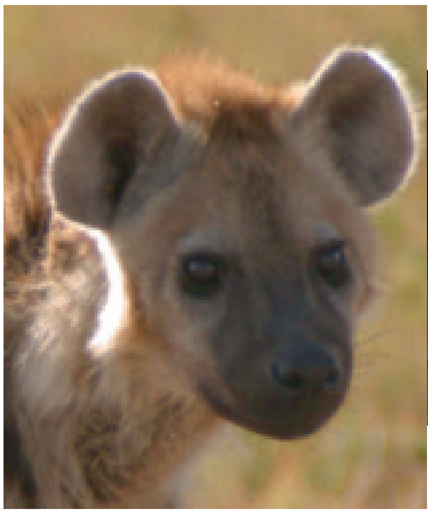
# The Tanzania Hyaena Conservation Action Plan

**Tanzania Wildlife Research Institute (TAWIRI)**

**23-24th February 2006, TAWIRI, Arusha, Tanzania**


**Tanzania Hyaena Conservation Action Plan**

Sarah M. Durant, Marion East, Oliver Höner, Julius Kibebe, Edwin Konzo, Inyasi Lejora, Laly Lichtenfeld, Alex Lobora, Novatus Magoma, Linus Minushi, Mwemezi Mwiza, George Sabuni, Nebbo Mwina, Charles Trout, Bettina Wachter

Edited by Durant, SM, East, ML, Lichtenfeld, L and Lobora, A

**Table of Contents**



**Citation:**
TAWIRI 2009. Tanzania Hyaena Conservation Action Plan. Pages 112-161 in *Tanzania Carnivore Conservation Action Plan*. TAWIRI, Arusha, Tanzania.

## 1. Agenda

**Day 1**

| **Time** | **Event** | **Responsible** |
|---|---|---|
| 08.30-08.45 | Registration | Flora Kipuyo |
| 08.45-08.50 | Official opening | George Sabuni |
| 08.50-09.00 | Self introduction | All |
| 09.00-09.30 | Meeting background | Sarah Durant |
| 09.30-09.45 | Agreement on the agenda | Alex Lobora |
| 09.45-10.30 | Behavioural ecology of spotted hyaenas | Marion East |
| 10.30-10.35 | Group photograph | All |
| 10.35-11.00 | Tea / coffee | |
| 11:00-11.15 | Hyaenas in Simanjiro | Laly Lichtenfeld |
| 11.15-11.30 | Spotted hyaena, striped hyaena and aardwolf distribution and abundance | Alex Lobora |
| 11.30-12.30 | What do we know?<br>Distribution<br>Density<br>Trends | All |
| 12.30-14.00 | Lunch | |
| *Current threats to each species* | | |
| 14:00-15:30 | Conservation threats – spotted hyaenas | All |
| 15:30-16:00 | Tea / coffee | |
| 16:00-16:30 | Conservation threats – striped hyaenas | All |
| 16:30-17:00 | Conservation threats – aardwolves | All |

**Day 2**

| **Time** | **Event** | **Responsible** |
|---|---|---|
| *Information and conservation needs* | | |
| 8:30-10:00 | Information needs on status and conservation threats by region and species | All - facilitated by Sarah Durant |
| 10.00-10.30 | Tea / coffee | |
| 10:30-12:00 | How to address and manage threats to each species | All |
| 12:00-12:30 | Recommendations for conservation by species | All |
| 12.30-14.00 | Lunch | |
| 14.00-15:30 | Regional Priority setting for research and conservation: all species | All |
| 15:30-16:00 | Tea / coffee | |
| 16:00-16:15 | Summing up | Sarah Durant |
| 16:15-16:30 | Official closing | TAWIRI representative |

## 2. EXECUTIVE SUMMARY

This report covers the proceedings of the First Tanzanian Hyaena Conservation Action Plan Workshop held on February 23rd-24th 2006. The workshop brought together key stakeholders to assess existing information and establish a consensus on priorities for research and conservation of all three species of hyaenid in Tanzania: spotted hyaena *Crocuta crocuta*; striped hyaena *Hyaena hyaena*; and aardwolf *Proteles cristatus*. Tanzania holds important populations of all three species and all participants at the workshop recognised Tanzania's importance in their conservation. However there was a need for better information on the distribution of hyaenids across the country, as well as more detailed data in specific regions.

Spotted hyaenas are widespread across Tanzania, but have larger and less threatened populations inside protected areas. Despite the wide distribution of this species, there was little information on density and trends across much of the range. The distribution of striped hyaena is restricted to the north of the country, covering the northern border with Kenya and extending down through the Maasai steppe, but stopping short of the wetter woodlands in southern and central Tanzania. The aardwolf is more widespread than the striped hyaena, but its distribution follows the distribution of *Trinervitermes* termites on which it depends.

The group agreed that there was a need to get better information on the distribution of hyaenas across the country, and identified clear data needs for specific regions, prioritising the Maasai steppe because of the accelerating impacts of land use change on the region. Information on distribution and trends was a high priority for all regions. The group went on to identify methods currently available for gathering such information, including spoor counts, call-in playback counts, tourist photos, detection dogs and transects, all of which had potential in certain circumstances. However, only radio collars could be used to collect unambiguous data on ranging patterns and demography – although the use of tourist photographs also showed some potential.

The group discussed potential threats to hyaena conservation and agreed that loss of habitat and land use change, poisoning, snaring and retaliatory killing may pose important threats to conservation. Inadvertent poisoning due to spraying of herbicides and pesticides were likely to have particular impacts on aardwolves due to the species dependence on termites. Death on roads and disease were thought to be less important although there was a need for more information on these threats. The techniques identified as useful for gathering information on hyaena status could also be used to provide information on threats. Radio collaring, because it allows the following of individual animals, is particularly useful in this, as well as a well designed questionnaire survey. Information on threats for all species was agreed to be of the highest priority in the Maasai steppe, particularly on retaliatory killing, due to the urgency and increasing rate of habitat conversion and loss from the region. However there was a need for information on striped hyaenas across their range in Tanzania. It was felt that many of the threats hyaenas faced were rooted in a negative attitude towards the species, and there was a need for a national approach to address these perceptions, perhaps through inclusion as part of a general predator awareness program within the national curriculum. The acceleration of the Wildlife Management Area (WMA) process was also thought likely to be beneficial to hyaena conservation. Establishing the patterns of spraying regimes was thought to be a fundamental first step towards planning for aardwolf conservation.

Managers need information on the status and threats to hyaena in their areas to plan management activities and to enable hyaena conservation, as well as assess the impact of their activities on hyaena conservation. All participants wished to improve the standards of information on hyaena across the country as, without better information, it is difficult to plan conservation and management for these species. It is hoped that this report provides a first step along this process, and will provide hyaena research and conservation in Tanzania with a new impetus to address the identified priorities hand in hand with training and capacity development.

## 3. INTRODUCTION

The First Tanzanian Hyaena Conservation Action Plan Workshop was held 23rd-24th February 2006 in the meeting room in the Tanzania Carnivore Unit, at the Tanzania Wildlife Research Institute (TAWIRI) headquarters in Arusha. The workshop brought together stakeholders to assess existing information and set priorities for conservation of the three species of hyaenid in Tanzania: spotted hyaena *Crocuta crocuta*; striped Hyaena *Hyaena hyaena*; and aardwolf *Proteles cristatus.* The workshop was attended by 15 participants from TAWIRI, Wildlife Division (WD), Tanzania National Parks (TANAPA), Ngorongoro Conservation Area Authority (NCAA), Forestry and Beekeeping Division (FBD) together with experts from the Serengeti and Ngorongoro Hyaena Research Projects and the People and Predators Fund (Appendix 1).

In the 2004 red list all three species of hyaena were classified as of least concern, however both spotted and striped hyaenas were subcategorised as conservation dependent. It should be noted that, despite this classification, across most of their range all species could be classed as data deficient (Mills and Hofer 1998). Each species has very specific habitat requirements, and so it is likely, given the extent of land use change, that their populations are in decline. Tanzania is a key country for the conservation of all three species, as it contains some of the largest protected areas within their range.

The 1998 Hyaena Action plan summarises what was known about the distribution of hyaena at that time (Hofer and Mills 1998). Aardwolves occurred in two discrete populations within Africa. One to the south of the continent centring around South Africa, Namibia and Botswana, the other in eastern Africa in Tanzania through Kenya and into Ethiopia and Eritrea. Within Tanzania the population was thought to be distributed across the Serengeti in the north and across the Maasai steppe. The striped hyaena occurs in non-forested areas in east, north and west Africa, and ranges across to Asia, through to India and Nepal. Within Tanzania, the species was thought to be limited to northern Tanzania, including the Maasai steppe, Serengeti ecosystem and Mkomazi Game Reserve. The spotted hyaena used to range across most of the unforested areas of sub-Saharan Africa. Within Tanzania, this species had the broadest distribution of the three species, and was reasonably widespread throughout the country, but was probably at low densities outside protected areas.

TAWIRI, through the Tanzania Carnivore Monitoring Project, has been collecting information on all carnivores in Tanzania including all species of hyaena since 2002. This information was used to inform the planning process in this workshop. Despite this effort, information on hyaenas in the country is still limited, making it difficult to plan for the conservation of these species. The workshop documented what was currently known about the status of hyaenas and their conservation across the country and set priorities for future research and conservation. These proceedings form a draft chapter for the hyaena section in the National Carnivore Conservation Action Plan.

**Fig. 1 Participants at the workshop, from back and starting from left: Back row: Linus Minushi, George Sabuni, Oliver Höner, Marion East; Middle row: Nebbo Mwina, Sarah Durant, Julius Kibebe, Laly Lichtenfeld, Novatus Magoma, Charles Trout; Front row: Bettina Wachter, Mwemezi Mwiza, Inyasi Lejora, Alex Lobora, Edwin Konzo.**

## 3.1 Presentations

### 3.1.1. Behavioural Ecology of spotted hyenas
### Marion L East

#### Hyena Society

Our research programme compares the behaviour and ecology of the spotted hyena, *Crocuta crocuta*, in two ecologically distinct locations within the Serengeti ecosystem. Our research in the Serengeti National Park began in 1987 and in the Ngorongoro Crater in 1996. The following outline is based on our research findings in the Serengeti ecosystem. A summary of spotted hyena research in other locations can be found in Mills and Hofer (1998).

Spotted hyenas in both the Serengeti National Park and Ngorongoro Crater live in stable social groups called clans that defend territories against neighbouring clans (Hofer and East 1993a; Höner *et al.* 2005). Females normally remain in their natal clan throughout their life, unless fission occurs in their social group (Höner *et al.* 2005). There is a strong linear social hierarchy among female clan members with high-ranking females maintaining priority of access to food resources (East *et al*. 1993; Hofer and East 2003). Coalitions among close female relatives are important for the acquisition and maintenance of social status and as a result daughters typically acquire a social rank just below that of their mother (Hofer and East 2003). All adult females breed and their cubs are typically reared in a communal den inside the clan territory (Hofer and East 1993a, 1995). Males normally disperse from their natal clan after reaching sexual maturity at about 2 years of age. When males disperse into a new clan, they join the immigrant male dominance hierarchy at the bottom. Immigrant males do not fight for social status but instead low-ranking males with short tenure increase in social status as higher ranking, longer tenured males die or leave the clan: a process that can be described as queuing for social status (East and Hofer 1991; East *et al*.

1993; East and Hofer 2001). All immigrant males are subordinate to all female clan members and males do not participate in parental care.

**Feeding Ecology**

In both the Serengeti National Park and Ngorongoro Crater the main prey of spotted hyena are wildebeest, *Connochaetes taurinus*, Thomson's gazelles, *Gazella thomsoni,* and zebras *Equus burchelli* (Hofer and East, 1993a; Höner *et al*. 2002). In the Serengeti, migratory movement of these herbivores cause large fluctuations in prey abundance within clan territories and as a result a high abundance (mean of 238 animals/ $km^2$) of herbivores is only present within any given territory for a limited part of the year (approximately 22-30%). Irrespective of social status, all clan members forage in the clan territory when there is a high abundance of prey (Hofer and East 1993b). When migratory herds are absent, the abundance of prey in a clan territory is dramatically reduced to a mean of 31 animals/ $km^2$ during periods when small herds of migratory and resident herbivores are present and to a mean of 3.3 animals/$km^2$ during periods when only resident herbivores are present (Hofer and East 1993a,b).

Conflict between clan members over access to food resources in the clan territory increases as the abundance of herbivores declines. In the Serengeti National Park conflict over access to declining food resources is avoided by clan members leaving their home territory on short-term (6-8 days for non-lactating animals), long distance (40-80km) foraging trips to the nearest concentration of migratory herbivores. Individuals of low social status regularly commute even when there are moderate densities of herbivores in the group territory, while females of high social status only commute when conditions of low prey abundance prevail. The commuting system of Serengeti hyenas permits clan size to rise well above that expected given the low density of resident herbivores within clan territories. Commuting dramatically increases foraging effort such that a low-ranking females may need to travel a minimum average distance of 1,000-1,300 km per year. For details on the commuting system see (Hofer and East, 1993a,b,c).

In the Ngorongoro Crater, although seasonal movements of herbivores also alter the abundance of prey in the eight hyena clan territories on the Crater floor. However, when the density of prey in a Crater clan territory declines, Crater hyenas normally only need to undertake relatively short distances foraging trips to more prey rich areas on the Crater floor (Höner *et al*. 2005). The difference in the foraging effort exerted by Serengeti compared to Crater hyenas is reflected in different levels of activity of the hypothalamic-pituitary-adrenal axis in these two populations. In accordance with their higher foraging effort, Serengeti female hyenas have higher corticosteroid concentrations in their faeces than females in the Crater (Goymann *et al*. 2001).

Over the last three decades, the main prey species of spotted hyenas in the Ngorongoro Crater substantially declined in number, whereas buffalo, *Syncerus caffer,* numbers increased (Runyoro *et al.* 1995). This change in the composition of the Crater herbivore population was most likely responsible for the decline in the Crater hyena population from 385 adults in the mid 1960s to 117 in 1996 (Höner *et al*. 2002). It also caused a change in prey species killed by Crater hyena (to include more buffalo calves and adult wildebeest), an increase in scavenging of food from lions (Höner *et al*. 2002), and an increase in foraging trips by individuals outside their territory (Höner *et al*. 2002).

## NATURAL CAUSES OF MORTALITY

### Inter-specific conflict

The main predator of both adult and young spotted hyena is the lion, *Panthera leo*. Although lions frequently kill spotted hyenas, our project has never observed lions consuming hyenas that they have killed.

**Intra-specific conflict**

Adult spotted hyenas do occasionally kill the offspring of other members of their clan (infanticide). Intra-specific aggressive interactions at clan boundaries or over food resources may also lead to serious injuries and death.

Spotted hyenas are one of the few mammalian species that exhibit sibling rivalry leading to siblicide (i.e. when one member of a litter kills another littermate). The litter size of spotted hyenas is one or two, rarely three young (Hofer and East 1997). Mothers produce highly nutritious milk (protein content 14.9%, fat content 14.1%, gross energy density 9.70 kJ/g) during a period of 12 – 18 months and mothers normally nurse only their own offspring (Hofer and East 1993c). Given this considerable maternal investment, the occurrence of facultative siblicide in spotted hyenas might be expected, as a cub in a twin litter that disposes of its littermate would gain exclusive access to highly nutritious maternal milk during the prolonged period of lactation. However, a cub should only sacrifice a littermate when the increase in Darwinian fitness acquired by such an act is greater than the fitness cost incurred. Such a situation will occur when the maternal supply of milk is insufficient to feed both members of a twin or triplet litter. Under such circumstances, the dominant offspring should seek to improve its chance of survival by monopolizing maternal milk supplies. Severe sibling rivalry between spotted hyena littermates occurs in the Serengeti when prey availability in a clan territory is low for an extended period. Lactating females faced with these conditions often fail to produce sufficient milk for both members of a twin litter because they are forced to undertake long commuting trips and thus return to nurse their offspring in the clan territory after periods of absence of many days (Hofer and East 1993c; Hofer and East 1997). Under these circumstances the dominant cub excludes the subordinate cub from access to maternal teats, and thus the dominant cub drinks the majority of the milk supplied by the mother when she returns to feed her young. If this persist for several weeks, large asymmetries in body size between littermates develop and eventually the subordinate littermate dies of starvation (Hofer and East 1997; Golla *et al*. 1999).

In habitats such as the Ngorongoro Crater, where the availability of food is normally sufficient for female hyenas to rear twins, siblicide is rarely observed (Wachter *et al*. 2002).

**Pathogens**

Pathogens (viruses, bacteria, parasites etc), are an important factor in ecosystem dynamics. Pathogens can influence the population dynamics of species and have also played an important role in both natural selection and sexual selection. It is equally important to understand the role of pathogens in shaping the ecology and behaviour of the spotted hyena as it is to understand the role of food resources and predators. The following is a brief summary of three pathogens and their ecological role in the population dynamics of spotted hyena populations in the Serengeti ecosystem. Other pathogen reported in Tanzanian spotted hyenas are reported elsewhere (Mills and Hofer 1998; East *et al.* 2004).

*Streptococcus*

Although the population of spotted hyenas in the Ngorongoro Crater has been monitored since 1996, cases of severe *Streptococcus* infection were not observed before 2001. A total of 16 individuals from 5 of the 8 Crater clans have been observed with signs of infection and most of these cases occurred between September 2002 and February 2003, suggesting an outbreak of infection during this period. Animals showed severe unilateral swelling of the head followed by abscess formation at the mandibular angle, respiratory distress, mild ataxia, and lethargy. Two (12.5%) of these individuals died within days of developing signs of disease. Analysis of the 16S rRNA gene of the bacteria revealed a Lancefield group C *Streptococcus* with a high level of homology to *S. equi* subsp. *ruminatorum*, a bacterium described from domestic sheep and goats with mastitis in Spain (for details see Höner *et al*. 2006). Two hyenas without obvious clinical signs also were found to be infected, suggesting that they may have been non-symptomatic 'carriers' of the bacterium. A zebra in the Crater was also found to be infected, suggesting inter-specific transmission may occur, possibly when hyenas consume infected zebra carcasses (Höner *et al*. 2006). The level of mortality caused during the Streptococcus outbreak was sufficient to halt the recent growth in the Crater spotted hyena population (Höner *et al*. 2005).

*Rabies*

Rabies is normally viewed as a viral disease that causes periodic epidemics in carnivore host populations, resulting in high mortality and thus top-down regulation of host populations. Our research on rabies in wild carnivore hosts in the Serengeti ecosystem, Tanzania, has revealed a more complex picture of viral diversity and rabies ecology (East *et al.* 2001), and these findings have important implications for our understanding of rabies ecology in African ecosystems and conservation management plans to prevent rabies mortality in vulnerable endangered African carnivores.

Two genetically distinct variants of genotype 1 rabies are maintained in different carnivore hosts in the Serengeti, and the levels of virulence of these variants to their host species vary from benign to highly virulent. A highly virulent rabies strain occurs in bat-eared foxes, *Otocyon megalotis*, other canids and a viverrid, the white-tailed mongoose, *Ichneumia albicauda*. Infected animals show marked behavioural and neurological abnormalities and die as a result of infection. In contrast, 37% of approximately 5,000 spotted hyenas in the Serengeti ecosystem are exposed to rabies, as demonstrated by significant rabies-specific virus-neutralising antibody titres, and approximately 13% of this population is infected with a benign rabies strain revealed by reverse transcriptase (RT) PCR. Although infected individual hyenas intermittently excrete rabies in their saliva, rabies infection does not reduce survivorship or longevity, and infected animals do not display any clinical symptoms. Patterns of seroprevalence mirrored contact rates between members of a social group. Phylogenetic comparison of the Serengeti rabies isolates with those from Tanzania and elsewhere showed that the Serengeti canid and mongoose isolates were highly similar (2.1% sequence divergence) and were gathered within one cluster of isolates that included those of domestic dogs in Tanzania. In contrast, the hyena isolates differed substantially (8.5% sequence divergence) from either Serengeti canid/mongoose isolates or those from domestic dogs. The hyena strain was most similar to rabies genotype 1 isolates from Europe and the Middle East.

Between 2003 and 2004, a rabies epidemic occurred in the domestic dog population in rural areas close to the northwestern boundary of the Serengeti National Park and in the Ngorongoro Conservation Area. Numerous domestic dogs died of rabies or were killed by villagers when they developed clinical signs of infection, and the incidence of domestic dogs biting humans and livestock increased significantly. A spotted hyena with clinical rabies outside the northwestern border of the Serengeti National Park that attacked a women, and two clinical cases of rabies on the rim of the Ngorongoro Crater (one of which attacked a tourist, the other a Masai herder) demonstrated that all these 3 clinical cases were infected with the domestic dog strain of rabies.

Despite the recent epidemic of rabies in domestic dogs on the borders of the Serengeti National Park and in the Ngorongoro Conservation Area, no cases of clinical rabies have been observed in hyenas inside the National Park or on the floor of the Ngorongoro Crater. Furthermore, there has been no reported cases of rabies in other carnivores inside the National Park or on the Crater floor. We consider that high exposure to a non-virulent rabies variant among Serengeti spotted hyenas may have prevented the spread of the rabies epizootic from domestic dogs outside the National Park to spotted hyenas inside the National Park. The low population densities, limited ranges and patchy distribution of bat-eared foxes, white-tailed mongooses, and other small carnivores within a structured natural landscape may have been factors that prevented the spread of the rabies epidemic in domestic dogs to these carnivore species in the National Park and on the floor of the Ngorongoro Crater.

*Canine Distemper Virus*

Serum samples collected from spotted hyenas between 1987 and 1993 in the Serengeti National Park have demonstrated that individuals in this population were exposed to canine distemper virus for many years before the 1994 outbreak of disease. During a period spanning several months at the end of 1993 and continuing in 1994, we monitored clinical cases of canine distemper in spotted hyenas in the Serengeti National Park. Clinical cases of disease were restricted to juvenile hyenas and there was an increase in juvenile mortality during this period (Haas *et al*. 1996). However, female hyenas that lost a litter to canine distemper infection produced a replacement litter within several months, thus the reproductive output of females was only retarded for a period of months. During 20 years of monitoring of the spotted hyena population in the Serengeti National Park, canine distemper has significantly increased mortality among young hyenas during a restricted period and the long-term importance of this virus as a cause of mortality in the Serengeti hyena population has been limited.

**Human Causes of Mortality Inside Protected Areas.**

*Snares*

The most important mortality factor influencing the adult spotted hyena population in the Serengeti National Park is human predation caused by wire snares set by game meat hunter. Commuting spotted hyenas from all parts of the Serengeti National Park are exposed to the danger of snares when they feed on migratory herbivores close to the western and north-western SNP boundary (Hofer *et al*. 1993). Because female spotted hyenas normally only nurse their own offspring, the dependent young of mothers that are killed in snares are doomed to die of starvation. In addition, game meat hunters are known to poison spotted hyenas around their camps.

Only a few cases of spotted hyenas with snare wounds have been observed in the Ngorongoro Crater, thus snares are not a major cause of mortality in this population.

*Vehicles*

Spotted hyenas are killed by vehicles inside the Serengeti National Park each year, particularly along the main road.

*Refuse*

Hyenas inside the Serengeti National Park have died after eating refuse, after getting their heads stuck inside large containers discarded in refuse pits and after falling into uncovered refuse pits.

*Capture of live animals and trophy hunting*

Spotted hyenas are captured for live export and hunted under licence inside game reserve.

**Causes of Mortality Outside Protected Areas**

Threats to spotted hyena populations outside protected areas are diverse e.g. poisoning, trapping, snaring, and other forms of hunting, habitat degradation and fragmentation, declining prey populations (for details see Mills and Hofer 1998). These threats are increasing in intensity as the size of the human population grows and as demand for agricultural land increases. All spotted hyena populations outside protected areas are therefore threatened by human activities. Although spotted hyenas are the most numerous large carnivore outside protected areas (Nyahongo *et al*. 2005) and are viewed as a threat to livestock (Mills and Hofer 1998), the loss of livestock to hyena predations is minimal when compared to other causes of livestock loss such as disease and poor husbandry (Nyahongo 2004).

**Education**

The spotted hyena is an important character in Tanzanian folklore and is associated with many supernatural myths. Generally the public image of spotted hyenas is poor and this has promoted negative attitudes and a lack of understanding of the important ecological role of spotted hyenas in African ecosystems. This problem can only be tackled by improved education, particularly of young people.

**Acknowledgements**

I thank all researchers associated with this programme including H Hofer, OP Höner, B Wachter, W Goymann, W Goller, K Wilhelm, D Thierer, J Nyahongo, G Riahani, R Albert, B Kostka, G Spong. I also thank the Tanzania Commission of Science and Technology, the Tanzania Wildlife Research Institute, the Tanzania National Parks and the Ngorongoro Conservation Area Authority and all collaborating scientists particularly W Wickler, J Cox, KLI Campbell, S Huish, T Burke, T Muller, E Möstl, K Möstl, L Haas, V Runyoro, R Fyumagwa, S Speck, G Wibbelt, V Benetka, A Ludwig, C Pitra, P Wohlsein, C Greig, FA Mturi, PD Moehlmann.

## 4. Distribution and abundance

The Tanzania Carnivore Project has been collecting information on the distribution of all three species of hyaena across the country since 2002 through its Carnivore Atlas Project. The majority of the information contributed is from the northern sector, principally due to better infrastructure and higher numbers of visitors in the region; whereas data from the south, west and central regions are limited.

The group agreed on the following regions as the basis for regional analysis:
**Northern** – Serengeti/Ngorongoro
**Maasai Steppe –** includes Tarangire/West Kilimanjaro/Mkomazi/Arusha region/Natron region
**Central/Western** – Ruaha complex; Katavi/Rukwa/Ugalla/Mahale complex; Moyowosi/Kigosi
**Southern** – Selous/Mikumi; Selous-Niassa corridor and coastal districts
**North west** – Ibanda/Burigi/Kagera/Buramulo
**Other** – Tabora; Dodoma –Singida; Northern coast – Saadani; Southern Highlands; Zanzibar
These regions roughly correspond with those in the other carnivore sections within the National Carnivore Conservation Action Plan.

### 4.1 Aardwolves: Summary of current knowledge.

**Ecology and behaviour**
The aardwolf, as already noted, occurs in two discrete populations within the African continent. Tanzania holds the southern limit of the northern aardwolf population, which is separated from the southern population by the wetter woodlands occurring to the south of the country. The populations represent two subspecies: *Proteles cristatus cristatus* of southern Africa and *Proteles cristatus septentrionalis* of eastern and northeastern Africa. In east Africa the species is found in open and bushed savannahs and its distribution is independent of drinking water. It has been found on the edge of forest in Mahale, but has not been recorded deep within forest or wetland habitats. Like the other hyaenids, it makes use of burrows during the day, often using springhare

and aardvark holes, but it can also dig its own borrows (Anderson 1994; Richardson 1985; Williams et al. 1997). There is not a great deal of information available about aardwolves, and much of what there is comes from the southern subspecies and very little is known about the northern subspecies.

Throughout its distributional range the aardwolf relies on one local species of naute harvester termite (genus *Trinervitermes*). In east Africa the preferred species is *T. bettonianus* (Kruuk and Sands 1972). These termites are less active during the wet season, when the diet is supplemented by a number of other termites belonging mainly to the genera *Odontotermes* and *Macrotermes* (Kruuk and Sands 1972). The aardwolf is primarily nocturnal, with activity periods determined largely by the activity of termites, some of which cannot tolerate direct sunlight. Aardwolves are solitary foragers, licking termites from the soil surface, rather than burrowing into termite colonies like other termite eaters such as aardvarks.

Aardwolves are monogamous, and mated pairs occupy territories with their most recent offspring, which remain in their natal territory for one year, dispersing at the time of birth of the next litter. Territory sizes have never been measured in eastern Africa, but in South Africa they are small, ranging from 1-4km$^2$, their size being determined by the availability of termites (Mills and Hofer 1998). The aardwolves construct 5-6 dens within their territory (Williams et al. 1997) and both sexes maintain territories by marking grass stalks with pasting secretions from the anal gland (Richardson 1987, 1991). Intruders are excluded from territories, usually being chased out of the territory and rarely through direct aggressive encounters, although fatal fights have been recorded. The aardwolf has no long distance call (Peters and Sliwa 1997).

In South Africa there is a discrete mating season around the first two weeks of July and mating is highly promiscuous (Koehler and Richardson 1990; Richardson 1985). There is a suggestion that further north in Botswana and Zimbabwe the breeding season is less restrictive (Smithers 1983), but there is no information from eastern Africa. The gestation period in South Africa is approximately 91 days with a mean litter size of 2.5 (range 1-4) (Williams et al. 1997). Cubs are born in dens from which they first emerge after a month, and start foraging for termites near the den after about 9 weeks, accompanying the adults after 12 weeks. They remain in the den for 4 months in total, after which they are weaned and able to forage independently throughout the territory (Koehler and Richardson 1990; Richardson 1985). Males help guard the young against jackals, probably their greatest natural predator, which substantially increases cub survival rates (Richardson 1985, 1987).

The aardwolf is thought to be the only African termite eater able to tolerate the terpene defence secretions of *Trinervitermes* soldiers (Richardson and Levitan 1994), and hence is unlikely to be in competition for food with any other major termite forager. The aardwolf, however, does suffer from predation by jackals, which will attack aardwolf cubs, as mentioned above. Cheetah have also been recorded to take adult aardwolves (Durant pers obs), but given that cheetah generally occur at very low densities, such predation is unlikely to have a major impact on aardwolf population viability. Aardwolf cubs are also vulnerable to drought, which can substantially increase mortality. Intraspecific fighting and disease are thought to be minor causes of mortality, although rabies has been recorded in aardwolves in southern Africa (Swanepoel et al. 1993). Outside protected areas aardwolves suffer from poisoning, particularly from spraying aimed at reducing periodic outbursts of locust plagues. These poisoning events can be catastrophic, killing half the local adult population and all of the cubs (Mills and Hofer 1998). Aardwolves can also be killed due to mistaken identity or ignorance, where the species is mistakenly assumed to be attacking livestock, and they can also be run over on roads. A recent study has reported that grazing by livestock at medium intensity might actually increase termites and benefit aardwolves (Fagerudd 2005).

**Status and Distribution**

The carnivore atlas project has received reports of aardwolves in Serengeti National Park, Ngorongoro Conservation Area, Tarangire National Park, and the Maasai steppe (Fig. 2). Outside these northern areas there are only three records, one on the border between Rukwa Game

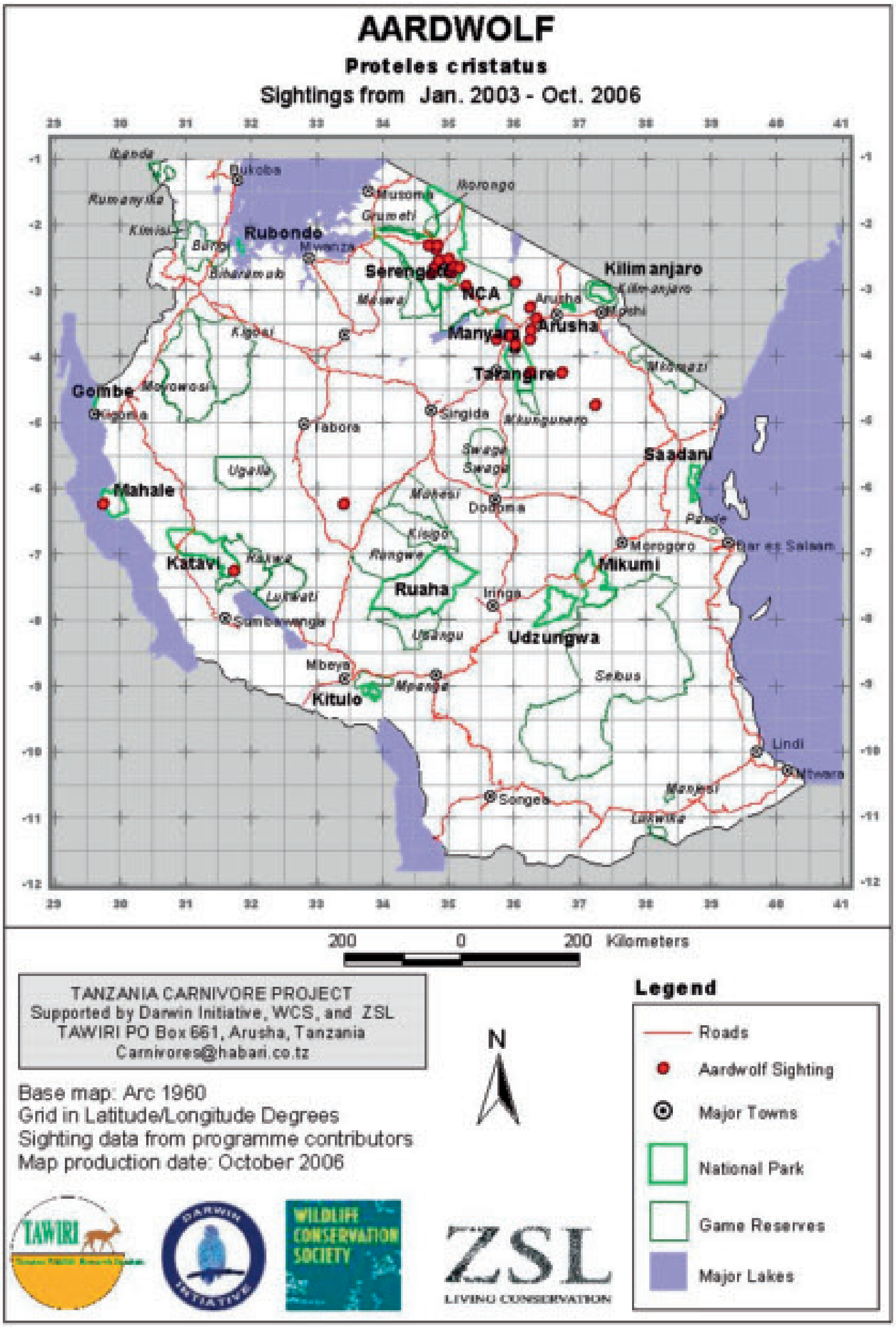



**Fig. 2** **Map of known sightings of aardwolves submitted to the Tanzania Carnivore Project since 2002 up until the time of the workshop. Data submitted is in two forms, either as direct GPS locations, or as a grid square as identified on the map. The former data type are plotted on the map directly, whilst the latter data type are plotted at the centre of the reported grid square.**

Reserve and Katavi National Park and one north west of Rungwe Game Reserve. The third sighting is from Mahale. There is no information on density of aardwolves across their range, however territory size estimates in southern Africa range from 1-4km$^2$, suggesting that, if territories are contiguous, it is possible they could reach reasonably high maximum densities of 0.25-1/km$^2$. Their distribution should map that of *Trinervitermes* termites, on which they depend.

### 4.1.1 Northern Region (Serengeti National Park, Maswa Game Reserve, Ngorongoro Conservation Area, Loliondo Game Controlled Area, Natron)

Aardwolves are thought to be distributed across the Serengeti National Park. The carnivore atlas has records of the species from the Serengeti plains in the south east, and close to Ikoma gate between the northern and western arms of the Serengeti National Park. They probably also occur in Ngorongoro Conservation Area, but there is only one record for them just to the north east of this region, south of Lake Natron. Density or trends are unknown for this species across the region.

### 4.1.2 Maasai Steppe (Tarangire, Arusha, Kilimanjaro and Manyara National Parks; Mkungunero and Mkomazi Game reserves; Simanjiro, West Kilimanjaro and Natron)

There are a substantial number of records of aardwolves in this region. The species has been recorded to the west of Arusha National Park, and to the north east and west of Tarangire. They have also been recorded in camera traps in Tarangire, but were trapped more frequently in a survey closer to the centre of the park, level with Silale swamp (Msuha pers. comm.) than in an earlier survey in the north of the park, where six sightings of aardwolves were recorded in 1169 camera trap days. There are also observations of aardwolves in the grid squares to the east of Tarangire National Park, on the Maasai steppe. There is no information on the species in West Kilimanjaro, and densities or trends are unknown across the region.

### 4.1.3 Central and western region (Ruaha complex, including Rungwa and Rukwa-Lukwati ecosystem; Ugalla; Katavi; Mahale; Moyowosi; Kigosi)

There are only three reports of aardwolves in this region, one to the northwest of Rungwa, one on the boundary between Rukwa Game Reserve and Katavi National Park, and one from Mahale Mountains National Park. There is little historical information on this species across this region, however the action plan lists an old record of aardwolves in the Ruaha area, and a confirmed recent record in the Rungwa area, but Katavi and Mahale were thought to be outside the historical range (Mills and Hofer 1998). There is no information on aardwolves in the Moyowosi-Kigosi complex, but the species is thought not to be present in this area. Finally, there is no information on density or trends of the species anywhere in the region.

### 4.1.4 Southern – Selous/Mikumi; Udzungwas; Selous- Niassa corridor and coastal districts

There is no information on aardwolves in this area, and they are thought not to be present.

### 4.1.5 The northwest – Ibanda; Burigi; Kagera; Buramulo

There is no information on aardwolves in this region, and no historical records.

### 4.1.6 Other – Tabora - Dodoma - Singida- shinyanga; Northern coast – Saadani; Southern Highlands; Zanzibar; Itigi

There is no information on aardwolves in this region, and no historical records.

## 4.2 Striped hyaena: Summary of current knowledge.

**Ecology and Behaviour**

Across most of its range the striped hyaena occurs in open habitat or light thorn bush country and has been recorded at altitudes of up to 3,300m in Pakistan (Roberts 1977). Whilst there are very limited data on the densities for the species, the species appears to occur at very low densities. The documented densities are 0.01-0.02/km$^2$ in the Serengeti in Tanzania (Kruuk 1976), <0.02/km$^2$ in Nazinga Gaem ranch in Burkina Faso (Mills and Hofer 1998), >0.016/km$^2$ in the Negev desert in Israel (Van Aarde et al. 1988), 0.009-0.01/km$^2$ and 0.005/km$^2$ in the West Kopeth–Dag Reserve in Turkmenistan (Mills and Hofer 1998). However all these estimates are based on a tiny number of individuals and more work is needed to produce a robust estimate of density in any of these areas. Home range sizes have been reported as a minimum of 44km$^2$ in the Serengeti (Kruuk 1976) and up to 460km$^2$ in Tadzhikistan (Mills and Hofer 1998), such large home ranges have rarely been reported in other species, and make the species particularly vulnerable to fragmentation and habitat change or loss.

The striped hyaena is a carrion scavenger, relying on the remains of kills of other large carnivores. However there is very little information on the diet of the species in the east African region. Across its range it is known to consume a wide variety of vertebrates, invertebrates, vegetables and fruits, and, around people, organic refuse (Mills and Hofer 1998). The massive teeth and jaw muscles allow the species to gnaw and break large bones and carapaces, giving access to the meat within. The striped hyaena may also kill smaller vertebrates, however there are no data on the contribution that kills versus carrion make to the overall diet. The species is nocturnal throughout its range. In the Serengeti, an individual covers 7-27km (mean 19km) per night, which is mainly spent foraging (Kruuk 1976). Food storage is practiced commonly by the species (Kruuk 1976). Striped hyaenas have been reported as attacking livestock during questionnaire surveys, but the possibility that apparent livestock depredation is actually scavenging of dead carcasses cannot be excluded in these surveys (Mills and Hofer 1998). In Tanzania the species has been recorded as taking sheep and goats rarely however livestock attacks are often unreported to the authorities. In Kenya, the species has been occasionally reported to take goats and sheep and, rarely, camels. In other areas of the range, such as Ethiopia, Israel, Algeria and Turkmenistan, the species has been occasionally reported as taking cattle, however attacks are never frequent across the range.

Striped hyaenas in East Africa are generally solitary, although hyaenas in North Africa and Asia are thought to be more social, having been repeatedly observed in small groups. In Tanzania, one female and one male were recorded as having home range sizes of 44km$^2$ and 72km$^2$ respectively, but were not thought to be territorial (Kruuk 1976). Despite this observed lack of territoriality, the striped hyaena does scent mark, pasting objects with the anal glands. Litter size ranges from 1-4 (median of 3) with a gestation of around 90 days (Mills and Hofer 1998) and no obvious breeding season. Cubs begin to eat meat at 30 days (Mills and Hofer 1998), but have been observed suckling up to 10-12 months (Kruuk 1976). Most females produce their first young by the age of 2-3 years in captivity (Mills and Hofer 1998). The striped hyaena is reported to prefer to den in caves, preferably with narrow entrances which are well hidden, however all such observations come from the Middle East and Asia. In Tanzania, they are known to make use of dug dens in earth, however whether they use these to give birth is unknown.

The striped hyaena competes with the spotted hyaena in east Africa, and is dominated by this species through much of its range. It is difficult to assess the impact of other large carnivores as the costs of potential kleptoparastism or predation may be outweighed by benefits from being able to scavenge at kills of other species. For instance, the species has been reported as scavenging from kills of leopard and cheetah, and even domestic dogs. Interestingly the species has been reported as playing dead if attacked by dogs or people, even if repeatedly bitten (Mills and Hofer 1998).

Humans are by far the most important source of mortality for the species across its range, particularly in north Africa and the Arabian peninsula where it is persecuted because it is perceived as being a grave robber (Mills and Hofer 1998). The striped hyaena is very susceptible to poisoning due to its tendency to scavenge from carcasses, even when it is not the target. In Asia the species is reported as attacking children, resulting in extensive retaliation, however no such reports have been recorded in east Africa, possibly because the east African subspecies is smaller and relies more on scavenging than direct killing (Mills and Hofer 1998). The species is also vulnerable to trapping, particularly snare lines laid out for herbivores, again, because they are scavengers they are likely to be attracted such lines due to the cries of herbivores already caught in snares. Roads also pose a significant risk in some areas, as they are reported to be attracted on to roads by the smell of small animals that are run over. There is little information on natural sources of mortality, including pathogens.

**Status and Distribution**

In the 1998 IUCN hyaena action plan, striped hyaenas were documented only in the northern sector of Tanzania. However the plan noted unconfirmed records for the Ruaha region. The Tanzania carnivore atlas project data reflect this pattern, covering the Serengeti region, Tarangire, and west Kilimanjaro, and Arusha regions. The data also include further unverified records for the Ruaha area, as well as the area to the northwest of the Selous Game Reserve and between the Selous and the coast. Tanzania has an estimated population of 100 individual striped hyaena (Mills and Hofer 1998), however this estimate is a guess, and is not based on data. The estimated global population size for the species is between 5,000 and 15,000 (Mills and Hofer 1998)

### 4.2.1 Northern Region (Serengeti National Park, Maswa Game Reserve, Ngorongoro Conservation Area, Loliondo Game Controlled Area, Natron)

Striped hyaenas are recorded in the southern Serengeti National Park, particularly around Olduvai, Ndutu and Kusini tented camp. They are also recorded in Loliondo Game Controlled Area to the north, and are frequently sighted in the Ndutu area in the Ngorongoro Conservation Area. They have also been recorded all along the south eastern border of the Serengeti Park as well as close to the northern edge of Lake Eyasi. There are no records from the Maswa, Ikorongo or Grumeti Game reserves. An estimate of the population size for this region has been published at 100 (Mills and Hofer 1998). Density or trends are unknown for this species across the region.

### 4.2.2 Maasai Steppe (Tarangire, Arusha, Kilimanjaro and Manyara National Parks, Simanjiro, Mkungunero, West Kilimanjaro; Natron; Mkomazi)

There are records of striped hyaena in this region to the west of Arusha National Park, and west of Kilimanjaro to the south east of Lake Natron. They have also been recorded within Arusha National Park and close to the road on the way from Arusha to Tarangire. There are no records in the north of Tarangire National Park, however they have been recorded in camera traps in the centre of the

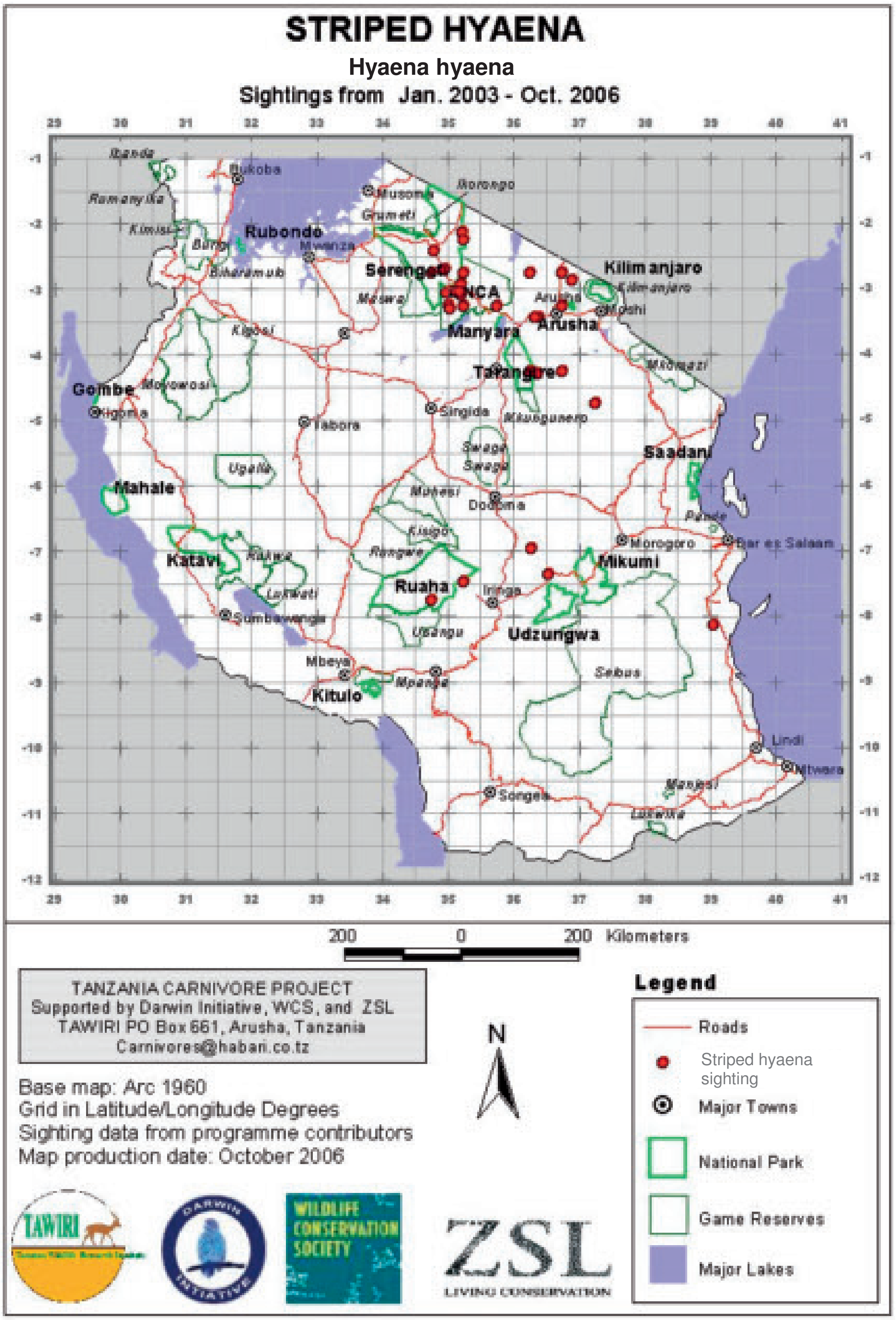



**Fig. 3** **Map of known sightings of striped hyaenas submitted to the Tanzania Carnivore Project since 2002 up until the time of the workshop. Data submitted is in two forms, either as direct GPS locations, or as a grid square as identified on the map. The former data type are plotted on the map directly, whilst the latter data type are plotted at the centre of the reported grid square.**

park, close to Silale swamp (Msuha pers. comm.), and there are also records of the species on the Maasai steppe to the east of the park. The species is listed as being present in Mkomazi Game Reserve. There are no other records of striped hyaena in the region, although the species was thought to be historically widespread across most of this area (Swynnerton 1951). Densities and trends are unknown across the region.

### 4.2.3 Central and western region (Ruaha complex, including Rungwa and Rukwa-Lukwati ecosystem; Ugalla; Katavi; Mahale; Moyowosi; Kigosi)

There is very little information on sightings in this region, however there are unconfirmed records around Ruaha National Park, these sightings need to be verified, particularly in the light of historical anecdotal records from this area (Mills and Hofer 1998). There is no information from Rukwa-Lukwati, Ugalla and Moyowosi/Kigosi Game Reserves, or Katavi and Mahale Mountains National Parks, however there is no historical evidence that striped hyaenas used to occur in any of these areas, and it is likely that the species is not present. There is no information on density or trends of the species anywhere in the region.

### 4.2.4 Southern – Selous/Mikumi; Udzungwas; Selous- Niassa corridor and coastal districts

There are some unverified records of sightings to the north east of the Udzungwa's however it is not clear whether these sightings might have been confused with aardwolves, which is not uncommon for observers not familiar with both species. There is also a record of a striped hyaena sighting close to the coast south of Dar es Salaam, again this is not verified, and could have been confused with aardwolf. The species has not been recorded historically in these areas. There is no information on striped hyaenas elsewhere across this area, including within the Selous Game reserve, the Udzungwa and Mikumi National Parks and the Selous-Niassa corridor. There is no evidence that they were ever present in these areas.

### 4.2.5 The northwest – Ibanda; Burigi; Kagera; Buramulo

There is no information on striped hyaenas in this region, and no historical records; it is unlikely they are present.

### 4.2.6 Other – Tabora - Dodoma - Singida- shinyanga; Northern coast – Saadani; Southern Highlands; Zanzibar; Itigi

There is no information on striped hyaenas in this region, and no historical records; it is unlikely they are present.

## 4.3 Spotted hyaena: Summary of current knowledge.

**Ecology and Behaviour**

The spotted hyaena ranges across semi-desert, savannah and open woodland, dense dry woodland and mountainous forest up to 4000m in altitude (Kruuk 1972). It is absent from, or occurs in only very low densities, in tropical rainforests and in coastal habitats. The species can occur at much higher densities than the striped hyaena, up to 1.7 individuals per $km^2$ in Ngorongoro Crater (Kruuk 1972), however the lowest density recorded is 0.003 individuals per $km^2$ in the Central African Republic (A. A. Green pers. comm. cited in Mills and Hofer 1998). In Tanzania, the lowest density recorded is 0.32 individuals/$km^2$ in Selous Game Reserve (Creel and Creel 1996). The only other density estimate in Tanzania is from the Serengeti National park, ranging from 0.6-0.8 individuals/$km^2$ in the Serengeti National Park (Hofer and East 1995; Hofer and East 1993a). Unusually among mammals, females are larger than males (Kingdon 1977;, Kruuk 1972; Smithers 1983).

Whilst the spotted hyaena is often regarded as a scavenger, it is a killer in its own right, taking a wide range of prey, including very large prey such as cape buffalo, zebra, warthog, and the young of giraffe, hippopotamus and rhinoceros (Mills and Hofer 1998). The species can also be very opportunistic and has been recorded as eating almost any mammal, bird, fish or reptile within its range, regardless of size (Mills and Hofer 1998). It is also often attracted to human refuse, consuming organic waste material, and will eat dung of some herbivores. Hyaenas have a wide variety of vocalisations. The whoop is a contact call and can be heard over several kilometres, whilst the laugh or giggle is a signal of submission and is commonly heard at kills.

In Tanzania, in the Serengeti ecosystem, where the species has been well studied, important prey include wildebeest, Thomson's gazelle, and zebra. In the Selous Game Reserve they have been recorded as feeding primarily on wildebeest and buffalo, as well as zebra, impala, giraffe, reedbuck and kongoni (Mills and Hofer 1998). There is no information from elsewhere in Tanzania, however, across the border in Kenya, in the Maasai Mara, spotted hyaenas concentrate on topi and Thomson's gazelle when no migrants are present. In nearby Kenya the dominant prey were bushbuck, suni and buffalo in forest habitat in the Aberdare mountains (Sillero-Zubiri and Gottelli 1992), whilst in arid regions in the north, Grant's gazelle, gerenuk, sheep, goats and cattle are likely to be important (Kruuk 1980). An unusual feature of hyaena foraging behaviour is their ability to move long distances to find prey in migratory systems such as in the Serengeti, where they commute an average 80km round trip, 40-50 times a year to the nearest migratory herds (Hofer and East 1993b). This behaviour has not been documented in any other ecosystem in Tanzania.

The spotted hyaena detects live prey by sight, hearing and smell. It is particularly good at locating carrion by smell, the noise of other predators feeding on the carcass, or, during day time, by cues from other scavengers such as vultures descending on carcasses. It has been recorded as picking up noises emanating from predators killing or feeding from distances of up to 10km (Mills 1990). When hunting, the spotted hyaena hunts either on its own, or in small groups of up to 5 individuals (Kruuk 1972). It is a 'coursing' hunter, and catches prey by running it down through its greater endurance, rather than a 'stalking' hunter, which catches prey by a short fast chase after stalking until very close. As such, the spotted hyaena is likely to select for slower or weaker individuals in a herd as these are the easiest for to run down, as has been recorded in another coursing hunter, the wild dog (FitzGibbon and Fanshawe 1989). Hunting success varies with group size, prey size and habitat. Young are caught more easily than adults (Mills 1990), and several hyaenas are required to take down adult buffalo and zebra (Kruuk 1972; Sillero-Zubiri and Gottelli 1992), whereas a strong and experienced hyaena may kill an adult wildebeest on its own (Mills 1990). Average daily food consumption is estimated at 2-4 kg per day, however a spotted hyaena can eat up to 18kg at one sitting and endure more than a week without food (Mills and Hofer 1998).

The impact of hyaenas on domestic stock is mainly on cattle, sheep and goats and varies widely in intensity between different regions (Mills and Hofer 1998). Perceptions often differ from reality, and a regularly scavenging species such as the spotted hyaena, may often be blamed for killing livestock when it has merely scavenged a carcass of an animal dead from disease or an animal killed by another predator. The extent of depredation of livestock depends on the availability of alternative prey (Mills and Hofer 1998), and livestock management practices (Kolowski and Holekamp 2006). Surplus killing of domestic stock has been reported in some areas (this report, page 34) and may pose a particular problem. Domestic dogs and the use of thorn enclosures or 'bomas' to protect stock at night greatly reduce the likelihood of attack (Kruuk 1980).

Spotted hyaenas have complex social behaviour. They live in social groups called clans that defend group territories with a strict dominance hierarchy (Mills and Hofer 1998). Top ranking females have priority of access when feeding at kills, and female cubs inherit the dominance of their mother and are positioned on the dominance hierarchy immediately below that of their mother, and above all adult females subordinate to their mother (Mills and Hofer 1998). Dominant females also have higher reproductive success than subordinates (Frank et al. 1995). Female cubs usually remain in their natal clan whilst males usually disperse at around 2.5 years old (Mills and Hofer 1998). Dispersing males enter the new clan's dominance hierarchy at the bottom and increase their social status as their tenure in the clan increases (Mills and Hofer 1998, East et al. 2001, Van Horn et al. 2003). Clan members forage alone or in small groups, but co-operate in defence of the territory, food resources and the clan den.

Clans vary in size from 3 in very arid habitats in southern Africa, up to 80 in the savannah areas of east Africa (Mills and Hofer 1998). Territory size and local prey density are thought to limit clan size in most environments (Mills and Hofer 1998). However in the Serengeti National Park, a dependence on migratory prey combined with a commuting foraging system, means that clan size is not limited by resident prey (Hofer and East 1993a), whilst in the adjacent Ngorongoro crater, clan sizes are not limited by prey densities on clan territories, but rather by densities across the crater floor (Höner et al. 2005). These examples suggest that clan dynamics may be more complex than first thought. Clans have been recorded as splitting if a territory in the neighbourhood becomes vacant (Holekamp et al. 1993; Höner et al. 2005) or groups of females can leave to join diminished nearby resident clans (Höner et al. 2005).

As with clan size, territory size is extremely variable in the spotted hyaena, ranging from 9-40km$^2$ in Ngorongoro Crater (Kruuk 1972, Höner et al. 2005) to over 1000km$^2$ in the Kalahari (Mills 1990). Communal territories are actively marked, patrolled and defended by clan members. In the Serengeti clan members tolerate hyaenas from other clans on their territory either when they transit through on commuting trips, or when foraging provided migratory herds are within the territory and hence food is plentiful. Local prey abundance is not the only factor affecting space use in the species, reproductive state and social rank have also been reported as affecting individual ranging patterns (Boydston et al. 2003, Höner et al. 2005). In both the Serengeti National Park and Ngorongoro Crater it has been demonstrated that females of low social status forage more often outside their clan territory than females of high social status (Hofer and East 2003; Höner et al. 2005). Females of low social status are also more likely to emigrate (Höner et al. 2005). Females with den-dwelling cubs have smaller home ranges, stay closer to the communal den, and farther from the territorial boundary than females with no den-dwelling cubs (Boydston et al. 2003). Whilst among females with no den-dwelling cubs, high ranking females have smaller home ranges, stay closer to the communal den and farther from the territorial boundary than low ranking females (Boydston et al. 2003).

Hyaenas give birth to cubs in a communal den or in a private birth den (East et al. 1989). Females can reproduce from 2 years, but may be as old as 5 years before they produce their first cubs (Frank et al. 1995; Hofer and East 1996). Conception can occur all through the year but in the Maasai Mara it has been reported to peak when food abundance is greatest (Holekamp et al. 1999). Litter size is usually 2, however it ranges between 1-3 (Frank et al. 1991). Multiple paternity is common in litters in the Serengeti National Park (East et al. 2003) and the Maasai

Mara (Engh et al. 2002). In males, the length of tenure in a clan is a strong determinant of reproductive success (Engh et al. 2002; East et al. 2003).

Hyaena cubs are born after an average 110 day gestation (Matthews 1939). The sex ratio is even or slightly female biased however deviations occur by the time they reach 2-3 months, which can be a consequence of sex specific siblicide after birth (Mills and Hofer 1998). If cubs are born in a private birth den they are later moved to a communal den (East et al. 1989). Female hyaena are characterised by an enlarged clitoris which forms a pseudo penis and is used extensively in greeting and communication. However birth must occur through this penis-like clitoris resulting in rupture and a large bleeding wound which can take weeks to heal (Mills and Hofer 1998, Drea et al. 2002). Cubs remain at the communal den for a period of approximately 12 months during which they rely on milk provided by their mother, and are weaned at between 14-18 months of age (Mills and Hofer 1998). Females usually will nurse only their own cubs (Mills and Hofer 1998), although communal suckling has been observed in the Kalahari (Knight et al. 1992).

The lion is a key competitor to the spotted hyaena with whom it frequently competes for kills (Mills and Hofer 1998). Which species dominates at a kill may also depend on numbers – whilst lions usually displace hyaenas at kills, if the ratio of spotted hyaenas to the number of adult females and subadult lions exceeds 4 then hyaenas may displace lions from a kill, unless an adult male lion is present in which case lions always dominate (Cooper 1991; Höner et al. 2002). The proportion of kills lost by hyaenas to other carnivores varies substantially between ecosystems (Mills and Hofer 1998). A single hyaena usually dominates a cheetah, leopard, striped hyaena, brown hyaena, all species of jackal, and a single African wild dog (but not a pack) (Eaton 1979; Kruuk 1972; Mills 1990).

Average annual mortality rates of adult hyaenas is around 13-15% (Frank et al. 1995; Hofer et al. 1993; Mills 1990). The most important source of mortality is humans, through shooting, trapping and poisoning, even within protected areas. Hyaenas are particularly vulnerable to snaring, as they are attracted into areas of high densities of game which are often the focus of illegal snaring activity (Nyahongo et al. 2005; Hofer et al. 1993). Within the Serengeti over 50% of adult mortality is due to snaring (Hofer and East 1995; Hofer et al. 1993). Sources of natural adult mortality include predation by lions, violent encounters between conspecifics either at kills or in clan wars, injuries associated with giving birth for the first time and injuries by prey when hunting (Mills and Hofer 1998). Around 39-60% of hyaena cubs survive to one year (Frank et al. 1995; Hofer and East 1995; Mills 1990, White 2005). There is no evidence that singleton cubs survive better than twins, and or that female and male cubs differ in survivorship (White 2005), however their sample size was small making the statistical power of tests low. Important sources of mortality to cubs include intraspecific factors such as infanticide and siblicide (Mills and Hofer 1998). Cubs may also starve to death when mothers die, while other sources of cub mortality include predation by lions and the collapse of communal dens after heavy rain (Mills and Hofer 1998).

The precise role disease plays in spotted hyaenas is unclear, although a large number of diseases and parasites have been documented in the species. Evidence of exposure to rabies, canine herpes, canine brucella, canine adenovirus, canine parvovirus, coronavirus, feline calici, leptospirosis, bovine brucella, morbillivirus, streptococcus and anaplasmosis have been found (Hofer and East 1995; Mills and Hofer 1998; East et al. 2004; Höner et al. 2006). These are discussed in more detail under threats (see section 5.3.5).

**Status and Distribution**

In the hyaena action plan, spotted hyaenas were documented to occur across a large part of the country, with no confirmed recent records (since 1970) close to the west and south western borders, or in the south east close to the coast (Mills and Hofer 1998). The species was reported to occur in most national parks and game reserves and the Ngorongoro Conservation Area, but was missing from Udzungwa Mountains National Park, Mahale Mountains National Park and Gombe

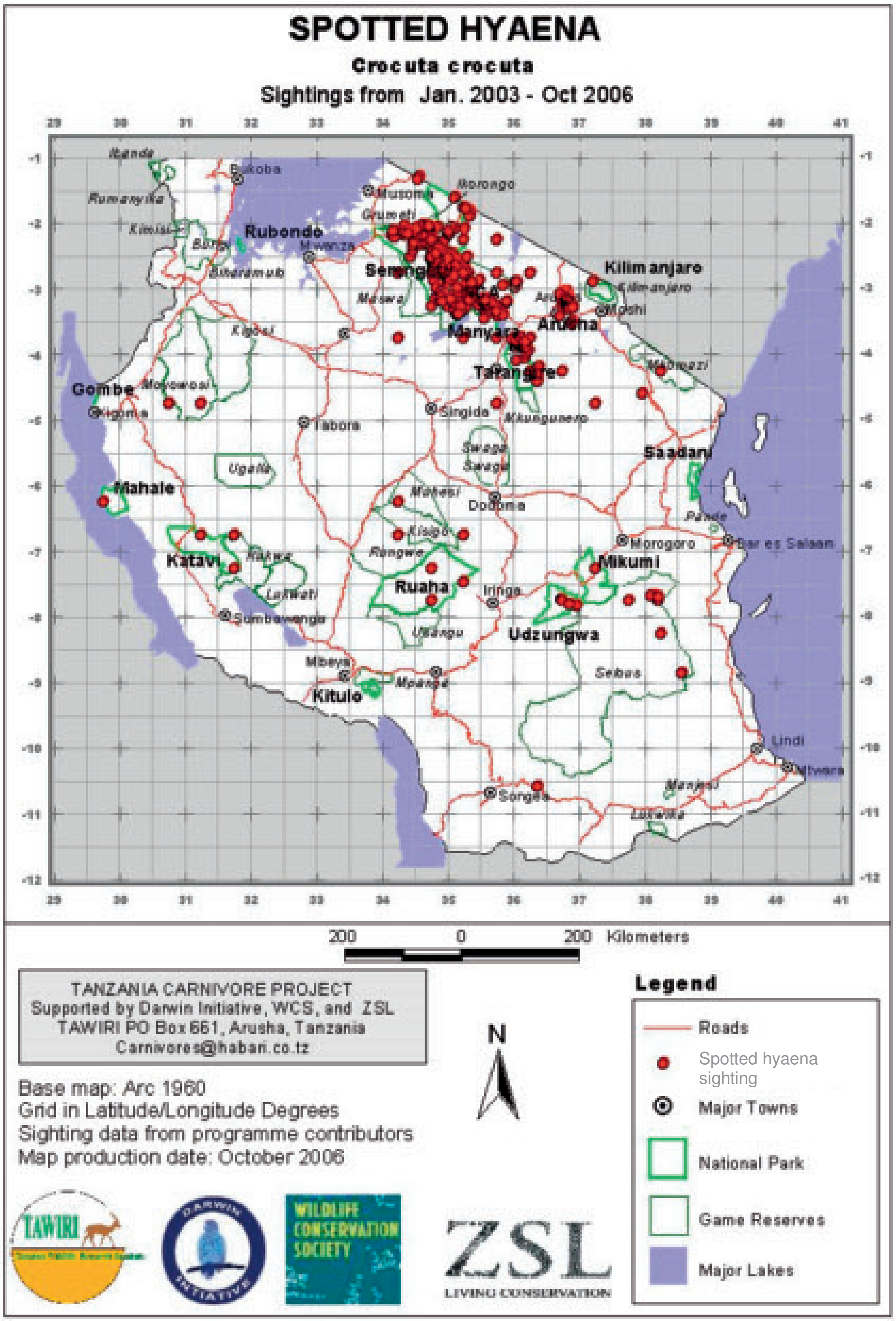



**Fig. 4** **Map of known sightings of spotted hyaena submitted to the Tanzania Carnivore Project since 2002 up until the time of the workshop. Data submitted is in two forms, either as direct GPS locations, or as a grid square as identified on the map. The former data type are plotted on the map directly, whilst the latter data type are plotted at the centre of the reported grid square.**

National Park (Mills and Hofer 1998). It also occurred at low densities outside protected areas, despite being widespread across the country. The Tanzania carnivore atlas project data largely reflect this pattern, but include verifiable confirmed sightings from camera trap surveys in Mahale and Udzungwa Mountains National Parks. There were also reliable records in Katavi National Park and Rukwa/Lukwati Game Reserves. This demonstrates that the species may be more widespread across Tanzania's protected areas than previously thought, and is able to adapt to a wide variety of habitats ranging from semi arid savannah to montane forest. Tanzania's spotted hyaena population was not estimated in the last species action plan, but was stated to be in excess of 10,000, with the population in the Serengeti alone numbering 7,000 individuals (Mills and Hofer 1998).

### 4.3.1 Northern Region (Serengeti National Park, Maswa Game Reserve, Ngorongoro Conservation Area, Loliondo Game Controlled Area, Natron)

Spotted hyaena are widely distributed across this area, with sightings from across the Serengeti National Park and Ngorongoro Conservation area, and from the surrounding game reserves, Grumeti, Ikorongo and Maswa. There are also a number of sightings outside the park to the east in Loliondo Game Controlled Area and around Lake Natron. There are sightings also to the south of the Serengeti, close to Lake Eyasi and Mto wa mbu, and south of the Maswa Game Reserve. However sightings to the west of the protected area system are scarce, with a couple of sightings close to the Kenya border to the north west of the park, and another sighting west of the Maswa. The population is estimated as 7,000 individuals in the Serengeti National Park including the Mara National Reserve, and is thought to be stable (East pers comm, Durant et al. under review). The highest recorded density of spotted hyaenas in the world was recorded in this region, in Ngorongoro Crater during 1965-1967, where an estimated total population of 385 adults resulted in a density of 1.7 adult hyaenas per $km^2$ (Kruuk 1972). Recorded densities have been substantially lower in the crater since this time, dipping to 117 adults in 1996 and rising to 333 adults and juveniles in 2002 (numbers based on total number of recognised individuals, Höner et al. 2005). The decline from 1960s levels observed in 1996 is thought to be due to a reduction in prey (Höner et al. 2005), whilst the subsequent increase is thought to be linked to a recovery of prey populations and reduced competition with a lower lion population at that time (Höner et al. 2005). This study demonstrates the importance of prey and competitors in the dynamics of hyaena populations.

The status of hyaenas outside the protected areas is unknown, although a call-in survey in the late 1990s showed that responses in the Loliondo Game Controlled Area were lower than responses on the Serengeti plains within the Serengeti National Park or within Ngorongoro Conservation Area, suggesting that densities were much lower in this area (Maddox 2002).

### 4.3.2 Maasai Steppe (Tarangire, Arusha, Kilimanjaro and Manyara National Parks, Simanjiro, Mkungunero, West Kilimanjaro; Natron; Mkomazi)

There are many sightings of spotted hyaenas in Tarangire, Lake Manyara and Arusha National Parks (Fig. 4). Spotted hyaenas have also been seen in Kilimanjaro National Park and Mkomazi Game Reserve. Sightings outside the protected area system are less commonly reported, however they have been seen to the south west and south east of Tarangire, far from the park to the east, and to the south east of Arusha, not far from the main town. Their density in all these areas is unknown, however it should be noted that a recent camera trap survey in Arusha National Park had a trapping success of 63 out of 1073 camera trap days, whereas a similar survey in Tarangire had a success of 48 out of 1169 in the same total area, suggesting densities may be higher in Arusha park. There is no information available on declines and trends, however given the level of threat across the Maasai steppe outside the protected areas, it is likely the population has been declining in this region over the last 10-15 years. Their status in west Kilimanjaro and Mkomazi Game Reserve is unknown. Spoor surveys by the People and Predators Project identified higher counts in Tarangire National Park than outside the park, counting 0.59 spoor/km in the park compared with 0.39 near Kikoti and 0.38 near Loibo Serrit (Lichtenfeld 2005). This suggests that densities are lower outside the park.

### 4.3.3 Central and western region (Ruaha complex, including Rungwa and Rukwa-Lukwati ecosystem; Ugalla; Katavi; Mahale; Moyowosi; Kigosi)

Data for southern and western Tanzania is much more sparse than that in the north, reflecting the lower number of visitors to this region. However spotted hyaenas have been recorded in most of the protected areas in the region, including Muhesi/Kisigo, Rungwa, Rukwa and Moyowosi game reserves as well as Ruaha, Katavi and Mahale Mountains national parks. There is no information from Kigosi or Ugalla game reserves or outside protected areas, however this is likely to be a reflection of the lack of observers in this region. There is little information on density of the species across the area, however a camera trap survey in Mahale yielded only 4 sightings in 653 camera trap days, suggesting the species is not common in this area. There is no information on trends across the entire region.

### 4.3.4 Southern – Selous/Mikumi; Udzungwas; Selous- Niassa corridor and coastal districts

Spotted hyaenas have been sighted in the northern and eastern parts of the Selous Game Reserve, they have also been recorded in Mikumi and Udzungwa Mountains national parks (Fig. 4). A study in the 1990s estimated the density of hyaenas in the Selous as 0.32 individuals/km$^2$ (Creel and Creel 1996), but this study was not extrapolated to provide a density estimate of the entire game reserve. Given that the study took place across only 5% of the reserve – in a 2,600km$^2$ study area in the north where prey densities are highest - it is likely that this estimate is relatively high compared to the rest of the reserve. There is little data on hyaenas from anywhere else in this region, with only one sighting close to the Selous-Niassa corridor to the east of Songea. There is no information on density outside the Selous or on trends anywhere in this region.

### 4.3.5 The northwest – Ibanda; Burigi; Kagera; Buramulo

There is no information on spotted hyaenas anywhere in this region. An extensive survey of Minziro forest reserve in August-September using camera traps and structured interviews yielded no evidence of spotted hyaenas in the region, although some individuals interviewed thought that the species used to be present 70-80 years ago. Hyaenas are also thought likely to be present in Burigi and Biharamulo game reserves. There is no information on density or trends.

### 4.3.6 Other – Tabora - Dodoma - Singida- shinyanga; Northern coast – Saadani; Southern Highlands; Zanzibar; Itigi

The Tanzania Carnivore Program has received no information on spotted hyaenas in any of these areas (Fig. 4), although the action plan lists them as present in Tabora, Dodoma, Singida, Shinyanga and Itigi (Mills and Hofer 1998). They are likely to be still present in Tabora, Singida, Shinyanga as they are sometimes kept captive by villagers for local medicinal and cultural use, as well as in Itigi, and the lack of records probably reflects a lack of observer coverage. There is no information from Saadani game reserve, and there is a need to survey this area for the presence of the species. There is no information on density and trends in any of these areas.

## 4.4 How to get information on status: Available methods

There are several methods that can be used to survey large carnivores. Which method is selected for use depends on information required and the suitability of that method for a particular region (Norton-Griffiths 1978). Key methods appropriate for hyaena surveys identified in this workshop include those identified by the International Cheetah Monitoring Workshop held in Tanzania in June 2004 (Bashir et al. 2004), and include spoor counts, radio collaring, line transect surveys, tourist photos, detection dogs, questionnaires, camera trapping and visual search. Additional methods relevant to hyaena are call-in playbacks, official records of attacks, trophy hunting records, den counts and baiting. The familiar whooping call of the hyaena is inappropriate for monitoring presence, as both striped and spotted have virtually identical calls. Each technique is discussed below, together with a list of their main advantages and disadvantages.

### 4.4.1 Questionnaires

Questionnaire surveys of residents within a region can be used to collect information on all three hyaena species in two key ways. Firstly, they can be used as a simple presence/absence survey, by gathering information from residents in an area on sightings. Secondly, they can be used as an in depth survey to not only gather information on distribution, but also to assess levels of conflict with people, threats and attitudes of residents to hyaena species in their area. All data gathered through questionnaire surveys needs to be interpreted with caution, as interviewees will not necessarily respond honestly and openly to questions.

*Advantages*

- Perhaps the only feasible method for mapping distribution at a national scale
- Relatively cheap
- Relatively low manpower demands
- Can be implemented by relatively unskilled field workers.
- Can provide extra information on potential threats – such as conflict with people.

*Disadvantages*

- Provides only very coarse data – cannot detect local changes in population density.
- Provides no information on other potentially important factors such as demographics, ranging patterns and disease.
- Requires highly skilled labour when combined within a GIS framework.

*Points of information*

- Time scales and area need to be clearly defined when implementing questionnaire surveys.
- All questionnaires need careful design and analysis, but particularly those looking at conflict and threats.

### 4.4.2 Spoor counts

In this method a vehicle is driven at a slow speed along existing tracks with a dusty or sandy covering that has a good potential to show spoor or tracks for hyaena species. The vehicle should be mounted with a specially modified chair on which a skilled tracker can be seated. The tracker should record all spoor that is fresh (less than 24 hours old) seen on the track. This information is then used to generate a spoor frequency, i.e. the number of kilometres travelled per spoor detected (Stander 1998), which can then be used as an index of density. The method is thought to be problematic when used for spotted hyaena because of their unpredictable ranging patterns, and problematic for striped hyaena because of their low density, however the method may be useful for aardwolves. Trackers need to be sufficiently trained to distinguish spoor accurately between the species.

*Advantages*

- Relatively easy to implement
- Can provide presence/absence data for spotted, relative abundance providing soil substrate and habitat similar, trends and density if calibrated against a known density for all species.
- Low technology
- Relatively cheap
- Trackers are in most cases available
- Can provide information about other carnivores in the area
- Can be used in areas where animals are shy and hard to locate
- Can be used at all times of year

*Disadvantages*

- A suitable soil substrate required in order to detect spoor
- The method is untested for all of the hyaena species
- Relies on accurate identification of spoor
- Relies on a good network of roads and trails
- Time intensive
- May not work for striped hyaenas as densities are extremely low

*Point of information*

- Technique should be better for spotted hyaenas and aardwolves but probably less suitable for striped hyaenas because of their low density

### 4.4.3 Driven or walked transects

In this method transects are driven and all individual hyaenas seen are counted along the transect line. For optimum effectiveness distance based methods should be used (Buckland et al. 1993) whereby the distance of each individual or group seen from the transect line is recorded. The data can then be analysed with DISTANCE software and used to generate an estimate of overall density. The method relies on a sufficient number of hyaena groups to be seen and recorded – generally a minimum of 30 groups are needed for a reasonably accurate estimate of density. This makes it unsuitable for use in areas where hyaena species are rarely seen or are very shy. In Tanzania its use is probably largely limited to open areas such as the Serengeti plains.

*Advantages*

- Relatively easy to implement
- Relatively cheap
- Can provide other useful data such as densities of other carnivores in the area

*Disadvantages*

- Will not work in areas where animals are very shy
- Will only work in open areas – cannot be used in bushy areas where animals are difficult to see.

### 4.4.4 Detection dogs

In this method highly trained domestic dogs are used to find hyaena scat, in much the same way as dogs are used by the police to find narcotics or by the army to find mines. Scat can either be counted as in spoor counts (see above) to give a density estimate, or DNA can be extracted and typed to provide a unique genotype that can then be used in a mark-recapture analysis framework to provide a more accurate estimate of density. The method has been used successfully in the US to estimate population densities of several carnivore species, including kit foxes and grizzly bears (Smith et al. 2001; Smith et al. 2003; Wasser et al. 2004), however, aside from a training program conducted by the Serengeti Cheetah Project in Laikipia in July 2004, the method is largely untested in Africa. The training program demonstrated that it is possible to train Kenyan dogs to locate and distinguish wild dog and cheetah scat from other scat such as that from jackals, and it is unlikely that scat from any of the hyaena species would present a problem.

*Advantages*

- Potentially useful outside protected areas
- Can provide genetic samples for individual identification and hence accurate monitoring
- Genetic samples can provide extra information – such as population structure
- Scat samples can provide extra information on diet
- Relatively cheap to implement (except when using DNA analysis).

*Disadvantages*

- Method untested in Africa
- Requires training of both dogs and handlers
- DNA analyses currently expensive and labour intensive
- Would require a change in permit regulations to be used inside protected areas

- Requires good veterinary care

*Requirements*

- Requires good safety protocols and pre planning
- Dogs require frequent breaks when working
- Dog needs to be bonded with handler

### 4.4.5 Camera traps

For this method cameras are positioned along animal trails which show active use, and linked to a beam that detects any changes in infrared in front of the camera, such as that which occurs when an animal moves along the trail. Whenever such a change is detected the camera takes a photograph, hence the expression 'camera trap', and in so doing produces photographic evidence of the carnivore community in an area. Photographs of all three species of hyaena can be used for individual recognition as each individual has unique markings, in the form of spots for spotted hyaena and stripes for aardwolf and striped hyaena. Once they are put in place, the cameras are generally left undisturbed for a minimum of two months, except for battery checks and changing film. Individual animals are recognized from their photographs and a library established of individuals within an area. Mark recapture analysis is then used to estimate population size. The technique has been very effective for surveying tigers and jaguars (Karanth and Nichols 1998; Silver et al. 2004). The method works best in forest and for species with relatively small home ranges.

*Advantages*

- Useful in forested and bushy areas where visibility is poor and most of the other methods difficult to implement
- Can provide accurate density estimates when using individual recognition.
- Can provide useful other additional information such as the carnivore and prey community in an area

*Disadvantages*

- Method has never been shown to work well for hyaenas
- Set up equipment is costly and can only be used in relatively secure areas, otherwise likely to be stolen.
- Works best for species with relatively small home ranges – probably would not work for striped hyaena.

### 4.4.6 Tourist photos

This method relies on encouraging visitors to an area with hyaenas to send in photographs that they take of any individual animals that they see. The photographs can then be used to identify individuals in the population and build up a profile of population size and structure. Such a scheme has been shown to have potential for monitoring cheetah in highly visited areas such as the Serengeti plains (Shemkunde 2004) and for uncovering the history of the Ngorongoro Crater lion population (Packer and Pusey 1987). The Tanzania Carnivore Project has a successful scheme in place for cheetah – the Cheetah Watch Campaign, which is receiving photos in increasing numbers. The method was originally initiated at the end of 2000 in the Serengeti region and has generated data sufficient for monitoring. The method, because it takes advantage of tourists visiting Tanzania, can potentially cover large areas of Tanzania, and hence can be useful for tracking individual animals across long distances, and hence for establishing the location of dispersal corridors.

*Advantages*

- Good for areas well visited by tourists
- Relatively easy to implement, provided an infrastructure exists.
- Has potential to provide good information on population size and demography.

*Disadvantages*

- Not suitable for areas seldom visited by tourists

- Depends on promotion by tourism industry to be successful
- Requires active promotion e.g. production of promotional materials such as leaflets
- Can be time consuming to implement and requires reasonably well trained manpower.
- Striped hyaenas and aardwolves are rarely seen whilst spotted hyaenas are rarely photographed and hence photographic returns are likely to be low.
- Works less well in areas with low domestic tourism

*Point of information*

- The method would probably only generate information on presence/absence – as photographic returns are likely to be too low for other measures

### 4.4.7 Visual search

This method relies on an observer locating individual hyaenas from a vehicle without using aids such as radio collars but by relying entirely on visual cues such as via binoculars or spoor. Since spotted and striped hyaenas range widely, and all species are largely nocturnal, relying on visual search may be problematic for generating sufficient information for monitoring. However visual search has particular value when species are social, and focus around a denning area, such as is the case with the spotted hyaena. In such a situation dens can be located and observed over a long period, and individuals returning to the den individually identified using distinctive markings unique to each individual. If a sufficient number of adjacent dens are monitored in this way, or the information is supported by additional information on ranging patterns, such as can be obtained by radio tracking, then it may be possible to estimate density. Visual search will have less value in solitary species, as dens will be harder to find, making it difficult to be sure of locating all dens within a particular area.

*Advantages*

- Can provide good information on the population - particularly given that hyaenas live in dens which are relatively easy to locate

*Disadvantages*

- Requires highly skilled personnel able to locate and follow hyaenas
- Requires locating dens, which is easier for spotted hyaenas than for aardwolves and striped hyaenas.
- Unlikely to work in areas where animals are shy

### 4.4.8 Radio collaring

With this method VHF, GPS, mobile phone or satellite collars are fitted to an individual hyaena to enable relocation or the recording of the animal's position. Most such collars allow subsequent relocation of the collared individual, due to a signal transmitted from the collar, either to a VHF receiver, via a mobile phone receiver or via a satellite. Some GPS collars do not transmit a constant signal, but store GPS reference points visited by the animal, at a set rate (once, twice or several times a day) and transmit a signal only when they drop off after a set time, to allow them to be located and the data retrieved and downloaded to a computer. In order to fit the collar the hyaena has to be immobilised, usually by darting. Once a collar is fitted, the method allows the collection of accurate data on ranging patterns that are not biased by habitat visibility, unlike methods relying on visual relocation. However VHF collars depend on frequent relocation, which may often need to be done from the air for wide ranging species such as spotted and striped hyaena. Where a species is territorial, such as aardwolf (but not striped or spotted hyaena), then information from radio collared individuals can also yield information on density, which can be calculated from estimates of territory size and degree of overlap between adjacent territories (e.g. Siedenstecker et al. 1999).

Hyaenas and aardwolves are often shy and hence are difficult to dart, this may introduce biases in which individuals are radio collared. Alternative capture techniques such as those using leg hold traps have been used to capture striped hyaenas, but such techniques need careful implementation and supervision. Other options such as using call-in playbacks can be used to facilitate darting attempts of shy animals, and have been shown to be effective for lions and leopards since they will lure resident leopards/lions to the speaker (Whitman, pers. comm.). Radio collaring can also yield valuable additional data on the behaviour of individual hyaenas if it is backed up by detailed study on the ground.

Radio collaring has already been used to generate important information on spotted hyaenas in a number of areas and across a range of habitats, including the Serengeti National Park (Hofer and East 1993a;1993b; 1993c), Maasai Mara Game Reserve (Boydston et al. 2005), the Kalahari in South Africa (Mills 1990) and Etosha National Park (Trinkel et al. 2004). However numbers in many studies are very small.

*Advantages*

- Can provide a wide range of relevant data, not only on population size, but also on disease monitoring, ranging patterns, identification of threats to the population and demographic information including birth and survival rates.
- Relatively low manpower demands
- Density estimation is accurate for territorial species without overlapping home ranges as density can be calculated via estimates of territory size – hence could be used to estimate density for aardwolves and striped hyaenas but not spotted hyaena.
- Gives good information on movements including habitat use, avoidance/attraction to people/livestock etc, when combined with GIS databases describing habitat and human use variables.

*Disadvantages – only if using satellite and GPS collars*

- Makes use of relatively complicated technology – and hence implementation requires some training.
- Relatively expensive
- Satellite and GPS collars are expensive
- Some satellite/GPS collars may require substantial support from manufacturers including further costs for data downloads
- Requires a well-trained veterinarian to minimize any potential risks of immobilisation
- Not popular with tourists unless accompanied by good PR

*Recommendations*

- In well known study populations where a specific individual's history is known, this should be taken into account when immobilising
- Collar should be as light and inconspicuous as possible

### 4.4.9 Call in playbacks

In this method a sound of a kill – an animal dying or hyaenas at a kill - is played at a loud volume, usually between 110-120DB, for a standardised time, usually one hour, and the numbers of individuals attracted to the sound are counted and, where possible, individually identified (Ogutu and Dublin 1998). As spotted and striped hyaenas often scavenge kills they can be attracted by such sounds.

*Advantages*

- Relatively easy to implement
- Relatively cheap
- Provides data on presence

*Disadvantages*

- Open to interpretation and bias.
- Does not provide much other useful information.
- Only appropriate for spotted hyaenas
- Depends on hunger level and prey availability and time of day
- There is a problem with habituation after repeated surveys

### 4.4.10 Records of attack

Records are kept by Wildlife Division (WD) in Dar and at district level on any reports of attacks on people and livestock. The main problem with these records is that reporting is seldom consistent between and within regions, especially for livestock attacks.

*Advantages*

- Indicate presence
- Indicate conflict hotspots
- Centralised record keeping
- Data are available at WD and district offices

*Disadvantages*

- Records of livestock attacks are under reported and inconsistent
- There are cultural variations in reporting (e.g. Maasai under report attacks)
- Absence of reports does not necessarily imply absence of conflict hotspot
- Unlikely to work for aardwolves

### 4.4.11 Baiting

This technique uses bait to attract hyaenas to an area for research and information - not for hunting. A well designed baiting survey in an area where animals are attracted to bait can yield information on numbers and density if combined with individual recognition of the animals coming to bait and a total count. It can also yield information on presence when not used in a rigorous design or without individual recognition.

*Advantages*

- Establishes presence.
- Repeated baiting in an area over several sites can provide information on trends and allow monitoring of individuals.
- May attract other carnivores which can provide useful information about predator community.

*Disadvantages*

- Labour intensive.
- Cost of providing bait.
- Most appropriate for spotted and striped hyaenas – not effective for aardwolves.
- There are potential consequences of conflict for local people if not planned carefully.
- Could be ineffective in many areas, particularly those with a history of poisoning.

### 4.4.12 Den counts

In this technique den sites are recorded in an area. All three species of hyaena make use of underground dens, which can often be located more easily than the individual animals, particularly for the communally living spotted hyaena.

*Advantages*

- Can provide information on presence and absence.

*Disadvantages*

- Difficulty in distinguishing dens of different species and between sleeping burrows and active communal dens.
- Requires training and repeated visits to establish whether a den is in active use.
- Striped hyaenas don't always use underground dens.

## 4.5 Status Summary

The group agreed that there was a need for more information on the status of all three species of hyaena across the country. Different regions are likely to have different specific needs, depending, in part, on what information already exists. Overall, status information needs can be broken into different levels depending on the quality of the data required: distribution, population trends, density, demographic parameters such as survival and reproduction and ranging patterns. Different areas are likely to require data of different quality depending on what data already exists and the likely threats. The methods available to gather relevant data on status are listed above and are summarised in Table 1 according to the types of information they can potentially provide on the status of aardwolves, striped hyaena and spotted hyaena. Not all methods will work in all areas, for example photo surveys can only work in an area which is regularly visited by tourists and spoor surveys in areas with sufficient tracks and suitable substrate.

No single technique generates good information under all categories. Potentially worthwhile techniques able to generate the full data requirements for aardwolves include visual search and radio collaring (Table 1a), however other methods showing potential included night transect counts, tourist photo surveys - although this is unlikely to be applicable in most areas because of a lack of visitors - and detection dogs, which shows much potential but is currently untested in Africa. Camera trapping is largely untested, although a recent survey in the centre of Tarangire National Park shows some potential in the method for monitoring aardwolves (Msuha pers. comm.). To be effective the method requires modifications in survey design to ensure camera spacing is appropriate for the species. Managers and policy makers do not always require detailed data, and often relatively coarse data, but across a wider area is more appropriate to their needs. In these situations, questionnaire data, and counts of indirect sign such as spoor and dens are particularly useful, as such data can be relatively easily collected across a large area. The group did not discuss the monitoring of *Trinervitermes* termites as an indication of aardwolf density, but such a method might generate potentially useful information, although it should be noted that these species generally do not produce conspicuous mounds.

The other two species of hyaena had a wider range of methods available for monitoring, however fewer methods were appropriate in generating all categories of information on species status. In the case of striped hyaena no method was able to generate all categories of information, and only radio collaring was able to provide information on ranging patterns and demography, although visual search, making use of known den sites, was thought to have potential in providing some information on demography, particularly if combined with baiting (Table 1b). Of the other methods, the group felt that only detection dogs showed any promise for gathering any other category of information apart from distribution. It is difficult to assess the data that could be accumulated from scat using detection dogs, as the method has not been used on this species, and its effectiveness depends on how easy it is for the dogs to locate scat. Trials with other species such as grizzly bears and tigers suggest that it has potential for providing very valuable information, and because it relies on secondary sign, is likely to involve minimal disturbance. If scat is relatively easy to locate, this technique, when used within a well designed survey, could provide information on all categories of information, even demography through a mark-recapture analysis of individually identifiable scat.

For information on distribution, questionnaire data, den counts, tourist photos, camera trapping and baiting were all judged to be capable of providing relevant information, in addition to from the more generally applicable methods mentioned above. Unfortunately, although hyaenas are hunted, hunting records currently do not differentiate between spotted and striped hyaena and so this source of information is useless for this purpose, unless the species are required to be differentiated in future records. Given that the striped hyaena is much less widespread and occurs at lower density than the spotted, there are many good reasons from a management perspective in differentiating between the species in hunting records. Spoor was thought to be less useful for a low density species such as the striped hyaena, as a vast number of kilometres would need to be surveyed in order to locate spoor. For cheetah, a species which occurs at similar densities, one spoor was found per 100km (Bashir et al. 2004). There are also difficulties in differentiating between striped and spotted hyaena spoor – although training would help surmount this problem.

## a) Aardwolf

| | Distribution | Relative Abundance | Trends | Density | Ranging | Demography |
|---|---|---|---|---|---|---|
| Questionnaire | Y | N | N | N | N | N |
| Den counts | Y | N | N | N | N | N |
| Spoor - where substrate suitable | Y | untested | untested | N | N | N |
| Transect counts | Y | Y (night only) | Y (night only) | Y (night only) | N | N |
| Tourist photos (only where sufficient tourists) | Y | N | N | N | N | N |
| Working dogs[1] | Y | Y | Y | Y | Possible | N |
| Camera Traps | Y | untested | untested | untested | untested - coarse data only | N |
| Visual search[2] | Y | Y | Y | Y | Y | Y |
| Radio Collars | Y | Y | Y | Y | Y | Y (with ground verification) |

## b) Striped hyaena

| | Distribution | Relative Abundance | Trends | Density | Ranging | Demography |
|---|---|---|---|---|---|---|
| Questionnaire | Y | N | N | N | N | N |
| Records of attacks | N | N | N | N | N | N |
| Hunting records | Possible[3] | N | N | N | N | N |
| Den counts | Y | N | N | N | N | N |
| Spoor - where substrate suitable | Possible | N | N | N | N | N |
| Baiting - where animals respond to bait | Y | N | N | N | N | N |
| Transect counts | Unlikely | N | N | N | N | N |
| Call-in playbacks | N | N | N | N | N | N |
| Tourist photos (only where sufficient tourists) | Y | N | N | N | N | N |
| Working dogs[1] | Y | Possible | Unlikely | Y | N | N |
| Camera Traps | Y | N | N | N | N | N |
| Visual search[2] | Y | Possible - in combination with bait | Possible | Possible | N | Possible |
| Radio Collars | Y | N | N | N | Y | Y (with ground verification) |

## c) Spotted hyaena

| | Distribution | Relative Abundance | Trends | Density | Ranging | Demography |
|---|---|---|---|---|---|---|
| Questionnaire | Y | Qualitative data only - from wildlife professionals | Qualitative data only | N | N | N |
| Records of attacks | Y | N | N | N | N | N |
| Hunting records | Y | N | N | N | N | N |
| Den counts | Y | N | N | N | N | N |
| Spoor - where substrate suitable | Y | untested | untested | N | N | N |
| Baiting - where animals respond to bait | Y | N | N | N | N | N |
| Transect counts | Y | Y (if behaviour same in both areas) | Y | Y | N | N |
| Call-in playbacks | Y | uncalibrated | Y (provided no habituation) | uncalibrated | N | N |
| Tourist photos (only where sufficient tourists) | Y | N | N | N | N | N |
| Working dogs[1] | Y | Y | Y | Y | N | Possible in multi-year survey |
| Camera Traps | Y | N | N | N | N | N |
| Visual search[2] | Y | Y | Y | Y | Y | Y |
| Radio Collars | Y | N | N | N | Y | Y (with ground verification) |

[1] method so far untested for these species
[2] relies on habituated individuals and individual recognition
[3] hunting records to date do not differentiate between striped and spotted hyaena, if hunting records are to be useful for monitoring they will only be effective if species differentiation is enforced in record keeping. There are many other good reasons for doing this as well.

**Table 1. Data generated by the different methods covered in the sections above for a) Aardwolf; b) Striped hyaena and c) Spotted hyaena. In each table 'Y' indicates that the method could generate appropriate data; 'N' the method could not generate appropriate data; 'coarse' the method might generate some appropriate data, but it will be crude and open to interpretation; 'possible' indicates that whilst the method could theoretically generate the appropriate data, it is unlikely that sufficient data would be collected to fulfil the objectives and 'untested' that the method has never been shown to generate appropriate data for this species – generally the group used this term when they felt the method would be unlikely to be useful; 'uncalibrated' means the method has never been shown to calibrate to the information category.**

The spotted hyaena is easier to monitor than the striped by virtue of its higher density, however monitoring is complicated by the commuting system the species employs in migratory ecosystems such as the Serengeti. The species' habit of using communal dens means that visual search can be a productive means of monitoring, generating useful information on most categories of status (Table 1c). However information on ranging patterns relies on following individuals when they leave the den site, and this is likely to be problematic for a wide ranging nocturnal species. The use of radio collars fitted to individuals at observed dens is more likely to enable unbiased and high quality information to be collected on ranging patterns. Radio collaring, combined with ground follow up was the only other method deemed to generate suitable information on demography. However, scat found by detection dogs used in a multi year survey was thought to be more likely to generate useful demographic information for this species than for striped hyaena, due to higher densities and hence higher likelihood of finding scat.

Transect counts, detection dogs and visual search are the only methods thought to be capable of providing estimates of density. Transect counts and visual search have both been shown to be effective on the Serengeti plains (Durant et al. under review, Hofer and East 1995), whilst the use of detection dogs and the use of transect counts in more bushy habitats than the open plains are both as yet untested. Camera traps have some potential for estimating density, and a recent survey in Arusha National Park demonstrated a number of spotted hyaenas in the survey area, however single individuals were caught in camera traps very far apart, making it difficult to interpret results, and the group felt that this made the method inappropriate for monitoring trends and relative abundance as well as absolute density. Call-in playbacks were thought to be potentially useful in monitoring trends in an area, provided individuals did not get habituated to the sounds – when they would be less likely to respond – but, as with the previous workshop on lions, the group felt there were problems in interpreting call-in data and the method needed to be calibrated to known densities to be effective. Methods useful for assessing distribution include spoor, questionnaire data, hunting records – assuming that the proportion of striped hyaena in these records is low, records of attacks on livestock and people, den surveys and baiting. Tourist photographs were thought to be less likely to be useful as tourists do not frequently photograph hyaenas and hence soliciting photographs is likely to be problematic for this species.

## 5. CONSERVATION THREATS

In this session the group examined potential threats to hyaena conservation in Tanzania. The group identified the threats for each species and discussed the evidence for each threat and its significance to populations. Aardwolves, due to their dependence on termites, were subject to a different set of threats to the other two species, spotted and striped hyaena. The latter two species were subject to an identical list of threats, although their relative importance differed between them.

### 5.1 Aardwolf

The threats to aardwolves fell into 4 main categories: toxins; land use/cover change; anthropogenic killing; and disease. Of these, toxins was thought to have by far the major potential impact.

Toxins

- Insecticide spray

Land use/cover change

- Change in termite population and distribution
- Habitat conversion
- Resource extraction
- Fragmentation

- New roads

Anthropogenic Killing

- Mistaken for hyaena (striped)
- Road kills
- Medicinal use – although none currently known

Disease

- Possible but not presently known to be a threat to populations

Each is discussed in detail below.

### 5.1.1 Toxins

Because of the aardwolves reliance upon insects – termites – it is particularly vulnerable to the impacts of spraying for insect pest control. Aardwolves may consume termites sprayed by such insecticide, and absorb lethal or sublethal doses of toxin. Each spraying event puts the aardwolves within a region at greater risk. Widespread spraying, such as in locust control, probably poses the greatest risk, particularly if such events are frequent. After one widespread spraying incident in the North Cape in South Africa the local aardwolf population took 4 years to recover (Mills and Hofer 1998).

### 5.1.2 Land use/cover change

Aardwolves are specialist carnivores, and depend on a sufficient density of *Trinervitermes* termites for their survival. Any changes that affect these densities and distribution will have an impact on aardwolf populations. Agriculture often destroys termite colonies, but habitat change instigated due to changes in fire regimes or grazing pressure may also have impacts. At present how these human induced changes affect termite distribution and density is little understood.

### 5.1.3 Anthropogenic killing

Aardwolves are not dangerous to people, neither do they have any impact on livestock and poultry; hence they are unlikely to be subject to targeted killing. Most anthropogenic killing is a result of confusion with striped hyaena. They are killed on the roads, and there are several such recorded deaths in Tanzania, including one on the road to Serengeti close to Mto wa Mbu (Hoare pers. comm.), but there is no information about the impact such deaths have on populations. Road kills are most likely to happen when vehicles are driven at speed, which is most likely to happen on tarmac roads. Given the limited extent of tarmac roads in Tanzania, it is unlikely road kills currently have a major impact on aardwolf populations. Medicinal or cultural use was suggested as a possible threat, however there is very little information on whether aardwolves are used at all for this purpose. The issue deserves further investigation.

### 5.1.4 Disease

Disease has never been shown to impact aardwolf populations, however there is virtually no information on disease in aardwolves. Rabies has been recorded in the species in Southern Africa (Swanepoel et al. 1993). Establishment of the full suite of diseases and parasites likely to affect aardwolves and their impact on populations deserves further investigation.

## 5.2 Striped hyaena

The threats to striped hyaena fell into 6 main categories: prey availability; land use/cover change; anthropogenic killing; poisoning; disease; and management issues. Of these, land use/cover change and anthropogenic killing were thought to have the major impacts in Tanzania. Some threats in other parts of the species range, such as hunting and trapping for fur, were not mentioned as important in Tanzania.

Prey availability
Land use/cover change
- Habitat conversion
- Resource extraction
- Fragmentation
- New roads

Anthropogenic killing
- Local trade – captive and medicinal
- Possible international trade (live)
- Road kills
- Snaring

Poisoning
- Preventative or retaliatory poisoning
- Arachnicides (feeding off of recently dipped livestock)
- Pesticides/herbicides

Disease
- Possible but not presently known to be a threat to populations

Management issues
Each is discussed in detail below.

### 5.2.1 Prey availability

As striped hyaenas rely on carcasses, they depend on the availability of carcasses within a landscape for their survival. Livestock for this purpose may be just as useful as wild prey, providing a reliable source of scavenged meat is maintained in the ecosystem.

### 5.2.2 Land use/cover change

Striped hyaena live at extremely low densities and have large home ranges, making them particularly vulnerable to land use change, especially when it leads to habitat fragmentation and the loss of large areas of connected habitat needed to support viable populations. As habitat is lost to agriculture then it becomes unusable by striped hyaenas: eventually this process risks leaving isolated small populations of hyaenas in habitat islands. Recorded densities of striped hyaenas lie between 0.01-0.02/$km^2$ and hence even an area of 10,000$km^2$ can harbour no more than 200 individuals, making striped hyaenas particularly vulnerable to this threat.

### 5.2.3 Anthropogenic killing

Striped hyaenas are potentially vulnerable to a variety of sources of anthropogenic killing, although there is no hard evidence for this having an impact on populations. Live spotted hyaenas are kept by traditional leaders, and hence it is possible that striped hyaenas might be kept for similar purposes, however there is no evidence that this happens. There is also a suspicion of a live trade in spotted hyaenas, but there is no evidence of an international trade in striped hyaenas. There is some evidence that striped hyaenas are vulnerable to being killed on the roads outside Tanzania (Mills and Hofer 1998), and there are recorded deaths of striped hyaenas on the roads in Tanzania, including one on the road between Makyuni and Arusha (Hoare pers. comm.). Striped hyaenas are thought to suffer a particularly high mortality on roads as they are often attracted to carcasses of other animals killed on the road. The low mileage of tarred road in Tanzania reduces the risk of road kills, but given the low density of this species, any deaths on the road provide cause for concern. The other source of anthropogenic killing, snaring, may also have an impact as spotted hyaena are known to be greatly affected by non-targeted trapping in snares. However at present, there is no evidence that striped hyaenas are caught in snares and hence no information about whether this threat affects populations. Given that the species occurs mainly in Maasai pastoralist areas, and Maasai seldom use snares to trap wildlife then, even if striped hyaena are occasionally caught in snares, snares are thought to be unlikely to impact the species in Tanzania.

### 5.2.4 Poisoning

Deliberate poisoning is named as a major risk to striped hyaenas in the last IUCN hyaena action plan (Mills and Hofer 1998). The species is very susceptible to the threat as it readily takes poisoned bait, even though in many cases it is not the target which is often another carnivore such as leopard or wolves. The striped hyaena was exterminated along the Mediterranean coast in Israel through strychnine poisoning during a rabies eradication campaign between 1918-1948 (Mills and Hofer 1998) and today striped hyaenas in Niger are threatened by large scale strychnine poisoning (Mills and Hofer 1998). There is no evidence that striped hyaenas are targeted by poisoning in Tanzania, however poisoning is known to occur in many areas, targeting other large carnivores often in response to livestock attacks, and given the species is likely to be attracted to carcasses it is extremely vulnerable to this threat. Further investigation is needed to assess how the species is impacted by poisoning. Other forms of poisoning include non deliberate poisoning due to livestock being treated with arachnicides and subsequently dying and being consumed by a striped hyaena, or from pesticides and herbicides in the environment. It is not known whether these forms of poisoning have an impact on striped hyaenas.

### 5.2.5 Disease

Disease has never been shown to impact striped hyaena populations, however there is virtually no information on disease in striped hyaenas. The issue deserves further investigation.

### 5.2.6 Management issues

Whilst strictly not a threat, as with striped hyaenas, the group were concerned that insufficient resources for anti-poaching is likely to affect snaring activity, and an increase in resources would help reduce this threat. The group also felt that it was important that management and policy makers consider the entire predator guild when making any population management decisions, as managing any of the predators will impact hyaena species.

## 5.3 Spotted hyaenas

The threats to spotted hyaenas are the same as those for striped hyaena, falling into 6 main categories: prey availability; land use/cover change; anthropogenic killing; poisoning; disease; and management issues. Of these, anthropogenic killing and poisoning were thought to have the major impacts in Tanzania.

Prey availability
Land use/cover change

- Habitat conversion
- Resource extraction
- Fragmentation
- New roads

Anthropogenic killing

- Local trade – captive and medicinal
- Possible international trade (live)
- Road kills
- Snaring

Poisoning

- Preventative or retaliatory poisoning
- Arachnicides (feeding off of recently dipped livestock)

- Pesticides/herbicides

Disease

- Possible but not presently known to be a threat to populations

Management issues

Each is discussed in detail below.

### 5.3.1 Prey availability

Spotted hyaenas depend on sufficient prey in an area for survival, either through direct predation or through a supply of carcasses. A lack of sufficient prey is unlikely to occur inside protected areas, and so decreases in prey availability predominantly affects hyaenas outside protected areas. As with striped hyaenas, scavengable meat may be sufficient to maintain spotted hyaenas in the ecosystem, and hence a reliable source of livestock carcasses may be sufficient.

### 5.3.2 Land use/cover change

Whilst spotted hyaenas live at much higher densities than striped hyaena, with recorded densities as high as 1.7km$^2$ in Ngorongoro Crater, they depend on protected areas for their survival because they are currently persecuted outside these areas. Therefore they are also affected by land use change, and are most secure in larger reserves where they can maintain viable populations.

### 5.3.3 Anthropogenic killing

Spotted hyaenas are vulnerable to a variety of sources of anthropogenic killing, some of which have been shown to impact populations. Live spotted hyaenas are kept by traditional leaders for cultural reasons, and there is evidence that there is an international trade. Two spotted hyaenas found in European zoos bought from animal dealers in the Middle East were found to have a mt-DNA haplotype similar to that of spotted hyaenas in the Ruaha region (East pers. comm.). There is also evidence that spotted hyaenas are killed on the roads in Tanzania both inside and outside protected areas (Hoare pers. comm., East this report). Like striped hyaenas, spotted hyaenas may be particularly vulnerable to mortality on roads as they can be attracted to carcasses of other animals killed on the road. Currently the low mileage of tarred road in Tanzania reduces the risk of road kills, but the risk is likely to increase as the tarred road network expands across the country.

The remaining source of anthropogenic killing, snaring, is known to have an impact on hyaenas in the Serengeti, as they are attracted to snare lines by carcasses and the calls of trapped prey. Whilst generally they can free themselves when trapped by biting through the wire snare line holding them, the snare digs into the neck and often tightens over time, leading to infection, weakness and ultimately reducing the life time of individuals. Snaring is thought to be responsible for more than 50% of adult spotted hyaena deaths in the Serengeti, reducing the annual rate of population increase by as much as 7% (Hofer and East 1995; Hofer et al. 1993). There is no evidence whether snaring has an impact on populations outside the Serengeti, but given the evidence from this ecosystem, any areas where there is a cultural propensity to use wire snares should give cause for concern.

### 5.3.4 Poisoning

Deliberate poisoning is likely to be a major risk to spotted hyaenas as the species readily takes poisoned bait. There is some evidence that spotted hyaenas are targeted by poisoning in Tanzania, and poisoning is known to occur in many areas, targeting large carnivores either in response to livestock attacks, or in order to prevent future livestock attacks. Further investigation is needed to assess how this threat affects populations. Other forms of poisoning include non deliberate poisoning due to livestock being treated with arachnicides and subsequently dying and being consumed by a spotted hyaena, or from pesticides and herbicides in the environment. It is not known whether these forms of poisoning have an impact at the population level. In general, perceptions of the frequency of livestock attacks are likely to be higher than the actual frequency. However the People and Predators project cited evidence from verified livestock attacks to suggest that hyaenas do pose a real threat to livestock. Lichtenfeld (2005) documented 21 livestock losses (9 goats, 7 cows, 4 sheep and 1 donkey) due to hyaenas in one village over little more than a year. Often, more than one animal was killed during each depredation event – in 6 cases, two animals were lost, and in one, 10 animals were lost. Most depredations occurred in the bush when animals wandered off and were lost, rather than at the boma.

### 5.3.5 Disease

Spotted hyaenas in Tanzania are exposed to a large number of pathogens, including rabies, canine herpes, canine brucella, canine adenovirus, canine parvovirus, feline calysi virus, coronavirus, leptospirosis, canine distemper, streptococcus, anaplasmosis and trypanosomes (Hofer and East 1995; East et al. 2004; Höner et al. 2006; Harrison et al. 2004, Lembo et al. 2006). A genetic investigation of rabies variants in wild carnivores in the Serengeti National Park demonstrated that the large Serengeti population of spotted hyaenas is infected with a genetic variant of rabies that has been reported to not cause clinical disease in the species or decrease survival in infected hyaenas (East et al. 2001). A genetically distinct rabies variant does cause clinical disease in other Serengeti carnivore species (East et al. 2001), and rabies (of unknown genetic strain) have caused clinical disease in other spotted hyaena populations (Mills 1990, Alexander et al. 1993). However, generally cases of rabies in spotted hyaenas are rarely reported from inside large National Parks in southern and Eastern Africa, despite the presence of rabies in domestic dog populations that surround such National Parks (Röttcher and Sawchuk 1978).

Between 2003 and 2005 a rabies epidemic in domestic dogs occurred in the rural areas bordering the Serengeti National Park and this epidemic also spread to domestic dogs on the rim of the Ngorongoro crater. "Spillover" infection of the genetic variant of rabies known to be maintained in the domestic dogs in Tanzania resulted in three clinical cases of rabies in spotted hyaenas in the rural area outside the Serengeti ecosystem, including one case near the village of Miseke in Serengeti District and two cases on the rim of the Ngorongoro crater (TAWIRI Annual Veterinary Report 2005, Lembo et al. 2007). Despite the rabies epidemic in domestic dogs there was no evidence of rabies "spillover" into the spotted hyena population inside the Serengeti National Park or to the spotted hyaena population on the floor of the Ngorongoro crater (East 1995, TAWIRI Annual Veterinary Report 2005). Spotted hyaenas are likely to have been responsible for several human rabies exposures, particularly within Ngorongoro district (Cleaveland pers. comm.).

A previously unknown genetic variant of coronavirus has recently been described from spotted hyaenas in the Serengeti ecosystem (East et al. 2004). Individuals infected with this viral type of coronavirus do not display severe clinical signs. Streptococcus infection can cause severe clinical disease and death of spotted hyaenas, as demonstrated during an outbreak of Streptococcus infection in the spotted hyaena population in the Ngorongoro crater between September 2002 and February 2003. As the same genetic form of the bacterium was found in zebra, transmission of infection between these two species is possible (Höner et al. 2006).

During the 1993-4 canine distemper epidemic in Serengeti, severe clinical symptoms and many cases of mortality were observed in spotted hyaena cubs (Haas et al. 1996) with only a few cases of mortality reported in adult hyaenas (Roelke-Parker et al. 1996). In other ecosystems in southern Africa rabies epizootics may play an important role in the population dynamics of spotted hyaena (Mills 1990). The issue deserves further investigation in Tanzania.

### 5.3.6 Management issues

Whilst strictly not a threat, as with striped hyaenas, the group were concerned that insufficient resources for anti-poaching is likely to affect any snaring activity, and an increase in resources would help reduce this threat. The group also felt that it was important that management and policy makers consider the entire predator guild when making any population management decisions, as managing any of the predators will impact hyaenas.

### 5.4 Information gathering for threats

The group agreed that some of the listed threats had potential to have strong negative impacts on hyaena populations and hence affect their conservation in Tanzania. However for most of the potential threats there is very little quantitative information on impacts at the population level, neither is there good information on the relative importance of the threats for each species across different regions in Tanzania. The techniques discussed in section 4.4 for gathering information on distribution and status are potentially also useful for collecting information about threats (Table 2), and hence the choice of a particular technique might depend on what other information the technique might additionally provide. For example a questionnaire survey could potentially provide information on anthropogenic killing, poisoning and land use change, whilst spoor surveys, detection dogs and camera traps could provide information on the other predators and prey in the ecosystem. Radio tracking, because it involves handling when fitting the collar, has the potential to provide good information on many diseases if a blood sample is collected, as detection of antibodies can be used to indicate past exposure to disease, although not necessarily active disease. In addition, because radio tracking makes monitoring individuals easier, causes of death can also sometimes be determined, allowing assessment of relative impacts of factors such as disease, anthropogenic killing, snaring and road kills. Finally, although radio tracking itself is not appropriate for assessing the direct consequences of land use change, it can provide information about how this threat affects ranging patterns and identify connected habitat, and hence be used as a tool to inform managers and policy makers about the management of land adjacent to protected areas. This is particularly important for a low density, wide ranging species such as the striped hyaenas.

**a) Aardwolf**

| | Questionnaire | Den counts | Spoor | Transect counts | Tourist photos[1] | Detection dogs | Camera Traps | Visual search | Radio Collars |
|---|---|---|---|---|---|---|---|---|---|
| **Toxins - insecticide spray** | Y | N | N | N | N | Y | N | Y | Y |
| **Change in termite distribution** | N | N | Y (if recorded) | Y (if recorded) | N | N | N | Y (if recorded) | N |
| **Land use/cover change** | | | | | | | | | |
| Habitat conversion | Y | Y (if recorded) | Y (if recorded) | Y (if recorded) | N | N | N | Y (if recorded) | N |
| Resource extraction | Y | Y (if recorded) | Y (if recorded) | Y (if recorded) | N | N | N | Y (if recorded) | N |
| Fragmentation | N | N | N | N | N | N | N | N | N |
| New roads | Y | Y (if recorded) | Y (if recorded) | Y (if recorded) | N | N | N | Y (if recorded) | N |
| **Anthropogenic Killing** | | | | | | | | | |
| Mistaken for striped or spotted hyaena | N | N | N | N | N | N | N | N | N |
| Local medical trade? | Y | N | N | N | N | N | N | N | N |
| Snaring | Y | N | N | Y | Y | N | Y | Y | Y |
| Road kill | Y | N | N | Y | Y | N | N | Y | Y |
| **Disease** | Y | N | N | Y (if visible) | Y (if visible) | Y | Y (if visible) | Y (if visible) | Y |

**b) Striped hyaena**

| | Questionnaire | Den counts | Spoor | Transect counts | Tourist photos[1] | Detection dogs | Camera Traps | Visual search | Radio Collars | Records of attacks | Hunting records | Baiting |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Prey availability (scavengers)** | | | | | | | | | | | | |
| Overall loss | N | N | N | Y (if recorded)[2] | N | Y | N | Y (if recorded) | Y (from ground) | N | N | N |
| **Land use/cover change** | | | | | | | | | | | | |
| Habitat conversion | Y | N | Y (if recorded) | Y (if recorded) | N | N | N | Y (if recorded) | N | N | N | N |
| Resource extraction | Y | N | Y (if recorded) | Y (if recorded) | N | N | N | Y (if recorded) | N | N | N | N |
| Fragmentation | N | N | N | N | N | N | N | N | N | N | N | N |
| New roads | Y | N | N | N | N | N | N | Y (if recorded) | N | N | N | N |
| **Anthropogenic Killing** | | | | | | | | | | | | |
| Local captive use? | Unlikely | N | N | N | N | N | N | N | N | N | N | N |
| Local medical trade | Y | N | N | N | N | N | N | N | N | N | N | N |
| Possible international illegal trade (live) | Unlikely | N | N | N | N | N | N | N | N | N | N | N |
| Snaring | Possibly | N | N | Unlikely | Y | N | Y | Y | Y | N | N | Y |
| Road kill | Y | N | N | N | Y | N | N | Y | Y | N | N | N |
| Poisoning deliberate | Y | N | N | N | N | Y | N | Possibly | Y | Possibly | N | N |
| Poisoning accidental | Y | N | N | N | N | Y | N | Possibly | Y | N | N | N |
| Pesticides/herbicides | Y | N | N | N | N | Y | N | Possibly | | N | N | N |
| **Disease** | Y | N | N | Unlikely | Y (if visible) | Y | Y (if visible) | Possibly | Y | Possibly | N | Y (if visible) |

**c) Spotted hyaena**

| | Questionnaire | Den counts | Spoor | Transect counts | Tourist photos[1] | Working dogs | Camera Traps | Visual search | Radio Collars | Records of attacks | Hunting records | Baiting | Call-in playbacks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Prey availability** | | | | | | | | | | | | | |
| Overall loss | Y | N | Y (if recorded) | Y (if recorded) | N | N | Y | Y (if recorded) | N | N | N | N | N |
| Change in prey - to livestock | Y | N | Y (if recorded) | Y (if recorded) | N | Y | Y | Y (if recorded) | Y | Possibly | N | N | N |
| **Land use/cover change** | | N | | | | | | | | | N | | |
| Habitat conversion | Y | N | Y (if recorded) | Y (if recorded) | N | N | N | Y (if recorded) | N | N | N | N | N |
| Resource extraction | Y | N | Y (if recorded) | Y (if recorded) | N | N | N | Y (if recorded) | N | N | N | N | N |
| Fragmentation | Y | N | N | N | N | N | N | N | Y | N | N | N | N |
| New roads | Y | N | N | N | N | N | N | N | N | N | N | N | N |
| **Anthropogenic Killing** | | | | | | | | | | | | | |
| Local captive trade | Y | N | N | N | N | N | N | N | N | N | N | N | N |
| Local medical trade | Y | N | N | N | N | N | N | N | N | N | N | N | N |
| Possible international trade (live) | Y | N | N | N | N | N | N | N | N | N | N | N | N |
| Snaring | Y | N | N | Y | Y | N | Y | Y | Y | N | N | Possibly | Y |
| Road kill | Y | N | N | N | Y | N | N | Y | Y | N | N | N | N |
| Poisoning deliberate | Y | N | N | N | N | Y | N | Y | Y | N | N | N | N |
| Poisoning accidental | Y | N | N | N | N | Y | N | Y | Y | N | N | N | N |
| Pesticides/herbicides | Y | N | N | N | N | Y | N | Y | Y | N | N | N | N |
| **Disease** | Y | N | N | Y (if visible) | Y (if visible) | Y | Y (if visible | Y | Y | Possibly (rabies) | N | Possibly | Y (if visible) |

[1] Method applicable only in areas where sufficient tourists

[2] carcasses rather than live prey should be recorded for this species

**Table 2 Data generated by the different methods covered in the sections above for a) aardwolf; b) striped hyaena and c) spotted hyaena. In each table 'Y' indicates that the method could generate appropriate data; 'Y (if recorded)' indicates that the method could be used to generate appropriate data provided the data concerned was additionally recorded when implementing the method; 'N' the method could not generate appropriate data; 'coarse' the method might generate some appropriate data, but they are likely to be open to interpretation; 'possibly' indicates that whilst the method could theoretically generate the appropriate data, it is unlikely that sufficient data would be collected to fulfil the objectives.**

## 6. CONSERVATION AND RESEARCH PRIORITIES

In the last part of the meeting the group examined the tools available to address conservation threats to enable hyaena conservation in Tanzania and went on to set priorities for research and conservation for each species. The inputs from the management and research authorities from WD, TANAPA, TAWIRI and NCAA were particularly important for this session.

### 6.1 Tools for management

For this discussion striped and spotted hyaena were combined as they were subjected to the same threats, but aardwolf was discussed separately.

#### 6.1.1 Aardwolf

The group identified the following list of tools to address aardwolf threats in Tanzania:

*Toxins (worst occurrences are associated with large scale pest invasions – particularly army worms and locusts)*
- Conservation education and awareness
- Alternative crop management strategies to minimise use of herbicides/pesticides

*Land use change – threat occurs outside protected areas (PAs).*
- Improved land use planning, particularly to maintain corridors and dispersal areas
- Facilitate establishment of WMAs
- Provide incentives to communities via improved livestock husbandry (outside WMAs)
- Assist communities to better manage sustainable offtake of herbivores (outside WMAs)
- Facilitate adoption of alternative sources of fuel to reduce resource extraction

*Changes in termite distribution and population (threat occurs outside PAs)*
- Monitoring to assess whether there is a decline in distribution, and to identify good areas
- If a decline is established and the area is good for aardwolves, then initiate education program to prevent destruction of termite colonies.

*Anthropogenic killings*
- Conservation education to raise awareness of different species
- Promote conservation education and awareness to ensure people drive more carefully

#### 6.1.2 Striped and Spotted Hyaena

The group identified the following list of tools to address striped and spotted hyaena threats in Tanzania:

*Prey availability – threat occurs outside PAs*
- Improved land use planning, particularly to maintain corridors and dispersal areas
- Facilitate establishment of WMAs
- Provide incentives to communities via improved livestock husbandry (outside WMAs)
- Assist communities to better manage sustainable offtake of herbivores (outside WMAs)

*Land use change*
- Facilitate adoption of alternative sources of fuel
- Others covered above

*Anthropogenic killing*
- Promote conservation education and awareness:
  - to ensure people drive more carefully;
  - to promote the value and role of hyaenas in the ecosystem (targeted at younger generation and tour operators);
  - to improve education people about the wider effects of toxins

- Liase with Traffic to monitor international trade
- Ensure hunting operators distinguish between species on hunting records
- Enhance anti-poaching operations (incentives are already provided for snares removed)

*Disease*

- Monitoring to establish status of threat outside PAs
- Domestic dog control and disease management program including education outside PAs coupled to an education program.

### 6.2 Research and conservation priorities

In this section the group used the information discussed so far in this report to establish research and conservation priorities. For this they used the information on species distribution and status; the tools available to address status information needs; the threats facing each species; and the tools available to address these threats to establish overall priorities for all three species of hyaena in Tanzania.

The group identified the following as clear overall national priorities:

**All species**:

1. Research to establish the underlying reasons behind negative attitudes towards hyaenas
2. Education in conservation awareness for all three species prioritising areas where negative attitudes established above.
3. Improved land use planning, prioritising the maintenance of corridors and dispersal areas
4. Assessment of the extent and impact of firewood collection in the NCA
5. Enhance facilitation of establishment of WMAs if approved.
6. Establish the impact and extent of poisoning – deliberate and accidental - on hyaenas, prioritising the Maasai steppe region
7. Enhance anti-poaching wherever snaring is a problem
8. Establish the extent of indigenous knowledge in different cultures within hyaena range

**Aardwolves:**

1. Improve the national database to establish the full extent of the distribution of aardwolves
2. Liase with ministry of agriculture to establish past and current spraying regimes in relation to distribution established in 1.
3. Establish one priority area for in depth study to identify density and threats outside PAs.

**Striped hyaenas**

1. Establish illegal and legal offtake
2. Research to establish ecological requirements, prioritising Maasai steppe but all areas within the species range were deemed important
3. Improve the national database to establish the full extent of the distribution of the species

**Spotted hyaenas**

1. Surveys of prey availability outside protected areas, prioritising potential corridors and/or dispersal areas
2. Improve reporting of livestock and human attacks at a national level
3. Research into establishing levels of conflict between hyaenas and humans prioritising potential corridors and/or dispersal areas
4. Establish the extent to which disease transmission occurs between humans and domestic animals and hyaenas in NCA, Maswa and Sonja

The identified priorities targeted the major threats identified in section 5, including poisoning and anthropogenic killing for striped and spotted hyaena and toxins for aardwolves and land use planning to ensure that corridors between protected areas are maintained. The Maasai steppe was deemed to be a particular priority for all species due to the urgency and increasing rate of habitat conversion and loss from the region. However as striped hyaenas occur at such low densities, information on any aspects of their status and distribution in the country was deemed to be important. Ensuring the identification of species of hyaena on trophy offtake forms submitted to WD is an important part of this process, as it both provides information on species distribution and the number of striped hyaena killed in legal offtake – important for such a low density species. The group felt that engagement with local communities was key to the long term conservation of all species. WMAs provide a mechanism by which to do this and so the establishment and approval of existing WMAs would provide an important tool to aid hyaena conservation. 16 pilot WMAs are already in place, and at the time of the workshop 4 WMAs have been approved as fully fledged WMAs. In August 2006 all pilot WMAs were scheduled to be evaluated for final approval. Whilst the WMA process is an important one, the group was concerned that should all 16 WMAs gain approval, there are not sufficient resources to maintain and support them. Nonetheless, the procedures needed to establish a WMA are slow and there was concern that these should be streamlined to enable faster processing of applications. The group were also concerned that important habitat outside existing WMA proposed areas was not neglected from this process, hence its inclusion within the priorities above.

Education was recognised to be a powerful tool for conservation, particularly considering the negative attitudes harboured by many people towards hyaenas. Such negative attitudes were recognised by the group to be a major impediment to their conservation. Conservation education awareness should therefore be used to address this negativity by promoting the value and role of hyaenas in the ecosystem, targeting young people and tour operators. There was also a need to improve education about the wider environmental and ecological impacts of toxins. If feasible, a clear way of achieving this improvement is to include these issues together with wider issues to do with carnivore conservation in the national curriculum.

Aardwolves were particularly vulnerable to national spraying campaigns targeted at insect pests, particularly locusts and army worms. The ministry of agriculture is currently investigating a biological control agent – a fungus – that can be used to control army worm with minimal environmental effects. Wherever possible such alternatives should be investigated and used instead of more harmful toxins.

## 6.4 The Way Forward

Managers need information on the status and threats to hyaenas in their areas to plan management activities to enable their conservation, as well as assessing the impact of these activities on their conservation. The proceedings of this workshop synthesise what is currently known about all three hyaena species in Tanzania, and make use of the participants' knowledge and experience to establish tools for their conservation, including conservation targeted research and management tools. The priorities laid out provide a clear approach to help ensure the conservation of hyaenas in Tanzania. All participants are deeply proud of Tanzania's international status for large carnivore conservation, and wish to maintain this reputation. The hard work that participants put into this workshop and report reflects this wish, and will hopefully lead to a more effective hyaena monitoring and management programme, hand in hand with training and capacity building.

**Acknowledgements**

We would like to thank the Tanzania Carnivore Centre staff for enabling this workshop to run smoothly, particularly Flora Kipuyo, Zawadi Mbwambo and Jumanne Ramadhani and Leah Martin. Maurus Msuha's involvement as project manager for the Tanzania Carnivore Project over the first three years of operation was essential to its success, Maurus also provided the aardwolf photo in the aardwolf section. We would also like to thank TAWIRI for their assistance in organising the workshop. A large number of individuals contributed to the database used to map distributions in this report, including Amanda Barrett, Anne Hilborn, Antonio Sirolli, Augustine Minja, Bernard Kissui, Carnivore Disease Project, Charles Foley, Chris Parker, Christian Kiffner, Claire Lewis, Daleen Funston, Daniela De Luca, Daudi Peterson, David Erickson, David Moyer, Denis Ikanda, Dorine Jansen, Edward J. Salali, Emanual John Matalika, Emilian Kihwele, Ephraim Mwangomo, Ernest Eblate, Ezra Ilomo, Flora Kipuyo, Francesco Rovero, Gemes Shayo, Giulia Gionchetta, Gus Mills, Hadas Kushnir, Ifura Ukio, Denis Ikanda, Howard Fredrick, Janemary Ntalwila, Jo Driessen, John M.Njita, Jules Knocker, Julie Hollywood, Julius Mollel, K Boswell, Kirsten Skinner, Laly Lichtenfeld, Lara Foley, Luca Giannone, Lydia Beaudrot, Jonathan Lymo, M.S. Licky, Machali Boniface, Marc Baker, Mike Peterson, Moses Mungure, A. Mziray, Ndutu Lodge, Nigel Theisen, Noah Mpunga, NOMAD, Paul Funston, Pete Coppolillo, Richard Hoare, Robert Fumyagwa, Richard Knocker, Samweli Mtoka, Serengeti Lion Project, Shaaban Langwen, Simon Braat, Sinyaeli Pallangyo, Stephan Kronow, Steve Makacha, Sultana Bashir, Thad Peterson, Theophil Ng'unyali, Thomas Shabani, Trevor Jones, Laura Vacondio, Viv and Peter Raymond, Hamisi, Zawadi Mbwambo. The workshop was funded by the Darwin Initiative of the UK and the Tanzania Carnivore Project has had additional support from the Wildlife Conservation Society and the Zoological Society of London.

**References**

Alexander, K.A., Smith, J.S., Macharia, M.J. and King, A.A. 1993. Rabies in the Masai Mara, Kenya: preliminary report. Onderstepoort Journal of Veterinary Research **60**: 411-414.

Anderson, M. D. 1994. The influence of seasonality and quality of diet on the metabolism of the aardwolf, *Proteles cristatus* (Sparrman 1783). M.Sc. thesis, University of Pretoria, Pretoria.

Bashir, S., B. Daly, S. Durant, H. Forster, J. Grisham, L. Marker, K. Wilson, and Y. Friedmann. 2004. Global Cheetah (*Acinonyx jubatus*) Monitoring Workshop Report., Ndutu.

Boydston, E. E., Kapheim, K. M., Szykman, M. and Holekamp, K. E. 2003. Individual variation in space use by female spotted hyenas. Journal of Mammalogy **84**:1006-1018.

Boydston, E. E., K. M. Kapheim, R. C. Van Horn, L. Smale, and K. E. Holekamp. 2005. Sexually dimorphic patterns of space use throughout ontogeny in the spotted hyena (*Crocuta crocuta*). Journal of Zoology **267**:271-281.

Buckland, S. T., D. R. Anderson, K. P. Burnham, and J. L. Laake 1993. Distance sampling: Estimating abundance of biological populations. Chapman and Hall, London.

Cooper, S. M. 1991. Optimal hunting group size the need for lions to defend their kills against loss to spotted hyaenas. African Journal of Ecology **29**:130-136.

Creel, S., and N. M. Creel. 1996. Limitation of African wild dogs by competition with larger carnivores. Conservation Biology **10**:526-538.

Drea, C. M., Place, N. J., Weldele, M. L., Coscia, E. M., Licht, P. and Glickman, S. E. 2002. Exposure to naturally circulating androgens during foetal life incurs direct reproductive costs in female spotted hyenas, but is prerequisite for male mating. Proceedings of the Royal Society, London B **269**: 1981-1987.

Durant, S. M., R. Hilborn, M. Craft, and S. Bashir. under review. Long term trends in carnivore abundance using distance sampling in Serengeti National Park, Tanzania. Journal of Applied Ecology.

East, M. L., and Hofer, H. 1991. Loud calling in a female-dominated mammalian society: II. Behavioural contexts and functions of whooping of spotted hyaenas, *Crocuta crocuta*. Animal Behaviour **42**: 651-669.

East, M. L. and Hofer, H. 2001. Male spotted hyenas (*Crocuta crocuta*) queue for status in social groups dominated by females. Behavioural Ecology **12**: 558-568.

East, M. L., Hofer, H. and Wickler, W. 1993. The erect penis is a flag of submission in a female-dominated society: greeting ceremonies in Serengeti spotted hyaenas. Behavioural Ecology and Sociobiology **33**:355-370.

East, M. L., Hofer, H., Cox, J. H., Wulle U., Wiik H. and Pitra, C. 2001. Regular exposure to rabies virus and lack of symptomatic disease in Serengeti spotted hyenas. Proceedings of the National Academy of Sciences USA **98**:15026-15031.

East, M. L., Moestl, K., Benetka, V., Pitra, C., Höner, O. P., Wachter, B. and Hofer, H. 2004. Coronavirus infection of spotted hyenas in the Serengeti ecosystem. Veterinary Microbiology **102**:1-9.

East, M. L., H. Hofer, and A. Turk. 1989. Functions of birth dens in spotted hyaenas (*Crocuta crocuta*). Journal of Zoology, London **219**:690-697.

East, M. L., Burke, T., Wilhelm, K., Greig, C. and Hofer, H. 2003. Sexual conflicts in spotted hyenas: male and female mating tactics and their reproductive outcome with respect to age, social status and tenure Proceedings of the Royal Society, London B **270**: 1247-1254.

Eaton, R. L. 1979. Interference competition among carnivores: a model for the evolution of social behavior. Carnivore **2**:9-16.

Engh, A. L., Funk, S. M., Van Horn, R. C., Scribner, K. T., Bruford, M. W., Libants, S., Skykman, M., Smale, L. and Holekamp, K. E. 2002. Reproductive skew among males in a female-dominated mammalian society. Behavioral Ecolology **13**: 193-200.

Fagerudd, J. 2005. The effect of grazing on aardwolves and how farmers in Namibia perceive the aardwolf. Masters Thesis, Uppsala University, Sweden.

FitzGibbon, C. D., and J. H. Fanshawe. 1989. The condition and age of Thomson's gazelles killed by cheetahs and wild dogs. Journal of Zoology, London. **218**:99-107.

Frank, L. G., S. E. Glickman, and P. Licht. 1991. Fatal Sibling Aggression, Precocial Development, and Androgens in Neonatal Spotted Hyenas. Science **252**:702-704.

Frank, L. G., K. E. Holekamp, and L. Smale. 1995. Dominance, demography, and reproductive success of female spotted hyenas. Pages 364-384 in A. R. E. Sinclair, and P. Arcese, editors. Serengeti II: Dynamics, management and conservation of an ecosystem. University of Chicago Press, Chicago.

Golla, W., Hofer, H. and East, M. L. 1999. Within-litter aggression in spotted hyaenas: effect of maternal nursing, sex and age. Animal Behaviour **58**:715-726

Goymann, W., East, M. L., Wachter, B., Höner, O.P., Möstl, E., Van't Hof, T.J. and Hofer, H. 2001. Social, state-dependent and environmental modulation of faecal corticosteroid levels in free-ranging female spotted hyenas. Proceedings of the Royal Society, London B **268**: 2453-2459

Haas, L., Hofer, H., East, M., Wohlsein, P., Liess, B. and Barrett, T. 1996. Canine distemper virus infection in Serengeti spotted hyenas. Veterinary Microbiology **49**:147-152

Harrison, T. M., J. K. Mazet, K. E. Holekamp, E. Dubovi, A. L. Engh, K. Nelson, R. C. Van Horn, and L. Munson. 2004. Antibodies to canine and feline viruses in spotted hyenas (*Crocuta crocuta*) in the Masai Mara National Reserve. Journal of Wildlife Diseases **40**:1-10.

Hofer, H., and M. L. East. 1993a. The commuting system of Serengeti spotted hyaenas: how a predator copes with migratory prey. I. Social organisation. Animal Behaviour **46**:547-557.

Hofer, H., and M. L. East. 1993b. The commuting system of Serengeti spotted hyaenas: how a predator copes with migratory prey. II. Intrusion pressure and commuters' space use. Animal Behaviour **46**:559-574.

Hofer, H. and East, M.L. 1993c. The commuting system of Serengeti spotted hyaenas: how a predator copes with migratory prey. III. Attendance and maternal care. Animal Behaviour **46**:575-589

Hofer, H., and M. East. 1995. Population dynamics, population size, and the commuting system of Serengeti spotted hyaenas. Pages 332-363 in A. R. E. Sinclair, and P. Arcese, editors. Serengeti II: Dynamics, management and conservation of an ecosystem. University of Chicago Press, Chicago.

Hofer, H. and East, M.L. 1997. Skewed offspring sex ratios and sex composition of twin litters in Serengeti spotted hyaenas (*Crocuta crocuta*) are a consequence of siblicide. Applied Animal Behaviour Science **51**:307-316

Hofer, H. and East, M. L. 2003. Behavioural processes and costs of co-existence in female spotted hyenas: a life history perspective. Evolutionary Ecology **17**:315-331

Hofer, H., M. East, and K. L. I. Campbell. 1993. Snares, commuting hyenas and migratory herbivores: Humans as predators in the Serengeti. Symposia of the Zoological Society of London **65**:347-366.

Hofer, H., and M. L. East. 1996. The components of parental care and their fitness consequences: a life history perspective. Verhandlungen der Deutschen Gesellschaftf tir Zoologie **892**:149-164.

Hofer, H., and M. G. L. Mills. 1998. Worldwide distribution of hyaenas. Pages 39-63 in M. G. L. Mills, and H. Hofer, editors. Hyaenas, Status Survey and Conservation Action Plan. International Union for Conservation of Nature, Gland, Switzerland.

Holekamp, K. E., J. O. Ogutu, H. T. Dublin, L. G. Frank, and L. Smale. 1993. Fission of a Spotted Hyena Clan - Consequences of Prolonged Female Absenteeism and Causes of Female Emigration. Ethology **93**:285-299.

Holekamp, K. E., Szykman, M., Boydston, E. E. and Smale, L. 1999. Association of seasonal reproductive patterns with changing food availability in an equatorial carnivore, the spotted hyena. Journal of Reproduction and Fertilty **116**: 87-93.

Höner, O. P., Wachter, B., East, M. L., Runyoro, V. A. and Hofer, H. 2005. The effect of prey abundance and foraging tactics on the population dynamics of a social, territorial carnivore, the spotted hyena. Oikos **108**: 544-554.

Höner, O.P., Wachter, B., Hofer, H. and East, M.L. 2002. The response of spotted hyenas to long-term changes in prey populations: functional response and interspecific kleptoparasitism. Journal of Animal Ecology **71**: 236-246.

Höner, O.P., Wachter, B., Speck, S., Wibbelt, G., Ludwig, A., Fyumagwa, F.A., Wohlsein, P., Lieckfeldt, D., Hofer, H. and East, M.L. 2006. Severe Streptococcus infection in spotted hyenas in the Ngorongoro Crater, Tanzania. Veterinary Microbiology **115**: 223-228.

Karanth, K. U., and J. D. Nichols. 1998. Estimation of tiger densities in India using photographic captures and recaptures. Ecology **79**:2852-2862.

Kingdon, J. 1977. East African mammals: An altas of evolution in Africa volume IIIA carnivores. Academic Press, London.

Knight, M. H., A. S. Vanjaarsveld, and M. G. L. Mills. 1992. Allo-Suckling in Spotted Hyaenas (Crocuta-Crocuta) - an Example of Behavioral Flexibility in Carnivores. African Journal of Ecology **30**:245-251.

Koehler, C. E., and P. R. K. Richardson. 1990. *Proteles cristatus*. Mammalian Species **353**:1-6.

Kolowski, J. M., and K. E. Holekamp. 2006. Spatial, temporal, and physical characteristics of livestock depredations by large carnivores along a Kenyan reserve border. Biological Conservation **128**:529-541.

Kruuk, H. 1972. The spotted hyaena: A study of predation and social behavior. University of Chicago, Chicago.

Kruuk, H. 1976. Feeding and social behaviour of the striped hyaena (*Hyaena vulgaris* Desmarest). East African Wildlife Journal **14**:91-111.

Kruuk, H. 1980. The effects of large carnivores on livestock and animal husbandry in Marsabit district, Kenya. IPAL Technical Report E-4, UNEP-MAB, Nairobi.

Kruuk, H., and W. A. Sands. 1972. The aardwolf (*Proteles cristatus,* Sparrman 1783) as a predator of termites. East Africa Wildlife Journal **10**:211-227.

Lembo, T., M. Niezgoda, A. Velasco-Villa, S. Cleaveland, E. Ernest, and C. E. Rupprecht. 2006. Evaluation of a direct, rapid immunohistochemical test for rabies diagnosis. Emerging Infectious Diseases **12**:310-313.

Lembo, T., Haydon, D.T., Velasco-Villa, A., Rupprechet C.E., Packer, C., Brandoi P.E., Kuzmin, I.V., Fooks, A.R., Barrat, J. and Cleaveland, S. 2007. Molecular epidemiology identifies only a single rabies virus variant circulating in complex carnivore communities of the Serengeti. Proceedings of the Royal Society B. **274**: 2123-2130.

Lichtenfeld, L. L. 2005. Our shared kingdom at risk: Human–lion relationships in the 21st century. PhD Dissertation, Yale University, New Haven, CT.

Matthews, L.H. 1939. Reproduction in the spotted hyaena, *Crocuta crocuta* (Erxleben). Philosophical Transactions of the Royal Society London **230**:1-78.

Mills, M. G. L. 1990. Kalahari hyaenas: the comparative behavioural ecology of two species. Unwin Hyman. London.

Mills, M. G. L., and H. Hofer, editors. 1998. Hyaenas Status Survey and Conservation Action Plan. International Union for Conservation of Nature, Gland, Switzerland.

Nyahongo, J.W. 2004. Impact of human activities on the carnivore populations in the Western Serengeti, Tanzania. MSc Dissertation, University of Dar es Salaam, Tanzania.

Nyahongo, J.W., Mturi, F.A., East, M.L. and Hofer, H. 2005. Patterns of illegal grazing and hunting in the Serengeti ecosystem. Environmental Conservation **32**: 326-332.

Maddox, T. 2002. The ecology of cheetahs and other large carnivores in a pastoralist-dominated buffer zone. Department of Anthropology. University of London, London.

Norton-Griffiths, M. 1978. Counting Animals, Handbooks on techniques currently used in African wildlife ecology. No.1, African Wildlife Leadership Foundation.

Nyahongo, J. W., East, M. L., Mturi, F. A. and Hofer, H. 2005. Benefits and costs of illegal grazing and hunting in the Serengeti ecosystem. Environmental Conservation **32**:326-332.

Ogutu, J. O., and H. T. Dublin. 1998. The response of lions and spotted hyaenas to sound playbacks as a technique for estimating population size. African Journal of Ecology **36**:83-95.

Packer, C., and A. E. Pusey. 1987. Retracing the history of the Ngorongoro lions. Swara **10**:30-31.

Peters, G., and A. Sliwa. 1997. Acoustic communication in the aardwolf, *Proteles cristatus* (Carnivora: Hyaenidae). Zeitschrift Fur Saugetierkunde-International Journal of Mammalian Biology **62**:219-238.

Richardson, P. R. K. 1985. The social behavior and ecology of the aardwolf, *Proteles cristatus* (Sparrman, 1783) in relation to its food resources. Thesis. University of Oxford.

Richardson, P. R. K. 1987. Aardwolf Mating System - Overt Cuckoldry in an Apparently Monogamous Mammal. South African Journal of Science **83**:405-410.

Richardson, P. R. K. 1991. Territorial Significance of Scent Marking During the Nonmating Season in the Aardwolf *Proteles-Cristatus* (Carnivora, Protelidae). Ethology **87**:9-27.

Richardson, P. R. K., and C. D. Levitan. 1994. Tolerance of Aardwolves to Defense Secretions of *Trinervitermes-Trinervoides*. Journal of Mammalogy **75**:84-91.

Roberts, T. J. 1977. The mammals of Pakistan. E. Benn, London.

Röttcher, D., and A. M. Sawchuk. 1978. Wildlife rabies in Zambia. Journal of Wildlife Diseases **14**: 513-517.

Runyoro, V.A., Hofer, H., Chausi, E.B. and Moehlmann, P.D. 1995. Long-term trends in the herbivore population of the Ngorongoro Crater, Tanzania. Pages 146-168 in A.R.E. Sinclair and P. Arcese, editors, Serengeti II: research, management and conservation of an ecosystem. University of Chicago Press, Chicago.

Shemkunde, J. 2004. The use of tourist photographs as a means of monitoring cheetahs in the Serengeti National Park, Tanzania. University of Wales, Aberystwyth.

Sillero-Zubiri, C., and M. D. Gottelli. 1992. Feeding necology of spotted hyaena (Mammalia: *Crocuta crocuta*) in a mountain forest habitat. Journal of African Zoology **106**:169-176.

Silver, S. C., L. E. T. Ostro, L. K. Marsh, L. Maffei, A. J. Noss, M. J. Kelly, R. B. Wallace, H. Gomez, and G. Ayala. 2004. The use of camera traps for estimating jaguar *Panthera onca* abundance and density using capture/recapture analysis. Oryx **38**:148-154.

Smith, D. A., K. Ralls, B. Davenport, B. Adams, and J. E. Maldonado. 2001. Canine assistants for conservationists. Science **291**:435-435.

Smith, D. A., K. Ralls, A. Hurt, B. Adams, M. Parker, B. Davenport, M. C. Smith, and J. E. Maldonado. 2003. Detection and accuracy rates of dogs trained to find scats of San Joaquin kit foxes (*Vulpes macrotis mutica*). Animal Conservation **6**:339-346.

Smithers, R. H. N. 1983. The mammals of the Southern African subregion. University of Pretoria, Pretoria.

Stander, P. E. 1998. Spoor counts as indices of large carnivore populations: the relationship between spoor frequency, sampling effort and true density. Journal of Applied Ecology **35**:378-385.

Seidensticker, J., P. Jackson, and S. Christie 1999. Riding the Tiger: Tiger Conservation in Human-Dominated Landscapes. Cambridge University Press, Cambridge.

Swanepoel, R., B. J. H. Barnard, C. D. Meredith, G. C. Bishop, G. K. Bruckner, C. M. Foggin, and O. J. B. Hubschle. 1993. Rabies in Southern Africa. Onderstepoort Journal of Veterinary Research **60**:325-346.

Swynnerton, G. H. 1951. A check list of the land mammals of the Tanganyika Territory and the Zanzibar protectorate. Journal of the East African Natural History Society **20**:274-312.

Trinkel, M., P. H. Fleischmann, A. F. Steindorfer, and G. Kastberger. 2004. Spotted hyenas (*Crocuta crocuta*) follow migratory prey. Seasonal expansion of a clan territory in Etosha, Namibia. Journal of Zoology (London) **264**:125-133.

Van Aarde, R. J., J. D. Skinner, M. H. Knight, and D. C. Skinner. 1988. Range Use by a Striped Hyena (*Hyaena-Hyaena*) in the Negev Desert. Journal of Zoology **216**:575-577.

Van Horn, R. C., McElhinny, T. L. and Holekamp, K. E. 2003. Age estimation and dispersal in the spotted hyena. J. Mammalogy **84**: 1019-1030.

Wachter, B., Höner, O.P., East, M.L., Golla W. and Hofer, H. 2002. Low aggression levels and unbiased ratios in a prey-rich environment: no evidence of siblicide in Ngorongoro spotted hyenas (*Crocuta crocuta*). Behavioural Ecology and Sociobiology **52**:348-356

Wasser, S. K., B. Davenport, E. R. Ramage, K. E. Hunt, M. Parker, C. Clarke, and G. Stenhouse. 2004. Scat detection dogs in wildlife research and management: application to grizzly and black bears in the Yellowhead Ecosystem, Alberta, Canada. Canadian Journal of Zoology-Revue Canadienne De Zoologie **82**:475-492.

White, P. A. 2005. Maternal rank is not correlated with cub survival in the spotted hyena. Beh. Ecol. **16**: 606-613.

Williams, J. B., Anderson, M. D. and Richardson, P. R. K. 1997. Seasonal differences in field metabolism, water requirements and foraging behaviour of free-living aardwolves. Ecology **78**: 2588-2602.

# Appendix I

## Participants

| Name | Organization/Institution | Contact | Email |
|---|---|---|---|
| Dr. Oliver Höner | Leibniz Institute for Zoo and Wildlife Research | Box 40, Ngorongoro | hoener@izw-berlin.de |
| Dr. Betina Wachter | Leibniz Institute for Zoo and Wildlife Research | Box 40, Ngorongoro | wachter@izw-berlin.de |
| Dr. Marion East | Leibniz Institute for Zoo and Wildlife Research | Box 12, Arusha | east@izw-berlin.de |
| Edwin Konzo | TCP and TMAP/TAWIRI | Box 661, Arusha | carnivore-atlas@habari.co.tz |
| Linus Munishi | TCP and TMAP/TAWIRI | Box 661, Arusha | linuskil@yahoo.co.uk |
| Dr. Laly Lichtenfeld | People and Predators Fund | Box 11306, Arusha | lichtenfeld@people-predators.org |
| Charles Trout | People and Predators Fund | Box 11306, Arusha | trout@people-predators.org |
| Novatus Magoma | NCAA | Box 1, Ngorongoro | ncaa_faru@cybernet.co.tz |
| Alexander Lobora | TCP and TMAP/TAWIRI | Box 661, Arusha | carnivores@habari.co.tz |
| Nebbo J. Mwina | Wildlife Division | Box 1994, Dar es Salaam | director@wildlife.go.tz |
| Julius Kibebe | Wildlife Division | Box 1994, Dar es Salaam | director@wildlife.go.tz |
| Mwemezi Rwiza | TCP and TMAP/TAWIRI | Box 661, Arusha | carnivore-education@habari.co.tz |
| Dr. George Sabuni | TAWIRI | Box 661, Arusha | tawiri@habari.co.tz |
| Dr. Sarah Durant | TCP, TMAP, ZSL and WCS | Box 661, Arusha | cheetah@habari.co.tz; sdurant@wcs.org |
| Inyasi A. Lejora | TANAPA | Box 3134, Arusha | ilejora@hotmail.com |