African Journal of Ecology

Note and record

Large carnivore abundance in the Benoue ecosystem, North Cameroon

Hans Bauer[1]*, Serge Alexis Kamgang[2], Iris Kirsten[3], Pricelia Tumenta[4], Adam Saleh[5], Philipp Henschel[6] and Claudio Sillero-Zubiri[1]

[1]*Wildlife Conservation Research Unit, Zoology Department, University of Oxford, The Recanati-Kaplan Centre, Tubney House, Tubney, OX13 5QL, U.K.,* [2]*EFG, P.O. Box 271, Garoua, Cameroon,* [3]*Leo Foundation, Roghorst 343, 6708 KX, Wageningen, The Netherlands,* [4]*CEDC, P.O. Box 410, Maroua, Cameroon,* [5]*ROCAL, s/c P.O. Box 410, Maroua, Cameroon and* [6]*Panthera, 8 West 40th Street, 18th Floor, New York, NY, 10018, U.S.A.*

Introduction

Large carnivores are keystone and flagship species, their abundance is an important parameter for ecosystem management but is difficult to measure (Thorn *et al.*, 2010). Spoor transects (Funston *et al.*, 2010) and call-ups (Midlane *et al.*, 2015) have been described as efficient and have been used across West Africa (Henschel *et al.*, 2014) and in parts of the Benoue ecosystem of North Cameroon (Bauer, 2007; Croes *et al.*, 2011). In February–March 2015, we did a spoor survey to assess the abundance of all large carnivore species throughout the Benoue ecosystem. Our results can be used to improve the sustainability of trophy hunting which was questioned by Croes *et al.* (2011).

The Benoue ecosystem is a 30 000 km^2 savannah landscape comprising three National Parks (NPs) and 32 Hunting Zones (HZs). Wildlife is not as depleted as in the rest of West and Central Africa (Mallon *et al.*, 2015), but cheetah (*Acinonyx jubatus*) and African wild dog (*Lycaon pictus*) are extirpated (de Iongh *et al.*, 2011), emphasizing the need to monitor lion (*Panthera leo*), leopard (*Panthera pardus*) and spotted hyaena (*Crocuta crocuta*, hereafter hyaena). With the demise of wildlife in the Central African Republic (Bouché *et al.*, 2012), our study area is the only remaining potential stronghold for lions in Central Africa (Riggio *et al.*, 2013).

The Benoue ecosystem is seasonally over run by livestock, and some areas are threatened by gold panning, poaching and agriculture, the central 'Benoue Block' probably more so than the eastern 'Bouba Ndjida Block' and western 'Faro Block' (H. Bauer, S. A. Kamgang, I. Kirsten, P. Tumenta & A. Saleh, pers. obs.). Safari hunting has been practised in the area for decades, with a lion hunting quota of approximately 30 (Croes *et al.*, 2011). Leopards are currently not on quota, and hyaena hunting is marginal due to low demand.

Materials and methods

We excluded some Hunting Zones where large carnivore records have been scarce in recent years, effectively limiting the study area to the three NPs and 21 HZs totalling 24 000 km^2, divided into three blocks each named after the NP in its centre. Wooded savannah vegetation and soils were fairly homogenous across the study area, leading to relatively good and constant spoor detectability (Croes *et al.*, 2011). Considering the expected densities and sampling intensity recommended by Funston *et al.* (2010), we worked out that 55 transects would deliver reliable estimates. In the absence of a road map, we could not preselect transects randomly from a pool of available survey tracks. Instead, we randomly allocated transects to NPs/HZs, deciding *ad hoc* on the placement of transects within those areas.

Transects were 15 km long, except for seven transects that had a dead end after ~12 km, totalling 803.5 km. We drove a four wheel drive vehicle at 10 km h^{-1}, with two trackers on the bonnet who stopped the vehicle at every large carnivore spoor detected. We took three pictures of every pugmark and recorded species, number of individuals, GPS position, age of track, time, condition of the road and observer data. Pictures were verified by an independent expert and then again by all team members, and if necessary, they were reclassified, thus reducing observer bias. We followed the protocol of Funston *et al.* (2010), meeting all assumptions for use of their formula for sandy soils.

**Correspondence:* E-mail: hans.bauer@zoo.ox.ac.uk

Table 1 Density and population estimates for large carnivores in the Benoue ecosystem

	# Tracks			Density (100 km^{-2})			# Individuals (95% CI)		
Unit (area in km^2)	Lion	Leopard	Hyaena	Lion	Leopard	Hyaena	Lion	Leopard	Hyaena
Entire study area (24 204)	24	35	142	1.03	1.31	5.69	250 (243–258)	316 (307–325)	1376 (1352–1400)
Block Faro (8077)	9	9	59	1.39	1.23**	8.75*	112 (102–122)	99 (89–109)	707 (673–741)
Block Benoue (6388)	10	5	32	1.28	0.49**	3.85*	82 (75–89)	32 (26–37)	246 (236–256)
Block Bouba Njida (9739)	5	21	51	0.59	2.03**	5.11*	57 (51–64)	198 (187–209)	498 (472–524)
All NPs (7300)	5	14	35	0.99	2.48*	6.39	72 (61–83)	181 (168–194)	466 (429–503)
All HZs (16 904)	19	21	107	1.05	0.97*	5.49	177 (170–184)	165 (157–173)	928 (907–949)

*Significant difference in density between areas ($P < 0.05$).
**Near-significant difference in density between areas ($P = 0.053$).

We used a Kruskal–Wallis test to investigate differences between blocks and a Mann–Whitney test to investigate differences between NPs and HZs.

Results and discussion

We found substantial numbers of all three species (Table 1), the estimate of 250 lions is of special importance since this species is rapidly disappearing from Central Africa (Brugière, Chardonnet & Scholte, 2015). Unexpectedly, the difference in density between blocks was not significant for lion, near-significant for leopard and significant for hyaena only ($F = 3.370$, $P = 0.185$; $F = 5.87$, $P = 0.053$; $F = 6.402$, $P = 0.041$, respectively, df = 2). We expected the putative higher degradation in the Benoue Block to affect lions and leopards more than hyaenas, which can coexist more easily with people (e.g. Yirga *et al.*, 2012). We hypothesize that hyaenas are more prone to the ecological trap of perceptible depredation opportunities outweighed by imperceptible mortality caused by nonselective poisoning (van der Meer *et al.*, 2014).

We found no significant difference in density between NPs and HZs for lions and hyaenas, but leopard density was significantly higher inside NPs ($P = 0.018$). In theory, NPs should have higher densities than HZs, but as leopards are not on quota, this is an unlikely explanation. Moreover, in practice, effectiveness of management is higher in privately run HZs than in the state-run NPs. Mayaka (2002), Mayaka *et al.* (2004) and Croes *et al.* (2011) demonstrated that herbivore biomass in HZs was not significantly lower than in NPs. This would explain why we found no significant difference in lion densities between HZs and NPs. We observed, however, that the persistence of lions in HZs has been serendipitous; annual lion off-take since 2000 has been less than a third of the quota (H. Bauer, S. Kamgang, I. Kirsten, P. Tumenta & S. Adam, unpublished data). Compared with our results, effective off-take is around the recommended maximum of 5% (Creel & Creel, 1997), whereas the quota is much higher. We conclude that hunting practices could be sustainable but are inadequately regulated.

Acknowledgements

We acknowledge the support of the German Development Cooperation, Garoua Wildlife College and Leo Foundation, especially Drs. Scholte, Bobo Kadiri and De Iongh. We also thank the US Fish & Wildlife Service, the ministry in charge of wildlife and staff in the NPs and HZs, in particular the lion guards and the professional hunters.

References

Bauer, H. (2007) Status of large carnivores in Bouba Ndjida National Park, Cameroon. *Afr. J. Ecol.* **45**, 448–450.

Bouché, P., Nzapa Mbeti Mange, R., Tankalet, F., Zowoya, F., Lejeune, P. & Vermeulen, C. (2012) Game over! Wildlife collapse in northern Central African Republic. *Environ. Monit. Assess.* **184**, 7001–7011.

Brugière, D., Chardonnet, B. & Scholte, P. (2015) Large-scale extinction of large carnivores (lion *Panthera leo*, cheetah *Acinonyx jubatus* and wild dog *Lycaon pictus*) in protected areas of West and Central Africa. *Trop. Conserv. Sci.* **8**, 513–527.

Creel, S. & Creel, N.M. (1997) Lion density and population structure in the Selous Game Reserve: evaluation of hunting quotas and offtake. *Afr. J. Ecol.* **35**, 85–93.

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. *Biol. Conserv.* **144**, 3064–3072.

Funston, P.J., Frank, L., Stephens, T., Davidson, Z., Loveridge, A., Macdonald, D.M., Durant, S., Packer, C., Mosser, A. & Ferreira, S.M. (2010) Substrate and species constraints on the use of track incidences to estimate African large carnivore abundance. *J. Zool.* **281**, 56–65.

Henschel, P., Coad, L., Burton, C., Chataigner, B., Dunn, A., Macdonald, D., Saidu, Y. & Hunter, L.T.B. (2014) The lion in West Africa is critically endangered. *PLoS ONE* **9**, e83500.

de Iongh, H.H., Croes, B., Rasmussen, G., Buij, R. & Funston, P.J. (2011) The status of cheetah and African wild dog in the Benoue Ecosystem, North Cameroon. *Cat News* **55**, 29–31.

Mallon, D.P., Hoffmann, M., Grainger, M.J., Hibert, F., van Vliet, N. & McGowan, P.J.K. (2015) *An IUCN situation analysis of terrestrial and freshwater fauna in West and Central Africa*. IUCN, Gland, 162 pp.

Mayaka, T.B. (2002) *Value Wildlife! An ecological and economic assessment of wildlife use in Northern Cameroon*. 175 pp. PhD dissertation, Leiden University, The Netherlands.

Mayaka, T.B., Stigter, J.D., Heitkönig, I.M.A. & Prins, H.H.T. (2004) A population dynamics model for the management of Buffon's kob (*Kobus kob kob*) in the Bénoué National Park Complex, Cameroon. *Ecol. Model.* **176**, 135–153.

van der Meer, E., Fritz, H., Blinston, P. & Rasmussen, G. (2014) Ecological trap in the buffer zone of a protected area: effects of indirect anthropogenic mortality on the African wild dog *Lycaon pictus*. *Oryx* **48**, 285–293.

Midlane, N., O'Riain, J., Balme, G. & Hunter, L. (2015) To track or to call: comparing methods for estimating population abundance of African lions *Panthera leo* in Kafue National Park. *Biodivers. Conserv.* **24**, 1311–1327.

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. (2013) The size of savannah Africa: a lion's (*Panthera leo*) view. *Biodivers. Conserv.* **22**, 17–35.

Thorn, M., Green, M., Bateman, P.W., Cameron, E.Z., Yarnell, R.W. & Scott, D.M. (2010) Comparative efficacy of sign surveys, spotlighting and audio playbacks in a landscape-scale carnivore survey. *S. Afr. J. Wildlife Res.* **40**, 77–86.

Yirga, G., de Iongh, H.H., Gebrehiwot, K., Deckers, J. & Bauer, H. (2012) Adaptability of large carnivores to changing anthropogenic food sources: diet change of spotted hyena (*Crocuta crocuta*) during Christian fasting period in northern Ethiopia. *J. Anim. Ecol.* **81**, 1052–1055.

(*Manuscript accepted 29 September 2015*)

doi: 10.1111/aje.12262