

ZOO-BASED CONSERVATION RESEARCH AROUND THE WORLD



Dr Greg Johnston

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Front cover. Entrance to the Department of Conservation Biology at the Smithsonian Institution's National Zoo in Washington DC. The animal crossing the lawn is a life-sized model of the extinct dinosaur, *Triceratops*.

Introduction

Zoos rely on accurate, reliable information about the animals they exhibit in order to successfully maintain them, educate the general public about them, and for zoo-based conservation programs. Nevertheless, research is a relatively new activity in the zoo world.

While some zoos, such as London Zoo, were established to house research collections, and subsequently were opened to the public, most zoos are primarily places for recreation and entertainment. They play a secondary role as places for education, conservation and research. While many zoos promote their role as conservation and research organizations, this has only been the general trend since the 1970s, and is largely restricted to zoos in first world countries. For example, in Africa there are 180 zoos. Of these only 44 aspire to play a role in conservation, education and research to the extent that they support the regional zoo association.

Education and conservation are widely claimed aims of zoos around the world. More and more, research is being added to this list of claims. This is partly because research is seen as a moral justification for holding animals in captivity. But research is also important to allow zoos to play a practical role in conservation. Few traditional research institutions, such as universities and museums, do the kind of research that is useful to zoos. Traditional exploration driven research has provided us with a framework of valuing biological diversity, and understanding the need to conserve it. However zoo-based conservation is a practical affair, requiring accurate fundamental information that is of use in day-to-day animal management.

Few academic granting bodies will fund studies to determine the conditions required to breed a rare reptile, or the length of the oestrus cycle of an elephant. Yet this is the kind of information zoos require. Granting bodies, justifiably, use taxpayers' money to fund studies of general interest, rather than those of specific use. Consequently zoos see an increasingly important role for scientific researchers to collect the detailed information required to manage captive animals in a sustainable way, and re-establish populations in the wild where they have disappeared.

Few zoos can afford to fund their own research. Research in Australian zoos has a very spotty history. In 2000, when Adelaide Zoo employed me to set-up a research department, Adelaide was the last major Australian zoo to appoint a researcher to its staff. By 2004, at the time of my application for a Churchill Fellowship, Adelaide Zoo was the only zoo in Australia that still employed dedicated research staff. Those zoos that had once had research departments had closed them down. More recently, two other Australian zoos have appointed or advertised research positions. While this suggests that zoo-

based research has a future in Australia, it illustrates the uncertain nature of this field of endeavour.

This report outlines findings from a 2004 Churchill Fellowship to visit zoos and other conservation organizations in Sri Lanka, South Africa, Zambia, the United Kingdom and the United States of America. The specific purposes of my fellowship were to learn:

- About different models of research administration relevant to zoos,
- How different institutions have been able to sustain their research activities, and
- To establish collaborative links in specific areas of common interest to the international and Australian zoos/conservation bodies.

My particular areas of expertise are the ecology and behaviour of animals in the wild. The fellowship has allowed me to better link my experience of wild animals in different parts of the world, to their captive management in zoos.

My study tour and the invaluable experiences I gained would not have been possible without:

- The financial support given to me by the Winston Churchill Memorial Trust.
- The support and commitment of the Royal Zoological Society of South Australia, particularly its Chief Executive Officer, Mr Ed McAlister.
- The institutions and individuals within them, who made me feel welcome, and were so willing to share their experience, ideas, and information.
- My wife Paula who kept hearth and kin safe and well while I was away for two months. Sorry for being absent for a significant proportion of your new lives, Emma (4%) and Jay (9%).

Executive Summary

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Fellowship objectives:

To learn about different models of research administration relevant to zoos, and how different institutions have been able to sustain their research activities. A third objective was to establish collaborative links in specific areas of common interest to the international and Australian zoos/conservation bodies.

Fellowship highlights:

The following points outline some personal highlights, in addition to the professional highlights of my Fellowship.

1. Sri Lankan Wildlife Heritage Trust – the best cup of tea I have ever had: fresh dried orange pekoe from 120-year-old bushes; being able to see Spotted-billed Pelicans and endemic Sri Lankan agamid lizards in the field.
2. South Africa – watching a wild African elephant at dusk grazing calmly at a distance of 15 metres; learning to appreciate the value of zoo associations in promoting the role of research for conservation and animal welfare.
3. Zambia – Hiking to the source of the Zambezi River; understanding the severe public health constraints on conservation in Africa.
4. United Kingdom – realizing (1) how many childhood images of zoos were based on reality at London Zoo, and (2) how much of what I know about the UK is based on “The Bill”.
5. Smithsonian National Zoo, Washington – beers with the guru of captive reptile husbandry, Jim Murphy; observing the fruits of one of the great scientific institutions in the world.
6. San Diego Zoo – night-time spotlighting for rattlesnakes in coastal Sagebrush of California; seeing those icons of zoo conservation, Californian Condors.
7. University of Oklahoma – eating deep-fried cucumber, a local delicacy, while discussing the reasons for egg size variation in brood reducing birds.

Findings:

There is considerable scope for improving the state of research in Australian Zoos by adapting and combining various models observed during my fellowship. Recommendations include:

- Developing mutually advantageous agreements between zoos and universities to create new opportunities to do conservation research,
- Australian zoos working collaboratively to build a zoo-based research capacity, rather than individual zoos. This collaborative approach could be brokered by the Australasian Regional Association of Zoological Parks and Aquaria (ARAZPA),
- Developing a role as “shop fronts” for the biological sciences and conservation in Australia, and
- Establishing a legislative basis to ensure minimum standards of animal welfare, conservation and research.

Dissemination of results

I have presented the results of my Churchill Fellowship in seminars while abroad. I have also given seminars at two Australian Universities and to various community groups since returning.

Two people I met during my fellowship have expressed interest in doing graduate studies in conservation biology with me. While in Australia they will enhance intellectual and cultural exchange among Australian, Sri Lankan and North American conservation biologists. When they return to their countries of origin, they will also build the capacity in zoo biology and conservation biology there.

During my fellowship, I collected data for a publication in a peer-reviewed scientific journal reporting new information on the biology of an endangered lizard that is endemic to Sri Lanka, *Ceratophora stoddarti*. This paper will combine observations of live animals in the Sri Lankan highlands with measurements of specimens from the British Museum of Natural History in London. I will also prepare articles for the various zookeeper and zoo industry newsletters.

Programme

People and organizations visited

DATE	COUNTRY	INSTITUTION
24-1 June	Sri Lanka	Wildlife Heritage Trust of Sri Lanka National Zoological Gardens of Sri Lanka
2-9 July	South Africa	National Zoo, Pretoria Wildlife Breeding Resource Centre Pan African Association of Zoological Gardens Aquaria and Botanical Gardens
9-19 July	Zambia	
20-26 July	United Kingdom	London Zoo Whipsnade Zoo Institute of Zoology British and Irish Association of Zoos and Aquaria British Museum of Natural History
27-29 July	USA	National Zoological Park, Washington DC
30 July		Baltimore Aquarium
30 July		Maryland Zoo
31 July-2 August		Conservation Research Centre, Virginia
3-10 August		San Diego Zoological Society
11-18 August		University of Oklahoma

Account of Fellowship

SRI LANKA

Wildlife Heritage Trust of Sri Lanka

I visited the Wildlife Heritage Trust of Sri Lanka (WHT) to learn about their administration and funding arrangements to support conservation research, and also to investigate the possibility of future collaborative conservation research.

The WHT is a non-profit organization dedicated to the scientific exploration and documentation of Sri Lanka's biodiversity. The trust was established in 1989 by Rohan Pethiyagoda, an engineer, who runs (and finds funds for) the trust out of his personal interest in natural history and conservation. The trust is an organization of modest means, engaged in a limited number of research projects, both independently and in association with Sri Lankan and overseas collaborators.

The WHT has established a well-maintained repository for Sri Lankan biological specimens. This facility is located at Agaruputana in the Sri Lankan highlands. It houses specimens derived from WHT surveys, along with specimens donated by visiting researchers. The collection is available for inspection to researchers on application to the WHT. This collection is run in parallel with those in the National Museum in Colombo. Mr Pethiyagoda explained that the WHT set up their own museum because the National Museum is under-funded to the extent that it could not guarantee permanent housing and maintenance of specimens donated to its collection.

Staff of the WHT have discovered and documented a large number of species not previously known to science. They have concentrated on groups of animals that are poorly known, and have value as environmental indicators. These groups include freshwater fish, amphibians, and freshwater crustaceans. By way of example, the WHT has increased the number of frog species known in Sri Lanka from 50 to 250. They have also shown that several of the previously known fifty species are probably extinct. This fundamental knowledge about the distribution and abundance of the fauna of Sri Lanka forms the basis of good management for conservation.

The WHT has engaged the interest of many young Sri Lankans. It encourages the more promising ones to do further study and build the capacity of Sri Lanka in the field of wildlife conservation. This encouragement has taken the form of negotiating scholarships with international Universities to fund projects that interest the WHT and provide training for young Sri Lankans. To this end WHT may provide partial funds for a student to explore improved methods of assessing populations of endangered endemic Sri Lankan dragon lizards under my supervision.

National Zoological Gardens of Sri Lanka

I visited the National Zoological Gardens of Sri Lanka to learn about their administration and funding arrangements to support conservation research, and also to investigate the possibility of future collaborative conservation research on the endangered spot-billed pelican.

The National Zoological Gardens of Sri Lanka has an interesting history. It began as a privately owned collecting depot for captured wild animals destined for the zoos of Europe. This company went bankrupt in 1936 and was purchased by the Government. The zoo was made an autonomous government department in 1946. The main 24-acre zoological garden is located in Dehiwela, a suburb of Colombo. The zoo also has responsibility for the 24 acre Pinnawela elephant orphanage, between Colombo and Kandy. The zoo houses 3000 animals of 350 different species. One point two million people visit annually. The annual budget consists of 50 million rupees of government funds, and 40 million rupees from gate takings. There is a veterinary hospital staffed by four veterinary surgeons, a library, meeting rooms and educational centre for school and university students.

The status of research at this zoo was difficult to determine. Despite prior arrangements being made to visit this zoo, no research staff made themselves available to speak with me while I was there. Staff of the Wildlife Heritage Trust claimed that the NZG employed 30 research staff, but were disparaging about their qualifications and research productivity. Having said that, I met one of the vets from NZG Sri Lanka at the Institute of Zoology in London, later in my fellowship. She was being trained to monitor mammalian reproductive cycles in the reproductive biology lab there. Clearly the NZG is training their veterinary staff at an eminent zoo research institution abroad.

A group of spotted-billed Pelicans has been introduced to the grounds of NZG. This species is the most endangered pelican in the world, with an estimated world population of 11000 individuals. This species was originally maintained in cages, but several groups were released in the zoo grounds between 1968 and 1974 to try and establish a free-ranging breeding population. This was achieved, and about 50 nests are now made in the trees around the Lake each year. During my visit I saw about 150 pelicans in the NZG grounds. Birds have dispersed from the Zoo colony and established other breeding sites in the area. I saw at least 40 of these pelicans spread across three separate areas of Colombo.

Professor Kotagama and students from the University of Colombo have monitored the spotted-billed pelicans in Sri Lanka. The total population in the country is currently estimated at 800 individuals. A collaboration is developing to use data that I have collected on Australian pelicans to assist conservation of the endangered spot-billed pelican.

SOUTH AFRICA

National Zoological Garden of South Africa

I visited the National Zoological Garden of South Africa (NZG) to learn about their administration and funding arrangements to support conservation research. The NZG was of particular interest to me because it had been a National Research Facility since April 2004. As such, the South African Government funds the zoo out of the country's science budget. This puts the NZG on a similar funding basis as the CSIRO in Australia.

The National Zoological Gardens of South Africa was established in 1899. The main functions of the National Zoo are conservation, education, research and recreation. The main zoo in Pretoria covers an area of about 80 ha. The National Zoo also has two game breeding centres at Mokopane and Lichtenburg, and a third property at Vanderbijlpark (Emerald Animal World). Despite being a National Research Facility for fifteen months, there were no research staff employed at NZG at the time of my visit. Research has been facilitated at the NZG, but this has been largely reactive, i.e. in response to specific requests from scientists at other institutions. A research coordinator has been appointed since my visit.

There was a large veterinary and research building at the NZG, which contained veterinary and animal holding facilities, and a single room designated as the research lab. At the time of my visit, Dr Dan York, an academic visiting from Hillsdale College in the USA, was using this room. Dr York uses the NZG laboratories as a base to train visiting students from the USA in genetic techniques, and for a study of the population genetics of captive and wild lion populations. This project is funded by Hillsdale College and research grants from the USA. There was no functioning library at the NZG. Consequently no staff have access to the recent information from professional journals in their field. Various staff expressed the hope that this would change with the zoo's status as a research facility.

Wildlife Breeding Resource Centre

I visited the Wildlife Breeding Resource Centre (WBRC) to learn about their administration and funding arrangements to support conservation research. WBRC was, until recently, a working group of the Endangered Wildlife Trust of South Africa. It is in the process of becoming part of a National Research Facility at the National Zoological Gardens. Under the Endangered Wildlife Trust, the WBRC relied on charitable donations, contracts and grants for its funding, including wages for staff. Presently the WBRC is housed in temporary buildings on the grounds of the Pelindaba Nuclear Facility near Hartbeespoort Dam approximately 35 km West of Pretoria.

The WBRC coordinates an extensive program to collect, process and bank animal tissues from a broad range of Southern African vertebrates. The kinds

of animal tissues collected include blood samples, hair, sperm, egg cells, embryos and skin. Samples may be obtained from live or dead animals. The director, Dr Paul Bartells, is particularly interested in promoting the use of stored tissues in assisted reproductive technology. This refers to techniques such as artificial insemination, embryo transfer and in vitro fertilization. Dr Bartells advocates these techniques as potentially powerful conservation tools for managing genetic diversity in endangered wildlife.

Graduate students do much of the research and development at WBRC, while Dr Bartells focuses on collecting and storing tissues. Students come from various local and international Universities. I met a student who was visiting the WBRC for a few weeks as part of her PhD at a US university on the viability of ungulate ova under different storage conditions. I also met a Zimbabwean student who was stationed at WBRC for the full three years of her PhD study on whether pollutants were reducing fertility in male ungulates by disrupting hormone metabolism. One of the achievements of the WBRC is the birth of an eland calf at Johannesburg Zoo. This calf was produced by in vitro fertilization of a frozen egg cell, using stored semen from a dead bull.

The move to become part of a National Research Centre has resulted in secure, long-term funding for staff and basic running costs. Dr Bartells is currently negotiating to have WBRC move to the National Zoological Gardens in Pretoria.

Pan African Association of Zoological Gardens Aquaria and Botanical Gardens

I visited Pan African Association of Zoological Gardens Aquaria and Botanical Gardens (PAAZAB) to learn about their administration and funding arrangements to support conservation research in zoos. PAAZAB represents African zoos within the international community of zoos and aquaria. It achieves its mission of "Conservation through Cooperation" through the coordination, representation and promotion of the interests of Zoos and Aquaria at national and international levels. The coordinating role of PAAZAB includes co-operative captive management of animals among African zoos. PAAZAB currently has 44 institutional and affiliate members in 8 countries.

PAAZAB has a policy of encouraging zoo-based research. However, Mr David Morgan, Executive Director of PAAZAB, provided a sobering background to the very promising role that research may play at the National Zoological Garden in Pretoria. There are over 180 facilities that fall within the remit of PAAZAB in 48 African countries. Most of the zoos in Africa are colonial artefacts, and were constructed between 1920 and 1950. Almost all are government-operated. Few of these zoos are tied to any international standards of ethical care and treatment of animals in their care. PAAZAB estimates that less than 40% of west and central African zoos are economically sustainable, and operate on insufficient government funding. A significant number of West African zoos are fronts for animal dealerships of

dubious legality. Few African zoos engage in research, or are in a position to respond to requests to assist with research.

ZAMBIA

I took a break from the major aim of my fellowship to visit friends in Zambia for a few days. During my time in Zambia, I visited Munda Wanga Zoo in Lusaka and the Chimfunzi Chimpanzee Orphanage. Munda Wanga Zoo does not have any direct involvement with research. Rather it focuses on education and animal rehabilitation. At the time of my visit, Chimfunzi was hosting a visiting academic from the USA, who was doing research into social behaviour of hand-raised chimps. This work was funded by grants from the USA.

I also visited the Conservation and Wildlife advisory centre in Lusaka. This centre advises the Zambian Government on matters related to wildlife conservation, including research. The centre is currently considering how to manage research in Zambia. A major concern to them was biological prospecting by international pharmaceutical companies. They were recommending to the Zambian Government to charge all visiting international scientists large sums of money for the right to do research in Zambia. They were aware that this approach had effectively stopped most conservation research by (relatively) poorly funded international scientists working in that field.

The average Zambian dies at the age of 37. AIDS and tuberculosis are the major causes of death. I was astounded to learn that the biology department at the University in Lusaka had all but closed down. Few Zambians are willing to invest in a prolonged and expensive tertiary education with such a low life expectancy. This brought into stark focus the challenges to conservation biology in third-world countries where immediate issues of personal health take priority over longer-term issues such as maintaining an environment that can support people beyond the next 37 years.

We spent much of my visit to Zambia banding birds as part of a study into the ecological relationship between fig trees and an endangered barbet, a small frugivorous bird. We also took the opportunity to hike into the headwaters of the Zambezi River near the confluence of the borders of Angola, Democratic Republic of the Congo and Zambia.

UNITED KINGDOM

While in the UK I visited three institutions that are part of the Zoological Society of London (ZSL). These included two zoos (London Zoo and Whipsnade Zoo), as well as the Institute of Zoology, the major research arm of the ZSL. The ZSL is one of the oldest and most eminent zoological societies in the world. It promotes zoological research through its institutions, and by publishing the prestigious peer-reviewed scientific journals *Animal*

Conservation and Journal of Zoology. I was interested to learn how these various bodies work together in the area of research, how this work was funded, and how research priorities were set across the Society. I was also able to make opportunistic visits to the British and Irish Association of Zoos and Aquaria, the British Museum of Natural History and Kew Gardens.

London Zoo

London Zoo was established in 1828. Initially the zoo housed animals for scientific study by members of the ZSL. The Zoo is located on a 36-acre site at the northern end of Regent's Park. It opened to the public in 1847, and currently houses 650 species. The zoo itself does not directly employ research scientists, and the animal collection is managed for public education and captive breeding, rather than the original scientific purpose. However, curatorial (senior supervising keeping) staff at the zoo are expected to devote a third of their time to zoo-based research. This research work is funded from the working budget of each curator's department, and supplemented by grants. The curator of invertebrates has focused on the genetic management of animals kept in colonies, where it is not possible to identify or manage individuals. This is relevant to London Zoo's breeding program for endangered Polynesian Snails. The curator of reptiles has done fieldwork in Indonesia mapping the distribution of Komodo dragon lizards. This fieldwork identified four distinct populations, and was done in conjunction with this species being exhibited at the zoo.

Whipsnade Wild Animal Park

Whipsnade is an open range zoo located in Bedfordshire, an hour's drive north of London. The park was opened in 1931 and covers 600 acres. Whipsnade houses 2,500 animals, mostly in sizeable enclosures. There are also free-ranging populations of peacocks, mara (a large, South American rodent) and red-necked wallabies. Whipsnade and London Zoo share a single director, and many senior and administrative staff work at both properties. This is a recent arrangement designed specifically to reduce historic tensions between the two properties.

Whipsnade has been the site of several significant research projects over the years. These have been done by visiting researchers from Universities or the Institute of Zoology. Until recently Whipsnade had no research staff. A research coordinator has been appointed to encourage further research there. At the time of my visit he had just completed the first census of the free-ranging animals at Whipsnade with a view to managing these populations. This census estimated there were 900 red-necked wallabies on the grounds of Whipsnade!

Institute of Zoology

The Institute of Zoology (IoZ) is the research division of the ZSL, and is located adjacent to London Zoo in Regents Park. The Institute undertakes scientific research into many fields of conservation biology. Its focus is not confined to the ZSL's collection of captive animals, but emphasizes conservation of animals in their natural habitat. IoZ staff and students are more likely to work in an international field site, than in a zoo.

The IoZ is formally linked to the Department of Zoology at Cambridge University. As such the IoZ is unusual in being an academic research body, able to train postgraduate students (whose degrees are conferred by Cambridge University), embedded within a conservation charity (ZSL). The core funding for the IoZ comes from the ZSL and the Higher Education Funding Council for England. This funding arrangement relies on the formal connection to a University. Additional research funding for specific projects comes from UK research councils (e.g. NERC, BBSRC, EPSRC) and research charities (e.g. Wellcome and Leverhulme trusts), as in university departments in the UK.

IoZ research covers the fields of evolutionary biology, genetics, ecology, reproductive biology, wildlife diseases, and animal health/welfare. A senior research fellow in the Institute leads each one of these research disciplines, but they are not restricted to working within this discipline. Considerable collaboration occurs between the research groups both within the Institute, and with other scientists in the UK and abroad. The Institute employs 35 academic, post-doctoral and veterinary staff, 24 technical staff, 9 administrative staff, and hosts around 30 postgraduate students. The IoZ plays a central role in the field of zoology by publishing long-standing learned journals, hosting regular thematic symposia in its meeting rooms, which are generally published as books, and through their wide-ranging and high quality research. The IoZ plays a major part in collating and publishing the Red Data Book, a compendium of data that defines the conservation status of all animal and plant species.

British and Irish Association of Zoos and Aquaria

I was able to meet briefly with staff from BIAZA in their offices at London Zoo. Like PAZAAB in Africa, BIAZA encourages communication, cooperation and maintenance of minimum standards of practice among zoos in their region. In the UK it is a legislated requirement of registration that zoos engage in conservation and research. There is no such requirement in Australia.

Many zoos in the UK allow tertiary students to use their collections for educational research, and consequently meet this requirement of registration as a zoo. Few zoos in the region employ dedicated research staff. BIAZA has commenced an annual research conference to encourage sharing of research

results among its member zoos. This innovation is only a few years old, and is not yet fully supported. For example staff of the Institute of Zoology do not attend the BIAZA research conferences, even though they are the leading zoo-based research institute in the region.

British Museum of Natural History

While in London I took the opportunity to visit the scientific reference collection at the British Museum of Natural History. This collection holds many specimens of Australian animals that are of historical importance. One of these is the type specimen of the Peninsula dragon lizard, *Ctenophorus fionni*. A type specimen is the reference specimen against which all others must be compared to ensure correct identification of animals.

I have been studying the Peninsula dragon lizards for many years, but had never before seen the type specimen. I had only photographs taken by others to work from. The staff at the BMNH very kindly allowed me to photograph and measure this specimen. Indeed when I arrived at the museum, they had laid-out the specimen, together with the original description of the species by Joan Proctor. Proctor described *C. fionni* in 1923 while she was Curator of Reptiles at the London Zoo. I was able to acquire some biographical information and photographs of Ms Proctor from the archives of the ZSL. Proctor became curator of reptiles, a position unusual for women at the time, in her 20s and died when she was in her 30s. She designed the first purpose-built reptile house at any zoo. This building still houses the reptile collection at London Zoo. Before she died, Proctor was confined to a wheelchair. She would walk (or wheel) around the grounds of London Zoo with a 3 metre long Komodo dragon lizard on a leash.

I was also able to photograph and measure specimens of dragon lizards from Sri Lanka while at the BMNH. These data will be combined with data I collected in Sri Lanka and published in a scientific paper on these little-studied, highly endangered animals. This paper will be published in collaboration with staff of the Wildlife Heritage Trust of Sri Lanka.

UNITED STATES OF AMERICA

National Zoological Park, Washington DC

The National Zoological Park (NZN) and Conservation Research Centre (CRC) are part of the Smithsonian Institution. The Smithsonian Institution aims to increase and disseminate knowledge. This aim was defined in James Smithson's original bequest that founded this world-renowned centre for scientific research and education. The NZN and CRC are a small part of the Smithsonian Institution, which has major institutes in the fields of Natural History, Art, Astronomy, Earth Sciences, and History. I visited the NZN and CRC because they are one of the pre-eminent groups of zoo-based conservation biologists. The funding base and administration of research

there was interesting because it is so different from anything that happens in science anywhere in Australia.

The National Zoological Park's occupies 163 acres within Rock Creek Park, Washington, DC. This free entry zoo houses 2200 specimens of 380 species of vertebrates and invertebrates, and a large inventory of native and exotic plants. In keeping with the primary research and education role of the NZP, Smithsonian employees manage the zoo's animal collection and research work. A separate organization, Friends of the National Zoo (FONZ), manage visitor services (restaurants, fund-raising, volunteers etc).

Science is fully integrated into the National Zoological Park's conservation, education, exhibit and education programs. Research is conducted in the areas of comparative pathology, animal behaviour, ecology, evolutionary biology, animal nutrition, reproductive physiology, comparative veterinary medicine, population genetics, conservation biology, bird migration and applied conservation. The National Zoological Park also has field sites in California, Gabon, south-eastern Brazil, Sri Lanka, northern Myanmar, and the eastern Mojave Desert. In addition to a substantial staff of professional scientists, the animal management staff at NZG are involved with collection-based research, though their major focus is to manage the living collections, develop and maintain exhibits.

My visit to the NZG and CRC was particularly productive. I was able to meet with staff from all levels in the organization, and gained a very good understanding of how the NZG works. Staff at the NZG were generally very highly qualified, and all had extensive (often international) experience in the zoo or science industries. The senior scientific staff at the zoo generally had experience in other high-level research institutes, elsewhere in the world, or in the Smithsonian. Many had adjunct position with Universities. There was substantial institutional funding available to all Scientists employed by the Smithsonian for their research. Many retired scientists from the NZG maintained offices in the research department, and continued to contribute to the research output, education programs and academic environment there.

During my visit to the NZG I was able to see a young Giant Panda that had been born four weeks previously. This little beast had been produced by artificial insemination by the research and veterinary staff. The finances surrounding the birth of this little beast brought home to me the magnitude of funding available in this zoo, relative to my home institution. The Chinese government hires Giant Pandas to zoos outside China for one million US dollars per year. The parents and baby Panda were costing the NZG three million US dollars, plus the costs of keeping them, the artificial insemination, and field research in China. The NZG spends more than half the entire annual budget of Adelaide Zoo on a single species each year!

Conservation and Research Centre, Front Royal, Virginia

Conservation and Research Centre (CRC) covers 3,200 acres in the Blue Ridge Mountains of northern Virginia. It is an off-exhibit facility dedicated to conservation research, training and education. Fenced paddocks, aviaries and indoor holding facilities accommodate large ungulates, carnivores, small mammals, and birds. These facilities allow for well-designed and replicated studies on captive animals to enhance field studies and conservation efforts.

A veterinary hospital serves clinical research and training in wildlife medical techniques and supports care of research collections. A Spatial Analysis Lab at the Centre has the tools needed to work with satellite imagery and Geographical Information Systems. Reproductive physiology laboratories undertake research and training in wildlife endocrinology, gamete biology and embryology. A Biodiversity Program includes surveys of areas where biodiversity is poorly known and biological data are needed to assist in making sound decisions regarding development and conservation. Projects at CRC encompass both terrestrial and marine vertebrates (birds, mammals & reptiles) and a wide range of habitats, from subpolar to tropical locations.

While the Smithsonian is extremely wealthy by most standards of international pure research, funding was an issue commonly discussed among scientists at the national Zoo and CRC. At the time of my visit, the Zoo was about to appoint a new director. There was some concern expressed that a new director may close the CRC facility at Front Royal, despite its central role in zoo-based research, in response to financial constraints on the Smithsonian Institution by the USA Federal Government.

Baltimore Aquarium.

I had an opportunity to visit the Baltimore Aquarium (BA) through contacts at the National Zoo. The aquarium is located on the docks next to the Baltimore central business district. It has recently invested \$US80 million in an Australian exhibit. This exhibit is housed in a five-story building, which contains an indoor replica of an Arnhemland Gorge.

The BA does not specifically employ research staff. However, a proportion of the running costs for the Australian exhibit has been allocated to conservation and/or research projects in Australia. This arrangement has been made under the auspices of the American Zoos Association. AZA member institutions are encouraged to allocate a proportion of their operating budget for new exhibits to support conservation work in the country from which the exhibit is derived.

The BA would like to exhibit Regent Honeyeaters, a species that has declined to 1500 birds in two populations in New South Wales. This bird was once found in South Australia, but has gone extinct there. We are negotiating to breed some Regent Honeyeaters at Adelaide zoo for display at BA. In return, BA would fund a program to release captive bred Regent Honeyeaters to the

Mount Lofty Ranges near Adelaide. Such a program might involve reciprocal exchange of staff between Adelaide Zoo and BA for training purposes, husbandry and conservation purposes.

Maryland Zoo

I visited Maryland Zoo because the opportunity came about casually through colleagues in the Herpetology Department of the National Zoo in Washington. The Maryland Zoo opened in 1880, and is owned by the local government. The grounds are pleasant, but this zoo clearly lacks the funding of the National Zoo.

Maryland Zoo had a major restructure in the last couple of years and is upgrading many of its exhibits and facilities. Despite financial constraints, Maryland Zoo is involved in several conservation projects. These are principally funded from outside sources. For example, Maryland Zoo staff have been involved with a Mountain Gorilla Veterinary Project, which provides health care to the highly endangered mountain gorillas in the countries of Rwanda, Uganda and the Democratic Republic of the Congo. This project relies on funding from the Morris Animal Foundation. In past years staff ran a conservation project studying bog turtles on the zoo grounds. But this project has been discontinued. The zoo is also part of a consortium of Panamanian and U.S. institutions that aims to preserve the Panamanian Golden Frog. This project consists of field studies, captive propagation, and education with the primary goal of ensuring against the extinction of golden frogs due to a fungal disease. Maryland holds an off-show breeding group of these frogs in its veterinary hospital. Conservation research at Maryland Zoo relies heavily on the interest, enthusiasm and goodwill of its staff, rather than being an integral part of the Zoo's normal role.

San Diego Zoological Society

The San Diego Zoological Society is a charitable organization that owns and runs the San Diego Zoo, one of the largest zoos in the world. The Society also has the open-range Wild Animal Park at Escondido in California. The Society has a membership of 250 000 people, mostly drawn from the San Diego area. I visited San Diego to learn about its research department, the Centre of Conservation Research for Endangered Species (CRES).

CRES is one of four major zoo-based research departments in the USA, along with the National Zoo in Washington, Chicago Zoological Society and the Wildlife Conservation Society, which runs the Bronx Zoo in New York. CRES employs 120 staff in the fields of evolution, biological diversity, reproductive biology, genetics, animal behaviour, endocrinology, and applied ecology. CRES' annual budget is \$US12 million. Seven million comes from the Society as base funding, and the remainder comes from sponsorships and grants. This group of remarkable scientists has been involved with some of the landmark conservation research projects in the zoo world.

CRES is in a period of change. Twelve months ago the Centre moved from the San Diego Zoo to a site adjacent to the Wild Animal Park. This move occurred when the purpose-built Beckman Building was completed. This building was donated from the Beckman scientific instrument-making family business. This building contains laboratory and office space for all CRES staff, as well as meeting rooms, a lecture theatre and a library. Animal holding facilities have also been built in the Wild Animal Park to house dedicated colonies of animals for research purposes.

Three weeks before I arrived at CRES, the director had resigned at the request of the board. This, understandably, caused some turmoil in the Centre. Despite it being a difficult time to have international visitors, the staff at CRES were very welcoming and helpful to me. During my visit I was able to meet a board member of the Zoo Society, the acting director of CRES, all of the senior scientific staff, postdoctoral fellows, graduate students, summer scholarship students, technicians and fund-raising staff. This gave me a broad range of perspectives on the current workings of CRES.

Within the San Diego Zoo Society, CRES is strictly linked to the Public Relations Department, who use it as a selling point when marketing the Zoo Society. Krishna Roy, a public relations and fund-raising consultant has been appointed specifically to raise funds to support CRES' research and conservation work. She distinguished three major sources of funds for charitable organisations in the USA: (1) individuals, (2) commercial funding, and (3) philanthropic foundations. She targets individuals and philanthropic foundations for CRES, and is working with CRES scientists to produce discipline and project outlines for potential donors. She emphasized telling the "wow" stories, rather than the "big" picture stories. She gave an example of the elephant scientists studying hormone cycles in elephants, who explained that their work would help characterize normal cycles for assessment of captive females. Krishna feels that pointing out that they would have access to 40 females, rather than the usual 2-5 in an American zoo will sell the project. This is because donors are convinced that elephant work is worthwhile, before they approach the zoo. They will be impressed by the uniqueness of the large sample size, rather than care about the details of the project.

Fund raising at CRES has not only provided for the working budget, but has also allowed appointment of permanent staff. The head of the genetics section at CRES, Dr Oliver Ryder, has an endowed Chair, which also pays for eight of his section staff. He also attracts competitive grants. Dr Ryder's major work is in collecting, storing and analysing animal tissues in what he calls a "frozen zoo". This is the same basic concept as the Wildlife Breeding and Resource Centre I visited in South Africa.

CRES senior scientific staff had developed a ten-year strategic plan for research and conservation work, which the Society has agreed to fund.

Research projects not included in this plan may be funded by ad hoc grants. They recognized the crucial role of communicating results of research projects, through scientific and popular publications, as well as interpretive material for visitors to the zoos. They see this as crucial to the scientific and financial success of their department.

University of Oklahoma

The University of Oklahoma is a public university that opened in 1890. It enrolls 31,000 students per year, has 2,000 full-time faculty members and it is one of 50 (or so) Universities in the USA for which research is a major focus. University of Oklahoma is unusual, in that it incorporates the Oklahoma Museum of Natural History, Oklahoma State Biological Survey, in addition to the more traditional academic departments. Museums and biological surveys are more usually part of the public service. The University has also taken responsibility for the Sutton Avian Research Centre, which focuses on bird conservation work.

Sutton Avian Research Centre, Bartlesville

I visited the Sutton Avian Research Centre (SARC) to learn about their administration and funding arrangements to support conservation research. The SARC was founded in 1983. The organization is dedicated to finding cooperative conservation solutions for birds and the natural world through science and education.

George Sutton was a major benefactor of the SARC. After his death in 1982, the SARC was established on 40 acres of an oak-covered hilltop near Bartlesville, Oklahoma. This had Sutton's private holiday property, and included a large house that was converted into the administration building. This building provides office, library, conference, and dining space for the Centre's staff. Several large laboratories and barns provide research areas and contain captive-breeding facilities.

Initially the SARC was an independent non-profit organization. Staff wages, running costs and project costs were funded completely by donations, grants and contracts. Since 1997 the SARC has been affiliated with the University of Oklahoma. The University now funds wages and basic running costs. Consequently the SARC uses funds from its traditional charitable and commercial sources entirely for research and conservation projects.

This has allowed the SARC to expand the scope of its activities. These activities include intensive, conservation-oriented, ecological field research on declining grassland birds, the reintroduction and monitoring of Southern Bald Eagles, captive breeding of endangered species, raptor surveys world wide, and educational outreach programs. The SARC employed nine staff at the time of my visit.

Department of Zoology, Norton

I visited the Department of Zoology to meet Professor Douglas Mock, who is an acclaimed world authority of brood reduction in birds. Brood reduction occurs when parents produce more offspring than usually mature. This happens at considerable cost to themselves in terms of producing and providing for one or more offspring that rarely survive. Brood reduction appears to be maladaptive and consequently offers a challenge to evolutionary theory. It occurs in just under half of the world's bird species, and is particularly prevalent in endangered species. If we can understand the mechanisms leading to the high mortality among young of brood reducing birds, we will be able to develop ways of reducing this mortality. This will be a significant use in conservation, because juvenile mortality is often a major limiting factor to population growth in birds.

I have been studying this phenomenon in Australian Pelicans for the past fifteen years, and have benefited greatly from reading about Professor Mock's longer (30 years), but parallel work on cattle egrets. The opportunity to meet Professor Mock, and exchange observations and ideas was invaluable to my research on brood reduction in Australia. I came away with several insights from work that Mock and his colleagues have completed, but not yet published. I also came away with ideas for several fruitful lines of investigation of brood reduction for which Australian pelicans are a suitable model, but for which other species being studied are not suitable. Professor Mock had also recognized the importance of understanding brood reduction for bird conservation, though he had not developed these ideas, as they were not his primary interest. Our meeting has confirmed and expanded the conservation implications of my work on brood reduction, and formed the basis for continued contact, and development of collaborations in the future.

Conclusions

Research administration in zoos

Scientific research is a unique activity. It involves the identification of areas in which we lack knowledge, exploration of those areas, and discovery. It is a field that, ideally, embraces uncertainty. These are features of scientific research that make it difficult to embrace and administer in any organization that is financially constrained and requires predictable and measurable productivity.

Most zoo administrators that I met during my fellowship (and during my professional career in the Australian zoo industry) have an unrealistic idea of what they (hope to) achieve by employing a scientist. Generally, they share the popular view of scientists as educated people who know a great deal, and can provide instant advice on any area of zoology. Coming from this point of view, many administrators I met expressed difficulty in adjusting to the need to continually redefine research priorities, the uncertainties of research funding and scientific staff who need to travel to far-flung field sites, collaborate with specialists from other (sometimes competing) organizations, and work odd hours. Clearly these comments are generalizations, but they hold true for most small zoo-based research departments.

The three large and very successful zoo-based research departments I visited (Institute of Zoology in London, National Zoo in Washington DC, and CRES in San Diego) had very successful research administrative structures. In the case of the National Zoo, this was built in to the structure of the parent organization. The Smithsonian is primarily a scientific organization, which runs the National Zoo for public education purposes. Most senior administrative officers at the Smithsonian are, or have been, scientists themselves. In the cases of CRES and the Institute of Zoology, the heads of the research departments were scientists and executive officers within their organizations. These people were relied upon to act as a conduit between scientific staff and other sections of their zoo's organization. The role played by the head of these large research departments was seen as crucial by the scientific staff within them, and by staff in the rest of those zoos. This was vividly illustrated to me during my visit to CRES shortly after the head of the research department had resigned.

I found no clear model that worked for research administration in small zoos during my fellowship. Zoos around the world have embraced the ideal of being involved with conservation research, but few have succeeded in doing so to the extent that they have been able to employ scientific staff, over any period of time, if at all.

I have formed the opinion that Australian zoos would do well to make formal connections between their scientific staff and local universities. This would

take advantage of administration arrangements and infrastructure already established for research within Universities. It would also enhance conservation biology as a discipline for teaching and research within Universities, producing better trained conservation professionals in the future.

Sustaining research in zoos

Financial constraints are the greatest limiting factor for zoo-based research. Those research departments I visited that consistently produced high quality, relevant research for the zoo industry had consistent and substantial funding available to them. For the most part, this was because research for conservation was a primary aim of the organization that hosted the department. Those organizations that gave inconsistent support for research and conservation were unable to produce high quality data of use to zoo-based conservation work.

During my fellowship I saw several zoo-based research departments that had solved the problem of funding in various ways. The first, and most direct, source of funding was from bequests or sponsorship deals for important positions, buildings or pieces of equipment. An example of this is the Beckman Building, which houses the research department (CRES) at the San Diego Zoological Society. This building was the result of a donation from the Beckman family, who became wealthy by producing scientific laboratory equipment. Even though CRES has a substantial annual operating budget, the building, which now houses CRES would not have been possible without the Beckman donation.

Another funding option was also exemplified at CRES. The CRES genetic research group is funded by a philanthropic endowment that covers the costs of the head of department, eight technical staff, and the maintenance of the "frozen zoo" (tissue bank) and some research. Unfortunately, sponsorship funding and philanthropy on this scale are not common in Australia. This may be due to the difference in the standing of research between the USA and Australia. It is also reflected in the different laws regarding taxation and philanthropic gifts in the two countries. In the US, research is better regarded and a more saleable activity, than it is in Australia. My impression is that most Australian companies would prefer to provide a single donation for an exhibit in a zoo, rather than continued support for even the most high profile of conservation research projects. Instead, it may be possible to attract funds from abroad to fund conservation research in Australian zoos. Australian animals are certainly very popular abroad, especially in the USA.

In Australia, research grants from traditional academic sources (federal or state funds) are a usual source of funds to undertake specific projects. They generally fund the research, on the assumption that the applicant has a secure wage. Grants also usually run on a two-three year cycle, so only short-term projects may be supported. Grants are very competitive to obtain, and are generally designed to support University or government-funded research

institute staff. Scientists who move into zoo-based research departments may enter this industry with competitive research and publication records, and be able to obtain grants initially. With the exception of those gaining positions in well-established research groups, such as the CRC at the Smithsonian, they often expressed difficulty in maintaining their scientific productivity and reputation. Over time, many zoo-based scientists I met found themselves no longer able to obtain competitive science grants, and having to rely on funds available through the zoo that had hired them. This was not usually well understood by zoos trying to set-up new research departments. I heard many stories of zoos that employed promising scientists on short-term contracts with the expectation that they would become self-funding through grants, only to find this was seldom possible. In Australia, the federal science funding bodies (Australian Research Council, and National Health & Medical Research Council) exclude scientists employed in zoos from applying for grants. Furthermore, few zoos could meet the strict and extensive administrative requirements to hold an ARC or an NH&MRC grant.

The most consistently-positive arrangement for securing zoo-based research positions and funding that I saw involved close relationships between zoos and Universities. Indeed every place I visited, including zoo-based and other conservation research bodies, utilized such a relationship in some way. This comes about because, in most countries, Universities have special funding status to promote research. In Australia each scientific paper bearing a University address accrues a financial benefit to the university. Similarly, each graduate student who completes their degree accrues funds for the university, over and above the costs of supervision, scientific equipment used by the student, scholarships etc. In the case of a PhD, the University awarding the degree receives \$30 000 per year of the student's candidature. Every dollar acquired by researchers in Universities attracts further funding from the federal government. This is not the case for zoos, where research is a financial drain.

St Louis Zoo in the USA offers an example of how Australian zoos could build their research potential by developing relationships with Universities. Although I was unable to visit St Louis Zoo, several scientists I met during my fellowship suggested it as a model for use in Australia. St Louis Zoo joined forces with a local University to fund eight endowed joint research positions. This is something that has not been done in an Australian Zoo. But satisfyingly, it is precisely the arrangement that the Royal Zoological Society of South Australia and the University of Adelaide have been discussing over the past year.

Areas of interest that are common to both zoos and conservation bodies in Australia and overseas.

What should zoo-based research scientists do? There are various answers to this question, each of which raises a fundamental issue of the role of research in zoos. My fellowship gave me the opportunity to visit a variety of zoo and

other conservation organizations to see how they answered this question. Each place I visited answered it in a different way, to suit its own purposes. It seems to me that the answer for any one zoo stems from the answers to several questions:

- Should scientists be of service to an individual zoo, or be of broader service to conservation (or the biological sciences)?
- Should zoo-based scientists provide expert advice based on what is already known, or create new knowledge via scientific research?
- If scientists are to do research, should it be applied or fundamental research?
- On what organisms should zoo-based scientists work? And who should decide, the institution or individual scientists?

In general I found that larger, better-funded institutes tended to choose the last answer to each of these questions, whereas the smaller institutions tended to choose the first answer.

In terms of scientific disciplines, most places I visited had a clear interest in assisted reproductive technologies, genetic management of their livestock, and nutrition. Fewer were interested in ecology and physiology of the animals in their natural environment, knowing what the normal behaviour of a species is in the wild (compared with captivity), or improvements to reintroduction protocols. While individual scientists were clear about what their own research interests were, there seems to be no general consensus on what the research priorities should be in the zoo world.

During my fellowship, I met several scientists with whom I share common research interests. In several cases my fellowship allowed me to make connections among international colleagues that may not otherwise have occurred, and which may lead to fruitful collaborations. Examples of this are:

- I will be collaboratively supervising a graduate student at the University of Colombo to work on better ways of assessing population health in relation to habitat patch size in endangered forest-dwelling lizards in Sri Lanka. The Wildlife Heritage Trust of Sri Lanka will fund fieldwork for this project.
- We are exploring the possibility of collaborative work with behavioural scientists at CRES in San Diego on koala management in the wild. This work may be funded by the visitor fees derived from the exhibition of koalas at San Diego Zoo.
- We are exploring the possibility of working collaboratively with the staff of the Australian exhibit at the Baltimore Aquarium to work on endangered Regent Honeyeaters. This project may be funded from visitor fees derived from the exhibition of Australian birds in Baltimore.

- A keeper at the Maryland Zoo may come to Australia to study the field ecology of Prehensile-tailed skinks in the Solomon Islands. This will be dependent on her obtaining the required scholarships from the University of Adelaide, and appropriate funding for fieldwork from zoos in the USA.

Disseminating the fruits of my Fellowship

Seminars

Invited presentations based on the results of my Churchill Fellowship have been made to:

- Dept. Conservation Research for Endangered Species, San Diego Zoological Society
- School of Earth & Environmental Sciences, University of Adelaide
- School of Biological Sciences, Flinders University of South Australia
- Staff, Adelaide Zoo
- Volunteers, Royal Zoological Society of South Australia

I have also been asked to speak to various community groups (Rotary, SA Frog Society) in the near future about my fellowship.

Publications

During my fellowship, I collected data for a publication in a peer-reviewed scientific journal reporting new information on the biology of an endangered lizard that is endemic to Sri Lanka, *Ceratophora stoddarti*. This paper will combine observations of live animals in the Sri Lankan highlands with measurements of specimens from the British Museum of Natural History in London. I will also prepare articles for the various zookeeper and zoo industry newsletters.

The Media

I am often asked to comment on issues of local scientific interest to the South Australian mass media. The information and experiences gained during my Churchill Fellowship will be widely used and acknowledged as opportunities permit.

Recommendations

- Australian zoos wishing to establish a research department should explore the benefits of working with a local University to establish joint positions to work in mutually agreed scientific disciplines. The benefits to zoos may include the advantage of special funding status of Universities, access to graduate students, appropriate science administration, and an established academic environment to encourage a high quality, productive research program. Universities would benefit from access to zoo collections for research, and access to scientists to teach and research in the popular area of conservation biology.
- Australian zoos are small by world standards and none have the capacity to build a comprehensive research department. So, those Australian Zoos wishing to establish a research capacity should work together to identify priority areas of research. Each zoo should employ specialists in different disciplines and build a research specialty. In this way specialist zoo-based scientists might ultimately be available in most required fields.
- The Australian Regional Association of Zoological Parks and Aquaria (ARAZPA), as the over-arching zoo industry body, could broker such an arrangement with a view to utilizing the pool of scientific staff across all properties in a co-operative and collaborative way.
- Through their scientific and public relations staff, Australian zoos should act as “shop fronts” for the biological sciences and conservation in Australia. This would involve informing the general public about the advantages of exploring and understanding the world that sustains us, and promoting science-based conservation research.
- The general public expects zoos to be involved in conservation, research and education. There is also an expectation of a high standard of animal husbandry. Consideration should be given to establishing a legislative basis for the existence of zoos in Australia, including minimum standards of activity in animal welfare, conservation and research. This would parallel the legislative basis for zoos in the UK.