

SHORT COMMUNICATION **OPEN ACCESS**

# Lions (*Panthera leo leo*) Movement Patterns in a Sudanian Wooded Savannah in Central Africa

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## ABSTRACT

Understanding the spatial ecology of African lions (*Panthera leo*) in human-dominated landscapes is critical for their conservation. Using GPS collar data from three lions monitored between 2024 and 2025, we provide insights into their movement across the Benoue ecosystem in northern Cameroon and potential transboundary links with Chad. Our findings confirm the use of corridors that connect Bouba-Ndjidda National Park with adjacent hunting zones, neighbouring Benoue National Park, and likely routes toward Sena Oura National Park in Chad. All three lions died before the end of the collar lifespan. The results highlight the urgent need to preserve ecological connectivity across the region and increase lion protection in transboundary and multi-use landscapes.

## 1 | Introduction

In the context of rapid habitat transformation across African savannas, understanding how large carnivores interact with ecological processes such as connectivity, resource distribution, and human land use is essential to maintain ecosystem functionality (Abell et al. 2024; Torres-Romero et al. 2025). African lion populations are declining rapidly across their range due to habitat loss, human-wildlife conflict, and fragmentation of protected areas (Nicholson et al. 2023). In West and Central Africa, lions face challenges due to small population sizes, isolated habitats, and limited connectivity between protected areas (Loveridge et al. 2022; Visser et al. 2023). Conservation planning for lions in these regions must be

informed by empirical data on movement ecology to ensure long-term viability.

Large carnivores live at low densities and have large ranges; their requirements typically exceed the size of single Protected Areas (PAs). Viability is higher in large landscapes with a mosaic of conservation areas (Finerty et al. 2023). Large PA complexes offer a diversity of habitats and conservation intensity gradients that create opportunities for the entire guild (Verschuere et al. 2024). However, the effectiveness of existing PAs is low across the current lion range (Robson et al. 2022). In most cases, the main issue is Human-Lion Conflict in corridors and buffer zones as lions disperse between the core areas of mosaic or transboundary landscapes (Bauer et al. threats paper, Abell et al. 2024).

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Understanding how lions move within and between these areas is essential for identifying ecological corridors and developing landscape-level conservation strategies (Henschel et al. 2014).

We hypothesized that GPS satellite collars would help map the migratory pathways of lions between BNNP and Sena Oura in Chad. Additionally, we aimed to investigate whether lion dispersal routes extended into central Cameroon, as suggested by the appearance of two lions in the Centre Region in 2020. We also sought to better understand lion movement patterns across the broader Benoue ecosystem.

This study addresses the following key questions:

1. What are the movement patterns of lions in and around Bouba-Ndjidda National Park?
2. Do lions use transboundary corridors between Cameroon and Chad?
3. How do lions navigate through the Benoue ecosystem, and what are the implications for conservation planning?

## 2 | Materials and Methods

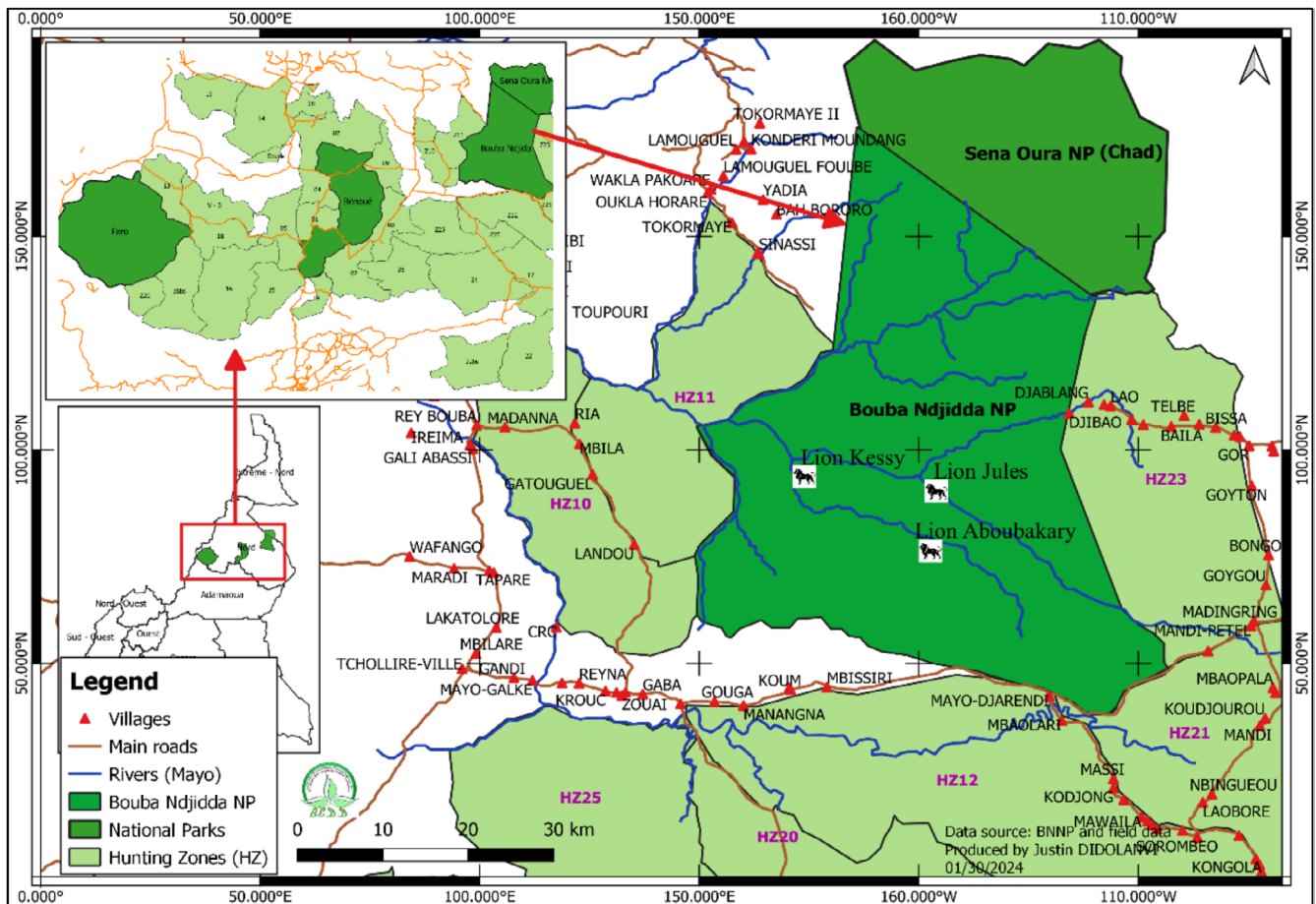
The Benoue ecosystem in northern Cameroon comprises a mosaic of national parks, hunting zones, and community lands.

Bouba-Ndjidda National Park (BNNP) borders Sena Oura National Park in Chad, forming a potential transboundary conservation complex.

Situated in the Sudanian wooded savanna of northern Cameroon (7°26'–9°5'N; 12°19'–15°15'E), the Bénoué Ecosystem spans approximately 24,000 km<sup>2</sup> and borders Nigeria to the west and Chad to the east. It comprises 32 hunting zones and three national parks—Faro, Bénoué, and Bouba-Ndjidda (Croes et al. 2011; de Jongh et al. 2011; Bauer et al. 2016). Bouba-Ndjidda (2200 km<sup>2</sup>) shares a transboundary protected area with Chad's Sena Oura National Park (735 km<sup>2</sup>), recently recognised as a UNESCO Biosphere Reserve.

The region receives 1200–1500 mm of annual rainfall, supporting dense savanna vegetation dominated by *Isoperlinia doka* and *Anogeissus leiocarpus*. The landscape is undulating, with rocky outcrops up to 500 m and perennial rivers such as the Faro and Déo. Wildlife includes elephants, buffalo, Kordofan giraffes, hippos, warthogs, and red river hogs. Local communities depend on natural resources like fuelwood, fish, gold, grazing land, and bushmeat (Weladji and Tchamba 2003).

This study focused on Bouba-Ndjidda, its adjacent hunting zones, Bénoué and Faro National Parks, and surrounding community lands, representing varying degrees of protection and



**FIGURE 1** | The study area highlighting the Benoue Ecosystem (inset), the position of collared lions and the Binational Sena-Oura & Bouba Ndjidda Conservation Landscape.

human pressure within the broader Bénoué Ecosystem (Croes et al. 2011) (Figure 1).

We monitored three lions (Table 1) fitted with satellite GPS collars (Figure S1) in the Bouba-Ndjidda National Park between 2024 and 2025. All capture and collaring operations were conducted under permits from the Ministry of Forestry and Wildlife (MINFOF, Cameroon) with full veterinary supervision, following established ethical guidelines for wildlife research. Each lion was fitted with a GPS collar manufactured by Africa Wildlife Tracking (South Africa), configured to record a geographic coordinate every 6h. In addition to GPS functionality, the collars included a VHF radio transmitter to facilitate ground-based tracking and signal monitoring using a VHF receiver. This setup enabled both remote data transmission and field verification of lion locations.

All GPS data were obtained from the Africa Wildlife Tracking online platform and processed in R. Records with missing coordinates, implausible movement speeds, or positional dilution of precision (PDOP) > 10 were removed. The cleaned dataset was then projected to the UTM coordinate system (Zone 33N) using the sf package for spatial analysis and home range estimation with the adehabitatHR package.

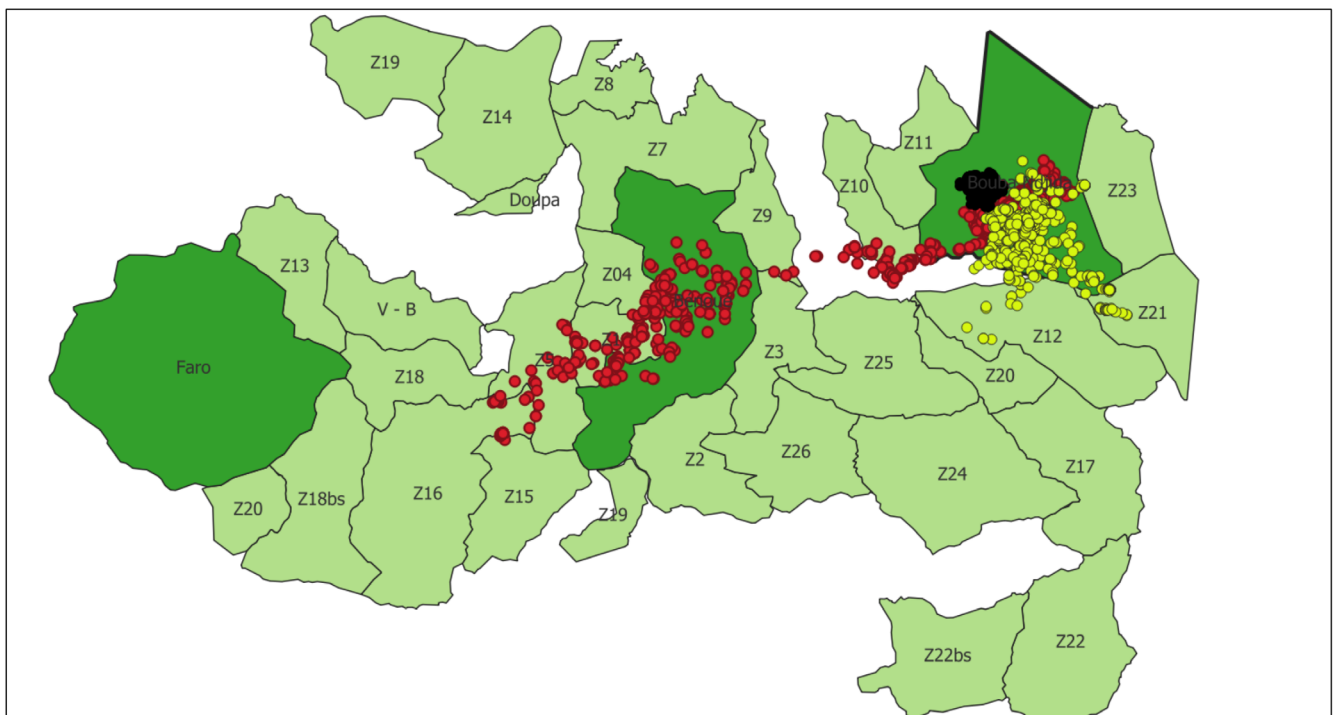
We determined each collared lion's 95% kernel density estimate (Home Range) and 50% kernel density estimate (Core Range) using the adehabitatHR package in R, after projecting GPS coordinates to UTM with the sf package and visualised the ranges over the Benoue Complex shapefile using ggplot2 to identify patterns of movement.

### 3 | Results

Quantitative movement metrics, including collar duration, number of GPS fixes or Tag-in, and individual home range estimates, are presented for each collared lion to provide a comparative overview of spatial use across the study area. All three collared lions (Figure S1) showed extensive movements across the landscape (Figure 2 and Table 2). The young male lion Jules moved from Bouba-Ndjidda (BNNP) through adjacent hunting zones and into Benoue National Park (BNP) (Figure S2), confirming the use of these multi-use areas as functional corridors (Figure S3). The data also suggest a potential transboundary connection to Sena Oura National Park in Chad, although limited tracking data in Chad preclude definitive confirmation.

**TABLE 1** | Characteristics of collared lions and key movement metrics.

Lion ID	Sex	Date	Age estimated (years)	Weight estimated (Kg)	Body length (Cm)	Neck circ. (cm)	Chest girths (Cm)	Shoulder height (Cm)
Jules	Male	17.01.2024	2.5–3	120–130	235	62	103	69
Aboubakary	Male	21.01.2024	7–8	180–200	289	80	121	83
Kessy	Female	19.01.2024	3–4	130–140	219	59	100	68



**FIGURE 2** | Movement pattern of the three lions across the Benoue Ecosystem.

**TABLE 2** | Key movement metrics of collared lions.

Lion ID	Capture location	Collar duration (month)	Tag-in count	Key areas used
Jule	BNNP (East)	17	1915	BNNP, BNP, HZs 1, 3, 4, 5, 9, 10, 15 and 16 (near Adamaoua); confirming connectivity between BNP-BNNP
Aboubakary	BNNP (South)	10	1033	PNBN, HZ 12, 21, 23: traced path back to North Region, confirming north-south connectivity path
Kessy	BNNP (West)	9	1220	BNNP

Movements extended near the Adamaoua Region, supporting the hypothesis that lions can disperse toward central Cameroon. These findings are consistent with the appearance of lions in the Centre Region in 2020 and suggest long-distance dispersal is feasible across fragmented landscapes, given adequate habitat and reduced conflict.

#### 4 | Discussion

The study provides evidence of large-scale lion movements within and potentially beyond the Benoue ecosystem. Our research questions were answered by showing extensive movements between components such as NPs and HZs of the transboundary landscape. However, the high mortality of lions is illustrative of the challenges facing lions. Declines in large carnivore abundance were documented for this area by Bakker et al. in 2020, and concerns have recently been raised about lion persistence in Benoue NP, particularly the most central element of the landscape (Kamgang et al. n.d.). This shows that mosaic landscapes are a solution in terms of providing habitat at the scale required by large carnivores but also a problem in terms of providing sufficient protection as wildlife moves across multiple use areas. This may lead to source-sink dynamics whereby areas of high lion mortality threaten the persistence of the species in core areas (Loveridge et al. 2006). Interpretation of the movement data should be made with caution, as the limited sample size and relatively short collar lifespans constrain the ability to generalise these findings to the wider lion population. Moreover, the need for collaborative conservation efforts spans across national boundaries, particularly between Bouba-Ndjidda and Sena Oura National Parks (Lindsey et al. 2017).

Lion movement patterns may extend well beyond traditionally recognized ranges, highlighting the potential for dispersal into central Cameroon (Kirsten et al. 2020). This has major implications for conflict mitigation, land-use planning, and conservation prioritization in regions previously thought to be outside of lion range (Bauer et al. 2015). These movement patterns illustrate how landscape configuration and anthropogenic pressures jointly shape lion spatial ecology, reinforcing the ecological importance of maintaining functional corridors across multi-use landscapes.

Collectively, our results advocate for an expanded view of lion conservation in Central Africa that includes transboundary cooperation, landscape connectivity, and the integration of multi-use

areas into management plans. In a region where wildlife is threatened (Bauer et al. 2022), and where resources need to be oriented strategically (Scholte et al. 2022), we argue that the restoration of connectivity across this landscape has the highest priority.

#### 5 | Conclusion

GPS collar data provide valuable insights into lion spatial ecology in northern Cameroon. Despite the small sample size, our results reveal the importance of transboundary corridors and multi-use landscapes for maintaining viable lion populations. Future studies should expand collaring efforts, integrate community-based monitoring, and promote regional cooperation to safeguard lions in this critically important part of their range. This study underscores the ecological importance of maintaining transboundary connectivity between protected and multiple-use landscapes in Central Africa. Future research should prioritize expanding the sample size, integrating community-based monitoring, and modeling habitat suitability to strengthen regional lion conservation strategies. Future research should expand GPS tracking coverage, integrate habitat modeling and community-based monitoring, and promote coordinated transboundary management to ensure the long-term persistence of lions in Central Africa's savannah ecosystems.

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#### Conflicts of Interest

The authors declare no conflicts of interest.

#### Data Availability Statement

The GPS collar data used in this study is available from the corresponding author upon reasonable request.

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## Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Data S1:** aje70116-sup-0001-DataS1.pptx.