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Comparative study of the mammalian community of the core zone and the community zone of the National Park of Lobeke (Cameroon) in terms of specific richness and composition by camera traps inventory

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Résumé :

Dans le contexte actuel de la sixième extinction de masse, l'enjeu de la conservation de la grande faune mammalienne, particulièrement menacée en Afrique centrale, est important. Dans cette optique, la connaissance des communautés animales en présence est primordiale afin d'assurer des mesures de gestion adaptées à l'état de la faune. A cet effet, les inventaires de faune par pièges-caméra occupent aujourd'hui une place de choix dans les techniques envisageables. Leur essor, à la suite du développement de technologies et logiciels liés, permet d'améliorer la qualité des inventaires par leur aspect peu intrusif et leur fonctionnement diurne comme nocturne.

Dans ce contexte, la présente étude porte sur une comparaison de deux inventaires, de mammifères terrestres et semi-terrestres, réalisés par pièges-caméras dans le parc national de Lobeke au Cameroun. Une première grille de pièges-caméra a été positionnée dans la zone communautaire du parc en 2021 et ce travail porte sur la mise en place de la seconde grille dans la zone non-communautaire, ou zone noyau, et sur la comparaison des résultats des deux inventaires. L'objectif principal du travail est donc de caractériser les différences entre ces deux communautés mammaliennes en termes de richesse spécifique et de composition.

Les deux grilles étaient composées de 40 pièges-caméras suivant les recommandations du protocole international TEAM. Les pièges-caméras étaient disposés de façon systématique avec une densité de 1 piège pour 2 km².

Dans un premier temps, un prétraitement des données à été effectué en deux étapes. La première étape a consisté à passer en revue toutes les captures vidéo pour identifier les espèces et les complexes d'espèces présents ainsi que leurs effectifs. La seconde a servi à nettoyer le jeu de données de façon à ne considérer que des événements indépendants par espèce, c'est-à-dire un événement toutes les 30 minutes par espèce, en considérant l'effectif maximal relevé sur cet intervalle en cas de groupe.

Dans un second temps, diverses analyses statistiques ont été réalisées afin de pouvoir comparer les deux communautés. Premièrement la richesse spécifique a été étudiée sous forme de liste d'espèce et de courbe d'accumulation du nombre d'espèce en fonction de l'effort d'échantillonnage. Deuxièmement l'étude du relative abundance index (RAI) par espèce a permis d'identifier les espèces présentes en majorité (top 5 pour chacun des deux inventaires) et de comparer les taux de détection des différentes espèces au sein des deux zones. Troisièmement une ordination non-metric multidimensional scaling a été réalisée sur base de la matrice de dissimilarité utilisant l'indice de Bray-Curtis afin d'observer les différences de compositions des deux communautés.

Les analyses effectuées ont montré une richesse spécifique plus importante dans la zone communautaire ainsi que des RAI généralement plus élevés, avec pourtant des communautés animales relativement semblables en termes de composition. Une probable pression de braconnage plus élevée dans la zone noyau que dans la zone communautaire pourrait expliquer ces différences.

MOTS CLEFS : Cameroun, parc national de Lobeke, pièges-caméras, communautés animales, pression anthropique, braconnage

Summary:

In the current context of the sixth mass extinction, the conservation of large mammalian fauna, particularly threatened in Central Africa, is an important issue. From this perspective, knowledge of the animal communities present is essential in order to ensure management measures adapted to the condition of the fauna. To this end, wildlife inventories using camera traps have become a key technique. Their development, following the development of related technologies and software, allows to improve the quality of the inventories by their low-intrusive aspect and their day and night operation.

In this context, this study compares two inventories of terrestrial and semi-terrestrial mammals species conducted by camera traps in the National Park of Lobeke in Cameroon. A first grid of camera traps was set up in the community zone of the park in 2021 and this work focused on the implementation of the second grid in the non-community zone, or core zone, and on the comparison of the results of the two inventories. The main objective of this work is to characterize the differences between these two mammalian communities in terms of species richness and composition.

The two grids were composed of 40 camera traps and were following the recommendations of the international TEAM protocol. The camera traps were placed systematically with a density of 1 trap per 2 km².

First, a pre-processing of the data was done in two steps. The first step was to review all video captures to identify the species and species complexes present and their numbers. The second step was to clean the dataset to consider only independent events per species, i.e., one event every 30 minutes per species, considering the maximum number of animals, detected in one video, in this interval in case of a group.

In a second step, various statistical analyses were performed in order to compare the two communities. First, the species richness was studied in the form of a list of species and an accumulation curve of the number of species according to the sampling effort. Secondly, the study of the relative abundance index (RAI) by species allowed us to identify the most common species present (top 5 for each of the two inventories) and to compare the detection rates of the different species within the two areas. Thirdly, a non-metric multidimensional scaling was performed based on the dissimilarity matrix using the Bray-Curtis index in order to observe the differences in the compositions of the two communities.

The analyses conducted showed a higher species richness in the community zone and generally higher RAI, yet they have relatively similar animal communities in terms of composition. A higher poaching pressure in the core zone compared to the community zone could explain these differences.

KEYWORDS: Cameroon, National Park of Lobeke, camera traps, animal communities, anthropic pressure, poaching

INTRODUCTION

The sixth mass extinction crisis (Cowie R.H. and al., 2022) currently underway is extremely alarming because of the rate at which species are disappearing. Indeed, they would disappear 100 to 1000 times faster than the natural rate of extinction (Lamkin M. and Miller A., 2016). The disappearance of fauna is mainly due to the fragmentation or disappearance of habitats, poaching, climate change, changes in land use and the spread of invasive species (Gibson L. and al., 2013; Seersholm F.V. and al., 2020; Bitty E.A. and al., 2014). These factors are closely linked to the constant increase in human demographic pressure (Leger J.F., 2016).

In this context, careful management of wildlife in protected areas is extremely important in the fight against biodiversity loss. To ensure that it is effective, it must, in addition to being reconciled with the needs of the human populations present, be based on in-depth knowledge of the fauna present in the protected area. This is particularly true in tropical rainforests, especially those in Central Africa, which contain more than 50% (Wilson E.O. and Peter F.M., 1998) of the animal species and where some human communities live very close to or even within protected areas. These communities often exploit the surroundings or the interior of the protected area and the risk of poaching, both for food and for larger-scale trafficking for monetary purposes, is high (Anderson B. and Jooste J., 2014; Hauenstein S. and al., 2019).

The pressures on these animal communities are causing the decline of some iconic species, and sometimes their local extinction. These include great apes such as gorillas (*Gorilla gorilla gorilla*) and chimpanzees (*Pan troglodytes*) as well as elephants (*Loxodonta cyclotis*). This is also the case for less iconic but equally threatened species such as the great pangolin (*Smutsia gigantea*) and some small pangolins (*Phataginus spp*.). Many other species found in these areas are classified as vulnerable according to the IUCN Red List (IUCN, 2022).

One of the most important causes of the decline of these species, which is emphasized in this work, is poaching (Anderson B. and Jooste J., 2014; Hauenstein S. and al., 2019). They are further threatened because of their slow reproductive rate and non-selective hunting techniques, which affect juveniles and pregnant females. Despite laws regulating hunting in Cameroon in terms of types of weapons, techniques used, maximum daily catch and hunting periods, a significant proportion of hunting in Cameroon is illegal (Ruppel O.C. and Yogo E.D., 2022). These laws, in addition to often being ill-adapted to the reality and not considering the needs of rural communities and potential human-wildlife conflicts, are poorly enforced, in particular because of a very high corruption factor in the country (Ngimbog L.-R., 2002). Bushmeat constitutes a large part of the protein sources of rural human communities (Bitty E.A. and al., 2014). With the improvement of hunting weapons and the increase in population pressure, this threat to wildlife tends to increase. Trafficking in illegally hunted animals for no food purpose is also on the rise, especially from the perspective of international networks (Poulsen J.R. and al., 2017). The notorious ivory trade is the major cause of the decline of elephant populations (Hauenstein S. and al., 2019). Tourist hunting, although often poorly controlled, is said to have a reduced impact on the decline of animal populations (Yasuda A., 2012).

Among the different methods of wildlife monitoring, such as the use of observation transects combined or not with distance sampling (Ward A.I., 2004), aerial counts or surveillance patrols (Poilecot P. and al., 2010), the use of camera traps is becoming more and more widespread. Particularly adapted to closed environments such as dense forests, the development of technologies and associated data processing programs has made them accessible and efficient in producing results from the information collected (Agha M. and al., 2018; Scotson L. and al., 2017). They have many advantages, notably being less intrusive for the fauna, being able to shoot both day and night, highlighting the presence of discreet and/or nocturnal species and requiring less time invested for a high inventory efficiency (Trolliet F. and al., 2014).

With the rise of camera traps in wildlife studies, a standardization of protocols has been necessary in order to make data from different studies comparable. This is the objective of the international TEAM protocol, which sets different criteria such as the density of cameras, which proposes a systematic sampling (in order to be as representative as possible of the area in terms of habitats, even if problems of accessibility sometimes arise), which suggests an ideal surface covered by the grid of camera traps, the number of camera traps to be used, or the laying time according to the number of cameras present. The results of studies that follow this protocol can therefore be compared or used for meta-analyses (Sanderson J.G., 2004).

The primary objective of this study is to compare terrestrial and semi-terrestrial mammal communities in two areas of Lobeke National Park (NPL). The research question is "Are there differences in mammalian communities between the community zone and the core zone of the NPL and if so, what are they?". More specifically, it can be translated as "What are the differences in detection rates, species richness, and species composition between the community and core zones of the park?" To do this, two animal communities were studied by two camera trap arrays set one year apart. The first device was set up and studied by Florine Poulain during her master's thesis (Poulain F., 2021) and the second during this study following the recommendations of the TEAM protocol. These two grids of 40 camera traps were positioned respectively in the community area in 2021 and in the core zone in 2022. We compared the two communities from the point of view of terrestrial and semi-terrestrial mammal species in terms of species richness, capture rate (RAI) of each species and by a non-metric multidimensional scaling (NMDS) analysis performed on the camera dissimilarity matrix.

MATERIALS AND METHODS

STUDY AREA

Our study area is located in southeastern Cameroon, in the Eastern Region of the Republic of Cameroon, in the Mboumba and Ngoko Department, straddling the districts of Salapoumbé and Moundou, within the Lobeke National Park (NPL) (Figure 1A). The NPL covers an area of approximately 217,854 ha. It is part of the "Trinational de la Sangha" (TNS) protected area complex, along with the Dzanga-Sangha Special Reserve in the Central African Republic and the Nouabalé-Ndoki National Park in the Republic of Congo. The objective of the TNS is the preservation of the tropical forest of the Congo Basin.

At the origin of the park in 2012 (when it was recognized as a UNESCO World Heritage Site), the community zone (then called the "community development zone") was allocated to the surrounding Bakas populations. The objective was to allow them to exercise fishing rights, harvest medicinal plants and other non-timber forest products (MINFOF, 2015). Then, in 2019, around the same time that the last management plan for the park, which is about to be renewed, ended, a Memorandum of Understanding (MINFOF and ASBABUK, 2019) was signed between the Ministry of Forests and Wildlife (MINFOF) and the Sanguia Baka Buma'a Kpode Association (ASBABUK). It gives access to the entire park to the Bakas communities and authorizes them to practice traditional hunting activities, in addition to the former rights of fishing and harvesting non-timber forest products and medicinal plants. However, the new zoning is a source of conflict which lead to the old zoning being enforced. In the following, the community zone describes the historical community development zone, despite its theoretical expansion to the entire park.

CAMERA TRAP INVENTORY

The study area is divided into two nearly contiguous zones; the first, located in the so-called "community" zone of the LNP, was studied in 2021 by F. Poulain and al.. The second, which is the subject of this study and was surveyed in 2022, is in the heart of the LNP in the so-called "non-community" or "core" zone (Figure 1B).

In each area, a grid of camera traps of about 80 km² was deployed, with a similar protocol in order to facilitate spatial and temporal comparisons.

In the second area, which is the subject of this work, the inventory was carried out according to the recommendations of the TEAM protocol and following as closely as possible the protocol followed for the study of the first area by Poulain et al. The CT grid was composed of 40 cameras (models: Bolyguard SG 2060X - 36MP, Bushnell Trophy Cam HD Agressor 24MP and Bushnell Trophy Trail Camera HD Essential 12MP) with a density of 1 CT/2 km². It was generated through *QGIS* (version 3.16.10) in order to obtain GPS coordinates for each camera trap to be set up. The first point was randomly placed in the study area and the rest of the grid was built systematically from this point (Figure 1C). The grid was installed between 2 and 11 km east of Djangui base camp, for a maximum of 36 days per TC (Figure 1C). The installation period was between the 16th and 20th of March 2022 and the removal period was between the 22nd and 23rd of April 2022 (straddling the major dry season and minor rainy season). The objective was to reach a plateau of 1000 camera.days (Carbone C. and al., 2001) in order to ensure the detection of a maximum of species, in particular rare and/or discreet species.

During installation, the TC was attached as close as possible to the theoretical GPS point (Appendix 1), within a maximum of 30 m (Capelle and al., 2019), at a height of 70 cm (N'Goran and al., 2016; Howe and al., 2017). The field of view area was unobstructed. The CT was oriented to the north with a 40° margin to produce data comparable to the first grid (Poulain and al., In Prep). The camera was calibrated to collect short videos of 5 to 10 seconds. The time between shots was set to 0 seconds. Data characterizing the location of the camera were also collected (Appendix 1) such as habitat type, presence of human and/or animal tracks, presence of fruit, potential proximity to a river (Appendix 2). The objective of collecting this information was to characterize potential habitat diversity, which would have a direct influence on the composition of animal communities, and to identify signs of potential poaching pressure.

The implementation of the experimental design is strongly based on the recommendations of the FauneFac tool[1].

SPECIES IDENTIFICATION AND PREPROCESSING OF THE DATASET

Captured videos were analyzed on *Timelapse* software (version 2.2.5.0) to identify species. The name of the species present and their respective numbers were filled in for each video. Only terrestrial and semi-terrestrial mammals were studied. Recordings of the same species were considered independent only if there was a 30-minute interval between two observations on the same camera. The number of individuals considered for the independent event was the number that maximized the number of

[1] Fonteyn Davy, Doucet Jean-Louis, Fayolle Adeline, Monseur Alain, Quevauvillers Samuel, Holvoet Justin, Poulain Florine, Delame Hugo, Peeters Quentin et Vermeulen Cédric, 2021. FauneFAC : Boite à outils méthodologique pour la mise en place d'inventaires par pièges photographiques. ULiège/Gembloux Agro-Bio Tech, PPECF. https://www.gembloux.ulg.ac.be/faunefac/

individuals in case of a group over the 30-minute period (Meek and al., 2014). This cleaning of the dataset to obtain independent events was performed on *R* (version 1.4.1717).

Some species whose identification is more difficult have been studied in "species complexes". This is the case of genets (*Genetta spp*.) which include *Genetta maculata* and *Genetta servalina*; bats (Bats); squirrels (Squirrels); galagos (Galagos) which include the genera *Euoticus*, *Galagoides* and *Sciurocheirus*; mongooses (Other mongooses), which include *Atilax paludinosus* and *Herpestes nano* (this complex does not include *Bdeogale nigripes*, which has been identified separately) and small pangolins (*Phataginus spp*.), which include *Phataginus tetradactyla* and *Phataginus tricuspis*.

Videos where the animal could not be identified were classed as "undetermined" and were not considered in the analyses.

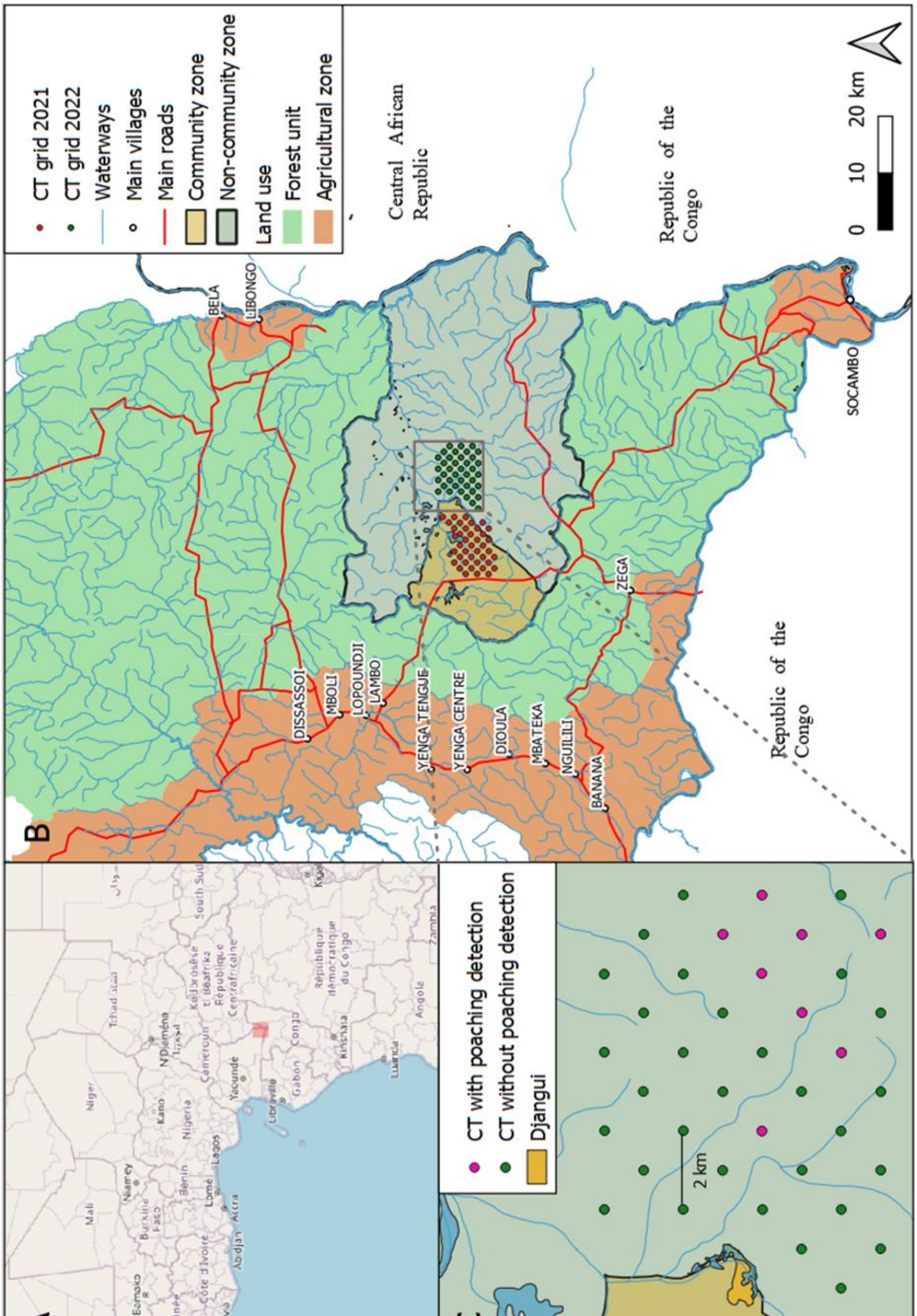

Figure 1 : (A) Position of the NPL (in red) in Cameroon on an OpenStreetMap map background. (B) Location of CT grids (in red for the community area and in green for the core area). (C) Zoom on the core zone sampling with a density of 1 camera/ 2km² and reporting

DATA ANALYSES

Table 1 : List of detected species with identifier (ID) later used in figures, IUCN status (LC = Least Concern, NT = Near Threatened, VU = Vulnerable, EN = Endangered, CR = Critically Endangered). The average relative abundance index (RAI) as well as the number

						Number of detections		RAI		Total	
Order	Family	Species	ID	IUCN	Body mass (kg)	Non-community zone	Community zone	Non-community zone	Community zone	Number of detections	RAI
Artiodactyla											
	Bovidae	*Cephalophus callipygus*	1	LC	22.05	1027	1608	0.8962	0.8490	2635	0.8668
		Cephalophus dorsalis	2	NT	21.3	113	368	0.0986	0.1943	481	0.1582
		Cephalophus leucogaster	3	NT	15.75	13	18	0.0113	0.0095	31	0.0102
		Cephalophus nigrifrons	4	LC	14.5	14	12	0.0122	0.0063	26	0.0086
		Cephalophus silvicultor	5	NT	62.5	23	91	0.0201	0.0480	114	0.0375
		Neotragus batesi	6	LC	2.5	4	4	0.0035	0.0021	8	0.0026
		Philantomba monticola	7	LC	5	723	1874	0.6309	0.9894	2597	0.8543
		Syncerus caffer nanus	8	NA	292.5	3	5	0.0026	0.0026	8	0.0026
		Tragelaphus eurycerus	9	NT	297.5	14	23	0.0122	0.0121	37	0.0122
		Tragelaphus spekii	10	LC	87.5	4	6	0.0035	0.0032	10	0.0033
	Suidae	*Hylochoerus meinertzhageni*	11	LC	227.5	/	2	/	0.0011	2	0.0007
		Potamochoerus porcus	12	LC	80	13	23	0.0113	0.0121	36	0.0118
	Tragulidae	*Hyemoschus aquaticus*	13	LC	11.5	4	51	0.0035	0.0269	55	0.0181
Carnivora											
	Felidae	*Caracal aurata*	14	VU	11	1	6	0.0009	0.0032	7	0.0023
		Panthera pardus	15	VU	46	/	2	/	0.0011	2	0.0007
	Herperstidae	*Other mongooses*	16	LC	4	46	33	0.0401	0.0174	79	0.0260
		Bdeogale nigripes	17	LC	3.4	18	82	0.0157	0.0433	100	0.0329
		Crossarchus platycephalus	18	LC	1.1	4	24	0.0035	0.0127	28	0.0092
	Nandiniidae	*Nandinia binotata*	19	LC	2.15	8	20	0.0070	0.0106	28	0.0092
	Viverridae	*Genetta spp.*	20	VU-LC	1.8	8	18	0.0070	0.0095	26	0.0086
Chiroptera											
		Bats	21	-	0.2	34		0.0297	/	34	0.0112
Pholidota											
	Manidae	*Phataginus spp.*	22	EN-VU	3.3	6	25	0.0052	0.0132	31	0.0102
		Smutsia gigantea	23	EN	30	4	9	0.0035	0.0048	13	0.0043
Primates											
	Cercopithecidae	*Cercocebus agilis agilis*	24	LC	9	110	185	0.0960	0.0977	295	0.0970
		Cercopithecus cephus	25	LC	4	6	8	0.0052	0.0042	14	0.0046
		Cercopithecus nictitans nictitans	26	NT	5.4	/	9	/	0.0048	9	0.0030
		Cercopithecus pogonias grayi	27	NT	3.6	1	1	0.0009	0.0005	2	0.0007
		Colobus guereza	28	LC	9.5	1	6	0.0009	0.0032	7	0.0023
		Lophocebus albigena albigena	29	LC	3.6	20	11	0.0175	0.0058	31	0.0102
	Galagidae	*Galagos*	30	NT-LC	0.2	2	9	0.0017	0.0048	11	0.0036
	Hominidae	*Gorilla gorilla gorilla*	31	CR	124	18	86	0.0157	0.0454	104	0.0342
		Pan troglodytes	32	EN	45	8	16	0.0070	0.0084	24	0.0079
Proboscidae											
	Elephantidae	*Loxodonta cyclotis*	33	CR	4350	52	66	0.0454	0.0348	118	0.0388
Rodentia											
	Hystricidae	*Atherurus africanus*	34	LC	2.9	105	257	0.0916	0.1357	362	0.1191
	Nesomyidae	*Cricetomys emini*	35	LC	0.9	131	39	0.1143	0.0206	170	0.0559
	Sciuridae	*Squirrels*	36	-	0.65	66	160	0.0576	0.0845	226	0.0743
Tubulidentata											
	Orycteropodidae	*Orycteropus afer*	37	LC	52.5	4	/	0.0035	/	4	0.0013

The analyses were performed in three steps. The first step was to study the species richness of the two zones and to compare the results. The second step compared the communities of the two zones in terms of detection rate with the relative abundance index (RAI). The third step studied the difference in composition of the two communities with a non-metric multidimensional scaling (NMDS) based on the Bray-Curtis dissimilarity index.

First, species richness was established by listing the terrestrial and semi-terrestrial mammal species detected in the two areas. Then the accumulation curves of species detection as a function of cameras.days for the two grids were put in parallel. These two elements were obtained by using the R Shiny *EurêCam!* application.

Secondly, the abundance matrix was established by using the RAI in order to study on one hand which species dominate the two communities (taking into account the 5 most common species within the detections by community (Salim A. and al., 2019)). On the other hand, a graph was established to compare the RAI by species according to their position compared to the first diagonal. This was done on the R software using the package *ggplot2* (Fonteyn D. and al., 2020).

Thirdly, a NMDS was performed to study and compare the specific compositions. For this purpose, the detection rate RAI was established based on the Bray Curtis index (Equation 1) in order to perform the ordination. These manipulations were performed on R using the package *vegan* (Dixon P., 2003). The relative richness was also studied during the ordination. It corresponds to the number of species detected by the camera divided by the number of days of operation of the camera.

$$BC_{ab} = 1 - \frac{2\sum_{i=1}^{k} \min(X_{ia}, X_{ib})}{\sum_{i=1}^{k}(X_{ia} + X_{ib})} \ (equation\ 1)$$

Where a and b are the samples between which dissimilarity is measured, X_{ia} is the detection rate of species *i* in sample *a* and X_{ib} the detection rate of species *i* in sample *b*.

RESULTS

INVENTORY DATA AND SPECIES RICHNESS

Of the 40 traps, 39 were set following a deficiency in one of the TCs and 38 recorded videos. For the 39 traps set (Appendix 1), the vast majority (97%) were located in an old growth secondary forest with a canopy opening between 25 and 50%. 7 TCs, or 17.95%, were in the vicinity of evidence of anthropogenic disturbance (Figure 1C) such as bushings, wire traps, footprints and a camp. An additional camera also captured a male. This is 20 .51% of the TCs with signs of human presence. 2 TCs (5.13%) were blinded in their first days by termites (soil deposits covering the lens) and are therefore unusable after an average of 6 days. Of the 39 TCs, 28 (71.79%) were still functioning at the time of recovery. The rest had dead batteries. Despite the TCs that did not operate for the full duration of the inventory, the sampling effort still exceeded the target threshold of 1000 camera.days with a total of 1146 cumulative operating days, with TCs operating an average of 29.38 days.

On average, one camera recorded 1 minute of activity per day (i.e., a dozen videos). This compares to an average of 5.5 minutes during the work of Poulain et al. (In Press) in 2021. TCs captured between 2 and 19 species. In comparison, this range was 8-19 during the 2021 work.

It's important to note that on the 9046 animal species detections, 91 (1%) did not allow the identification of the animal and were therefore classified as "undetermined"; 3446 (38%) corresponded to false triggers or triggers during the installation and/or recovery of the CT; 112 (1,24%) were related to non-mammalian species (birds (111 detections) or reptiles (1 detection)) not studied in this work and for which the identification did not go any further.

During the survey period, 28 species and 6 species complexes were recorded in the core zone, compared to 31 species and 5 species complexes in the Community area (Table 1). Among these 34 species and complexes, 5 are classified as Endangered (EN) or Critically Endangered (CR) by the IUCN. These are *Phataginus tripcuspis*, *Smutsia gigantea*, *Gorilla gorilla gorilla*, *Pan troglotydes* and *Loxondonta cyclotis*. These are the same as in the 2021 inventory.

The species accumulation curve (Figure 2) represents the increase in the number of species detected as a function of cumulative camera days. It tends to stabilize after a similar inventory effort for the 2 curves, around 600-700 cameras.days. The presence of these thresholds is the sign of a sufficient sampling effort to represent the species richness. Since the accumulation curve of the core zone is slightly below that of the community area, the species richness is slightly lower there. However, the differences in species richness are mostly associated with species with few events recorded (with a maximum of 10 detections). This is the case of *Hylochoerus meinertzhageni* (2 detections), *Panthera pardus* (2 detections), *Cercopithecus nictans nictans* (9 detections) and *Orycteropus afer* (4 detections). The latter is the only one present in the community area and not in the core zone. Only the Bats, absent in the community zone, exceed this limit with 34 detections.

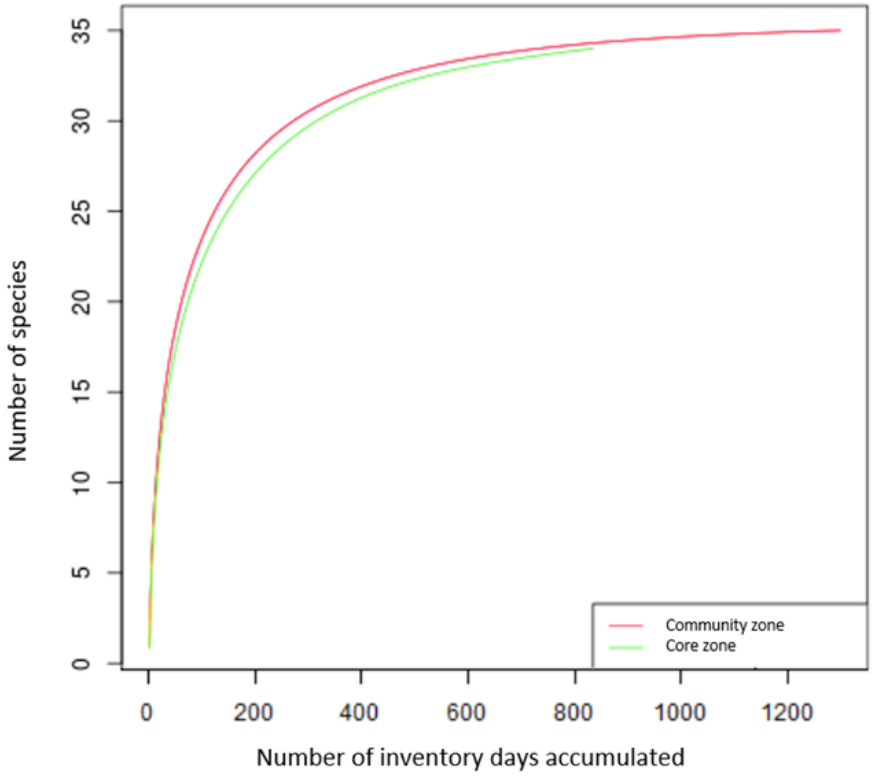

Figure 2 : Accumulation curve representing the accumulation of the number of species of terrestrial mammals as a function of the number of cameras.days accumulated in the two zones of the National Park of Lobeke

COMPARISON OF DETECTION RATES

Figure 3 represents the comparison of the detection rate of the different species between the two studied areas. This detection rate is studied by the RAI. The closer the point corresponding to the species (ID from Table 1) is to the 1:1 line, the more similar the RAI of the community zone and the RAI of the core zone are. If the point is located at the top of the line, the RAI of the core zone is higher and, on the contrary, if it is located below, the RAI of the community zone is higher.

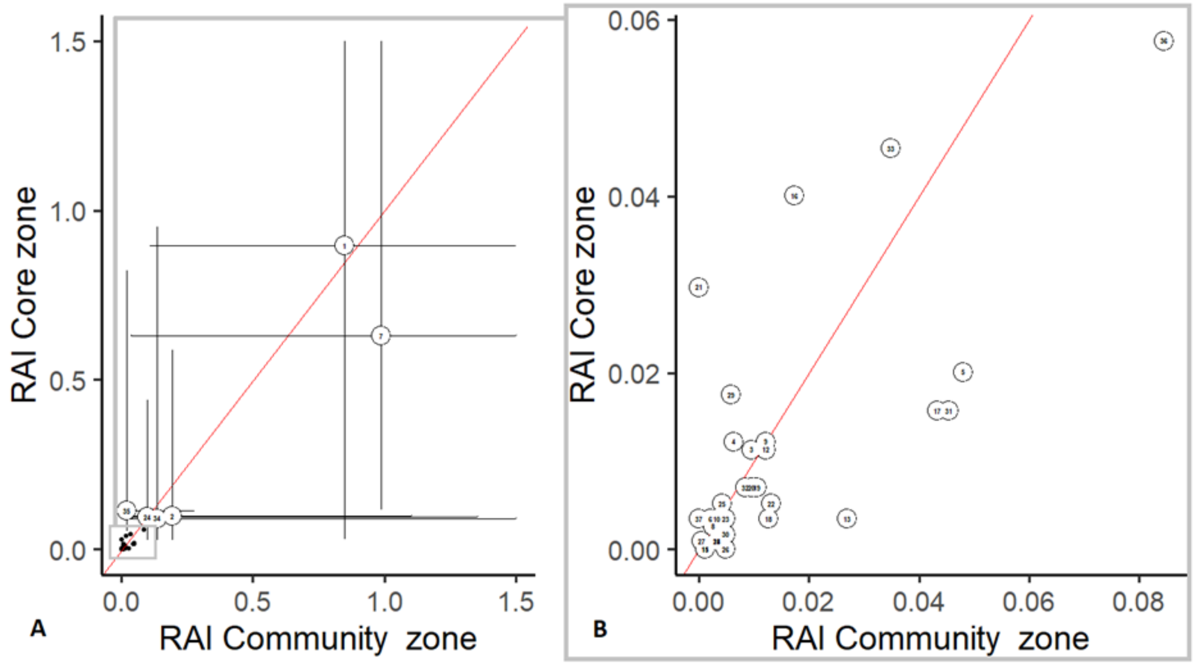

Figure 3 : (A) Relative abundance index (RAI) for each species in each zone (community and core) and (B) zoom on the less detected species. One point per species, ID from Table 1

A significant number of species are not found near the 1:1 line. This means that there is high variability in the detection rate of these species between the two surveys. For species with high detection rates (Figure 3A), their RAI is generally highest for the community zone. This is the case for *P. monticola* (7) for which the difference is very marked, *C. dorsalis* (2) and *A. africanus* (34). *C. agilis agilis* (24) has a similar RAI between the two areas. *C. callipygus* (1) and *C. emini* (35) are slightly more abundant in the core zone. This variability is even more true and marked for species with low detection rates (Figure 3B). For these last ones, the RAI is also generally higher in the community zone.

COMPARISON OF THE COMMUNITIES WITH NMDS

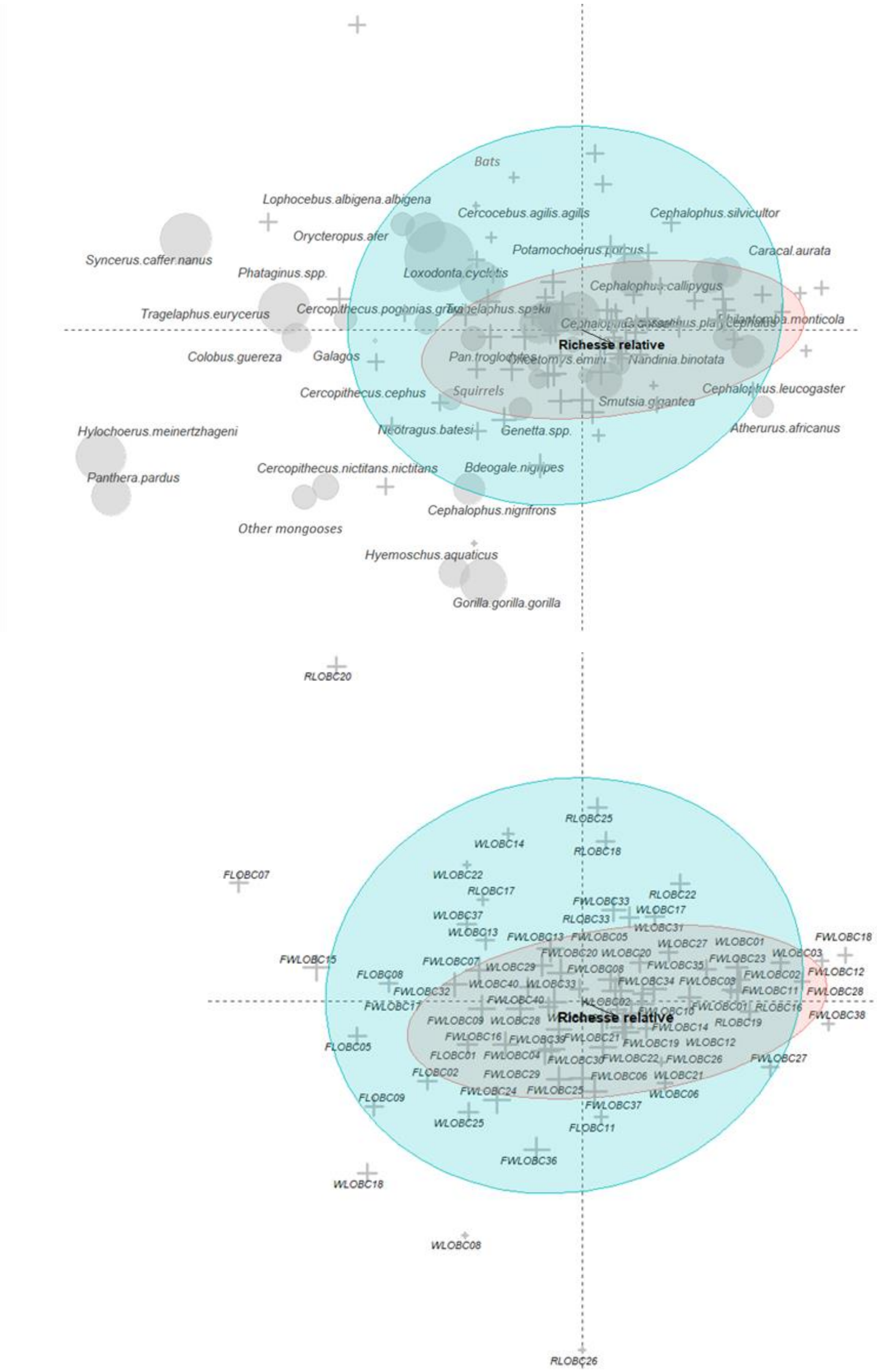

Figure 4 : Non-metric multidimensional scaling analysis (NMDS) performed on the dissimilarity matrix between CTs, corresponding to the Bray-Curtis index from the average relative abundance index per species. (A) Species (gray dots with size proportional to the body mass (Table 1) of the species) and (B) cameras (represented by crosses of size proportional to the running time) are represented along the ordination axes. The projection of the additional variable "Richesse relative" is represented by the black arrow. The red ellipse corresponds to the community zone and the green ellipse corresponds to the core zone.

Figure 4 represents the NMDS ordination performed on the dissimilarity matrix based on the Bray-Curtis index. The community zone is represented by the red ellipse and the TC names composed of FWLOBC + a two-digit number. The core zone is represented by the green ellipse and the camera names composed of F/R/W+LOBC+ a two-digit number. The "Relative richness" variable represents the number of species detected by the CT divided by the number of days. This corresponds to the number of species detected per day for the camera.

Since the ordination have a stress value of 0.1757 (< 0,2), it is significantly representative of the data's variability.

The overlap of the communities of the two zones is quite strong and their ellipse centers are close as shown by the ordination (Figure 4). This means that overall, the two communities are relatively similar. However, the ellipse of the community zone is slightly shifted to the right following the relative wealth gradient. This means that, on average, cameras in the community zone recorded more species per day. The core zone has much greater intra-community variability than the community zone as evidenced by the much larger size of its ellipse. This means that, although less rich, communities in the core zone have greater compositional richness. Species associations vary more according to the cameras. In contrast, species associations vary much less between cameras within the community zone.

A gradient seems to emerge in the species composition, corresponding to the average adult weight. Indeed, animals of high mass are found more in the surveys with lower species richness, on the left of the ordination. These include *Syncerus caffer nanus*, *Tragelaphus eurycerus*, *Loxondonta cyclotis*, Panthera pardus, *Hylochoerus meinertzhangeni* and *Tragelaphus spekii*. The variable "Relative wealth" partially explains this distribution.

The species that stand out the most from the ordination are those that few TC have detected such as *P. pardus* or *H. meinertzhangeni*. In contrast, species, such as *P. monticola* or *C. callipygus*, that were widely detected are found in the middle.

Some cameras are isolated in the ordination. This is the case for RLOC20, RLOBC26, FLOB07, WLOBC016, WLOBC08 and FWLOBC15. The latter is the only one in the community zone and its isolation is less marked. WLOBC08 and RLOBC26 are 2 TCs that have been turned for a short time (2 and 3 days respectively).

DISCUSSION

Wildlife surveys are particularly important for protected area management decisions. Here we compared two animal communities in two areas of different status. Given the importance of the communities, particularly the Bakas, in the park's surroundings and in the exploitation of its resources, it is essential to study their impact on biodiversity conservation. This is even more the case in the context of conflict over their place and rights to exploit park resources.

INVENTORY DATA AND SPECIES RICHNESS

The set up during this study was in a particularly homogeneous environment of secondary forest, rather old, with a canopy opening between 25 and 50%. There were therefore no different habitats likely to influence the composition of the animal community.

Both devices reached the minimum sampling effort of 1000 camera.days allowing the detection of a maximum of rare and/or discrete species. The relatively exhaustive aspect of the two samplings is confirmed by the fact that a plateau was reached in the accumulation curve of the number of species as a function of the cumulative number of camera days (Figure 2). The animal communities of the core and community zones of the park are thus composed of 28 and 31 species respectively, as well as 6 and 5 species complexes. Of these, 5 are classified by the IUCN as EN or CR, which confirms the importance of the park in terms of international conservation. The species that differ between the two communities are mostly species that are not detected very often. It is therefore possible that the second device could not detect them by chance. Although slightly lower in the core zone, the species richness of these two inventories demonstrates the high biodiversity of the park.

In surrounding areas, in recent camera trap surveys conducted under similar conditions, the number of species detected is generally lower. In the Dja Reserve (southern Cameroon), 26-31 mammal species were recorded (Bruce et al., 2018; Lhoest et al., 2021). In Boumba-Bek and Nki parks (southeastern Cameroon), 32 mammal species were detected during the inventory (Hongo and al., 2020). Moving beyond Cameroon to the Congo Basin, Lobeke is again among the richest in terms of species diversity. In Gabon, 16-23 mammal species were recorded in 2020 (Fonteyn and al., 2020) and in Congo 37 species, which is quite similar to the results of this study (Mavinga, 2018).

It should be noted, however, that during the installation of the camera-trap grid, numerous poaching activities were detected on the southeast side of the grid (wire traps, shell casings, tracks and camps). This was the case for nearly 18% of the TCs, in an area covering approximately 80 km². This area is therefore a priority in terms of monitoring effort.

COMPARISON OF DETECTION RATES

Both communities are dominated by the same species: *P. monticola*, *C. dorsalis*, *C. agilis agilis* and *C. callipygus*. However, their detection rate is generally higher for the community zone. Species with low detection rates also often have a higher RAI in the community zone. Although the differences are small, this would rather conclude a higher number of animals in the community zone.

COMPARISON OF THE COMMUNITIES WITH ORDINATION

The greater variability of composition for the core zone demonstrated by the ordination leads to the hypothesis of a greater diversity of composition in this zone. Indeed, the ellipse containing 90% of the variability (Figure 4) is much larger than for the community zone. It even tends to cover it almost entirely. This ordering also confirms the greater specific richness in the community zone, given the shift to the right of the graph of the ellipse corresponding to this zone. This is indeed in the positive direction of the "Relative richness" variable.

Animal species with large masses tend to be found in surveys with low relative richness. Although this phenomenon must probably be related to various factors, one hypothesis seems to be able to partially explain it. From a logistical point of view, for cameras with poor visibility, notably due to poor image quality or a restricted field of view, only the largest species will be easily spotted and identified by the operator.

The isolated cameras in the ordination graph are sometimes explicable by a very short running time (2 and 3 days). Only one TC with poaching detection (FLOBC07) is isolated. This means that despite numerous traces of poaching in the southeast zone, its impact on the mammalian community could not be demonstrated by the analyses carried out in this work. In order to study the impact of poaching on the mammalian community, a study focusing on the species targeted during illegal hunting activities and the evolution of their population over a longer period of time (in terms of age pyramids for example) would surely be more appropriate.

CONCLUSION

Based on the results obtained, it is possible to conclude that the species richness and detection rates are higher in the community zone. However, the compositional richness is much higher in the core zone of the park. This information, combined with the evidence of poaching in the southeastern part of the core zone, could lead to the conclusion that poaching pressure is probably higher there.

Although it may not be intuitive at first glance that the community zone has higher species richness and detection rates, various hypotheses may explain these findings.

First, the core zone is less monitored since communities should not normally be in it (the zoning of the previous management plan is still applied on the ground). In addition, its lack of accessibility for park staff also explains a lesser monitoring effort.

Second, artisanal gold mines are present along the road to Socambo, a village south of the park (Figure 1B), sometimes serving as a cover for poaching: people pretend to go for gold if they are caught in the area when in fact, they go into the forest to poach. It is also possible that people who actually mine near the park are also hunting for food.

The eastern border of the park (with the Central African Republic and Congo) has many villages directly on the park's border, while the western border is primarily a forest area between the main road (where the Mambélé Conservation Base is located) and the park. Anthropic pressure, both legal and illegal, is therefore likely to be greater in the east.

Based on this study, the following recommendations can be made for the management of the park. Firstly, it is recommended that the NPL increase surveillance in the core zone to limit poaching. Secondly, it would also appear that, a priori, the Memorandum of Understanding between MINFOF and ASBABUK that allows communities to benefit from the entire park can be respected without endangering the mammal community. This is obviously only true if the limits of activities are respected. For example, traditional and moderate hunting, not an intensive.

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APPENDICES

Appendix 1: Summary table of camera trap installation data

Mise en place											
Date	Heure	Dist point GPS théo (m)	Lat	Long	Altitude (m)	Orientation	Circonf arbre (cm)	Géomorphotype	Habitat	Ouverture canopée (%)	Pr
18-03-22	10 h 18	2	N02,28148	E015,75728	580	10°	40	Pente	Jeune forêt II	25-50	NU
17-03-22	8 h 40	3	N02,34466	E015,78428	405	20°	57	Plateau	Jeune forêt II	25-50	NU
18-03-22	9 h 28	2	N02,29053	E015,76626	557	10°	58	Plateau	Vieille forêt II	25-50	NU
16-03-22	15 h 45	6	N02,32662	E015,78431	418	20°	31	Plateau	Jeune forêt II	25-50	NU
18-03-22	8 h 38	2	N02,29955	E015,77524	539	0°	29	Plateau	Jeune forêt II	25-50	NU
17-03-22	10 h 07	3	N02,33565	E015,79326	412	-15°	23	Plateau	Jeune forêt II	25-50	NU
16-03-22	14 h 02	0	N02,30849	E015,78427	493	40°	42	Pente	Jeune forêt II	25-50	NU
18-03-22	11 h 28	7	N02,28149	E015,77530	550	0°	70	Plateau	Vieille forêt II	25-50	NU
16-03-22	14 h 57	3	N02,31761	E015,79324	433	20°	55	Plateau	Jeune forêt II	25-50	NU
17-03-22	9 h 27	2	N02,34458	E015,80232	416	10°	19	Plateau	Jeune forêt II (sous-bois)	25-50	NU
18-03-22	13 h 40	2	N02,29048	E015,78428	495	20°	23	Plateau	Jeune forêt II	25-50	NU
17-03-22	10 h 50	7	N02,32658	E015,80233	433	-10°	15	Pente (très légère)	Jeune forêt II	25-50	NU
19-03-22	9 h 24	4	N02,29945	E015,79330	440	0°	29	Pente (légère)	Jeune forêt II	50-75	NU
17-03-22	16 h 10	5	N02,30862	E015,80224	456	0°	23	Pente	Vieille forêt II	25-50	25
17-03-22	11 h 40	8	N02,33575	E015,81130	432	20°	29	Pente (légère)	Jeune forêt II	25-50	NU
18-03-22	13 h 15	0	N02,28146	E015,79328	497	0°	54	Pente	Jeune forêt II	25-50	15
17-03-22	15 h 27	2	N02,31755	E015,81125	442	0°	28	Plateau	Jeune forêt II	25-50	NU
18-03-22	15 h 06	0	N02,29054	E015,80224	499	0°	49	Pente (25°)	Jeune forêt II	0-25	NU
17-03-22	12 h 15	1	N02,34466	E015,82028	429	0°	22	Plateau	Vieille forêt II	25-50	NU

Description site					Récupération						
Proximité rivière	Traces animaux	Fruits	Perturbations anthropo	Perturbations naturelles	Date	Heure	Etat caméra	Nbr jours activité	Etat carte SD	Date dernière prise	Heure dernière prise
NULL	Petits et moyens céphalophes	NULL	NULL	NULL	23-04-22	15 h 45	Fonctionne toujours	36	OK	23-04-22	15 h 45
NULL	Couloir d'éléphants	NULL	NULL	NULL	22-04-22	9 h 11	Fonctionne toujours	36	OK	22-04-22	9 h 11
NULL	Petits et moyens céphalophes) + P-Oryctérope	NULL	NULL	NULL	23-04-22	16 h 30	Fonctionne toujours	36	OK	23-04-22	16 h 30
NULL	Petits et moyens céphalophes	NULL	NULL	NULL	22-04-22	16 h 37	Fonctionne toujours	37	OK	22-04-22	11 h 43
NULL	Petits et moyens céphalophes	NULL	NULL	NULL	23-04-22	17 h 20	Piles à plat	34	OK	21-04-22	2 h 31
NULL	Couloirs d'éléphants (cam orientée vers cette piste) + Petits et moyens céphalophes	NULL	NULL	NULL	22-04-22	10 h 45	Fonctionne toujours	36	OK	22-04-22	10 h 42
NULL	Petits et moyens céphalophes	NULL	NULL	Châblis, 5m	23-04-22	8 h 53	Fonctionne toujours	38	OK	23-04-22	7 h 53
NULL	Moyens céphalophes	NULL	NULL	NULL	23-04-22	14 h 50	///	0	RIEN ENREGISTRE	///	///
NULL	Petits et moyens céphalophes	NULL	NULL	NULL	23-04-22	16 h 30	Fonctionne toujours	38	OK	23-04-22	16 h 26
NULL	Couloir d'éléphants + Petits et moyens céphalophes	Fruits du figuier (Ficus)	NULL	NULL	22-04-22	10 h 05	Piles à plat	34	OK	20-04-22	13 h 32
NULL	Couloirs d'éléphants + Petits et moyens céphalophes	NULL	NULL	NULL	23-04-22	14 h 00	Termites aveugle	3	OK	21-03-22	15 h 54
NULL	Couloirs d'éléphants + Petits et moyens céphalophes	NULL	NULL	Châblis, 2m	22-04-22	15 h 38	Piles à plat	16	OK	02-04-22	18 h 05
NULL	Petits et moyens céphalophes	NULL	NULL	NULL	23-04-22	9 h 53	Fonctionne toujours + Termites	35	OK	23-04-22	9 h 52
25m, Est	Petits et moyens céphalophes	NULL	NULL	NULL	22-04-22	8 h 45	Fonctionne toujours	36	OK	22-04-22	8 h 44
NULL	Couloir d'éléphants + Petits et moyens céphalophes	NULL	NULL	NULL	22-04-22	11 h 50	Fonctionne toujours	36	OK	22-04-22	11 h 46
153m, Nord-Est	Petits et moyens céphalophes	NULL	NULL	NULL	23-04-22	13 h 15	Fonctionne toujours + Termites	36	OK	23-04-22	13 h 12
NULL	Petits et moyens céphalophes	NULL	NULL	Plusieurs petits châblis	23-04-22	15 h 50	Fonctionne toujours	37	OK	23-04-22	15 h 47
NULL	Eléphants + petits et moyens céphalophes	NULL	NULL	NULL	23-04-22	10 h 50	Termites aveugle	2	OK	20-03-22	9 h 01
NULL	Petits et moyens céphalophes	NULL	NULL	Châblis, 20m	22-04-22	12 h 20	Piles à plat	24	OK	10-04-22	10 h 05

20	WLOBC37	35	17-03-22	14 h 45	5	N02,32662	E015,82022	464	0°	28	Pent (très légère)	Jeune forêt II	25-50	NU
21	WLOBC03	6	19-03-22	10 h 29	3	N02,29957	E015,81128	534	15°	18	Pente (légère)	Jeune forêt II	50-75	NU
22	WLOBC13	38	19-03-22	11 h 16	7	N02,30855	E015,82020	527	-30°	23	Pente	Trouée	50-75	NU
23	FLOBC09	18	17-03-22	13 h 56	6	N02,33565	E015,82931	456	-10°	25	Pente	Vieille forêt II	25-50	10
24	WLOBC31	39	18-03-22	14 h 10	2	N02,28143	E015,81124	568	0°	42	Plateau	Vieille forêt II	0-25	96
25	WLOBC14	2	20-03-22	13 h 38	2	N02,31758	E015,82927	535	0°	18	Pente (forte)	Vieille forêt II	25-50	NU
26	WLOBC27	40	19-03-22	12 h 51	14	N02,29042	E015,82017	592	5°	33	Plateau	Jeune forêt II	25-50	NU
27	RLOBC19	23	17-03-22	13 h 15	12	N02,34469	E015,83816	435	10°	25	Pente	Vieille forêt II	25-50	NU
28	WLOBC18	5	19-03-22	11 h 55	4	N02,29954	E015,82925	566	0°	23	Plateau	Jeune forêt II	25-50	4r
29	FLOBC11	3	20-03-22	13 h 00	7	N02,32662	E015,83817	494	0°	33	Pente (légère)	Vieille forêt II	25-50	NU
30	RLOBC18	37	20-03-22	9 h 34	12	N02,30866	E015,83829	587	0°	23	Plateau	Jeune forêt II	25-50	NU
31	WLOBC12	10	19-03-22	13 h 29	4	N02,28145	E015,82928	618	30°	38	Plateau	Jeune forêt II	50-75	NU
32	RLOBC20	13	20-03-22	12 h 04	5	N02,33560	E015,84725	444	0°	52	Pente	Forêt mature	25-50	50
33	WLOBC22	8	20-03-22	10 h 11	2	N02,31754	E015,84727	591	5°	52	Plateau	Jeune forêt II	25-50	NU
34	WLOBC06	28	19-03-22	14 h 10	6	N02,29036	E015,83821	600	10°	22	Plateau	Jeune forêt II	25-50	2r
35	PAS MIS (CAM DEAD)													
36	FLOBC05	22	20-03-22	8 h 56	5	N02,29946	E015,84722	608	0°	32	Plateau	Vieille forêt II	25-50	NU
37	FLOBC08	27	20-03-22	11 h 20	1	N02,32660	E015,85627	534	0°	43	Pente (légère)	Jeune forêt II	25-50	NU
38	WLOBC33	17	20-03-22	8 h 15	5	N02,30860	E015,85624	578	5°	23	Pente (légère)	Jeune forêt II	50-75	NU
39	WLOBC21	14	19-03-22	15 h 04	4	N02,28146	E015,84732	615	15°	29	Plateau	Jeune forêt II	25-50	NU
40	RLOBC16	20	19-03-22	15 h 53	4	N02,29055	E015,85625	621	-5°	12	Plateau	Jeune forêt II	25-50	NU

NULL	Couloir d'éléphants (cam orientée vers cette piste)	NULL	NULL	NULL	22-04-22	14 h 40	Fonctionne toujours	36	OK	22-04-22	14 h 40
NULL	Petits	NULL	NULL	NULL	22-04-22	10 h 00	Fonctionne toujours	34	OK	22-04-22	9 h 57
NULL	Petits et moyens céphalophes	NULL	NULL	NULL	22-04-22	11 h 16	Fonctionne toujours	34	OK	22-04-22	10 h 35
10m, Ouest	Baïe à 40m avec buffles (position 8h p/r cam) + Céphalophes + Potamochères	NULL	NULL	NULL	22-04-22	14 h 00	Fonctionne toujours	36	OK	22-04-22	13 h 55
96m, Nord-Ouest	Eléphants + petits et moyens céphalophes	NULL	NULL	Châblis	23-04-22	12 h 00	Fonctionne toujours	36	OK	23-04-22	12 h 00
NULL	Petits et moyens céphalophes	NULL	NULL	NULL	23-04-22	14 h 34	Piles à plat	15	OK	04-04-22	17 h 34
NULL	Petits et moyens céphalophes	NULL	Douilles + Signes de passage	NULL	22-04-22	14 h 05	Fonctionne toujours	34	OK	22-04-22	13 h 55
NULL	Petits céphalophes	NULL	NULL	Châblis, 12m	22-04-22	13 h 20	Fonctionne toujours	36	OK	22-04-22	13 h 16
4m, Nord	Petits et moyens céphalophes	NULL	Pièges à câble + Campement	NULL	22-04-22	11 h 22	Fonctionne toujours	34	OK	22-04-22	11 h 22
NULL	Petits et moyens céphalophes (crottes)	NULL	NULL	NULL	23-04-22	13 h 50	Fonctionne toujours	21	OK	10-04-22	21 h 45
NULL	Petits et moyens céphalophes + Chimpanzés (nids)	NULL	Traces de passage + Pièges à câble	NULL	23-04-22	10 h 11	Fonctionne toujours	34	OK	23-01-22	10 h 10
NULL	Petits et moyens céphalophes	NULL	NULL	NULL	22-04-22	14 h 55	Fonctionne toujours	34	OK	22-04-22	14 h 35
50m, Nord-Est	Petits et moyens céphalohes + Eléphants (crottes)	NULL	NULL	NULL	23-04-22	13 h 00	Fonctionne toujours	34	OK	23-04-22	12 h 54
NULL	Petits singes (vocalisations) + Petits et moyens gorilles (visuel) + Céphalophes (crottes)	NULL	Traces de passage + Pièges à câble	NULL	23-04-22	10 h 54	///	6	BUG : Certaines photos noires et date incorrecte sur les dernières. Seuls les 6 premiers jours sont exploitables	26-03-22	15 h 15
2m, Nord-Ouest	Petits et moyens céphalophes (empreintes et crottes) + Eléphants (empreintes)	NULL	NULL	NULL	22-04-22	15 h 30	Piles à plat	28	OK	16-04-22	12 h 43
NULL	Petits et moyens céphalophes (crottes et empreintes) + Elephants (crottes et empreintes)	NULL	Traces de passage	NULL	23-04-22	9 h 25	Fonctionne toujours	34	OK	23-04-22	9 h 22
NULL	Petits et moyens céphalophes + Eléphants (crottes)	NULL	NULL	NULL	23-04-22	11 h 47	Fonctionne toujours	34	OK	23-04-22	11 h 45
NULL	Petits et moyens céphalophes + Eléphants (crottes)	NULL	Pièges à câble	NULL	23-04-22	8 h 21	Fonctionne toujours	34	OK	23-04-22	8 h 21
NULL	Petits et moyens céphalophes (crottes + empreintes)	NULL	Douilles + Signes de passage	NULL	22-04-22	16 h 19	Piles à plat	8	OK	27-03-22	15 h 54
NULL	Petits et moyens céphalophes	NULL	NULL	NULL	22-04-22	17 h 10	Fonctionne toujours	34	OK	22-04-22	17 h 06

Appendix 2: Camera installation and removal sheet

Numéro sur la grille : /40		Nom de la caméra :	
Mise en place			
Date	/ /	Heure	h
Coordonnées	Latitude	Altitude	
	Longitude	Orientation	
Distance du pt GPS théorique		Circonférence arbre	
A checker	○ Calibration date/heure de la caméra ○ Régler caméra sur vidéos courtes et redéclenchement après 0 sec ○ Visée de l'objectif parallèle au sol ○ Vision dégagée ○ Etanchéité assurée et feuilles sous la caméra pour limiter les éclaboussures ○ Vidéo test et caméra bien en marche		
Description du site			
Géomorphotype	○ Plateau ○ Pente ○ Crête ○ Vallée ○ Autre :		
Habitat	○ Forêt mature ○ Vieille forêt secondaire ○ Trouée ○ Clairière ○ Jeune forêt secondaire ○ Forêt périodiquement inondée ○ Marécage - Avec Raphia - Sans Raphia ○ Autres :		
Ouverture de la canopée (%)		Rivière à proximité	○ Non ○ Oui ; à m, vers
Traces d'animaux	○ Non ○ Oui ; espèce(s) =		
Présence de fruits (<100 mètres)	○ Non ○ Oui ; espèce(s) =		
Perturbations anthropiques	○ Non ○ Oui ; observations =		
Perturbations naturelles	○ Non ○ Oui ; ¤ châblis ¤ autre :		

Récupération			
Date	/ /	Heure	h
Etat de la caméra	○ Fonctionne toujours ○ Piles à plat ○ Manquante ○ Abimée :		
Code carte SD		Nombre jours actifs	
Etat carte SD	○ Ok ○ Abimée	Dernière prise (date et heure)	
Observations/Remarques :			

Appendix 3 : Acknowledgements

Puisque les personnes à qui ces remerciements s'adressent parlent principalement français, c'est naturellement que je retourne vers cette langue pour les rédiger. Après tout c'est dans notre langue maternelle que les mots ont le plus de poids.

Je voudrais commencer par remercier mon promoteur, le Professeur Cédric Vermeulen, pour m'avoir offert ce passionnant sujet de TFE. Ses conseils, parfois passé dans la bonne humeur d'un petit message vocal, et son aide précieuse ont été une fondation solide pour l'aboutissement de ce travail. Une petite pensée de gratitude également à Jean-Yves pour son aide à la préparation logistique du voyage dans la situation particulière du moment.

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