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A lion population under threat : understanding lion (*Panthera leo* Linnaeus, 1758) ecology and human-lion interactions related to livestock predation in Waza National Park, Cameroon

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General introduction

1.1 Introduction

Top predators play an integral role in maintaining rich ecosystems because they are regulators of food webs (Beschta & Ripple, 2009; Letnic *et al.*, 2009; Fraser, 2009; Miller *et al.*, 2001). Recent knowledge on natural processes that maintain biodiversity suggests that top predators have a crucial and irreplaceable role (Terborgh *et al.*, 2001). The absence of top predators appears to alter the structure of entire ecosystems, resulting in simplification of ecosystem linkages, shifts in habitat and extinction of species (Terborgh *et al.*, 2001). Top predators generally occur in low densities and range widely (Schaller, 1976) to meet their ecological needs. For these reasons they are considered umbrella species. Their conservation is not only relevant for the species themselves but it also promotes the protection of natural biological systems upon which many other species depend (Johnson *et al.*, 2007; Estes *et al.*, 2011). Commonly known as kings of the African savannah, lions (*Panthera leo*) are the largest of the African top predators. They are a symbol of power and have great traditional and cultural value, as reported in Kenya (Maddox, 2003) and Benin (Sogbohossou, 2004). Lions are keystone species and as such are ecological indicators for wilderness areas (IUCN/SSC, 2006). They are also flagship species in research programmes and charismatic species of great importance to tourism.

As with other large predators, lion conservation seems to be a daunting task. The numbers of lions and their geographic range have declined significantly all over the world (Woodroffe, 2000). The literature suggests that lions were historically widespread, ranging from Southern Africa to Northern Europe and across Central and South Asia (Nowell & Jackson, 1996; Turner & Anton, 1997; Kingdon, 2003). Today there are two remaining sub-species of lion: *Panthera leo leo*, also known as *Panthera*

leo, is restricted to Sub-Saharan Africa while the other, *Panthera leo persica*, with a small endemic population of approximately 400 lions, to the Gir forest in India (Schaller, 1972; Nowell & Jackson, 1996). Lion populations are increasingly becoming threatened throughout Africa. Only three areas in Sub-Saharan Africa are known to host relatively stable populations of 2000 or more individuals, the Serengeti-Mara ecosystem, the Okavango-Chobe-Hawange complex and Kruger National Park. In West and Central Africa, populations are small and fragmented, making them even more vulnerable to threats. Lion experts estimate that there are in total between 23,000 (Bauer & van der Merwe, 2004) and 39,000 (Chardonnet, 2002) African lions remaining. In fact, even less than 10% of the population of African lions as a whole is located in protected areas in West and Central Africa (Bauer & van der Merwe, 2004).

The decline of lion populations is mainly due to the severe range contraction observed in the last century, resulting in increasing human-lion conflicts (Loveridge *et al.*, 2001; Kingdon, 2003; IUCN/SSC, 2006). The human population of Sub-Saharan Africa is increasing at a rate of between 2 and 3% per year, accompanied by a strong increase in cropland use and livestock production (IUCN/SSC, 2006; Binot *et al.*, 2006; de Iongh & Bauer, 2008). The main threats to lion populations in West and Central Africa (IUCN/SSC, 2006) include loss and fragmentation of habitat, decline of prey populations and retaliatory killing of lions after livestock depredation (East, 1999; Fischer & Linsenmair, 2001; de Iongh *et al.*, 2004; Caro & Scholte, 2007; Craigie *et al.*, 2010; Bauer & van der Merwe, 2004; Sogbohossou, 2011). In addition, sport hunting of lions in and around protected areas exposes lion populations to disturbances, which have been reported to have a negative impact on population densities and social structure (Whitman *et al.*, 2004; Loveridge *et al.*, 2007; Packer *et al.*, 2011a; Croes *et al.*, 2011; Sogbohossou, 2011). Most protected areas in West and Central Africa, such as Waza National Park in Cameroon, are small and the surrounding savannah landscapes are degraded and fragmented, resulting in the isolation of lion populations (Bauer *et al.*, 2001). These small and isolated populations face a higher risk of extinction (Woodroffe & Ginsberg, 1998) and are susceptible to inbreeding depression (Karanth *et al.*, 2010).

Recent findings suggest that lions in West and Central Africa are genetically different from lions in East and Southern Africa and are more closely related to Asiatic lions (Bertola *et al.*, 2011). Morphologically, the Asiatic lions clearly differ from lions in West and Central Africa in traits such

as colour of mane and body mass. There are indications that both are, however, smaller in body mass than lions from East and Southern Africa and that both have a belly fold as a typical trait (de Jongh & Bauer, 2008). This available information suggests that there is a sub-species yet to be defined, further substantiating the need to conserve the lion in this region for the preservation of biological diversity. In order to conserve a species, a sound scientific knowledge is required of its ecology, behaviour and interactions within the social context in which such a species occurs. As stated by Schaller (1972), good science, sound policy and support by local people are needed to enable a species to survive. There is a gap in knowledge on all aspects of lions in West and Central Africa compared to lions of East and Southern Africa.

Lions are impacted by changing ecological conditions induced both naturally (drought, low rainfall) and by the activities of man in the environment (poaching, encroachment and livestock grazing). Because of these pressures on the remaining lion populations, there is a need for ongoing research and monitoring in order to manage and conserve lions and their habitats. Conservation planning in the West and Central African region has been hindered by a general lack of scientific studies across and within lion populations (Bauer *et al.*, 2003; Henschel *et al.*, 2010; Burton *et al.*, 2011; Sogbohossou, 2011). This thesis covers one of the remaining most northern isolated lion populations in Sub-Saharan Africa in Waza National Park, Cameroon. The overall research goal is to fill the gap in knowledge and provide scientific information needed for improved management and conservation of the lion in Central Africa. This study focuses on the following aspects: the status of the Waza lion population and the threats faced by this population; lion spatial ecology; movement and activity patterns of lions; diet composition and prey selection; the effect of moon phase on livestock predation by lions; human-lion conflicts and the methods used by resident and nomadic pastoralists to reduce livestock depredation.

1.2 Lion conservation and population status

The African lion is listed as *Vulnerable* on the global IUCN Red List of Threatened Species. Due to declines and increasing threats, the West African lion population is described as *Regionally Endangered* (Bauer & Nowell, 2004). The species is listed on Appendix II of CITES (Convention on International Trade in Endangered Species), which includes species

that are not necessarily threatened with extinction at the moment but will become extinct if international trade is not controlled. The current status of the species continues to raise concern among lion specialists across its range in Africa. Recent studies indicate that, while populations in East and Southern Africa are relatively stable, it is evident that they are declining at an alarming rate across West and Central Africa (Bauer & van der Merwe, 2004; Bauer *et al.*, 2008; Henschel *et al.*, 2010). Historically, lions occurred throughout the whole region of North, West and Central Africa, except the coastal forests of West Africa and the Congo basin extending to Nigeria (Nowell & Jackson, 1996). In the Sahara region and in North Africa, lions became extinct during the 19th and 20th century. Compared with the data presented by range states during the lion workshop of 2005 (IUCN/SSC, 2006), recent surveys of lion populations conducted in West and Central Africa further suggest that there are large gaps in the lion's range in this region (Henschel *et al.*, 2010),

The region of West and Central Africa hosts in total 1800-4000 adult lions within 11 Lion Conservation Units (Bauer & van der Merwe, 2004; Chardonnet, 2002; IUCN/SSC, 2006). Cameroon is an important range state in Central Africa, having the second largest lion population (240-360) in the region, after the Democratic Republic of Congo (Bauer & van der Merwe, 2004; IUCN/SSC, 2006). However, the number of 240-360 lions is an estimate from 2003 and is expected to be much lower at present, probably approximately 220 adult individuals (Croes *et al.*, 2011; Riggio *et al.*, *in prep.*). Lions in Cameroon occur in two Lion Conservation Units. The first, the **Bénoué complex, which includes three National Parks and 28 hunting zones**, is the larger area hosting the majority (200-300) of the country's lion population. This complex is particularly important for lion conservation in the region of West and Central Africa because until recently, it was connected to lion populations in Chad and Nigeria (IUCN/SSC, 2006; Croes *et al.*, 2011). Unfortunately, a recent survey in the Gashaka-Gumti protected area in Nigeria, adjacent to this complex, has no longer revealed evidence for the presence of lions in this area (Henschel *et al.*, 2010). The second conservation unit concerns Waza National Park, which in contrast to the **Bénoué complex, is small and geographically isolated**, hosting a small lion population with low probability of genetic exchange with other populations through natural dispersal. However with the legal protection accorded to this park [article 2 (1) decree N°95/466/PM of July 20, 1995] and the protected status of the lion as a category A species in Cameroon [decision N°0565/A/DFAP/SDF/SRC/ of August 14, 1998], the lion population in Waza National Park, even though small, ap-

pears to have been relatively stable for the past three decades of the last century (Bauer, 2003; IUCN/SSC, 2006; Scholte *et al.*, 2007; de Jongh & Bauer, 2008).

The historic distribution range of lions in Cameroon extended from the extreme north to the centre region of the country, at the border of the dense equatorial forest (Depierre & Vivien, 1992). No data exist on historic numbers of lions in Cameroon. However, in Waza National Park Flizot (1962) reported 100 lions in the 1960s whilst a population of 40-60 lions was estimated in 2002 through call-up stations in two different studies (Schultz & Turks, 2002; Bauer & van der Merwe, 2004). In the Bénoué complex a population of 200-300 lions was reported around 2003 (Bauer & van der Merwe, 2004; IUCN/SSC, 2006). Recent findings of Croes *et al.* (2011) in this area demonstrated extremely low lion densities in the hunting zones situated between the three national parks in this complex, indicating a recent declining trend. The aim of this research was to analyse the size and structure of the Waza lion population and identify threats faced by this population to give an update of the lion's status.

1.3 Spatial ecology of lions

Information on the spatial ecology of large carnivores is paramount in conservation planning. As with other species of wild fauna, lion conservation in West and Central Africa is challenged by a lack of data on almost all aspects of lion ecology. A species' risk of extinction may be determined both by intrinsic biological traits as well as by exposure to external anthropogenic threats (Cardillo *et al.*, 2004). Species at a high trophic level, occurring at low densities, require large areas for ranging, which increases their vulnerability and compounds their extinction risk in heavily-impacted ecosystems. The Waza area is highly impacted by human pressures such as poaching, encroachment for agriculture, digging of fishing canals and grazing by livestock. There is no transitional buffer zone between the park and surrounding human settlements. As described by Bauer (2003), it is a hard-edged park that is surrounded by human population densities of more than 30 inhabitants/km². There are more than 100,000 resident farmers, pastoralists and fishermen who use resources in the eastern periphery of the park, not to mention the yearly influx of pastoralists during transhumance from Nigeria, Chad and southern Cameroon. Lions live in family units and are highly susceptible to anthropogenic pressure. This

study investigated the lion's ranging behaviour and its movement and activity patterns inside and outside Waza National Park in order to improve management and conservation planning.

1.4 Lion diet and prey selection

Research on lion feeding ecology elucidates how prey size and abundance determine the lion's diet and how prey availability and accessibility may impact lion populations. This information contributes substantially to the understanding of the lion's behavioural ecology (Mills, 1992). Prey may be available but not accessible for several reasons. Accessibility of prey is influenced by intrinsic factors of the prey species (such as size, mobility and defensive capacity) and external factors (such as habitat cover, geographical barriers and competition with other predators). Prey availability and prey accessibility are also related to prey distribution, which is influenced by season, showing higher dispersion of prey during the wet season and more concentration around water holes during the dry season. These dynamics influence prey selection and hunting success (Fuller *et al.*, 1992, Sunquist & Sunquist, 1997), and may also influence the lion's activity pattern and spatial distribution (Henschel & Skinner, 1990). Habitat factors such as grass, shrub and tree cover, time of day, moonlight and weather conditions can also affect the lion's hunting success (van Orsdol, 1984; Stander & Albon, 1993; Mills *et al.*, 1995; Funston *et al.*, 2001).

The feeding ecology of large savannah carnivores has been well studied in East and Southern Africa (Kruuk & Turner, 1967; Pienaar, 1969; Mills & Biggs, 1993; Hayward & Kerley, 2005). However, there are only a small number of scientific studies on the diet of large carnivores in West and Central Africa (Wanzie, 1986; Gross, 1997; Di Silvestre, 2000; Korb, 2000, Breuer, 2005; Henschel *et al.*, 2005), with very few concerning lions (Wiggers, 2007). Studies on lion diet in East and Southern Africa show that lions prefer large prey species irrespective of their availability (Hayward & Kerley, 2005). According to Bauer *et al.* (2008) lions in the region of West and Central Africa prefer medium-sized prey. Recently, another study on lion diet in the Pendjari biosphere reserve in Benin showed, however, that the lions there also preferred large-sized prey such as African buffalo (*Syncerus cafer nanus*), just as lions in East and Southern Africa (Sogbohossou, 2011). This highlights the need for more findings on the lion's diet in the region of West and Central Africa. In Waza National Park large-

sized prey species such as the buffalo have gone locally extinct, which may explain the preference for medium-sized prey. However, also natural medium-sized prey are presently declining in Waza National Park (de Iongh *et al.*, 2004; Scholte *et al.*, 2007; de Iongh & Bauer, 2008; Foguekem *et al.*, 2010). On the other hand, densities of livestock are increasing along the periphery of the park Foguekem *et al.* (2010), and intrusions into the park are also frequent. There are clear indications that lions predate on livestock, thus the contribution of livestock to the lion's diet was also investigated.

A further point of interest concerns the influence of moonlight on livestock raiding. The full moon has been demonstrated to be a reliable indicator of impending danger of lion attacks on humans in Tanzania, because most lion attacks on humans occur during full moon (Packer *et al.*, 2011b). Lion attacks on humans are rare in West and Central Africa, but attacks on livestock are common. This raises the question whether full moon phases also influence the behaviour of lions and predation on livestock in Waza National Park.

1.5 Human-lion conflicts due to livestock predation

Human-lion conflicts are a common problem throughout the lion's range in Africa (Stander, 1990; Butler, 2000; Bauer *et al.*, 2001; Loveridge *et al.*, 2001; Patterson, 2004; Patterson *et al.*, 2004; van Bommel *et al.*, 2007) and are a real challenge for lion conservation. This problem is one of the major threats to lion populations, especially in West and Central Africa, as it often results in retaliatory killing of lions (Nowell & Jackson, 1996; Bauer *et al.*, 2001; Sogbohossou, 2011). Together with the strong decline of natural prey, human pressures such as high livestock density and habitat encroachment result in frequent interactions between the lion and livestock in areas where humans live at close proximity to wildlife habitats. Factors that make predators vulnerable to local extinction as well as the damage caused by predation have been documented around Waza National Park (Bauer, 2003; van Bommel *et al.*, 2007). Methods that could mitigate livestock predation by lions in this park have until recently not been investigated. Recently, Bauer *et al.* (2010) assessed methods that mitigate livestock predation in the region of West and Central Africa. The building of (experimental) enclosures in six villages south of Waza National Park was demonstrated to considerably reduce livestock depredation. In this study, a broader investigation was made of various possible

methods to mitigate human-lion conflicts. This study aims to characterize methods used by resident and nomadic pastoralists for preventing livestock predation by lions, and to investigate the effectiveness of these methods.

1.6 Main aim and research questions of the thesis

The main aim of this thesis is to fill the gap in knowledge on lion research in West and Central Africa compared to East and Southern Africa. Until now, findings on lions in East and Southern Africa have been assumed to hold true for lions in West and Central Africa in the absence of scientific data from this region. This thesis studies lions in the entire Waza National Park including the floodplain area, which have not been studied before. The research aims presented in the above sections lead to the following research questions:

- What is the current population status and social structure of lions in Waza National Park? What are the threats faced by this lion population? (Chapter 2)
- How does the declining prey population impact on the lion's spatial ecology in Waza National park? Are there seasonal and intersexual variations in home range sizes of lions in Waza National Park? (Chapter 3)
- What is the movement and activity pattern exhibited by lions in Waza National Park and what factors influence this pattern? (Chapter 4)
- What constitutes the lion's diet in Waza National Park? How much does livestock contribute to the lion's diet? (Chapter 5)
- Does moon phase influence attacks by lions on livestock in Waza National Park? (Chapter 6)
- How intense are human-lion conflicts around Waza National Park? Do resident and nomadic pastoralists practice the same methods to mitigate predation by lions on their livestock? Which of these methods are effective in mitigating livestock losses to lions? (Chapter 7)

1.7 Study area

Location

The Waza National Park, established in 1968, is located in the extreme north region of Cameroon. Situated between latitudes 10°50' and 11°40'

and longitudes 14°20' and 15°00', it lies in close proximity to the frontiers of Nigeria in the West and Chad in the East. It covers a surface area of approximately 1,700 km². It was classified as a biosphere reserve in May 1979 (WCMC, 1983).

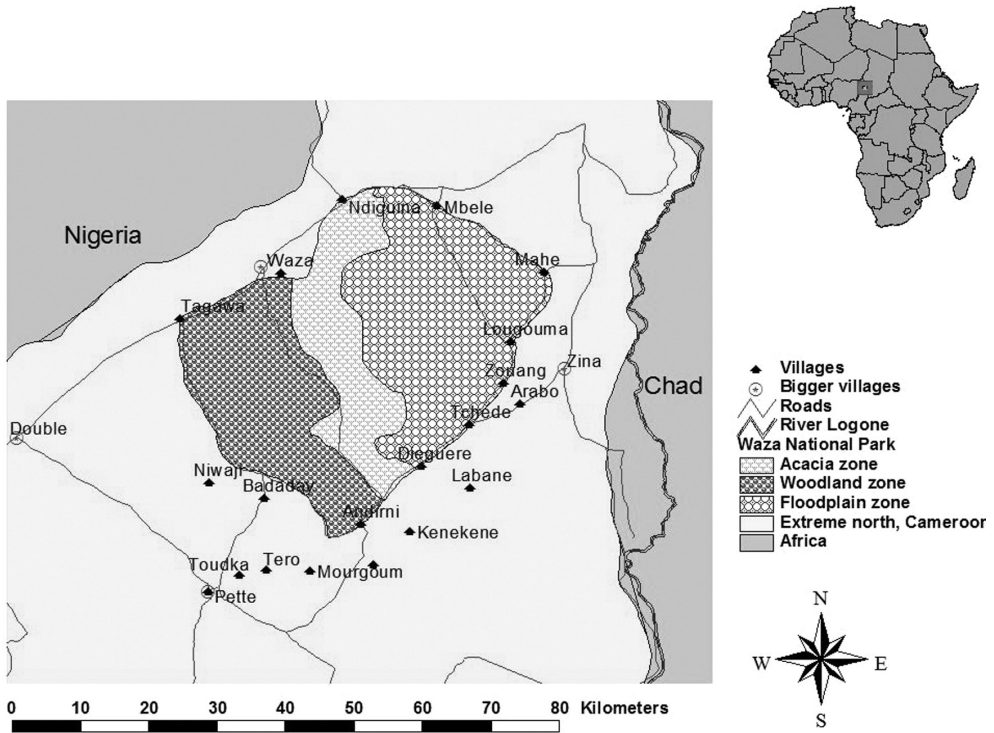


Figure 1.1 Map of Waza National Park, Cameroon

Physical environment

Waza National Park is situated in the Sudano-Sahelian ecological zone. The climate is semi-arid tropical characterized by three seasons: a wet season, from June to October; a cold dry season, from November to February; and a hot dry season, from March to May. Rainfall is low and irregular between years, with an annual mean of 600 mm (Beauvilain, 1995). Temperatures vary from a mean minimum of 15° C in December to a mean maximum of 48° C in April. Situated in the Lake Chad basin south of Lake Chad, the topography is flat, ranging from 300-320 m above sea level from east to west. Exceptions include the three granite inselbergs in Waza village, at the park entrance, that rise up to 480 m. Soils in the

western half of the park are sandy while the eastern half has clay soils. The eastern part of the park lies within the Logone floodplain (yaérés) and is inundated during the rainy season and part of the cold dry season with rain and flood waters from the River Logone and its tributaries. There is no permanent flowing water source in the park; rather, there are artificial and natural waterholes that are filled by rain and flood waters. Most of the waterholes dry out during the dry months but some do retain water throughout the year. The flooding of the park and the entire floodplain has been greatly reduced since the construction of the Maga dam in 1976. One of the containment dykes along the Logone River was opened in 1994 by the IUCN Waza Logone project to mitigate the adverse ecological effects caused by the Maga dam on the natural flooding regime of the Waza Logone floodplain.

Biotic environment

Waza National Park has three main vegetation types: 1) In the eastern half with heavy cracking clay soils (vertisols), the floodplain vegetation is dominated by grasses such as *Sorghum arundinaceum*, *Pennisetum ramosum*, *Echinochloa pyramidalis*, *Oriza longistaminata*, *Hyparrhenia rufa* and *Vetiveria nigritana*; 2) The area between the floodplain and the woodland zones, also with clay soils, consists mainly of *Acacia seyal* trees interspersed with *Balanites aegyptiaca*, *Pilostigma reticulata* and *Sorghum arundinaceum*; 3) The woodland zone on sandy soils in the west of the park is dominated by *Sclerocarya birrea*, *Anogeissus leiocarpus* and *Lannea humilis* (Wit, 1975).

Waza National park used to be an important tourist destination, but tourist numbers have dropped from 7,000 per year in the 1990s to 2,000 per year in recent years (Loth, 2004). The park is listed as an Important Bird Area (Fotso *et al.*, 2001) and is the first RAMSAR site in the country due to its wetland. Waza National Park is also listed by IUCN as one of the locations for threatened antelopes (East, 1999). It has an important animal diversity, with 379 bird species including the ostrich (*Struthio camelus*) and the black crowned crane (*Balearica pavonina*) (Scholte *et al.*, 1999). There are at least 30 species of mammals, including elephant (*Loxodonta africana*, *africana*), lion (*Panthera leo leo*), giraffe (*Giraffa camelopardalis*), spotted hyena (*Crocuta crocuta*), striped hyena (*Hyaena hyaena*), golden jackal (*Canis aureus*), side-striped jackal (*Canis adustus*), western kob (*Kobus kob kob*), topi (*Damaliscus korrigum*), roan antelope (*Hippotragus equinus*), gazelle (*Gazella rufifrons*), warthog (*Phacochoerus*

africanus), reedbuck (*Redunca redunca*) and Grimm's duiker (*Sylvicapra grimmia*) (Tchamba, & Elkan, 1995). The last two species are becoming very rare. Species that have become locally extinct during the past two decades include: leopard (*Panthera pardus*), cheetah (*Acinonyx jubatus*), waterbuck (*Kobus ellipsiprymnus*), bushbuck (*Tragelaphus scriptus*), African buffalo (*Syncerus cafer nanus*) and red flanked duiker (*Cephalophus rufilatus*) (Bauer & Kari, 2001).

Human environment

The Waza National Park is a hard-edged park with no transitional zone between human settlement and the park boundaries. There are about 19 villages near the park boundaries and a host of nomadic camps of pastoralists that practice transhumance in the area. The main production systems around the Waza Logone area are fisheries, animal husbandry and agriculture. Extensive pastoralism is carried out in the areas neighbouring the park. The largest ethnic groups involved in pastoralism are the Fulbé and the Choa Arab. Arab pastoralists are nomadic while the Fulbé can be grouped into nomadic pastoralists and agro-pastoralists. Resident ethnic groups in the floodplain are the Kotoko, who are mainly involved in fisheries, and the Mousgoum, involved in agriculture and small-scale animal husbandry. Most of the villages on the eastern borders of the Waza National Park were formerly within the park and were relocated, except one (Baram village) when the area was given the status of a National Park in 1968.

1.8 Thesis outline

This study comprises eight chapters. The first chapter is a general introduction and review of the study topic. It presents the research questions to be addressed and describes the study site. Chapter two deals with the research question addressing the status of the lions in Waza National Park. This chapter covers a review of the anthropogenic pressure on the park. The third and fourth chapters address lions' use of space and their movement and activity pattern in the park as well as the surrounding landscape. Chapter five examines lion diet composition and lion prey preference within the livestock-dominated Waza Logone area. The sixth chapter examines the relationship between livestock attacks and the lunar cycle. Chapter seven addresses the human-lion conflict in and around Waza National Park, with a focus on the anti-predation management

practices among nomadic and resident pastoralists. The effectiveness of some of the methods used to mitigate livestock predation by pastoralists in the area are tested and described. The last chapter discusses results and draws conclusions from the research findings. The thesis rounds up with recommendations for adaptive management and conservation of the lion in Waza National Park and the region as a whole.

References

- Bauer, H. (2003) *Lion conservation in West and Central Africa. Integrating social and natural science for wildlife conflict resolution around Waza National Park, Cameroon*. PhD thesis, Leiden University, The Netherlands.
- Bauer, H., de Iongh, H.H., Princée F.P.G. & Ngantou, D. (2001) Status and needs for conservation of lions in West and Central Africa. *Information Exchange Workshop, Limbe, Cameroon*.
- Bauer, H. & Kari, S. (2001) Assessment of the human-predator conflict with thematic PRA around Waza National Park. *PLA notes*, **41**, 9-13.
- Bauer, H., de Iongh, H.H., Princée F.P.G. & Ngantou, D. (2003) Research needs for lion conservation in West and Central Africa. *C. R. Biologies*, **326**, 112-118.
- Bauer, H. & Nowell, K. (2004) Endangered Classification for West African Lions. *Cat News*, **41**, 35-36.
- Bauer, H. & van der Merwe, S. (2004) Inventory of free ranging lions *Panthera leo* in Africa. *Oryx*, **38**, 26-31.
- Bauer, H., Vanherle, N., Di Silvestre, I. & de Iongh, H.H. (2008) Lion-prey relations in West and Central Africa. *Mammalian Biology*, **73**, 70-73.
- Bauer, H., de Iongh, H.H. & Sogbohossou, E. (2010) Assessment and mitigation of human- lion conflict in West and Central African. *Mammalia*, **74**, 363-367.
- Beauvilain, A. (1995) *Tableau de la pluviométrie dans les bassins du Tchad et de la Bénoué de la création des stations a décembre 1994*. Unpublished Report. Centre national d'appui a la recherche, Tchad.
- Bertola, L.D., van Hooft, W.F., Vrieling, K., Uit de Weerd, D.R., York, D.S., Bauer, H., Prins, H.H.T., Funston, P.J., Udo de Haes, H.A., Leirs, H., van Haeringen, W.A., Sogbohossou, E., Tumenta, P.N. & de Iongh, H.H. (2011) Genetic diversity, evolutionary history and implications for conservation of the lion (*Panthera leo*) in West and Central Africa. *Journal of Biogeography*, **38**, 1356-1367.
- Beschta, R.L. & Ripple, W.J. (2009) Large predators and trophic cascades in terrestrial Ecosystems of the western United States. *Biological Conservation*, **142**, 2401-2414.
- Binot, A., Castel, V. & Caron, A. (2006) Wildlife-livestock interference in Sub-Saharan Africa. *Secheresse*, **17**, 349-361.

- Breuer, T. (2005) Diet choice of large carnivores in Northern Cameroon. *African Journal of Ecology*, **43**, 181-190.
- Burton, A.C., Buedi, E.B., Balangtaa, C., Kpelle, D.G., Sam, M.K. & Brashares, J.K. (2011) The decline of lions in Ghana's Mole National Park. *African Journal of Ecology*, **49**, 122-126.
- Butler, J.R.A. (2000) The economic costs of wildlife predation on livestock in Gokwe communal land, Zimbabwe. *African Journal of Ecology*, **38**, 23-30.
- Cardillo, M., Purvis, A., Sechrest, W., Gittleman, J.L., Bielby, J. & Mace, G.M. (2004) Human Population Density and Extinction Risk in the World's Carnivores. *PLoS Biology*, **2**, 0909-0914.
- Caro, T. & Scholte, P. (2007) When conservation falters. *African Journal of Ecology*, **45**, 233-235.
- Chardonnet, P. (2002) *Conservation of the African lion: Contribution to a status survey*. International Foundation for the Conservation of Wildlife, France & Conservation Force, USA.
- Craigie, I.D., Baillie, J.E.M., Balmford, A., Carbone, C., Collen, B., Green, R.E. & Hutton, M. (2010) Large mammal population declines in Africa's protected areas. *Biological Conservation*, **143**, 2221-2228.
- Croes, B.M., Funston, P.J., Rasmussen, G., Buij, R., Saleh, A., Tumenta P.N. & de Iongh, H.H. (2011) The impact of trophy hunting on lions (*Panthera leo*) and other large carnivores in the Bénoué Complex, northern Cameroon. *Biological Sciences*, **144**, 3064-3072.
- De Iongh, H.H., Bauer, H. & Hamling, P. (2004) *A review of nine years on a lion populations in Waza National Park, North Cameroon*. Paper for Conference 'Wildlife as a National Resource', Paris.
- De Iongh, H.H. & Bauer, H. (2008) Ten years of ecological research on lions in Waza National Park, Northern Cameroon. *CAT News*, **48**, 29-32.
- Depierre & Vivien, J. (1992) *Mammals of Cameroon*. French Cooperation, Fontainebleau, France.
- Di Silvestre, I., Novelli, O. & Bogliani, G. (2000) Feeding habits of the spotted hyaena in the Niokolo Koba National Park, Senegal. *African Journal of Ecology*, **38**, 102-107.
- East, R. (1999). *African antelope database*. IUCN/ SSC Antelope Specialist Group, IUCN, Gland.
- Estes, J.A., Terborgh, J., Brashares, J.S., Power, M.E., Berger, J., Bond, W.J., Carpenter, S.R., Essington, T.E., Holt, R.D., Jackson, J.B.C., Marquis, R.J., Oksanen, L., Oksanen, T., Paine, R.T., Pickett, E.K., Ripple, W.J., Sandin, S.A., Scheffer, M., Schoener, T.W., Shurin, J.B., Sinclair, A.R.E., Soulé, M.E., Virtanen, R., David A. & Wardle, D.A. (2011) Trophic Downgrading of Planet Earth. *Science*, **333**, 301-306.

- Fisher, F. & Linsenmair, E.K. (2001) Decrease in ungulate population densities. Examples from Como National Park, Ivory Coast. *Biological Conservation*, **101**, 131-135.
- Flizot, P. (1962) The Waza National Park in Northern Cameroon. *African Wildlife*, **16**, 293-297.
- Foguekem, D., Tchamba, M.N. & Omondi, P. (2010) Aerial survey of Elephants (*Loxodonta africana africana*), other large mammals and human activities in Waza National Park, Cameroon. *African Journal of Environmental Science and Technology*, **4**, 401-411.
- Fotso, R., Dowsett-Lemaire, F., Dowsett, R.J., Cameroon Ornithological Club, Scholte, P., Languy, M. & Bowden, C. (2001) In L.D.C. Fishpool and M.I. Evans (eds). *Important bird areas of Africa and associated islands: priority sites for conservation*. Pisces Publications and BirdLife International, Newbury and Cambridge, UK. *BirdLife Conservation*, **11**, 133-159.
- Fraser, C. (2009) *Rewilding the World: Dispatches from the Conservation Evolution*. 400 pp. Metropolitan Books, Macmillan, New York, USA.
- Fuller, T.K., Kat, P.W., Bulger, J.B., Maddock, A.H., Ginsberg, J.R., Burrows, R., McNutt, J.W. & Mills, M.G.L. (1992) Population dynamics of African wild dogs. In *Wildlife 2001: Populations*. McCullough, D. R. & Barrett, H. (eds), Elsevier Science Publisher, London, UK.
- Funston, P.J., Mills, G.G.L. & Biggs, H.C. (2001) Factors affecting the hunting success of male and female lions in the Kruger National Park. *Journal of Zoology*, **253**, 419-431.
- Gross, P. (1997) Leopards in Ivory Coast. *Cat News*, **27**, 12-13.
- Hayward, M.W. & Kerley, G.I.H. (2005) Prey preferences of the lion (*Panthera leo*). *Journal of Zoology*, **267**, 309-322.
- Henschel, J.R. & Skinner, J.D. (1990) The diet of the spotted hyaena (*Crocuta crocuta*) in Kruger National Park. *African Journal of Ecology*, **28**, 69-82.
- Henschel, P., Abernethy, K.A. & White, L.J.T. (2005) Leopard food habits in the Lope National Park, Gabon, Central Africa. *African Journal of Ecology*, **43**, 21-28.
- Henschel, P., Azani, D., Burton, C., Malanda, G., Saidu, Y., Sam, M. & Hunter, L. (2010) Lion status updates from five range countries in West and Central Africa. *Cat News*, **52**, 34-39.
- IUCN SSC, Cat Specialist Group (2006) *Conservation Strategy for the Lion in West and Central Africa*. Yaounde, Cameroon.
- Johnson, C.N., Isaac, J.L. & Fisher, D.O. (2007) Rarity of a top predator triggers continent-wide collapse of mammal prey: dingoes and marsupials in Australia. *Proceedings of the Royal Society B*, **274**, 341-346.
- Karanth, K.K., Nichols, J.D., Ullas Karanth, M.K., Hines, J.E. & Christensen, N.L.Jr. (2010). The shrinking ark: patterns of large mammal extinctions in India. *Proceedings of the Royal Society B: Biological Sciences*, **277**, 1971-1979.

- Kingdon, J. (2003) *The Kingdon field guide to African Mammals*. Kingdon, J. (ed), Princeton University Press, USA.
- Korb, J. (2000) Methods to study elusive spotted hyaenas in the Comoé National Park IUCN/SSC *Hyaena Specialist Group Newsletter*, **7**, 3-11.
- Kruuk, H. & Turner, M. (1967) Comparative notes on predation by lion, leopard, cheetah and wild dog in Serengeti area, East Africa. *Mammalia*, **31**, 1-27.
- Letnic, M., Koch, F., Gordon, C., Crowther, M.S. & Dickman, C.R. (2009) Keystone effects of an alien top-predator stem extinctions of native mammals. *Proceedings of the Royal Society B*, **276**, 3249-3256.
- Loth, P. (2004). *The return of the water. Restoring the Waza Logone floodplain in Cameroon*. IUCN Gland, Switzerland.
- Loveridge, A.J., Lyman, T. & Macdonald, D.W. (2001) *Lion Conservation Research Workshop 1: Survey Techniques*. Wildlife Conservation Research Unit, Oxford, UK.
- Loveridge, A.J., Searle, A.W., Murindagomo, F. & Macdonald, D.W. (2007) The impact of sport-hunting on the population dynamics of an African lion population in a protected area. *Biological Conservation*, **134**, 548-558.
- Maddox, T. (2003) *The ecology of cheetahs and other large carnivores in a pastoralist-dominated buffer zone*. PhD thesis. University of London, London, UK.
- Miller, B., Dugelby, B., Foreman, D., Martinez del Río, C., Noss, R., Phillips, M., Reading, R., Soulé, M.E., Terborgh, J., Louisa Willcox, L. (2001) The Importance of Large Carnivores to Healthy Ecosystems. *Endangered Species UPDATE*, **18**, 202-210.
- Mills, M.G.L. (1992) A comparison of methods used to study food habits of large African carnivores. In *Wildlife 2001: Populations*, McCullough, D.R. & Barrett, H. (eds), pp. 1112-1124. Elsevier Applied Science, London, UK.
- Mills, M.G.L. & Biggs, H.C. (1993) Prey apportionment and related ecological relationships between large carnivores in Kruger National Park. *Symposium Zoological Society, London*, **65**, 253-268.
- Mills, M.G.L., Biggs, H.C. & Whyte, I.J. (1995) The relationship between lion predation, population trends in African herbivores and rainfall. *Wildlife Resources*, **22**, 75-88.
- Nowell, K. & Jackson, P. (1996) *Wild cats, status survey and conservation action plan*. IUCN SSC, Cat Specialist Group, Gland, Switzerland.
- Packer, C., Brink, H., Kissui, B.M., Maliti, H., Kushnir, H. & Caro, T. (2011a) Effects of trophy hunting on lion and leopard populations in Tanzania. *Conservation Biology*, **25**, 142-153.
- Packer, C., Swanson, A., Ikanda, D., & Kushnir, H. (2011b) Fear of darkness, the full moon and the nocturnal ecology of lions. *PLoS ONE*, **6**, 1-5.
- Patterson, B.D. (2004) *The Lions of Tsavo: Exploring the Legacy of Africa's Notorious Maneaters*. McGraw-Hill, New York.

- Patterson, B.D., Kasiki, S.M., Selempo, E. & Kays, R.W. (2004) Livestock predation by lions (*Panthera leo*) and other carnivores on ranches neighbouring Tsavo National Park, Kenya. *Biological conservation*, **119**, 507-516.
- Pienaar, U. de V. (1969) Predator-prey relationship amongst the larger mammals in the Kruger National Park. *Koedoe*, **12**, 108-176.
- Riggio, J., Jacobson, A., Dollar, L., Bauer, H., Becker, M., Dickman, A., Funston, P., Groom, R., Henschel, P., De Iongh, H., Lichtenfeld, L. & Pimm, S. (In prep) The size of savannah Africa: a lion's view.
- Schaller, G.B. (1972) *The Serengeti lion: A Study of Predator-Prey Relations*. Schaller G.B. (ed), University of Chicago press, Chicago, USA.
- Schaller, G.B. (1976) *The Serengeti Lion: A study of Predator-Prey Relations*. Schaller, G.B. (ed), University of Chicago Press, Chicago, USA.
- Scholte, P., De Kort, S. & van Weerd, M. (1999) The birds of the Waza Logone area, Far North Province, Cameroon. *Malimbus*, **21**, 16-49.
- Scholte, P., Adam, S. & Serge, B.K. (2007) Population trends of antelopes in Waza National Park (Cameroon) from 1960 to 2001: the interacting effect of rainfall, flooding and human interventions. *African Journal of Ecology*, **45**, 431-439.
- Schultz, S. & Turk, R. (2002) *Population ecology of the lion (Panthera leo) in Waza National Park, Cameroon. Student report no. 153*. Institute of Environmental Sciences, Leiden University, The Netherlands.
- Sogbohossou, E.A. (2004) *Etude des conflits entre les grands carnivores et les populations riveraines de la Réserve de Biosphère de la Pendjari, Nord Bénin*. Bourse Jeune Chercheurs MAB UNESCO.
- Sogbohossou, E.A. (2011) *Lions of West Africa: Ecology of lion (Panthera leo Linnaeus 1857) populations and human-lion conflicts in Pendjari Biosphere Reserve, North Benin*. PhD Thesis. Leiden University, Leiden, The Netherlands.
- Stander, P.E. (1990) A suggested management strategy for stock-raiding lion Namibia. *South African Journal of Wildlife Resources*, **20**, 37-43.
- Stander, P.E. & Albon, S.D. (1993) Hunting success of lions in a semi-arid environment. *Symposium of the Zoological Society*, **65**, 127-143.
- Sunquist M.E. & Sunquist F.C. (1997) Ecological constraints on predation by large felids. In *Riding the tiger: tiger conservation in human dominated landscapes*. Seidensticker J., Christie S. & Jackson P. (eds). London: Zoological Society of London and Cambridge University Press.
- Tchamba, M. & Elkan, P. (1995) Status and trends of some large mammals and ostriches in Waza national park, Cameroon. *African Journal of Ecology*, **33**, 366-376.
- Terborgh, J., Lopez, L., Nuñez, P., Rao, M., Shahabuddin, G., Orihuela, G., Riveros, M., Ascanio, R., Adler, G.H., Thomas D. Lambert, T.D., & Balbas, L. (2001) Ecological Meltdown in Predator-Free Forest Fragments. *Science*, **294**, 1923-1926.

- Turner, A. & Anton, M. (1997) *The big cats and their fossil relatives: an illustrated guide to their evolution and natural history*. Columbia University Press, New York, United States of America.
- Van Bommel, L., de Vaate, M.D.B., de Boer, W.F. & de Iongh, H.H. (2007) Factors affecting livestock predation by lions in Cameroon. *African journal of ecology*, **45**, 490-498
- Van Orsdol, K.G. (1984) Foraging behaviour and hunting success of lions of lions in Queen Elizabeth National Park, Uganda. *African Journal of Zoology*, **22**, 79-99.
- Wanzie, C. (1986) Mortality factors of Buffon's kob (*Kobus kob kob*) (Erxleben) in Waza National Park, Cameroon. *Mammalia*, **50**, 351-356.
- Whitman, K., Quadling, H., Starfield, A. & Packer, C. (2004) Sustainable trophy hunting in African lions. *Nature*, **428**, 175-178.
- Wiggers, H. (2007) *Predator-Prey interactions in North-Cameroon; Predation patterns and diets of Lion (Panthera leo), Spotted Hyaena (Crocuta crocuta) and Leopard (Panthera pardus) in Bénoué National Park*. Student Report no 213. Environment and Development, Leiden University and University of Utrecht, The Netherlands.
- Wit, P. (1975) Preliminary notes on the vegetation of Waza National Park, FAO report, Rome.
- Woodroffe, R., & Ginsberg, J.R. (1998) Edge effects and the extinction of populations inside protected areas. *Science*, **280**, 2126-2128.
- Woodroffe, R. (2000). Predators and people: using human densities to interpret declines of large carnivores. *Animal Conservation*, **3**, 165-173.
- World Conservation Monitoring Centre (1983) www.biology.uni-hamburg.de/online/afrika/wcmc/waza.htm

