

Preliminary population estimate of Kordofan giraffe (*Giraffa camelopardalis antiquorum*) in two areas of the Bénoué complex, Cameroon

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Abstract

The Kordofan giraffe (*Giraffa camelopardalis antiquorum*) is a critically endangered subspecies. To manage and conserve this taxon, up-to-date population estimates are crucial. We provide a population assessment of Kordofan giraffe in Bénoué National Park (BeNP) and nearby Hunting Zone 18 (HZ18), in northern Cameroon, using individual identification techniques from images captured in the field from opportunistic sightings and ad hoc camera trap efforts. Additionally, we assess connectedness between sites. We estimated populations of 27 and 25 individuals in BeNP and HZ18, respectively. No giraffes were captured in both sites. Findings highlight the area's importance and emphasise the need for continued conservation efforts. Our study provides a baseline for future monitoring and supports the development of a standardised wildlife monitoring framework.

Résumé

La girafe du Kordofan (*Giraffa camelopardalis antiquorum*) est une sous-espèce très menacée. Pour gérer et conserver ce taxon, il est essentiel de disposer d'estimations actualisées de la population. Nous fournissons une évaluation de la population de girafes du Kordofan dans le Parc National de la Bénoué (PNBe) et dans la Zone de Chasse 18 (ZC18), au nord du Cameroun, en utilisant des techniques d'identification individuelle à partir d'images capturées sur le terrain lors d'observations opportunistes et d'efforts ad hoc de piégeage photographique. En outre, nous évaluons la connectivité entre les sites. Nous avons estimé les populations à 27 et 25 individus dans le PNBe et la ZC18, respectivement. Aucune girafe n'a été capturée dans les deux sites. Les

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résultats mettent en évidence l'importance de la zone et soulignent la nécessité de poursuivre les efforts de conservation. Notre étude fournit une base de référence pour la surveillance future et soutient le développement d'un cadre normalisé de surveillance de la faune et de la flore.

1 | INTRODUCTION

The Kordofan giraffe (*Giraffa camelopardalis antiquorum*) is a subspecies of giraffe (*Giraffa camelopardalis*) that is resident to Western and Central Africa (Fennessy & Marais, 2018). The subspecies has declined from 13,704 to an estimated 1942 individuals since 1980s (Fennessy & Marais, 2018) and is now limited in range to fragmented populations spread across Cameroon, the Central African Republic, Chad, the Democratic Republic of the Congo and South Sudan (Fennessy & Marais, 2018). In consideration to the extent of the decline, the status of this subspecies has been elevated to Critically Endangered on the IUCN Red List (Fennessy & Marais, 2018). These populations are often small and isolated with little cross interactions between groups (Fennessy et al., 2016), but nonetheless represent significant strongholds for the species and the genetic diversity they harbour (Chillingworth, 2021; Coimbra et al., 2021; Fennessy & Marais, 2018; O'Connor et al., 2019).

After Chad, the second largest population of Kordofan giraffe occurs in Cameroon (Fennessy & Marais, 2018) and aerial counts indicate that northern Cameroon harbours a vital proportion of the subspecies. Aerial surveys carried out between 2007 and 2008 across the region's four national parks (Waza, Bouba Njida, Faro and Bénoué) led to an observation of 630 individuals, with only six detected in Bénoué National Park (BeNP) (Foguem et al., 2010; Omondi et al., 2008). However, aerial surveys often undercount animals in habitats with reduced detectability

(Barnes, 1993), such as the forested savannah landscape that makes up the majority of the Bénoué Complex (Klop & Van Goethem, 2008). Population estimates derived from aerial counts are therefore likely to be underestimated, indicating a need for updated data.

Climate change-induced desertification and terrorism-related displacement have led to an influx of refugees across the region and Northern Cameroon's parks now face mounting human pressures (Scholte et al., 2022; UNHCR, 2021). These stressors have resulted in a reduction in habitat availability and connectivity across the northern Cameroonian landscape and since 2016, habitat availability across the range of the northern giraffe subspecies has declined by 37% (O'Connor et al., 2019). As a result, Wildlife populations, including giraffe, now appear to be declining rapidly, within this increasingly fragmented landscape, but reliable estimates of abundance and movement patterns do not yet exist. Population baselines, and subsequent monitoring are needed to inform management strategies that improve giraffe conservation in the park.

This study aims to use an image repository from opportunistic giraffe sightings and ad hoc camera trap efforts to (a) estimate the abundance of Kordofan giraffe in BeNP and nearby hunting zone (HZ18), (b) assess age and sex structure and (c) assess connectivity within the landscape by identifying the movement of individuals. Giraffe abundance and distribution estimates are vital if effective conservation management is to be enacted.

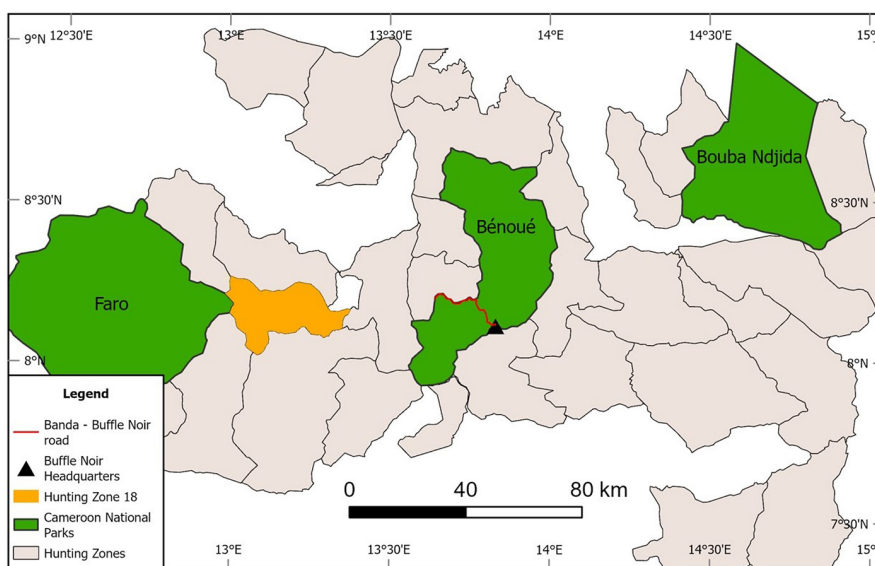


FIGURE 1 Location of BeNP and HZ18 (in orange) within the larger Bénoué Complex. All camera traps within BeNP were within 800m of the Buffle Noir Headquarters.

2 | METHODOLOGY

2.1 | Study site

The BeNP is a 1980 km² protected area in the North of Cameroon (8°20′52.9″ N 13°53′33.6″ E). Hunting Zone 18 is a 602 km² area designated for commercial hunting located 20 km to the West of BeNP at its closest point. Both areas form part of the larger Bénoué Complex (Figure 1) which consists of two other national parks—Bouba Ndjida (2115 km²) and Faro (3497 km²), and 29 other hunting concession zones (23,263 km²). The landscape consists of a Sudano-Guinean savannah ecosystem characterised by *Isoberlinia doka* woodland savannah and *Terminalia macroptera* open savannah (Klop & Van Goethem, 2008). Annual rainfall ranges from 1200 to 1500 mm with a dry season from November to April. As well as Kordofan giraffe, the area supports populations of several threatened mammals species (Scholte & Iyah, 2016; Parks, 2021). Medium-sized antelopes are the primary target of hunters (Fa & Brown, 2009) but giraffes in the park are also illegally hunted (Bristol Zoological Society Takes Action to Help Threatened Giraffe | Bristol Zoo, 2021). Anecdotally, giraffe encounter rates are also lower than those encountered 20 years ago (BeNP Conservator pers. comm.).

2.2 | Data collection

Images and videos were captured by handheld Canon DSLR camera and camera traps (Bushnell Trophy Cam). Eight camera traps were deployed at BeNP from 2019 to 2021 for 611 active camera trap days: six at salt licks and two at non-salt licks (Figure 1). These images were sifted manually by a researcher, and those containing giraffe were collated for analysis. Images were also captured ad hoc when giraffe were encountered during tourism and management activities between 2019 and 2021 in Hunting Zone 18 and between 2016 and 2018 in BeNP.

2.3 | Data processing

All giraffe images were sorted by date, location, sex and encounter and named accordingly. Encounters were defined as a group of images that were taken at the same location within 2 h of the first image, reducing the chance of repeat counting. As it was the most prevalent in data, images of the left side of giraffes were used for analysis. If no left-side images were available, the right-side image was compared with images from other encounters where both sides of the individuals were captured.

2.4 | Individual identification

All images containing giraffe were uploaded to GiraffeSpotter (Crall et al., 2013; WildMe, 'GiraffeSpotter', 2021), a machine learning

algorithm, which classifies individuals by their unique pelage (Bolger et al., 2012). Classifications were subsequently reviewed by a researcher.

Sex was noted for individuals when it could be visually determined, otherwise sex was classified as unknown. Individuals were classified as juveniles if they were noticeably smaller than other individuals in the encounter and had limited signs of wear on their ossicones. Individuals who were of mature size with less worn pelage or ossicones were labelled sub-adult. All other individuals were classified as adults.

2.5 | Population estimation

Given the proximity of camera traps and absence of coordinate data for hand-held images, population size was estimated using a non-spatially explicit Schumacher–Eschmeyer method in R (R Core Team, 2019) using the equation set out by Krebs (1989, 2014). We included all images from across the study period and assume that closure was not violated as there were no reports of giraffe dispersing across the boundaries of the national park, no detection of giraffe mortalities during anti-poaching patrols and limited to no evidence of births with just one juvenile observed. Camera location was fixed at salt licks following recommendations by Prichard et al. (2023), which we assume attracted giraffe equally, thereby giving all individuals an equal chance of capture in a given sample. See Krebs (2014) for a full methodological breakdown.

3 | RESULTS

3.1 | Population estimation and distribution

A total of 998 images of giraffe were captured during this study. Of these, 744 were recorded by camera trap in BeNP. For the ad hoc data set, 149 images were taken in Hunting Zone 18 (HZ18) and 105 images were taken in BeNP. In total, there were 31 encounters made up of 93 observations, 55 of which were in ad hoc data set and 38 of which were in the camera trap data set. From these images, 26 unique individuals were identified in the BeNP. From 37 observations, 23 unique individuals were identified in HZ18 data. We found no evidence of movement between HZ18 and BeNP given that no single giraffe was recorded at both in both sites. Using the Schumacher–Eschmeyer method, the estimated population size was 27.02 [CI 95% 24.06, 30.80] for BeNP and 25.92 [CI 95% 22.90, 29.86] for HZ18 (Table 1).

3.2 | Population structure

In BeNP, the observed age class ratio in this data set was 1:0.08 (adult 93.3%: subadult/juvenile 6.7%) and the sex ratio (based on 19/24 individuals where sex was identifiable) was female biased at

TABLE 1 Table of population estimates for both BeNP and HZ18. BeNP from 2016 to 2021 and HZ18 from 2019 to 2021.

	Location	Captures	Recaptures	Population estimate	Lower 95% confidence interval	Upper 95% confidence interval
Schumacher-Eschmeyer	HZ18	32	14	25.92	22.9	29.86
	BeNP	93	27	27.02	24.06	30.8

0.46:1 (male: female). In HZ18, there was also an adult skewed age class ratio of 1:0.13 (adult 87%: subadult/juvenile 13%) and a female skewed sex ratio (based on 13/23 where sex was identifiable) of 1:0.63.

4 | DISCUSSION

Overall, we estimate that a population of approximately 27 Kordofan giraffe occur within BeNP, substantially more than previous estimates recorded by Omondi et al. (2008) who reported a population of six. We interpret this not as a real increase in population size but as artefact of differing sampling approaches whereby aerial surveys led to an undercounting of giraffe. Such a small population remains highly susceptible to extinction vortices without strengthening conservation management practices within the park (Colston et al., 2023).

Our study used salt licks to increase animal detection rates (Green et al., 2020). This may have concentrated giraffe around the camera traps leading to higher capture and recapture rates but should not have influenced the population estimation. The presence of incentives can still allow for population estimation as long as all individuals have equal access to the incentive, which is the case in this study (Prichard et al., 2023). The same can be said about ad hoc data collection, which was done on the same road each collection period. The long study period (2016–2021) may have provided opportunity for recruitment or loss within the population, and thereby violate the closure assumption. However, we found no evidence of mortality despite frequent ground patrols, and births were limited to observation of a single juvenile. Dispersal is plausible but is likely limited to the same seasonal movements and overall population isolation also seen in D'haen et al. (2019), making it reasonable to assume that closure is maintained between years. Given that a minimum of 26 unique individuals were recorded from a roughly 7200-hectare area, or 4% of the park, our estimate represents a reliable minimum population size for the park. Furthermore, it is probable that due to the limited nature of our survey many giraffe resident to other areas of the park were undetected and the total population size may be even greater. A larger-scale systematic camera trap survey of the entire park would help increase the robustness of these population estimates.

We also estimate a population of approximately 26 individuals occurs in HZ18. No individual giraffe was observed in both BeNP and HZ18. This apparent lack of overlap is surprising given the distance between the two sampled regions is 30 kilometres and therefore within the estimated range of Kordofan giraffe (Clark et al., 2023; D'haen et al., 2019). This suggests that the movement of Kordofan

giraffe populations in the Bénoué Complex may be restricted by fragmentation. The two areas are bisected by arable land and the Garoua to Ngaoundere highway. Radio and satellite telemetry tracking should therefore be considered to investigate whether the BeNP population exists as an isolated fragment or as a part of a wider metapopulation by determining whether roads and arable land are creating barriers to giraffe movement or if there are usable corridors (Clark et al., 2023). Genetic profiling of the park's population could reveal interrelatedness of individuals and determine the extent of gene flow from outside of the park.

The population in both BeNP and HZ18 was skewed female; this is consistent with other findings on Kordofan giraffe populations (e.g. D'haen et al., 2019) but not with the expected 50:50 ratio defined by Fennessy (2004). Marealle et al. (2010) noted that giraffe populations influenced by poaching were more strongly skewed female, while Paoletti and Cantarino (2002) hypothesised that the same skew could be linked to high levels of habitat destruction. This may suggest that there is poaching or habitat pressure on the BeNP population whereby males are specifically targeted or more likely to be hunted due to their differing dispersal patterns and social habits (Muller & Harris, 2022).

5 | CONCLUSION

The results of this study show that there is a substantial population of Kordofan giraffes within BeNP and at least one of the surrounding hunting zones. The baseline estimates of population size and improved understanding of dispersal presented here are vital for the design of effective conservation management policies within the Benoue Complex. Going forward, larger systematic camera trap deployments should be used to reduce deviance in population estimates. Future repeats of such surveys could in turn indicate changes in population size and distributions and therefore help to determine long-term success in the conservation of the species in Cameroon.

ACKNOWLEDGEMENTS

First and foremost, we would like to acknowledge and thank all members of the teams that patrol the Bénoué National Park and the surrounding areas, for their tireless dedication. In particular, we would like to dedicate this article to Ayang Clément who gave his life in defence of the park and its wildlife. We would also like to thank Michael Brown of Giraffe Conservation Foundation and Smithsonian Conservation Biology Institute, the San Diego Zoo Wildlife Alliance and WildMe for their support with analysis.

CONFLICT OF INTEREST STATEMENT

There is no conflict of interest declared in this article.

DATA AVAILABILITY STATEMENT

The data for this project were collected by the Bristol Zoological Society and made available to researchers affiliated with the organisation. It was also made available to other researchers via GiraffeSpotter. Researchers with access to this data are vetted by the WildMe team to ensure that data are only used for research purposes. No data from other researchers were used in this study. The data for this study, including spreadsheets, images and other files, were made available to the University of Bristol upon submission of this manuscript, which was undertaken in the context of a final research project in the Master of Science program in Global Wildlife Health and Conservation within the Faculty of Health Sciences. Data were not made available elsewhere to ensure the integrity of the research and protect the subpopulation in question.

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How to cite this article: Parks, C., Penny, S., Goue, A. M., Nyugha, D., Pauline, T. T., Vannier, X., & Johnson, C. (2023). Preliminary population estimate of Kordofan giraffe (*Giraffa camelopardalis antiquorum*) in two areas of the Benoué complex, Cameroon. *African Journal of Ecology*, 00, e13249. <https://doi.org/10.1111/aje.13249>