is available among captive-bred or propagated, wild-caught or taken, or free-living stock for research not detrimental to the survival of a threatened species, IUCN recommends the option contributing most positively to sustaining wild populations of the species.

IUCN recommends that research programmes on threatened species that do not directly contribute to conservation of the species should acknowledge an obligation to the species by devoting monetary or other substantial resources to their conservation, preferably to sustaining populations in the natural environment.

Whether animals involved are captive-bred, wild-caught, or free living, or whether plants involved are propagated, taken from the wild, or in their natural habitat, IUCN opposes research that directly or indirectly impairs the survival of threatened species and urges that such research not be undertaken.

Approved by the 27th Meeting of IUCN Council, Gland Switzerland, 14 June 1989

Appendix VI. Zoo research: EAZA Benchmarking Survey

During 2005, a survey on research was conducted among EAZA members, upon the request of the EAZA Research Committee. The survey had two main aims:

- To obtain baseline data (where are EAZA members now regarding research?)
- To identify how the EAZA Research Committee can best support EAZA members to achieve their research potential and follow statutory requirements (e.g. via the EU Zoos' Directive, *q.v.*).

The questionnaire was designed by EAZA Research Committee members. Production, distribution and analysis of the survey results was conducted by staff at the EAZA Executive Office, Amsterdam, and presented at the EAZA Annual Conference 2005, in Bristol and Bath (Hiddinga, 2006). A total of 133 questionnaires were completed, representing 44% of the EAZA membership, and the key findings were:

Staff: 25 of 133 of EAZA members (19%) have a research department. Considering 'research' as at least a part of staff job descriptions means almost three-quarters of the respondents formally include research as part of their collection's activities. When expanded to include staff time, responding members employ more than 130 full-time equivalents in research staff.

Written research policy: 'having an institutional policy can assist in directing research and ensure it is conducted on subjects relevant to achieving your collection's mission'. Only 40 respondents out of 133 (30%) have a written research policy EAZA members with a research department were more likely to have such a policy; 19 of 25 (76%).

Relationships: many EAZA members have either a formal or informal relationship with neighbouring research institutions. For this survey, a formal relationship was defined as one in which cooperation between the EAZA member and research institution has been specified in a written contract or memorandum of understanding; otherwise the relationship was considered informal. Half of the respondents (67 of 133 or 50%) have a formal relationship with one or more universities or other scientific institutions. Most EAZA members with a research department have such formal relationships (22 of 25 or 88%). Although it was more common that the institution was within the same country (48 of 67 or 87%), there were 4 examples of scientific partners from outside Europe. Almost all of the respondents (117 of 133) have informal relations with one or more universities and/or scientific institutions.

Funding: most (95 of 133 or 71%) respondents do not have a specific budget for research; not surprisingly, all those with a research department are included in the remaining 36 EAZA members who do budget for research. On a positive note, 22 of 36 (61%) have had their budget allocation increased during the period 2002 - 2005, independent of inflation. Just 35 of 133 EAZA members (26%) receive external research funding and the sources include: support from 'friends of the zoo', private individuals and bequests, national government grants, national and international non-government organisations. Responses to the questionaire were not always precise but EAZA estimates that the overall spending on research annually among members to be at least €2,680,500.

Communicating research results: conducting research within the EAZA member institution is important but it is also essential to communicate the findings. Many members contribute poster and oral presentations at professional meetings however this does not translate into an equal volume of scientific reports and publications or, still less, peer-reviewed publications.

Conclusions: on the basis of 133 responses from EAZA member zoos and aquariums, more than 130 full-time equivalent staff are employed to conduct research. There are formal relationships with almost 200 international scientific institutions and over €2.68 million is spent on research annually. These figures are encouraging and repeating the EAZA Research Survey at suitable intervals is a part of the Research Strategy and will be an effective means of benchmarking collective progress and that of individual zoos and aquariums. A survey of research in Eurasian zoos has been conducted by EARAZA (*q.v.*) in 2006.

Appendix VII. Zoo research: European model projects

European zoos and aquariums already conduct research, both basic and complex or multi-faceted, building on the opportunities presented by their collections. It is beyond the remit of this document to present the complete array of research topics that are undertaken by zoos. Instead, the examples described below illustrate (more-or-less in order of difficulty or complexity) the many different ways in which zoos can be involved in research. The selected examples highlight the range of involvement, species, disciplines and other organisations with which zoos and their staff can cooperate when carrying out or supporting research. Full literature citations for publications are listed in the References. Additional examples of research projects undertaken by or in zoos can be found in the EAZA Research Newsletter, compiled annually and available from the EAZA Executive Office or on the EAZA Research Committee's webpage at www.eaza.net. The abstracts and proceedings of the Annual Conference on Zoo and Wildlife Research (hosted by IZW, Berlin) should also be consulted for good recent examples.

EAZA Research Project Example

The longevity legacy – the problem of old mammals in zoos

Size and scale	One or more zoos providing animal material to scientific institution to facilitate research
Collaborators	Multiple zoos, Royal Museums of Scotland
Disciplines	Morphology; osteology; pathology
Summary	As our knowledge of animal husbandry in zoos has increased there has been a concurrent increase in the maximum and minimum longevities of most species. However, old age brings its own problems including physical decline of the skeleton and teeth, reproductive senescence, and deterioration of behavioural and cognitive function, all of which may compromise breeding programmes. Using dead animal specimens collected over the previous decade from many zoos, the authors survey skeletal and dental pathologies to determine how widespread they are. They also consider whether there are any significant interspecific differences that might be influenced by morphology, behaviour and environment.
Citation/Source	Kitchener and Macdonald (2005)

Illustration

Right lateral view of the skull of a 33+ year old female brown bear. Note the abscess that has developed at the root of the canine, owing to infection spreading along the pulp cavity from the broken tip of the canine.

PHOTO:
Trustees of the National Museums of Scotland

EAZA Research Project Example

Copulation behaviour in Vasa parrots

Size and scale	Zoo staff carrying out basic behaviour observations and writing publication
Collaborators	North of England Zoological Society
Disciplines	Behaviour; reproductive biology
Summary	Males of two species of Vasa parrot possess an extremely enlarged cloaca in the breeding season. This was, at one time, erroneously thought to be a prolapse but observations made at Chester Zoo indicate this engorged organ enables the parrots to form a copulatory lock when mating. Observations indicate that copulation is (unusually for birds) extremely protracted and that birds may be locked in copulation for bouts of over 100 minutes. The cloacal protrusion and form of copulation are unique in birds. The unusual cloacal structure and behaviour was hypothesised to be associated with sperm competition, the females being polyandrous and regularly copulating with more than one male during any one breeding cycle.
Citation/Source	Wilkinson and Birkhead (1995)
Illustration	

PHOTO:
Roger Wilkinson

EAZA Research Project Example

Moulting of the hawk owl

Size and scale	Zoo staff collect samples and analyse and publish results in cooperation with external organisation
Collaborators	Poznan Zoological Garden; Ekofundusz
Disciplines	Natural history; developmental biology
Summary	Under normal exposure in the zoological garden of Poznan a pair of third-calendar-year Hawk Owls attempted breeding: the first brood was unsuccessful and the second abandoned. The aviary was under everyday control, and the identification of the feathers found enabled to reconstruct the process of exchange of remiges and rectrices in both birds. The male exchanged all feathers and his moulting was highly symmetrical and very rapid, especially the first phase of the process. The female exchanged all feathers except s6 (in the previous season she had not exchanged the 7th secondary), and her moulting was less symmetrical and slower initially but then very fast. The loss of the first brood and the second breeding attempt had a great influence on the course of moulting in the female. In both birds new feathers grew at a pace of *ca* 5 mm per day. At a comparable moulting sequence, the moulting process of the studied pair was earlier (due to geographic conditions) than in free-living birds and more complete; the latter case probably owing to a better diet, as feeding can strongly affect the moulting.
Citation/Source	Cieślak, M. and Kwieciński, Z. (2005)
Illustration	

PHOTO:
Jakub Hepner

EAZA Research Project Example

White-faced saki studbook research

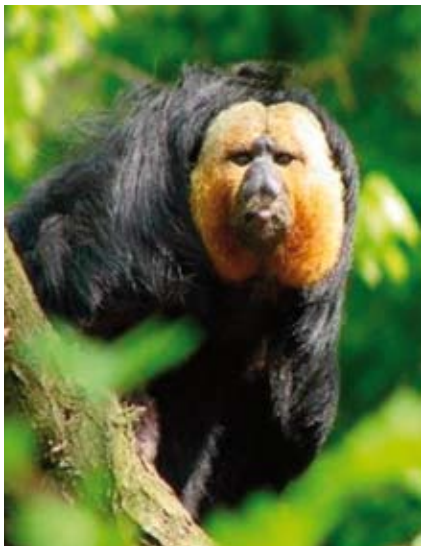
Size and scale	Using studbooks to make evidence-based management decisions
Collaborators	Paignton Zoo Environmental Park; European Endangered species Programme (EEP) participants
Disciplines	Zoo management; animal records
Summary	The author illustrates the practical and academic applications of research using studbook datasets, citing examples taken from a recent analysis of the white-faced saki monkey EEP (*Pithecia pithecia*). A recent husbandry survey carried out with all zoos participating within the EEP highlighted discrepancies in opinion in several management areas, such as minimum ages for transfer from the natal group. These opinions are based on anecdotal evidence as no systematic research has been conducted into these areas. This studbook contains a statistically viable data set and detailed demographic information for the last three decades, which can be used to investigate such issues as the effect of age at removal from breeding group on subsequent breeding success. The information can then be applied to the management of the European white-faced saki monkey population through the provision of husbandry guidelines.
Citation/Source	Pullen (2005)
Illustration	

PHOTO:
Lilian Bartens

EAZA Research Project Example

Conservation genetics of the Jamaican yellow boa (*Epicrates subflavus*)

Size and scale	Zoo staff member coordinates research of genetic samples provided by breeding programme participants
Collaborators	Members of the Jamaican boa EEP, coordinated by Museum of Natural History and Vivarium, Tournai; Free University Brussels, Belgium
Disciplines	Conservation genetics; reintroduction biololgy
Summary	Intense persecution of the endemic Jamaican yellow boa (*Epicrates subflavus*) by locals, predation by introduced mammals, coupled with continuing habitat loss and fragmentation of remnant forest patches, has put this species under serious threat of extinction. In the 1970s, a breeding programme for this critically endangered species was initiated at the Durrell Wildlife Conservation Trust. Thirty years later, approximately 70 individuals are being kept at 14 institutions affiliated to EAZA. Despite careful management of the European Studbook, little information is available about the genetic diversity of the initial and current *ex situ* populations. Furthermore, no investigation has so far been carried out on the phylogeography, population diversity and structure, and demographic history of the species in its natural habitat. The aim of this project are to (a) isolate species-specific molecular markers necessary for characterizing *ex situ* and natural populations of the Jamaican yellow boa; (b) characterize the population through genotyping of all zoo-bred individuals; (c) characterize the remnant populations in Jamaica, and (d) improve the breeding programme and initiate repatriation programmes, as it has been successfully done for other reptilian species.
Publication	Tzika *et al.* (2005)
Illustration	

PHOTO:
Michel Milinkovitch

EAZA Research Project Example

Paratuberculosis in zoo animals: development of molecular tools for detection and characterisation

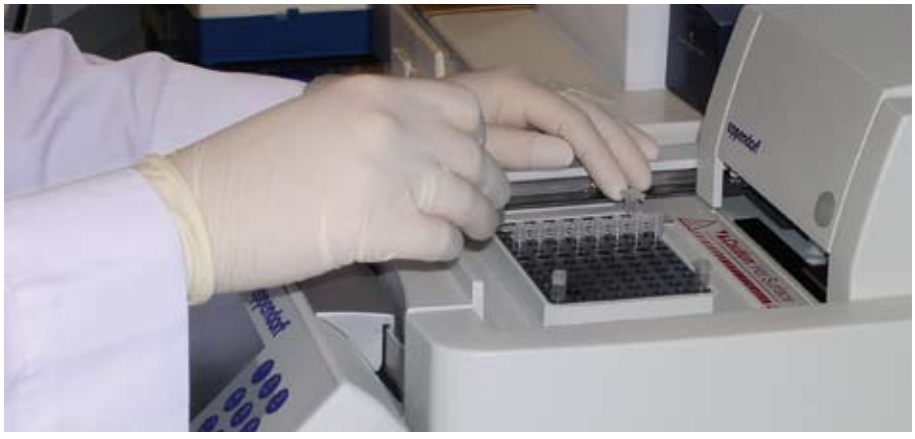
Size and scale	Practical problems in zoo management translated into fundamental research
Collaborators	Royal Zoological Society of Antwerp; University of Ghent; Institute for Tropical Medicine, Antwerp, Belgium
Disciplines	Molecular biology; veterinary medicine
Summary	Paratuberculosis is a chronic intestinal disease of ruminants caused by *Mycobacterium avium* subspecies *paratuberculosis* ('*Map*'). Very little is known about the status of paratuberculosis in European zoos. The existing diagnostic methods were not sufficiently specific, sensitive and rapid to be used in a survey of the occurrence of *Map*. To this end new specific and rapid tests had to be developed, including the design of a more specific polymerase chain reaction (PCR) assay, the development of a faecal DNA extraction method and the development of a PCR based typing method. The presence of *Map* in the animal collection of the Royal Zoological Society of Antwerp (RZSA) was investigated using faecal and post mortem samples from 48 ruminants. DNA from faeces, tissue and positive cultures were tested by PCR. Additionally, 448 serum samples were tested with an ELISA kit. There is evidence that *Map* is present in the RZSA, although no high level faecal shedders were detected. The new specific PCR assay in combination with the newly developed faecal DNA extraction procedure was shown to be useful in the zoo environment. Our method can be further used to complete the picture of *Map* infection in European Zoos.
Publication	Vansnick *et al.* (2005)
Illustration	

PHOTO:
Zjef Peereboom

EAZA Research Project Example

Ethological research in a zoo chimpanzee colony

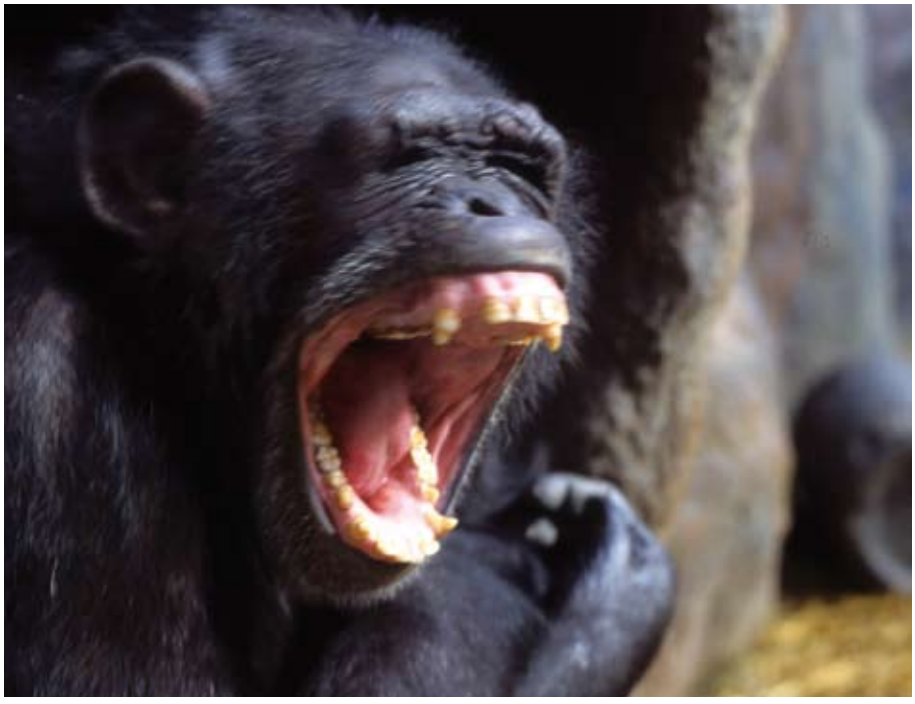
Size and scale	Zoo provides facilities for university research team to carry out behavioural observations long-term
Collaborators	Burgers Zoo, Arnhem; University of Utrecht
Discipline	Behaviour
Summary	The Burgers Zoo chimpanzee colony was established in 1971 with the object of providing a habitat which would both be suitable and large enough for the maintenance of a chimpanzee group of natural composition. It was hoped to give the animals the opportunity to behave as naturally as possible with the minimum of interference by humans. At the same time long-term studies were initiated on the group's social behaviour.
Publication	Multiple and ongoing; see Adang *et al.* (1987) for an overview of developments up till 1985, while social behaviour forms the basis of a book by de Waal (1998).
Illustration	

PHOTO:
Purestock

EAZA Research Project Example

Breeding biology and reintroduction of amphibians

Size and scale	Collaborative working group for breeding amphibians
Collaborators	Moscow Zoo; various research institutes
Disciplines	Natural history; *in situ* wildlife management
Summary	A special Working Group for breeding of endangered, exotic and problem amphibian species was established in the 1980's by scientists from Moscow Zoo, the Koltzov Institute of Developmental Biology and the State Research Centre's Institute of Biophysics. As a consequence of studying breeding biology, methods for hormone stimulation of amphibian reproduction and husbandry guidelines for all life stages have been developed. These methods made it possible to establish new wild populations of the banded newt *Triturus vittatus* and Eastern spadefoot toad *Pelobates syriacus*, within their natural habitats in the Caucasian Natural Reserve and Armenia respectively. These populations are still thriving and further reintroductions within the natural range of *P. syriacus* are underway. See also Amphibian Ark Project (Glossary).
Publication	Goncharov *et al.* (1989)
Illustration	

PHOTO:
I. Serbinova

EAZA Research Project Example

‘Zoo College’: cooperation between Zodiac Zoos and a university

Size and scale	Zoo consortium and professional university cooperate on training of students and incorporating research projects in that training
Collaborators	Zodiac Zoos and Van Hall Institute, The Netherlands
Discipline	Research training
Summary	Zoo College started in September 2003 as a unique cooperation between Zodiac Zoos and the Van Hall Institute. Zodiac Zoos is the coordinating organisation of three EAZA member zoos in The Netherlands: Dierenpark Wissel in Epe, Zoo Parc Overloon in Overloon and Aqua Zoo Friesland in Leeuwarden. The Van Hall Institute is a University of Professional Education for Agriculture, Food Technology and Environmental and Animal Sciences (also part of a consortium with Wageningen University and Research Centre). It offers students Bachelor and Master of Science degree study programmes, which focus on such themes as nature, the environment, animal science, rural resources, sustainability and nutrition.
Publication	www.zoo-college.nl
Illustration	

PHOTO:
Zodiac Zoos/Hogeschool van Hall-Larenstein

EAZA Research Project Example

Reproduction of stony corals (CORALZOO project)

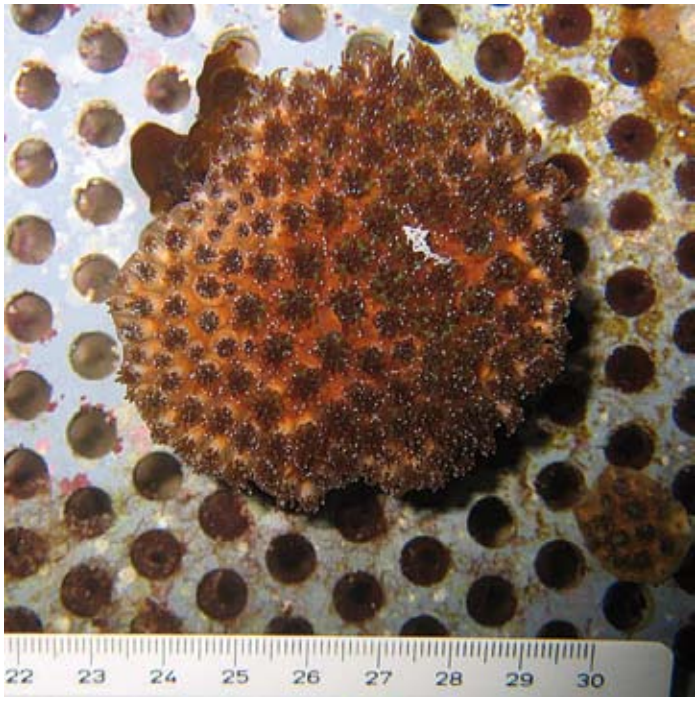
Size and scale	Zoo association, zoos, research institutions and commercial companies cooperate on husbandry research, with supporting funding from EU
Collaborators	Consortium of European partners including aquariums, universities and research institutions
Disciplines	Animal Husbandry; marine biology; reproductive biology
Summary	CORALZOO is an EU funded, collective research project which is acting on behalf of the members of EAZA. Its goal is to undertake science and technology research activities which will develop methodologies to better culture and maintain corals in *ex situ* environments. Outputs from this research will form practical tools to help EAZA members with coral husbandry.
Publication	Jones (2006)
Illustration	

PHOTO: CORALZOO

EAZA Research Project Example

Semi-wild flocks and a new migration route for the Waldrapp ibis

Size and scale	Well-established, long running, multi-disciplinary projects with animals, financial and other in-kind support provided by various zoos.
Collaborators	Three main projects, carried out by the Konrad Lorenz Forschungsstelle, Grünau/ Austria and the Waldrappteam respectively. Financially supported by individual zoos in Austria, Germany and Switzerland and the national zoo associations of those countries; and also supported by government agencies, private companies and NGOs.
Disciplines	Conservation Biology; establishing migration routes and habitat; reintroduction biology
Summary	The Northern bald ibis or Waldrapp ibis (*Geronticus eremita*) is a critically endangered species with only about 250 specimens surviving in the wild in Morocco and an even smaller number in Turkey and Syria. In contrast, close to 2000 birds are living in zoos and are reproducing successfully. Thus, it seems timely to consider re-establishing new colonies in suitable habitats. However, all attempts to release *ex situ*-bred birds had failed. Consequently, research projects need to be undertaken before any release can take place; in agreement with the IUCN Guidelines for Reintroduction and an internationally agreed strategy for the conservation of the Waldrapp ibis. The Grünau Project concerns a local, non-migratory colony of semi-tame birds established to investigate social behaviour and hormone status, behavioural and ecological aspects of natural foraging, and the establishment of traditions via social learning. The Scharnstein Project is establishing a migratory Waldrapp colony by introducing a new migration route with ultralight planes. Austrian agencies and 'Proyecto Eremita' aim to evaluate the efficacy of different releasing techniques in the La Janda area of Southern Spain.
Publications	Multiple and ongoing; see Bohm *et al.* (2007).
Illustration	

PHOTO:
Johannes Fritz/Waldrappteam

Appendix VIII. Zoo research: sample serial publications

This list provides examples of printed and online serial sources of research information and potential outlets for zoo-associated research papers. It has, with kind permission, been adapted and expanded from a list in the *World Zoo and Aquarium Conservation Strategy* (Chapter 3) but is by no means comprehensive. Please refer to the EAZA website (www.eaza.net) for updates.

Animal Behaviour
Animal Conservation
Animal Welfare
American Zoo and Aquarium Association Conference Proceedings (Annual and Regional)
Animal Keepers Forum
Applied Animal Behaviour Science
Aquarium Sciences and Conservation
Australasian Regional Association of Zoological Parks and Aquaria (ARAZPA Newsletter, website)
Bongo (Journal of the Berlin Zoo, contains scientific articles on animal husbandry and conservation)
British and Irish Association of Zoos and Aquaria (BIAZA Research Newsletter, BIAZA Research Symposium Proceedings, BIAZA Research Guidelines)
Conservation Biology
Copeia (American Society of Ichthyologists and Herpetologists)
Dodo (Journal of Durrell Wildlife Conservation Trust)
European Association of Zoos and Aquaria (EAZA Research Committee Newsletter, EAZA News, EAZA Conference Proceedings, EAZA website)
International Zoo News
International Zoo Yearbook
Journal of Applied Animal Welfare Sciences
Journal of Fish Biology
Journal of Herpetology
Journal of Mammalogy
Journal of Wildlife Management
Journal of Zoo and Wildlife Medicine
Oryx: The International Journal of Conservation
Pan African Association of Zoological Gardens, Aquaria and Botanic Gardens (PAAZAB News, website)
Ratel (publication of the Association of British Wild Animal Keepers)
Reproduction
South East Asian Zoos Association (scientific papers from conferences available on SEAZA website)
Thylacinus (Australasian Society of Zoo Keeping)
Turtle and Tortoise Newsletter (Chelonian Research Foundation)
Wildlife Information Network
World Association of Zoos and Aquaria (WAZA News, WAZA Conference Proceedings and website)
Zeitschrift des Kölner Zoo (Journal of Cologne Zoo)
Zoo Biology
Der Zoologische Garten (The Zoological Garden)
Zoo Vet News (American Association of Zoo Veterinarians)

Glossary of terms

Amphibian ARK (AARK): The Amphibian ARK is a global partnership initiative between WAZA and the IUCN-SSC Conservation Breeding Specialist Group and IUCN-SSC Amphibian Specialist Group. It is designed to address the catastrophic global decline in amphibian populations and the extinction threats to many species caused, in part, by the spread of a lethal chytrid fungus. EAZA is a major regional partner in the AARK and, as a contribution to the International Year of the Frog 2008, has organised an Amphibian Alarm campaign to widely communicate this major issue and raise funds to support activities in conservation, education and research.

Assurance breeding programmes: these are managed zoo and aquarium breeding programmes intended to ensure the survival of species which have become extinct in the wild.

Biodiversity: biological diversity, or 'biodiversity', is often understood in terms of the wide variety of plants, animals and micro-organisms. However, it also includes genetic variation – in chromosomes, genes, and DNA – that determine the uniqueness of each individual and each species. It also concerns the immense variety of habitats and ecosystems. Biodiversity 'hotspots' (areas of species 'richness', with high numbers of endemic species) are often the focus of conservation and research efforts, although much important biodiversity exists even in 'impoverished' regions such as deserts, polar zones and in the depths of oceans. See also Global Biodiversity Assessment, Appendix IV.

Biotechnology: the application of biological processes to producing and improving materials in biology and medicine (including zoo biology and veterinary medicine). An example here would be assisted reproduction programmes involving hormone therapy. Standard studbook-based breeding programmes are sometimes regarded as 'traditional biotechnology'.

Botanic Gardens Education Network (BGEN): see Global Strategy for Plant Conservation.

CBSG: see Conservation Breeding Specialist Group

CITES: see Convention on International Trade in Endangered Species

CMS: see Convention on Migratory Species

Conservation: actions that substantially enhance the survival of species and habitats, whether conducted in nature or outside the natural habitat.

Conservation biology: a relatively new multi-disciplinary science which has developed to address the crisis facing biodiversity. It investigates human impact on biological diversity and develops practical approaches to reduce the rate of extinctions. Conservation biology complements the applied resource management disciplines (including collection management in zoos and aquariums) with academic disciplines such as population biology, taxonomy, zoogeography and ecology. The WZACS (*q.v.*, below) defines conservation research as 'any research that benefits conservation of species or habitats, directly or indirectly'. This can range from husbandry studies that support *ex situ* conservation breeding to researching means to motivate stakeholders and decision-makers. This broad scope means that there are plenty of opportunities for all zoos and aquariums to become involved in various aspects of conservation research in a small or large way.

Conservation Breeding Specialist Group (CBSG): established in 1978, the CBSG is a functional group of the World Conservation Union (IUCN-Species Survival Commission). It has major involvement in *ex situ* conservation activities including communications, training and the organisation of various conservation workshops. CBSG has close links with zoos and zoo organisations. Some of the conservation products of CBSG involve or require research, e.g. Conservation Assessment Management Plans (CAMPS) and Population and Habitat Viability Analyses (PHVA's).

Conservation psychology: defined as 'the scientific study of the reciprocal relationships between humans and the rest of nature, with a particular focus on how to encourage conservation of the natural world' (www.conservationpsychology.org). It aims to understand two broad outcome areas; how people behave towards nature, and how people care about or value nature.

Convention on International Trade in Endangered Species (CITES): CITES is an international agreement to which governments (countries) adhere voluntarily. Annually, international wildlife trade is estimated to be worth billions of dollars and to include hundreds of millions of plant and animal specimens. CITES' aim is it to ensure that international trade of wild animals and plants does not threaten their survival.

Convention on Migratory Species (CMS): the CMS (also known as the Bonn Convention) was signed in 1979 in Bonn and entered into force in 1983. It is an intergovernmental treaty, concluded under the *aegis* of the United Nations Environment Programme and concerned with the conservation of wildlife and habitats on a global scale. CMS has over 100 members including Parties from Africa, Central South America, Asia, Europe and Oceania with the aim to conserve terrestrial, marine and avian migratory species throughout their range.

EARAZA: see Eurasian Regional Association of Zoos and Aquariums.

Earth Summit: a United Nations Conference on the Environment and Development (convened by the World Commission on Environment and Development) was held in Rio de Janiero in June 1992, with 178 governments and 500 interest groups represented. The aim of the 'Rio Conference' was to find ways to minimise the potentially negative impacts of economic development on the environment and biodiversity. Five agreements were signed including the *Framework Convention on Climate Change* (*q.v.*) aimed to minimise anthropogenic impacts; and the *Convention on Biodiversity* (see Appendix III) aimed to protect the world's species and ecosystems. The *Rio Declaration* includes 27 principles to guide action on development. *Agenda 21* is one action plan aimed at introducing governments and the public to sustainable development and from which sprang the motto 'think global, act local'.

EAZA: see European Association of Zoos and Aquaria.

EAZA *In situ* Conservation Database: established in 2006 and available on-line since 2007, this field-oriented database is an important and rapidly developing analytical tool for conservation research and for conservation planning among EAZA zoos and aquaria; and among a far wider international range of partner organisations. It includes data and contact information for 436 *in situ* conservation projects from 94 different countries worldwide. This new search machine enables EAZA members to identify specific projects based on country of project, type of habitat, type of project, species involved and much more besides. It provides data for various analyses of *in situ* conservation projects such as project type versus zoo size, involvement in specific countries or with particular species and financial contributions over time.

EEP: see European Endangered species Programme

Eurasian Regional Association of Zoos and Aquariums: EARAZA represents 43 member institutions from 11 countries, including Azerbaijan, Armenia, Byelorussia, Czech Republic, Estonia, Israel, Kazachstan, Moldova, Russiia, Ukraine and Uzbekistan. It has an elected governing body, the Presidium and an Executive Office (http://earaza.yard.ru). The Moscow Zoo is the lead institution for EARAZA and this association places a strong emphasis on scientific research and the publication of results (with more than 290 research articles being published by the group between 2000 and 2005 – www.zoo.ru/moscow). A survey carried out by S. Popov in 2006 and reported to EAZA revealed a very wide range of research activity including many significant conservation programmes in Eurasia for European bustard, European crane, Steller's sea eagle, Siberian spruce grouse, Amur tiger, Dahl's gerbil, mountain ungulates, eastern spadefoot toad and European banded newt. There is increasing cooperation between EARAZA and EAZA.

European Association of Zoos and Aquaria (EAZA): the main functions of EAZA are to promote cooperation for furthering collection planning and wildlife conservation, particularly through internationally-coordinated breeding programmes of wild animals such as the European Endangered species Programmes (EEP); promote education, in particular environmental education; contribute to relevant meetings and discussions of the supra-international organisations, such as the United Nations, The World Conservation Union (IUCN), the European Union, the Convention on International Trade in Endangered Plant and Animal Species (CITES) etc. and advise, as required, the European Union, or other representative committees such as the European Parliament and European Council (www.eaza.net).
See also European Association of Zoos and Aquaria (EAZA) Research Committee.

European Association of Zoo and Aquaria (EAZA) Committees and Working Groups: many different committees and scientific working groups convened within EAZA, focus on various matters of concern: EAZA EEP Committee, Membership and Ethics Committee, Aquarium Committee, Legislation Committee, Conservation Committee, Research Committee, Education Committee, PR and Marketing Committee, Technical Assistance and Animal Welfare Committee, Veterinary Committee, Bushmeat Working Group, Nutrition Group, Population Management Advisory Group (EPMAG), Rainforest Working Group, Transport Working Group and Zoohorticulture Group.

European Association of Zoo and Aquaria (EAZA) Research Committee: established in 1990, the Research Committee has, since 2002, operated with co-chairs and members from many countries, including in Eastern Europe. Its main aim is to support and promote research activity within EAZA and to have research interests represented in all other committees, where appropriate. A prime function of the Committee is to develop strategy, policy and guidelines and to respond to scientific needs and concerns among the membership. The EAZA Nutrition Group is included as a major sub-set of the Research Committee and represents specialised nutritional interests in research and development. The Committee has a liaison officer from the EAZA Executive Office, and conducts at least two formal meetings a year. Among other tasks, EAZA compiles surveys of research activities and specialisms among the membership. Every year a detailed *Research Committee Newsletter* is published and also made available on the EAZA website. EAZA supports an annual International Symposium on Physiology, Behaviour and Conservation of Wildlife, hosted by the IZW, Berlin, Germany. A section in this symposium is dedicated to research work conducted in EAZA institutions. A second showcase for European, zoo-centred research is the annual International Conference for Zoo Research, Poznan, Poland.

European Endangered species Programme (EEP): an EEP is the most intensive type of population management for a species. Specialists coordinate decisions on which animals should breed or not breed and genetic, and which animals should move to other collections.

***Ex situ*:** activity taking place outside of the natural habitat, either in the range country or elsewhere, out of this range.

FAO: see Food an Agriculture Organization of the United Nations

Framework Convention on Climate Change: see Earth Summit.

Food and Agriculture Organization of the United Nations (FAO): FAO was found in 1945, since then it leads international effort to defeat hunger and provite food security by improvement of the production and distribution of agricultural products. FAO acts as a neutral forum where all nations can negotiate agreements and debate policy. FAO also helps developing countries and countries in transition to modernize and improve agriculture, forestry and fisheries practices. Such activities often relate closely to issues in wildlife conservation.

Frozen Ark Project: the mission of the Frozen Ark Project (www.frozenark.org) is to collect, preserve and store DNA and viable cells from animals in danger of extinction. The project will focus on the thousands of animals that are expected to disappear within the next few decades. Research on such materials, often supplied by zoos, can be applied to the conservation of living populations.

Global Strategy for Plant Conservation (GSPC): the GSPC was adopted by the Convention on Biological Diversity (see Appendix III) in accordance with Decision VI/9 of its Conference of the Parties in April 2002. It has been developed by the CBD in conjunction with Botanic Gardens Conservation International to halt the current and continuing loss of plant diversity and provides a framework for action at the global, regional, national and local levels. It is entirely compatible with the *World Zoo and Aquarium Conservation Strategy* (*q.v.*) and has specific scientific objectives including the need to "sponsor botanical survey or research as part of a stand-alone project or as part of an animal habitat assessment". Clearly, zoological gardens (mainly for terrestrial plants) and aquaria (mainly for aquatic and emergent plants) will wish to engage with this strategy which provides the opportunity for a holistic approach to the conservation of biodiversity. Other plant organisations of importance to zoos include Plantnet and the Botanic Gardens Education Network (BGEN).

GSPC: see Global Strategy for Plant Conservation

***In situ*:** activity taking place in the natural habitat (including reintroduction).

International Species Information System (ISIS): established in 1973, ISIS is now an international non-profit membership network governed by an international board of trustees elected by members from more than 600 institutions on six continents. EAZA is an Association Member of ISIS and has a permanent seat on the Board of Trustees. Members keep and share standardized and detailed information on almost two million specimens of 10,000 taxa, using specially developed software. ISIS is managing the development of a new, web-based Zoological Information Management System (ZIMS). See also ZIMS.

ISIS: see International Species Information System.

IUCN: see Appendix V.

NGO: see non-governmental organisation.

NMRI scanning: see Nuclear Magnetic Resonance Imaging.

Non-governmental organisation (NGO): an NGO is any non-profit group which is organised on a local, national or international level. There are many conservation NGO's including WWF, CI, FFI, and Save the Rhino.

Nuclear Magnetic Resonance Imaging (NMRI): NMRI is a non-invasive method used to render images of the inside of an object. It is mostly used in medical imaging to demonstrate alterations of living tissue and to determine pathologies.

Partnership: a working together, often through national and regional networks. In zoos this can mean to collaborate together to, for example, fund studies, support a researcher, buy equipment, provide samples. Another form is to partner up with academic or science-based institutions or organisations, including NGO's (*q.v.*).

Plantnet: see Global Strategy for Plant Conservation.

Reintroduction Specialist Group (RSG): the RSG is a disciplinary Specialist Group of the IUCN Species Survival Commission (*q.v.*). The role of the RSG is to promote the re-establishment of animal and plant populations in the wild. This can be done through translocation from existing wild populations, or by reintroducing zoo-bred animals or artificially propagated plants.

Research: the process used to assemble and test knowledge using the scientific method. Research itself can be considered to be: "an endeavour to discover new or collate old facts by critical study". In the traditional context, zoo research is considered to be mainly an enterprise in biological science. However, with the increasing sophistication of zoo operations both at home and abroad, 'research' can also, for example, include areas covered by the physical and chemical sciences or engineering, information technology, sociology, psychology, anthropology, ecotourism, marketing and education. Field studies on carnivore conservation, for example, could involve techniques in satellite tracking or sociological consideration of factors creating human and animal conflict. Educational research could involve cross-cultural studies on the effectiveness of educational interpretation or 'market research' on visitor attitudes and perceptions.

Rio Conference: see Earth summit.

Science: a body of knowledge essentially based on observation and experiment and used to understand the natural and physical world. It is characterised by objective research methods, a systematic approach and testable hypotheses and predictions.

Species Survival Commission (SSC): the IUCN (*q.v.*) Species Survival Commission is a science-based network of some 7,000 volunteer experts from almost every country of the world. Members include researchers, government officials, wildlife veterinarians, zoo and botanical institute employees, marine biologists, protected area managers, and experts on plants, birds, mammals, fish, amphibians, reptiles, and invertebrates. Most members are deployed in more than 100 specialist groups and task forces. Some groups address conservation issues related to particular groups of plants or animals while others

focus on topical issues such as reintroduction of species into former habitats, or wildlife health. SSC's major role is to provide information to IUCN on biodiversity conservation, the inherent value of species, their role in ecosystem health and functioning, the provision of ecosystem services, and their support to human livelihoods. SSC members also provide scientific advice to conservation organisations, government agencies and other IUCN members, and support the implementation of multilateral environmental agreements.

Strategy: here defined as a long-term development plan, extending up to or beyond five years, to integrate EAZA's major goals, policies, decisions and sequences of action with regard to research.

Sustainability: meeting the resource needs of the present without compromising the needs of future generations or sacrificing a healthy environment and natural biodiversity. See also Earth Summit.

Taxon Advisory Group (TAG): each TAG focuses on a specific group of animals and consists of professional zoo and aquarium people who have special expert knowledge of these animal species.

Technology: frequently partnered with science as 'the practical or industrial application of science or engineering'. Biotechnology (*q.v.*) is one subset of technology.

UNEP: see United Nations Environment Programme.

UNESCO: see United Nations Educational, Scientific and Cultural Organization.

United Nations Conference on the Environment and Development: see Earth Summit.

United Nations Educational, Scientific and Cultural Organization (UNESCO): the UNESCO was founded on the 16th of November 1945. Its objective is to contribute to peace and security by promoting collaboration among all nations through education, science and culture. Today, UNESCO functions as a laboratory of ideas, a standard-setter and a discussion forum to forge universal agreements on emerging issues.

United Nations Environment Programme (UNEP): the UNEP was established in 1972 as the voice for environment within the UN System. UNEP tries, together with a wide range of partners, to support the wise use and sustainable development of the global environment. It cares for the environment by inspiring, informing, and enabling nations and people to improve their quality of life without compromising that of future generations.

WAZA: see World Association of Zoos and Aquariums.

WCMC: see World Conservation Monitoring Centre.

World Association of Zoos and Aquariums (WAZA): EAZA is a regional member of the *World Association of Zoos and Aquariums* (www.waza.org). WAZA recommends that all zoos should be actively involved in appropriate research and other scientific activities regarding their animals and distribute the results to colleagues. Appropriate areas of research include exhibit design, basic observations, welfare, behaviour, management practices, nutrition, animal husbandry, veterinary procedures and technology, assisted breeding techniques, biological conservation and the cryopreservation of eggs and sperm. Each zoo undertaking such research should have a properly constituted research committee and should have an

ethical review process. Invasive procedures designed to assist in medical research are not to be performed on zoo animals, although the opportunistic collection of tissues during routine procedures and collection of material from cadavers will, in most cases and subject to stringent precautions, be appropriate. Commercial trade in rare animal parts or products such as tiger skins and sharks jaws is proscribed

World Commission on Environment and Development: see Earth Summit.

World Conservation Monitoring Centre: established before 1988, the World Conservation Monitoring Centre (http://www.unep-wcmc.org) is, since 2000, an executive agency collaboration between the United Nations Environment Programme (UNEP) and WCMC, a UK based conservation NGO operating as a charity. It provides scientifically-based information services on the conservation and sustainable use of the world's living resources and supports others to develop their own information systems. It has a particular remit in supporting the CBD (*q.v.*) and CITES (*q.v.*). WCMC activities include assessments and early warning studies (including of the impacts of climate change) in forest, dryland, freshwater and marine ecosystems. Earthwatch scientists working in collaboration with WCMC are an important resource for up-to-the-minute field data.

World Zoo and Aquarium Conservation Strategy (WZACS): EAZA and its constituent committees intend to implement the relevant parts of 'Building a Future for Wildlife': The World Zoo and Aquarium Conservation Strategy (WAZA, 2005). Chapter 3 deals specifically with the value of science and research to the global zoo community and wildlife conservation agencies; the EAZA Research Strategy is designed to compliment the WZACS, providing a more in-depth coverage and regional detail to fit more closely with the European context.

WZACS: see World Zoo and Aquarium Conservation Strategy.

ZIMS: see Zoological Information Management System.

Zoological Information Management System (ZIMS): currently under development by ISIS, ZIMS will be a global, web-based, comprehensive, accurate scientific database that will automate much studbook data collection, track groups, serve aquarium needs, meet modern veterinary and epidemiological needs and include an 'easy-to-query' option for management questions and research initiatives. It will provide a continuously updated and well-validated body of zoo and aquarium knowledge with almost endless possibilities for scientific analysis. See also ISIS.

References

1. Adang, O.M.J., Wensing. J.A.B. & van Hooff, J.A.R.A.M. (1987) The Arnhem Zoo colony of chimpanzees, development and management techniques. *International Zoo Yearbook* 26: 236–248.

2. Araújo, M.B., Thuiller, W., & Pearson, R.G. (2006) Climate warming and the decline of amphibians and reptiles in Europe. *Journal of Biogeography* 33: 1712–1728.

3. Araújo, M.B. & New, M. (2007) Ensemble forecasting of species distributions. *Trends in Ecology and Evolution* 22: 42–47.

4. Balmford, A., et al., (2007) Message received? Quantifying the impact of informal conservation education on adults visiting UK zoos. In *Zoos in the 21st Century: Catalysts for conservation?* Zimmerman, A., Hatchwell, M., Dickie, L. & West, C. (Eds). Cambridge University Press, Cambridge, pp. 120–136.

5. Benirschke, K. (1996) The need for multidisciplinary research units in the zoo. In *Wild Mammals in Captivity: Principles and Techniques*. Kleiman, D.G., Allen, M.E., Thompson, K.V. & Lumpkin, S. (Eds). The University of Chicago Press, Chicago, pp. 537–544.

6. BIAZA. (2002) Zoo Research Guidelines: *Research Sampling Guidelines for Zoos*. Research Group of the British and Irish Zoo and Aquarium Association BIAZA, London.

7. Böhm C., Bowden, C.G.R., Jordan, M. & King, C. (2007) *Proceedings of the International Advisory Group for the Northern bald ibis (IAGNBI) Meeting*. Vejer, Spain.

8. Bolton, M. (Ed.) (1997) *Conservation and the use of wildlife resources.* Chapman & Hall, London.

9. Bottle, R.T. & Wyatt, H.V. (1966) *The use of biological literature*. Butterworths, London.

10. Browman, H.I. & Skiftesvik, A.B. (Eds). (2007) Special Issue: Welfare of Aquatic Organisms. *Diseases of Aquatic Organisms* 75(2): 85–182.

11. Cäsar, C & Guimareães, L. (2007) Researcher for a day at the PUC Minas Museum of Natural Sciences, Belo Horizonte, Brazil. *International Zoo Educators Journal* 43: 18–19.

12. Cieślak, M. & Kwieciński, Z. (2005) Pierzenie sów jarzębatych *Surnia ulula* w poznańskim ogrodzie zoologicznym [Moulting of the hawk owl *Surnia ulula* in the Poznan Zoological Garden.]. *Notatki Ornitologiczne* 46: 143–157.

13. Cockcroft, J. (Ed.) (1965) *The organisation of research establishments*. Cambridge University Press, Cambridge.

14. Cooper, J.E., Dutton, C.J. & Allchurch, A.F. (1998) Reference collections: Their importance and relevance to modern zoo management and conservation biology. *Dodo, Journal of the Wildlife Preservation Trust* 34: 159–166.

15. Daszak, P., Cunningham, A.A., & Hyatt, A.D. (2000) Emerging infectious diseases of wildlife – threats to biodiversity and human health. *Science* 287: 443-449.

16. de Waal, F. (1998) *Chimpanzee Politics: Power and Sex among Apes*. Johns Hopkins University, Baltimore & London.

17. Dierenfeld, E.S. (1997) Captive wild animal nutrition: a historical perspective. *Proceedings of the Nutrition Society* 56(3): 989–99.

18. DEFRA (2006) *Climate change and biodiversity in Europe: a review of impacts, policy responses, gaps in knowledge and barriers to the exchange of information between scientists and policy makers.* http://www.defra.gov.uk/wildlife-countryside/resprog/findings/climatechange-biodiversity/report.pdf

19. European Community (1999) *The European Zoos Directive.* Brussels: 199/22/EC.

20. Feistner, A.T.C. & Price, E.C. (2000) Working together for conservation: A win-win strategy for zoos and universities. In *Proceedings of the 2nd Annual Symposium on Zoo Research*: 23–30. Federation of Zoological Gardens of Great Britain and Ireland, London, UK.

21. Francis, D., Esson, M. & Moss, A. (2007) Following visitors and what it tells us. The use of visitor tracking to evaluate 'Spirit of the Jaguar' at Chester Zoo. *International Zoo Educators Journal* 43: 20–24.

22. Gansloßer, U., Hodges, J.K. & Kaumanns, W. (Eds). (1995) *Research and Captive Propagation*. Filander Verlag, Fuerth.

23. Garn, K. & Holst, B. (2006) EAZA *in situ* Conservation Database. In Hiddinga, B. (Ed.) *Proceedings of the EAZA Conference, Bristol, UK, 2005*. EAZA Executive Office, Amsterdam, pp.145-150.

24. Goncharov B.F., Shubravy O.I., Serbinova I.A. & Uteshev V.K., (1989) The USSR programme for breeding amphibians, including rare and endangered species. *International Zoo Yearbook* 28: 10–21.

25. Hardy, D.F. (1996) Current research activities in zoos. In *Wild Mammals in Captivity: Principles and Techniques*:. Kleiman, D.G., Allen, M.E., Thompson, K.V. & Lumpkin, S. (Eds). The University of Chicago Press, Chicago, pp. 531–536.

26. Hare, J.F. (2005) Guidelines for the treatment of animals in behavioural research and teaching. *Animal Behaviour* 69: i–vi.

27. Hediger, H. (1965) *Mensch und Tier im Zoo: Tiergarten Biologie, Mueller, Ruschlikon-Zurich*. Translated by Vevers, G. & Reade, W. (1970) *Man and Animals in the Zoo: Zoo Biology*. Routledge & Kegan Paul, London.

28. Hiddinga, B. (2006) Where are we regarding research? In Hiddinga, B. (Ed.) *Proceedings of the EAZA Conference 2005, Bristol, UK.* EAZA Executive Office, Amsterdam, pp. 118–125.

29. Hill, D, Fascham, M, Tucker, G., Shewry, M. & Shaw, P. (Eds). (2006) *Handbook of Biodiversity Methods: Survey, Evaluation and Monitoring*. Cambridge University Press, Cambridge.

30. Holt, W.V., Pickard, A.R., Rodger, JC. & Wildt, D.E. (Eds). (2003) *Reproductive science and integrated conservation*. Cambridge University Press, Cambridge.

31. Huntley, B., Collingham, Y.C., Green, R.E., Hilton, G. M. Rahbek, C. & Willis, S.G. (2006) Potential impacts of climatic change upon geographical distributions of birds. *Ibis* 148: 8–28.

32. Hutchins, M., Dresser, B. & Wemmer, C. (1995) Ethical considerations in zoo and aquarium research. In *Ethics on the Ark: zoos, animal welfare and wildlife conservation.* Norton, B.G., Hutchins, M., Stevens, E.F. & Maple, T.L. (Eds). Smithsonian Institution Press, Washington DC, USA, pp. 253-276.

33. Hutchins, M., Paul, E. & Bowdon, J.M. (1996) Contributions of zoo and aquarium research to wildlife conservation and science. In: *The Well-being of Animals in Zoo and Aquarium Sponsored Research*. Burghardt, G.M., Bielitski, J.T., Boyce, J.R. & Schaeffer, D.O. (Eds). Scientists Center for Animal Welfare, Greenbelt, USA, pp. 23–39.

34. Hutchins, M. (1986) Zoo research: its application to management problems. *Proceedings of the Annual Conference of the American Association of Zoological Parks and Aquariums* pp. 420–429.

35. Hutchins, M. (1988) On the design of zoo research programmes. *International Zoo Yearbook* 27: 9–19.

36. Hutchins, M. (2001) Research. In: *Encyclopedia of the World's Zoos*. Volume 3. Bell, E. (Ed.) Fitzroy Dearborn, Chicago & London, pp. 1076–1080.

37. IUCN (1987) *IUCN Policy Statement on Research on Endangered Species*. IUCN, Gland.

38. IUCN (2006) Migratory species and climate change: impacts of a changing environment on wild animals. UNEP/CMS Secretariat, Bonn.

39. Jones, R. (2006) Aquariums and research: the CORALZOO project. In Hiddinga, B. (Ed.) *Proceedings of the EAZA Conference, Bristol, UK*, 2005. EAZA Executive Office, Amsterdam, pp. 142-144.

40. Kitchener, A.C. (1997) The role of museums and zoos in conservation biology. *International Zoo Yearbook* 35: 325–336.

41. Kitchener, A. & Macdonald, A.A. (2005) The longevity legacy – the problem of old mammals in zoos. In: *Proceedings of the EAZA Conference 2004 Kolmarden*. Hiddinga, B. (Ed.) EAZA Executive Office. Amsterdam, pp. 132–137.

42. Kleiman, D.G. (1985) Criteria for the evaluation of zoo research projects. *Zoo Biology* 4: 93–98.

43. Kleiman, D.G. (1992) Behavior research in zoos: Past, present, and future. *Zoo Biology* 11: 301–312.

44. Kleiman, D.G. (1996) Special research strategies for zoos and aquaria and design of research programs. In: *The Well-being of Animals in Zoo and Aquarium Sponsored Research*. Burghardt, G.M., Bielitski, J.T., Boyce, J.R. & Schaeffer, D.O. (Eds). Scientists Center for Animal Welfare, Greenbelt, USA, pp 15–22.

45. Kuhar, C.W. (2006) In the Deep End: Pooling Data and Other Statistical Challenges of Zoo and Aquarium Research. *Zoo Biology* 25: 339–352.

46. Kuhar, C.W., Bettinger, T.L., Lehnhardt, K., Townsend, S. & Cox, D. (2007) Evaluating the impact of a conservation education programme in the Kalinzu Forest Reserve, Uganda. *International Zoo Educators Journal* (43): 12-15.

47. Lawrence, E. (Ed.) (2000) *Henderson's dictionary of biological terms*. 12th Edition. Pearson Prentice Hall: Harlow.

48. Lindburg, D.G. (2001) Research: behavioural. In: *Encyclopedia of the World's Zoos.* Volume 3. Bell, E. (Ed.) Fitzroy Dearborn, Chicago & London, pp. 1080–1083.

49. Leus, K. & Van Elsacker, L. (2006) Research – what a big zoo can do. In Hiddinga, B. (Ed.) *Proceedings of the EAZA Conference 2005, Bristol, UK*, EAZA Executive Office, Amsterdam. pp. 126-133.

50. Lewis, J.C.M. (2006) An introduction to conservation medicine and the role of zoos. In Hiddinga, B. (Ed.) *Proceedings of the EAZA Conference 2005, Bristol, UK.* EAZA Executive Office, Amsterdam, pp. 86-91.

51. Luey, B. (1992) *Handbook for academic authors.* Revised edition. Cambridge University Press, Cambridge.

52. McCormick-Ray, M.G. (1993) Aquarium science: The substance behind an image. *Zoo Biology* 12: 413–424.

53. National Research Council (1995) *Science and the Endangered Species Act.* National Academy Press, Washington, D.C.

54. Norton, B.G., Hutchins, M., Stevens, E.F. & Maple, T.L. (1995) *Ethics on the Ark.* Smithsonian Institution Press, Washington DC.

55. Olney, P.J.S., Mace, G.M. & Feistner, A.T.C. (Eds). (1994) *Creative conservation: interactive management of wild and captive animals.* Chapman & Hall, London.

56. Parmesan, C. (2006) Ecological and evolutionary responses to recent climate change. *Annual Review of Ecology, Evolution, and Systematics* 37: 637–69.

57. Pullin, A.S., Knight, T.M., Stone, D.A. & Charman, K. (2004) Conservation managers use scientific evidence to support their decision-making? *Biological Conservation* 119: 245–252.

58. Princee, F.P.G. (2001) Research in zoological gardens. *Lutra* 44(2): 75–80.

59. Pullen, K. (2005) The EEP / ESB programmes as a zoological and academic tool. Presentation at *The 7th Annual Symposium on Zoo Research*, 7-8 July 2005, Twycross Zoo.

60. Radford, K. & Creek, J. (2007) The art of securing funding. *Occupational Therapy News* April 2007: 30–31.

61. Ratajszczak, R. (2006) Research in zoos – what a medium/small zoo can do. In Hiddinga, B. (Ed.) *Proceedings of the EAZA Conference 2005, Bristol, UK.* EAZA Executive Office, Amsterdam, pp. 134–136.

62. Reid, G.McG. (1994) Live animals and plants in natural history musems. In Stansfield, G., Mathias, J. & Reid, G.McG. (Eds) *Manual of Natural History Curatorship*. Museums & Galleries Commission, HMSO, London, pp. 190–212.

63. Reid, G.McG. (2001) Biotechnology. In Bell, E. (Ed.) *Encyclopedia of the World's Zoos.* Volume 1. Fitzroy Dearborn, Chicago & London, pp. 132–135.

64. Reid, G.McG. (2005) Ethical issues relating to scientific research in zoos and aquariums. In Hiddinga, B. (Ed.) *Proceedings of the EAZA Conference 2004, Kolmarden, Sweden.* EAZA Executive Office, Amsterdam, pp. 105–108.

65. Reid, G.McG. (2006) Developing the research potential of zoos and aquaria. In P. Cwiertnia, R. Ratajszcak, R. Ziomek, J. & Zgrabczynska, E. (Eds) *Proceedings of the 3rd International Conference on Zoo Research: Animals, Zoos and Conservation*, 8-9 June 2006., Poznan, Poland.

66. Reid, G.McG.(2006) Introduction to research in zoos and aquariums. In Hiddinga, B. (Ed.) In *Proceedings of the EAZA Conference 2005, Bristol, UK.* EAZA Executive Office, Amsterdam, pp. 116–117.

67. Reid, G.McG. (2007) Science in Zoos. *Science in Parliament* 64(2): 6–7.

68. Reid, H. (2006) Climate change and biodiversity in Europe. *Conservation and Society*, 4: 84–101.

69. Robinson, M.H. (1998) Enriching the lives of zoo animals, and their welfare: where research can be fundamental. *Animal Welfare* 7: 151–175.

70. Rodriguez, J.P. et. al. (2007) Globalization of Conservation: a view from the South. *Science* 317: 755-756.

71. Ryder, O. & Feistner, A.T.C. (1995) Research in zoos: A growth area in conservation. *Biodiversity and Conservation* 4: 671–677.

72. Secretariat of the Convention on Biological Diversity (2002) *Global Strategy for Plant Conservation*. Richmond, London: Botanic Gardens Conservation International.

73. Simmonds M.P. & Isaac, S.J. (2007) The impacts of climate change on marine mammals: early signs of significant problems. *Oryx* 41: 19–26.

74. Smale, M. *et al.* (2004) Research on Elasmobranchs in Public Aquariums. In *The Elasmobranch Husbandry Manual: Captive Care of Sharks, Rays and their Relatives.* 533–541. Smith, M., Warmolts, D., Thoney, D. & Hueter, R. (Eds). Special Publication of the Ohio Biological Survey.

75. Stoinski, T.S., Lukas, K.E. & Maple, T.L. (1998) A survey of research in North American zoos and aquariums. *Zoo Biology* 17: 167–180.

76. Sutherland, W. (2000) *The conservation handbook: research, management and policy.* Blackwell Science, Oxford.

77. Sutherland, W.J., Pullin, A.S., Dolman, P.M. & Knight, T.M. (2004) The need for evidence-based conservation. *Trends in Ecology and Evolution*, 19: 305–308.

78. Thompson, S. (1993) Zoo research and conservation: beyond sperm and eggs towards the science of animal management. *Zoo Biology* 12: 155–159.

79. Tomasova, K. (2006) Research and the white rhino (*Ceratotherium simum*) EEP. In Hiddinga, B. (Ed.) *Proceedings of the EAZA Conference 2005, Bristol, UK.* EAZA Executive Office, Amsterdam, pp. 137–141.

80. Tzika, A., Remy, C. & Milinkovitch, M.C. (2005) Conservation genetics of the Jamaican yellow boa (*Epicrates subflavus*). www.ulb.ac.be/sciences/ueg/html_files/yellowsnake_project.html.

81. United Nations Environment Programme (1995) *Global Biodiversity Assessment: Summary for Policy Makers*. Cambridge University Press, Cambridge, UK for UNEP.

82. Vallejo, X. de M., Garcia, C.M. (2007) The scientific method as a learning model. Schools web and educational and investigation centres. *International Zoo Educators Journal* 43: 10-11.

83. Vansnick E., F. Vercammen, L. Bauwens, E. D'Haese, H. Nelis, & Geysen D. (2005) A survey for *Mycobacterium avium* subspecies *paratuberculosis* in the Royal Zoological Society of Antwerp. *The Veterinary Journal* 170: 249–256.

84. Vervaecke, H. & van Elascker, L. (2001) Behavioral research facility. In: *Encyclopedia of the World's Zoos*. Volume 1. Bell, E. (Ed.) Fitzroy Dearborn, Chicago & London, pp. 109–110.

85. Vevers, G. (Ed.) (1976) The Zoological Society of London 1826-1976 and beyond. *Proceedings of the Symposium of the Zoological Society of London* held on 25 and 26th March, 1976. No. 40. Academic Press, London.

86. Warrell, D. & Anderson, S. (Eds) (2002) *Expedition medicine*. 2nd Edition. Royal Geographical Society with the Institute of British Geographers. Profile Books, UK.

87. Watts, P.C., Buley, K.R., Sanderson, S., Boardman, W., Ciofi, C. & Gibson, R. (2006) Parthenogenesis in Komodo dragons. *Nature* 444: 1021–1022.

88. WAZA (2005) *Building a Future for Wildlife - The World Zoo and Aquarium Conservation Strategy*. P.J.S. Olney (Ed.) World Association of Zoos and Aquariums, Executive Office, Bern.

89. Wehnelt, S. & Wilkinson, R. (2005) Research, conservation and zoos: the EC Zoos Directive – a response to Rees. *Oryx* 39: 132–133.

90. Wemmer, C.M. & Thompson, S. (1995) A short history of scientific research in zoological gardens. In *The Ark evolving: zoos and aquariums in transition*. Wemmer, C.M. (Ed.) Smithsonian Institution Conservation and Research Center, Front Royal, Virginia.

91. Wemmer, C. Rodden, M & Pickett, C. (1997) Publication trends in Zoo Biology: a brief analysis of the first fifteen years, *Zoo Biology* 16(1): 3–8.

92. Wharton, D. (2007) Research by zoos. *In Zoos in the 21st Century: Catalysts for conservation?* Zimmerman, A., Hatchwell, M., Dickie, L. & West, C. (Eds). Cambridge University Press, Cambridge, pp. 178–191.

93. Wildt, D.E., Rall, W.F., Critser, J.K., Monfort, S.L. & U.S. Seal (1997) Genome resource banks: living collections for biodiversity conservation. *BioScience* 47(10): 689–698.

94. Wilkinson, R. & Birkhead, TR (1995) Copulation behaviour in the Vasa Parrots *Coracopsis vasa* and *C. nigra*. *Ibis* 137(1): 117–119.

95. WRI/ IUCN/ UNEP (1992) Global Biodiversity *Strategy: guidelines for action to save, study and use earth's biotic wealth sustainably and equitably.* World Resources Institute, Washington DC, The World Conservation Union, Gland Switzerland, and the United Nations Environment Programme, Nairobi, Kenya.

96. Zimmerman, A., Hatchwell, M., Dickie, L. & West, C. (Eds). (2007) *Zoos in the 21st Century: Catalysts for conservation?* Cambridge University Press, Cambridge.

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