Title: Camera trap survey of mammals in the Fazao-Malfakassa National Park, Togo, West Africa

Running Title: Camera trap survey in Fazao-Malfakassa Togo

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Abstract

For the first time in Togo, we used camera trapping to investigate the mammal community in Fazao-Malfakassa National Park (FMNP), a forest and savanna mosaic landscape subject to poaching and other detrimental anthropogenic activity. We compiled a species inventory, i.e. species occurrence, habitat use, and activity patterns during dry and wet seasons. Based on images from >80 locations during 9,007 camera days, we identified 32 mammal species, which, when combined with other published studies, increases the total number of mammals (excluding bats) historically reported to 57 species. Our results confirm the presence of five mammal species evaluated as threatened according to the IUCN Red List, highlighting the significant conservation value of the FMNP. Specifically, it appears to be the only protected area in Togo where the African savanna elephant and the African forest elephant occur sympatrically, and only the second site currently known with direct observations of Walter's duiker. We also report the presence of poachers and other anthropogenic activity within the FMNP. We recommend that continued survey efforts should be combined with detailed ecological data collection, effective law enforcement, community outreach, and eco-tourism development, to safeguard the remaining mammal species communities necessary for a functioning ecosystem in the park.

Résumé

Au Togo, pour la première fois, nous avons utilisé les pièges photographiques pour étudier les mammifères du Parc National Fazao-Malfakassa (PNFM), un paysage en mosaïque de forêt et de savane soumis au braconnage et à d'autres activités anthropiques néfastes. Nous avons dressé la liste des espèces inventoriées et étudié leur occurrence, leur utilisation de l'habitat, et leurs modes d'activité pendant les saisons sèche et pluvieuse. Sur la base des images provenant de plus de 80 sites de caméras pendant 9 007 jours de capture, nous avons identifié 32 espèces de mammifères qui, combinées aux résultats des autres publications, porte à 57 le nombre total de mammifères (à l'exclusion des chauves-souris) historiquement déclarés pour le PNFM. Nos résultats confirment la présence de cinq espèces de mammifères évaluées comme menacées selon la Liste Rouge de l'UICN, soulignant l'importante valeur de la conservation du PNFM. Plus précisément, le PNFM semble être la seule aire protégée au Togo où l'éléphant de savane et l'éléphant de forêt vivent en sympatrie, et le deuxième site actuellement connu pour des observations directes du céphalophe de Walter. Nous avons observé aussi la présence de braconnage et d'autres activités anthropiques au sein du PNFM. Nous recommandons que les efforts continus d'inventaire soient combinés avec des collectes de données écologiques détaillées, une application effective de la loi, une sensibilisation des communautés riveraines et le développement de l'éco-tourisme afin de sauvegarder les populations d'espèces de mammifères restantes dans cet écosystème fonctionnel.

Keywords: Camera traps, Forest elephant, Walter's duiker, Mammals, Fazao-Malfakassa, Togo, West Africa

1. Introduction

Camera traps have become an increasingly popular non-invasive tool for inventorying elusive and rare species (O'Connell et al., 2010). In recent decades they have been successfully used to collect essential data needed to underpin wildlife conservation efforts. For example, with regards to mammals, camera traps have been used to estimate occurrence, abundance, density, activity patterns, and habitat use, (e.g. D'Cruze et al., 2013; Singh & Macdonald 2017;

77 Can et al., 2020) as well as species richness, community structure, and diversity
78 (e.g. Can & Togan, 2009; Hedwig et al., 2018).
79
80 Camera trap studies (either published as project reports, PhD/MSc. thesis or as
81 peer-reviewed scientific papers) have been conducted in various western
82 African countries, with a focus on large carnivores, ungulates and primates,
83 exemplified by Guinea-Bissau (Wenceslau, 2014), Sierra Leone (Garriga, 2012;
84 Garteh, 2013), Liberia (Collen et al., 2011), Côte d'Ivoire (Eshuis, 2011; Després-
85 Einspenner, 2016), Ghana (Burton et al., 2010, 2011, 2012; McPherson et al.,
86 2016); Benin (Sogbohossou & Kassa, 2017; Sogbohossou et al., 2017), Niger
87 (Harris et al., 2019), Nigeria (Emmanuel et al., 2017) and Cameroon (De Iongh
88 et al., 2011; Giordano et al., 2017; Bruce et al., 2018). Few studies were
89 established to assess either smaller carnivores or the overall mammalian fauna
90 (Bruce et al., 2017; Sogbohossou & Aglissi, 2017; Soiret et al., 2019; Hongo et
91 al., 2020) or record the presence of a single species group or species (Maurice
92 et al., 2019; Nolan et al., 2019) while others assess behavioural traits of species
93 groups (e.g. Klailova et al., 2012) or human impacts on mammal communities
94 (Harris et al., 2019). However, overall there appears a strong focus on surveying
95 the presence of critically endangered lions in western Africa (see Henschel et
96 al., 2014; Kane et al., 2015). Only recently, camera traps have been utilized in
97 one scientific study in Togo to supplement the data from fieldwork
98 (Segniagbeto et al., 2018a). Togo is a relatively small West African country
99 (56,600 km^2) bordered by Ghana to the west, Benin to the east, Burkina Faso to
100 the north and the Gulf of Guinea to the south.
101
102 Studies on Togolese mammals were initiated in the 19^{th} century (e.g. Matschie,
103 1893) and numerous subsequent studies have focused both on particular
104 taxonomic groups e.g. bovids (Baudenon, 1952), bats (De Vree, 1969), and
105 primates (Segniagbeto et al., 2017; 2018b) as well as mammals more generally
106 (e.g. Robbins, 1980; Schmidt et al., 2008; Segniagbeto et al., 2018a). Most
107 recently, an updated list of the mammal species occurring in Togo (based on
108 an extensive literature search, voucher specimens, and hitherto unpublished
109 data) reported 178 species extant mammals including 52 Chiroptera and 47
110 Rodentia species representing the most speciose groups (Amori et al., 2016).
111 Despite these valuable studies, currently there remains a shortage of knowledge
112 focused on vertebrates in the "Dahomey Gap," a biogeographically distinct 200
113 km wide corridor dominated by a forest-savanna mosaic in Benin, Togo and
114 eastern Ghana that separates the Upper and Lower Guinean rain forest blocks

(Demenou et al., 2016). Furthermore, despite being one of the smallest countries in Africa, Togo has established over 83 protected areas that cover approximately 14% of its territory (Atsri et al., 2018). Yet, detailed inventories and other important ecological data remain lacking for many of these important areas of biodiversity in the country (Amori et al., 2016).

Fazao-Malfakassa National Park (FMNP) is the largest national park in Togo and one of the most important protected areas in this country (Segniagbeto et al., 2017; Atsri et al., 2018). It is also considered to be one of the largest protected areas, representative of the semi-deciduous forest-savanna mosaic of the Guinea-Sudanese transition zone in West Africa (Atsri et al., 2018). In 2012 it was added to the UNESCO World Heritage Tentative List [in the mixed (cultural + natural) category] (Atsri et al., 2018). Biodiversity surveys carried out in Togo (based on an examination of literature, voucher specimens, and direct observations) have identified at least 52 mammals species that could occur within the FMNP (Amori et al. 2016; Segniagbeto et al. 2017), and 287 species of birds (Radley & Campbell, 2008; Dowsett-Lemaire & Dowsett, 2016). The FMNP is threatened by a number of illegal activities including hunting, cattle grazing, timber exploitation, bush fires and agricultural encroachment (Segniagbeto et al., 2017; Atsri et al., 2018). Given the current information gaps and increasing anthropogenic threats facing the mammals within this protected area, we present here the first biodiversity survey of mammals in semi-deciduous forests and savanna woodlands portions of the FMNP using camera traps. We envisage that our findings will complement existing species records and build upon baseline information that can aid future conservation planning for this important biodiversity site.

2. Materials and Methods

2.1. Study Site

FMNP (08°40'N, 00°43'E) covers 192,000 ha (3.4% of Togolese territory) ranging between 300 and 800 m in elevation, which includes Mt Fazao (861 m a.s.l.) and Mt. Malfakassa (713 m a.s.l.) (Segniagbeto et al., 2017; Atsri et al., 2018). Located at the limit between the Sudanian and the Guinean ecological zones, FMNP is characterised by dense semi-deciduous forests and scattered savanna woodlands, the latter occurring in the southern portions of the park (Segniagbeto et al., 2017). Annual rainfall ranges between 1,200 and 1,500 mm,

with most rain fall between April and October (Atsri et al., 2018). Dry season mean temperature is approx. 27.5 °C, while mean temperature in the wet season is 25 °C (Adjoussi, 2000).

FMNP was created in 1975, when the forest reserves of Fazao (162,000 ha) and Malfakassa (30,000 ha) were combined (Atsri et al., 2018). Up until 1990, the Ministry for the Environment and Forestry Resources (MERF) managed the park. Between 1990 and 2015 it was managed by the Franz Weber Foundation (FFW), and thereafter once again by MEFF (Atsri et al., 2018). An estimated 120,000 people (from the Tem, Kotokoli, Agnanga, Adélé, Bassar and Kabyè ethnic groups) live in villages surrounding the park (Atsri et al., 2018). In 2014, eco-guard brigades and checkpoints were established in the south-eastern part of the FMNP to discourage agricultural encroachment (e.g. the cultivation of yam, maize, and cotton) (Atsri et al., 2018), and timber extraction.

Currently, FMNP is also characterized by a 10 km "peripheral area" that serves as an unofficial "buffer zone". Although these territories are not yet legally constituted as such by the governmental authorities, and no management strategy is in place, some patrolling is conducted in some of these peripheral areas where large mammals are present (Atsri et al., 2020). The current lack of legal status allows the local population to exercise their rights of use in these areas and conflicts recur between the neighboring populations and the park management authorities (Atsri et al., 2020) (Figure 1).

2.2. Survey Design & Data Analysis

This study was carried out during the dry season (09 February and 13 April 2019) and the beginning of the wet season (03 April to 22 June 2019) for approximately five months at six sites within the FMNP (known as Bounako, Kalaré, Cabane, Point de Vue, Elavagnon and Koui) (Figure 1). Study sites allowed us to investigate species (including human) presence in a variety of habitat types within the National Park. A total of 100 camera traps (50 Cuddeback Ambush IR 1187 and 50 Cuddeback Professional Color, Model 1347 camera traps) were installed where mammal trails or traces were found to maximize capture probability.

Cameras were set up to an approximate height ranging from 40 to 90 cm above ground, with motion sensors set to take one photo per trigger with intervals of

fifteen seconds between pictures when movement was detected. Cameras operated 24 hours per day, recording date and time of each photograph with power supplied by alkaline batteries. Camera traps were checked twice during the entire survey period.

To ensure that the camera events were independent, photos of the same species captured within 30 minutes of each other by the same camera were treated as a single event. For each camera event, we noted the date and time of day, species and the habitat type.

Species identification was based on (Kingdon, 2015; Lamarque, 2004; Oates, 2011; Granjon & Duplantier, 2009; Trape et al., 2012; Borrow & Demey, 2015). In case of doubt, we consulted experts for the respective taxa. Where animals could not be identified to species level, we present the nearest known higher taxonomic level. We excluded days when a camera trap was not filming due to technical problems from the analysis. In total, the cameras were functional for 9,007 camera days (4,431 in the wet season and 4,576 in the dry season).

We evaluated the completeness of our inventory for both wet and dry season phases by inspecting accumulation curves plotting the cumulative number of species detected against the number of camera days (Fisher et al., 1943). We also calculated the sampling coverage $Q = 1-(N_1/I)$ where N_1 is the number of species captured once and I the total number of camera events (Fagen & Goldman, 1977). A Q close to one means that the probability of observing a novel species in an additional camera event is low.

For each species, we calculated the relative abundance index (RAI) as the number of camera captures divided by the sampling effort (i.e. number of camera days) multiplied by 100, indicating the number of camera captures per 100 days of camera trapping (O'Brien, 2011). In addition, we computed the naïve occupancy as the number of camera trap sites at which we detected each species divided by the total number of camera trap sites (e.g. Jenks et al., 2011; Rovero et al., 2014). We excluded camera traps that failed to deploy from our analysis (with 87 camera traps being operational in the dry season and 76 operational in the wet season).

The camera trapping survey covered a mosaic of forest and savanna habitats, ranging from dense forest to open savanna woodland. The dense forests are dominated by tree species such as the large-leaved mahagony (*Khaya*

grandifoliola, Meliaceae), *Aubrevillea kerstingii* (Fabaceae), *Maranthes glabra* (Chrysobalanaceae), the velvet tamarind (*Dialium guineense,* Fabaceae) and the ochol (*Pseudospondias macrocarpa,* Anarcadiaceae). Savannah woodlands are dominated by *Crossopteryx febrifuga* (Rubiaceae) (see Segnigbeto et al., 2017; Atsri et al., 2018). For the purpose of this study, the habitat at each camera station was categorised according to these two habitat types.

3. Results

We assessed our species inventory for the selected study areas as close to complete, given the applied data collection method, based on the cumulative number of species having reached asymptote after about 45 camera days (Figure 2). We identified 32 mammal species belonging to 7 taxonomic groups across the entire selected study area (Table 1; Figure 3). We treated the African savanna elephant (*Loxodonta a. africana*) and African forest elephant (*Loxodonta a. cyclotis*) as two separate species (Nature, 2016; Table 1). The number of detected species differed only slightly between the two seasons; with 31 species detected in the dry season and 25 species in the wet season (Table 1, Figure 3).

In both seasons, ungulates were the most frequently observed taxonomic group, followed by primates (Table 1). We recorded African palm civet (*Nandinia binotata*), African savanna hare (*Lepus victoriae*) identified as *Lepus microtis* by Heuglin (1865), caracal (*Caracal caracal*), common Cusimanse (*Crossarchus obscurus*), Hausa genet (*Genetta thierryi*), red-legged sun squirrel (*Heliosciurus rufobrachium*), and Walter's duiker (*Philantomba walteri*) in the dry season only, and common duiker (*Sylvicapra grimmia*) only in the wet season (Table 1).

Across both seasons, the bushbuck (*Tragelaphus scriptus*), patas monkey (*Erythrocebus patas*), kob (*Kobus kob*), crested porcupine (*Hystrix cristata*), African brush-tailed porcupine (*Atherurus africanus*), waterbuck (*Kobus ellipsiprymnus defassa*), African forest elephant, olive baboon (*Papio anubis*), African civet (*Civettictis civetta*), white-tailed mongoose (*Ichneumia albicauda*), side-striped jackal (*Canis adustus*), and red-flanked duiker (*Cephalophus rufilatus*), were the 12 most frequently observed species (RAI ≥ 1). However, whereas the bushbuck, crested porcupine and red-flanked duiker showed higher RAIs for the wet season, the patas monkey, kob, African brush-tailed

porcupine, waterbuck, African forest elephant, olive baboon, African civet, white-tailed mongoose, and side-striped jackal showed higher RAIs for the dry season (Table 1).

Overall, bushbuck, kob, patas monkey, crested porcupine, African forest elephant, red-flanked duiker, white-tailed mongoose, waterbuck, olive baboon, African civet, side-striped jackal, and hartebeest (*Alcelaphus buselaphus major*) were observed in the highest number at different sites (>20 across both seasons; average naïve occupancy ≥ 0.13 across both seasons). All nine species were recorded on at least three more sites in the dry season compared to the wet season, except for the olive baboon that was detected at one more location during the wet season (Table 1). With regards to habitat type, 21 species (66%) were only encountered in open woodland savanna, and 11 species (34%) were encountered in both open woodland savanna and dry dense forest (Table 1).

The distribution of the number of captures across the hours of the day indicated clear diurnal activity patterns for olive baboon, patas monkey, and the Tantalus monkey (*Chlorocebus tantalus*); whereas nocturnal activity patterns have been recorded for African brush-tailed porcupine, African civet, crested porcupine, bushbuck, large spotted genet (*Genetta maculata*), side-striped jackal, and white-tailed mongoose. Diurnal to crepuscular activity pattern has been recorded for the red-flanked duiker (Figure 4). The forest elephant, savanna elephant, and kob, appeared to be cathemeral (Figure 4).

Humans were encountered at more than 25% of camera trap stations in both the dry and wet season (n = 32 and 25 respectively), and in both open woodland savanna and dry dense forest (Table 1). In total, camera trapping documented 290 independent events involving humans (172 in the dry season and 118 in the wet season). These events involved park rangers (N = 186), members of the local communities (N = 28), and poachers (N = 76), with the majority of events taking place during daylight hours (Figure 4). During the dry season, dogs and cattle were also encountered within the boundaries of the National Park (in 17 events at eight locations, and 19 events at 12 locations respectively) in open woodland savanna only (Table 1).

4. Discussion

Historically, a total of 52 mammal species (excluding bats) have been reported to occur within the FMNP, based on an examination of literature, voucher specimens, and direct observations (see Amori et al. 2016; Segniagbeto et al. 2017; Online Supplemental Table S1). During our study, 25 of these species could not be confirmed, either with camera traps or with opportunistic observations by field staff. These species were the bay duiker (*Cephalophus dorsalis*), the yellow backed duiker (*Cephalophus silvicultor*), the roan antelope (*Hippotragus equinus koba*), the oribi (*Ourebia ourebi*) the bohor reedbuck (*Redunca redunca*), Derby's Eland (*Taurotragus derbianus*), the bongo (*Tragelaphus eurycerus*), the sitatunga (*Tragelaphus spekii*), the African golden cat (*Caracal aurata*), the African wild cat (*Felis silvestris*), the serval (*Leptailurus serval*), the African lion (*Panthera leo*), the leopard (*Panthera pardus*), the Egyptian mongoose (*Herpestes ichneumon*), the banded mongoose (*Mungos mungo*), the spotted hyena (*Crocuta crocuta*), the rock hyrax (*Procavia capensis kerstingi*), the Mona monkey (*Cercopithecus mona*), the lesser white-nosed guenon (*Cercopithecus p. petaurista*), the white-thighed Colobus Monkey (*Colobus vellerosus*), the Senegal galago (*Galago senegalensis*), the Demidoff's Dwarf Galago (*Galagoides demidoff*), the Thomas's dwarf galago (*Galagoides thomasi*), the striped ground squirrel (*Xerus erythropus*), and the forest giant squirrel (*Protoxerus stangeri*). However, our application of camera traps provides evidence of five species of mammal that had not previously been officially reported within the FMNP, i.e. the African palm civet, African savanna hare, common Cusimanse, Hausa genet and red-legged sun squirrel.

Overall, when combined with observations made during the research published earlier, our study increases the total number of mammals (excluding bats) reported for the FMNP to 57 species. In particular, a noteworthy contribution of our camera trap survey is the confirmation of Walter's duiker within the FMNP. This diminutive antelope was only recently described (Colyn et al., 2010) based on specimens (including skulls and whole carcasses) obtained from bush meat markets in Benin, Togo, and Nigeria. Walter's duiker was previously assumed to inhabit various forms of "scrub habitat" in the Dahomey gap (IUCN SSC Antelope Specialist Group, 2016), and during recent fieldwork in Togo, it has been observed in the Togodo protected areas complex (Togodo North and South National Parks), the FMNP (Amori et al., 2016; Segniagbeto et al., 2018a), and most recently in Akissa and Avévé forests in the Mono Transboundary Biosphere Reserve according to interviews conducted with local hunters (Segniagbeto et al., 2018a). However, this species is currently assessed as "Data

Deficient" on the IUCN Red List, with data on population trends for this species also considered as "unknown" (IUCN SSC Antelope Specialist Group, 2016).

Importantly, our camera trap survey also confirmed the presence of both the African savanna elephant and African forest elephant, which appear to have an overlapping distribution, in the FMNP. Despite evidence that African forest elephants are taxonomically and functionally distinct (Nature, 2016), the International Union for the Conservation of Nature (IUCN) currently only recognizes one species, i.e. *Loxodonta africana,* which is categorized as Vulnerable on the IUCN Red List (Blanc, 2008). However, poaching is rapidly extirpating African forest elephants from most of their historical range (Poulsen et al., 2017), and based on a regional assessment the Central African forest elephant can be considered Endangered (Blanc, 2008; Brittain et al., 2020). This study confirms that elephant has not yet disappeared from the FMNP. In fact, within the network of protected areas in Togo, the FMNP appears to be the only confirmed site in which the African savanna elephant and the African forest elephant occur sympatrically. However, although it remains a stronghold for Togo's elephant population, the illegal ivory trade may pose a significant threat to both species in the FMNP (cf. Segniagbeto et al., 2020a).

The confirmed presence of the Western Hartebeest or Kanki (one of eight subspecies of Hartebeest, following Gosling and Capellini (2013) is notable as it is currently considered as Vulnerable, due to major population declines across its geographic range, including in protected areas, mainly due to hunting and habitat loss (IUCN SSC Antelope Specialist Group, 2017). The confirmed presence of the aardvark (*Orycteropus afer*) and common Cusimanse within the FMNP is also noteworthy as neither species currently have Togo listed by the IUCN as part of their current geographic range (Taylor & Lehmann, 2015; Angelici & Do Linh San, 2015). Specifically, the aardvark is considered widely distributed across much of sub-Saharan Africa (Taylor & Lehmann, 2015), however its distribution in West African forest habitats is poorly known (Taylor, 2013). Prior to our study it was only reported for the FMNP in an unpublished report (Atsri et al., 2013). With regards to the common Cusimanse, our camera trapping in FMNP now appears to represent the second record of this species within Togo. It was previously recorded from the border area between Ghana and Togo south of FMNP (Grubb et al., 1998), and more recently reported from Kpalimé in Togo (Amori et al., 2016).

Despite the importance of its mammalian fauna, when these current and other recent published studies are taken into account, the FMNP is currently known to support a relatively low number of mammal species of an elevated conservation status (N = 5): the African forest elephant (Vulnerable), African savanna elephant (Vulnerable), African golden cat (Vulnerable), white-thighed Colobus monkey (Critically Endangered) and hartebeest (Vulnerable) when compared to other protected areas in West-central Africa that also comprise a mixture of both forest and savanna habitats (e.g. Batéké Plateau National Park, Gabon, 12 mammal species (Hedwig et al., 2018). Noticeable, from our survey is the absence of other threatened taxa such as the African lion (Vulnerable) and leopard (Vulnerable) both of which are currently considered as possibly extinct in Togo (Bauer et al., 2016). In addition, the absence of Mona monkey (Near Threatened), lesser spot-nosed guenon (Near Threatened), white-thighed Colobus monkey (Critically Endangered), and white-bellied pangolin (*Phataginus tricuspis*) (Endangered) is noticeable given that these species have been previously reported from within the FMNP (Segniagbeto et al., 2017; Segniagbeto et al., 2020b).

In addition to the importance of its relatively rich mammal fauna, the FMNP is also recognised as an "Important Bird Area" (Checke, 2001). Most recently, the total bird list for this national park was increased to 287 species following fieldwork carried out in 2005 (Radley & Campbell, 2008) and 2016 (Dowsett-Lemaire & Dowsett, 2016). Although not our main focus, during the present study, camera traps also confirmed the presence of the Hadada Ibis (*Bostrychia hagedash*) (Least Concern), which was potentially misidentified as the Glossy Ibis (*Plegadis falcinellus*) by Radley & Campbell (2008; see Dowsett-Lemaire & Dowsett, 2016). Similarly, given that recent detailed survey work focused on its herpetofauna is also relatively lacking, it is important to note that camera traps detected two large-sized species of reptile within the FMNP, i.e. the Nile monitor lizard (*Varanus niloticus*) and the west African crocodile (*Crocodylus suchus*). With regards to the latter, the West African crocodile, that has been identified as being genetically distinct from the Nile crocodile (*Crocodylus niloticus*) (Schmitz et al., 2003), has yet to be formally assessed according to IUCN Red List criteria. However, West African populations are considered as likely depleted and less numerous than the Nile crocodile, and as such further delineation between the ranges of both species has been recommended to ensure that any conservation action plans are specific for each species (Isberg et al., 2019).

With regards to anthropogenic activity, in light of other recently published research, it is unsurprising that our camera traps documented evidence of poachers, local community members, domesticated dogs, and cattle within the boundaries of the FMNP. For example, Atsri et al. (2018) reported that since the late 1980s closed-canopy forest and tree-savanna has become severely degraded and fragmented within the FMNP, largely due to agricultural expansion, bush fires and timber extraction. Similarly, another study (Atsri et al., 2020) reported that 60% of the buffer zone surrounding the FMNP is also now degraded, with agriculture, charcoal, and firewood production cited as being the main drivers that detrimentally affect habitats. In addition, hunting activity (mostly targeting mammals, especially ungulates) has been reported in undisturbed and degraded areas of the FMNP buffer zone (Atsri et al., 2020), and illegal hunting activity (which is carried out to supply demand for bush meat, traditional medicine, and the international exotic pet trade) has been reported within the boundaries of the National Park (Segniagbeto et al., 2020b). Globally, such anthropogenic influences are considered to have caused biodiversity loss, species and population extirpations and declines in local species abundance (IPBES, 2019), including other parts of the West African forest-savanna mosaic.

5. Recommendations

It is important to note that our camera trapping survey is unlikely to have generated a complete species list for the FMNP and that additional camera trapping (and other data collection methods) could result in the detection of further mammal species in future. Similarly, although RAI and naïve occupancy are useful measures to monitor the occurrence of a given species, they are influenced by sampling design such as the set-up and location of camera traps, as well as a species' behaviour (e.g., Sollmann et al., 2013). Yet, this study provides important baseline data that can be used as a starting point from which future monitoring of the mammal species within the FMNP can begin. The FMNP is the largest protected area in Togo and is unique within the current network of protected areas in West Africa due to its combination of semi-deciduous forests and savanna woodland habitats (Segniagbeto et al., 2017; Atsri et al., 2018). Hence, we recommend that future monitoring should include additional areas, particularly in the Mazala, Mt. Kpaza, Kamassè, Guidjoguidji and Sourkou portions within the park, with a more specified focus on the

different vegetation types. Although a special focus on bats, felids, pangolins and primates is warranted, the recording of other vertebrates (reptiles, birds) should not be neglected. Furthermore, given the current shortage of knowledge focused on vertebrates in the "Dahomey Gap," (Demenou et al., 2016) our findings could also inform wider efforts to protect wildlife in this part of West Africa.

Efforts to gain more detailed insights into drivers responsible for anthropogenic activity within the FMNP and local attitudes towards particular management measures could also pay dividends. Moreover, firstly we recommend increased enforcement effort and capacity (potentially bolstered by the involvement of local communities, e.g. Atsri et al., 2018) to help minimize any illegal anthropogenic activities (Segniagbeto et al., 2020b). Secondly, the definition of controlled subsistence hunting areas for local communities in the "Buffer Zone" could reduce the importance of poaching within the FMNP. Thirdly, outreach projects could help to empower local communities to more effectively manage and protect the FMNP and surrounding buffer zone (e.g. via improved agricultural production systems, cattle grazing management, and human-elephant conflict reduction initiatives). Finally (and cognisant of the travel restrictions imposed at the time of writing as a result of the COVID-19 pandemic), we suggest that the presence of mammal species, including species of IUCN threatened status like forest and savanna elephants, could be used profitably for enhancing eco-tourism and regular scientific activity (Atsri et al., 2020; Wrangham and Ross, 2008).

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Conflict of interest

The authors declare that they have no conflict of interest.

Data availability statement

The data that supports the findings of this study are available on request from WildCRU (represented by Dr. Neil D'CRUZE: neil.dcruze@zoo.ox.ac.uk). The data are not publicly available due to privacy or ethical restrictions.

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843 **TABLE 1 -** Overview of mammal species identified from February and June 2019 in Fazao-Malfakassa National Park based on a total
844 of 9,007 camera days. Indicated is the number of captures of a given species per 100 camera days (relative abundance index; RAI) and
845 the proportion of locations at which a species was recorded (naïve occupancy) in the overall study time period, as well as during the
846 dry season and the wet season only. DD: Data Deficient; LC: Least Concern, NT: Near Threatened, VU: Vulnerable (IUCN 2020).
847

Species		IUCN	Habitat	RAI			Naïve Occupancy		
				Overall	Dry 1	Wet 2	Overall	Dry 1	Wet 2
Carnivora									
Canis adustus	Side-striped Jackal	LC	WS	1,077	1,963	0,219	0,159	0,218	0,100
Caracal caracal	Caracal	LC	WS	0,056	0,113	0,000	0,023	0,046	0,000
Atilax paludinosus	Marsh Mongoose	LC	WS	0,278	0,474	0,087	0,053	0,069	0,038
Crossarchus obscurus	Common Cusimanse	LC	WS	0,067	0,135	0,000	0,011	0,023	0,000
Ichneumia albicauda	White-tailed mongoose	LC	WS	1,166	1,535	0,809	0,183	0,253	0,113
Mungos gambianus	Gambian Mongoose	LC	WS	0,222	0,384	0,066	0,058	0,092	0,025
Nandinia binotata	African Palm Civet	LC	DDF, WS	0,022	0,045	0,000	0,011	0,023	0,000
Civettictis civetta	African Civet	LC	WS	1,410	2,663	0,197	0,164	0,241	0,088
Genetta maculata	Large spotted genet	LC	WS	0,633	1,196	0,087	0,070	0,103	0,038
Genetta thierryi	Hausa Genet	LC	WS	0,011	0,023	0,000	0,006	0,011	0,000
Cetartiodactyla									
Alcelaphus buselaphus major	Hartebeest	VU	WS	0,444	0,609	0,284	0,125	0,138	0,113
Cephalophus rufilatus	Red-flanked Duiker	LC	WS	1,066	0,858	1,267	0,197	0,207	0,188
Kobus ellipsiprymnus defassa	Waterbuck	NT	DDF, WS	2,098	3,791	0,459	0,183	0,241	0,125
Kobus kob	Kob	LC	DDF, WS	4,485	6,545	2,491	0,438	0,563	0,313

Sylvicapra grimmia	Common Duiker	LC	DDF, WS	0,377	0,000	0,743	0,050	0,000	0,100
Syncerus caffer	African Buffalo	NT	DDF, WS	0,067	0,045	0,087	0,018	0,011	0,025
Tragelaphus scriptus	Bushbuck	LC	DDF, WS	6,106	4,897	7,277	0,562	0,586	0,538
Philantomba walteri	Walter's duiker	DD	WS	0,022	0,045	0,000	0,011	0,023	0,000
Phacochoerus africanus	Common Warthog	LC	WS	0,266	0,248	0,284	0,108	0,103	0,113
Potamochoerus porcus	Red River Hog	LC	DDF, WS	0,144	0,271	0,022	0,041	0,069	0,013
Lagomorpha									
Lepus victoriae	African Savanna Hare	LC	WS	0,033	0,068	0,000	0,011	0,023	0,000
Primates									
Chlorocebus tantalus	Tantalus Monkey	LC	WS	0,766	1,286	0,262	0,089	0,115	0,063
Erythrocebus patas	Patas Monkey	NT	WS	4,796	8,508	1,202	0,398	0,483	0,313
Papio anubis	Olive Baboon	LC	DDF, WS	1,432	1,828	1,049	0,186	0,172	0,200
Proboscidea									
Loxodonta africana	African Elephant	VU	DDF, WS	0,278	0,271	0,284	0,092	0,034	0,150
Loxodonta africana africana	African savanna elephant	VU	DDF, WS	0,855	1,512	0,219	0,094	0,126	0,063
Loxodonta africana cyclotis	African forest elephant	VU*	DDF, WS	1,743	2,618	0,896	0,209	0,218	0,200
Rodentia									
Atherurus africanus	African Brush-tailed Porcupine	LC	WS	2,443	2,821	2,076	0,059	0,080	0,038
Hystrix cristata	Crested Porcupine	LC	WS	3,198	2,325	4,043	0,213	0,264	0,163
Cricetomys gambianus	Gambian Rat	LC	WS	0,200	0,316	0,087	0,053	0,069	0,038
Heliosciurus rufobrachium	Red-legged Sun Squirrel	LC	WS	0,044	0,090	0,000	0,011	0,023	0,000
Thryonomys swinderianus	Greater Cane Rat	LC	WS	0,222	0,384	0,066	0,052	0,092	0,013
Tubulidentata									
Orycteropus afer	Aardvark	LC	DDF, WS	0,178	0,271	0,087	0,065	0,092	0,038
Other									

Bos taurus	Cattle	-	WS	3,220	3,882	2,579	0,340	0,368	0,313
Canis familiaris	Dog	-	WS	0,211	0,429	0,000	0,069	0,138	0,000
Homo sapiens	Human	-	DDF, WS	0,189	0,384	0,000	0,046	0,092	0,000

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851 **Online Supplemental Table S1-** A comparison between the species reported by the literature to occur within the FMNP (source of
852 recording, IUCN status, date of assessment) and the present camera trapping study (0 = Not recorded, 1= Recorded)
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Species reported by Amori et al. (2016) & Segniagbeto et al. (2017) within FMNP	**Common name**	**Source of record**	**IUCN**	**Date of assessment**	**Species recorded by the present camera trapping study**
Alcelaphus buselaphus major (Blyth, 1869)	Western Hartebeest	Direct observation by the authors	VU	26 July 2016	1
Cephalophus dorsalis Gray, 1846	Bay Duiker	Direct observation by the authors	NT	07 January 2016	0
Cephalophus rufilatus Gray, 1846	Red-flanked Duiker	Voucher specimens	LC	07 January 2016	1
Cephalophus silvicultor (Afzelius, 1815)	Yellow-backed Duiker	Voucher specimens	NT	07 January 2016	0
Hippotragus equinus (É. Geoffroy Saint-Hilaire, 1803)	Roan Antelope	Direct observation by the authors	LC	09 May 2016	0
Kobus ellipsiprymnus (Ogilbyi, 1833)	Waterbuck	Direct observation by the authors	LC	07 January 2016	1
Kobus kob (Erxleben, 1777)	Kob	Direct observation by the authors	LC	07 January 2016	1
Ourebia ourebi (Zimmermann, 1783)	Oribi	Voucher specimens	LC	07 January 2016	0
Philantomba walteri (Colyn et al. 2010)	Walter's Duiker	Direct observation by the authors	DD	07 January 2016	1
Redunca redunca (Pallas, 1767)	Bohor Reedbuck	Voucher specimens	LC	07 January 2016	0
Sylvicapra grimmia campbelliae (Gray, 1843)	Common Duiker	Direct observation by the authors	LC	07 January 2016	1
Syncerus caffer (Sparrman, 1779)	African Buffalo	Direct observation by the authors	NT	24 February 2018	1
Taurotragus derbianus (Gray, 1847)	Derby's Eland	Literature	VU	25 July 2016	0

Tragelaphus derbianus (Gray, 1847)					
Tragelaphus eurycerus (Ogilbyi, 1837)	Bongo	Voucher specimen	NT	07 July 2016	0
Tragelaphus scriptus (Pallas, 1766)	Bushbuck	Direct observation by the authors	LC	14 June 2016	1
Tragelaphus spekii Speke, 1863	Sitatunga	Direct observation by the authors	LC	14 June 2016	0
Phacochoerus africanus (Gmelin, 1788)	Common Warthog	Direct observation by the authors	LC	17 February 2016	1
Potamochoerus porcus (Linnaeus, 1758)	Red River Hog	Direct observation by the authors	LC	08 February 2016	1
Canis adustus Sundevall, 1847	Side-striped Jackal	Direct observation by the authors	LC	14 March 2014	1
Caracal aurata (Temminck, 1827)	African Golden Cat	Voucher specimens	VU	20 April 2014	0
Caracal caracal (Schreber, 1776)	Caracal	Voucher specimen	LC	09 May 2014	1
Felis silvestris Schreber, 1777	Wild Cat	Voucher specimens	LC	01 January 2008	0
Leptailurus serval (Schreber, 1776)	Serval	Voucher specimens	LC	20 April 2014	0
Panthera leo (Linnaeus, 1758)	Lion	Literature	VU	20 June 2014	0
Panthera pardus (Linnaeus, 1758)	Leopard	Direct observation by the authors	VU	11 July 2015	0
Atilax paludinosus (G.[Baron] Cuvier, 1829)	Marsh Mongoose	Voucher specimens	LC	28 February 2015	1
Herpestes ichneumon (Linnaeus, 1758)	Egyptian Mongoose	Voucher specimens	LC	27 February 2016	0
Ichneumia albicauda (G. Cuvier, 1829)	White-tailed Mongoose	Voucher specimens	LC	28 February 2015	1
Mungos gambianus (Ogilby, 1835)	Gambian Mongoose	Voucher specimens	LC	28 February 2015	1
Mungos mungo (Gmelin, 1788)	Banded Mongoose	Voucher specimens	LC	28 February 2015	0
Crocuta crocuta (Erxleben, 1777)	Spotted Hyaena	Voucher specimens	LC	01 October 2014	0
Civettictis civetta (Schreber, 1776)	African Civet	Voucher specimens	LC	12 May 2015	1
Genetta maculata (Gray, 1830)	Large-spotted Genet	Voucher specimens	LC	29 December 2015	1
Procavia capensis kerstingi (Matschie, 1899)	Rock Hyrax	Voucher specimens	LC	20 January 2014	0
Cercopithecus mona (Schreber, 1775)	Mona Monkey	Direct observation by the authors	NT	20 June 2019	0

Cercopithecus petaurista petaurista (Schreber, 1774)	Eastern Lesser Spot-nosed Monkey	Direct observation by the authors	NT	24 October 2016	0
Chlorocebus tantalus (Ogilby, 1841)	Tantalus Monkey	Direct observation by the authors	LC	14 October 2019	1
Colobus vellerosus (I. Geoffroy Saint-Hilaire, 1834)	White-thighed Colobus	Direct observation by the authors	CR	27 February 2020	0
Erythrocebus patas (Schreber, 1774)	Patas Monkey	Direct observation by the authors	NT	25 January 2020	1
Papio anubis (Lesson, 1827)	Olive Baboon	Direct observation by the authors	LC	28 January 2020	1
Galago senegalensis É. Geoffroy Saint-Hilaire, 1796	Senegal Lesser Galago	Direct observation by the authors	LC	27 July 2017	0
Galagoides demidoff (G. Fischer, 1806)	Demidoff's Dwarf Galago	Voucher specimen	LC	24 October 2016	0
Galagoides thomasi (Elliot, 1907)	Thomas's Dwarf Galago	Literature	LC	04 August 2016	0
Loxodonta africana (Blumenbach, 1797)	African Savanna Elephant	Direct observation by the authors	VU	30 June 2008	1
Loxodonta cyclotis (Matschie, 1900)	African Forest Elephant	Direct observation by the authors	VU	30 June 2008	1
Atherurus africanus Gray, 1842	African Brush-tailed Porcupine	Direct observation by the authors	LC	09 September 2016	1
Hystrix cristata Linnaeus, 1758	Crested Porcupine	Voucher specimens	LC	19 February 2016	1
Xerus erythropus Desmarest, 1817	Striped Ground Squirrel	Voucher specimens	LC	18 August 2016	0
Cricetomys gambianus Waterhouse, 1840	Gambian Rat	Voucher specimens	LC	03 August 2018	1
Orycteropus afer (Pallas, 1766)	Aardvark	Voucher specimens	LC	21 January 2014	1
Protoxerus stangeri (Waterhouse, 1842)	African Giant Squirrel,	Voucher specimens	LC	18 August 2016	0
Thryonomys swinderianus (Temminck, 1827)	Greater Cane Rat	Direct observation by the authors	LC	07 September 2016	1

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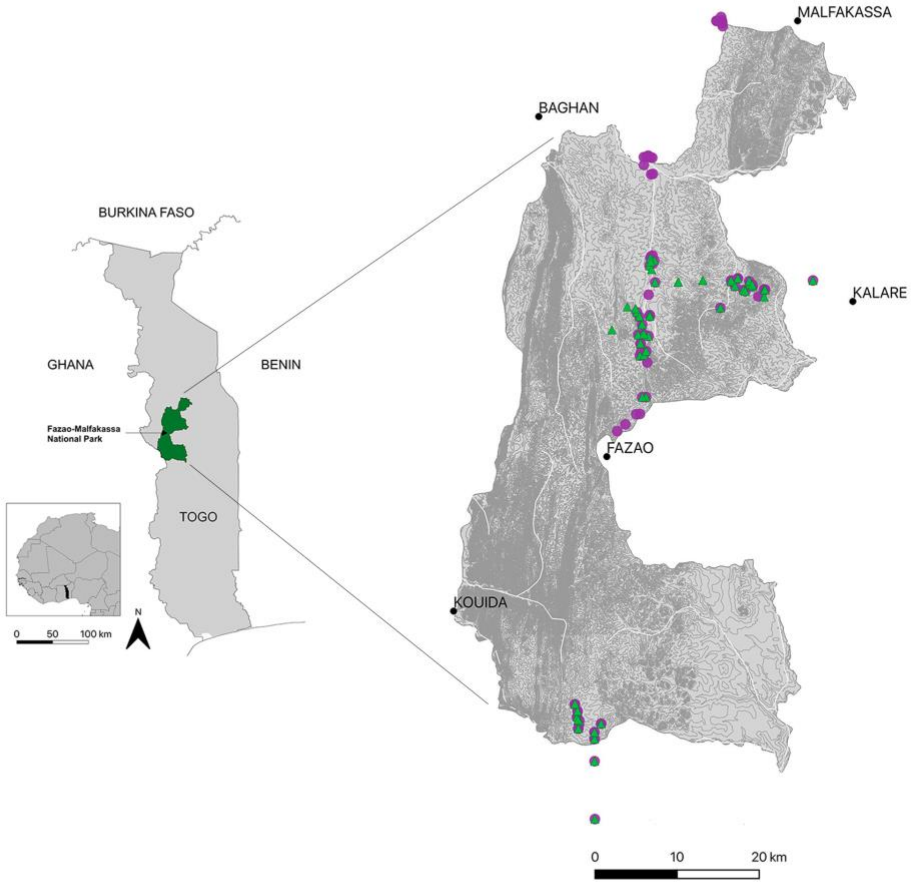

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856 **FIGURE 1 –** Map of the Fazao-Malfakassa National Park showing locations of
857 the 100 camera traps during the dry and wet seasons. Purple dots indicate
858 camera trap locations during the dry season and green triangles represent
859 camera trap locations during the wet season. GIS data were obtained from
860 DIVA-GIS website (https://www.diva-gis.org/gdata).

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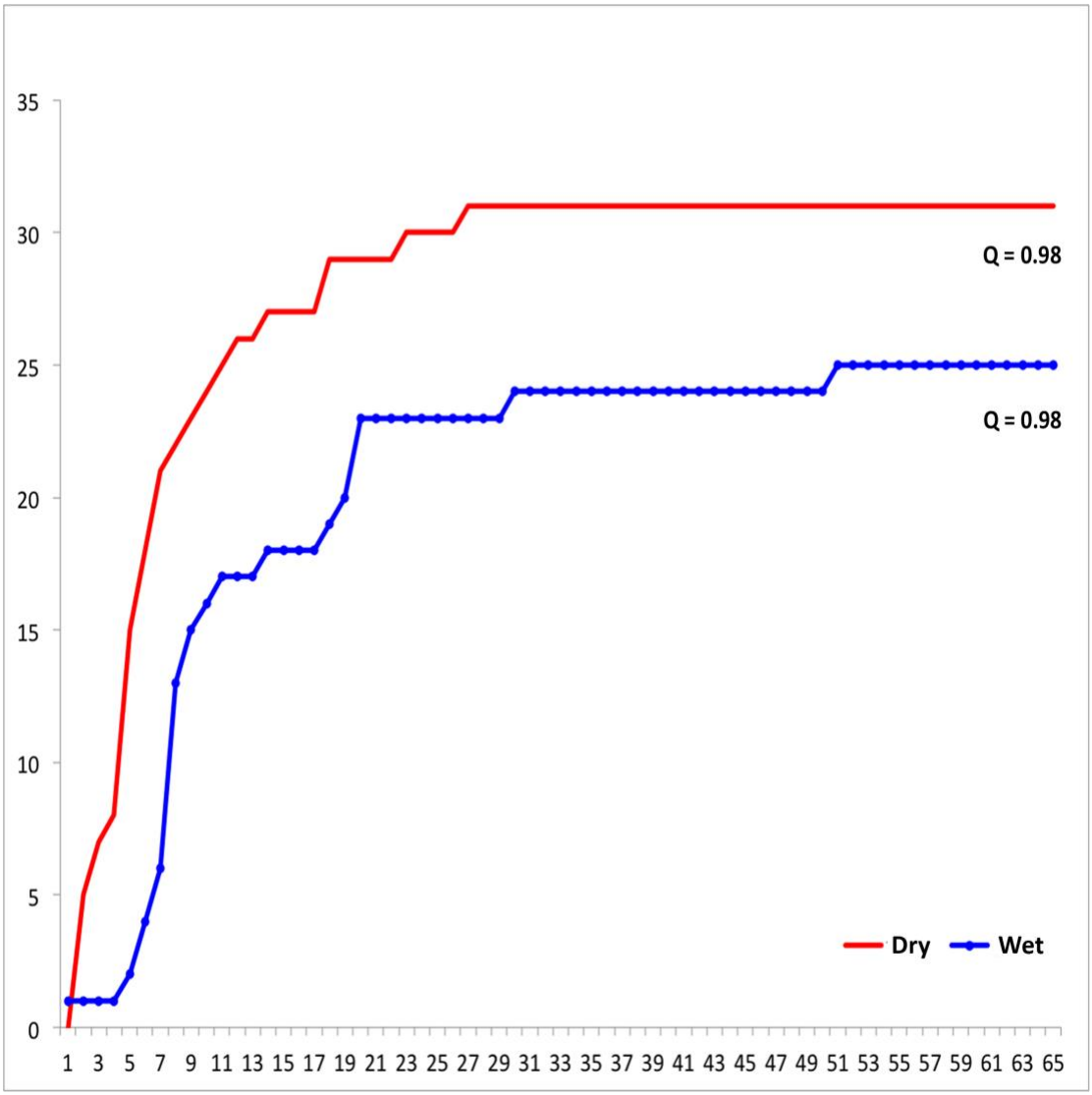

FIGURE 2 - Cumulative sum of the number of identified species over the number of camera days, as well as sampling coverage Q based on N = 2,174 camera events across the dry season and N = 1,129 for camera events across the wet season.

FIGURE 3 – Camera trap images of some species identified in the Fazao-Malfakassa National Park. First row (left to right): Walter's duiker (*Philantomba walteri*), bushbuck (*Tragelaphus scriptus*), waterbuck (*Kobus ellipsiprymnus defassa*), kob (*Kobus kob*); second row: African savanna elephant (*Loxodonta a. africana*), African forest elephant (*Loxodonta a. cyclotis*), side-striped jackal (*Canis adjustus*), aardvark (*Orycteropus afer*); third row: red-legged sun squirrel (*Heliosciurus rufobrachium*), large-spotted genetta (*Genetta maculata*), caracal (*Caracal caracal*), olive baboon (*Papio anubis*); fourth row: red river hog (*Potamochoerus porcus*), warthog (*Phacochoerus aethiopicus*), African buffalo

(*Syncerus caffer*), crested porcupine (*Hystric cristata*); last row: poacher, white-tailed mongoose (*Ichneumia albicauda*), greater cane rat (*Thryonomys swinderianus*), common Cusimanse (*Crossarchus obscurus*).

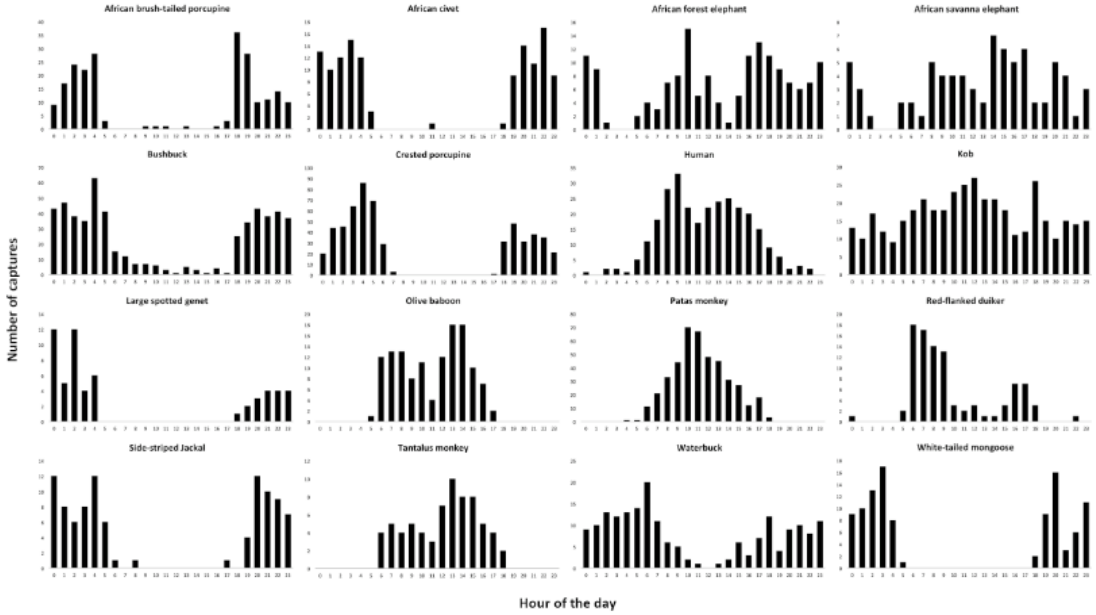

FIGURE 4 - Number of camera events per time of day for species with more than 50 camera trap events (across both dry and wet seasons).