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Diversity of small carnivores in Pendjari biosphere reserve, Benin

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Abstract
Small carnivores, important members of ecosystems are poorly studied in Africa. In order to fill this gap, we camera trapped 103 sites in Pendjari Biosphere Reserve, West Africa. The specific objectives were to assess the species richness in the small carnivore guild and whether the land use system affect this diversity. For a total trapping effort of 3607 days between November 2014 and April 2015, we got 543 independent captures of at least ten species. The trapping success of small carnivores was 15 pictures/100 days in the reserve. Small carnivores were found in 68% of the sites. Jackal and genet were the most abundant distributed species in the park while mongooses and genets were more common in hunting zones. Hunting zones being more prone to human disturbance, our results suggested that Felidae were more vulnerable to anthropogenic activities than other carnivores. These species and jackal could be used as indicator species in Pendjari ecosystem. Conservation efforts should be improved, especially in hunting zones, to guaranty the survival of small carnivores in this ecosystem.

Keywords: Small mammals, species richness, camera trapping, West Africa

1. Introduction
Like other components of biodiversity, small carnivores are important ecologically [26]. They contribute to regulate smaller members of ecosystems [5, 7] and then affect higher trophic levels. They are ideal indicator species for conservation planning [32]. When larger carnivores are exterminated, small carnivores become apex predators in ecosystems [12, 27]. They also contribute to seed dissemination and plant pollinization. Through the regulation of rodents' populations, they contribute to improved agricultural yield [1]. Particularly in Africa, small carnivores are hunted and used as food, medicinal and magico-religious purposes [2, 13, 14, 15]. Despite their importance, they carnivores are usually less studied than their counterparts, large carnivores. As pointed out by [16], few small carnivores have been well studied in Africa. Considering the increasing threats on large carnivores and wildlife in general in Africa, it is important to assess the diversity and the ecology of these small carnivores in order to better gauge the threats they faced and improve conservation actions towards them. If they are indeed common compared to larger carnivores, a greater attention to them will allow to avoid them to become endangered.
According to [16], among the 55 small carnivore species found in Africa only 4 were vulnerable and none was endangered. However for almost half of the species the population trends are unknown, pointing out the need of information on population ecology and dynamics. The mean richness per country is 15 species [16].
Benin Republic is a country located in a dry gap within the west-african equatorial belt. While [16] reported between 11-15 small carnivores species, [2] reported 21 species for the same country. These species are found throughout the country, both within and outside protected areas. Despite there are well distributed, they are threatened by their habitat fragmentation and their uses as bushmeat or for medicinal and magical purposes [2, 14, 15]. Data that should be used to assess their current status and take appropriate conservation measures are scarce. On another side, the few surveys done were based mainly on interviews, transects, which are not the best choices to study nocturnal and secretive species such as most small carnivores.
The current study was aimed to contribute to fill this gap through a camera trap survey in one of the richest ecosystems in savanna area of Benin and West Africa: Pendjari Biosphere Reserve. The specific objectives are to (a) assess the species richness in the small carnivore guild and (b) assess whether the land use system (national park versus hunting zones) affect the species richness.

We hypothesize that most of small carnivores typical of west African savanna will be present and that the national park will have the same richness but a higher occupancy compared to hunting zones.

2. Materials and Methods

2.1. Study area

The study was carried out in Pendjari Biosphere Reserve (Fig. 1). The reserve consists of Pendjari NP (2,660 km²), Pendjari Hunting Zone (1,600 km²) and Konkombri hunting zone (250 km²). The climate in Pendjari is characterized by one dry season (November- May) and one rainy season (May-October). Rainfall varies from 800 mm in the North to 1,000 mm in the South and means temperature ranges from 18.6°C to< 36.8°C. Most rivers and waterholes dry up between February and May with water available only in parts of the Pendjari River and a few important natural waterholes. In the rainy season, many areas of the reserve are flooded and inaccessible. The vegetation is a mosaic of savannah, floodplains and gallery forests [31]. The mammalian fauna is characteristic of the West African savannah including lion *Panthera leo*, leopard *Panthera pardus*, cheetah *Acinonys jubatus*, spotted hyaena *Crocuta crocuta* and elephant *Loxodonta africana* [31]. Pendjari hunting zone is bordered by about 23 villages. Main activities of local people are extensive agriculture and husbandry.

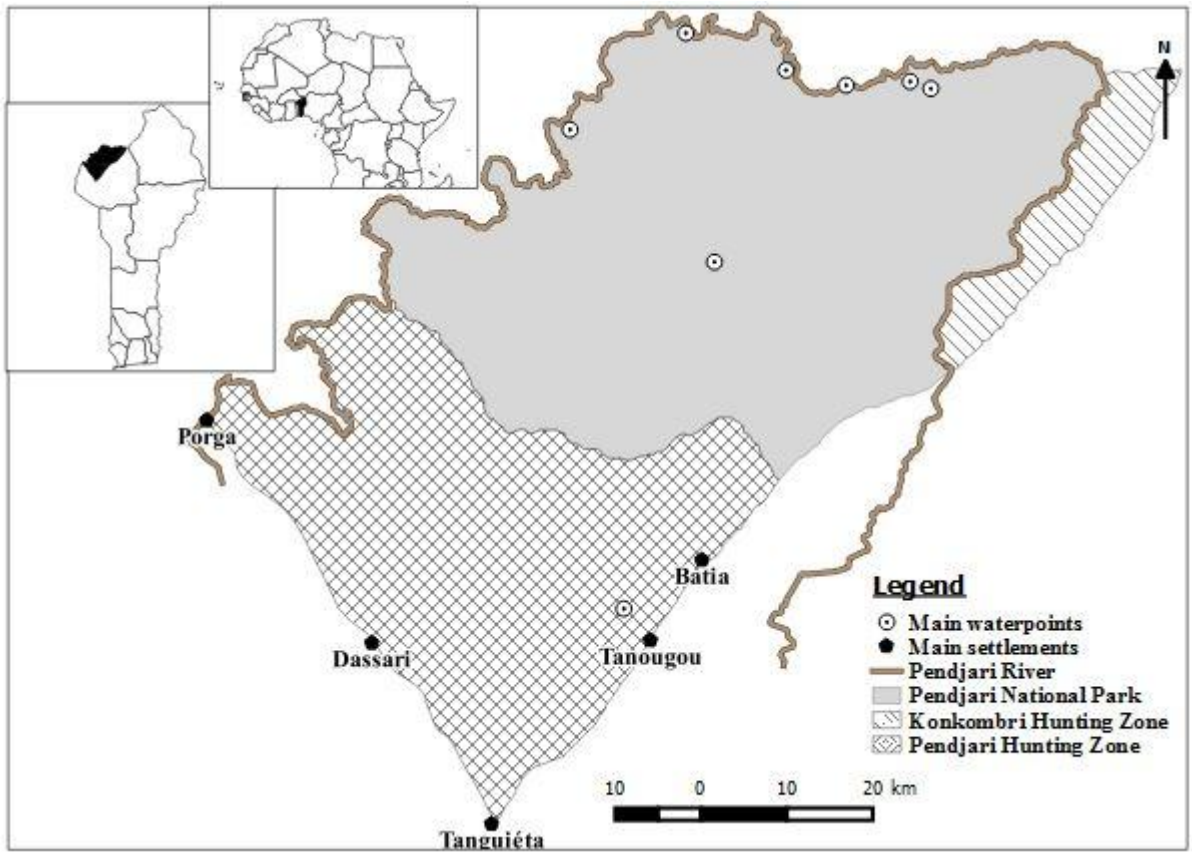

Fig 1: Location of Pendjari Biosphere Reserve in Benin.

2.2. Methods

We surveyed 103 sites from November 2014 to April 2015. In each site, we set a camera trap composed of one infrared camera. Traps were installed on trees at diverse distance from roads, with 2 to 5 km between two consecutive traps. Cameras (Bushnell Trophy Cam HD, Moultrie M-990i infrared cameras and Scoutguard SG565 Flash Camera) were active 24 hours a day and stayed at each station 30 to 40 days. Pictures showed the date and time of caption. Cameras were checked every 10 to 15 days to change batteries and download pictures when necessary.

We considered small carnivores as defined by IUCN [29] but we include jackals from Canidae in this group. Pictures were copied from SD cards and photo without small carnivores were excluded from the analysis. Only pictures taken at least 30 minutes apart were considered for the analysis to avoid pseudoreplicaton [37] and entered in Camera base®. The survey effort or camera trapping days was calculated as the number of active camera traps multiplied by the number of active calendar nights [18]. The trap success (TS) and naive occupancy (NO) have been estimated. The trap success is the number of independent capture by 100 trapping days, excluding days where cameras did not function [9, 24, 35]. The naive occupancy is the proportion of the stations in which the species has been detected [9, 21]. We identified the different species based on the UICN Red List (www.redlist.org), Arkive (www.arkive.org) and the WAP mammals guide [20].

3. Results

The total trapping effort were 3607 days with 2196 days in the national park and 1023 and 388 days respectively in Pendjari and Konkombri hunting zones. They were 543 independent pictures of small carnivores. At least ten species of small carnivores from five families have been identified (Fig. 2). For analysis, we considered genets as one species and mongooses as one species. About genets, at least the large spotted genet (*Genetta tigrina*) has been identified in pictures. Regarding mongoose, the white-tailed mongoose (*Ichneumia albicauda*), the Egyptian mongoose (*Herpestes ichneumon*) and the marsh mongoose (*Atilax paludinosus*) were clearly identified. But some pictures were blurry so maybe there were more species of genets and mongooses. To limit bias, we then

considered genets and mongooses respectively as one species. The table 1 presents the different species captured by cameras.

The trapping success of small carnivores was 15 pictures/100 days in the reserve. It was slightly higher in the hunting zones (15.59 pictures/100 days) than in the park (14.6 pictures/100 days). Most abundant species in the reserve were jackal followed by mongooses, genets and civet. In the national park, most trapped species were jackal followed by genets, civet and mongooses. In hunting zones, mongooses followed by genets and jackal. The Felidae: serval, caracal and African wild cat were absent from hunting zones.

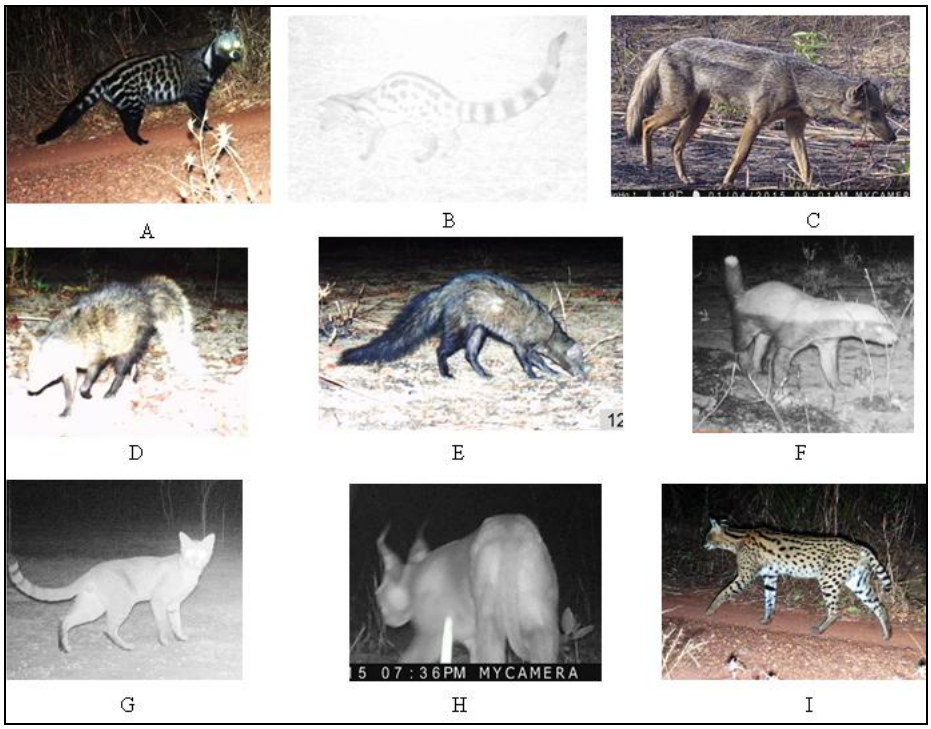

Fig 2: Different small carnivores' species captured in Pendjari Biosphere Reserve: A- African civet *Civettictis civetta*, B- Genet *Genetta tigrina*, C- Jackal *Canis aurus* , D & E- Mongooses, F- Honey badger *Mellivora capensis*, G- African wild cat *Felis silvestris*, H- Caracal *Caracal caracal*, I- Serval *Leptailurus serval*

In general, small carnivores were well distributed in the reserve with a presence in 68.93% of the surveyed sites. They were more distributed in the park (naïve occupancy of 0.75) than in hunting zones (naïve occupancy of 0.60). Genets were the best distributed species in the reserve with naïve occupancy of 0.46. Jackal had the highest occupancy in the national park but also in hunting zones closely followed there by mongooses. Caracal was the less distributed species in the reserve.

Table 1: Camera trapping results for small carnivores in the national park and hunting zones of Pendjari Biosphere Reserve.

Families	Species	Indépendant captures IC and Trap success TS								Detection stations DS and Naive occupancy estimate NO							
		PBR		PNP		PHZ		KHZ		PBR		PNP		PHZ		KHZ	
		IC	TS	IC	TS	IC	TS	IC	TS	DS	NOE	DS	NO	DS	NO	DS	NO
Viverridae	*Genetta spp.*	149	4.13	70	3.19	68	6.65	8	2.06	47	0.46	26	0.43	18	0.56	3	0.27
	Civettictis civetta	91	2.52	66	3.01	24	2.35	1	0.26	31	0.30	23	0.38	7	0.22	1	0.01
Canidae	*Canis spp.*	134	3.71	92	4.19	13	1.27	29	7,47	41	0.40	27	0.45	7	0.22	7	0.63
Herpestidae	*Herpestes spp.*	129	3.57	58	2.64	51	5.00	20	5.15	43	0.42	25	0.42	12	0.20	7	0.63
Mustelidae	*Mellivora capensis*	15	0.41	10	0.46	5	0.49	0	0	8	0.07	5	0.08	3	0.09	0	0
Felidae	*Leptailurus serval*	9	0.25	9	0.41	0	0	0	0	7	0.07	7	0.12	0	0	0	0
	Felis silvestris	9	0.25	9	0.41	0	0	0	0	7	0.07	7	0.12	0	0	0	0
	Caracal caracal	7	0.20	7	0.32	0	0	0	0	5	0.05	5	0.08	0	0	0	0

Legend: TS: Trap success – IC: number of independent captures – NO: Naive occupancy Estimate – DS: Number of stations where species were detected

PBR: Pendjari Biosphere Reserve – PNP: Pendjari National Park – PHZ: Pendhari hunting zone – Konkombri hunting zone.

4. Discussion

This survey confirmed an important diversity of small carnivores in Pendjari Biosphere Reserve and provided evidence of the presence of some species which are not usually seen during visits in the park. This demonstrates the effectiveness of the camera trap methodology to assess reliably the biodiversity of an area. Indeed with the line transect methods, only jackal and civet were usually observed [8, 31].

Several species found in African savannas have been detected during this study [6, 10, 22]. The most common families were Viverridae, Canidae and Herpestidae which are also the most

common observed in forested Africa except for Canidae [17]. Honey badger was rare. This species status in Pendjari is the same at continental level as despite it is widely distributed in Africa; it exists at very low density across its range [16]. However we did not found few species reported to be present in the area. Zorilla *Ictonyx striatus*, African palm civet *Nandinia binotata*, side-striped jackal *Canis adustus* and sand fox *Vulpes pallida* were reported to be present in Pendjari reserve, mainly based on questionnaire surveys and markets surveys [14]. The absence of these species from pictures could mean that they are rare or absent. Indeed rarest species with particular ecological requirements could be difficult to capture. In this study, due to the low density of roads and logistical constraints, we were unable to access some parts of the protected area. This may affect the detection of species that avoid proximity with humans or prefer micro-habitats we did not survey. However we did not expect African palm civet which is an arboreal species adapted to the more humid habitats of southern and central Benin. Sand fox, side-striped jackal and zorilla have been observed close to settlements [19, 30, 33]; suggesting their absence in pictures is due to their rarity or extirpation from the reserve. We also did not focus on aquatic habitats, which explain why we didn't captures otters which were reported to be present in the reserve [14]. An increase in the number of sites will allow confirming the persistence of few small carnivores' species in the reserve. In fact, several thousands of camera trapping days can be necessary to capture all the species present in an area [28]. For species inventory, despite the area sampled seems to have little impact on the number of species detected [35], [28] adviced to sample all different habitats with a maximum spacing of 2 km between two consecutive cameras. The current survey was focused on large carnivores, what explain the spacing between the cameras. For future surveys targeting small carnivores, the number of sites should be increased.

Small carnivores are known as resilient species [29] and we expected them to be present as well in hunting zones, disturbed by human activities, as in the national park. Previous studies showed that according to the place and probably species, small carnivores can survive face to human encroachment and persecution [6, 7, 10] or avoid disturbed habitats [22]. The Felidae and other largest small carnivores (jackal and honey badger) seem to be the most vulnerable to anthropogenic activites in Pendjari reserve. Jackals were the most abundant and well distributed species in the less disturbed areas in the reserve: the national park and Konkombri hunting zone. Genets, mongooses were the most common and distributed species, especially in the Pendjri Hunting Zone which is the most disturbed part of the reserve by anthropogenic activities. Some species of genet and mongoose have be found to be positively correlated with human presence [25] while the contrary has been observed for jackal. Indeed genets and mongooses probably benefit from mesopredator release hypothesis [11, 12].

We noticed that Felidae were the least detected species and they were absent from hunting zones. Despite trophy hunting is the main difference between hunting zones and the park, we do not think this explain the absence of these species in hunting zones as there are not trophy hunted. Caracal and wild cat low density and absence from hunting zones could be related to persecution as the species have been reported to be involved in livestock depredation [4, 7, 23, 36]. [7] reported wild cat and caracal were negatively affected by predator control measures in Kalahari region in South Africa. However serval is reported to be rarely involved in livestock depredation [34]. At contrary, [10] found that caracal, unlike species such as large-spotted genet and marsh mongoose has a higher detectability near park edge, suggesting the species do not avoid proximity with humans. Traditional uses do not seem to be an important threat to small carnivores from Felidae family compared to Viverridae and Herpestidae [2]. This threat should not have an important impact on these species occurrence in hunting zones. It will be interesting to investigate the competition between large felids and small felids. Indeed large carnivores can kill small carnivores [3]. As the density of large carnivores is higher in the national park and even Konkombri hunting zone than in Pendjari hunting zone, the persecution of small species by the larger ones could contribute to explain the low density or absence of the first in hunting zones.

5. Conclusion

Pendjari Biosphere Reserve hosts a diverse small carnivore population. While the genets and jackals were the most common, genets and mongooses were the ones with highest occupancies in the reserve. At contrary to our hypotheses, hunting zones were less rich than the park but the small carnivores occupancy were higher in the park than in hunting zones. We found that jackals were the most common in the less disturbed areas. Our survey suggested that small felids were the most vulnerable to human pressure. These species and jackal could be used as indicator species and closely monitored. The sudy raised the need for a better knowledge of small carnivores' ecology. This will allow better understanding the ecological relations between large carnivores and small ones and the threats to the small carnivores' species. Conservation efforts should be increased in hunting zones, particularly in Pendjari hunting zone to guaranty a brighter future to small carnivores and wildlife in general.

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