(RESEARCH ARTICLE)

The role of the Gbétitapéa Sacred Forest in Mammal conservation (Central-Western Côte d'Ivoire)

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Abstract

Sacred forests are traditional management systems aimed at biodiversity conservation, yet few studies focus on the mammalian fauna of these ecosystems. This study aims to assess mammal diversity in the Gbétitapéa sacred forest to promote this endogenous conservation approach. Specifically, it seeks to identify the mammal species present in this forest through local population surveys and on-foot surveys using linear transects and reconnaissance walks. Results show the presence of 13 mammal species across five orders (Rodents, Carnivores, Primates, Artiodactyls, and Bats), with Lowe's Monkey (*Cercopithecus lowei*) being the most abundant. All identified species are classified as Least Concern (LC) except for Lowe's Monkey, classified as Vulnerable (VU), and the Lesser Spot-nosed Monkey (*Cercopithecus petaurista*), classified as Near Threatened (NT) according to the IUCN Red List. Mammal diversity is closely linked to religious and cultural belief systems that shape conservation attitudes, practices, and policies. Integrating these cultural dimensions into conservation efforts could yield more sustainable and effective biodiversity conservation outcomes.

Keywords: Sacred forest; Mammal; Gbétitapéa; Côte d'Ivoire; Conservation status

1. Introduction

In Africa, sacred sites, particularly sacred forests, are attracting increasing interest from scientists and conservation organizations [1, 2, 3]. These forests have long been recognized for their ecological and cultural importance [4, 5, 6]. However, forestry policies have often viewed local users as potential destroyers of these resources. However, it is clear that local communities are the most invested in the sustainable management of forests, as these ecosystems represent their main source of livelihood. Additionally, these communities possess deep knowledge of forest ecosystem function and management practices [7].

In Côte d'Ivoire, between 1996 and 1998, [8] recorded 6702 sacred forests covering a total area of 37000 hectares. Yet, very few studies have been conducted on the wildlife diversity within these forests. Access to most of these sacred forests is restricted to initiates or individuals from neighboring villages [8, 9, 10]. For villagers, these forests are considered dwellings for ancestors or protective spirits, with local beliefs suggesting that any desecration of these sites could bring misfortune (such as illness, drought, or infertility) upon the community [11], 2005).

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Despite these examples of local management, the biodiversity of these sites now faces significant pressures, including land scarcity, soil degradation, and rapid population growth. Logging, often conducted without regard for the sacred nature of these sites, is particularly concerning [11]. What, then, is the current state of conservation for these traditional management systems ? The village of Gbétitapéa, where a sacred forest hosts monkeys that live harmoniously alongside humans, is the focus of this study. This research aims to assess the diversity of mammalian fauna within the Gbétitapéa sacred forest, with the goal of promoting this endogenous management system as a model for biodiversity conservation.

2. Material and methods

2.1. Study Site

This study was conducted in the Central-Western region of Côte d'Ivoire, specifically in the village of Gbétitapéa, located 5 km from Daloa, between latitude 6°47'12.2'' N and longitude 6°27'9.7'' W (Figure 1). This area experiences a humid tropical climate characterized by four distinct seasons: two rainy seasons and two dry seasons. The rainy seasons include a major rainy season from mid-March to mid-July and a minor rainy season from September to November. Similarly, the dry seasons consist of a major dry season from December to mid-March and a less pronounced minor dry season in August. The average annual precipitation ranges from 1,200 mm to 1,600 mm [12, 13, 14]; and Kra, 2013). As a prime wetland area, the region exhibits high humidity and an average annual temperature of 26°C [14].

Hydrographically, the region is influenced by the Sassandra River and its tributaries, the Lobo and Davo Rivers, as well as the Buyo Dam lake. Additionally, numerous seasonal streams drain the region, creating fertile lowlands that support a substantial population [14]. The terrain is predominantly characterized by plateaus interspersed with many valleys. The soils are generally ferrallitic, of granite origin, moderately to weakly desaturated, and support dense semi-deciduous vegetation. The local economy primarily relies on agriculture [14].
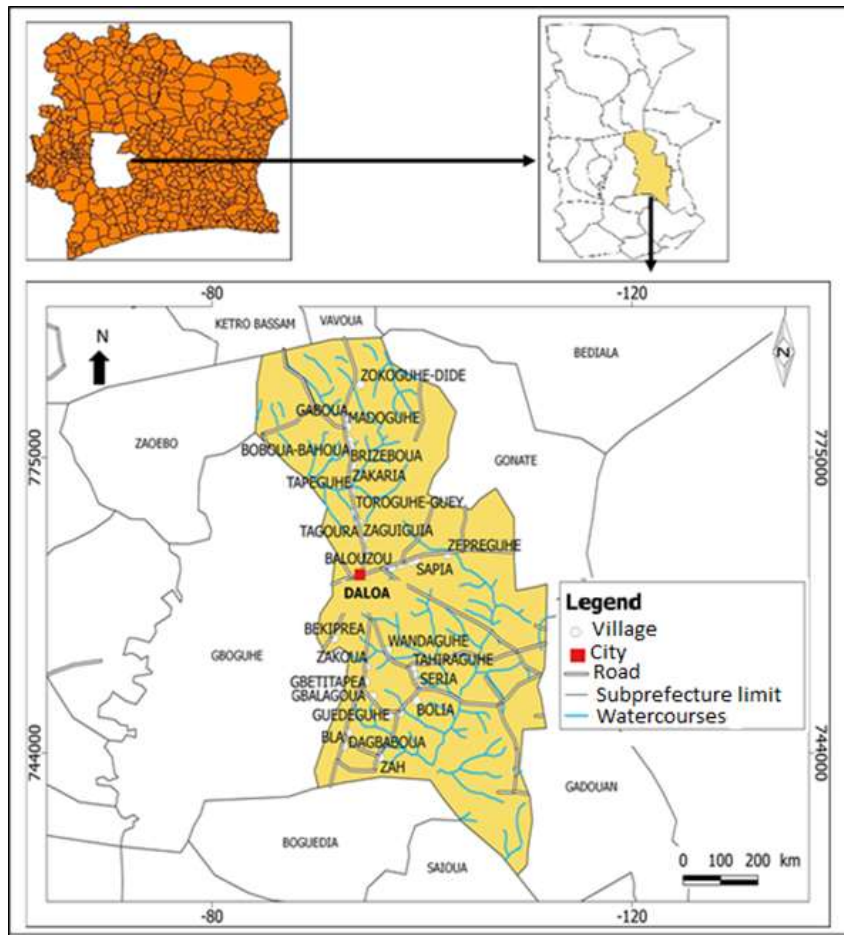
(Source : [15])

Figure 1 Study site location

2.2. Data Collection

2.2.1. Surveys with Local Communities

Prior to the studies conducted in the sacred forest, we conducted surveys in the village of Gbétitapéa. Interviews were held with hunters and elders who possess a comprehensive knowledge of the local wildlife in the study area, identified based on recommendations from our guide. This survey enabled us to compile a list of mammal species likely to be present in the region.

2.2.2. Field Surveys

A combination of transect surveys and reconnaissance walks (recce) was employed to cover our study site (6 ha), addressing the limitations of linear transect methods. Virtual linear transects of known lengths (600 meters) were established within the sacred forest [15].

2.2.3. Data Analysis

Species identification was carried out using our knowledge of the local fauna, referencing Kingdon's (2013) guide to African mammals. Encounter frequencies of species were calculated to estimate their abundance. To evaluate the international conservation status, we consulted the IUCN Red List [16] of threatened species, considering the various classification categories. The local conservation status of the inventoried species was determined based on the results of surveys conducted with local communities. Thus, species were classified as follows: (+++) for abundant species, (++) for uncommon species, and (+) for rare species. To assess the diversity of mammals in the sacred forest, we calculated the Shannon diversity index and Piélou's evenness index to evaluate species distribution within each population.

3. Results

3.1. Species Diversity of Mammals

3.1.1. Surveys

**Table 1** Species Richness of Mammals in the Sacred Forest Based on Respondent Surveys

Order	Family	Species	Scientific Name	Citation (%)
Rodentia	Thryonomyidae	Aulacode	*Thryonomys swinderianus*	100
	Sciuridae	Stanger Giant Squirrel	*Protoxerus stangeri*	88.23
	Anomaluridae	Beecroft's Flying Squirrel	*Anomalurus beecrofti*	17.35
	Sciuridae	Naked Mole Rat	*Xerus erythropus*	82.35
	Nesomyidae	Gambian Giant Rat	*Cricetomys gambianus*	94.11
	Hystricidés	African Brush-tailed Porcupine	*Atherurus africanus*	57.23
Hyracoidea	Procaviidae	Tree Hyrax	*Dendrohyrax dorsalis*	30.11
Carnivora	Nandiniidae	African Palm Civet	*Nandinia binotata*	5.58
	Herpestidae	Brown Mongoose	*Crossarchus obcurus*	73.23
	Vverridae	African Civet	*Civettictis civetta*	23.82
Lagomorpha	Leporidae	Cape Hare	*Lepus saxatilis*	25.70
Pholidota	Manidae	Common Pangolin	*Manis tricuspis*	55.23
Artiodactyla	Bovidae	Red-flanked Duiker	*Cephalophus rufilatus*	25.94
		Black-backed Duiker	*Cephalophus niger*	15.35
		Maxwell's Duiker	*Philantomba maxwellii*	50.00
		Harnessed Guib	*Tragelaphus scriptus*	88.31

	Suidae	Warthog	*Phacochoerus africanus*	5.88
Primates	Cercopithecidae	Green Colobus	*Procolobus verus*	11.76
		White-nosed Guenon	*Cercopithecus petaurista*	88.50
		Lowe's Mona	*Cercopithecus lowei*	95.01
Bats	Pteropodidae	Hammer-headed Bat	*Hypsignathus monstrosus*	32.23

During this study, 85 individuals (15 hunters and 70 elders) were interviewed, who reported a total of 21 mammal species present in the forest. The species mentioned by the respondents were classified into eight (8) orders and sixteen (16) families. The most frequently cited species were the Aulacode (100%), the Lowe's Monkey (95.01%), the Gambian Giant Rat (94.11%), the White-nosed Guenon (88.50%), the Harnessed Guib (88.31%), the Stanger Giant Squirrel (88.23%), and the Naked Mole Rat (82.35%), followed by the Brown Mongoose (73.23%), the African Brush-tailed Porcupine (57.23%), the Common Pangolin (55.23%), and Maxwell's Duiker (50%).

Certain species, including the Hammer-headed Bat (32.23%), Tree Hyrax (30.11%), Red-flanked Duiker (25.94%), Cape Hare (25.70%), and African Civet (23.82%), were cited less frequently. The species with the lowest citation rates were the Beecroft's Flying Squirrel (17.35%), the Black-backed Duiker (15.35%), the Green Colobus (11.76%), the Warthog (5.88%), and the African Palm Civet (5.58%) (Table 1).

3.2. Pedestrian prospections
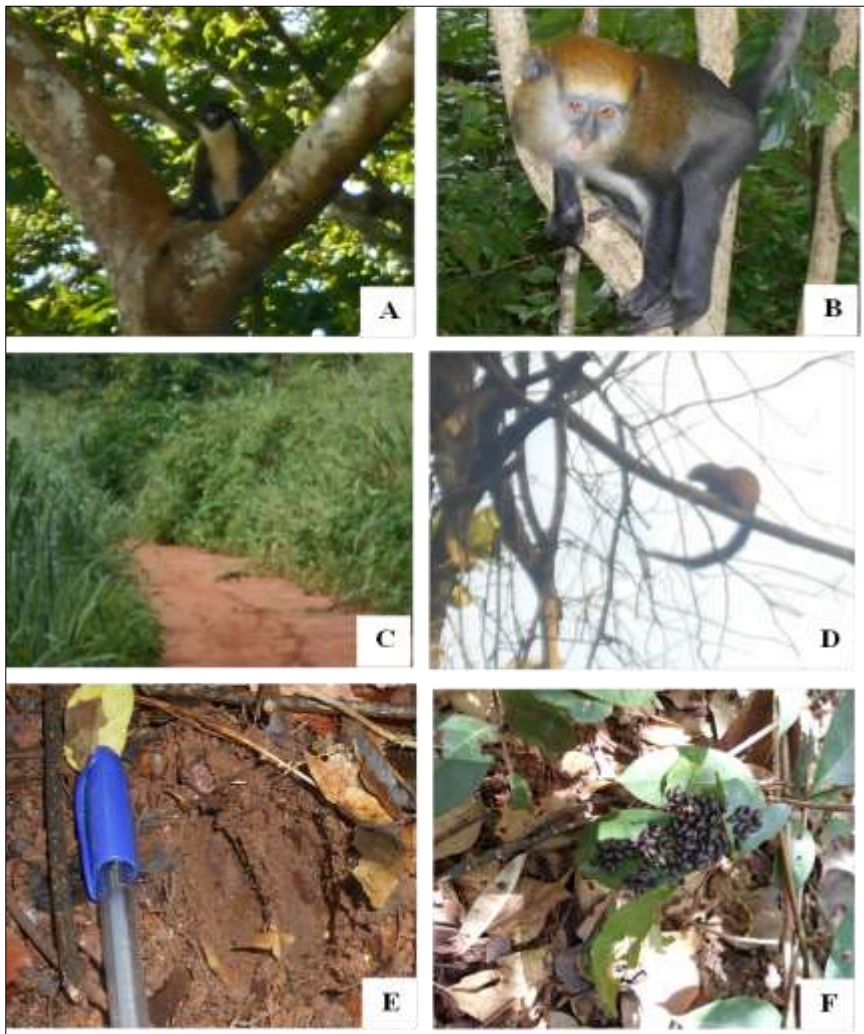
A: White-nosed Guenon, B: Lowe's Mona, C: Naked Mole Rat, D: Stanger Giant Squirrel, E: Track of Harnessed Guib, F: Feces of Red-flanked Duiker

Figure 2 Some Signs of Mammal Presence

The pedestrian inventories conducted in the forest allowed for the documentation of 254 signs of mammal presence, defined by direct observations, feeding traces, footprints, or feces (Figure 2). Analysis of these signs confirmed the presence of 13 mammal species. All these species belong to nine (9) families and are distributed across five (5) orders: Rodents, Carnivores, Primates, Artiodactyla, and Chiroptera. The order of Rodents was the most frequently observed in this forest, accounting for 41.34% of the signs, followed by the order of Primates at 29.53%. The order of Carnivores came next, representing 15.35% of the presence indices. The orders of Artiodactyla and Chiroptera were the least observed, with presence indices of 11.02% and 2.76%, respectively.

In terms of species diversity, the sacred forest of Gbétitapéa exhibits a high level of mammalian fauna diversity, as evidenced by a Shannon diversity index of 2.27. Moreover, these species are almost uniformly distributed within the populations of this forest, according to the Piélou evenness index (0.76). Among the identified animals, *Cercopithecus lowei* is the most frequently observed species, representing 17.72%, followed by *Xerus erythropus* (15.75%) and *Crossarchus obscurus* (15.35%). The species *Cercopithecus petaurista* (11.81%) and *Protoxerus stangeri* (10.63%) are less common, followed by *Cricetomys gambianus* (5.91%), *Philantomba maxwellii* (5.91%), and *Tragelaphus scriptus* (5.12%). Other species are very poorly represented, notably *Thryonomys swinderianus* (3.15%), *Hypsignathus monstrosus* (2.75%), *Anomalurus beecrofti* (2.36%), *Epixerus ebii* (1.97%), and *Atherurus africanus* (1.57%) (Table 2). It is important to note that *Hypsignathus monstrosus*, *Protoxerus stangeri*, *Epixerus ebii*, and *Xerus erythropus* were identified through both direct and indirect observations, while the other species mentioned rely solely on indirect observations.

Table 2 Species Richness of Mammals in the Sacred Forest According to pedestrian urveys

Order	Family	Species	Scientific Name	N	Frequency (%)
Rodents	Thryonomyidae	African cane rat	*Tryonomys swinderianus*	8	3.15
	Sciuridae	Stanger Giant Squirrel	*Protoxerus stangeri*	27	10.63
		Naked Mole Rat	*Xerus erythropus*	40	15.75
		Ebi Squirrel	*Epixerus ebii*	5	1.97
	Anomaluridae	Beecroft's Flying Squirrel	*Anomalurus beecrofti*	6	2.36
	Nesomyidae	Gambian Giant Rat	*Cricetomys gambianus*	15	5.91
	Hystricidae	African Porcupine	*Atherurus africanus*	4	1.57
Carnivores	Herpestidae	Brown Mongoose	*Crossarchus obscurus*	39	15.35
Artiodactyls	Bovidae	Maxwell's Duiker	*Philantomba maxwellii*	15	5.91
		Harnessed Guib	*Tragelaphus scriptus*	13	5.12
Primates	Cercopithecidae	White-nosed Guenon	*Cercopithecus petaurista*	30	11.81
		Lowe's Mona	*Cercopithecus Lowei*	45	17.72
Bats	Pteropodidae	Hammer-headed Bat	*Hypsignathus monstrosus*	7	2.75

3.3. Conservation Status

According to local communities, the African cane rat (*Thryonomys swinderianus*), Stanger's giant squirrel (*Protoxerus stangeri*), the African ground squirrel (*Xerus erythropus*), the Gambian giant rat (*Cricetomys gambianus*), the bushbuck (*Tragelaphus scriptus*), the white-nosed monkey (*Cercopithecus petaurista*), and Lowe's monkey (*Cercopithecus lowei*) are considered very abundant (+++) in the region. In contrast, species such as the African brush-tailed porcupine (*Atherurus africanus*), Maxwell's duiker (*Philantomba maxwellii*), and the brown mongoose (*Crossarchus obscurus*) are regarded as moderately abundant (++). The Ebi squirrel (*Epixerus ebii*), Beecroft's flying squirrel (*Anomalurus beecrofti*), and the giant fruit bat (*Hypsignathus monstrosus*) are considered rare (+).

Regarding international conservation status (IUCN), all species identified in the sacred forest are listed as of least concern (LC), except for Lowe's monkey, which is classified as vulnerable (VU), and the white-nosed monkey, which is classified as near threatened (NT) (Table 3).

Table 3 Local and international conservation status of mammalian species

Order	Family	Species	Scientific Name	Local Status	IUCN Status
Rodents	Thryonomyidae	African cane rat	*Tryonomys swinderianus*	+++	LC
	Sciuridae	Stanger's giant squirrel	*Protoxerus stangeri*	+++	LC
		African ground squirrel	*Xerus erythropus*	+++	LC
		Ebi squirrel	*Epixerus ebii*	+	LC
	Anomaluridae	Beecroft's flying squirrel	*Anomalurus beecrofti*	+	LC
	Nesomyidae	Gambian giant rat	*Cricetomys gambianus*	+++	LC
	Hystricidae	African brush-tailed porcupine	*Atherurus africanus*	++	LC
Carnivores	Herpestidae	Brown mongoose	*Crossarchus obscurus*	++	LC
Artiodactyls	Bovidae	Maxwell's duiker	*Philantomba maxwellii*	++	LC
		Bushbuck	*Tragelaphus scriptus*	+++	LC
Primates	Cercopithecidae	White-nosed monkey	*Cercopithecus petaurista*	+++	NT
		Lowe's monkey	*Cercopithecus Lowei*	+++	VU
Bat	Pteropodidae	Hammer-headed Bat	*Hypsignathus monstrosus*	+	LC

+++ : Abundant; ++ : Moderately abundant; + : Rare

4. Discussion

In total, only 13 mammal species have been confirmed in the sacred forest, compared to 21 species identified through surveys. This discrepancy can be attributed to several factors threatening the survival of these animals and impacting their populations. Deforestation, urbanization, and land conversion for agriculture have significantly reduced natural habitats, leading to biodiversity loss and declines in animal populations. Fragmented habitats hinder movement, limiting reproductive success and access to essential resources [17, 18, 19]. Furthermore, overexploitation due to excessive hunting and poaching has led to declines in many species, with some populations now so diminished that they struggle to reproduce effectively due to inbreeding pressures. Resource exploitation, such as logging and mineral extraction, also harms habitats and the species dependent on them [20, 21, 22, 23]. Additionally, climate change-induced variability affects ecosystems and species life cycles, with global warming altering species distributions and causing local extinctions. Extreme weather events, such as droughts or floods, disrupt habitats and endanger animal populations [24, 25, 26]. Pollution of air, water, and soil adversely affects the health of animals and ecosystems, with toxic chemicals leading to diseases, reproductive disorders, and mortality in sensitive species. Plastic waste and other forms of pollution also impact animals, resulting in population declines [27, 28, 29].

The rich diversity of mammalian fauna in this forest may be attributed to its sacred status. Belief systems can strengthen community networks around conservation efforts. Communities united by common spiritual values may collaborate to protect threatened habitats and species. Religious beliefs can also promote the conservation of entire ecosystems ; for example, the veneration of certain natural sites as sacred can lead to efforts to protect the habitats of the many mammals residing there [30].

Rodents were the most frequently encountered order in this forest. This abundance may be explained by their adaptability and resilience. Rodents often have high reproductive rates, enabling them to rapidly colonize favorable habitats. Their ability to adapt to various habitat types and modify their diets based on resource availability may also contribute to their habitat occupancy [31, 32, 33, 34]. As for the significant presence of primates in this forest, it may be linked to their sacred nature. In many cultures, certain mammals are considered sacred or symbolic; for instance, elephants in India and monkeys in certain African cultures are protected due to their religious status. This can lead to conservation efforts that safeguard not only these species but also their habitats. Religious rituals may involve the protection of specific animals, with some societies having dietary taboos that prohibit hunting or consuming certain species, contributing to their survival and the diversity of mammals [35, 36, 37].

5. Conclusion

This study highlights the presence of 13 mammal species in the sacred forest of Gbétitapéa, with rodents and primates being the most abundant groups. The majority of mammal species found in this forest are classified as of least concern (LC) according to the IUCN Red List, except for Lowe's monkey (*Cercopithecus lowei*), which is categorized as vulnerable (VU), and the white-nosed monkey (*Cercopithecus petaurista*), which is considered near threatened (NT). The findings of this study emphasize that the diversity of mammals in this sacred forest is closely linked to local religious and cultural belief systems, which can significantly influence attitudes, practices, and conservation policies.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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