Etosha Centennial Symposium – Abstracts

Session 1. Opening: Etosha at 100 years

Hu Berry
Etosha: the Human Footprint

Hei//om hunter-gatherers first inhabited this area. Then indigenous pastoralists immigrated from the north 300 years ago. Their livestock, agriculture and iron-smelting technology domesticated the area. The first European explorers, hunters and traders in 1851 drastically changed the social environment. They were succeeded by the German colonial military, which created a chain of restrictive outposts to control movement of local peoples and prevent the spread of rinderpest virus. The proclamation of Game Reserve No. 2 in 1907 created an area of 80 000 km^2 that was progressively reduced to 22 912 km^2 in 1963, largely through political ambitions. In 1953 a Nature Conservation Section was created with the appointment of Bernabè de la Bat as Etosha's first Warden / Biologist. He was followed by legendary conservators who collectively developed Etosha into an icon of conservation. The Etosha Ecological Institute opened in 1974, hosting research *inter alia* on geology, pedology, water quality, vegetation types, wildebeest, elephant, lion, anthrax, flamingo and pelican. An exceptionally dry phase experienced in the 1980s compelled the cull of elephant and the capture and cull of zebra, oryx and springbok. Present day Etosha bears little resemblance to the pristine systems that functioned here before the advent of modern humans.

Werner Kilian
The ungulate assemblage in Etosha, with special emphasis on black rhinoceros

This talk is intended as a brief overview and introduction to complement talks to follow at the landscape, community and individual levels. The major bottom-up and top-down processes that shape and influence the ungulate assemblage in Etosha is mentioned. An overview of the historical decline in the blue wildebeest and plains zebra populations is given, followed by aspects of the black-faced impala, Hartmann's zebra and elephant populations. Emphasis in this talk is placed on aspects of black rhino population dynamics. The purpose and development of a deterministic matrix model is discussed and the results of several manipulations to the model are presented. The importance of the model is stressed in view of improving our understanding of the population dynamics of black rhino as well as providing a sound scientific basis for the management of black rhino in Etosha.

Flip Stander
The ecology of big cats in Etosha - a perspective on evolution and conservation

Aspects of the ecology of lions, leopards, and cheetahs are presented, based on studies carried out between 1980 and 2003. The data are evaluated against social evolution theories, and are discussed in terms of wildlife management and conservation. The demography of lions, leopards, and cheetahs suggests contrasting land tenure systems, and data are presented on population dynamics. Direct observations on the foraging activities of the three species reveal that they hunt mostly at night. Lions hunt in groups and co-operate. Individual lionesses repeatedly occupy the same position in a co-ordinated hunting formation. Under the semi-arid conditions of Etosha, group hunting and co-ordinated co-operation by lions are the most important variables influencing the outcome of hunts and therefore also *per capita* food intake. Despite the resource and reproductive advantages for leopards in maintaining exclusive home ranges, the degree of home range overlap is substantial. Human Wildlife Conflict is arguably the biggest threat to lion, leopard, and cheetah populations in Namibia. The spatial and temporal patterns of conflict with people along the borders of Etosha are presented and the conservation options for the three species are discussed.

Session 2. Etosha: Landscape and Ecosystem

Johan T. du Toit
Identifying the most effective intervention points for wildland conservation: working across spatio-temporal scales

Practitioners of conservation biology and park management are faced with a common dilemma: how to effectively deploy limited financial and human resources and respond quickly to perceived conservation crises. If practitioners 'get it wrong' they waste time and money, and damage the essential trust that has been nurtured between stakeholders and park managers. To be successful, interventions should be applied at the spatial scale at which the problem is generated, even if the immediate problem was perceived at a different scale. By way of analogy, consider how a microscope is used – the investigator racks up and down using lenses of different magnification before selecting a setting that provides the clearest view – but the final setting could not be arrived at without first racking up and down. In contrast, wildland conservation interventions are often directed at "pet projects" that cannot possibly lead to long-term solutions because causes of the problem occur at different spatial/temporal scales or levels of institutional organization. Furthermore, the timing of an intervention (initiation and duration) should be considered on the basis of its likelihood of success – if a problem is beyond feasible help then resources should be redirected to more promising projects. Finally, the opportunity costs of imposing a conservation 'solution' to a social-ecological system should be thoroughly evaluated prior to intervention. African savanna case studies will be used to illustrate these issues. My aim is to stimulate discussion about the management of Etosha in the context of the broader social-ecological system within which it is embedded.

Rudi van Aarde, Sam Ferreira, Jessi Junker & Yolandi de Beer
Elephants in time and across space: the Namibian experience

The management of southern Africa's elephants is complex. This is also true for Namibia where high elephant numbers are blamed for degrading vegetation and where elephants come into conflict with the subsistence way of living. However, across southern Africa high elephant numbers often result from management interferences that limit dispersal and seasonal movements. Elephant numbers of the Etosha National Park show no definable trend for the past 20 years. Population growth for the relatively small population in the west of Namibia is not following a specific trend. Populations elsewhere in the Caprivi and Kavango districts are either increasing or decreasing. These populations, however, are no more than administrative entities, as is also supported by our satellite tracking studies. Trends here therefore are primarily the outcomes of inter-population and even between country movements, the dynamics of which are poorly understood. In Namibia, like elsewhere spatial utilisation by elephant is dictated by the distribution of water more than anything else. The artificial distribution thereof therefore affects landscape utilisation patterns and ultimately, the impact elephants may have for other species. Past management practices focussed on dealing with numbers and ignored the forces that gave rise to high numbers. Different to these, management that aims at recovering dispersal and seasonal movements can allow populations to be driven by natural events. Such an approach relies on restoring spatial utilisation of landscapes associated with season and the distribution of water. It lets habitat selection determine habitat occupation and nurtures sub-populations with distinct dynamics as discrete entities within a metapopulation.

Peter Van Coeverden de Groot
Conservation genetics of Namibian black rhino

Major conservation efforts have increased *Diceros bicornis bicornis* from ~ 100 (1960s) to > 600 alive in Namibia. With 9 microsatellites from 145 adult *D. b. bicornis* collected 1989-2000, we asked are: a) the founders of introduced *D. b. bicornis* in Waterberg N. P. representative of Etosha N. P. genetic diversity, b) there genetic groups within *D. b. bicornis*, c) there spatially distinct genetic groups within Etosha N.P. rhino and d) there differences in dispersal scale among

male and female rhinos. Waterberg founders had similar levels of expected heterozygosity to Etosha rhinos: He = 0.526 ± 0.014 (±SE) vs. 0.522 ± 0.004, but s lower number of alleles: 3.8±0.3 vs. 5.2 ± 0.2. Bayesian analyses (STRUCTURE) showed no genetic structure in the 145 rhino under conditions of admixture/no admixture of source populations and correlated/uncorrelated allele frequencies for sexes combined and apart. Spatial analyses (BARRIER) of inter-individual genetic distance among all Etosha residents (n=110), suggested no subdivision. However males in the northwest appear segregated from other Etosha males. Inter-individual spatial genetic autocorrelation suggest Etosha rhinos are not randomly dispersed, with females showing greater autocorrelation at lower distance classes than males at 10, 25 and 40km scales. Although spatial-genetic signals are stronger when limited to 1998-2000 samples, it is likely to few generations have passed for putative social groups to be genetically differentiated.

Christian Wissel, M. Franz, W. Kilian, J. Groeneveld, S. Kramer-Schadt
Simulation of vegetation change caused by elephants around waterholes

A process-based, spatially explicit simulation model is introduced which describes the interaction of variable rain fall, woody vegetation dynamics and elephant foraging behaviour around waterholes. An aggregated description of the vegetation and the elephants is used which reduces model complexity and number of parameters. In this way a good parametrization could be obtained which reproduces the empirical findings sufficiently well. Parameter values for which no empirical data exist could be determined by pattern-oriented modelling (inverse modelling). In this procedure field data on the spatial distribution of elephants at different times of day are used. A sigmoid vegetation gradient around waterholes is found by the model. It has been investigated how its characteristics are influenced by the number of elephants and amount and temporal pattern of rain.

Anna Treydte
Does a grazer need trees? The attractiveness of below-crown grasses in African savannas

The current decline in large tree cover raises questions about the importance of trees for the surrounding flora and fauna in African savannas. Trees compete with but also facilitate growth of the herbaceous layer underneath their canopies but studies on differences in sub-canopy grass quality for grazing wildlife have been scarce. We studied the nutrient content, structure, standing crop, and species composition of the grass layer beneath and outside of canopies for different eastern and southern African savannas over season. Grass leaf nitrogen and phosphorus contents were up to 25% higher beneath than outside canopies in the site of lowest rainfall and soil fertility. Grass structure and species composition differed strongly beneath and outside of trees, with the tall and nutrient-rich *Panicum maximum* dominating sub-canopy. Sub-canopy grasses were grazed more than outside of canopies, and wild herbivore species, such as the zebra (*Equus burchelli*), grazed more often than expected underneath canopies compared to open grassland. We propose that large trees are important grass quality improvers and, consequently, provide an essential food resource for grazing ungulates in savanna ecosystems. Hence, conservation efforts should aim at protecting trees, particularly in dry and dystrophic savannas, as their sub-canopy grasses seem to benefit grazing wildlife. Management strategies of both protected areas and livestock pastures should further maintain large trees to ensure sustainable grass resources for herbivores in African savannas.

Chuck Rumsey
Kunene Regional Ecological Assessment

A regional ecological assessment for the Huab, Koigab, Uniab and Haunib river catchements is now underway in Namibia's northwest. The assessment is focused on the collection of detailed information on the region's wildlife, ecosystems, and land uses, and will make use of the best available scientific data alongside of local and traditional knowledge. Information will be organized and mapped in order to build a robust knowledge-based framework that can continue to grow and be shared with local communities and decision-makers over time. We view this ecological assessment as a critical step for the establishment of coordinated conservation

management planning and decision-support across multiple administrative boundaries and jurisdictions, including the proposed linkage of Skeleton Coast and Etosha National Parks.

Session 3. Etosha: Individuals and Communities

Peter C.B. Turnbull

A quarter century of progress on understanding anthrax in Etosha and its wider applications and benefits

A population crash among blue wildebeest (*Connochaetes taurinus*) in Etosha between 1955 and 1975 was perceived to be the result of a combination of natural and human-induced factors. One of the principal factors thought to be involved was an upsurge of anthrax, in turn believed to be related in some way to the gravel pits which resulted from excavations of gravel for constructing the tourist roads in the Park. In 1982, anthrax was obviously still occurring with considerable frequency in Etosha and, at a chance meeting, Park veterinarian Ian Hofmeyr asked Peter Turnbull if he might be able to help address the questions: (1) how extensive is anthrax in Etosha? (2) is it a "problem"? (3) how is it getting around?, and (4) how should it be dealt with? The result of this chance meeting was a collaborative research endeavour to address these questions between Peter Turnbull and colleagues in the UK and USA and Namibian Ministry of Environment and Tourism veterinarians and research scientists lasting a quarter of a century. In general, while incidence levels and seasonalities showed that anthrax is ever-present in some 'enzootic areas' of the Park, albeit with seasonal variation in numbers of cases, it was not rate-limiting for any of the affected species except the elephant (*Loxodonta africana*), in which it was only very slightly rate limiting. It was not, therefore, *sensu strictu* "a problem". Ecological studies over the 25-year period included (1) examination of water holes to test the theory of an association between these and the disease incidence; (2) contamination levels and persistence of contamination at anthrax carcass sites; (3) behavioural studies of *Bacillus anthracis* within blood from anthrax victims contaminating soils and water hole water; (4) spore levels in scavenger faeces to ascertain the likely importance of these in transmission of the disease; (5) the importance of wind in transmission of anthrax, and a number of subsidiary other studies, such as the survival of anthrax spores exposed to the Etosha sunlight. Other studies, taking advantage of techniques that became fashionable with time over the 25-year period, included serological studies to determine (1) whether, and to what extent, naturally acquired immunity develops in herbivores and carnivores in the Park, and (2) whether vaccination protocols being used or planned in Etosha for endangered species, rhino (*Diceros bicornis*) and cheetah (*Acinonyx jubatus*) were effective. Apart from vaccination, other approaches to control were addressed by discussion and logic, rather than by practical science. The results of all these studies have been published and can be found in the references cited below. Beyond the boundaries of the Etosha National Park, they have made a substantial contribution to the understanding of anthrax, and thence to formulating management policies on an informed basis for other wildlife reserves, and also for the disease in livestock and humans. Being so easy to identify and confirm, it has been easy to focus on anthrax as a major disease entity in Etosha. Regrettably, the morbidities and mortalities of other diseases that probably influence the Park ecosystem in fundamental and major ways have largely been neglected. While there is yet a great deal more to learn and understand about anthrax, it is this author's earnest hope that it will not continue to be studied in isolation and that databases on other important diseases will be built up to the same extent as that on anthrax in the next quarter century.

Hym Ebedes

Memoirs of the first wildlife vet in the Great Etosha

In 1965 I was appointed as a Professional Officer or Biologist at Okaukuejo. Several years later Head Office discovered that I was a Veterinarian. Etosha needed one and I admit that I was not a Biologist. Previous experience with wildlife was limited to some work on captive animals in a little zoo in Springs There were many Firsts. We flew 38 Black faced Impala in a SA Airforce

Dakota from near the Cunene River to Namutoni. They were all tranquilized and only one animal died. Many ewes were pregnant and I could not see these animals traveling that long distance by road in December. A few years later 72 fully immobilized and anaesthetized Roan Antelope were flown from Bushmanland to Otjovasandu. Transporting these rare animals by air saved them from extinction in Namibia. Anglia Television made films called "The VIP'S and "Air Support". Other firsts included the immobilization of the first elephant, black rhino, lion, zebra, wildebeest, kudu, giraffe and springbok and marking some of them for migration studies. Using a helicopter for the immobilization of rhinos and elephants was a big first in Africa. We hit the record of marking 10 elephants in one day. The Bushmen helpers thought it was magic or witchcraft when the elephant stood up and wandered off after the antidote was injected. After a visit to Hluhluwe and Umfolozi Game Reserves we learnt a lot and were able to build bomas, rhino crates and start a fully equipped capture team under the supervision of my late vet. colleague Dr Ian Hofmeyr. Because I found so many Anthrax cases, the staff rumoured that I introduced the disease to Etosha. The many gravel pits used for graveling roads were suspected of being important sources of the infection because they filled with rainwater and attracted many animals during the rainy season. Most of the gravel pits or "mini dams" and some of the windmills were disinfected and closed and this seemed to control the disease to some extent. Other firsts were aerial censuses to count Etosha's wildlife populations; getting an Ecological Institute with offices, laboratories, a PM Room, and a Tea Room; getting university students like Roy Bengis, Willie Labuschagne and Russel Biggs in December and January to help out help with doing patrols etc when most of the rangers were on holiday; getting the Red Line fence to be patrolled by staff of the Veterinary Department instead of rangers who had other more important conservation duties; getting additional research staff in 1968 for the Department (from 3 to 12) and my own ranger and a secretary; getting a committee that had to sort out local problems in Etosha; capturing and saving hundreds of fledgling flamingoes from starvation and thirst when the Etosha Pan dried up; proving to the Vet. Department that not all wild antelope were carriers of Foot and Mouth Disease in SWA; getting a fence around Sprokieswoud to stop elephants destroying the rare Moringas; starting the Wildlife Group of the SA Veterinary Association with the late Dr Eddie Young and Dr Piet Basson and organizing the first wildlife capture symposium at Onderstepoort.

Wayne M. Getz
A new anthrax study in Etosha

Anthrax provides a useful model system for studying fundamental questions in disease ecology. Our proposed research presents an integrative program to study anthrax in Etosha with its annually occurring seasonal outbreaks of the disease. Many factors can lead to seasonality of disease outbreaks, including environmental effects on pathogen survival and transmission, development of parasites outside of hosts, host aggregation, seasonal shifts in host immunity, timing of breeding and reproduction for both hosts and pathogens and host foraging behavior. Using 40 years of spatially-explicit wildlife mortality and distribution data, targeted multi-year field and laboratory research, and statistical, dynamic and population models, this study provides an exceptional opportunity to identify factors that dictate the spatio-temporal pattern and intensity of anthrax outbreaks. The proposed research uses cutting-edge molecular techniques in combination with detailed field monitoring and ecological experimentation to assess the relative contributions of 1) scavenging of infected host carcasses, 2) pathogen survival and reproduction in the environment, 3) pathogen genetics, 4)host genetics, 5) seasonal changes in host stress and immunity, 6) coinfection by macroparasites and 7) seasonal changes in host spatial use and behavior, to the timing and intensity of anthrax outbreaks. This research program will advance our understanding of a disease that, despite being known since ancient times, has remained something of a mystery in large part because its spores can persist for decades in the environment.

Wendy C. Turner, William C. Gasaway, J. Werner Kilian, George Wittemyer, Wilferd Versfeld, Kathleen T. Gasaway, Norman Owen-Smith
Population dynamics of zebra, wildebeest and springbok in Etosha National Park

Populations of plains ungulates in Etosha National Park, Namibia declined from the mid-1900s through the 1980s. These declines have been attributed to fencing of the reserve and adjacent

farmland and the effects of anthrax, drought and predation. Concern over the viability of these populations prompted the initiation of a twice-yearly monitoring program of group composition for Burchell's zebra, wildebeest and springbok. Using these data from 1995-2006, we re-evaluate the dynamics of these populations to assess how environmental variability affects juvenile recruitment and survival. Environmental variability is quantified using measures of rainfall and the Normalized Difference Vegetation Index (NDVI), proxies for forage abundance and vegetation growing season length.

Martina Trinkel
Spotted hyenas in Etosha National Park, Namibia

Spotted hyena social and spatial organisation and the interaction between hyenas and lions are described. Clan size and structure differed between Central and Eastern Etosha. The study clan in Central Etosha comprised 8 adult hyenas, while the two study clans in Eastern Etosha comprised 15 to 17 adults each. Reproductive success and survival rate were higher for hyenas in Eastern Etosha. The spatial organization of the clan in Central Etosha was investigated during the dry and the wet season. The clan occupied a home range of 160 km2 in the dry season and 320 km2 in the wet season. The dry season home range contained low densities (1 animal/km2) of resident herbivores, such as gemsbok, kudu, giraffe, steenbok and ostrich. The migratory species are the more important prey (12 animals/km2) with springbok, zebra and wildebeest. During the wet season, the migratory herbivores migrated to northwest and left the area of the dry-season home range of the hyena clan. There existed a strong relationship between the abundance of hyenas within their dry and wet season home ranges regarding the abundance of their prey. In Central and Eastern Etosha, hyenas were unable to prevent kleptoparasitism by lions and failed to acquire kills from lions. The reasons were the small ratio of hyenas to female and sub-adult lions at kills and the presence of adult male lions. Because of the hyenas small clan sizes and large territories they seemed to be unable to recruit sufficient clan members to take over lion kills or deter lions from their own kills. In Etosha, 71% of hyena mortality was due to lions.

Caitlin O'Connell-Rodwell
Multi-modal communication, relationships and hormones in the African elephant: Applications for conservation

The structure of African elephant society is primarily matriarchal in nature, where dominant female elephants make decisions for the herd as a whole with regard to safety, movements, resource choices and affiliations. Aspects of elephant society that contribute to survival will be discussed in the context of long distance communication, local environmental and social pressures, as well as character of individual herd members. New findings about elephant bull society will be reviewed, highlighting the importance of bonding and mentoring and addressing potential applications to conservation.

Eline Lorenzen
Using genetic data to investigate potential hybridization between black-faced and common impala in Etosha National Park

Nuclear genetic markers were used to determine if, and to what extent, hybridization occurs between the vulnerable endemic black-faced impala and introduced common impala in Etosha. No evidence of interbreeding between the two subspecies was found.

Session 4. Etosha and Beyond

Mutjinda Katjiua
Pastoralists' perceptions and realities of vegetation change and browse consumption in the northern Kalahari, Namibia

Pastoral production around artificial watering points in semi-arid environments affects the density and composition of plant communities. In the Kalahari desert of southwestern Africa, bush encroachment is often regarded as the major form of land degradation resulting from

pastoral production around watering points. We investigated the OvaHerero pastoralists' perceptions of the extent of vegetation change since the establishment of artificial watering points in the northern Kalahari desert of Namibia, and related this to ecological data on vegetation change. We determined the utility of woody vegetation to pastoralists' livelihoods in terms of provision of construction material, fuel wood and browse. We quantified local knowledge of cattle browse consumption and correlated this with field data. We also assessed the purposes for which major livestock types were used. Our results showed that: 1) pastoral knowledge of bush encroachment and browse consumption was consistent with concurrently-collected field data, 2) the current level of bush encroachment was perceived to be beneficial for pastoral production, and 3) cattle played an important role in the production of milk and milk by-products for domestic use, and served as a source of cash income, while sheep and goats were primarily kept for meat consumption. This result contrasts with historical studies that mainly portray cattle as a symbol of social status among OvaHerero pastoralists.

Keith Leggett
The home ranges and movements of GPS collared elephants in Northwest Namibia

This paper examines the home ranges and seasonal movements of ten GPS-collared elephants (two females and eight males) in the northwestern Kunene region of Namibia. The home ranges of the GPS collared elephants during the period 2002-2006 varied from between 769 to 14310 km^2. Minimum Convex Polygon (MCP) analysis was used to determine home ranges. In the eastern section of the research area, the elephants generally had smaller home ranges and were at their least during the hot and cold dry seasons expanding during the wet season. In the western areas, the elephants moved between the Hoanib and Hoarusib Rivers in response to available vegetation that did not necessarily correspond to rainfall. While, in the north the elephants appear to have relatively small home ranges except for one male who moved between Etosha National Park and the northern Omusati region, this movement does not appear to be related to onset of the wet season. The length of movement of collared elephants varied from 55 to 625km, over periods of up to 5 months. The collared elephants showed defined home and seasonal ranges, annual variations in home range appear to be linked to rainfall.

George Wittemyer
Social dominance, seasonal movements, and spatial segregation in African elephants: A contribution to conservation behavior

The structure of social relationships among individuals in a population is known to influence their fitness, access to resources, risk of predation, and even energy budgets. Among elephants, studies of population spatial structuring typically focus on the relationship between elephant range and distribution in relation to limiting factors such as water availability. In a study conducted on the semi-arid Samburu population of northern Kenya, GPS radio telemetry provides data to evaluate the influence of both the distribution of resources and social relationships on population spatial structure and ranging tactics. Data collected from seven families of different rank demonstrate that dominant groups disproportionately use preferred habitats, limit their exposure to predation/conflict with humans by avoiding unprotected areas, and expend less energy than subordinate groups during the dry season. Hence our data provides strong evidence of rank derived spatial partitioning in this migratory species. These behaviors, however, were not found during the wet season indicating that spatial segregation of elephants is related to resource availability. Range-constriction increasingly confines elephant populations to ever shrinking safe areas. Our study offers a rare and timely insight into the use of space in a population of elephants that still range relatively unconstrained. Our conclusions indicate social relationships can serve to mitigate the impacts of elephant density by driving dispersal of low ranking groups from favored areas during periods of constraints. Such impacts are only possible where dispersal regions and their corridors are maintained.

Selma M. Lendelvo
Understanding the importance of local level wildlife management to the livelihoods of the communal Ehirovipuka Conservancy, west Etosha

This case study focuses on the Ehirovipuka communal conservancy, which is located in the northwestern part of the Namibia and directly bordering Etosha National Park. Northwest is regarded as the richest region for wildlife species in the country. The aim of this study was to understand the importance of conservancies in supporting livelihoods in a shifting society. Households were randomly interviewed, using a structured questionnaire, from villages in the conservancy including focused group discussions. The findings of the study showed that the livelihood activities have been maintained over the years, although some changed in order of importance. The current most important livelihood activities ranked by most households were mainly the cash-income. This suggests the shifting of the rural community to respond to the national cash economy lifestyle. Three factors that maintained the livelihoods activities in the Ehirovipuka conservancy emerged as access through strong social relations, diversification of livelihood activities and the emergence of the community level support institutions such as the conservancy. In conclusion, the conservancy is perceived as community level support that contributes to the improvement of natural resources which most livelihood activities depend on, hence, leading to the resilience of most livelihood activities.

Peter Erb
Future tourism developments in Etosha

The presentation gives and overview of the current tourism activities in Etosha and a summary of developments planned to expand and diversify tourism, both in the short-term as well as options for the longer term. Assuming a 5% growth, tourist visiting Etosha could increase from currently about 155 000 per year to 525 000 by 2030, i.e. over the next 25 years. To manage this potential demand responsibly will ingenuity and some strategic far sightedness.

Poster Session

Steve Bellan
Scavenger effects on *Bacillus anthracis* spore concentration at carcass sites

Anthrax infects mammalian livestock and wildlife when susceptible hosts ingest *Bacillus anthracis* spores. Spores then germinate into rapidly reproducing vegetative cells, killing hosts within days. Terminal hemorrhaging exposes vegetative cells to oxygen, facilitating sporulation. By opening carcasses, scavengers may expose more vegetative cells to oxygen, stimulating more sporulation. By moving carcasses, they may also increase the area of spore contamination. Spore concentration and distribution influence the number of new anthrax cases seeded by spores at a carcass site. However, sporulation only continues for up to two days after host death. I will experimentally exclude scavengers from fresh anthrax-infected zebra (*Equus burchelli*) carcasses for three days and compare the subsequent spore concentrations and distributions at these and unmanipulated control carcasses. While anecdotal and observational evidence suggests that scavengers play a key role in the interannual maintenance and within-season epidemiology of anthrax in herbivore assemblages, this will be the first experimental study to quantify their direct effect on spore loads at carcass sites.

Rachel Brand and Morris Gosling
Mating strategies of male giraffes (*Giraffa camelopardalis*) in Etosha National Park

The giraffe (*Giraffa camelopardalis*) occupies a variety of habitats across sub-Saharan Africa. It is characterised by a loose social organisation, and a dominance-driven polygynous mating system. This project sought to test the hypothesis that dark pelage colour in male giraffe is selected through sexual selection for a costly status signal. We also sought to test the hypothesis that in a semi-arid environment, limited resources (food and water) would predictably concentrate females, increasing the potential for dominant males to monopolise matings. Field work was carried out in Etosha NP, Namibia. Using photographic records, we identified 431 individual giraffe. The study area was surveyed regularly and data were collected on group composition, movements and behaviour. Darker males tended to be older and more dominant

than lighter males, associated less with females, but had greater success in courting females. At waterholes, encounter rates were increased and consequently mating and agonistic interactions more frequent. Paler males had a greater chance of interacting with females at waterholes because of higher intruder pressure, but when present, darker males always monopolised courtship opportunities. Mature males demonstrated a diversity of ranging strategies that affected association with females. These individual differences are assumed to relate to status and probably affect individual reproductive success. Evidence suggests male reproductive success is skewed towards mature dark males, but may also vary among dark males, with some potentially being excluded from mating.

Carrie A. Cizauskas
Seasonal aspects of host susceptibility to anthrax

This work will involve the study of natural, seasonal anthrax outbreaks in plains ungulates in Etosha National Park, Namibia. We will test the hypothesis that seasonal trends in anthrax outbreaks correspond with times of increased host stress and decreased host immunity. We will also investigate the immunomodulatory effects of gastrointestinal parasite coinfections in the context of seasonal anthrax outbreaks. This research employs a novel approach to disease ecology both by examining internal host factors relating to disease in a natural system, and by studying the immunological mechanisms of disease in wildlife. Examining the immunological status and response of a host to a pathogen is important for understanding why natural hosts get the diseases that they do when they do. This, in turn, is critical for predicting and controlling outbreaks when necessary.

Betsy Fox and Hu Berry
Synchrony of drinking in Double-banded Sandgrouse, *Pterocles bicinctus*, at Etosha National Park, Namibia

Double-banded Sandgrouse, *Pterocles bicinctus*, at Etosha National Park in Namibia exhibit a predictable and remarkably synchronized activity pattern when flying to drink at water-holes. The primary environmental cue that activates this pattern appears to be decreasing light intensity. The species is highly synchronized in this regard, with an average interval of 16 minutes after time of sunset and the time when sandgrouse arrive at water. Birds stay at water for 28 minutes on average. *P. bicinctus* numbers decrease significantly at artificially supplied water when rain falls. Floodlights have no significant effect on times of arrival or times of departure of these birds at drinking places. The predominantly crepuscular nature of Double-banded Sandgrouse may have evolved as part of their survival strategy by placing them less at risk to diurnal raptors, and may also save energy and reduce evaporative water loss.

Holly H. Ganz
Pathogen genetics and the ecology of anthrax in Etosha National Park

Genetic factors are likely to influence *Bacillus anthracis* virulence, playing a critical role in the patterns of anthrax emergence. Differences in the timing of anthrax infection between zebra and elephant, for example, may be due to the occurrence of multiple pathogen genotypes but it is unknown whether different host species harbor, or are susceptible to, different genetic subtypes of *B. anthracis*. Recently *B. anthracis* strains were differentiated using variable-number tandem repeat (VNTR) loci into six major strain groups worldwide, divided into two supergroups A and B. Type A genotypes are distributed around the world, including southern Africa, and account for most anthrax outbreaks. Type B genotypes are dominated by isolates from southern Africa. One Type B genotype appears to play an important role in the ongoing Kruger National Park anthrax outbreaks. Using molecular techniques, we can determine whether an outbreak is caused by one or several genotypes of a pathogen. We can also determine whether there is an association between pathogen genotype and species of infected host. All isolates collected from Etosha so far belong to supergroup A. Although the amount of genetic variation in *B. anthracis* in ENP is not fully characterized, Keim found seven genotypes of *B. anthracis* in Namibia, from 23 isolates, and Beyer found ten genotypes in 54 Namibian isolates. Among 32 isolates collected solely from Etosha, Beyer differentiated five

genotypes. One of these isolates represents a new genotype of *B. anthracis*. Two genotypes infected a broad range of hosts. However, isolates from cattle and goats in Namibia clearly differ from genotypes found infecting other hosts, suggesting that *B. anthracis* has the capacity to evolve some degree of host specificity.

Martin A. Haupt, Craig J. Tambling* & Elissa Z. Cameron
Telemetry applications

We illustrate some of the current GPS technology, ranging from the now widely used GPS/GSM collars to advancements based on a proximity tag system. Additionally, the ways in which data can be transmitted from the collars to a computer or server are discussed. Finally, we present some recommendations on the sizes of animals that each different collar type can be deployed on as well as suggestions to what collars would be best suited to research in Etosha.

Mark Jago
Incidence of rabies in Namibia

Rabies is a notifiable disease in Namibia. The first confirmed case dates back to 1906 in Swakopmund. Canine rabies entered Namibia during the late 1940s from southern Angola/Zambia and was later found to be phylogenetically different from the endemic mongoose (viverrid) strains circulating in the region. The disease cycling in black-back jackal soon appeared. By the mid 1970s the diseases was sporadic but endemic, with the dog/human form the most common in northern parts of the country, jackal/cattle in the central farmlands, and sporadic canine or mongoose in the arid southern sheep lands. Kudu (*Tragelaphus stresiceros*) rabies first appeared in 1975 near Windhoek. The epizootic began north of Okahandja in 1977 with the number of cases rising steadily throughout 1978-79. Peaking in 1980, the disease in kudu had subsided by 1985 by which time an estimated 30-50 000 kudu (20% of the population) had died. In 2002/3 another kudu outbreak in the Omaruru/Wilhelmstal area resulted in estimated losses of 2500 animals on more than 81 farms (1). The social behaviour of kudu may have contributed to the spread of rabies, and one theory is that mouth lesions from the browsing of thorn bushes may have been the route of entry due to the presence of Classical Rabies Virus (RABV) in saliva deposited on browse by other infected kudu. The kudu epizootics in Namibia have provided an example of non-bite transmission with horizontal spread between kudu. The incidence of rabies in this species appears to be related to the population density of the kudu. The rapid expansion of game-proof fences in the central farmlands has had the effect of both fencing in and out animals, there by creating pockets and corridors of artificially high numbers and possibly predisposing to rabies spread. A panel of 37 rabies virus isolates originating mainly from the northern and central regions of Namibia between 1980 and 2003 demonstrated a high degree of genetic similarity. Virus isolates from kudu shared 97.2%-100% similarity with jackal isolates and 97-100% similarity with those from domestic dogs (2). 104 cases of human rabies (3) reported between 2001 and the present, occurring mainly in Northern Namibia, demonstrate that the disease remains a serious zoonosis with the domestic dogs being the primary source. Dog vaccination programs, stray dog control, and awareness campaigns on post exposure treatment continue in an attempt to mitigate the effects of the disease. Reasons as to why rabies has been maintained within the kudu population are speculative at best. Studies into behavioural ecology of the greater kudu are required to help to evaluate and quantify possible pathways of rabies transmission. Greater knowledge of the social interaction between and within groups of kudu, feeding behaviour and food preferences of kudus and other herbivores, the seasonal appearance of rabies and the effects of fencing and kudu-densities within fenced and non-fenced areas may help to answer some questions.

Pauline L Kamath
The role of host genetics in susceptibility to anthrax among Burchell's zebra (*Equus burchelli*) of Southern Africa

Anthrax, caused by the bacteria *Bacillus anthracis,* is a highly infectious and often fatal epizootic disease affecting mammals. Today, even under the increased surveillance of national control

programs, *B. anthracis* has a global distribution that threatens human health, agricultural production, biodiversity, and public security. Host genetic characteristics are likely to influence *B. anthracis* virulence and host susceptibility across individuals, populations, and species, playing a critical role in the observed patterns of anthrax outbreaks. Here, I present a proposal to investigate the role of host genetics in anthrax susceptibility within Burchell's zebra (*Equus burchelli*), the primary host species in Etosha National Park. First, a candidate gene approach will be used to isolate and describe the variability in potential anthrax susceptibility genes within the Etosha zebra population. Next, a preliminary population-based association study will be conducted to identify gene variants that may be associated with the disease phenotype (i.e. anthrax mortality). Finally, an inter-population comparison will be conducted to address the genetic basis for the differences observed across zebra populations under varying levels of anthrax intensities. These results may have implications for ecological risk assessment and could be used for screening individuals/populations to identify risk levels in wild and domestic ungulates, as well as humans. Furthermore, these data will be incorporated into more comprehensive models of anthrax dynamics that may be useful for predicting and controlling future outbreaks.

Birgit Kötting
The Role of the Custodianship Program in the adaptive management of black rhinoceros *Diceros bicornis bicornis* in Etosha National Park

Initiated in 1993, the Black Rhinoceros Custodianship Program of the Namibian Ministry of Environment and Tourism facilitated the introduction of the first eleven black rhinoceroses to two free-hold farms with a combined size of 21 300 hectares. Today, 14 years later, the Custodianship Program has grown into a respectable 26 land units of 1 083 000 hectares, thus making large progress towards re-establishing this valuable subspecies in its former range within Namibia. Etosha National Park still remains the single most important donor of black rhinoceros by providing 65% of all animals introduced to the Black Rhinoceros Custodianship Program up to the end of 2006. This commitment carries with it a series of opportunities and challenges, which will determine the way forward for black rhinoceros conservation in Namibia.

Gabriel Shatumbu and Meed Mbidzo
Monitoring the illegal killing of elephants in Etosha National Park, Namibia

MIKE (Monitoring the Illegal Killing of Elephants) was established by CITES to measure and identify trends in the illegal killing of elephants in all elephant range states, to determine changes in these trends and to assess whether and to what extent these trends are a result of changes in the status of elephants within CITES. Overall, the purpose of MIKE is to provide information needed for elephant range states to make appropriate management and enforcement decisions. The MIKE project was implemented in Etosha National Park (ENP) beginning of 2000, and it has been running since then. The MIKE programme is based on the principle of routine and systematic collection of data using standardized protocols and techniques. In ENP, data is collected during routine vehicle and foot patrols as well as during aerial surveys that take place every second year. Data collected include live observations of elephants, elephant carcasses and any sign of illegal activities. Elephant population estimates are made from aerial survey data. Information is analyzed and summarized in form of monthly and annual reports.

Craig J. Tambling, Wayne M. Getz, Johan T. du Toit & Elissa Z. Cameron
Application of technology to future lion diet studies

GPS/GSM collars were used to determine the diet of lion in the Satara region of Kruger National Park and the application of this technique as an alternative to continuous observations was investigated. On average feeding sites (kills/scavenged carcasses) were located 32 days following lion activity. The technique employed performed well with 303 feeding sites being located. In only 4% of all sites was the species consumed not determined. Known feeding sites were classified into known sex (86%) and known age (50%, excluding juveniles). There was no difference in determining the age or sex of the consumed individual at the feeding site if the point was followed up after a shorter time period. Feeding sites could, however, be located with

greater accuracy if proximity tags and a 24 hour ratio were employed. The results suggest that the use of GPS/GSM collars performs adequately in determining lion diets (even down to the age determination of prey); although alternative methods are needed to augment this method if behavioural data is to be collected. A pilot period is suggested to determine if these results are replicated in other regions.

Peter Turnbull, Maria Diekmann, Werner Kilian, Wilferd Versfeld, Valerius de Vos, Lorraine Arntzen, Kerri Wolter, Paul Bartels and Antoinette Kotze
Naturally acquired antibodies to *Bacillus anthracis* protective antigen in vultures of Southern Africa

Elevated antibody titres to the anthrax toxin protective antigen (PA) were found in 12 of 19 (63 %) wild caught Namibian vultures as compared with 0 of 12 South African equivalents. The results parallel the incidence of anthrax in northern Namibia and South Africa and the likely contact of the vultures tested with anthrax carcasses. Numbers in the Namibian group were too small to determine any significances in species-, sex- or age-related differences within the raw data showing elevated titres in 4 of 6 Cape Griffons (*Gyps coprotheres*), 6 of 10 White-backed vultures (*Gyps africanus*) and 1 of 3 Lappet-faced vultures (*Aegypius tracheliotus*), or in 5 of 6 males *versus* 3 of 7 females, and 10 of 15 adults *versus* 1 of 4 juveniles. It is not known whether elevated titre indicates infection *per se* in vultures or absorption of incompletely digested epitopes of the toxin or both. The results are discussed in relation to distances travelled by vultures as determined by new tracking techniques, how serology can reveal anthrax activity in an area and the issue of the role of vultures in transmission of anthrax.

Peter J. Van Coeverden de Groot, Nicholas Georgiadis, Keith Leggett, Betsy Fox, Don J. Melnick, Stephen J. OBrien and Alfred L. Roca
Genetic variation in Namibian elephants

Desert-adapted elephants inhabit the northwest Namibian deserts near the Hoanib and other river catchments, such as the Hoarusib. While these unprotected animals currently number 800-1000, numbers were as low as 257 in the early 1980s. The population rebounded to more than 600 individuals by the mid 1990s with the increase likely including some influx from populations to the east especially Etosha National Park (current size ~ 2600). To examine the genetic distinctiveness of desert-adapted elephants from other African savanna elephants (*Loxodonta africana*), and to look for genetic differentiation within Etosha and across Namibia, we amplified and sequenced mitochondrial DNA from desert-adapted elephants and from other Namibian populations. We sequenced portions of the mitochondrial cytB and control region in DNA from dung samples, and a 2.6 kb region of mitochondrial ND5 and ND6 in DNA from tissue samples. Additionally, 11 short tandem repeat (STR) or microsatellite nuclear loci were amplified using DNA from the tissue samples. Our results indicated that desert elephants are related to other African savanna elephants, especially those from nearby populations in Namibia. A low level of genetic diversity is present among Namibias elephants, suggesting limited gene flow between them and outside populations.

Wilferd Versfeld
Etosha's small Blue Crane population: a genetic and conservation puzzle

The Blue Crane *(Anthropoides paradiseus)* is the most range-restricted species of all the cranes. There are currently 20 000 birds in Southern Africa, but an isolated group of birds exist in Namibia. The question arises as to how these Blue Cranes survive in these predator rich and arid conditions. The project entails a census of actual birds to previous estimates, as well as a study to compare the genetic material, and the behavioural patterns, of these Namibian birds to other Blue Crane populations. The results from the investigations will assist in compiling a species management plan for the Blue Cranes in Namibia. The objective of this species management plan is to harmonize the sharing of habitats, between people and cranes.