

(RESEARCH ARTICLE)



## Distribution of mammalian fauna in the Matiamba and Kobo Classified Forests in the Bandama Valley District, Central Côte d'Ivoire

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### Abstract

The Bandama Valley District, located in central Côte d'Ivoire, is a forest-savannah transition zone, home to a diversity of habitats for many animal species. However, knowledge about the mammalian fauna of this region is still fragmentary. This study aimed to provide information on the distribution of mammal species in the classified forests of Matiamba and Kobo. Linear transects and reconnaissance walks methods were performed for data collection. The results showed that in the classified forest of Matiamba, the orders of Artiodactyls and Rodents are widely present. Specifically, the bushbuck and Maxwell's duiker have a uniform distribution, while the Aulacode is almost everywhere except in the west. Lagomorphs, represented by the Cape Hare, are also present everywhere except in the Centre and the West. Carnivores and primates are less common. In the Kobo Classified Forest, Artiodactyls and Rodents are also well distributed, with frequent sightings of Bushbuck and Maxwell's Duiker everywhere. The Grasshopper and the Palm Rat are less present in the south and west, and the Cape Hare is observed almost everywhere except in the West. These results will serve as a reference for scientific research and provide essential information for the sustainable management of the Matiamba and Kobo classified forests.

**Keywords:** Distribution; Mammals; Classified forests; Bandama Valley District; Central Côte d'Ivoire

### 1. Introduction

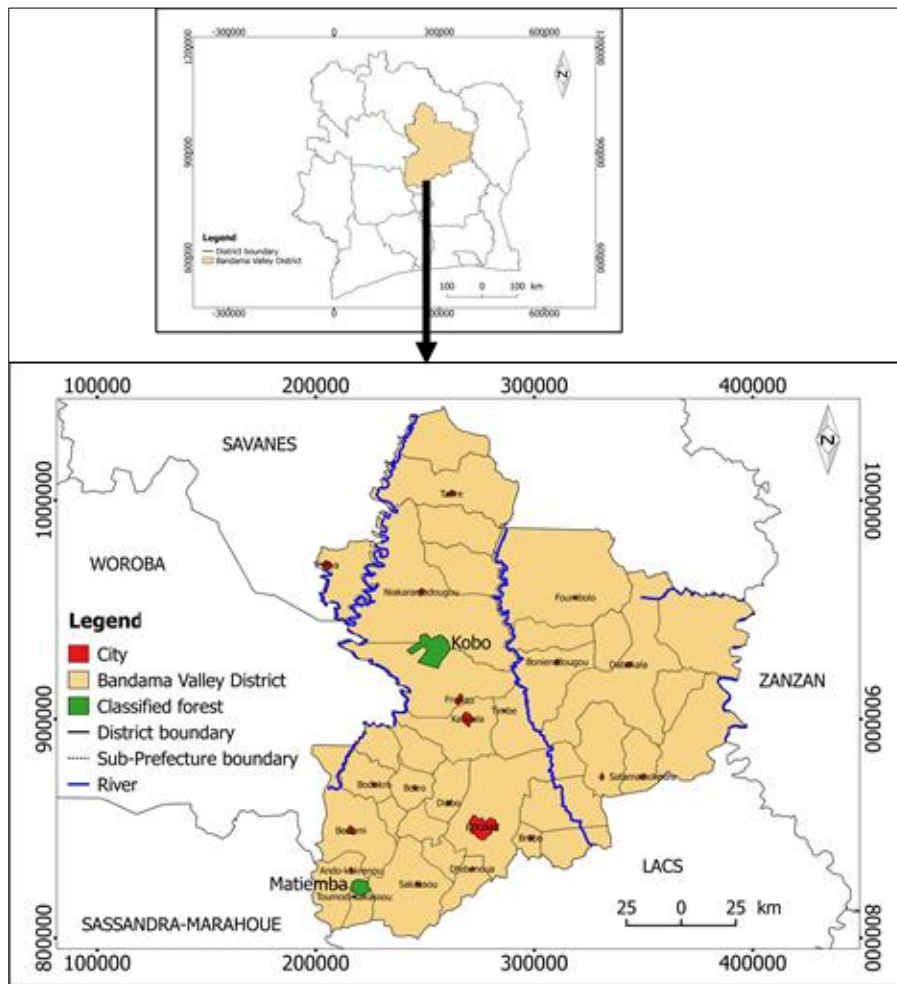
Disturbance of natural environments by human activities is one of the main causes of biodiversity loss [1, 2, 3]. When these anthropogenic pressures are strong, the disappearance of many mammal species remains inevitable. Indeed, the fact that these animals are more ecologically demanding to larger home ranges for some and low population densities for others, makes them more vulnerable [4]. A better knowledge of these species in their natural habitat is therefore fundamental for the implementation of sustainable conservation strategies [5]. As a result, several studies have been conducted on mammalian fauna in Côte d'Ivoire. Most of these studies have been carried out in Protected Areas such as the Banco [6], Marahoué [7], Taï [8, 9] and Azagny [10] National Parks. The observation remains the same in the Bandama Valley District where the majority of scientific work on mammal species is also focused on the Haut-Bandama Fauna and Flora Reserve [11, 12]. However, the distribution areas of mammalian fauna extend beyond the boundaries of Protected Areas. A few studies carried out in classified forests on mammals show this assertion [13, 14, 15]. In the Bandama Valley District, rare studies have concerned the populations of mammals in the classified forests of Matiamba and Kobo. It is therefore necessary to have reliable information on the mammalian fauna of these forests in order to enable managers to implement a better conservation strategy for these protected areas. This study aims to determine the distribution of mammalian fauna in the classified forests of Matiamba and Kobo.

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## 2. Material and methods

### 2.1. Study environment

This work was carried out in the classified forests of Matiamba and Kobo, located in the Bandama Valley District. This geographical area is part of the transition zone between the forest and the savannah of Côte d'Ivoire [16, 17]. It is home to many protected areas that stand out for the Haut-Bandama Fauna and Flora Reserve with an area of 123000 hectares. It is an area irrigated by the Bandama, N'Zi, Kan, Sagbo and N'bé rivers. The climate is subhumid tropical with two seasons including a rainy season and a dry season and annual temperatures that oscillate around 39°C [18, 17]. The average annual rainfall recorded varies between 1000 and 2500 mm [19, 20]. The forests of Matiamba and Kobo have been designated as classified forests since March 27, 1939. The Matiamba forest is located in the Department of Sakassou, straddling the sub-prefectures of Toumodi-Sakassou and Ando-Kékrénou with an area of about 6000 hectares and that of Kobo, in the Department of Katiola near the locality of Ouréguékaha with an area of 11600 hectares (Figure 1).



**Figure 1** Presentation of the study area

To carry out this work, two efficient and complementary data collection methods were combined in order to optimize the results.

### 2.2. Linear transects

Sampling using this method is based on the detection of animal presence cues along predefined virtual transects. During this study, 10 linear transects, including 4 for the classified forest of Matiamba and 6 for that of Kobo with a length ranging from 2 to 14 km, were prospected. They are separated from each other by 2.5 km.

### 2.3. Recognition Walks

This method consists of walking through each classified forest using paths of least resistance between the different linear transects in order to cover a large study area.

### 2.4. Data analysis

Point-based mapping of animal distribution is a method commonly used in ecology and biogeography to spatially represent the distribution of a species. The spatial distribution of the species can then be analysed from the distribution of points on the map. We can thus identify areas of concentration, limits of the range, areas of more sporadic presence, etc. [21, 22]. To this end, the QGIS 2.14.9 software was used to realize the spatial distribution of each mammal species in the classified forests. To establish a relationship between the different species encountered with the different environments, the data were subjected to a Correspondence Factor Analysis (CFA) using the SPSS Statistics 22 software. The AFC aims to represent, from a contingency table, the modalities of two qualitative variables in the same design in order to highlight the strong links between the modalities. This analysis highlighted the species' habitat preferences that influence its geographic distribution.

## 3. Results

### 3.1. Mammal species found in classified forests

During this study, 17 species of mammals were recorded in the two classified forests through the indices of animal presence. The classified forest of Matiamba recorded the greatest richness with 17 species of mammals divided into 10 families and 5 orders, namely the Artiodactyls, Rodents, Carnivores, Primates and Lagomorphs. The order Artiodactyls was the most represented with 8 species. It is followed by the order of Rodents which has 5 species. Then comes the order of Carnivores comprising 2 species. Finally, the orders Primates and Lagomorphs are represented by a single animal species. Concerning the Kobo classified forest, 12 mammalian species grouped into 8 families and 4 orders have been identified. The order Artiodactyls was also the most observed with 5 species. This is followed by the order of Rodents (4 species). Then come the orders of Lagomorphs and Carnivores, which are represented by one and 2 species respectively (Table 1).

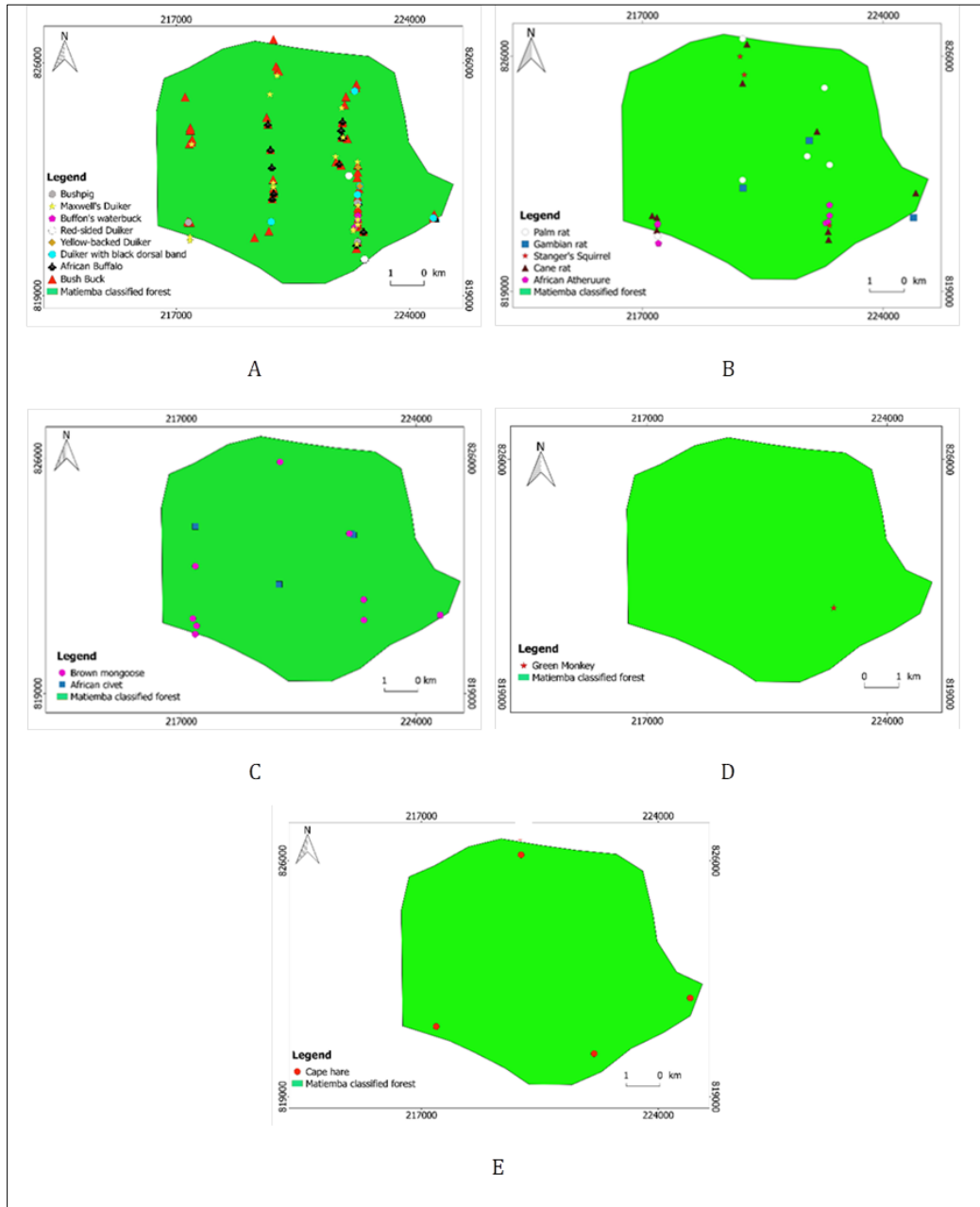
**Table 1** List of mammal species identified in classified forests

Order	Family	Common name	Scientific name	Classified forest	
				Matiamba	Kobo
Artiodactyls	Bovidae	African buffalo	<i>Syncerus caffer</i>	X	
		Buffon's waterbuck	<i>Kobus kob</i>	X	
		Bush buck	<i>Tragelaphus scriptus</i>	X	X
		Yellow-backed Duiker	<i>Cephalophus silvicultor</i>	X	
		Duiker with black dorsal band	<i>Cephalophus dorsalis</i>	X	X
		Red-sided Duiker	<i>Cephalophus rufilatus</i>	X	X
	Maxwell's Duiker	<i>Philantomba maxwellii</i>	X	X	
	Suidae	Bushpig	<i>Potamochoerus porcus</i>	X	X
Primates	Cercopithecidae	Green Monkey (Callitriche)	<i>Chlorocebus sabaues</i>	X	
Rodents	Hystricidae	African Atheruure	<i>Atherurus africanus</i>	X	
	Thryonomyidae	Cane rat	<i>Trynomys swinderianus</i>	X	X
	Nesomyidae	Gambian rat	<i>Cricetomys gambianus</i>	X	X
	Sciuridae	Palm rat	<i>Xerus erythropus</i>	X	X
		Stanger's Squirrel	<i>Protoxerus stangeri</i>	X	X
Carnivores	Viverridae	African civet	<i>Civettictis civetta</i>	X	X

	Herpestidae	Brown mongoose	<i>Crossarchus obscurus</i>	X	X
Lagomorphs	Leporidae	Cape hare	<i>Lepus capensis</i>	X	X
Total				17	12

### 3.2. Spatial distribution of mammals in classified forests

#### 3.2.1. Matiemba Classified Forest



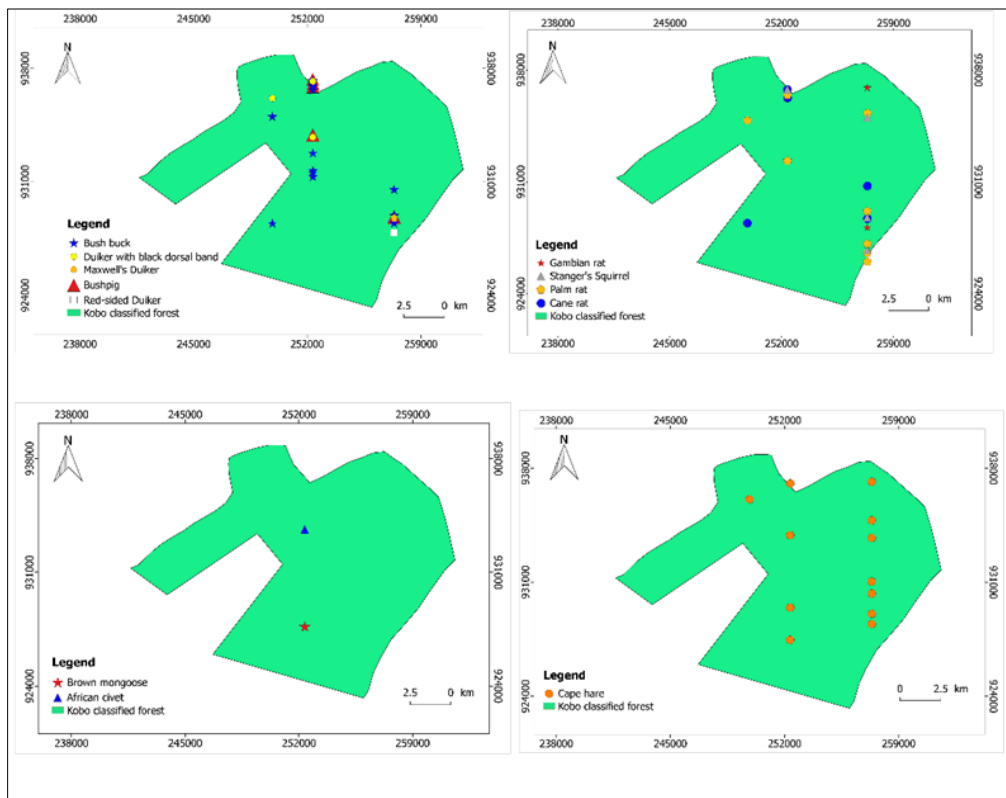
**Figure 2** Distribution of Mammals in the classified forest of Matiemba

The distribution of mammal species in the classified forest of Matiemba differs from one order to another. Thus, the order Artiodactyls has been found practically over the entire extent of this forest. At the specific level, the bushbuck and Maxwell's duiker had an almost homogeneous distribution. The black dorsal duiker has been observed almost everywhere except to the west of the classified forest. The Yellow-backed Duiker and the Buffon's Waterbuck have been identified in the Centre-East and South-East respectively. The Red-sided Duiker and the African Buffalo have been seen in the south and centre, but the distribution of the latter species extends to the east. As for the bushpig, it has been

identified to the south, southeast and southwest of the Matiamba classified forest (Figure 2a). The order of Rodents has been relatively distributed in the classified forest of Matiamba. The Aulacode is found almost everywhere except to the west of this forest, while the Palm Rat has not been observed to the south and west. The Gambian rat has been reported in the east and centre while the African Atherure has been reported in the south-east and south-west. The Giant Stanger's Squirrel has been encountered to the southeast and north of this protected area (Figure 2b). Concerning the order of Carnivores, the distribution of the Brown Mongoose was almost homogeneous while the African Civet was observed in the Centre, West and East (Figure 2c). The order of Primates, consisting of a single species, the Green Ape, was only seen in the southeast, while the order of Lagomorphs, also containing a single species, the Cape Hare, was not seen in the Centre and West (Figures 2d and 2e).

### 3.3. Kobo Classified Forest

The mammal species of the Kobo classified forest occupy this space differently. Referring to the distribution map of the Artiodactyls, these animals have been distributed over almost the entire surface of this forest. Specifically, the bushbuck has been observed almost everywhere except in the Northeast and South. The Red-sided Duiker and Maxwell's Duiker were present in the southeast, while the Black-dorsal Duiker was present in the Centre and North. The bushpig has been seen in the southeast, center and north (Figure 3a). Rodents have also been identified on both sides of this forest. In terms of species, the Palm Rat and the Aulacode have been found almost throughout the forest except in the south and west. The Gambian rat and the Stanger's giant squirrel have been reported in the southeast and north of the Kobo classified forest (Figure 3b). Concerning the Carnivores, the Mongoose was inventoried in the South while the African Civet was inventoried in the Centre of the protected area (Figure 3c). As for the Lagomorphs, the Cape Hare has been spotted over almost the entire area of this forest except in the west (Figure 3d).



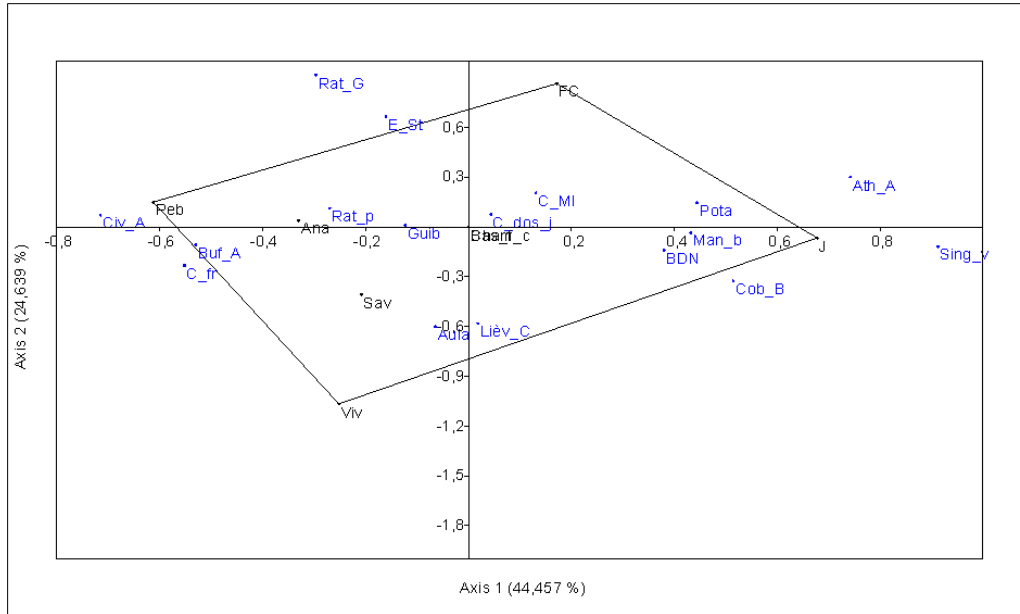
**Figure 3** Distribution of mammals in the Kobo classified forest

### 3.4. Distribution of mammals according to habitats

#### 3.4.1. Matiamba Classified Forest

The distribution of mammal species in the classified forest of Matiamba is linked to the different types of habitats encountered in this forest. Thus, the bushpig, the African Atherure, the Green Monkey, the Brown Mongoose, the Black-banded Duiker, and the Waterbuck were more observed in fallows. While the African civet, the African buffalo and the red-sided duiker have been more identified in reforestation. In addition, the Gambian rat and the Stanger's giant squirrel

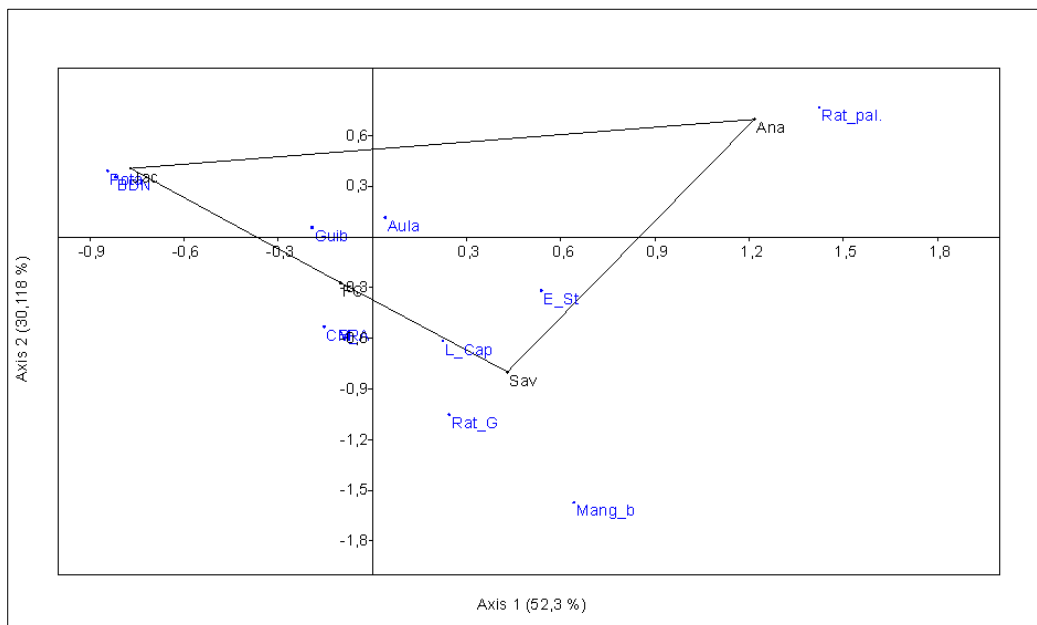
were more sampled in reforestation and open forests. In addition, the Aulacode and the Cape Hare have been observed in almost all habitats but more spotted in food fields. However, Maxwell's Duiker, Yellowback Duiker, Bushbuck, and Palm Rat do not have a habitat affinity and have been found almost everywhere in this forest (Figure 4).



**Figure 4** Distribution of mammals according to habitats in the classified forest of Matiamba

FC: Open Forest; Reb: Reforestation; J: fallow; Viv : Food fields; Sav: Savannah; Ana: Cashew field; Rat\_G: Gambian rat; E\_St: Stanger's Giant Squirrel; Rat\_p: Palm rat; Ath\_A: African Atherure; Aula: Aulacode; Civ\_A: African civet; Man\_b: Brown mongoose; Guib : Bushwort ; Pota: Bushpig; C\_MI: Maxwell's duiker; C\_fr: Rufous-sided duiker; C\_dos\_j: Yellow-backed duiker; BDN: Black dorsal duiker; Cob\_B: Buffon's waterbuck; Buf\_A: African buffalo; Sing\_v: Green Monkey; Lièv\_C: Cape Hare

### 3.4.2. Kobo Classified Forest



**Figure 5** Distribution of mammals according to habitats in the Kobo classified forest

FC: Open Forest; J: fallow; Sav: Savannah; Ana: Cashew field; Rat\_G: Gambian rat; E\_St: Stanger's Giant Squirrel; Rat\_p: Palm rat; Aula: Aulacode; Civ\_A: African civet; Mang\_b: Brown mongoose; Guib : Bushwort ; Pota: Bushpig; C\_MI: Maxwell's duiker; C\_fr: Rufous-sided duiker; BDN: Black dorsal duiker; L\_Cap: Cape Hare

The Kobo classified forest is not uniform in terms of habitats, there are cashew fields, fallows, open forests and savannahs. The mammal species that live there prefer some habitats over others. Thus, the Cape Hare, the Gambian Rat and the Brown Mongoose were more often encountered in the savannahs. As for the Palm Rat, it has been more identified in cashew fields. Also, the Maxwell's Duiker and the Red-sided Duiker prefer open forests where they have been more detected. In addition, the bushpig and the duiker with black dorsal stripe were more spotted in fallows. The Giant Squirrel of Stanger, on the other hand, prefers savannahs and cashew fields. However, the bushbuck and the Aulacode have been found in almost all the habitats of this forest.

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#### 4. Discussion

The study of the observed distribution of mammals from the classified forests of Matiamba and Kobo shows that Artiodactyls have been almost identified in all the habitats of these forests. The distribution of these animals could be linked by the availability and quality of food resources. Indeed, these ungulates concentrate in areas where vegetation is abundant and nutritious, providing them with an adequate source of food. The presence of plants with high nutritional values, such as grasses or legumes, attracts a greater number of herbivores [23]. These animals seek out areas with plant cover to protect themselves from predators and extreme weather. The presence of wooded areas or brush can provide them with favourable shelter. For the most part, these animals are better adapted to particular habitats, such as mountainous areas, grasslands or forests, and anthropogenic areas, which influence Sub-Saharan. Their natural habitat is characterized by the presence of dense vegetation, with alternating wooded areas and clearings [27]. Although preferring natural environments, the bushbuck and the Maxwell's duiker have been able to adapt to certain anthropogenic areas, such as plantations, agricultural areas and peri-urban areas [28, 27, 29]. For the African buffalo, this species is generally associated with savannahs and dense forests. However, during this study, it was widely observed in reforestation areas. Forest regeneration in these areas provides new sources of food and water, which attracts the Buffalo in search of vital resources. Reforestation programs can create vegetation corridors for buffalo to move and colonize new habitats [30]. The fragmentation of natural environments by human activities is one factor among many others that can condition the distribution of several animal species. This is the case of the red-sided duiker, which is naturally a forest species, but has been able to adapt to more open habitats, such as reforestation areas. Young plantations and regenerating forests offer favourable conditions in terms of vegetation cover, food availability and refuge opportunities for this species. Several studies have reported an increased presence of the Red-sided Duiker in reforestation areas, compared to primary forests [31].

Like the Artiodactyls, rodents also had an almost homogeneous distribution in the classified forests of Matiamba and Kobo. This wide distribution could be due to the diversity of food resources (seeds, fruits, mushrooms, etc.) and shelters (hollow trees, nests, burrows, etc.) offered by forest environments. The same is true for the savannah areas that host more terrestrial rodents, such as the Palm Rat, the African Atherure, the Aulacode and the Gambian Rat [32]. These open environments offer them vast spaces for movement and foraging (seeds, grasses, insects). Also, rapid reproduction and large litters allow these animals to quickly colonize these environments [33]. This would explain the wide distribution of the Aulacode. Indeed, this rodent has a very diverse natural habitat. The Grasshopper, also known as the "field rat", is native to Africa and is found in a wide variety of natural habitats, including forests, savannahs, grasslands, and swampy areas [34, 35]. Also, in these anthropogenic environments, the Aulacode benefits on the one hand from a reduction in its natural predators and on the other hand from less competition with other species of rodents. This contributes to its survival and proliferation [36].

The analysis of the distribution of Lagomorphs shows that the Cape Hare is almost distributed over the extent of the classified forests studied. Numerous studies reveal that several species of Lagomorphs are well adapted to open environments such as savannahs. Indeed, these savannahs, dominated by herbaceous and shrubby vegetation, provide them with an abundant source of food, including grasses, herbaceous plants and young shoots. This diverse vegetation provides Lagomorphs with a varied diet rich in essential nutrients. In addition, the open and heterogeneous structure of the savannah, with denser vegetation areas interspersed with more sparse spaces, provides them with an ideal habitat. This allows them to effectively hide from predators while having good visibility to detect dangers. The vegetation cover also provides protected nesting and calving sites [37, 38, 39].

For carnivores, the presence and abundance of potential prey in a natural environment are key factors for their distribution. Indeed, these animals are generally more frequent in ecosystems rich in mammals, birds and other vertebrates on which they feed. The diversity and size of prey populations influence the carrying capacity and density of carnivore populations [40]. These animal species require a habitat that provides shelter, tranquility and suitable hunting areas. The structure of the vegetation, the presence of wooded, rocky or thicket areas influence the distribution of carnivores. Some are adapted to open environments while others prefer dense forest environments. Habitat fragmentation, urbanization, and human activities can restrict the distribution of carnivores. Some species are more

tolerant of human disturbance than others [41]. These different ecological, behavioural and geographical factors could limit the distribution of the African civet and the brown mongoose in the classified forests of Matiamba and Kobo.

Tropical and subtropical forests are home to the greatest diversity of primates in the world. These intact forests provide primates with dense vegetation cover, an abundance of food, and nesting opportunities. However, deforestation and fragmentation of these habitats threaten many primate populations. Some primate species may adapt to younger or disturbed forests, but their diversity is generally lower. The loss of forest habitat forces many primates to take refuge in these substitute environments, with negative consequences on their populations. The conversion of forests to agricultural and plantation areas has greatly reduced primate habitat in many regions [42, 43, 44, 45]. These different factors could explain the restriction of primates to fallow land in the Matiamba classified forest and their absence in the Kobo forest.

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## 5. Conclusion

At the end of this work, it should be noted that the mammal species found in the classified forests of Matiamba and Kobo occupy these protected areas differently. While some species have an almost homogeneous distribution, others are dependent on a habitat type. Thus, in the classified forest of Matiamba, the order Artiodactyls and that of Rodents are found practically everywhere. At the specific level, the bushbuck and Maxwell's duiker have a uniformly distributed distribution, while the Aulacode is found almost everywhere except to the west of this forest fragment. As for the order of the Lagomorphs, containing a single species, the Cape Hare, its distribution covers almost the entire surface of this forest except the Centre and the West. The other orders (Carnivores and Primates) are the least distributed. Concerning the classified forest of Kobo, the orders of Artiodactyls and Rodents are also more widespread throughout this protected area. Specifically, the bushbuck, Maxwell's duiker and red-sided duiker are almost everywhere except in a few places. The Aulacode and the Palm Rat are found almost throughout the forest except in the south and west. As for the Lagomorphs, the Cape Hare has been spotted almost over the entire area of this forest except in the West. The order of Carnivores is the least distributed in this forest island. This study provides information on mammal species that could be a reference for research and sustainable management of the Matiamba and Kobo classified forests.

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## Compliance with ethical standards

### *Disclosure of conflict of interest*

No conflict of interest to be disclosed.

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