DECADE-LONG MONITORING IN LOMAKO-YOKOKALA FAUNAL RESERVE, DRC: IMPACTS OF RANGER PATROLS ON MAMMAL POPULATION STATUS

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ABSTRACT

Protected areas are crucial for biodiversity conservation, and effective monitoring of animal population trends is critical for proper management. However, sustaining long-term monitoring remains challenging. In 2023, we conducted a reserve-wide survey in the Lomako-Yokokala Faunal Reserve, Democratic Republic of Congo, to evaluate mammal population change over the past decade. This reserve, a Bonobo (*Pan paniscus*) study site since 1974, has been managed with ranger patrols since 2006. To ensure comparability, we replicated the methods of a 2010 survey, using index sampling and reconnaissance methods – cost-effective approaches for rainforest mammal monitoring. Encounter rates for most target species increased since 2010, with one monkey and four duiker species showing at least fourfold rises, while hunting signs declined. Some large mammals displayed uneven distributions, reflecting historical hunting pressures during periods of political instability, whereas others showed recovery even in areas with poaching signs. Although detectability differences between surveys cannot be excluded, the observed increase in encounter rate indicates the effectiveness of ranger patrols. Further research into detectability factors and thresholds for significant changes will enhance the reliability of indices as long-term monitoring tools in tropical forests.

Keywords: Bonobos, Index sampling, Long-term monitoring, Rainforest

INTRODUCTION

Protected areas are crucial for biodiversity conservation, playing an essential role in large-scale conservation programmes by maintaining ecological functions and providing sustainable land-use options for humans (Bruner et al., 2001; DeFries et al., 2007; Stokes et al., 2010). The presence of rangers and also long-term tourism and research activities significantly enhance the conservation status of protected areas (Campbell et al., 2011; Tranquilli et al., 2012). However, protected areas can only fulfil their conservation role if they are properly managed (Fischer, 2008; Kapos et al., 2009). Monitoring wildlife to track trends in animal populations is critical for assessing the impact of potential threats and the effectiveness of conservation interventions (Carrillo et al., 2000; Kühl et al., 2008). Despite its importance, long-term monitoring data are often scarce (e.g. Hoppe-Dominik et al., 2011). While absolute estimates of animal abundance are ideal, often practical and financial constraints limit surveys and monitoring programmes to estimating indices (Carrillo et al., 2000; Kühl et al., 2008). Monitoring mammal populations in tropical rainforests, for example, requires substantial effort and expense due to poor visibility in dense vegetation (Carrillo et al., 2000; Plumptre, 2000). In areas with hunting pressure, direct observation is further complicated, as animals tend to flee and hide from humans. Consequently, index sampling of indirect signs, such as dung and nests, is widely used in mammal population monitoring programmes (e.g. Barnes, 2001; Kuehl et al., 2007; Stokes et al., 2010).

Relative abundance indices can provide valuable information on spatiotemporal changes in distribution and population status when derived from standardised sampling methods. However, careful consideration must be given to the underlying assumptions (Kühl et al., 2008). Key assumptions are that population indices and density have a linear relationship, and that the detection probability of the index remains constant over space and time, although these assumptions are invalid in many field studies (Kühl et al., 2008; Pollock et al., 2002). Detection probability may vary depending on the observer and vegetation type. Furthermore, translating the density of indirect signs (such as dung and nests) into animal density requires an understanding of production and decay rates of these signs, which can vary significantly with season, weather, habitat, diet and other factors (Kuehl et al., 2007; Laing et al., 2003; Walsh & White, 2005). Reuse of the same transects in subsequent surveys is one strategy to minimise variability in detection probability (Plumptre, 2000).

Conservation activities often face challenges such as political instability, shifting stakeholders and limited funding, making long-term monitoring difficult. The Lomako forest in the Democratic Republic of Congo (DRC) exemplifies these challenges. It has been a long-term study site for Bonobos (*Pan paniscus*), an endangered species of great ape endemic to the DRC (IUCN & ICCN, 2012), since the 1970s, with early recognition of the need for a protected area (Badrian & Badrian, 1977). Attempts to formally protect the Lomako forest in the 1980s were disrupted by political instability and warfare in the 1990s (Dupain & Van Elsacker, 2001). However, the Lomako-Yokokala Faunal Reserve (RFLY) was officially established in 2006 and has since been managed by the Congolese Institute for the Conservation of Nature (ICCN) (Sakamaki et al., 2020). Although anecdotal evidence suggests an increase in the number and distribution of large mammals (e.g. Maputla et al., 2020), there is limited data on trends in mammal populations.

In this study, we present the results of a reserve-wide survey conducted in 2023, assessing the populations of medium and large mammals, as well as human activities, within RFLY. The primary objective was to evaluate changes in mammal populations over the past decade by comparing our findings with data from previous surveys. Several surveys prior to RFLY's establishment focused on studying the region's flora (Boubli et al., 2004), large mammals, and human disturbances (Dupain et al., 2000; Omasombo et al., 2005). However, these surveys were limited to specific parts of the Lomako forest. The first comprehensive survey covering the entire RFLY was conducted in 2006 (Omasombo & Mpiana, 2006), followed by subsequent surveys. The earliest survey with comparable data was conducted in 2010 (Vosper, 2010). To enhance comparability, we used the same survey design as in 2010. The available 2010 data included encounter rates for medium and large mammals, collected via reconnaissance ('recce') methods, and Bonobo density estimates based on line-transect distance sampling (Kühl et al., 2008; Vosper, 2010). In this study, we also examined the distribution patterns of mammal populations, as events in the Lomako forest over several decades may have influenced their current distributions. The long-term study site, established in the 1970s (Dupain & Van Elsacker, 2001; Sakamaki et al., 2020), may have deterred commercial hunters from entering the area. A logging company operated in the north-western region until it abandoned its concession in 1987 (Dupain et al., 2000). During the political instability of the 1990s and 2000s, commercial hunters used old logging roads to enter the area from the west (Dupain & Van Elsacker, 2001). Since the creation of RFLY in 2006, ranger patrols have been implemented. We hypothesised that (1) if ranger patrols were effective, mammal populations that declined during the 1990s and 2000s would have improved over the past decade, and (2) mammal relative abundance would be higher near ranger patrol bases and long-term study sites. We examined the distribution of poacher signs and mammal populations relative to the locations of patrol bases, and we discuss overall population changes and the effectiveness of ranger patrols in RFLY.

METHODS

Study area

RFLY is located between the Lomako and Yokokala Rivers, covering an area of 3,625 km^2 (Supplementary Online Material 1). The terrain is flat, with an average elevation of approximately 400 m above sea level. The region receives over 2,000 mm of mean annual rainfall, with a drier period typically occurring between January and March (Boubli et al., 2004). The vegetation primarily consists of evergreen lowland tropical rainforest, categorised into four distinct physiognomic types: (1) Mixed forest – a 'primary' forest with various species, many large trees, and a high, continuous canopy without dominant species; (2) Monodominant forest – similar to mixed forest but dominated by a single tree species, typically *Gilbertiodendron dewevrei*, often found around inundated areas; (3) Secondary forest – areas previously used for human agriculture or affected by tree-fall gaps, characterised by dense undergrowth and an absence of large trees; and (4) Inundated forest – areas that are seasonally or permanently flooded (Boubli et al., 2004; White, 1992; White & Edwards, 2000). RFLY contains two long-term study sites: Ndele (also known as Isamondje), established in 1974, and Iyema, founded in 1995 (Dupain & Van Elsacker, 2001) (Figure 1). The reserve's headquarters are located at Lingunda,

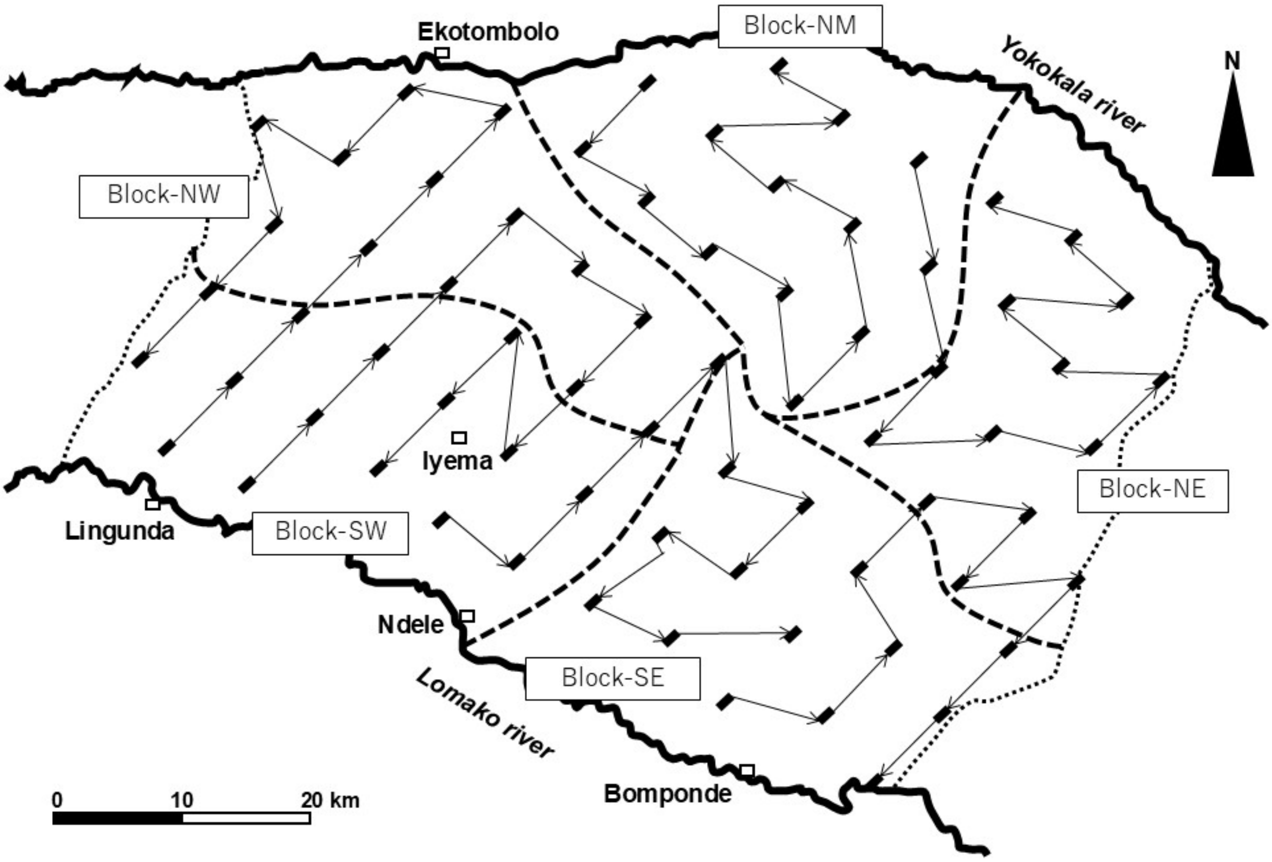

Figure 1. Map of RFLY showing 71 line transects (1 km each, bold straight lines) and 65 recces (straight arrows) from the 2023 survey. The northern and southern boundaries of RFLY are the Yokokala and Lomako Rivers, respectively, while the western and eastern boundaries are marked by dotted lines. The area is divided into five blocks (broken lines) based on three ranger patrol sectors (approximately SW, NW+NM, and NE+SE). Iyema and Ndele have been long-term study sites since 1995 and 1974, respectively. Lingunda serves as the RFLY headquarters, while Bomponde and Ekotombolo are additional ranger patrol stations.

in the south-west, with two additional patrol stations at Bomponde (south-east) and Ekotombolo (north-west) (Figure 1). The area around Bomponde is inhabited by members of the Kitiwalists, a Christian religious group who live in isolated forest camps and are not governed by state authority (Dupain & Van Elsacker, 2001).

Survey design

We systematically placed 71 one-kilometre-long transects throughout RFLY (Figure 1). The number and length of transects were determined based on the encounter rate of Bonobo nests from a preliminary 2008 study and a time limit of two months for survey completion (Vosper, 2010). Reconnaissance walks (recces) were used to connect the end of one transect and the start of the next. The transects and recces were divided into six circuits (Figure 1), each containing 12 transects and 11 recces, except for one circuit, which had 11 transects and 10 recces. Some recce routes were adjusted from the previous layout due to logistical considerations, but the total number of recces remained the same as in the 2010 survey. We followed straight transects using a 50-metre tape measure, a compass and a GPS navigator (Garmin GPSMAP 65s), verifying the coordinates of every 100-metre point. Three transects were shortened due to relatively large rivers, resulting in a total transect length of 70.4 km. Along recces, we followed a straight path as closely as possible, with one major detour around a natural gap caused by fallen trees. The total length of recces was 461.5 km (N = 65 recces, mean = 7.10±SD 1.00 km, range = 6.35–10.22 km), and the total length of all census routes combined was 531.9 km.

Data collection

Two teams surveyed three circuits each from 13 March to 16 May 2023. Each team comprised a team leader (YM and LLF, respectively) and five ICCN rangers, including two observers – one focusing on detecting ground-based animal signs and the other on tree-dwelling animals and Bonobo nests. To improve inter-observer reliability, a training programme and preliminary survey were conducted in September and October 2022. Teams walked at approximately 0.5 km/h on transects and 1 km/h on recces, recording vegetation types, direct and indirect observations of mammals, and signs of human activity along the routes, while marking their positions with GPS devices. Vegetation was categorised using the four physiognomic types described earlier, with changes noted whenever a transition occurred. For mammals, species were recorded along with the number of individuals and detection types, including direct observations, vocalisations, fleeing sounds, footprints, dung, food remnants or marks, digging holes and Bonobo nests. Species were identified by dung based on characteristics such as size, shape and colour, with at least two team members verifying each identification. Dung from three similarly sized duiker species (Black-fronted (*Cephalophus nigrifrons*), Weyns's (*C. weynsi*) and Bay Duikers (*C. dorsalis*)) was grouped into a single category. For diurnal monkeys, sightings were counted based on group detections. Indicators of human activity recorded included traps (both active and inactive), hunting camps, gunshot sounds, shotgun cartridges, poisoned arrows, agricultural fields, direct encounters with people, human trails and machete cut marks. To estimate Bonobo nest density, we used the standing crop nest count method and distance sampling (Thomas et al., 2010; Tutin & Fernandez, 1984), following the same approach as in the 2010 survey. For each nest group detected along transects, we recorded nest age class, group size, and perpendicular distance from centre of the group to transect line. Nest age was categorised into four classes (Tutin & Fernandez, 1984): Fresh – all leaves in the nest are green and fresh; Recent – leaves are drying and changing colour; Old – nest structure remains intact, with most leaves brown; and Very old – the nest has holes and few or no leaves but is still identifiable by bent twigs. Nests within the same age class and located within 30 m of each other were grouped as belonging to the same nest group.

Rangers receiving training © Sakamaki-AZF

Data analysis

To compare mammal indices, we calculated encounter rates (i.e. the number of detections per km) along recces, following the method used in the 2010 survey (Vosper, 2010). The target species included 15 mammals: Forest Elephant (*Loxodonta cyclotis*), detected through dung; Bonobo, detected through nest groups and individual nests; four species of diurnal monkeys – Angola Colobus (*Colobus angolensis*), Black Crested Mangabey (*Lophocebus aterrimus*), Wolf's Monkey (*Cercopithecus wolfi*) and Red-tailed Monkey (*C. ascanius*) – detected through direct observation and vocalisations; five species of duikers – Blue Duiker (*Philantomba monticola*), Black-fronted Duiker, Weyns's Duiker, Yellow-backed Duiker (*C. silvicultor*) and Bay Duiker – detected through dung; and three large and one small artiodactyl species – Red River Hog (*Potamochoerus porcus*), Bongo (*Tragelaphus eurycerus*), Sitatunga (*T. spekii*) and Water Chevrotain (*Hyemoschus aquaticus*) – detected through dung. For comparisons of Bonobo nest density, we used DISTANCE software (ver.7.5) (Thomas et al., 2010) to estimate density based on the number of nest groups along each transect, transect length, nest group size, and perpendicular distance. Several detection functions were tested, with the detection function using a uniform key providing the best fit based on Akaike's Information Criterion. We also examined other variables such as nest group size and nest age classes. For hunting signs, we calculated the encounter rates of traps, hunting camps, shotgun cartridges and poisoned arrows.

To analyse the distribution patterns of mammals, we divided the study area into five blocks: south-west (SW), south-east (SE), north-west (NW), north-middle (NM) and north-east (NE). Each block included 14 transects and 13 recces, except for the SW block, which had 15 transects and 13 recces (Figure 1). These blocks

Table 1. Potential factors affecting mammal distribution in RFLY. The study area was divided into five blocks based on the locations of ranger patrol bases.

	Block					
Factors	**SW**	**SE**	**NW**	**NM**	**NE**	**Total**
Ranger patrol bases	headquarters	station	station	no	no	---
Long-term study sites since the 1970s	yes	no	no	no	no	---
Old logging roads abandoned in 1987	no	no	yes	no	no	---
Vegetation types (%):						
- mixed forest / monodominant forest	67 / 17	65 / 11	71 / 16	72 / 17	65 / 16	68 / 15
- inundated forest / secondary forest	15 / 1	20 / 3	12 / 0	12 / 0	17 / 1	15 / 1

were based on three ranger patrol sectors (i.e. SW, north and east), with the north and east sectors further subdivided. The patrol sectors roughly correspond to the SW, NW+NM, and NE+SE blocks (Table 1). To assess patrol effort in each block, we obtained monthly patrol route data from 2017 to 2022 (excluding three months in 2021). The frequency of ranger patrols per year was calculated based on monthly records, and differences in yearly patrol ratios across the five blocks were tested using the Kruskal-Wallis test ($N = 6$ years, $df = 4$). Significant results ($P < 0.05$) were followed by Tukey's honestly significant difference (HSD) test for pairwise comparisons. All statistical analyses were performed in the R statistical environments (R Core Team, 2019). For poacher activity, we analysed not only hunting signs but also all other indicators of human presence, including human trails and machete cut marks, assuming that most intrusions into RFLY were hunting-related. Encounter rates along each recce were calculated, and differences among the five blocks were tested using the Kruskal-Wallis test (13 recces in each block, $df = 4$), followed by Tukey's HSD test. Regarding mammal distributions, encounter rates for each species were calculated along each recce and analysed similarly to poacher intrusions. Due to low detection numbers, Bongo and Water Chevrotain were excluded from the analysis. Elephant signs, including dung and other traces, were grouped together as there was no confusion with other mammals. For Bonobos, both nest groups and individual nests were analysed. Since vegetation type may influence mammal distribution, we calculated the proportion of each vegetation type along the survey routes in each block. However, vegetation variation among the blocks was minimal: mixed forest consistently occupied 65–72 per cent of each block, while secondary forest ranged from 0–3 per cent (Table 1).

RESULTS

Comparisons with the 2010 survey

Encounter rates of mammal signs increased for most target species compared to the 2010 survey, with rates for one species of diurnal monkey and four species of duikers rising fourfold or more (Supplementary Online Material 2). It was difficult to assess changes for less frequently encountered species, such as Elephants, Water Chevrotains and Bongos (Supplementary Online Material 2). The encounter rate of Bonobo nest groups showed a modest 5 per cent increase, while that of individual nests increased by over threefold (213 per cent) (Supplementary Online Material 2). This comparison is based on data collected along recces, as the number of nest groups along transects was not reported in Vosper (2010). The number of transects where Bonobo nests were detected was higher in 2023 than in 2010 (26 out of 71 transects vs. 17 out of 70) (Supplementary Online Material 2). The average nest group size was approximately threefold larger than in the 2010 survey (9.98 vs. 3.36 nests). The age class distribution of detected nest groups also differed: in 2010, most nests were classified as "old" rather than "fresh" or "recent" (Vosper, 2010), whereas in 2023, "fresh" and "recent" nests dominated observations (31 per cent and 55 per cent, respectively). Nest density increased more than fivefold (25.5 vs. 133.5 nests/km2). In contrast, encounter rates of hunting signs decreased compared to the 2010 survey (traps: -82 per cent; hunting camps: -40 per cent) (Supplementary Online Material 2).

Distribution patterns

The frequency of ranger patrols varied significantly across the five blocks (Kruskal-Wallis test, $P = 0.00014$), with the highest patrol frequency observed in the SW block, and higher frequencies in the SE and NW blocks compared to the NM and NE blocks (Figure 2). Similarly,

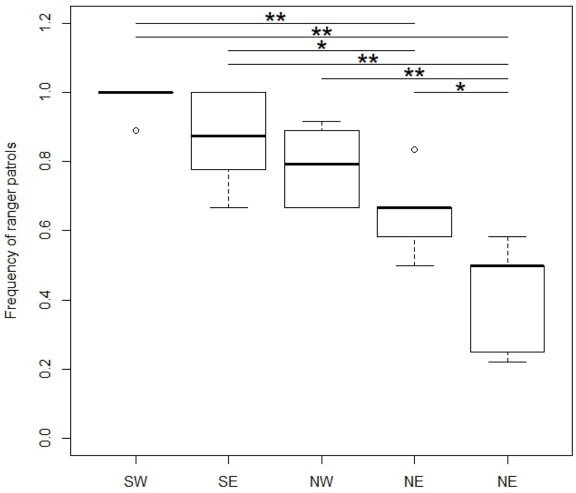

Figure 2. (a) Frequency of ranger patrols (yearly ratios) in five blocks (SW, SE, NW, NM and NE) of RFLY in 2017 to 2022.

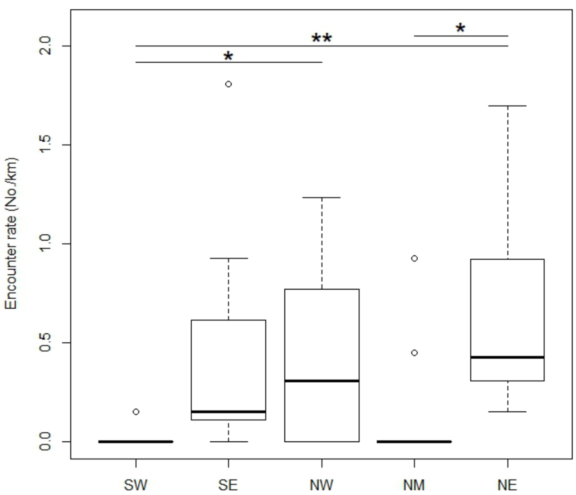

Figure 2. (b) Encounter rates of poacher signs along each recce in five blocks (SW, SE, NW, NM and NE) of RFLY. There was a significant difference in encounter rates among the five blocks (Kruskal-Wallis test, P < 0.01). Significant differences between pairs of blocks are indicated (Tukey's HSD test, *: P < 0.05, **: P < 0.01).

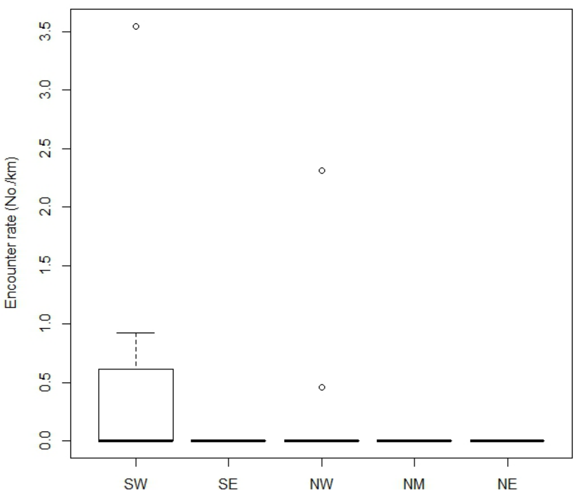

Figure 3. Encounter rates of (a) Elephants

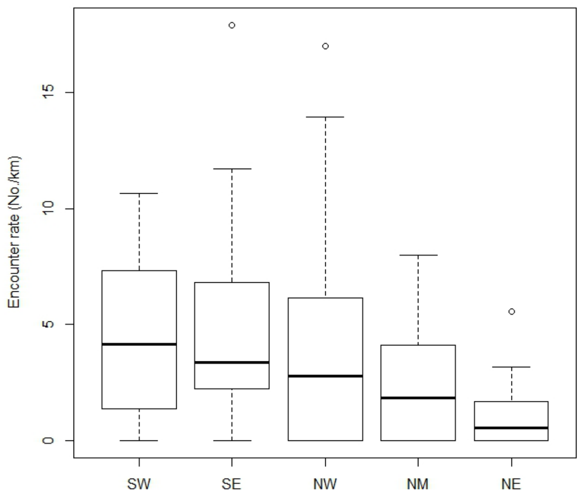

Figure 3. Encounter rates of (b) Bonobos (individual nests)

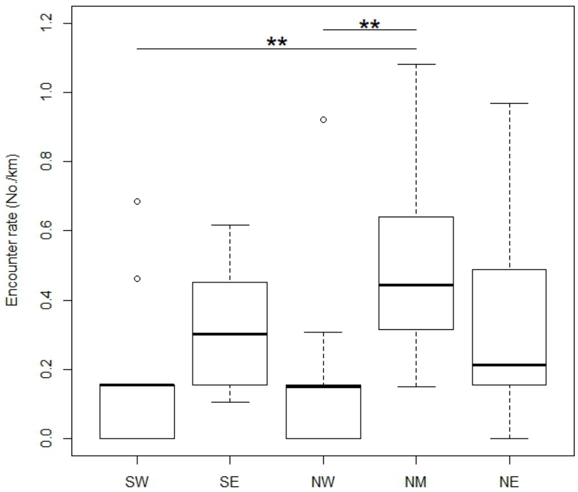

Figure 3. Encounter rates of (c) Red River Hogs

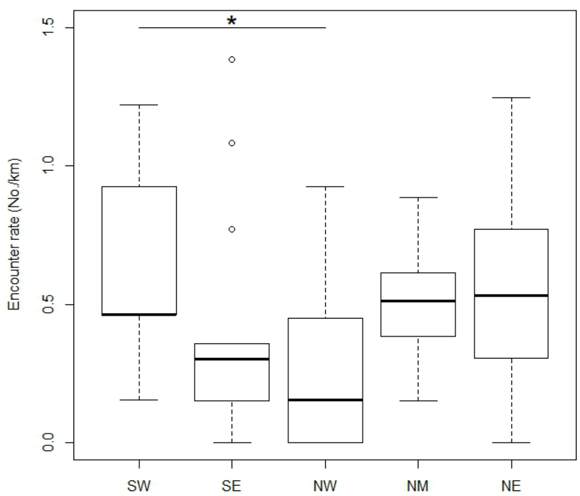

Figure 3 Encounter rates of (d) Yellow-backed Duikers along each recce in five blocks (SW, SE, NW, NM and NE) of RFLY. Significant differences among the five blocks were found for all four species (Kruskal-Wallis test, P < 0.05). Significant differences between pairs of blocks are indicated (Tukey's HSD test, *: P < 0.05, **: P < 0.01).

encounter rates of poacher signs differed significantly across the blocks (P = 0.00001), with the highest rate recorded in the NE block and the lowest in the SW block (Figure 2). Significant differences in encounter rates were found among the five blocks for four mammal species: Elephants (P = 0.0046), Bonobos (individual nests, P = 0.041), Red River Hogs (P = 0.00085) and Yellow-backed Duikers (P = 0.014) (Supplementary Online Material 2). Distribution patterns varied among these species: Elephants, Bonobos and Yellow-backed Duikers showed the highest encounter rates in the SW block, while Red River Hogs had the highest rates in the NM block (Figure 3).

DISCUSSION

Overall changes in mammal populations

In 2023, we conducted a reserve-wide survey of medium and large mammals, as well as human activities, in RFLY, facilitating a direct comparison with the previous survey from 2010 (Vosper, 2010). Our findings show that encounter rates for most mammal species have increased, with rates for one species of diurnal monkey and four species of duikers rising by more than fourfold. This suggests a steady growth in mammal populations in RFLY over the past decade. Additionally, indices of hunting signs have decreased substantially. During the political instability of the 1990s and 2000s, we assume that mammal populations in this area – particularly in the northern parts of RFLY – were severely impacted by commercial hunting (Dupain et al., 2000; Dupain & Van Elsacker, 2001). However, our results suggest that ranger patrols, implemented following the establishment of RFLY in 2006, have been effective. These findings are particularly significant, given that large mammals, as well as duikers and monkeys, are prime targets for both local and commercial hunters (e.g. Fa et al., 2005), and that large mammal populations have continued to decline even in protected areas across Africa (e.g. Craigie et al., 2010).

The substantial increase in mammal indices suggests growing mammal populations. However, when making temporal comparisons, it is important to consider whether detection probabilities remain consistent (Kühl et al., 2008; Pollock et al., 2002). Although the same survey design was employed as in the previous study, several factors could still influence detection probability. First, the ability of observers to detect animal signs may have improved due to accumulated experience, as the observers in this study were rangers who regularly patrolled the area, collecting data on animal signs and human activities for law enforcement purposes. Second, the likelihood of directly observing some animals may have increased as a result of behavioural changes. Specifically, diurnal monkeys tend to flee and hide from humans in areas with hunting pressure, while in well-protected areas like the Iyema site, they do not exhibit such behaviours (Sakamaki, personal observations). Consequently, detectability through direct observation may increase in response to effective ranger patrols. Third, unlike direct observation, the detection of terrestrial mammal dung remains a reliable indicator for temporal and spatial comparisons, as it is unlikely to be influenced by conservation interventions or hunting, provided that survey routes are randomly set. One concern, however, is the potential impact of rainfall, as even a single rain event can affect dung decay rates. Although both the 2010 and 2023 surveys included a drier period between January and March, specific rainfall data for the survey periods are unavailable. In any case, to enhance the utility of indices for temporal and spatial comparisons, it is crucial to validate a linear relationship between indices and abundance. This can be achieved by comparing them with independent absolute density estimates from alternative methods, such as camera traps and genetic surveys (Barnes, 2001; Bradley et al., 2008; Guschanski et al., 2009; Nakashima et al., 2013). Furthermore, it is essential to establish the threshold of index variation that constitutes statistical significance (e.g. Crawford, 1991; Plumptre, 2000).

The Bonobo nest density, based on distance sampling along line transects, increased fivefold compared to the 2010 survey. However, this drastic rise seems questionable given the long birth interval of wild Bonobos (4.8 years: Hashimoto et al., 2022). While the encounter rates of nest groups remained nearly unchanged, the encounter rates of individual nests rose substantially, indicating that the average nest group size increased threefold. This discrepancy could be partially attributed to variations in nest age classes between surveys: in 2010, more "old" nests were detected, whereas in 2023, "fresh" and "recent" nests dominated the observations. Since older nests are more likely to disappear, the 2010 survey may have underestimated the actual number of nests. However, this factor alone is unlikely to fully explain the threefold increase in nest group size. Human disturbance may have contributed to the smaller nest group sizes observed in 2010. Unhabituated Bonobos often disperse into smaller parties when encountering humans or experiencing disturbances, especially in areas where they are hunted (Sakamaki, personal observations). In contrast, the Bonobos in RFLY appear to have adapted their behaviour and grouping patterns to more natural conditions as human threats have diminished. Although further research is needed to assess the effects of human disturbance on nest group sizes and its impact on density estimation, our findings suggest that the Bonobo population in RFLY has increased over the past decade.

Distributions and patrol effectiveness

We divided RFLY into five blocks based on the locations of patrol bases and observed a gradient in patrol efforts. Patrol frequency was highest in the SW block, where the headquarters and long-term study sites are located, and higher in the SE and NW blocks, where patrol stations are situated, compared to the NM and NE blocks. The rate of poacher signs was highest in the NE block, suggesting that poachers may have entered the area from the east, and second highest in the NW block, where old logging roads are present (Dupain et al., 2000). Interestingly, poacher activity was low in the NM block, which lacks a patrol base, suggesting that this area is the most difficult to penetrate. Significant differences in mammal indices among the five blocks were found for Elephants, Bonobos, Red River Hogs and Yellow-backed Duikers – all relatively large mammals. Some of these distributions may reflect the legacy of past hunting impacts. For example, Elephants likely survived in only a small portion of the Lomako forest during or even before the period of active commercial hunting in the 1990s and 2000s (Dupain et al., 2000). Since previous surveys recorded their range in the same area (Maputla et al., 2020; Vosper, 2010), it appears that Elephants have not significantly expanded their range. Bonobo indices were slightly higher in the southern blocks, likely reflecting past hunting pressures along the northern Yokokala River (Dupain et al., 2000).

It is important to note that other mammals were distributed more evenly throughout RFLY, suggesting that historical population declines caused by commercial hunting have had a limited impact on their present-day distributions. The high rates of increase observed for certain species indicate the effectiveness of ranger patrols, even in areas with frequent poacher intrusions. Future surveys comparing these indices will help determine whether these populations continue to grow and reach their carrying capacity under well-protected conditions.

CONCLUSIONS

This study demonstrates that replicating the design of a previous survey, along with relatively simple and inexpensive methods, is practical for evaluating overall changes in mammal populations and assessing the effectiveness of ranger patrols over a decade. However, detection probabilities for some mammal indices may have varied during this period. Furthermore, the range of statistically significant index changes remains unclear due to the lack of statistical assessment. For example, integrating regular patrols that collect encounter rate data using the Spatial Monitoring and Reporting Tool (SMART) could help quantify the inherent variability in indices and identify factors beyond animal density that influence this variability. Addressing these limitations in future studies would enhance the reliability of index sampling for long-term monitoring of mammal populations and the evaluation of conservation interventions. We emphasise that indices should ideally be complemented with alternative methods such as camera traps and genetic surveys to obtain precise population estimates, while still benefiting from the cost-effectiveness of standardised index approaches.

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SUPPLEMENTARY ONLINE MATERIAL

Supplementary Online Material 1. Additional figure of study area

Supplementary Online Material 2. Tables for Results and Discussion section

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RESUMEN

Las áreas protegidas son cruciales para la conservación de la biodiversidad, y el seguimiento eficaz de las tendencias de las poblaciones animales es fundamental para una gestión adecuada. Sin embargo, mantener un seguimiento a largo plazo sigue siendo un reto. En 2023, realizamos un estudio de toda la reserva en la Reserva Faunística de Lomako-Yokokala, República Democrática del Congo, para evaluar los cambios en la población de mamíferos durante la última década. Esta reserva, lugar de estudio del Bonobo (*Pan paniscus*) desde 1974, ha sido gestionada con patrullas de guardabosques desde 2006. Para garantizar la comparabilidad, reprodujimos los métodos de un estudio de 2010, utilizando muestreo índice y métodos de reconocimiento, enfoques rentables para el seguimiento de mamíferos de la selva tropical. Las tasas de encuentro de la mayoría de las especies objetivo aumentaron desde 2010, con un mono y cuatro especies de duiqueros que mostraron un aumento de al menos cuatro veces, mientras que los indicios de caza disminuyeron. Algunos grandes mamíferos mostraron distribuciones desiguales, lo que refleja presiones históricas de caza durante periodos de inestabilidad política, mientras que otros mostraron recuperación incluso en zonas con indicios de caza furtiva. Aunque no pueden excluirse diferencias de detectabilidad entre los distintos estudios, el aumento observado en la tasa de encuentros indica la eficacia de las patrullas de guardabosques. Nuevas investigaciones sobre los factores de detectabilidad y los umbrales de los cambios significativos aumentarán la fiabilidad de los índices como herramientas de seguimiento a largo plazo en los bosques tropicales.

RÉSUMÉ

Les zones protégées sont essentielles à la conservation de la biodiversité, et un suivi efficace de l'évolution des populations animales est indispensable à une bonne gestion. Cependant, le maintien d'un suivi à long terme reste un défi. En 2023, nous avons mené une étude à l'échelle de la réserve dans la réserve de faune de Lomako-Yokokala, en République démocratique du Congo, afin d'évaluer l'évolution des populations de mammifères au cours de la dernière décennie. Cette réserve, site d'étude du Bonobo (*Pan paniscus*) depuis 1974, est gérée par des patrouilles de gardes forestiers depuis 2006. Pour assurer la comparabilité, nous avons reproduit les méthodes d'une étude de 2010, en utilisant l'échantillonnage indiciel et les méthodes de reconnaissance - des approches rentables pour le suivi des mammifères de la forêt tropicale. Les taux de rencontre pour la plupart des espèces cibles ont augmenté depuis 2010, avec un singe et quatre espèces de céphalophes qui ont au moins quadruplé, tandis que les signes de chasse ont diminué. Certains grands mammifères présentaient des distributions inégales, reflétant les pressions historiques de la chasse pendant les périodes d'instabilité politique, tandis que d'autres ont montré un rétablissement même dans les zones présentant des signes de braconnage. Bien que l'on ne puisse exclure des différences de détectabilité entre les enquêtes, l'augmentation observée du taux de rencontre indique l'efficacité des patrouilles de gardes forestiers. Des recherches plus approfondies sur les facteurs de détectabilité et les seuils de changements significatifs permettront d'améliorer la fiabilité des indices en tant qu'outils de surveillance à long terme dans les forêts tropicales.