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RESEARCH ARTICLE

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Diversity, habitat and activity patterns of mesocarnivore assemblages in an Afrotropical protected forest savannah mosaic of Central Cameroon

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Abstract

Little is known about the diversity and ecology of mesocarnivores in the Mpem and Djim National Parks in central Cameroon. Therefore, we undertook a rapid assessment using camera traps from September 2021 to December 2021. The main objective of our study was to collect data on the diversity, abundance and relative frequency of mesocarnivores per habitat type and their activity period using camera traps with a distance sampling method. In 1700 trap nights, we recorded 53 events of seven mesocarnivores, all belonging to the family of Viveridae, Herpesdidae and Felidae which yield 3.12 mesocarnivores per 100 days. The black-legged mongoose (*Bdeogale nigripes*, Pucheran, 1855) exhibited the highest capture rate (CR, 0.88). The long-nosed mongoose (*Xenogale naso*, Winton, 1901) was found in all habitats class and was the more active mesocarnivore. The Shannon-Weaver diversity index (H) showed a high diversity of species in the community with high diversity in the near primary forest. We obtained a lower dominance of one species over the other, a lower richness and a more even distribution of species between habitats. Our results suggest a possible spatio-temporal niche partitioning between the species recorded, with blotched genet (*Genetta maculata*, Gray, 1830), showing no clear peak of activity. However, the rarefaction curve indicates that the effort expended was insufficient, suggesting that additional sampling is required to obtain a reasonable estimate of species richness within our community. The activity patterns of the recorded mesocarnivores were generally similar to those reported elsewhere but suggest some behavioural flexibility. Although all these species are listed as Least Concern by the IUCN, the low number of recorded events may indicate that mesocarnivores may be threatened in this area if effective conservation strategies are not implemented.

KEYWORDS
abundance, activity period, camera trap, capture rate, habitat class, mesocarnivores, relative frequency

Résumé

La diversité et l'écologie des mésocarnivores dans le parc national de Mpem et Djim, au centre du Cameroun, sont peu connues. Par conséquent, nous avons entrepris une évaluation rapide à l'aide de pièges photographiques de septembre 2021 à décembre 2021. L'objectif principal de notre étude était de collecter des données sur la diversité, l'abondance et la fréquence relative des mésocarnivores par type d'habitat et leur période d'activité en utilisant des pièges photographiques avec une méthode d'échantillonnage à distance. En 1700 nuits de piège, nous avons enregistré 53 événements de sept mésocarnivores, tous appartenant à la famille des Viverridés, des Herpestidés et Félins, ce qui donne 3.12 mésocarnivores pour 100 jours. La mangouste à pattes noires (*Bdeogale nigripes*, Pucheran, 1855) a présenté le taux de capture le plus élevé (CR, 0.88). La mangouste à long museau (*Xenogale naso*, Winton, 1901) a été observée dans toutes les classes d'habitats et était le mésocarnivore le plus actif. L'indice de diversité de Shannon-Weaver (H) a révélé une grande diversité d'espèces dans la communauté, avec une grande diversité dans la forêt primaire environnante. Nous avons obtenu une moindre dominance d'une espèce par rapport à l'autre, une moindre richesse et une répartition plus homogène des espèces entre les habitats. Nos résultats proposent une répartition spatio-temporelle possible des niches entre les espèces recensées, la genette panthère (*Genetta maculata*, Gray, 1830) ne présentant pas de pic d'activité clair. Cependant, la courbe de raréfaction indique que l'effort déployé était insuffisant, ce qui suggère qu'un échantillonnage supplémentaire est nécessaire pour obtenir une estimation raisonnable de la richesse des espèces au sein de notre communauté. Les schémas d'activité des mésocarnivores recensés étaient généralement similaires à ceux rapportés ailleurs, mais indiquent une certaine flexibilité comportementale. Bien que toutes ces espèces soient classées dans la catégorie « préoccupation mineure » par l'UICN, le faible nombre d'événements enregistrés peut indiquer que les mésocarnivores peuvent être menacés dans cette zone si des stratégies de conservation efficaces ne sont pas mises en œuvre.

1 | INTRODUCTION

The production and consumption needs of an increasing human population have put enormous pressure on natural habitats including tropical rainforests (Brockington & Duffy, 2010; Fotsing et al., 2024). Africa is particularly affected by the ongoing biodiversity decline caused by swift environmental transformations (Fotsing et al., 2024). Among threatened rainforest species are small carnivores with a body mass below 21.5 kg (hereafter, mesocarnivores). Mesocarnivores occur throughout the world and 30% of species are threatened or near threatened by extinction (San et al., 2022). However, for 46% of species, population trends are unknown (Do linh San et al., 2013) and the conservation status of mesocarnivores is often unclear. Mesocarnivores are not as charismatic as mega-carnivores, for example, lions and leopards but, they are similarly important in the ecosystem since they can occupy multiple trophic levels (Roamer et al., 2009; San et al., 2022), and since some species also feed on fruits, they contribute to seed dispersal

(Mudappa et al., 2010; Mullu & Balakrishnan, 2014). Mesocarnivores can also become dominant predators at sites where humans have extirpated larger carnivores (Do Linh San et al., 2022).

Mesocarnivores are not easy to study due to their elusive and nocturnal nature. Motion-activated camera traps (hereafter, CTs) are a tool to solve this problem, as they can provide data on animal presence and activity and are therefore well suited for documenting the spatiotemporal niches of mesocarnivores (Frey et al., 2017). Several studies have used CTs to assess the activity of mesocarnivores (Easter et al., 2020; Monterroso et al., 2020), but mainly in North America, Asia and Europe.

Only a few studies applied the method in studies of African mesocarnivores (Easter et al., 2020; Gittleman et al., 2001; Grabowski et al., 2024; Maddock & Perrin, 1993; Pelton et al., 2003). These African studies have provided important insights into African mesocarnivores ecology; however, there is a great disparity regarding how research efforts have been distributed among regions and species. Some species have been intensively studied, and others superficially or not at all (Do Linh San et al., 2022). For example, Civet have been a focus of some study in Assia specifically in Cambodia (Gray et al., 2010), Malaysia (Low, 2010) and in Borneo (Eaton et al., 2010) while in Africa, Pousargues's Mongoose (Aebischer et al., 2020), Bushy-tailed Mongoose (Engel & Van Rompae, 1995), African Palm Civet (Perkin, 2004, 2005) received little attention and Genet was a bit more studied (Gaubert, 2003; Gaubert et al., 2006; Pacheo et al., 2013). Most African mesocarnivores are listed as Least Concern by the IUCN, mainly due to their relatively large distribution ranges, locally high abundance and their presence in several protected areas (Do linh San et al., 2013). However, according to the IUCN, their populations decline in some areas due to habitat loss and bushmeat hunting.

According to Kingdom (2013), some of these species also occur in Cameroon, including the Mpem and Djim National Park (hereafter, MDNP; Table S1) where, only *Caracal aurata* and *Leptailurus serval* have been recently confirmed (Simo et al., 2019, 2021). However, in relation to the actual local threat in MDNP it should be necessary to update the current diversity of mesocarnivores in MDNP. MDNP covers a highly threatened habitat, the rainforest-savannah transition zone (Fotsing et al., 2024). The diversity and abundance of mesocarnivores within the park is not known and we therefore set out to collect the missing information to fill the literature gap.

Possibly, 15 species may occur in the park, among them three otters that are confined to wetlands. We expected that most of mesocarnivores in MDNP would belong to the Viveridae (2–3 species) and Herpestidae (up to 7). Given these numbers, we also expected to find interspecific differences in habitat preference and temporal niche, that is, activity periods as in other studies (Monterroso et al., 2020).

We sought to confirm the presence of mesocarnivores in the national park, their diversity, activity period, habitat preference and relative frequency with a systematic camera trap survey. Specifically, considering the strong human pressure on the park over the last 10 years, we asked: (1) What mesocarnivores are present, in which habitats, and with what frequency? (2) What is the activity period of each species in each habitat? (3) Based on mesocarnivores activity time recorded by CTs, is there any possible spatial and/or temporal niche partitioning?

2 | METHODS

2.1 | Study area

The study was carried out in the Mpem and Djim National Park (MDNP, 5°–5°20′N, 11°30′-12°E) in the Central Region of Cameroon (Ntui Division) (Figure 1). MDNP was established in 2004 (Law No. 2004/0886/PM). The size of the park is 974.8 km^2, with an average altitude of 640 m above sea level (Fotsing et al., 2024). The park lies in northern Congolian forest savannah mosaic consists of a mosaic of closed-canopy forest, savannah grasslands and gallery forests that are home to both forest and savannah-dwelling species (Fotsing et al., 2024). The annual minimum and maximum temperature in the park are 22.9°C and 29.1°C, respectively, with an annual average precipitation of 1500 mm distributed in two wet seasons (Santoir & Bodba, 1995).

2.2 | Classification of habitats

Different types of vegetation can be found in MDNP (Donfack, 2021). These include open savannah, woodland savannah and grassland savannah, which in this study we refer to as savannah (SAV); old secondary forest (also called dense forest) and permanently inundated swamp forest, which we also refer to as near primary forest (NPF); young mixed secondary forest which we refer to as secondary forest (SF); savannah forest transition zone, also called mosaic forest savannah and gallery forest, which we refer to as gallery forest (GF) (Donfack, 2021).

2.3 | Data collection

We deployed 22 camera traps (CTs; Bushnell Trophy Trail Camera 20MP, infrared, Model 119717CW) along 11 line transects of 2 km length in the western part of the national park. The transects run in the east–west direction and were evenly spaced by 2 km, partly in parallel or in row (Figure 1). Two CTs with angle of view $\theta = 45°$, were set at 250 and 1750 m from the western start point of each transect. Between 16.09.2021 and 11.12.2021, CTs spent approximately 3 months (81 ± 7 days) at each of the 22 locations. To avoid any disturbance caused during data collection along the transects, cameras were systematically positioned 50 m to the north or south of the transect line, oriented north between 40 and 50 cm above-ground (Bessone et al., 2020). The cameras were set with motion sensor on high sensitivity (to increase detection), continuous triggering, that is, 60 s second interval between consecutive videos, and the picture quality was set at high resolution (20 megapixels). The date, habitat and time for each camera were recorded during the installation.

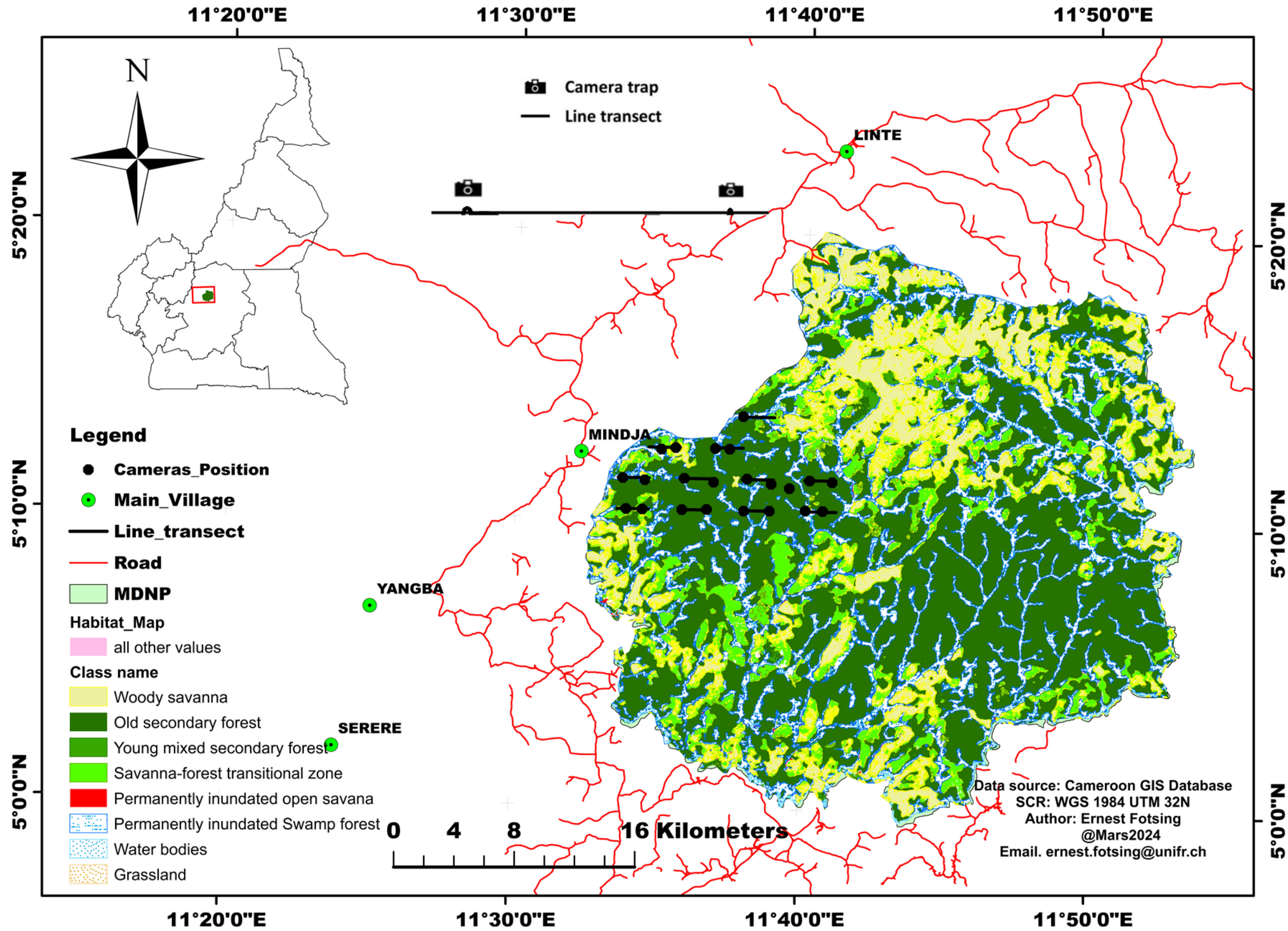

FIGURE 1 Map of the Mpem and Djim National Park in central Cameroon with the position of 11 line transects (black lines) and the positions of the camera traps (black dots) along the lines. Top left inset map of the Republic of Cameroon with the park in the red frame.

Three CTs were set up in the Gallery Forest (GF), 10 in the Near Primary Forest (NPF), five in the Savannah (SAV, one camera malfunctioned and was not considered) and four in the Secondary Forest (SF) (Figure 1).

2.4 | Data analysis

Video images were collected and all photographed animals were identified to species level by the first author assisted by other authors using the second edition of African mammals Field guide book (Kingdom, 2016). Videos without wildlife were categorised as 'ghost shots' which may occur due to sudden shift in ambient temperature (Azlan, 2006) or other natural phenomena (e.g. wind, rain, tree fall.). Ghost shots and other images that could not be identified at the species level were excluded from our analysis. Videos with one or more individual(s) of the same species were considered as a single camera event (Grassman et al., 2006). One hour threshold in the sequence of observations of a specific species, where no further picture was taken, was introduced to prevent double counting of individual animals lingering in front of the camera (Tobler et al., 2008). After identification, we generated a detection record of all mesocarnivores using the camtrapR package v4.3.2 (Niedballa et al., 2016) in R V4.3.2 (Core Team, 2022). For the preliminary univariate analysis, we used GraphPad Prism 10.2.0 to perform descriptive and summary statistics.

2.4.1 | Sampling effort

We defined the sampling effort as the total trapping days first, across all habitats class and secondly within each habitat class individually. To find out whether the sampling effort was sufficient, we performed a rarefaction and extrapolation curve using Inext package (Chao et al., 2014; Hsieh et al., 2016), latest version 3.0.0 (July 2022) with R version 4.2.3 (Core Team, 2022). This latest version uses the bootstrapping method to obtain confidence intervals for the coverage-based rarefaction, and the facet.var='Assemblage' argument was used to create a separate plot for each diversity order assemblage (species and habitat in our case).

Sampling effort per day in each habitat

Of the 21 trapping sites, the effort made was 247, 820, 319 and 314 trap nights in GF, NPF, SAV and SF respectively. The total number of trap nights was 1700 (81 ± 7 days) (see Table 1 for more details).

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2.4.2 | Capture rate

We calculated the capture rate (CR) per 100 days for each species as the total number of events per species/1700 trapping days * 100. Additionally, we repeated this for each habitat class as the total number of events per species within the habitat class/number of trapping days within the habitat class * 100) (McPhee, 2015; O'Brien et al., 2003). The capture rate will provide information on how often a species uses a specific habitat class, and also information on habitat preference or species activities patterns.

2.4.3 | Relative frequency

We calculated the relative frequency (RF) of events per species over all habitat class as follow: number of events per species/total number of events; and for each habitat class separately as: number of events per species per habitat class/number of all events per habitat class. Relative frequencies will provide information on species abundance within a given habitat class.

2.4.4 | Times of activity and activity pattern

As time of activity (also called detection time), we used the duration of how long a species was seen in an event (Te Wong et al., 2004). The activity time will provide information on the time of activity spent by a species in a given habitat class. Variations in detection times across different habitat class can provide information about habitat preferences and usage patterns. For example, longer detection times in certain habitats may suggest preferred foraging or resting areas. To evaluate the activity pattern of each species we used the activity package version 1.3.4 (Rowcliffe et al., 2014). To achieve our task, we proceed as follow: we first convert the time of day of a camera triggering event into the fraction of the 24 h cycle when the event took place, measured in radians. In other words, an event occurring at midday is recorded π and an event occurring at midnight is recorded as 2π. Secondly, with the radian conversion of the camera triggering times, the distribution of the triggering events times is smoothed, using a kernel smoother by the function fitact. This function estimates the proportion of time (in a 24-h day) animals were active. A plot of the histogram of triggering

TABLE 1 Number of trapping days per camera (CTs) within each habitat class. Overall, we had 1700 trapping days.

Camera ID	Habitat class GF	NPF	SAV	SF
1	84	84	84	78
2	84	84	78	79
3	79	85	78	78
4		81	79	79
5		80		
6		80		
7		80		
8		80		
9		80		
10		86		
Number of CTs	3	10	4	4
Effort per habitat	247	820	319	314
Days, mean ± sd	82.3 ± 2.9	82.0 ± 2.4	79.8 ± 2.9	78.5 ± 0.6

TABLE 2 Number of events per habitat class, capture rate (CR), activity time (s) and relative frequency (RF) of each species.

Species	Habitat	Events	CR	Activity time	RF
Bdeogale nigripes	GF	7	2.83	73	0.47
	NPF	6	0.73	27	0.4
	SAV	0	0	0	
	SF	2	0.64	4	0.13
	All	15	0.88	104	0.28
Civettictis civetta	GF	0	0	0	
	NPF	1	0.12	5	0.25
	SAV	0	0	0	
	SF	3	0.96	29	0.75
	All	4	0.24	34	0.08
Genetta maculata	GF	0	0	0	
	NPF	2	0.24	8	0.5
	SAV	2	0.63	27	0.5
	SF	0	0	0	
	All	4	0.24	35	0.08
Genetta servalina	GF	6	2.43	36	0.43
	NPF	2	0.24	30	0.14
	SAV	0	0	0	
	SF	6	1.91	80	0.43
	All	14	0.82	146	0.26
Xenogale naso	GF	1	0.4	18	0.08
	NPF	2	0.24	6	0.17
	SAV	4	1.25	178	0.33
	SF	5	1.59	17	0.42
	All	12	0.71	219	0.23
Caracal aurata	GF	0	0	0	
	NPF	1	0.12	3	0.33
	SAV	0	0	0	
	SF	2	0.93	7	0.67
	All	3	0.18	10	0.06
Leptailurus serval	GF	0	0		
	NPF	1	0.12	15	1.00
	SAV	0	0		
	SF	0	0		
	All	1	0.12	15	0.02
All		53	3.12	563	

times, along with the fitted smooth is therefore provided by a plot function applied to the object returned by fitact.

2.4.5 | Diversity indices

To describe the diversity of mesocarnivores community, we estimated four major diversity indices using the Vegan package Version 2.4–3 (Oksanen et al., 2020) as follow:

1. *The Shannon-Weaver diversity index* (*H*) *is used as a* measure of species diversity in our community, taking into account both species richness (the number of different species) and species evenness (the relative abundance of species).
2. The dominance index (D), which helps to quantify the extent to which a few species dominate the community in terms of abundance, while others are less abundant.
3. Chao1 is used as a non-parametric estimator to estimate the true species richness of our community based on the observed species richness. It takes into account both the number of rare species observed and the number of singletons (species represented by only one individual).

2.4.6 | Principal components analysis

Purpose of conducting PCA in the context of studying mesocarnivores in different habitats was to uncover patterns, relationships and underlying structures in the data, thereby providing valuable insights into the ecological dynamics of mesocarnivores populations and their interactions with different habitat types. To achieve this, we used a set of packages in R which include 'FactoMineR (v.2.9)', 'ggcorrplot (v.0.1.4)' and factoextra (v. 1.0.7). To avoid biased results, data were normalised to ensure that each attribute has the same level of contribution, preventing one variable from dominating others. Normalisation was done by subtracting variable mean and dividing it by its standard deviation.

2.4.7 | Contribution of each variable

To determine how much each variable is represented in a given component, we used the fviz_cos2 function to obtain the cos2 values (cos2 corresponds to the square cosine) for each variable. A low value of cos2 means that the variable is not perfectly represented by that component, while a high value, on the other hand, means a good representation of the variable on that component.

3 | RESULTS

3.1 | Capture rate and number of records

In total, we obtained 53 events with photographs of seven mesocarnivores species, all belonging to the families Felidae, Viveridae, and Herpestidae. We also had 563s of activity time for all mesocarnivores. We obtained 15 events of black-legged mongoose (*Bdeogale nigripes*, Pucheran, 1855) (*B.n*, CR, 0.88 per 100days, RF, 0.28); four events of African civet (*Civettictis civetta*, Schreber, 1776) (*C.c*, CR, 0.24 per 100days, RF, 0.08); four events of blotched genet (*Genetta*

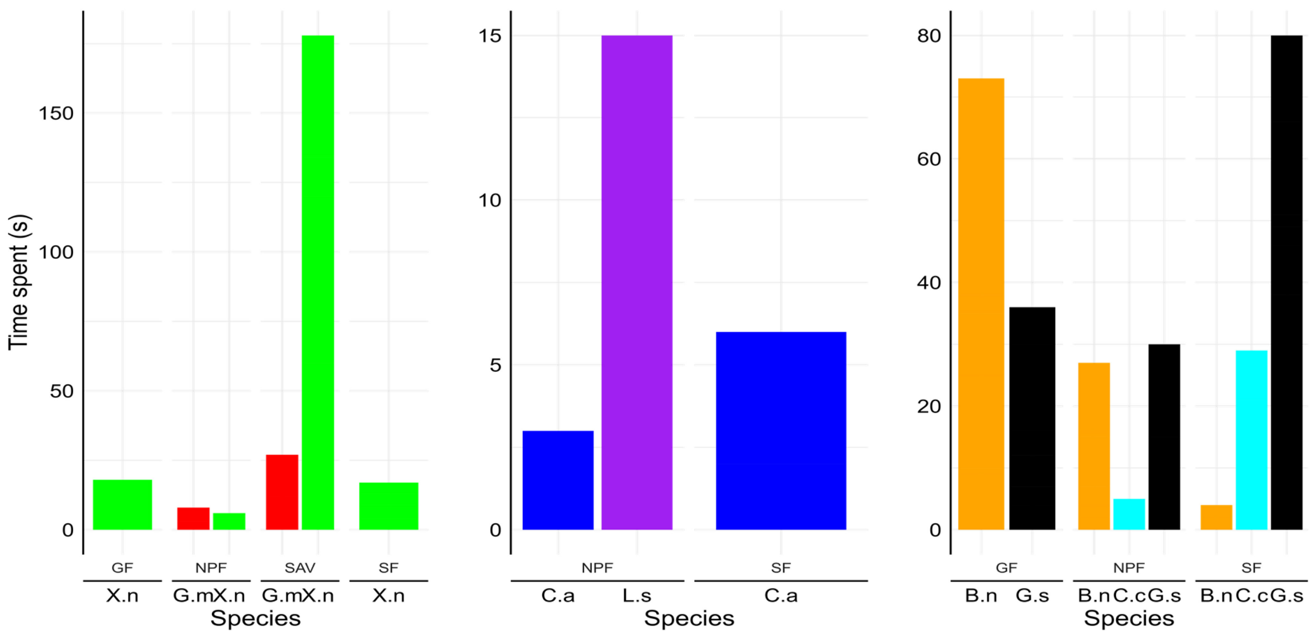

FIGURE 2 Time spent by each species in each habitat. B.n, *Bdogale nigripes*; C.a, *Caracal aurata*; C.c, *Civettictis civetta*; G.m, *Genetta maculata*; G.s, *Genetta servalina*; GF, Gallery Forest; L.s, *Leptailurus serval*; NPF, Near Primary Forest; SAV, Savannah; SF, Secondary Forest; X.n, Xenogale naso.

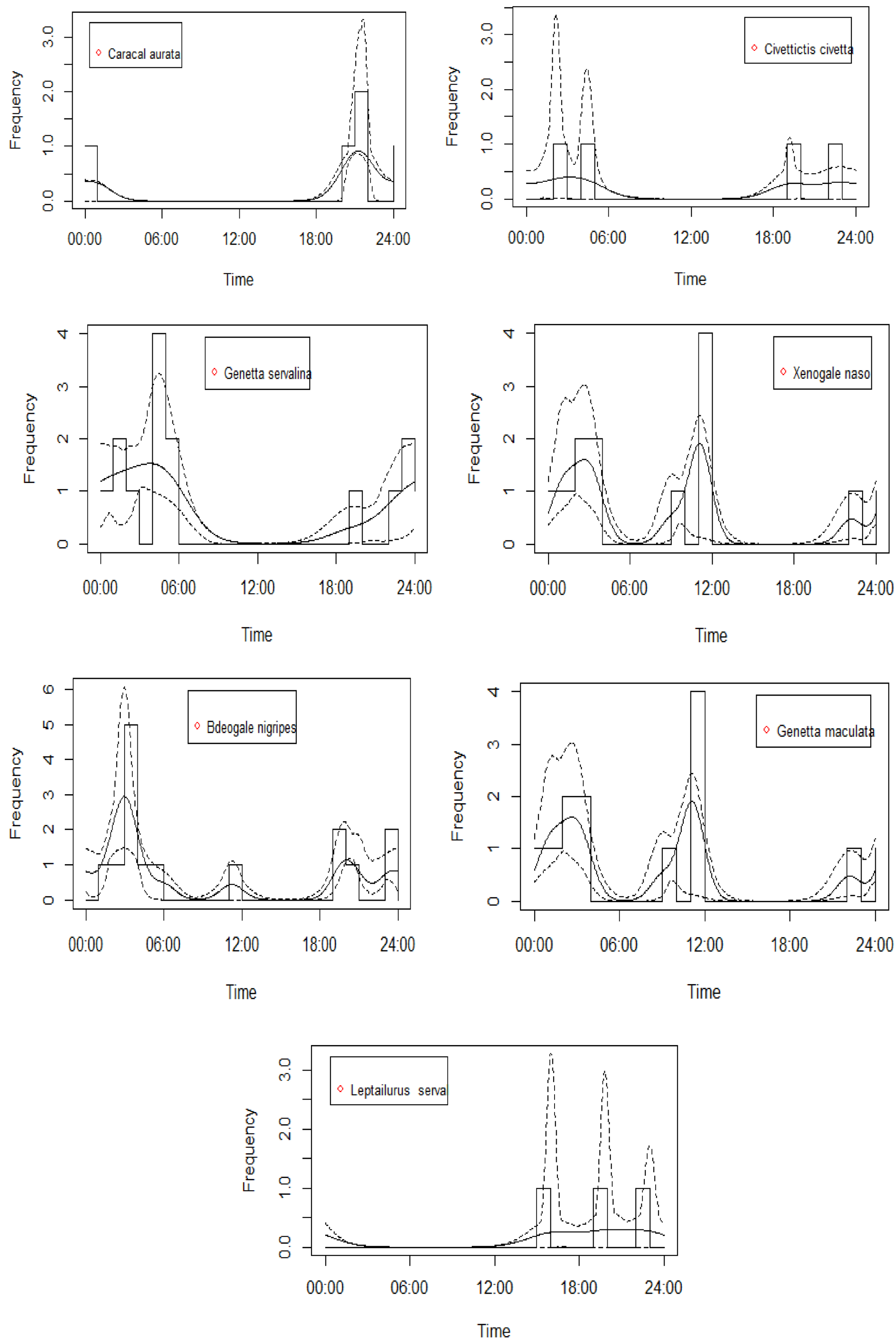

FIGURE 3 Daily activity patterns of the seven mesocarnivores. Fitted smooth to histogram of camera triggering times for Mesocarnivores data recorded in MDNP.

maculata, Gray, 1830) (*G.m*, CR, 0.24, RF, 0.08), 14 events of servaline genet (*Genetta servalina*, Pucheran, 1855) (*G.s*, CR, 0.82, RF, 0.26), 12 events of long-nosed mongoose (*Xenogale naso*, Winton, 1901) (*X.n*, CR, 0.71, RF, 0.23), threes species of African golden cat (*Caracal aurata*, Temminck, 1827) (*C.a*, CR, 0.18, RF, 0.06) and one record of serval (*Leptailurus serval*, Schreber, 1776 (*L.s*. CR, 0.12, RF, 0.02), (see Table 2 for more details). Number of events recorded per habitats and the corresponding date for each species are provided in Appendix S1).

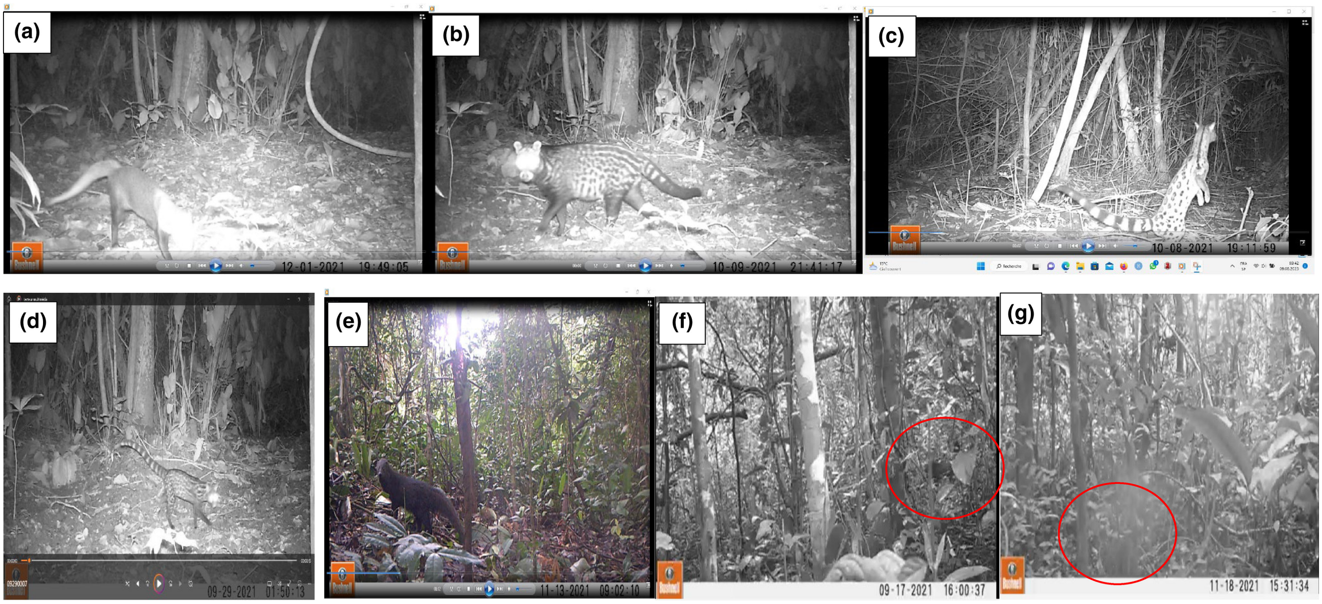

FIGURE 4 Camera trap images of mesocarnivores recorded in Mpem and Djim National Park: (a) *Bdeogale nigripes*, (b) *Civettictis civetta*, (c) *Genetta maculata* (d) *Genetta servalina* and (e) *Xenogale naso*. (f) *Caracal aurata*, (g), Leptailurus serval).

TABLE 3 Diversity indices.

	GF	NPF	SF	SAV
Individuals	14	16	17	6
Dominance_D	0.4388	0.2109	0.2595	0.5556
Shannon_H	0.8982	1.754	1.452	0.6365
Chao-1	3	7.2	5	2

3.2 | Habitat and activity pattern

Our results show habitat specificity as well as a variation in activity time between the individual species. *B.n* was found only in GF, NPF and SF with an activity time of 104 s, but was more active in GF (73 s); *C.c* was found only in NPF and SF with an activity time of 34 s, but was more active in SF (29 s); *G.m* was found in NPF and SAV with an activity time of 35 s, but was more active in the savannah (27 s); *G.s* was found in GF, NPF and SF with an activity time of 146 s, but was more active in SF (80 s); *C.a* was found only in NPF and SF with an activity time of 10 s, but was more active in SF (7 s); *L.s* was only found in NPF with an activity time of 15 s; *X. n was* found in NPF, SF, SAV and GF and was the more active mesocarnivores with the highest activity time of 219 s, but was more active in SAV (178 s) (see Table 1 and Figure 2).

The results also show that the spatio-temporal activity of the recorded species does not overlap, suggesting a possible niche partitioning between the species. Although the Figure 3 below tends to show a multimodal activity pattern of all species, *B.n*, and *G.s* tend to have nocturnal activity pattern but exhibited activity peak around 3 AM and 4 AM respectively. In contrast, *C.c*, which also tend to be nocturnal species, were more active around 9 PM. *X.n* and *G.m* were both active in the savannah but showed a clear difference in their activity pattern. *X.n* exhibited a pick of activity around 11 AM and can be considered as a diurnal species while *G.m* does not really show a clear peak in activity pattern, with activity occurring at any time during the 24 h of the day but starting at 2 AM (Figures 3 and 4). Similarly, we found that *B.n*, *C.c*, *C.a*, *L.s* and *G.s* were not active in the savannah compared to *G.m* and *X.n*. This observation hints that these species may compete for resources which appear to be limited in the savannah. Similarly, we observed that *C.a* and *L.s* appearing to be nocturnal species were able to coexist with other mesocarnivores in NPF but exhibited a separate time of activity. The Appendix S2: Figure S1a,b, give another overview of Niche Partitioning Patterns observed between species pairs.

3.3 | Diversity indices

Overall, the Shannon-Weaver diversity index (H) showed a high species diversity of mesocarnivores in the community. The highest diversity was found in NPF (H = 1.754). There was a relatively even distribution of individuals among species and a *low* or moderate dominance of one or two species on the other. We obtained the lowest abundance of mesocarnivores in all habitats, as shown by the Chao-1 estimator (i.e. lowest species richness) (Table 3). More details on diversity indices with confidence intervals can be found in Table S2.

3.4 | Effect of sample size: Rarefaction and extrapolation curve

The rarefaction curve in Figure 5a indicates that there is relatively little benefit in sampling beyond 53 events. This suggests that the greater the effort (i.e. more CTs days), the greater the chance of encountering less common and/or even rare taxa. However, in Figure 5b, the extrapolation curve tends to indicate that additional

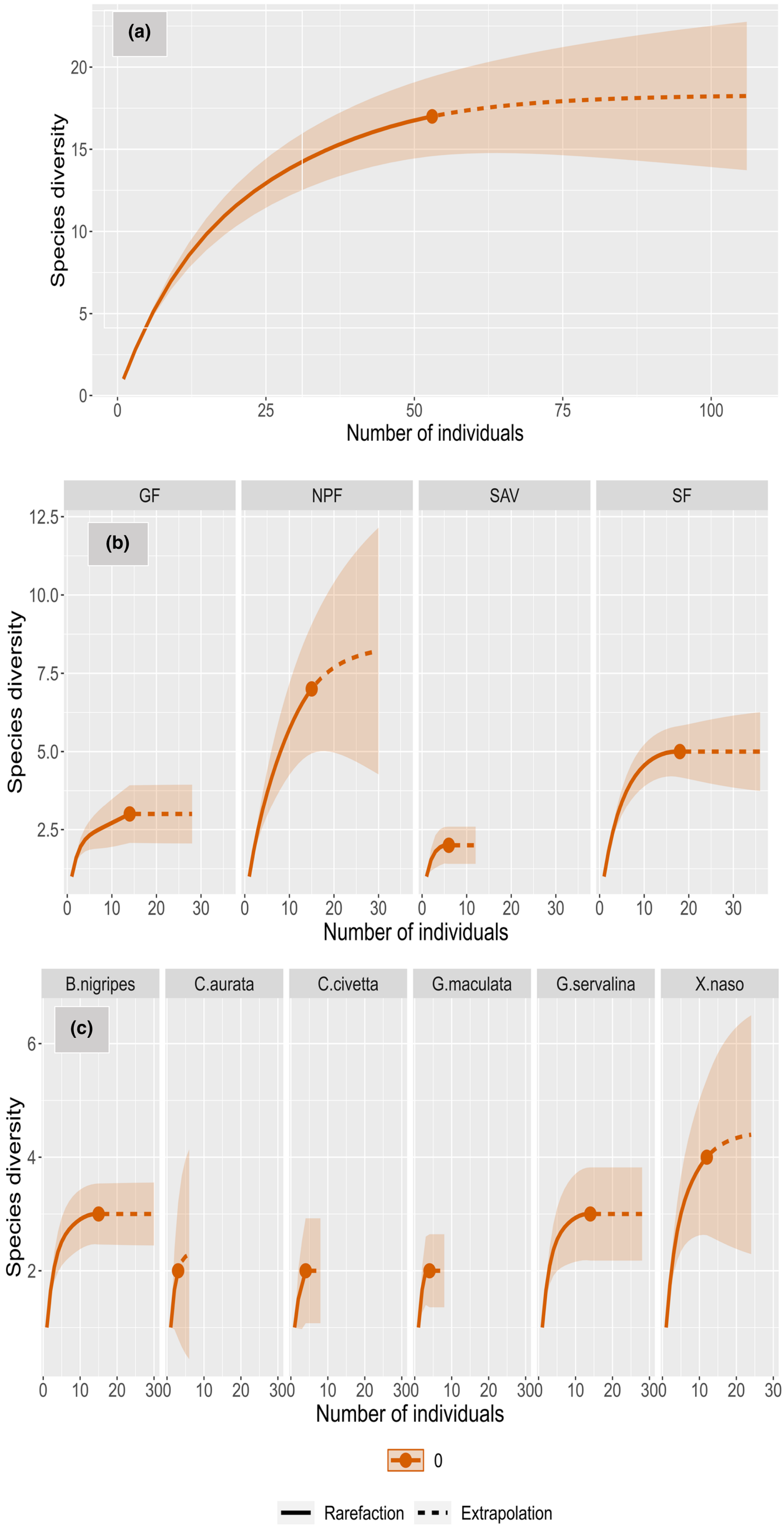

FIGURE 5 Sample-based rarefaction and extrapolation curves, based on camera-trapping data of 21 sites in Central Cameroon for all species (a), across all habitats class, (b) within each habitat (b) and (c) for each species. GF, Gallery Forest, NPF, near-primary forest, SAV, Savannah, SF, Secondary Forest.

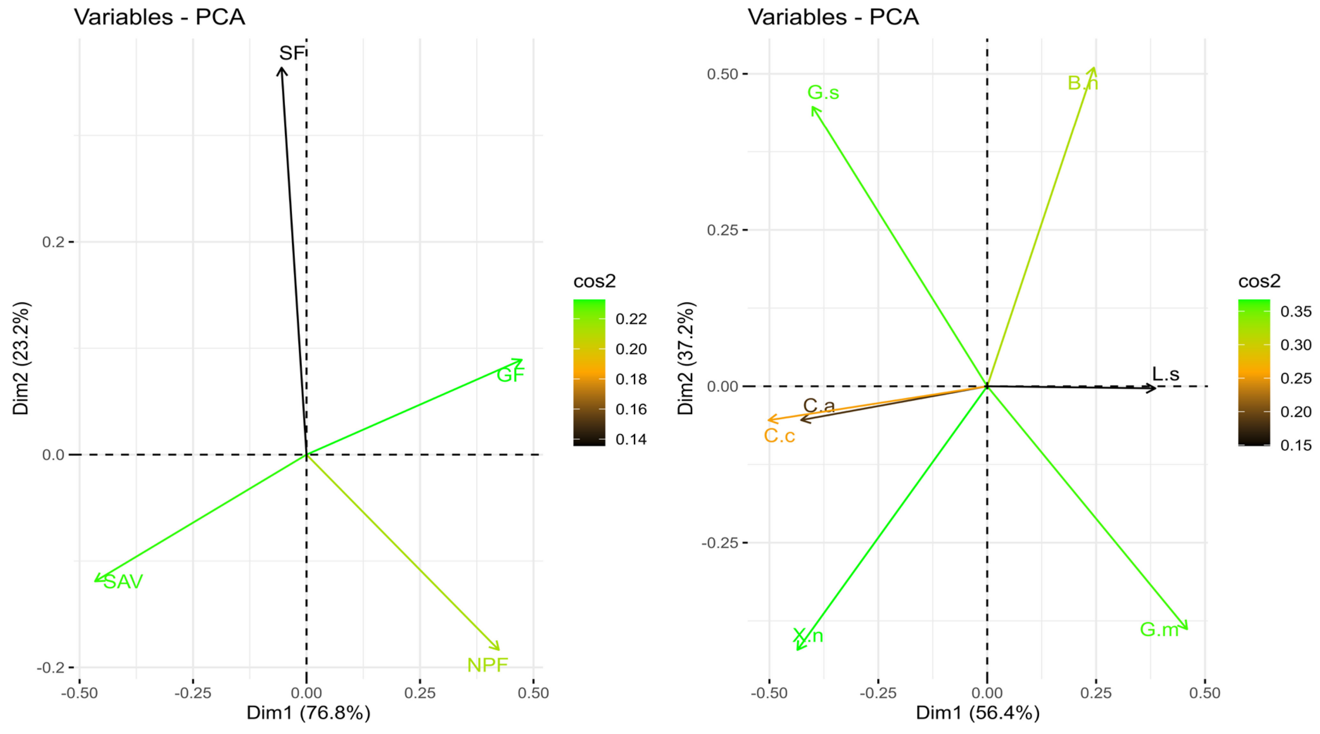

FIGURE 6 Biplot combined with cos2 for habitat class and species. The High cos2 attributes are coloured in green: SAV and GF for habitat class; *X.n*, *G.m* and *G.s* for species. Mid cos2 attributes have an orange colour: NPF for habitat class; *C.c* and *B.n* for species. Finally, low cos2 attributes have a black colour: SF for habitat class; *C.a* and *L.s* for species.

sampling is likely to reveal new species or new taxa only in NPF, as the curve has not yet reached the asymptote and the number of different individuals increase more than in SF, GF and SAV, where more effort does not seem to be needed. Furthermore, the extrapolation curve in Figure 5c indicates that new species of *X.n* and *C.a* can be recorded with additional sampling. Estimation was not robust for *L.s* as we got only one event.

3.5 | Selection of principal component

In the cumulative proportion section, the first principal component explains almost 77% and 56% of the total variance for habitat class (Figure 6, left) and species (Figure 6, right) respectively. This means that almost two thirds and more than half of the data in the set of four habitat class and seven species variables respectively can be represented by just the first principal component. The habitat class loading matrix shows that the first principal component has high positive values for NPF and GF. However, the values for SAV and SF are relatively negative. This may indicate that NPF and GF are the more favourable habitats for mesocarnivores in MDNP.

3.6 | Contribution of each variable

The biplot below (Figure 6) shows that SAV and GF for habitat class, *G.s*, *X.n* and *G.m* for species are well represented on the first principal component, while SF, *C.a* and *L.s* are not.

4 | DISCUSSION

The activity patterns of mesocarnivores are seldom studied, especially within human-dominated landscape where species are highly threatened such as in MDNP. We present the first published records of seven mesocarnivores in central Cameroon with the aim of contributing to the growing understanding of African mesocarnivores ecology and highlighting their importance within the MDNP ecosystem, and the need of a multispecies sustainable conservation programme in MDNP. This study also provides the first evidence of microscale allopatry between mesocarnivores in the area.

Of the seven mesocarnivores recorded in our study, five belong to the Herpestidae and Viverridae families, confirming our prediction and the taxonomy of the IUCN Red List, which highlights that most small carnivores species found on the continent belong to both families (Do linh San et al., 2013). On average, African countries, including MDNP, contain 15 species of mesocarnivores (Do linh San et al., 2013). We only found seven species, but the extrapolation curve shows that it is more likely to record new taxa with additional effort in NPF. However, the frequency and capture rate was globally low especially for *C.c* and *G.m* Similar results were also found by Gonzalez-Maya et al. (2009). In some contexts, the local threats towards mesocarnivores may vary between species, as seen in coastal forests of Kenya and Tanzania (Taylor, 2013). These results were further confirmed by the lowest estimated species richness which can be explained by the actual local threat faced by these species, thus, confirming the observation of Do linh San et al. (2013) suggesting that the threat level of mesocarnivores belonging to Viveridae and

Herpestidae is over 70%. In recent years, the migration of people from conflict areas in south-eastern Cameroon to the periphery of the park (Ernest Fotsing, Pers obs) may have increased pressure on mesocarnivores, as bushmeat is the main source of protein for local people (Fotsing et al., 2024). However, accurate data on the species composition of mesocarnivores and population densities would be needed to better conclude.

The species, *C.a* was recorded in SF and NPF while *L.s* was recorded only in NPF. This result is inconsistent with the findings of Simo et al. (2019, 2021), who recorded *L.s* in the SAV and GF and *C. a* in GF and NPF in their study in Cameroon. Similarly, the CR of *L.s* and *C.a was* 0.12 and 0.18 per 100 days respectively, which contrasts with a studies in the Dja Biosphere Reserve DBR, Cameroon (Bruce, 2017; Bruce et al., 2018) and in central Gabon (Bahaa-el-din et al., 2016), where the capture rate of these species was higher. Globally, the differences between our study and the above studies may be mainly due to sample size, the fact that some species are more generalist in terms of habitats class used and probably seasonality, especially since we conducted our study during the dry season when prey is scarce for mesocarnivores (Vieira & Baumgarten, 1995). In fact, our results do not support the findings of Raimundo (2020), who reported a high detection probability of civets and genets during the dry season. *L.s* and *C.a* activity pattern recorded contrasts with Simo et al. (2021) study in the same area, while the activity pattern of other mesocarnivores found in this study is similar to those found in Costa Rica (Gonzalez-Maya et al., 2009) and in Brazil (Vieira & Baumgarten, 1995).

Although the mesocarnivores recorded belong to the same guild of prey, the distribution of their activities shows a recognisable pattern in terms of time of activity and habitat class used. Of the four habitats class monitored, some species occur only in two habitats (e.g. *C.c* and *G.m*) while one species, *X.n* occurs in all habitats. According to this interpretation, X.n can be considered as a more generalist species in the habitat class used, which explains the variation in the saturation curve obtained for all species and for all species in each habitat, especially in NPF. Africa is home to the most functionally diverse guild of large carnivores (Dalerum et al., 2009) and its members are therefore exposed to a wide range of potential competitive interactions. The spatiotemporal partition highlighted in this study, particularly between *X.n* and *G.m* found in the savannah may reflect resource partitioning and competitive avoidance (Shen et al., 2021), as we have seen in Tanzania were large carnivores in Ruaha-Rungwa employ fine-scale partitioning mechanisms to facilitate coexistence with both sympatric species and humans (Searle et al., 2021) or in other groups of species such as primates competing with some birds (Charles-Dominique, 1975), but contrasts with a study in Mozambique that found no evidence of spatiotemporal partitioning among mesocarnivores (Grabowski et al., 2024). Similarly, Our results also corroborate the findings of Li et al. (2022) who found spatial segregation between the Asiatic golden cat, Siberian weasel and ferret badger, and temporal niche segregation between the leopard cat, palm civet and ferret badger, with no clear diurnal pattern for the hog badger. In some cases, human activity might also contribute to reduced partitioning of niche space by carnivores that consume similar resources, both by promoting tolerant species while also altering behaviour of species (e.g. activity patterns) (Smith et al., 2018).

B.n, *C.c*, *C.a*, *L.s* and *G.s* were not recorded in the savannah compared to *G.m* and *X.n*. This observation suggests that these species may be competing for resources that appear to be limited in the savannah, which has probably led to the split into two groups occupying different habitat class. This confirms the principle of competitive exclusion, which states that species that are too ecologically similar cannot coexist because one species will eventually outcompete the other (Gause, 1934). In such ecosystems, dietary niche partitioning also facilitates coexistence by reducing both interference and exploitation competition over shared prey species (Lu et al., 2023). Spatiotemporal niche partitioning has been documented in many systems (Bianchi et al., 2016; Di Bitetti et al., 2009) as a way to minimise the risk of negative competitive interactions. Other factors likely to influence these patterns in MDNP may be related to predation pressure, competition for food, food supply, dietary category and prey activity patterns (Vieira & Baumgarten, 1995). However, for each species, there must be a balance between the costs of predator avoidance and adequate foraging time within each habitat. Indeed, previous studies of mammal communities have also shown a clear separation between nocturnal, diurnal, and crepuscular species, and have emphasised that nocturnal activities are generally reported to be more common in tropical forests (e.g. Van Schaik & Griffiths, 1996).

We did not really sample many habitats throughout the park, which may also have influenced the interpretation of our results and can be considered a major limitation of our study. As the rarefaction curve indicates that more sampling effort is needed, this could be achieved in both seasons by setting a more even number of CTs in each habitat throughout the park (i.e. sample in a large area), as these species may show different patterns during the raining season. Such a study will therefore help to record more species activity and will help to understand whether the differences in activity periods suggested here are indicative of behavioural changes and biotic and/or abiotic factors.

We also acknowledged the fact that this study is a baseline study useful to orientate future study. Future studies could therefore apply a multispecies occupancy model to assess spatial partitioning among mesocarnivores and quantify the environmental factors that influence species-specific habitat use. It will also be good to analyse in more detail the temporal activity overlaps among the recorded mesocarnivores and to identify species-specific habitat covariates that influence each species detection probabilities. For conservation purposes, other factors such as habitat diversity and species interactions should also be considered during future research. The study confirms the persistence of these seven mesocarnivores in MDNP. We recommend that the status of these species on the IUCN Red List distribution map be updated and that documentation of their records throughout their range (especially for Cameroon) continue to be published or otherwise made available to researchers and the public.

Our study is a baseline study providing information on mesocarnivores that contributes to the growing understanding of African mesocarnivores ecology and highlights the importance of understanding these dynamics for effective multispecies conservation in MDNP.

AUTHOR CONTRIBUTIONS

Ernest Dadis Bush Fotsing: Conceptualisation, methodology, data collection, curation and analysis, writing grant proposal, preparing the original and final draft. Michelle Fany Meigang Kamkeng: Conceptualisation, methodology, data collection, project administration, writing and editing the draft. Salah Marcel Senge: Data curation. Dietmar Zinner: Supervision and contributed critically to the drafts. All authors gave their final approval for publication.

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CONFLICT OF INTEREST STATEMENT

The author(s) declared that there are no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

DATA AVAILABILITY STATEMENT

All data are archived in the first author Github repository account and can be found at https://github.com/Fotsing2023/Mesocarnivores-ecology-in-MDNP-Cameroon.git.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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