

Int. Zoo Yb. (2011) **45**: 30–37

DOI:10.1111/j.1748-1090.2011.00133.x

The National Zoological Gardens of South Africa: a National Research Facility

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The National Zoological Gardens of South Africa (NZG) has been a declared National Research Facility of the National Research Foundation (NRF) since 1 April 2004. As an independent government agency, the NRF promotes and supports research in all knowledge fields. The National Research Facilities, placed under the custodianship of the NRF, contribute to the provision of a high-quality research platform for the research community across the national science system. The NZG as a National Research Facility is in a unique position to generate new knowledge, core technologies and data pools/collections commensurate with international standards. It provides a critical mass of equipment, skills and users and the potential for networking and attracting collaboration. The facility offers unique opportunities for the advancement of science and for an interface between science and the public, and the additional provision of opportunities for people development. The broad strategic contexts of the NZG are thematic drivers. These drivers focus on the way the organization attracts, develops and retains talent. The aim is to uphold excellence in all investments in knowledge, people and infrastructure.

Key-words: National System of Innovation; platform; research; strategic drivers.

INTRODUCTION

The National Zoological Gardens of South Africa (NZG) was founded in 1899 when the government of the time purchased the farm *Rus in Urbe* from the celebrated South African author J. F. Cilliers to establish a zoo. Today, it operates four sites in three provinces. Each site plays an important role in adding value to the core functions of the organization. The main site and headquarters

are located in South Africa's capital city, Pretoria, in the form of an 85 ha zoo. The 6000 ha Biodiversity Conservation Centre in Lichtenburg in the North-West Province of the country has distinguished itself as a semi-*in situ* site where White rhinoceros *Ceratotherium simum* have been bred successfully. The 1500 ha Biodiversity Conservation Centre in Mokopane in the Limpopo Province, located in the north of South Africa, houses threatened species such as Roan antelope *Hippotragus equinus* and Black rhinoceros *Diceros bicornis*, as well as other flagship species that include Cape buffalo *Syncerus caffer* and Red-billed oxpeckers *Buphagus erythrorhynchus*. In association with a commercial venture on the banks of the Vaal River in Gauteng Province, the NZG also jointly manages a 14 ha zoo and an 89 ha animal park.

Collectively, these sites house one of the largest animal collections in Africa, comprising 3117 specimens of 209 species of mammal, 1358 specimens of 202 species of bird, 3871 specimens of 190 species of fishes, 388 specimens of four species of invertebrate, 309 specimens of 93 species of reptile and 44 specimens of seven species of amphibian. A reptile park and the largest inland marine aquarium further complement the collection. Acquired in 1916, the NZG is the only one of the four governmental zoos in South Africa with national status. The only Komodo dragons *Varanus komodoensis* and

Koalas *Phascolarctos cinereus* on the African continent are housed at the NZG. The 51 Bald ibises *Geronticus eremita* maintained by the NZG constitute the largest breeding population of these birds in Africa and the NZG observed the first ever zoo birth of a Southern white rhinoceros *C. s. simum* (Brand, 1980).

The NZG is a member of the international zoo and aquarium community through the World Association of Zoos and Aquariums (WAZA). The NZG has clearly aligned itself strategically with the new roles and functions that zoos and aquariums are required to play in the conservation of biodiversity, with conservation research, education and science awareness being integral parts of the activities (WAZA, 2005; Zimmermann *et al.*, 2007; Dick & Gusset, 2010). Through this global connectedness, the NZG established linkages, partnerships, collaborations and sister relationships with zoos from all corners of the world. Partnerships are also in place with research and conservation organizations that undertake *in situ* conservation of threatened species.

In the African landscape, the NZG was the founder member of the regional African Association of Zoos and Aquaria (PAAZAB). PAAZAB serves as a forum for shared knowledge in *ex situ* conservation of wildlife biodiversity, skills development and technical development in professional zoo practice, wildlife conservation education and conservation research. The New Partnership for Africa's Development *Science and Technology Consolidated Plan of Action* sees Africa's biodiversity as a major source of economic and social transformation, although it is underutilized and being lost at an alarming rate (Mugabe & Ambali, 2006). The action plan argues for African countries to establish regional networks of scientific centres of excellence to drive conservation and sustainable use of the continent's biodiversity. As the only zoo in the continent with a statutory mandate to undertake scientific research, the NZG is appropriately positioned to lead and deliver on this continental responsibility.

THE NEW MANDATE

On 1 April 2004, the NZG was declared a National Research Facility and transferred to the management of the South African National Research Foundation (NRF). South Africa's National Research Facilities are high-end scientific and technical facilities with specialist equipment and skills that are not duplicated anywhere else in the country. They serve as important research platforms that are made accessible to the entire research community, including universities and other components of the science system locally and internationally. All National Research Facilities are managed by the NRF on behalf of the nation and under the political direction of the National Department of Science and Technology. The NRF is an autonomous government agency charged with supporting research and human-resource development for science, engineering and technology in South Africa.

The fact that over 200 000 learners/scholars visit the facility annually was a primary consideration in the declaration of the NZG as a National Research Facility, in recognition of its potential to play a pivotal role in the advancement of science in society. However, the NZG, which is a classical and old (110 years old) zoo, had neither a distinguished history of research nor the primary infrastructural platform to fulfil its new mandate at the time of its declaration as a National Research Facility.

National Research Facilities are expected to: (1) provide a platform for high-quality research, accessible to the wider research community both locally and internationally; (2) undertake high-quality research and generate knowledge in areas of strategic national importance and competitive advantage; (3) develop technology and pursue innovation in support of the national effort for scientific, technological and social innovation; (4) grow human capital through research and technology development in areas of strategic national importance and for the development of a knowledge economy; (5) advance science in society through:

- provision of platforms for enhancing science awareness and public engagement;
- supporting teaching and learning in science, engineering and technology;
- communication of the relevance, importance, products and benefits of science to/for society.

This meant that the organization had to undergo fundamental transformation to position itself to fulfil the new mandate and the expectations that came with it.

ORGANIZATIONAL TRANSFORMATION

A comprehensive strategic planning process to review the activities of the NZG critically and to position it within South Africa's National System of Innovation commenced in 2005. This process culminated in the development and the adoption of a new NZG Strategic Plan in 2006 (NZG, 2006), which focused largely on the transformation of the NZG into a National Research Facility.

During this time, however, strategic shifts within the NRF occurred and were subsequently embodied in a new strategy document *NRF Vision 2015* (NRF, 2008). As a result, the NZG revised its newly adopted Strategic Plan in order to align with the corporate NRF strategy. The result was *Agenda2015*, a plan aimed at appropriate positioning of the facility within its new context focusing on delivery of the revised mandate.

Key aspects of the NZG's new strategic framework

Agenda2015 highlights five strategic drivers, the first of which, by virtue of its declaration as a National Research Facility, is '*to grow the NZG as a centre of excellence for conservation and biodiversity research on the one hand, and conservation medicine on the other, working at the in situ/ex situ interface*'. In delivering on the expectations of being a modern zoo as envisioned in the *World Zoo and Aquarium Conservation Strategy*

(WAZA, 2005), the second driver is '*to establish the NZG as a world-class 21st century zoological garden*'. The NZG is committed to being a family attraction of first choice that inspires discovery, appreciation, care, knowledge and respect for nature to fulfil the expectations of the 600 000 or so visitors who pass through the gates every year. To this end, *Agenda2015* commits the NZG to become '*a top-class metropolitan ecotourism facility that places a premium on environmental sustainability*'. While advancing science in and for society, the NZG also aims to be '*a place of learning and a source of inspiration to action for science and biodiversity*'. No organization can achieve any of its strategic objectives without defining capabilities, people, culture and its values. Therefore, the final strategic driver is '*the organization: transforming the NZG into an organization that is capable, diverse, responsive, knowledge-led and embedded in core values*'.

In giving the above exposition of the strategic framework of the NZG, the description of its vision and mission was left until the end to tie together all the strategic aspects into what the organization aspires to be. The vision of the NZG is *Nature and Humanity in Balance*. NZG is committed to creating dynamic opportunities for people and animals to connect and, thus, inculcate a healthy mutual respect and acceptance of the other's place within nature's cycle. The mission statement '*inspired conservation of wildlife through knowledge, understanding and connection*' denotes the organization's commitment to the following.

1. Develop knowledge through research that can underpin conservation practice and management of biodiversity. Improve zoo operations and practice through continuous monitoring and review. Evaluate and establish an evidence base for our actions and decisions through knowledge generation.
2. Promote the understanding that humans are an integral part of natural biodiversity and can act to protect the environment, nature, species and their habitats. Promote the understanding that through action and changing our ways of life we can protect the environment

and save species and their habitats. Inculcate understanding of the natural requirements of species and habitats that will enable them to survive as a basis for protecting the earth for future generations to enjoy.

3. Illustrate the connection between wildlife, domestic animals, humans and ecosystems as an integrated circle of life. Support education in schools using conservation as a science and the school curriculum. Promote the animal collections and (saving) species and their habitats in the wild and the science of conservation and biodiversity management, on the one hand, and human-resource development on the other.

HATCHING THE WAY TO BEING A NATIONAL RESEARCH FACILITY

Several research areas have been established over the last 2–3 years and these are laying the foundation for future research excellence. The NZG has a wildlife biomaterials bank (wBRC), which is unique in that it encompasses components of multiple biobanks, such as microbial and cell cultures, sperm bank, tissue bank, pathology bank and environmental tissue bank. This represents an ideal platform for the development of a Knowledge Hub for both the banking of biomaterials and reproductive physiology research. The wBRC forms an integral part of an international partnership known as the South African International Centre for Integrated Cryobiology, Research and Learning in partnership with the University of KwaZulu-Natal, the University of the Witwatersrand and collaborators from the United Kingdom. Internationally, the wBRC is linked to and participates in the International Society for Biological and Environmental Depositories, Frozen Ark and the Barcode of Life initiatives, all being coalitions aimed at deriving value from natural biodiversity residing in the form of biomaterials in order to develop technologies and knowledge to benefit both nature and humanity.

In March 2009, the NZG launched its Centre for Conservation Science (CfCS), a

Knowledge and Training Hub that focuses on Conservation Biology and Wildlife Biodiversity research. After wide local and global consultation, in particular with the Leibniz Institute for Zoo and Wildlife Research in Germany and the Centre for Research and Conservation, Royal Society of Antwerp, Belgium, the disciplines of wildlife epidemiology, behavioural ecology, molecular genetics, wildlife nutrition and reproductive biology are targeted within the *ex situ/in situ* interface. As the CfCS is well placed within the conservation community to develop new and improved technologies through research, it also provides an opportunity to offer research-orientated services and quality, efficient and professional expertise to other zoological gardens, academic institutions, conservation agencies and organizations. The CfCS has dedicated laboratories for wildlife pathology, veterinary parasitology and molecular genetics with a sequencing laboratory and a veterinary hospital. The staff, comprising a veterinary pathologist, a veterinary parasitologist, a molecular geneticist, an ecologist, an animal nutritionist and three clinical veterinarians, play a complementary role by contributing conservation medicine input.

Planning is under way to establish a Centre for Conservation Medicine and Research, to expand the current Veterinary Hospital and establish it as a centre of research excellence in this emerging science. Successful development of this area will position the NZG as leader not only in the African continent but also globally within an emerging knowledge field.

Wildlife disease epidemiology focuses on targeted research and diagnostics to investigate the causes, prevalence, distribution and evolutionary consequences of wildlife diseases of captive and wild animals in Africa (Espie *et al.*, 2009; Junker *et al.*, 2009; de Garine-Wichatitski *et al.*, 2010). The NZG has an extensive wildlife disease database and opportunistic, retrospective and prospective research is carried out in order to understand the complex links between animals, their environment and diseases. Current projects

include the investigation of the pathology of free-ranging and captive Cheetahs *Acinonyx jubatus* in southern Africa. The first record of pathology of free-ranging Leopards *Panthera pardus* in the Kruger National Park is an important project in collaboration with South African National Parks (SANParks). Investigations into the pathology of free-ranging Bottlenose dolphins *Tursiops truncatus* and Humpback dolphins *Sousa chinensis*, in collaboration with the South African Institute for Aquatic Biodiversity, is the first South African survey of marine mammals. Dolphins are important sentinels indicating habitat degradation, and pathogen and/or chemical pollution. Avian influenza surveillance of live, dead, captive and free-ranging birds is monitored in collaboration with the University of Cape Town as part of an international programme with global significance. An *ex situ/in situ* emerging disease surveillance molecular database for chytridomycosis in amphibians (the only one in Africa) is a first step towards developing and applying key molecular diagnostic tests (Stuart *et al.*, 2004; Rödder *et al.*, 2009).

Technological, competitive and innovative research is undertaken to develop *in situ* hybridization techniques, molecular diagnostics for parasite (blood, zoonotic) and disease detection, and investigate parasite pathogens, diseases and vector control in wildlife. Roan antelope and Sable antelope *Hippotragus niger* (on an individual and population scale) are the focus for an interdisciplinary approach and multiplex detection of bacterial pathogens and molecular detection of *Cryptosporidium*, toxoplasmosis and anaplasmosis. Cooperation with other research groups is essential and includes the University of the Free State and University of Venda in South Africa and, internationally, the National Research Centre for Protozoan Diseases, Obihiro University of Agriculture and Veterinary Medicine, Japan, and the Oklahoma State University in the United States. Specific research projects are an epidemiological and genetic diversity study of bovine anaplasmosis in South Africa (Shkap *et al.*, 2009); developing a dual priming oligonucleotide

system for the multiplex detection of bacterial pathogens in captive animals; characterization of genes and proteins that can be used as vaccine candidates against parasitic infections; genome sequencing of South African isolates of protozoan parasites and the development of cell culture-derived vaccines for various animal diseases.

The aim is to improve understanding of zoonotic diseases and to optimize occupational health of staff at the NZG through collaboration with the National Institute on Communicable Diseases, Sandringham, South Africa. Together with regional veterinary and academic institutions, capacity development in the Southern African Development Community region is engaged in wildlife-disease diagnosis, particularly at the interface between human, domestic animals and wildlife. The NZG is instrumental in the development of a wildlife-diagnostic course with partners at the Veterinary Faculty, University of Pretoria, SANParks and veterinarians representing different organizations from Mozambique and Zimbabwe.

The NZG has built up a unique resource to conduct and promote molecular genetic research in Africa. As a result of habitat fragmentation, a need to understand the relationships between the degree of genetic diversity, phylogenetics and genetic factors that determine population viability is essential. National genetic databases are being maintained and expanded for species such as Blue wildebeest *Connochaetes taurinus* and Black wildebeest *Connochaetes gnou* (Grobler *et al.*, 2005), Black and White rhinoceros, Cheetahs, Southern ground hornbills *Bucorvus leadbeateri*, oxpeckers, pangolins *Manis* sp, Sable antelope, Tsessebe *Damaliscus lunatus* and African elephant *Loxodonta africana*. Research projects range from the development and implementation of genetic techniques using genetic markers to sequencing of genomes and DNA profiling as an aid for genetic management of threatened populations and wildlife forensic-science investigations (Kotze *et al.*, 2008). A profitable and specialist unit has been established where molecular genetic services are rendered on

behalf of the African continent. Gender determination in threatened birds, reptiles and mammals is part of a community conservation project, whereby a free service is provided to all zoos in South Africa (Dalton *et al.*, 2010; Monadjem *et al.*, 2010). A strong emphasis is on transfer of DNA technology and here NZG collaborates nationally with several universities, national and provincial conservation agencies and organizations. NZG has strong links with the University of Vienna and the Research Institute for Wildlife and Ecology in Vienna, Austria, on Cheetah molecular research, and with the Zoological Society of London, UK, on chytrid detection using molecular techniques. The NZG is also working towards the validation of cross-species and species-specific genetic markers in various wildlife for forensic investigations. One of the flagship projects is the development of single nucleotide polymorphisms as a tool for forensic investigations and genetic characterization in White rhinoceros.

Scientific information on the dietary and nutritional requirements of every animal maintained by the NZG is an existing challenge to the nutritional management of the animal collection. The specialization of diets, energy budgets and feeding ecology is a focus while the building of scientific capacity to become a leader in applied wildlife nutrition is still a long-term aim. Links have been fostered with the University of Pretoria, the Tshwane University of Technology in Pretoria and the University of KwaZulu Natal. Nutrition-related projects include the detection of necrobacillosis in captive Springbok *Antidorcas marsupialis* and a community-based food-production initiative.

The focus of behavioural ecology is on finding ways to determine which elements in the natural habitat of a particular animal species are most essential (essential habitat features). Such elements would have to be present in the environment provided for that species in captivity, as well as in areas identified for relocation or reintroduction. Furthermore, attempts to identify indicators, both behavioural and physiological, that signal the lack of one or more essential habitat

features is an aim and, to facilitate this, strong links have been developed with the Mammal Research Institute of the University of Pretoria and the University of the Witwatersrand (Fick *et al.*, 2006; Kinahan *et al.*, 2007; Meyer *et al.*, 2008). Another theme within this focus area is the management of fragmented populations in the urban environment where a highly fragmented Giant bullfrog *Pyxicephalus adspersus* population in Gauteng was investigated. The project is based on the prediction that without management the population fragments will become extinct one-by-one as a result of stochastic processes and genetic deterioration. Behaviour and movements of individuals are monitored using radio frequency identification tags combined with accelerometers.

A public interface and engagement research focus area include four components, namely conservation psychology, learning in an informal environment, exhibit design and visitor studies. The nature and dynamics of the interface between the NZG and the public, the impact of the science advancement activities of the NZG and the extent to which the NZG meets the expectations and requirements of its visitors and audiences are determined and examined. This programme is a collaborative effort between the marketing, guest relation services, animal collection, research and education functions of the NZG. Research projects currently under way include the comparative evaluation of educational programmes at the NZG, Uganda Wildlife Education Centre and Zoo Negara in Malaysia, two masters studies at the University of Pretoria on experience management, and a survey of consumer perceptions and attitudes in a South African organization.

A further aim of the NZG is to create a critical mass of African scientists, veterinarians and technicians with skills to engage in wildlife conservation science. In this respect, the CfCS provides a platform for scientists, veterinarians and students to conduct research, and access to facilities and sharing of expertise on biodiversity conservation and animal health. With the dedication of training undergraduate and postgraduate students, the

CfCS adds value to a growing and diverse body of conservationists, veterinary scientists, zoologists and wildlife managers for Africa.

CONCLUSION

To achieve the aims described above, the critical success factors will be a strong, sustained and diverse resource base, an optimum number of quality, qualified, productive and passionate staff, and the ability to establish, maintain and improve first-class facilities and equipment for the animal collection, staff and visitors. It is clear that the NZG as a National Research Facility can play a unique role fulfilling its mandate for conservation of biodiversity. The only way of achieving success is to work in close collaboration with other institutions in South Africa, Africa and internationally. It is these institutions that need to recognize and acknowledge the new role of the NZG. In return, the NZG will aim to assist these organizations to achieve their respective mandates ultimately enhancing the collective efforts in southern Africa for the conservation of regional biodiversity.

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Manuscript submitted 25 May 2010; revised 9 December 2010; accepted 17 December 2010