
Threat of rapid extermination of the lion (*Panthera leo leo*) in Waza National Park, Northern Cameroon

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Abstract

Lion populations in West and Central Africa are small and fragmented. In areas where park management is weak, threats will likely facilitate the extinction of the lion. Wildlife management requires knowledge of the population estimate. The population of lions in Waza National Park (Waza NP) was assessed by individual identification of members in the population. The population was assessed to comprise of 14–21 adult individual lions. The age structure was skewed towards adults; cubs comprised 22% of all lions identified while the sex ratio was 1 : 3. Two out of four collared lions were lost to illegal, retaliatory killings within 1 year; and probably two more males and one more female were also killed during this period. The lion population appears to have declined during the last 5 years with six lions dying per year, which is at a much higher rate than observed in the previous decades. Human-livestock pressure has increased tremendously in this period, resulting to frequent human-lion conflicts. To ensure the survival of the lion in Waza NP and in the entire region, management needs to intensify efforts to mitigate the pressure from humans and their livestock.

Key words: Cameroon, lion population decline, retaliatory killings

Résumé

Les populations de lions d'Afrique centrale et de l'Ouest sont petites et fragmentées. Dans les régions où la gestion des parcs est médiocre, des menaces risquent de faciliter l'extinction des lions. La gestion de la faune sauvage exige de connaître l'estimation des populations. On a évalué la population de lions du Parc National de Waza (PN Waza)

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en identifiant individuellement ses membres. On a estimé que cette population comptait de 14 à 21 adultes. La structure d'âge était biaisée en faveur des adultes; les lionceaux représentaient 22% de tous les lions identifiés et le sex-ratio était de 1/3. Deux des quatre lions équipés d'un collier émetteur furent tués illégalement en un an, en guise de représailles; deux autres mâles et une autre femelle furent aussi tués pendant cette période. La population de lions semble avoir décliné au cours des cinq dernières années, avec la mort de six lions par an, ce qui est un rythme beaucoup plus rapide que celui observé au cours des décennies précédentes. La pression des hommes et du bétail a terriblement augmenté pendant cette période, ce qui a entraîné de fréquents conflits entre hommes et lions. Pour garantir la survie des lions dans le PN Waza et dans toute la région, la gestion doit intensifier ses efforts pour atténuer la pression des hommes et de leur bétail.

Introduction

Lion populations in West and Central Africa are under serious threat. Bauer et al. (2003) had previously expressed their fears of an increasing risk of extinction of the lion in this region but the situation seems to have aggravated in recent years. Currently, the lion is classified as regionally Endangered in West Africa (Bauer & Nowell, 2004). Unlike in East and Southern Africa where, with a few exceptions, lion populations are large and relatively stable, the West and Central African lion populations are small and their ranges generally fragmented (Nowell & Jackson, 1996; Bauer & Van der Merwe, 2004). Recent estimates in this region range from only 1750 (Bauer & van der Merwe, 2004) to nearly 4000 individuals (Chardonnet, 2002). Concurrently, in this region a decline of the natural prey base of the lion has been observed (East,

1999; Fischer & Linsenmair, 2001; De Iongh, Bauer & Hamling, 2004; Scholte, 2007; Caro & Scholte, 2007), accompanied by a strong increase of livestock (Binot, Castel & Caron, 2006; De Iongh & Bauer, 2008). Semi-nomadic herding activities in the Sudano-Sahelian belt increase the frequency of interactions between humans, livestock and wildlife leading to an increase of human-lion conflicts. The replacement of natural prey by livestock and the subsequent increase of human-lion conflicts may therefore be a core factor in the present decline of the West and Central African lion population.

This article focuses on the lion population in Waza NP, Northern Cameroon. In this park the above trends are all being observed. The lion population seems to have declined from 100 individuals in 1962 (Flizot, 1962) to between 40 and 60 in 2002 (Bauer et al., 2003; Bauer & Van der Merwe, 2004). Similarly the population of the Western kob antelope (*Kobus kob kob*), which is the most abundant natural prey in Waza NP, has dramatically dropped from 25,000 in 1962 to about 6000 in 2000 and to below 1600 in 2007 (De Iongh et al., 2004; Scholte et al., 2007; Omondi, Mayienda & Tchamba, 2007). Regarding livestock, Scholte et al. (2003) reported that after the reflooding in 1994, a threefold increase in livestock grazing intensity was observed around Waza NP due to an immigration of pastoralists into the Logone floodplain. According to them, the antelope number increased only slightly as a consequence of the reflooding. These findings were confirmed by an aerial survey conducted by Worldwide Fund for Nature in early 2007, which revealed 21,000 heads of livestock within a 5 km buffer of the park against only about 2600 heads of all natural prey counted in and around the park (Omondi et al., 2007).

This article presents the status of the lion population in Waza NP and highlights the illegal killing of lions in and around this park. Various data are used to make the most probable estimate of the current Waza lion population for comparison with previous estimates. The population structure of these lions will be described and the vitality of the population discussed. An attempt will be made to evaluate the human-livestock activities in this park.

Methods

Study area

This study was performed in the Waza NP that covers a surface area of approximately 1700 km² and lies between

latitudes 10°50' and 11°40' and longitudes 14°20' and 15°00'. About half of the park (the northern and eastern side) is located within the floodplain of the Logone River. Here the topography is flat with clay soils that are prone to seasonal inundation. The south-western side of the park is situated on sandy deposits of the fringe of the Lake Chad basin. At 320 m above sea level, this part of the Park is about 20 m higher than the north-eastern part. It is slightly undulating, with height differences of a few meters, and is never flooded. Three granite inselbergs at Waza village form the main entrance to the Park. The climate of the region is semi-arid, with a dry season from October to May. Rainfall is irregular, with an annual mean of 600 mm. Temperatures range from 15°C (December mean minimum) to 48°C (April mean maximum).

The Waza NP is habitat to a rich wildlife and is a popular tourist destination where animals are easily observed on its open floodplain. The park has at least 30 mammal species including lion (*Panthera leo leo*), elephant (*Loxodonta Africana Africana*), giraffe (*Giraffa camelopardalis*), roan antelope (*Hippotragus equinus*), topi (*Damaliscus korrigum*), kob antelope (*Kobus kob kob*), red fronted gazelle (*Eudorcas rufifrons*) and warthog (*Phacochoerus africanus*); and an avifauna of 379 species including ostrich (*Struthio camelus*) and black-crowned crane (*Balearica pavonina*) (Scholte, De Kort & Van Weerd, 1999). The park has no permanent flowing water source but is supplied by flood waters from the rivers Logone and Logomatya as well as from rain water. Water is held in artificial and natural reservoirs in the park but during the dry months of the year most of these waterholes dry out. However, most waterholes in the floodplain section of the park and a few in the woodland retain water all year round. The park has three distinct vegetation zones, from the west to the east: woodland zone (31%) dominated by *Sclerocarya birrea*, acacia zone (27%) dominated by *Acacia seyal* and floodplain (42%) which consist of grassland. The first two vegetation zones are located in the south-western side of the park with sandy soils while the third vegetation zone is located in the north-eastern side of the park with clay soils.

Sampling techniques

The main approach for the assessment of the lion population in Waza NP consisted of the identification of individual lions during the study period from May 2007 to June 2008. In this way a full description of the lion population was achieved in the assessed area. This individual

identification was achieved by directly observing the lions during field work, lion collaring as well as from photos of a camera trapping survey.

Encounters of the researchers with lions permitted their identification as well as mapping of the lions in Waza NP. For each encounter, a pre-structured format was filled, indicating group size and group composition. Individual features, like vibrissae patterns, scars and ear cuts were drawn on a full face outline and other features like broken teeth were noted (Pennycuick & Rudnai, 1970). Photographs of each individual were taken when possible. Assessment of age was done as described by Smuts, Anderson & Austin (1970) and Schaller (1972). Structured questionnaires deposited at the entrance to the park were completed by tourists, tour guides and park guards. Questions dealt with when and where lions were sighted, group size and group composition. A total of 95 forms were completed and analysed during the research period. These forms were checked regularly and recent lion sightings were verified by visiting the reported sites.

Lion collaring operations were conducted in May 2007 and May 2008 in Waza NP for monitoring purposes. Four Vectronic GPS-PLUS collars equipped with a VHF transmitter, supplied with a Handheld Terminal that communicates with the collars, were fixed on two male (Adam and Jean-Pierre) and on two female lions (Elizabeth and Fanne) in May 2007. One Vectronic GPS-PLUS collar and two African Wildlife Tracking GPS GSM collars were fixed on one male (Falama) and two female lions (Rossie and Fanne) in May 2008 respectively. Lions were attracted within darting distance using a calling station set-up adapted from Ogutu & Dublin (1998). Calls were played 30–45 min alternated by 15 min of silence until lions showed up. An MP-3 player connected to a 400 W amplifier and two speakers (50 Watt each) placed on the roof of the car supplied the sound playback. Before attaching the bait (kob antelope) firmly to a tree, a trail of about 1 km was made in different directions. Darting was accomplished from a Dan-inject immobilization gun with a 1.5 ml dart containing Zoletil 100. Lions that responded to the calling stations were identified.

A camera trapping survey was conducted from the 5th of March to the 17th of April 2008 to provide further information about the lion population in Waza NP. Our set up was adapted from Karanth & Nichols (1998, 2000) and Henschel & Ray (2003). Camera trapping sites were selected based on cues such as lion tracks, droppings, sightings and presence of waterholes while large gaps were

randomly filled. The survey was accomplished by dividing the park into three sampling blocks almost respecting the three vegetation zones of the park. Given the number of cameras available, all 21 cameras were placed in the first block and relocated twice to the second and third blocks for 2 weeks each. Cameras were revisited after 6 days to replace batteries and/or film. Following the sizes of the vegetation zones of the park, 22 trapping sites were in the woodland zone, 11 in the acacia zone and 30 in the floodplain zone bringing the total number of trapping sites to 63. These trapping sites were also considered as sighting sites for they were visited at least twice by researchers. All locations visited at least twice by researchers within the surveyed area were considered potential sites for encountering lions and were referred to as sighting sites.

Each camera (stealth Cam type MC2-GV) with a built in infrared moving sensor, was attached to a tree at knee height. A trail, bait and catnip (pheromone) were used to lure lions to the cameras. The kob antelope was chosen as bait and the trail of approximately 300 m was made by dragging the bait (1/10th of an adult kob) from different directions to the trapping site. The bait was attached on a tree opposite the camera at 1.5 m above the ground. The catnip was sprayed at the base of the tree holding the bait and on trees around to retain the lion in the vicinity (McElvain, Walters & Bright, 1942 and Hill et al., 1976).

Results

Based on the total observations from May 2007 to June of 2008, including the period of the camera trapping survey, a total of 26 individual lions (adults plus cubs) were identified in Waza NP (Table 1). At the end of the study period, two collared male lions were killed by livestock owners. In January of 2008, rumours about the killing of a group of lions, one carrying a collar, in a Cameroon-Nigerian border village prompted the researchers to start tracking collared lions out of the park. A signal was received from 'Jean-Pierre' in a peripheral village south of the park. Using triangulation, the signal strength was strongest in another village. Shockingly after a search in this village, the collar was found hanging from a tree. GPS data obtained from the collar revealed that the lion stopped activity at another location 4 km from where the collar was found. The location was visited and after an intensive search, scat was collected but there were no clues of the lion carcass. At about 700 m from this location (the next

Table 1 Observation of individuals and groups of lions in Waza NP from May 2007 to June 2008

Date	Location	Group composition	Group size	Encounter
05-05-07	Gobe	Jean-Pierre, Elizabeth, FI, CM1, CM2, CF3, CF4	3	Collaring
06-05-07	Gamzemia	Fanne	1	Collaring
10-05-07	Louloubaya	Adam, M1, M2, F2	4	Collaring
17-05-07	Sawarware	Jean-Pierre	1	Telemetry
17-05-07	Gobe	Elizabeth, F1, CM1, CM2, CF3, CF4	2	Telemetry
20-05-07	Dalazoa loop	Adam, M1, M2, F2	4	Telemetry
21-05-07	Sawarware	Jean-Pierre	1	Telemetry
21-05-07	Sawarware	M3, F3	2	Field work
21-05-07	Gobe	Elizabeth, F1, CM1, CM2, CF3,CF4	2	Telemetry
21-05-07	Talabal	Fanne	1	Telemetry
16-01-08	Kouloudika	CM5,CM6	0	Field work
19-01-08	Louloubaya-Bodelaram	F4	1	Field work
23-01-08	Village south of park	-	0	Killed18-11-07
02-02-08	Louloubaya-Bodelaram	F4,M4,C7,C8,C9	2	Field work
07-03-08	Bodelaram	F4,C7,C8	1	Field work
20-03-08	Sawarware	Fanne	1	Field work
29-03-08	Kouloudika-Louloubaya	Adam	1	Telemetry
08-04-08	Gamzemia	Falama	1	Field work
15-04-08	Mbouiet-Zeila	F1,F3,F5,F6	4	Field work
15-04-08	Goumbouremaram	Rosie, F7,CM5,CM6	2	Field work
16-04-08	Mengeng	Falama	1	Field work
16-04-08	Mengeng	M3	1	Field work
16-04-08	Gamzemia	Fanne	1	Field work
29-04-08	Waza NP limit	-	0	Killed04-04-08
30-04-08	Dalazoa	F4,M4,C7,C8	2	Field work
01-05-08	Gamzemia-Mengeng	Fanne,M3	2	Field work
18-05-08	Gamzemia	Falama	1	collaring
18-05-08	Goubouremaram	Rosie,CM5,CM6	1	collaring
19-05-08	Sawarware	Fanne,M3,F8,F9	4	collaring
28-05-08	Alaza	F5,F6	2	Field work
28-05-08	Alaza	Falama	1	Telemetry
04-06-08	Alaza	Fanne, F8	2	Field work
05-06-08	Toukouneram	M3	1	Field work
11-06-08	Goumbouremaram	F4,M4	2	Field work
12-06-08	Mbouiet	Elizabeth	1	Telemetry

F, adult female; M, adult male; CM/CF, male/female cub; killed, M1, M2 & F2, probably killed; CM1, CM2 & C9, probably death; CF3 & CF4, cubs to sub-adults.

location fix), a cattle carcass was found. In the nearest village to these sites, all investigations met aggression. Visits to other location fixes out of the park revealed lots of cattle carcasses. The villagers were intolerant to livestock depredation by lions. Later a signal from another lion 'Adam', was received with similar tracking. Although the time interval between when 'Adam' was killed and when the collar was discovered was relatively short, no carcass was recovered. Visits to 'Adam's' location fixes also revealed carcasses of raided livestock.

Probably also an adult female and two other adult males were killed. Two large cubs (CM1 and CM2) and one small cub (C9) probably did not survive. Of the eighteen individual lions remaining, three were males, eleven females and four cubs. All sightings made by tourists, guides and guards were verified and there were no additional individuals, besides the ones identified. Also there were no new individuals in photographs taken during the camera trapping survey besides those already identified. Lions identified during the camera trapping

survey were F4, M4, C7, C8, CM5, CM6, M3 and Falama (Table 1).

The surface area which was visited at least twice, including the investigated roads and all camera trapping sites represented 63% of the park. One may be tempted to extrapolate the number of identified lions to the total area of the park. This is not realistic however, as in the hot dry season both natural prey and cattle remain close to waterholes and lions follow their prey. All waterholes within the park were inside the investigated area. Therefore, the observed number is assumed to be the total population inside the park. However, there may also be a number of lions close to waterholes outside the park, where the cattle concentration is also high. It is assumed that these make up maximally seven adult individuals. Therefore, the total Waza lion population is assessed to comprise of 14–21 adult individuals.

In total six lion groups were mapped in this park. There were two groups in the woodland zone. One consisted of two small cubs, a female and an adult male with a less developed mane. The other was made up of two older male cubs and two adult females. The remaining four groups in the floodplain zone showed the fission-fusion patterns, splitting up at times in singles or pairs. A group of four adult females were identified that were occasionally seen in pairs; a group of an adult female, two sub-adult females and an adult male; and two solitary adult lions, male and female. The sex ratio based on mature individuals was 1 : 3 while the percentage of cubs in the population was 22%. The average group size of lions in this park was 1.6.

From the camera trapping survey, a total of 1914 photographs were taken: 1008 “blank” photos, 437 photos of carnivores, 186 photos of herbivores and 283 photos of humans and/or cattle. Blank photographs included those triggered by monkeys, birds, falling leaves and sand storms. The human and/or cattle category consisted of herdsmen, cattle, poachers and probably fishermen, all within the park. In the woodland zone of the park, 2 out of the 22 camera trapping sites had photographs of humans and/or cattle; in the acacia zone 1 out of 11 and in the floodplain 17 out of 30.

Discussion

The current estimate of 14–21 adult lions in Waza NP differs greatly from the estimate of Bauer et al. (2003) and Bauer and Van Der Merwe (2004). The decline reported by Bauer et al. (2003) from 100 individuals in 1962 to 40–

60 individuals around 2002 implied that approximately one lion was lost every year. The present findings when compared with Bauer et al. (2003) and Bauer and Van Der Merwe (2004) demonstrate an alarming rate of about six lions lost in Waza NP each year. At this rate within the next 4 years, the lion will likely go extinct in Waza NP. There may be more than the assessed seven lions further away from the periphery of the park, given the fact that GPS data from the collared lions indicate that lions do make long excursions outside the park. However, such large scale movements are unlikely during the critical period that the survey was conducted. At this period all water dries out but for waterholes in the park and a few at the periphery that retain water. Most natural prey congregate at these waterholes and lions do stay close for easy meals.

The killing of two reproductive males within 1 year represents a higher percentage of research lions lost to illegal, retaliatory killings than that reported by Bauer (2003). Although the numbers are too small to give too much weight to this difference, they must not be overlooked given the small size of this population. The death toll may be higher than the confirmed cases as indicated above. ‘Adam’ for instance, was in a group of four lions during collaring (a coalition of three adult males and one adult female). ‘Adam’ was sighted several times with other members of the group after collaring. Rumors about the killing of this group in a Cameroon-Nigerian border village were effectively confirmed from the GPS data of ‘Adam’ which revealed that this group was around the borders between November and December of 2007. ‘Adam’ was alone when sighted in March of 2008, and was later killed by nomadic Uda pastoralists during a short excursion to their camp, 500 m from the park limit. ‘Jean-Pierre’, the other collared lion killed, became solitary shortly after collaring. Because of seasonal floods and the dispersal of the declined natural prey population, lions leave the park and follow migrating nomadic livestock. Out of the park the lions raid livestock and consequently get into conflict with humans. Retaliatory killings are illegally carried out by livestock owners using bow and arrows poisoned with cobra venom. These results together with the case reported by Bauer (2003) suggest that lions are continuously being killed illegally in and around this park, even though there are no systematic records. Although lions are mostly killed in retaliation for taking livestock, poaching seems to be going on as well. The carcasses of both lions were never recovered. Communities around the park attach socio-

economic values to various parts of the lion and there are indications of trade of these parts.

The lion population age structure is skewed towards adults indicating a negative growth for the lion population in this park. External threats such as illegal killings which increase mortality in this population will likely drive it to extinction if the causal factors are not abated. The presence of cubs in the population (22%) and a sex ratio of 1 : 3 however, indicate that the population still has the reproduction capacity.

The results of the camera trapping survey supported the conclusion that the human-livestock pressure on the park is very heavy. Out of 63 trapping sites, human/cattle were present at 20. Compared to other groups of animals captured by the camera traps, human-livestock represented 31% of the photographs. During field work, poachers, fishermen, herdsman and cattle herds ranging from 150 to 2,000 heads were occasionally encountered. This situation conforms to the conjecture made by Scholte (2003) that the disappearance of wildlife in nearby Kalamaloue NP due to advanced human encroachment was a bleak perspective for Waza NP.

Nevertheless, although the current status of the Waza lion population seems critical, there are still possibilities for this population to fully recover and stabilize. Studies in East and Southern Africa have shown that lion populations are resilient. When park management is good, ensuring better habitat conditions, a lion population is able to recover within a short period of time. This suggests that, if an immediate attempt is made by the government to stop all illegal activities within the park and its buffers, the lion population in Waza NP will bounce back. Specifically, the park boundaries should be clearly demarcated to prevent intrusion by herdsman and their livestock. Furthermore, an increase in security patrols will substantially increase the effectiveness of conservation efforts, as demonstrated by Hilborn et al. (2006) and Dobson & Lynes (2008). Eventually, management should consider raising awareness and sensitizing all communities involved.

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References

- BAUER, H. (2003) *Lion conservation in West and Central Africa: The Case of Waza National Park, Cameroon*, PhD Thesis. Leiden University, Leiden.
- BAUER, H., DE IONGH, H.H., PRINCE, F.P.G. & NGANTOU, D. (2003) Research needs for lion conservation in West and Central Africa. *Comp. Rend. Biol.* **326**, S112–S118.
- BAUER, H. & NOWELL, K. (2004) Endangered classification of the lion in West Africa. *CAT News*, **41**, 3–36.
- BAUER, H. & VAN DER MERWE, S. (2004) Inventory of free-ranging lions *Panthera leo* in Africa. *Oryx* **38**, 26–31.
- BINOT, A., CASTEL, V. & CARON, A. (2006) Wildlife-livestock interference in Sub-Saharan Africa. *Secheresse* **17**, 349–361.
- CARO, T. & SCHOLTE, P. (2007) When conservation falters. *Afr. J. Ecol.* **45**, 233–235.
- CHARDONNET, P. (2002) Conservation of the African lion: contribution to a status survey, International Foundation for the Conservation of Wildlife. Conservation Force.
- 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.
- DE IONGH, H.H., BAUER, H. & HAMLING, P. (2004) Nine years of research on a lion (*Panthera leo*) population in the Waza National Park (Cameroon): a review. *Game Wildlife Sci.* **21**, 433–446.
- DOBSON, A.P. & LYNES, L. (2008) How does poaching affect the size of national parks? *Trends Res. Ecol. Evol.* **23**, 177–180.
- EAST, R. (ed.) (1999) *African Antelope Database*. IUCN/SSC Antelope Specialist Group, IUCN, Gland.
- FISHER, F. & LINSEMAIR, E.K. (2001) Decrease in ungulate population densities. Examples from Como National Park, Ivory Coast. *Biol. Conserv.* **101**, 131–135.
- FLIZOT, P. (1962) The Waza National Park in Northern Cameroon. *Afr. Wildlife*, **16**, 293–297.
- HENSCHL, P. & RAY, J. (2003) *Leopards in African Rainforest: Survey and Monitoring Techniques*. WCS Global Carnivore Programme, New York.
- HILBORN, R., ARCESE, P., BORNER, M., HANDO, J., HOPCRAFT, J.G.C., LOIBOOKI, M., MDUMA, S. & SINCLAIR, A.R.E. (2006) Effective enforcement in a conservation area. *Science*, **314**, 1266.
- HILL, J.O., PAVLIK, E.J., SMITH, G.L., BURGHARDT, G.M. & COULSON, P.B. (1976) Species-characteristic responses to catnip by undomesticated felids. *J. Chem. Ecol.* **2**, 239–253.
- KARANTH, K.U. & NICHOLS, J.D. (1998) Estimation of tiger densities in India using photographic captures and recaptures. *Ecology*, **79**, 2852–2862.
- KARANTH, K.U. & NICHOLS, J.D. (2002) *Monitoring Tigers and Their Prey: A Manual for Researchers, Managers and Conservationists in Tropical ASIA*. Centre for Wildlife Studies, Bangalore.
- MCELVAIN, S.M., WALTERS, P.M. & BRIGHT, R.D. (1942) The constituents of the Volatile Oil of Catnip. *J. Am. Chem. Soc.* **64**, 1828–1831.

- NOWELL, K. & JACKSON, P. (1996) *Wild Cats, Status Survey and Conservation Action Plan*. IUCN/SSC Cat Specialist Group, Gland, Switzerland.
- OGUTU, J.O. & DUBLIN, H.T. (1998) The response of lions and spotted hyenas to sound playback as a technique for estimating population size. *Afr. J. Ecol.* **36**, 83–95.
- OMONDI, P., MAYIENDA, R. & TCHAMBA, M. (2007) *Total aerial count of elephants, giraffes, roan antelopes and other wildlife species and ostrich in Waza National Park, Cameroon*, WWF. Central Africa Regional Office, Yaounde.
- PENNYCUICK, C. & RUDNAL, J. (1970) A method of identifying individual lions, *Panthera leo*, with an analysis of the reliability of the identification. *J. Zool.* **160**, 497–508.
- SCHALLER, G.B. (1972) *The Serengeti lion: a study of predator-prey relationships*. Wildlife Behaviour series, 33–64 and 167–193. The University of Chicago press, Chicago, USA.
- SCHOLTE, P. (2003) Immigration: a potential time bomb under the integration of conservation and development. *AMBIO J. Hum. Environ.* **32**, 58–64.
- 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. *Afr. J. Ecol.* **45**, 431–439.
- SCHOLTE, P., DE KORT, S. & VAN WEERD, M. (1999) The birds of the Waza Logone area, Far North Province, Cameroon. *Malimbus*. **21**, 16–49.
- SMUTS, G.L., ANDERSON, J.L. & AUSTIN, J.C. (1970) Age determination of *Panthera leo*. *J. Zool.* **185**, 115–146.
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