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Occurrence and relative abundance indices of the western roan antelope (*Hippotragus equinus koba*) and other mammals at mount Sangbé National Park, Côte d'Ivoire

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ABSTRACT

Due to recent socio-political unrest in Côte d'Ivoire, information data gaps of mammals, including the western roan antelope (*Hippotragus equinus koba*), have persisted. This study therefore aims at measuring the diversity and population status of mammals and their relative abundance at Mount Sangbé National Park (MSNP for conservation. We conducted camera trapping surveys from February until May 2018 at two sites in the northern and eastern sections of MSNP. After 731 trap days, we confirmed the presence of *H. Equinuskoba* and 26 other mammals' species belonging to five Orders: Cetartiodactyls, Carnivores, Primates, Rodents, and Tubulidentata with 15, five, four, two, and one species observed within the orders, respectively. The roan antelope occurred in the surveyed sites with a Relative Abundance Index (RAI) of 8.91 and 0.27, respectively. The RAI varied among three species: *Potamochoerus porcus, Tragelaphus scriptus,* and *Philantomba maxwellii* which we found to have relatively high RAI values of 11.76, 10.67, and 10.40, respectively. Alpha diversity indices differed between the woodland and savanna habitats in species richness ($p<0.001$), in their Shannon indices ($p<0.001$), in their dominance indices ($p<0.001$) and for the equitability index ($p=0.008$). Similarly, we found differences between the dry forest and savanna habitats in species richness ($p<0.001$), Shannon indices ($p<0.001$), in dominance indices ($p<0.001$), but no difference the equitability indices of these habitats ($p=0.424$). We recommend further studies in all habitat types of the entire park to better understand the population status of mammals inhabiting MSNP in order to ensure the conservation of its biodiversity.

Key words : *Camera trap, Mammal occurrence, Relative abundance, Roan antelope, Mount Sangbé.*

Introduction

Wild mammals are directly threatened by hunting, but also indirectly by various factors that negatively affect their habitats, including logging, agriculture, and the loss of critical resources (Ripple *et al.*, 2014).

The loss of those mammals can have a number of cascading effects, including disruption of the food web and alter the balance of the ecosystem (Berger *et al.*, 2001). Because competition promotes niche differentiation among sympatric species in an ecosystem, maintaining coexistence mechanisms of species and species diversity within an ecological community is key to contribute to the conservation and management of those communities (Zhao *et al.*, 2020).

Bushmeat remains the main source of protein in rural and urban areas in Côte d'Ivoire, western Africa, despite an official ban on bushmeat hunting since 1974 (Kouassi *et al.*, 2019). Hunters typically target medium and large-sized mammals because of the higher financial benefit they provide relative to smaller mammals and other taxa (Bitty *et al.*, 2014; Wilkie *et al.*, 2016). Within commonly hunted species, antelopes are a specifically targeted taxa, especially the Western Roan antelope (*H. equinus koba*). This subspecies constitutes a genetically separated group from other roan antelopes of Africa, and ranges predominantly in the woodland savannah of the northwestern corner of the country and in savannah habitats generally in northern Côte d'Ivoire (Alpers *et al.*, 2004). Although, the conservation status of *H. equinus* is of least concern (IUCN SSC Antelope Specialist Group, 2017), about 60% of the subspecies' total population currently occurs in protected areas (Chardonnet and Crosmary, 2013; Havemann *et al.*, 2016). However, the species is commonly used as an indicator of the health status of the ecosystems in which it occurs (Havemann *et al.*, 2016), and plays a role in maintaining the structure and functioning of the ecosystem as a result of their feeding and movement patterns (Waller and Alverson, 1997). Socio-culturally, the species is sacred in some clans of the Lobi ethnic group and is represented by masks because they embody a myth (Dibloni, 2003).

Over the recent decade (2002-2011) of socio-political crisis in Côte d'Ivoire, protected areas in the north and western sections of the country have experienced marked increases in human pressure on wildlife habitats (Fischer, 2004). In such a context, the Mount Sangbé National Park (MSNP) which is located in the north-west of Côte d'Ivoire was illegally infiltrated by human populations for agricultural, poaching, and logging activities (United Nations Environment Programme, 2015), thereby leading to environmental damage and its consequences to wildlife.

Prior to this disturbance, *H. equinus koba* was particularly abundant, revered as an emblematic mammal of the MSNP, and therefore of high conservation priority within the park (Lauginie, 2007). Yet, almost a decade after the crisis, the presence of *H. equinus koba* has not been formally confirmed by local park rangers, nor has any assessment of the diversity of remaining sympatric large and medium-sized mammals in the park been made since this crisis. Thus, the relative abundance and distribution of mammals remains unknown at MSNP, generally impeded by a lack of resources to perform these surveys, as well as to an inability to integrate more cost-effective advances in ecological survey tools such as camera trapping. Camera traps are a cost-effective, non-invasive tool particularly suitable for detecting elusive as well as nocturnal species compared to other survey approaches such as recce, transects and interview surveys (Hedwig *et al.*, 2018; Shannon *et al.*, 2014).

The overall goal of this study is to assess the population status of various mammalian fauna within the MSNP using camera trap sampling, in order to better equip resource managers in effectively conserving these species. Specifically, this study was undertaken at two survey sites located in the northern and eastern areas of MSNP with the aim to: (1) provide evidence for the occurrence of the western roan antelope within these survey sites and habitats, and (2) assess the diversity and relative abundance of large and medium-sized mammals within these survey sites and habitats.

Materials and Methods

Study areas

The study was conducted over approximately three months from February to May 2018 at MSNP which is located in the mountainous area of western Côte d'Ivoire. It covers an area of 95 000 hectaresand is precisely located between 7 ° 51'and 8 ° 10' north latitude and 7 ° 03' and 7 ° 23' west longitude. The MSNP borders with the departments of Biankouma, Touba and Séguéla (Figure 1). The site is characterized by rugged terrain dominated by mountains with altitudes varying between 500 and 1200 m. Mount Sangbé, whose name has been attributed to the park, has an altitude of 1072 meters (Lauginie, 2007). Rainfall varies from 1100 to 1600 mm with the majority of precipitation occurring in June, July and in September. The average annual temperature range between 19 °C and 34 °C, and an average relative humidity of 75%. Savannah and mountainous forest vegetations types are encountered at MSNP. The presence of 49 species of large sized mammals was previously identified in the park (Lauginie, 2007).

Data collection

To collect data on the occurrence and the relative abundance of the Western Roan antelope and other mammals', we conducted camera trap surveys at two sampling sites (hereafter, Site 1 and Site 2) within the northern and eastern sections of MSNP, respectively (Figure 1). Each sampling site was chosen randomly from all unreported observations of the Western Roan antelope made by local rangers prior to the Ivorian post-electoral crisis. Before data collection, we superimposed a systematic grid to the two sites of about 11 000 ha and 10 000 ha area size for Site 1 and Site 2, respectively. The size of each grid cell was 2km x 2km, and it aimed to maximize the number of medium and large mammal species that can be captured by accounting for the number of traps available.

Using this grid, we installed one camera trap (Type, Acorn Ltl-5310) along animal trails or close to fruiting trees within every second grid cell, to maximize capture probability (Shannon *et al.*, 2014). Installation of each camera was done so that the field of view of each trap targeted signs (tracks or dung) of the western roan antelope. Cameras were secured at tree trunk at about 50 cm average height above ground depending on topography (minimum 40 m and 70 cm). At each location we recorded habitat type, GPS location, and date and time of installation. Habitat type was defined based on vegetation type classification from Chidumayo and Gumbo (2010). In each of sampling site, we installed 10 camera traps (20 cameras for both sites) for 40 to 45 days eachand they were set operational 24h per day.

Data analysis

We assess the occurrence of the western roan antelope and other mammals, and their relative abundance from animals' images or detections obtained from camera traps. We identified species following the morphological descriptions (body size, presence or absence of horn, color of pelage, etc.) provided by Kingdom *et al.* (2013). We assessed four commonly used alpha diversity indices (species richness, Shannon index, dominance index, equitability index) for thetwo sites surveyed and for the different habitat types encountered by using the software PAST version 3.25 (Hammer *et al.*, 2001; Tuomisto, 2010). We

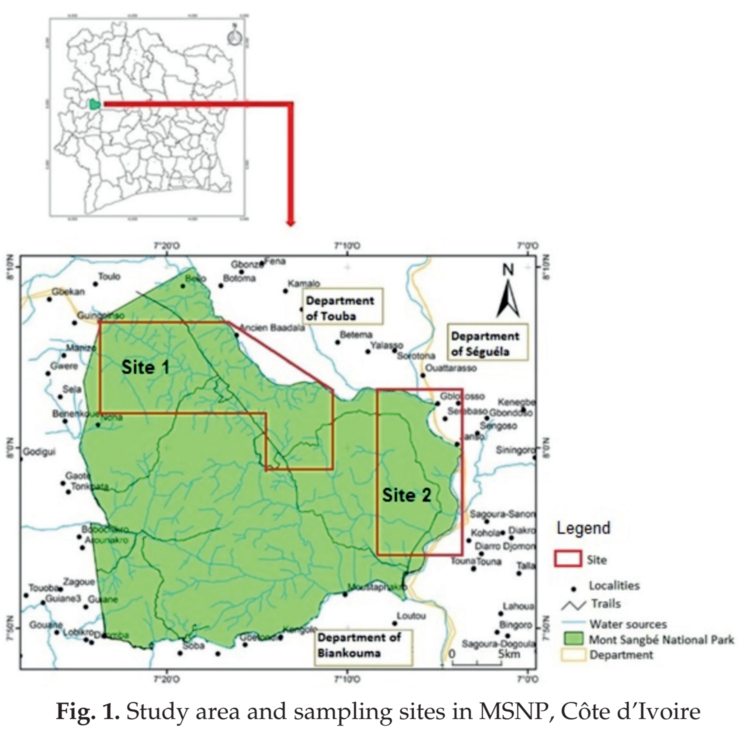


Fig. 1. Study area and sampling sites in MSNP, Côte d'Ivoire

used the diversity permutation test module to compare the alpha diversities indices at the two survey sites and for the habitats using random permutations with 9999 random matrices provided by the default option of the software (Hammer *et al.*, 2001). We computed the Shannon index (H) for each site which accounts for the number of individuals as well as the number of taxa (i):

$H = -\sum \frac{ni}{n} \times \ln \frac{ni}{n}$; where ni is number of individuals of taxon i.

H varies from 0 for communities with only a single taxon to high values for communities with many taxa, each with few individuals. However, the dominance (D) index ranges from 0 (all taxa are equally present) to 1 (one taxon dominates the community completely) with $D = \sum \left(\frac{ni}{n}\right)^2$. The dominance index is a measure of the information energy of a system such as a community (Thukral *et al.*, 2019). Therefore, if one or a few species have the maximum number of individuals, then that community has more dominance.

The equitability index, also known as Pielou evenness index (J), is a measure of the evenness with which individuals are divided among the taxa present (Harper, 1999; Pielou, 1966). It is obtained with the following formula: $J = \frac{H}{\ln(S)}$ where H and s are the Shannon index and the number of taxa, respectively. More descriptions of the indices can be found with Harper (1999); Magurran (2004) and Tuomisto (2010).

To facilitate comparisons with other studies using camera trapping as survey method (e.g., Jenks *et al.*, 2011; O'Connell *et al.*, 2011), we computed the relative abundance index (*RAI*) is a measure of all detections for each species as follows: RAI = C x 100 /N; with *C* being the number of captures or detections of a particular species by all cameras, and *N* the number of camera trap nights by all the cameras throughout the study area. We considered animal detections to be independent if the time between consecutive images or photos of the samespecies was more than 30 min apart. Photos with more than one individual in the frame were counted as one detection for the species (Palmer *et al.*, 2018). We assessed the conservation status of each mammal species included in our study by referencing the IUCN Red List website (https://www.iucnredlist.org/)

Results

Camera trap days and the occurrence of the western roan antelope within the two survey sites of MSNP

Data were collected over a total of 731 trap days during the survey at the 20 independent camera trapping locations within the two sites (Figure 1). Survey effort was 359 trap days and 372 trap days at Site 1 and Site 2, respectively. In total we obtained 16951 photos across the two surveyed sites, although camera trap triggers were disproportionate, with 27.8% of detections obtained at Site 1 (4713 photos), and 72.2% (12238 photos) obtained at Site 2. Of camera trap triggers, only 17.03% (2887 photos) were observations of mammals.

Our camera trap surveys confirmed the presence of the western roan antelope in both sites (Figure 2a). Indeed, the western roan antelope was detected at four camera traps locations at Site 1(32 captures) and one location at Site 2 (one capture) in the north-

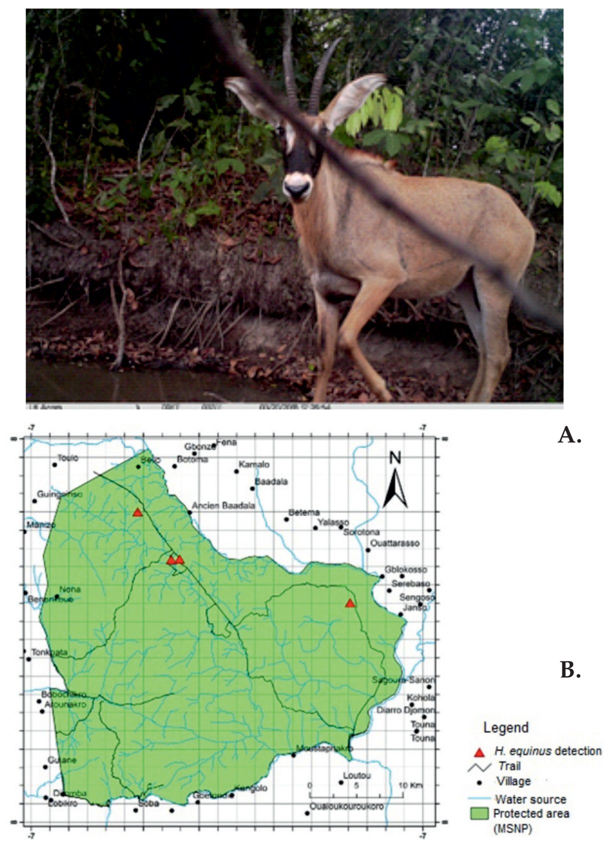


Fig. 2. Evidence of the western roan antelope (*H. equinus koba*) occurrence with (A) a photograph of the animal from a camera trap and (B) detection locations during the study at MSNP

western and in the northeastern areas of the park, respectively (Figure 2b). Those 33 captures were distributed within three habitat types with 29 captures in the savanna (87.88% of the species captures), and two captures in the dry forest and the other two captures within the woodland habitat. Animal capture events were concentrated to late evening, with only 10 detections (30.30%) occurring between 6h00 and 18h00 but 69.70% of detections occurring between 18h:00 min and 0h:00 min.

Diversity of mammals and the habitats of occurrence

A total of 27 species of large and medium-sized mammals representing five orders were captured at the two sites. Conservation status of these species ranged across categories, with 20 species listed as least concern, five species listed as near threatened and two species listed as vulnerable (Table 1). We provide a few example photographs in Figure 3. Our observations indicated that the order of Cetartiodactylais represented at MSNP by at least 15 species, and serves as the most diverse order in the Park relative to the four other orders of mammals (Carnivora Primates, Rodents, and Tubulidentata) observed in our study sites. Overall, 19 species and 20 species of mammals were observed at survey Site 1 and Site 2, respectively. Eleven species were common to both sites, including seven Cetartiodactyla and two primate species. The Tubulidentata were represented by only one species (*Orycteropus afer, Aardvark:* Figure 3g) which was captured only once. Seven other species from the four other orders also occurred relatively rarely within our data set. We observed that all four species of primates detected occurred at Site 2. Among the five Carnivora species captured only the Spotted-necked otter (*Lutra maculicollis*) was observed at both sites. Four Carnivora species occurred at Site 1 while two species were observed at Site 2 (Table 1).

Alpha diversity indices did not differ between the two surveyed sites of MSNP (Table 2), indicating no difference in the species richness (p=0.870), inthe Shannon index (p= 0.646), in the dominance index (p=0.784), andin the equitability index (p=0.982). The Shannon index ranged between 2.26 and 2.43 at Site 1 and between 2.29 and 2.46 at Site 2). The values of the dominance index D were 0.120 at Site 1 and 0.117 at Site 2. Thus, all taxa at both sites tend to be equally present, thus no single taxon

Table 1. Species richness ofmammals captured by camera traps in MSNP, their relative abundance indices for both survey sites (S1 and S2), and their conservation status

Order and common name of species	Scientific name of species	Total Observed individuals	RAI*	Number of captures	Site[a]	IUCN status[b]
CARNIVORA						
African civet	*Civettictis civetta*	6	0.82	6	S1, S2	LC
Common genet	*Genetta genetta*	2	0.27	2	S1	LC
Pardine genet	*Genetta pardina*	1	0.14	1	S1	LC
Spotted-necked otter	*Lutramaculicollis maculicollis*	2	0.27	2	S1,S2	NT
Tigrine genet	*Genetta tigrina*	1	0.14	1	S2	LC
CETARTIODACTYLA						
African buffalo	*Syncerus caffer*	6	0.68	5	S1, S2	NT
Black duiker	*Cephalophus niger*	1	0.14	1	S2	LC
Bohor reedbuck	*Redunca redunca*	1	0.14	1	S2	LC
Bongo	*Tragelaphus eurycerus*	3	0.41	3	S2	NT
Buffon's Kob	*Kobus kob kob*	44	4.65	34	S2	VU
Bushbuck	*Tragelaphus scriptus*	81	10.67	78	S1, S2	LC
Common duiker	*Sylvicapra grimmia*	1	0.14	1	S1	LC
Common warthog	*Phacochoerus africanus*	19	1.50	11	S1, S2	LC
Defassa waterbuck	*Kobus ellipsiprymnus defassa*	68	6.84	50	S1, S2	NT
Forest hog	*Hylochoerus meinertzhageni*	19	0.68	5	S1	LC
Maxwell's duiker	*Philantomba maxwellii*	96	10.40	76	S1	LC
Red-flanked duiker	*Cephalophus rufilatus*	24	3.15	23	S1, S2	LC
Red river hog	*Potamochoerus porcus*	159	11.76	86	S1, S2	LC
Western hartebeest	*Alcelaphus buselaphus*	3	0.41	3	S1	VU
Western roan antelope	*Hippotragus equinus koba*	54	4.51	33	S1, S2	LC

Fig. 3a. Baboon (*Papio anubis*)

Fig.3b. Western hartebeest (*Alcelaphus buselaphus*)

Fig. 3c. African Buffalo (*Syncerus caffer*)

Fig. 3d. Buffon's Kob (*Kobus kob kob)*

Fig 3e. Bushbuck (*Tragelaphus scriptus*) near a termite mound

Fig. 3f. Herd of the Red River Hog (*Potamochoerus porcus*)

Fig. 3g. An individual Aardvark (*Orycteropus afer*)

Fig. 3h. An individual of Crested porcupine (*Hystrix cristata*)

dominates the community largely. The evenness with which individuals are divided among the taxa present at each site was similar between Site 1 (J=0.789) and Site 2 (J=0.788). Furthermore, of alpha diversity indices for the three habitat types indicated different patterns (Table 3). We did not find any difference between the dry forest and the woodland habitats for the species richness (p= 0.614), for the Shannon index (p= 0.904), for the dominance index (p=0.649) nor for the equitability index (p=0.473). However, we found differences between the woodland and savanna habitats for species richness (p<0.001), for the Shannon index (p<0.001), for the dominance index (p<0.001) and for the equitability index (p=0.008). Similarly, we found differences between the dry forest and savanna habitats in species richness (p<0.001), for the Shannon index (p<0.001), for the dominance index (p<0.001), butno difference in the equitability indexacross these habitats (p=0.424).

Relative Abundance Indices (RAI) of mammals

Over our data set, the number of captures (mean=37; range:1-86) and the RAI (mean=2.63; range: 0.14-11.76) varied according to species (Table I). The bushbuck (*Tragelaphus scriptus*) and the Red river hog (*Potamochoerus porcus*) were the most captured species during the study period with 86 and 78 captures, respectively. Among primates observed, the Grivet monkey (*Cercopithecus aethiops*) had the highest RAI(2.87). Among the Cetartiodactyls and the Rodents, the Red river hog (*Potamochoerus porcus*) and the Crested porcupine (*Hystrixcristata*) had the highest RAI (11.76 and 6.16), respectively.

Figure 4 indicated for each site, the values of RAI

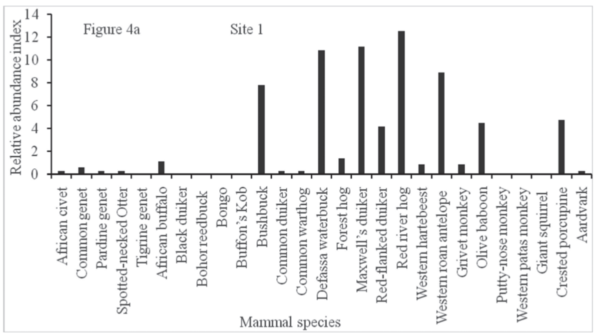
Tableau I. Species richness ofmammals captured by camera traps in MSNP, their relative abundance indices for both survey sites (S1 and S2), and their conservation status (continued)

Order and common name of species	Scientific name of species	Observed individuals	RAI*	Number of capture	Site[a]	IUCN status[b]
PRIMATES						
Grivet monkey	*Cercopithecus aethiops*	23	2.87	21	S1, S2	LC
Olive baboon	*Papio anubis*	47	2.19	16	S1, S2	LC
Putty-nose monkey	*Cercopithecus nictitans*	16	1.78	13	S2	NT
Westernpatas monkey	*Erythrocebus patas patas*	1	0.14	1	S2	LC
RODENTS						
Giant squirrel	*Protoxerus stangeri temminckii*	1	0.14	1	S2	LC
Crested porcupine	*Hystrix cristata*	50	6.16	45	S1, S2	LC
TUBULIDENTATA						
Aardvark	*Orycteropus afer*	1	0.14	1	S1	LC

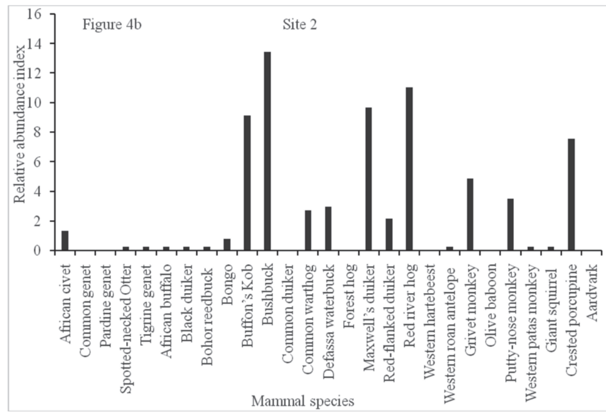
*RAI: Relative abundance index; [a]S1: site 1; S2: site 2; [b]LC: Least Concern; NT: Near Threatened; VU: Vulnerable VU for the different species. At Site 1 where RAI values ranged from 0.28 to 12.53, among the 19 species that occurred, the Red river hog (*P. porcus*), Maxwell's duiker (*Philantomba maxwellii)* and Defassa waterbuck (*Kobus ellipsiprymnus defassa)* had the highest values of RAI with 12.53; 11.14 and 10.86, respectively (Figure 4a). At Site 2, RAI values ranged from 0.27 to 13.44 with the Bushbuck, the Red river hog and the Maxwell's duiker having the highest values of RAI with 13.44; 11.02 and 9.68, respectively (Figure 4b).

Discussion

This study is the first to measure the diversity and relative abundance of large and medium-sized mammals in Mount Sangbe National Park in the last decades. Our study provided, through camera trap-



(4a)



(4b)

Fig. 4. Relative abundance indices of the mammals captured by camera traps at survey Site 1 (Fig. 4a) and Site 2 (Fig. 4b) in MSNP, Côte d'Ivoire

Tableau 2. Comparison of alpha diversity indices (Shannon index, dominance index, and equitability index) through a diversity permutation testfor the two surveyed sites of Mount Sangbe National Park, Côte d'Ivoire

Alpha diversity indices	Site 1	Site 2	p-value
Species richness	19	20	0.870
Shannon index (H) with 95% conf. int.[a]	2.323[2.259 - 2.431]	2.362[2.290 - 2.462]	0.646
Dominance index (D) with 95% conf. int.[a]	0.120[0.108 - 0.132]	0.117[0.105 - 0.131]	0.784
Equitability index (J) with 95% conf. int.[a]	0.789[0.767 - 0.826]	0.788[0.771 - 0.830]	0.982

[a] 95% conf. int.:95% Confidence interval

Tableau 3. Comparison of alpha diversity indices (Shannon index, dominance index and equitability index) through a diversity permutation testfor three habitat types encountered at Mount Sangbe National Park, Côte d'Ivoire

Alpha diversity indices	Dry forest[1]	Woodland[2]	Savanna[3]	p-value[1,2]	p-value[2,3]	p-value[1,3]
Species richness	23	20	8	0.614	<0.001	<0.001
Shannon index (H) with 95% conf. int.[a]	2.349 [2.278 - 2.479]	2.336 [2.240 - 2.494]	1.398 [1.185 - 1.559]	0.904	<0.001	<0.001
Dominance index(D) with 95% conf. int.[a]	0.130 [0.112 - 0.145]	0.136 [0.111 - 0.161]	0.318 [0.268 - 0.384]	0.649	<0.001	<0.001
Equitability index (J) with 95% conf. int.[a]	0.749 [0.732 - 0.796]	0.780 [0.748 - 0.833]	0.672 [0.603 - 0.763]	0.473	0.008	0.424

[1]Dry forest habitat; [2]Woodland habitat; [3]Savannahabitat; [1,2]p-value: comparison between dry forest and woodland habitats; p-value[2,3]: comparison between woodland and savanna habitats; p-value[1,3]: comparison between dry forest and savanna habitat

ping, evidence ofoccurrence ofthe western roan antelopeand at least 26 sympatric mammals within the northern and eastern areas of MSNP. Our findings may indicate that the resumption of patrolling and other conservation management activities by park staff in 2012 may have contributed to the persistence of these species in the Park (Kablan *et al.*, 2017; Morrisson *et al.*, 2007). However, that our reported species richness is relatively lower than the previous 46 species measured by Lauginie (2007) is possibly attributed to the fact that the earlier study was carried out over the entire extent of the MSNP for a longer period whereas our study was carried out over three months in two locales in the northern and eastern areas representing about 22% (i.e., 21 000 ha of 95 000 ha) of the Park area.

Although camera trapping is considered as one of the most effective techniques for sampling diverse species typically difficult to observe by humans over a short period of study, the method may be less effective for surveying arboreal and volant-mammals (O'Connell *et al.*, 2011). We detected four species of wild primates but they did not include the critically endangered western chimpanzee (*Pan troglodytes verus*), which is known to occur in the Park (Lauginie, 2007) likely due to sampling in habitats not previously identified as chimpanzee locations. Multiple species were detected across multiple trapping locations, but the aardvark was only observed on a single camera at Site 1, suggesting that it may occur relatively rarely in this landscape. The comparatively higher encounter rates of termite mounds at Site 1 (more than 10 mounds per kilometer walked) relative to Site 2 (about five per kilometer walked) may contribute to this discrepancy, as aardvarks consume African termites (Taylor *et al.*, 2002). The lower captures of carnivores (twelve captures for four species detected) at both sites raises concern. One could justify this by fact those animals often occur at lower densities within tropical habitats than most ungulates (Gray, 2018; McCarthy *et al.*, 2013).

Despite these differences, the alpha diversity indices (species richness, Shannon index, dominance index, equitability index) did not differ between our two surveyed sites at MSNP. These results suggest that overall, the community composition of mammals at Site 1 was indistinguishable from that of Site 2. Such a similarity may reflect overall similarities in vegetative land coverage at the sites. Furthermore, we could have failed to find an effect of sites on the alpha diversity indices due limited sampling locations per site (i.e low statistical power). The mammal communities inhabiting each site and habitat type (Table 2 and 3) were moderately divers, as indicated by positive Shannon index values. When comparing alpha diversity indices between different habitat types, we found differences between the dry forest and savanna, also between woodland and savanna. This could suggest differences in mammalian communities within these habitats, with the exception of dry forest relative to woodland habitats. Furthermore, as mammal community structure is strongly influenced by tree cover (Louys *et al.*, 2011), this may be one pontential contributor to our observed habitat differences.

The relative abundance indices indicated high values for most Cetartiodactyls species including Maxwell's duiker (*Philantomba maxwellii)*, the Bushbuck (*Tragelaphus scriptus)*, Red river hog (*Potamochoerus porcus)* in comparison with the other species detected at both sites (Figure 4). The least abundant species detected during this study are the species listed in the Order of Rodents, Carnivores and Tubulids, although we must interpret these findings cautiously as body size and various behaviours such as ranging, grouping, and activity periods are known to affect animal capture rates (O'Connell *et al.*, 2011). Furthermore, different species may respond differently to various habitat disturbances such as intensive poaching that could have occured in the absence of rangers or minimum patrol activities during the last decade of socio-political crisis in Côte d'Ivoire (Fischer, 2004; N'guessan *et al.*, 2018). At the same time, the distribution of mammals in the park ecosystem could be shaped by habitat structure, landscape characteristics and sources of human disturbance, and topographic factors (Djagoun *et al.,* 2014; Soiret *et al.,* 2019).

The majority of the detections of the western roan antelope (97%, i.e., 32 of 33 detections) occurredat Site 1 which may provide more safety conditions (with less hunting signs) or probably due the availability of more feeding resources. For instance,a number of natural licks were observed at that site and those licks could serve as areas which can compensate for mineral deficienciesduring the dry season where grass or plant resources were less likely to be available for the species to feed (Dibloni, 2003; Matsubayashi *et al.*, 2006). Furthermore, duringour study period corresponding to the dry season, 87.88% of the species occurrence were observed in the savanna, 6.06% in the dry forest, and 6.06% in woodland habitats, which may reflect species' habitat preferences (Kingdon *et al.,* 2013). For example, our results conform to the expectation that roan antelope tend to avoid areas of short grass (Kingdon *et al.,* 2013), in that the majority of the species occurrence were in the savanna habitat with longer grasses. The area covered by our study sites deserves, furthermore, to be taken into account for a better understanding of the habitats used by the species and its sympatric mammals in MSNP. Due to a lack of study on the western roan antelope and other mammals at MSNP using camera traps, it was difficult to compare the relative abundance of the species with other data collected locally.

In conclusion, diverse large and medium-sized mammals including the western roan antelope inhabit the two surveyed sites in the North and Eastern sections of the MSNP. These results suggest that all habitat types require particular attention from park managers in terms of patrol activities to ensure the conservation the biodiversity of MSNP.Lastly, to better understand the population status of the roan antelope and other mammals inhabiting MSNP, we recommend intensive and extensive additional camera trapping at the entire scale of the park.

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