Lion (*Panthera leo*) and Spotted Hyena (*Crocuta crocuta*) abundance in Bouba Ndjida National Park, Cameroon; trends between 2005 and 2014

Authors: Iris Kirsten, Elise Bakker, Laura Lucas Trujillo, Paul Bour, Nadia Nhiomog, Hans Bauer and Hans de Iongh

Postal Address:
Foundation Leo,
Roghorst 343
6708 KX, Wageningen
The Netherlands

Email addresses:
iriskirsten@hotmail.com
cebakker91@gmail.com
laura.gema.lucas@gmail.com
bourpaul@gmail.com
nhiomoglina@yahoo.fr
hans.bauer@zoo.ox.ac.uk
iongh@cml.leidenuniv.nl

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Corresponding author: Iris Kirsten, iriskirsten@hotmail.com

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Introduction

Large carnivore numbers have declined in and around protected areas of West and Central Africa over the last decades (Brugiere *et al.,* 2015; Bauer *et al.,* 2015; Henschel *et al.,* 2014; Riggio *et al.,* 2013; Durant *et al,* 2016). Considering recent functional extinction of cheetah (*Acinonyx jubatus,* Schreber) and wild dog (*Lycaon pictus,* Temminck) in North Cameroon, there is concern about the status of lion (*Panthera leo,* L.), leopard (*Panthera pardus,* L.) and spotted hyena (*Crocuta crocuta,* Erxleben) populations (De Iongh *et al.,* 2011).

In the context of lion populations in Central Africa, the estimated population of 250 lions in the Bénoué Complex, consisting of 3 national parks and 32 hunting zones (Bauer *et al.,* 2016), is probably larger than in most other lion populations in the Central African Republic and the Democratic Republic of the Congo. The abundance of lion and spotted hyena in Bouba Ndjida National Park (BNNP) was previously assessed by Bauer (2007) in 2004 with a calling station survey and Croes *et al.* (2011) between 2007 and 2010 with a spoor survey. These surveys estimated that BNNP contained approximately 60 lions and 120 spotted hyenas.

Low carnivore densities and poor infrastructure in Central Africa make surveying large carnivores expensive and time consuming. Therefore indirect methods are preferable (Midlane *et al,* 2015). Our study used call-ups, broadcasting recorded animal distress calls to attract lions and spotted hyenas (Ogutu and Dublin, 1998). Here we present the results of a call-up survey held from April-May 2014 in BNNP using the same methodology as Bauer (2007).

Material and methods

Research area

BNNP is situated in the eastern part of the Bénoué complex and comprises 2200 km². The southern sector of the park is 1467 km² and is relatively well protected; the northern sector, covering 733 km² of the park is threatened by poaching, gold mining and illegal grazing (Croes *et al.,* 2011) (Figure 1).

The habitat comprises open wooded savannah, dominated by *Terminalia, Burkea africana* and *Detarium microcarpum* (Mayaka, 2002). Water is available throughout the year (Stark and Hudson, 1985), leading to rich typical savanna biodiversity in the well protected parts.

Methodology

Call-ups were done (cf. adapted according to Ogutu and Dublin,1998, Mills *et al.,* 2001; Thorn *et al.,* 2010) from April through May 2014 using the same protocol as Bauer (2007). We used a 400W amplifier and two speakers of 50W/16Ω to play hyena (whooping and laughing call) and African buffalo *Syncerus caffer* calf distress call (courtesy of the African Lion Working Group) from a car (Toyota Hilux) roof. We used the same audio recordings as applied by Bauer (2007). Each call-up was a cycle of four sessions of ten minutes of broadcast and ten minutes of silence, in which the spotted hyenas and buffalo recordings were alternated each broadcast. After five minutes of broadcast, the speakers were turned 90 degrees to cover the area evenly with the call-ups. After each broadcast, the area around the car was scanned with a weak light (Maglight Mini AA) for eye reflections. The area was again scanned with a strong light (Maglight Magcharger LED) after each ten minutes of silence to assess the presence of lions or spotted hyenas.

To minimize effects of weather, broadcasting time and habituation on response, we designed and executed the call-up surveys as followed: call-ups were played when carnivores were most active, from 7 pm to 12 pm. Secondly, we selected a random point on the main road, and thereafter spaced survey points 5 km apart on roads (straight-line distance; Figure 1). When visibility was limited by the vegetation, we relocated the call-up point a maximum of 500m in either direction. Each point was recorded with a GPS (Garmin E-trex 10). To avoid double-counting that may arise from attracting the same animals to adjacent sample points (Mills *et al.,* 2001), two randomly chosen points were

completed per night. No broadcasts were made with rain or high wind velocities, although wind speed and luminosity were not specifically recorded.

Many animals which were attracted by the call-ups were skittish, so approaching lions and hyenas were mainly counted based on their vocalisations and eye reflections. When animals were close, individuals could be observed, followed with a torch and counted. The spotlight was also used to check for possibly undetected hyenas and lions after each call-up (Bauer, 2007). To minimise double counting the same individual, calls that originated from the same location and could not be differentiated clearly, were counted as one individual. The eye reflections counts were only a minimum count and more individuals could have been around the car.

Because of high poaching incidence and lack of infrastructure in the northern sector of BNNP, call-ups in this part were dangerous and were abandoned after one failed attempt. Consequently, our results are limited to the southern section of the park, and 28% of that section was covered by 21 call-ups (Figure 1). The mean response, in combination with the area covered per calling station was used to calculate lion and hyena density, and then extrapolated to the surface of the entire southern sector.

Due to logistic and ecological constraints, local calibration of the call-ups was not possible. In order for the call-up surveys to be compatible for comparison, we followed Bauer's (2007) assumptions; both species had an effective range of 2,5 km and response rate of 75%, to give a mean ±SEM density per call-up. This calibration was selected, because (1) the survey took place in the same habitat type, (2) in the same period of the dry season, (3) the same buffalo calf distress and hyena call audio track were used and (4) there were non-baited call-ups. Since large carnivore densities in our survey areas are low, double counting is unlikely (Croes *et al.*, 2011; Bauer *et al.*, 2016).

To estimate lion and hyena densities, responses to a call-up were corrected with a response rate of 75% and a mean response±SEM per calling station was calculated. Secondly, the mean reponse±SEM was extrapolated to generate a large carnivore density per km^2. Finally, to estimate the number of lions and hyenas present in the southern section of BNNP, the calculated density (no of lions or hyenas per km^2) was multiplied by the total surface area of the southern section. Furthermore, we generated a plausible range of the population size using the extreme values for the response rate (25-100%) found in the literature (Ogutu and Dublin, 1998; Mills *et al.*, 2001; Ferreira and Funston, 2010; Cozzi *et al.*, 2013; Ferreira and Funston, 2016).

Results

Call-up responses

In total, a minimum of 19 lions responded to six call-ups (Figure 1). 14 animals have been observed in close range of the car and an additional minimum of 5 animals were heard at four different calling stations.

A minimum of 34 spotted hyenas responded to 15 different call-ups (Figure 1). A total of 28 animals were observed close to the car and the remaining 6 animals were a minimum count based on vocalisations.

Population densities and sizes

Using a response rate of 75%, our results indicate a lion density of 0,061±0,029 km^{-2} and a spotted hyena density of 0.110±0.031 km^{-2}. When extrapolated this gives an estimate of 90±42 lions and 161±45 hyenas for the southern sector of the park. Accounting for possible response rates gives a plausible range of 36-397 lions and 87-618 hyenas for the southern sector of BNNP.

Discussion

Our population size estimates more than double earlier population estimates of lions and hyenas in BNNP, although our confidence intervals overlap with population estimates of 2004 and 2009 (Bauer, 2007; Croes *et al.*, 2011).

The distribution of lion-only, hyena-only, both species, and no response is different than the expectation that all responses would occur in equal proportions. This suggests that hyenas are avoiding lions or that the call-ups have a different response rate by both species or that hyenas wander over larger ranges than lions.

To avoid such density calculations should ideally be based on a local calibration: an empirical assessment of effective range and response rate. However, low lion and spotted hyena densities in BNNP, limited access and low road density, vegetation type and probability of opportunistic encounter with large carnivores meant that attempts at calibration would be costly and time-consuming, produce small sample sizes and have risk of negative habituation of the carnivores and thus outweigh the benefits of calibration. Therefore, we have used assumptions from literature instead (Ogutu and Dublin, 1998; Mills *et al.*, 2001; Ferreira and Funston, 2010; Cozzi *et al.*, 2013; Ferreira and Funston, 2016).

Confidence intervals of our estimates of population sizes with assumed response rate of 75% fall within the plausible range of estimates generated with alternative extreme response rates of 25% and 75%. Despite large confidence intervals, we find our approach to be efficient (accuracy and precision of population estimates) and effective (minimising time and monetary cost) in giving meaningful rough estimates for lion and spotted hyena population sizes in the southern sector of BNNP.

Our coverage of the southern sector is sufficient, our call-up survey effort was above the 20 % minimum area coverage recommended by Ogutu and Dublin (1998) and the eight call-ups covering 1,000 km², proposed by Ferreira and Funston's (2010). We did not extrapolate to the entire BNNP, because of high human encroachment in the northern sector would bias the results. Large carnivores are notoriously hard to count with precision, and it is difficult to detect significant changes in small populations. It appears that density fluctuates over time but remains stable over the longer term in response to continued conservation effort (Bour, Pers. Obs). This result contrasts with large carnivore population estimates in other National Parks in West and Central Africa, which show a precipitously decline in their large carnivore populations over the last decades (Henschel *et al.*, 2014; Tumenta *et al.*, 2010).

In 2015, a spoor survey gave considerably lower population estimates, with only 57 lions and 498 spotted hyenas in the area comprising BNNP and nine surrounding hunting zones (Bauer *et al.*, 2016). Midlane *et al.* (2015) found a discrepancy in precision, but not in accuracy, between call-ups and spoor transects. We have no plausible explanation for differences found in BNNP. A comparison of methods at the same temporal and spatial scale as part of continued monitoring of carnivore and prey populations in BNNP and adjacent hunting zones to create more powerful estimates is recommended.

Calling stations have been described as an efficient and accurate census technique to determine lion and spotted hyena densities in small populations (Mills *et al.*, 2001.Midlane *et al.*, 2015). Because of lack of calibration, only rough estimates can be generated which must not be over-interpreted. This constraint compromises the general usefulness of this method for parks in West and Central Africa. However the call-up survey technique with a mix of other techniques can help to monitor current and future threats, and evaluate the effectiveness of existing and planned management interventions (Funston *et al.*, 2010; Pollock *et al.*, 2012).

There is growing literature on trends in lion numbers, showing great concern over West and Central Africa (Bauer *et al.*, 2016). We show that BNNP still is an important lion population in Central Africa that deserves to be monitored continuously. There is much less literature on trends in

hyena numbers; a priori our assumption based on niche similarity is an equal downward trend regionally, possibly even range-wide. Many lion monitoring programs could, and do, generate data on hyenas but these often remain unpublished. We hope to contribute to a body of publications that will allow the documentation of trends in hyena abundance.

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