INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 21, No. 3, p. 52-62, 2022

RESEARCH PAPER OPEN ACCESS

Diversity, abundance, occurrence, and conservation status of mammals on the islands of Azagny National southern Côte d'Ivoire

Djaha André Koffi[1,2*], Kouamé Bertin Akpatou[2,3], Salifou Koné[3], Dédé Azani[4], Yao Célestin Kouakou[1,2]

[1]*Université Jean Lorougnon Guédé, Laboratoire de Biologie et Ecologie Tropicale. B.P 150 Daloa, Côte d'Ivoire*

[2]*Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Groupe de Recherches Conservation et Valorisation des Ressources Naturelles, 01 BP 1303 Abidjan 01, Côte d'Ivoire*

[3]*Université Félix Houphouët Boigny, Laboratoire des Milieux naturels et Conservation de la Biodiversité, 22 B.P 582 Abidjan 22, Côte d'Ivoire*

[4]*Office Ivoirien des Parcs et Réserves de Côte d'Ivoire, Direction de Zone Sud, Secteur Azagny, 06 BP 426 Abidjan 06, Côte d'Ivoire*

Key words: Islands, Mammals, Azagny National Park, Conservation status.

http://dx.doi.org/10.12692/ijb/21.3.52-62 Article published on September 06, 2022

Abstract

This study was carried out on two islands of the Azagny National Park (ANP) located about halfway along the coast in the south of Côte d'Ivoire. The survey lasted from August to October 2021. It aims to contribute to the conservation of the parc by providing the manager with primary scientific data on mammal communities of the islands. The objective of this study is to determine the specific richness, relative abundance, occurrence, and conservation status of the Mammals of the two islands using the camera trapping method. Thus 18 species belonging to six Orders, 10 families and 17 genera, were detected. Mammals are present on both islands. However, the largest island exhibits greater diversity (15 species) than the smallest (09 species). Furthermore, six species have been observed on both islands. Five of the surveyed species are of conservation interest according to the International Union for Conservation of Nature (IUCN) red list, including the west African chimpanzee (*Pan troglodytes' verus*) a critically endangered species and the white-naped mangabey (*Cercocebus lunulatus*), an endangered species. This pioneering exploration reveals a high conservation value of ANP including its islands.

* **Corresponding Author:** Djaha André Koffi ✉ andre.koffi@csrs.ci

Introduction

Africa has the most abundant wildlife of any continent (Bigalke, 1964). Currently, African wildlife is a declining resource. Several once abundant species have disappeared or are critically endangered (Koffi *et al.*, 2015; Kouakou *et al.,* 2020; Kouakou *et al.,* 2021). Hunting and agriculture are the main causes of extinction or rarefaction of these species (Koffi *et al.*, 2015).

Côte d'Ivoire, like other tropical countries, is not exempt from this reality of the century. Indeed, for several decades, Ivorian protected areas have suffered continuous degradation (Lauginie, 2007 ; Bitty *et al.,* 2013 ; Kadjo *et al.,* 2014). Opposite, the Ivorian authorities display a political will to relaunch conservation.

However, a better knowledge of the diversity, abundance, and conservation value of the biological component of a protected area are necessary for its sustainable management (Adou Yao, 2005; Kouamé *et al.*, 2014; Evans *et al.*, 2018). Undeniably, wildlife is an essential component of natural habitats in the tropics. It plays an important role in maintaining the dynamics of ecosystems and especially in assessing their state of conservation. Indeed, wildlife in general and particularly mammals are better indicators of the level of anthropogenic disturbances on natural ecosystems in the tropics. Thus, in protected areas, mammalian fauna represents an essential component because of its ecological role (Blake *et al.,* 2009; Akpatou *et al.*, 2018). It is therefore understandable that many protected area management programs make special emphasis on the need to know the diversity and abundance of mammals (Triplet, 2009; Masumbuko and Somda, 2014).

The Azagny National Park, created in 1981, has benefited from some scientific investigations, most of which are focused on the flora (Konan, 2008; Kouamé *et al.*, 2008; Gnagbo *et al.*, 2016; Adiko *et al.,* 2020). On the other hand, the park has been the subject of very few investigations in terms of its fauna (Marchesi *et al.,* 1995, Lauginie, 2007). Thus, the mammalian fauna of the islands has not yet been documented. This study is the first to focus on the mammal communities that inhabit these two exceptional environments. Indeed, these two islands are relatively less disturbed due to their isolation from the large part of the park and the physical barrier formed by the body of water and the belt of swamps that surrounds them.

The present work aims to contribute to the conservation of the islands of the Azagny National Park through a better knowledge of the diversity, abundance, occurrence, and conservation status of the mammal communities they shelter.

Materials and methods

Study area

Azagny National Park is located in the Ivorian coastal sector. It is between the North latitudes 5°09' and 5°16" and the West longitudes 4°48' and 4°58". The park straddles the departments of Grand-Lahou and Jacqueville, the largest cities in the region. The ANP is limited to the North by village farms, to the South by the artificial channel of Azagny dug in 1920 to facilitate the exploitation of manganese in the Tadio lagoon, to the East by the Ebrié lagoon and to the West by the Bandama river (Lauginie, 2007). Classified as a National Park in 1981, it now covers an area of 21,850 hectares. This park is the only coastal forest site to benefit from a protection status over its entire area (Lauginie, 2007). Azagny National Park has been identified as a Ramsar site since 1996. Both islands are located in the center of the park and separated from the mainland by swamps (Fig. 1).

Data collection

The survey was conducted continuously from August to October 2021. Camera traps were placed on the two islands for data collection. Neighbor cameras were set up systematically with equidistant 500 meters on the large island and 250 meters on the small island. Thus, the camera trapping device covered both environments. From a survey within a radius of 100 meters around the systematized trapping points, the camera traps were installed considering the frequent

presence of animal signs (footprints, food remains, droppings) but also the presence of streams and fruit trees (Kouakou *et al.,* 2021). Camera traps were placed firmly against tree trunks at a height of about 60 cm from the ground to optimize the chances of capturing large and small mammals. The geographical coordinates of the trees on which the cameras were fixed were recorded using a Global Positioning System (GPS). Fourteen camera traps were installed in three trapping sessions, including two on the large island and one on the small island. The first session on the large island and the unique session on the small island lasted 12 days each. The second session on the large island lasted 20 days. The camera traps were set to video mode, allowing one-minute video footage to be recorded.

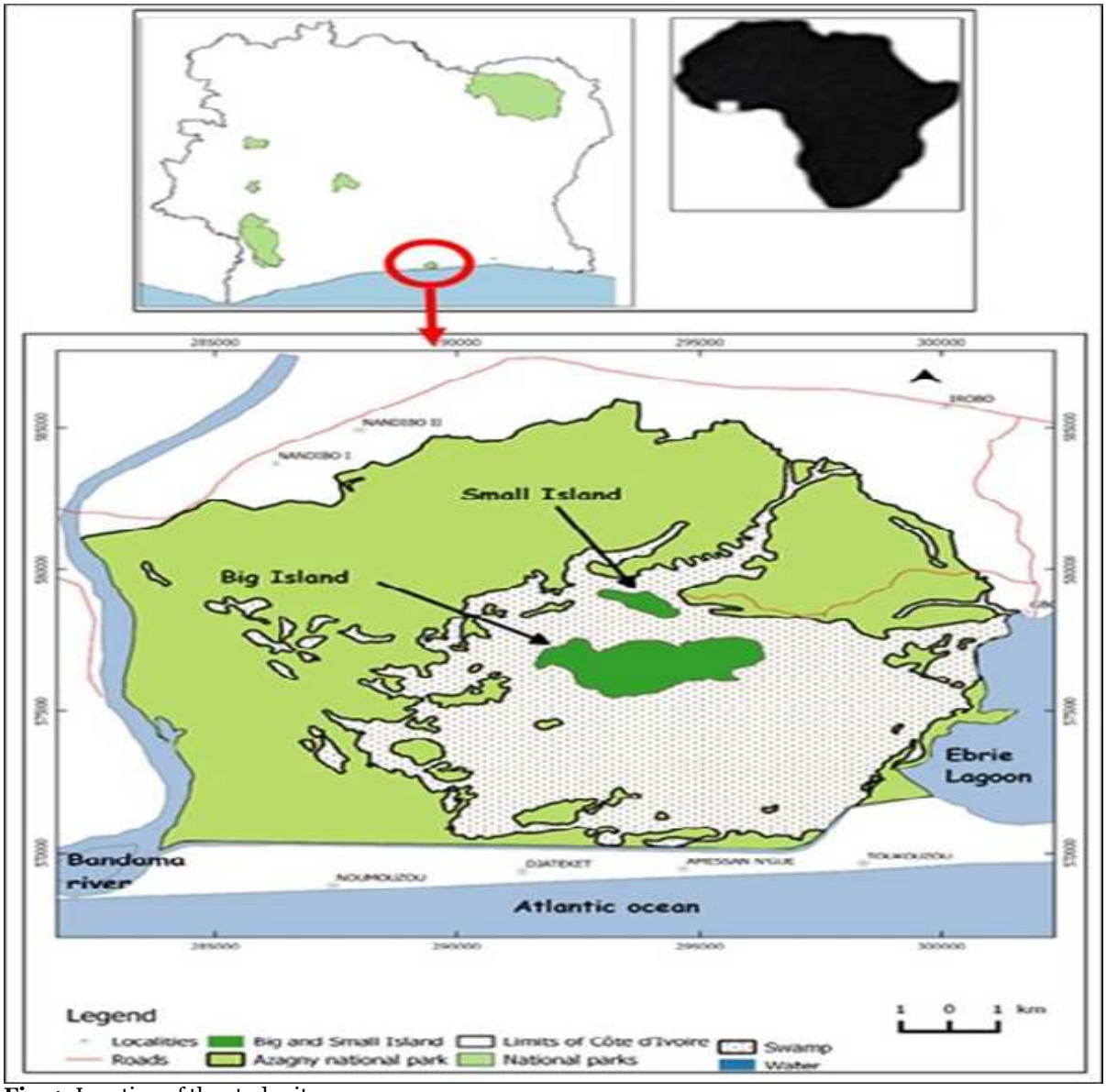

Fig. 1. Location of the study site.

The time interval between two consecutive videos has been set to one second to give more chance of capturing images of animals. To ensure continuous operation of the camera traps for the duration of trapping, AA-size alkaline batteries were used and replaced as needed between installation sessions. Data from SD cards were downloaded to an external hard drive after each trapping session prior to installation for the next session. In total, 42 trapping points representing 14 cameras x 3 installation sessions covering all the two islands were investigated (Fig. 2).

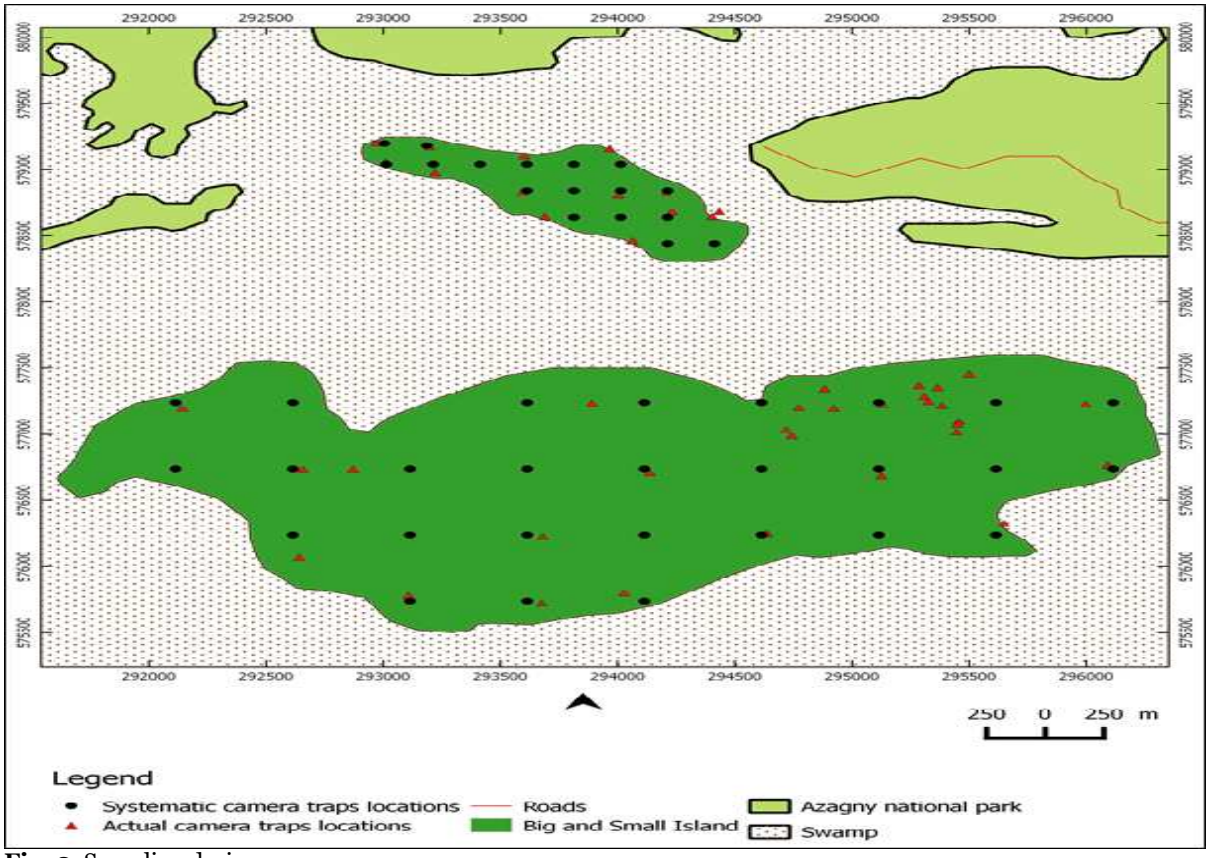

Fig. 2. Sampling design.

The African Mammals Identification Guide (Kingdom, 2015) was used to categorize mammal species.

Data analysis

Diversity

Specific richness (S) is defined as the total number of species recorded in a given environment (Magurran, 2004). The evaluation of the diversity of the mammalian fauna was made through the calculation of the Shannon-Wiener index (H') with "Past 3"software. It makes it possible to compare the richness in mammalian biodiversity of the two islands. Through Past 3 software, the T-test was used to compare the level of biodiversity richness of the two islands. The Piélou equitability index was calculated using the formula below.

It makes it possible to measure the distribution of individuals within species, independently of specific richness (Tuomisto, 2010). Its value varies from 0 (dominance of one of the species) to 1 (uniform distribution of individuals within the species).

$$E = \frac{H'}{H'max}$$

$H'_{max} = \log (N) = -\Sigma\, pi \times \log (pi)$

H' is the Shannon index.

N, the total number of individuals of all species in the sample.

pi, the proportional abundance.

$$pi = \frac{ni}{N}$$

With n*i* the number of individuals of species *i* in the sample.

N the total number of individuals of all species in the sample.

Similarity

The β Sorensen similarity index meanwhile was calculated and was used to measure the similarity in species between both islands according to the formula:

$$\beta = \frac{2c}{S1 + S2}$$

C is the number of species common to both islands
S1 the total number of species recorded on the small island
S2 the total number of species recorded on large island.

The β Sorensen index varies from zero when there is no common species to the two sites, to one when all the species found on the small island also exist on the large island.

Relative Abundance

Relative abundance was calculated using the following formula:

$$RAI = \frac{\text{Number of independent events}}{\text{Number of trap days}} X100$$

With RAI = Relative Abundance Index

An independent event is all the videos taken at the same trapping point during a period of less than or equal to 30 minutes (Hausser *et al.*, 2016; Zurkinden, 2017).

Trap-day (trapping effort) is the total number of 24-hour days that a camera remains active at a site.

Naïve occupancy

It is the number of cameras having detected a given species out of the total number of cameras. It gives an indication of the extent of occupancy of a species in the reference area.

$$\text{Naïve Occupancy} = \frac{nCTi}{NCT}$$

nCTi is the number of cameras that detected species i
NCT is the total number of cameras.

Results

Diversity and abundance of mammals

In total, a trapping effort of 616 trap-nights, including 168 on the small island and 448 on the large one, was carried out. This made it possible to detect 18 species of mammals, including 15 on the large island and nine on the small island.

The Sorensen similarity index (β = 0.50) shows that these two sites are not similar but nevertheless have several species (06) of mammals in common.

However, the difference in biodiversity richness between these two islands is very highly significant [t = -2.7515; dof = 164.74; p(same) = 0.0065]. The large island has the highest biodiversity index (H' = 2.093) versus (H' = 1.739) for the small island. Furthermore, the number of individuals is not evenly distributed within the animal species. Piélou's equitability indices on the small island (E = 0.79) and on the large island (E = 0.77) reveal that certain species are dominant.

Table 1. Relative abundance of mammal species from both islands.

Famille	Espèce	Event		Relative Abondance Index (RAI) %	
		Small island	Large island	Small island	Large island
Bovidae	*Syncerus caffer*	0	8	0	1,79
	Philantomba maxwellii	4	13	2,38	7,74
	Tragelaphus scriptus	2	21	1,19	12,5
Cercopithecidae	*Cercocebus lunulatus*	0	3	0	0,67
	Cercopithecus petaurista	0	1	0	0,22
	Cercopithecis lowei	0	1	0	0,22
Herpestidae	*Crossarchus obscurus*	0	11	0	2,46
	Atilax paludinosus	10	2	5,95	0,45
Hominidae	*Pan troglodytes verus*	0	3	0	0,67
Hystricidae	*Atherurus africanus*	27	0	16,07	0
Nesomyidae	*Cricetomys emini*	21	10	12,5	2,23
Pteropodidae	*Hypsignathus monstrosus*	0	77	0	17,19
Sciuridae	*Heliosciurus rufobrachium*	0	14	0	3,13
	Funisciurus lemniscatus	3	0	1,79	0
	Protoxerus stangeri	2	0	1,19	0
Suidae	*Potamochoerus porcus*	5	18	2,98	4,02
Viveridae	*Civettitis civetta*	0	9	0	2,01
	Genetta genetta	2	4	1,19	0,89

Thus, on the small island, *Atherurus africanus, Cricetomys emini*, two rodents and *Atilax paludinosus* a carnivore are dominant while *Hypsignathus monstrosus* a Megabat, *Tragelaphus scriptus* and *Philantomba maxwellii* two Artiodactyla dominate mammal's communities of the largest island. As a result, these six mammals show the highest relative abundances on the two respective islands (Table 1). This study did not reveal any primates on the small island. On the other hand, there is a higher abundance of rodents.

Occurrence and conservation status of mammals

Animal occurrence is low on both islands. No species has an occurrence reaching 0.50 (Fig. 3).

In other words, less than half of the camera traps detected animal species on each island.

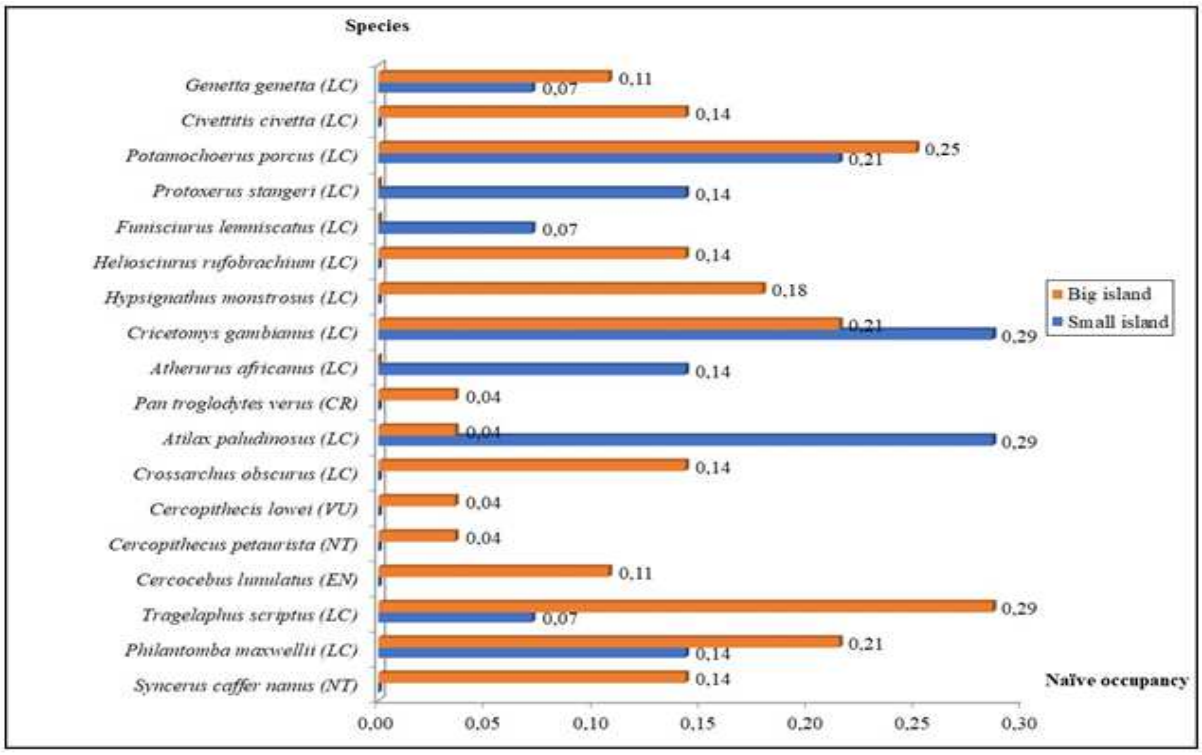

Fig. 3. Mammal species occurrence on both islands.
(CR) = Critical Endangered, (EN) = Endangered, (LC) = Least Concern, (NT) = Near Threatened, (VU) = Vulnerable].

The animals would therefore not be distributed over the entire extent of the islands but would rather be confined to certain areas of the site. However, *Atilax paludinosus* (Ψ = 0.29), *Cricetomys emini* (Ψ = 0.29) and *Potamochoerus porcus* (Ψ = 0.21) have a greater land occupation on the small island and *Tragelaphus scriptus* (Ψ = 0, 29), *Potamochoerus porcus* (Ψ= 0.25), *Philantomba maxwellii* (Ψ = 0.21) and *Cricetomys emini* (Ψ = 0.21) on the large Island.

Special status species (critically endangered, endangered, vulnerable and near threatened) on the IUCN Red List are only found on the large Island where they have very low land use. These are *Pan troglodytes verus* (CR), *Cercocebus lunulatus* (EN), *Cercopithecis lowei* (VU), *Cercopithecus petaurista* (NT) and *Syncerus caffer nanus* (NT). An illustration of these species can be found in Fig. 4 except for *Cercopithecus lowei* whose image from a distant view is not of good quality. In contrast, all species listed on the small island are of Least Concern (LC) according to the IUCN Red List.

Discussion

This study reveals a quite high species richness and the relative abundance of the mammalian fauna of the

islands of the Azagny National Park. Indeed, with a trapping effort estimated at 616 trap-days for the two islands, a total of 18 mammal species were detected. This specific richness is close to that of the Tanoé-Ehy marsh forest, a similar environment where 22 species of mammals have been inventoried (Koffi *et al.*, 2019). All the species surveyed on the two islands have already been observed in the other habitats of the park (Vergnes and Mao, 2012). No alien species were reported in this study. This is not the case for the real islands where exotic species are often mentioned (Walsh *et al.*, 2012). The two sites of this study are really islets of forest surrounded by permanently flooded swamps, but which can be crossed by animals and with difficulty by humans.

This situation would explain the low intensity of illegal anthropogenic activities. Both sites are therefore refuges for mammals. Although being good swimmers for most of the mammals that live on the two islands, they do not seem to want to leave these places to colonize the other habitats of the park. Indeed, signs of the presence of buffaloes, chimpanzees and monkeys have rarely been observed in the neighboring forests where anthropogenic pressures are greater (Vergnes and Mao, 2012).

Fig. 4. Endangered species detected on the big island.

The two islands in the park have six of the 18 species of mammals detected in common. However, the large island has the highest diversity index (H' = 2.093). Separated by more than 800 meters from the small island, the large island is further away from human activities and enjoys greater stability for animals. Indeed, several authors agree on the assertion that the anthropization of an environment is the main cause of the disturbance and disappearance of its wildlife (Ngandjui and Blanc, 2001; Tim *et al.*, 2021).

In addition, the large island with an area of 613 ha is nine times larger than the small island (68 ha). It is generally accepted that the larger the surface area of an ecosystem, the greater the availability of ecological niches and consequently a great specific richness and a significant relative abundance of its faunal component (Currie, 1991; Tews *et al.*, 2004; Stein *et al.*, 2014). Of the 18 species of mammals encountered, five have special conservation status. These are *Pan troglodytes verus* Critically Endangered (CR), *Cercocebus lunulatus* Endangered (EN), *Cercopithecus lowei* Vulnerable (VU), *Cercopithecus petaurista* and *Syncerus caffer nanus* Near Threatened (NT). These species with special conservation status have only been encountered on the Big Island. Like most mammals, they are cryptic species and very sensitive to human activities (Johns, 1985; Zuberbühler, 2000b). Their presence on the large island testifies to the relative security and certain tranquility offered by this island which, moreover, can be considered as an ecosystem with high biodiversity conservation value (Brown *et al.*, 2013).

However, mammals have a low occurrence on both islands. The naïve occupancy indices are very low (<0.29). The accuracy of this ecological parameter depends on several factors including the density of animal populations, the movement of individuals, the probability of detection but also the number of camera traps and their operating time (Guillera *et al.*, 2012; Bailey *et al.*, 2014; Neilson *et al.*, 2018). Only 14 camera traps were installed with a spacing of 250 m for 12 days on the small island and 500 m for 32 days on the large one. This low trapping effort led to low occupancy rates in the study area, also called naïve occupancy. Swamp mongoose (*Atilax paludinosus*) and Emin's giant rat (*Cricetomys emini*) exhibit the highest naïve occupancy (Ψ = 0.29) on the small island. This island is made up of a mosaic of swamps and waterways which are the preferred habitats of the swamp mongoose. Emin's Giant Rat prefers dry land habitats. The large island has more swampy areas and a greater diversity of habitats, which would justify the presence of the bushbuck (*Tragelaphus scriptus*), a ubiquitous species with the greatest naïve occupation (Ψ = 0.29) followed by the bushpig (*Potamochoerus porcus*, Ψ= 0.25) which loves muddy areas.

Species with special conservation status all have a very low occurrence on the large island where they have only been detected. On this island, these mammals seem to have chosen specific sites to settle in order to get further away from humans. This is for example the case of chimpanzees (*Pan troglodytes verus*) which are confined to a portion of dense forest in the middle of the island and lunula monkeys (*Cercocebus lunulatus*) which occupy swampy parts of the forest that are difficult to access.

Conclusion

The islands of the PNA located in a mainly marshy area have been the subject of very little research on their faunal component. The biodiversity of the big island, which is more difficult to access, has never been investigated.

This survey was able to inventory 18 species of mammals using camera traps on these two islands. Five of them have special conservation status. Among them, *Pan troglodytes verus* is in critical danger of extinction and *Cercocebus lunulatus* is an Endangered species. Although the mammals encountered on the two islands have a low occurrence, the large island has a higher species richness and relative abundance than the small island. Threatened species were only detected on the large island. This island can therefore be considered a site of high value for biodiversity conservation in the Azagny National Park.

Acknowledgements

The authors of this article would like to convey their deep gratitude and recognition to the Heads of Institutions and Structures that have made it possible to carry out this study. The « Office Ivoirien des Parcs et Réserves (OIPR) » funded research work on the Azagny National Park. The « Centre Suisse de Recherches Scientifiques en Côte d'Ivoire » provided camera traps for data collection. Thanks, are also due to the anonymous referees who contributed to improving this manuscript.

References

Adiko AEG, Houphlet SDK., Dogbo SF, Vroh Bi TA, Kouame D, Gone Bi ZB, Gnagbo A, Bene JCK, Adou-Yao CY. 2020. Variabilité des traits fonctionnels des espèces arborescentes dans la reconstitution de la végétation du Parc National d'Azagny (Côte d'Ivoire). International Journal of Biological and Chemical Sciences **14(2),** 424-439. http://dx.doi.org/10.4314/ijbcs.v14i2.10

Adou-Yao CY. 2005. Pratiques paysannes et dynamiques de la biodiversité dans la forêt classée de Monogaga (Côte d'Ivoire). Thèse Doctorat unique, Département Hommes Natures et Société, Université MNHN, Paris, France, p 233.

Akpatou KB, Yao KA, Bohoussou KH. 2018. Diversité et Abondance Relative des Mammifères des Forêts Classées de Mabi et de Yaya au Sud-Est de la Côte d'Ivoire : Un État des Lieux. European Journal of Scientific Research **150(2),** 213-228.

Bailey LL, MacKenzie DI, Nichols JD. 2014. Advances and applications of occupancy models, Methods in Ecology and Evolution **5(12),** 1269–1279.

https://doi.org/10.1111/2041-210X.12100

Bigalke RC. 1964. The Odendaal Report and wildlife in South West Africa. African Wildlife **18(3),** 181–188.

Bitty EA, Kadjo B, Gonedelé Bi S, Okon OM, Kouassi KP. 2013. Inventaire de la faune mammalogique d'une forêt urbaine, le Parc National du Banco, Côte d'Ivoire. International Journal of Biological and Chemical Sciences **7(4),** 1678-1687. http://dx.doi.org/10.4314/ijbcs.v7i4.23

Blake S, Deem SL, Mossimbo E, Maisels F, Walsh P. 2009. Forest elephants: tree planters of the Congo. Biotropica **41,** 459-468. http://dx.doi.org/10.1111/j.1744-7429.2009.00512.x

Brown E, Dudley N, Lindhe A, Muhtaman DR, Stewart C, Synnott T. 2013 (Octobre). Directives communes pour l'identification des Hautes Valeurs de Conservation. HCV Resource Network, 65.

Currie DJ. 1991. Energy and large-scale patterns of animals and plant species richness. The American Naturalist **137**, 27-49.

Evans K, Guariguata MR, Brancalion PHS. 2018. Participatory monitoring to connect local and global priorities for forest restoration. Conservation Biology **32(3),** 525-534.

Gnagbo A, Kouame D, Adou-Yao CY. 2016. Diversité des épiphytes vasculaires de la strate inférieure des formations végétales du Parc National d'Azagny (Sud de la Côte d'Ivoire). Journal of Animal and Plant Sciences **28(1),** 4366-4386.

Guillera-Arroita G, Lahoz-Monfort JJ. 2012. Designing studies to detect differences in species occupancy: power analysis under imperfect detection. Methods in Ecology and Evolution **3(5),** 860-869. https://doi.org/10.1111/j.2041-210X.2012.00225.x

Hausser Y, Tagand R, Vimercati E, Mermod S, Fischer C. 2016 Comparing survey methods to assess the conservation value of a community-managed protected area in western Tanzania. African Journal of Ecology **55,** 1-11. https://doi.org/10.1111/aje.12301

IUCN, 2022. IUCN Red List of Threatened Species: Version 2022-1. Available from: https://www.iucnredlist.org/species/4206/92247733

Johns AD. 1985. Differential detectability of primates between primary and selectively logged habitats and implications for population surveys. American Journal of Primatology **8,** 31-36. http://dx.doi.org/10.1002/ajp.1350.080104

Kadjo B, Azani D, Tsague L, Gomse A. 2014**.** Etat des lieux des populations d'Hippopotames et autres grands mammifères du Parc National de la Marahoué (Côte d'Ivoire). Agronomie Africaine **26 (2),** 89-101.

Kingdon J. 2015**.** The Kingdon field guide to African mammals, UK: Bloomsbury Publishing. London, p 640.

Konan KE. 2008. Conservation de la diversité végétale et activités humaines dans les aires protégées du sud forestier ivoirien : l'exemple du Parc National d'Azagny. Thèse Unique Université d'Abidjan-Cocody, p 269.

Koffi BJC, Dao D, Nguessan E. 2015**.** Gestion durable de la faune et des ressources cynégétiques en Côte d'Ivoire, Rapport pour les Etats généraux de la forêt, de la faune et des ressources en eau, Ernst & Young Advisory p 67.

Koffi DA, Kassi NJJD, Bene JC, N'guessan KA, Kouakou YC. 2019. Diversity and abundance of terrestrial mammals in the northern periphery of Tanoe-Ehy forest in rainy season (South-eastern of Côte d'Ivoire), Journal of Biodiversity and Environmental Sciences **15(5),** 61-68.

Kouakou JL, Gonedelé Bi S, Bitty EA, Kouakou CY, Yao AK, Kassé KB, Ouattara S. 2020**.** Ivory Coast without ivory: Massive extinction of African forest elephants in Côte d'Ivoire. PLoS ONE **15(10),** e0232993. https://doi.org/10.1371/journal.pone.0232993

Kouakou CY, N'gorand CJ, Koffi AD, Kely RM, N'guessan AK, Diarrassouba A, Tondossama A, Béné JCK. 2021**.** Diversity and distribution of large and medium-sized mammals of PK28 and Apollinaire quasi-island of the north of Taï National Park, Côte d'Ivoire, International Journal of Innovation and Applied Studies **33(3),** 541-550.

Kouamé D, Adou-Yao CY, Kouassi KE, N'guessan KE, Akoi K. 2008. Preliminary floristic inventory and diversity in Azagny National Park (Côte d'Ivoire). European Journal of Scientific Research **23**, 537-547.

Kouamé NG, Konan JCBYN, Adepo-Gourène AB, Gourène G, Rödel MO. 2014**.**The amphibians of the Yakassé-Mé village forest, a threatened rainforest of southeastern Ivory Coast. Herpetology Notes **7,** 657-665.

Lauginie F. 2007**.** Conservation de la nature et aires protégées en Côte d'Ivoire, Edition CEDA/NEI | Abidjan, Côte d'Ivoire, p 668.

Magurran E. 2004**.** Measuring Biological diversity. Oxford, UK: Blackwell publishing, p 256.

Marchesi P, Marchesi N, Fruth B, Boesch C. 1995**.** Census and distribution of chimpanzees in Cote d'Ivoire. Primates **36,** 591-607. https://doi.org/10.1007/BF02382880

Masumbuko B, Somda J. 2014**.**Analyse des liens existant entre le changement climatique, les aires protégées, et les communautés en Afrique de l'Ouest. UNEP-WCMC technical report, p 35.

Neilson EW, Avgar T, Burton AC, Broadley K, Boutin S. 2018**.** Animal movement affects interpretation of occupancy models from camera-trap surveys of unmarked animals. Ecosphere **9(1),** 1-15. http://onlinelibrary.wiley.com http://dx.doi.org/10.1002/ecs2.2092/full

Ngandjui G, Blanc CP. 2001. Activités humaines et mammifères dans la réserve du Dja, Sud-Cameroun. Bois & Forêts des Tropiques **269(269),** 19-29. https://doi.org/10.19182/bft2001.269.a20087

Rovero F, Zimmermann F. 2016.Camera Trapping for Wildlife Research. Exeter: Pelagic Publiching, UK, p 232. https://doi.org/10.1002/jwmg.21293

Stein A, Gerstner K, Kreft H. 2014. Environmental heterogeneity as a universal driver of species richness across taxa, biomes and spatial scales. Ecology Letters **17,** 866-880. http://dx.doi.org/10.1111/ele.12277

Tews J, Brose U, Grimm V, Tielborger K, Wichmann MC, Schwager M. 2004. Animal species diversity driven by habitat heterogeneity/diversity: the importance of keystone structures. Journal of. Biogeography **31,** 79-92. http://dx.doi.org/10.1046/j.03050270.2003.00994.x

Tim SD, Graeme CH, Don AD. 2021. Human disturbance causes widespread disruption of animal movement. Nature Ecology and Evolution **5,** 513-519. http://dx.doi.org/10.1038/s41559-020-01380-1.

Triplet P. 2009. Manuel de gestion des aires protégées d'Afrique francophone. Awelye, Paris, p 1234.

Tuomisto H. 2010. A consistent terminology for quantifying species diversity? Yes, it does exist. Oecologia **164,** 853-860. http://dx.doi.org/10.1007/s00442-010-1812-0

Vergnes V, Mao NR. 2012. Réalisation d'une étude sur l'état de la biodiversité des parcs nationaux et réserves de Côte d'Ivoire : Evaluation rapide de la diversité faunique terrestre de quatre parcs nationaux en Côte d'Ivoire, Rapport Afrique Nature International, p 33.

Walsh JC, Venter O, Watson JEM, Fuller RA, Blackburn TM, Possingham HP. 2012. Exotic species richness and native species endemism increase the impact of exotic species on islands. Global Ecology and Biogeography **21(8),** 841-850. http://wileyonlinelibrary.com/journal/geb http://dx.doi.org/10.1111/j.1466-8238.2011.00724.x

Zuberbühler K. 2000b. Causal knowledge of predators' behaviour in wild Diana monkeys. Animal Behaviour **59,** 209-220. https://doi.org/10.1006/anbe.1999.1296

Zurkinden D. 2017. Etude de l'abondance relative et de la structure d'une communauté de carnivores dans un écosystème de forêt sèche sur une base de données de pièges photographiques. Thèse de bachelor of Science Haute Ecole Spécialisée Suisse Occidentale, Genève, Suisse, p 67.