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Diversity of hunting fauna affected by hunting in the savannah region of northern Côte d'Ivoire

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Abstract

Meat from wild animals, commonly known as bushmeat, has always been a significant source of protein for many households in Côte d'Ivoire and other tropical regions of the world. However, population growth in recent decades, improved hunting methods and increased demand for bushmeat have intensified the burden on wildlife through the profits derived from its marketing. In the Bandama Valley, Savannah and Denguélé districts, there are a limited number of scientific studies on hunting and the animal species involved in game trafficking. The aim of this research is to provide wildlife managers with information on the particular diversity of game fauna in the study districts, with a view to promoting sustainable management. In order to achieve this objective, weekly inventories of game offered for sale in markets and restaurants in the districts visited were carried out. In all, 4,356 specimens were counted, divided into three classes, 12 orders, 22 families and 36 animal species. Among these species, the small-scaled pangolin (*Manis tricuspis*), the Gabon viper (*Bitis gabonica*), the dwarf crocodile (*Osteolaemus tetraspis*) and the tortoise (*Kinixys belliana*) are among those in danger of extinction. In terms of abundance of specimens, mammals make up the largest number, with 77.41% of species identified. The Greater Cane Rat (*Thryonomys swinderianus*), is the species most killed with 1392 individuals or 31.96% of the total number of specimens inventoried. This work is helping to perfect and extend sustainable natural resource management strategies.

Keywords: Bushmeat; Hunting; Diversity; Districts; Côte d'Ivoire

1. Introduction

Wildlife hunting has been practised for several centuries [1]. It has socio-cultural [2, 3], economic [4, 5] and food [6, 7] value. For some peoples, hunters occupy a special social position [8]. Hunting is also a source of income for several stakeholders in the bushmeat supply chain [9, 10, 11]. In terms of food, hunting products, which were once used for family and community self-consumption, have become increasingly popular consumer goods on the world market [12, 13]. In 1990, it was estimated that over 5 million tons of wild animal meat were consumed each year worldwide, including 4.9 million tons in tropical Africa [14]. [15] have shown that in tropical Africa nearly 6 million tons of wild mammal meat are consumed each year.

In Central and West Africa, meat from wild animals, also known as bushmeat, has always been an important source of animal protein [16, 17, 13]. It includes a wide range of animals, such as amphibians, reptiles, birds and mammals [13]. This use of wildlife is not without consequences for biodiversity. For example, [18] report that nearly 301 species of

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terrestrial mammals are now threatened with extinction. If nothing is done, we will witness a mass extinction of species at a rate that could be up to 1,000 times greater than that of the last century [19, 20]. In reality, with the demographic explosion of recent years, the population has obviously increased and, to satisfy the multiple uses of wildlife by local populations [21], quantities of species of all kinds have increased sharply. In addition, hunters in Africa may also use a variety of hunting tools, including traps, firearms, nets and dogs [22, 20]. The use of most of these tools remains illegal as they pose a significant threat to target and non-target wildlife, compromising animal biodiversity in general.

Like other African countries, Côte d'Ivoire is not immune to this loss of biodiversity. Indeed, the uncontrolled exploitation of wild animal species, whether for subsistence or commercial purposes, is one of the many causes that have led to the rarefaction of wildlife in this country [23, 24, 25]. Despite the closure of hunting in 1974, the quantity of game found on Ivorian markets does not seem to be decreasing [26, 27]. Hunting is still practised in the savannah areas of central, northern and north-western Côte d'Ivoire, particularly in the Bandama Valley, Savannah and Denguélé districts. This activity, which was once restricted to rural areas, has developed into a network connecting the large wildlife reserves and the large urban centers, where huge quantities of game are transported and traded [28, 17, 29]. However, in these districts of Côte d'Ivoire, harvesting is not monitored and controlled to enable wildlife conservation.

This study aims to improve the state of knowledge on wildlife harvesting in order to contribute to conservation decision-making. Specifically, the aim is to determine the specific diversity of game harvested in the Bandama Valley, Savannah and Denguélé districts.

2. Methodology

2.1. Study area

This study was carried out in the central, northern and north-western parts of Côte d'Ivoire in the Bandama Valley, Savannah and Denguélé district, specifically in the towns of Bouaké, Katiola, Korhogo, Tengréla and Odiéné (Figure 1).

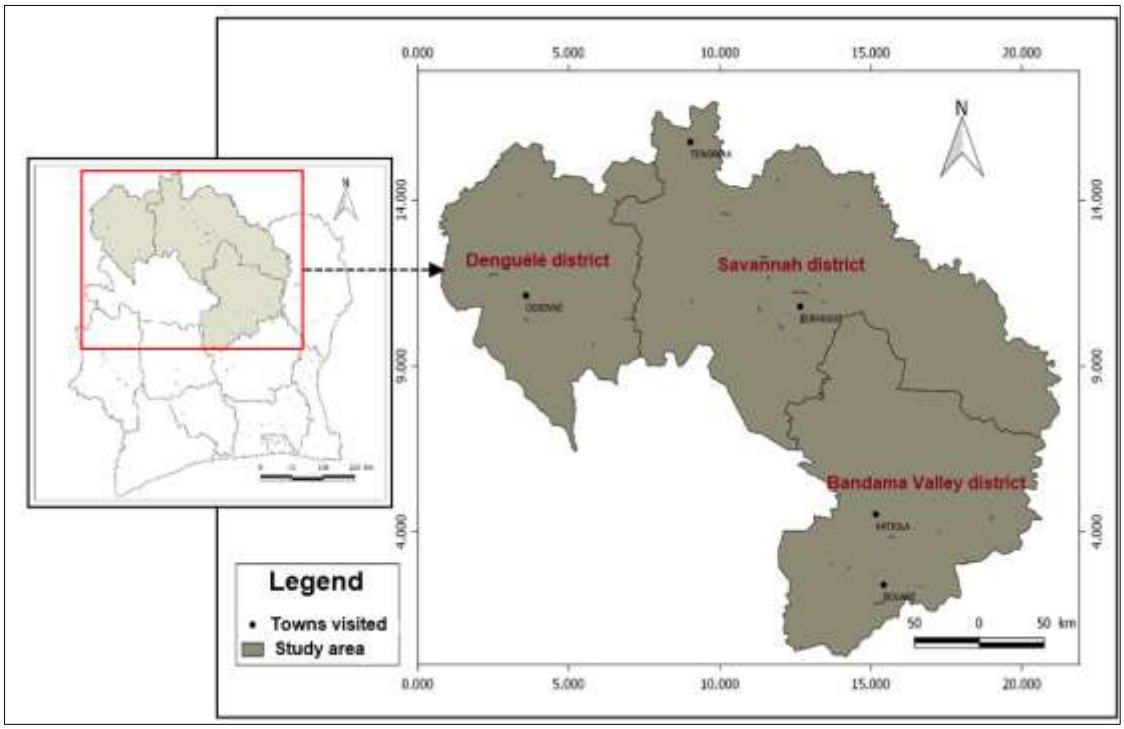

Figure 1 Location of the study area

The Bandama Valley district is located in central Côte d'Ivoire and covers an area of 28,530 km^2. It is characterised by vegetation dominated by savannah interspersed with patches of dense dry forest [30, 31]. The climate is subhumid tropical, with annual temperatures hovering around 39°C. There are four seasons in this climate zone, including two dry seasons from November to March and July to August, and two rainy seasons from August to October and March to June [31]. Average annual rainfall varies between 1,000 mm and 2,500 mm [32, 33].

The savannah and Denguélé districts, as in the whole of northern Côte d'Ivoire, are characterised by a Sudanese-type climate with two seasons, a rainy season from June to October and a dry season from November to May [34]. The dry season is marked by the harmattan. Average annual rainfall varies between 1,000 and 1,200 mm and average annual temperatures are around 36°C [35]. Over 80% of the vegetation consists of savannah formations interspersed with patches of dense forest [35, 36, 34].

2.2. Inventory of wildlife consumed

In order to identify the animal species subject to hunting, we carried out weekly inventories of game sold in markets and restaurants in the towns of the Valley du Bandama, Savannah and Denguélé districts. This method made it possible not only to identify the animal species hunted but also to obtain information on the tools used and the provenance of the game [37, 38]. Data were collected from 9 bushmeat sellers and 14 restorers, including eight (8) in Bouaké, four (4) in Katiola, five (5) in Korhogo, two (2) in Tengréla and four (4) in Odiénné.

Each selected site was visited once a week between 6am and 10am in the morning and between 5pm and 7pm in the evening. These times correspond to the times when bushmeat is delivered by hunters or intermediaries. When a specimen is observed, it is identified using identification guides [39, 40, 41, 42] and then photographed. Information on provenance is collected.

2.3. Identification of game species

The mammal species sampled were identified on the basis of [39] book and our own knowledge of the mammalian fauna. This identification was based on various morphological characteristics of the species (coat color, horn structure, appearance and length of tail). Birds were identified using the identification guide by [40]. In some cases, knowledge of local guides was necessary for species identification. For Reptiles, identification was based on the scales on the cephalic plate (dorsal, ventral and profile), anal and sub-caudal [41, 42].

2.4. Data Analysis

The data recorded in the field were processed using mathematical expressions. The results of the inventories and surveys of protected area managers and bushmeat industry stakeholders were subjected to several statistical analyses.

2.4.1. Species richness

Species richness (S) expresses the number of species observed in an ecological community, landscape or region [43]. This parameter makes it possible to quantify the number of species identified by inventories of the fauna hunted and/or marketed in the various restaurants and in the various localities inspected. It is expressed using the following mathematical expression:

$$S=\sum species$$

2.4.2. Absolute and relative abundance

Absolute abundance is defined as the number of individuals (N) of a species or taxonomic group in a given biotope or sample. Relative abundance is defined as the percentage of the number of individuals of a species (i) or taxonomic group in a given biotope or sample. Relative abundance indicates the relative importance of each species compared with all those recorded in a given habitat [44]. Its mathematical expression is:

- $Ar\ (\%) = (ni/N) \times 100$
- Ar (%) = Relative abundance;
- ni = number of individuals of species i in the sample;
- N = total number of individuals of all species in the sample.

2.4.3. Shannon-Weaver diversity index (H')

Specific diversity is a measure of the species composition of an ecosystem, in terms of the number of species and their relative abundances [45]. However, species richness and relative abundance alone are not sufficient to characterise and describe the structure of a population satisfactorily. Numerous indices have therefore been developed to measure species diversity.

In the case of our study, the [46] diversity index is the most commonly used and is recommended by various authors [47]. This index quantifies biodiversity by taking into account the number of species and the abundance of individuals within each species. This index, denoted 'H'', enabled us to determine the diversity of animal species hunted.

The Shannon diversity index (H') is minimal when the locality is dominated by a single hunted species. Conversely, the H' index is maximum (theoretically infinite) when all the species hunted in the locality are co-dominant. The value of the index will therefore vary from 0 (marked dominance of one species) to log S (codominance of several species). This index is calculated using the following mathematical formula:

$$H' = - \sum [(ni / N) \log2 (ni / N)]$$

ni= number of individuals of species i in the sample;

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

The higher the value of the H' index, the greater the diversity. The relative abundance structures of species determine the equitability or dominance component of diversity.

2.4.4. Piélou equitability index

Piélou's equitability index [48], also known as the regularity index [49] or equidistribution [50], is used to compare the diversity of two stands with different numbers of species [51]. It also gives an account of the distribution of species in a sample. Equitability is the ratio between the effective diversity of a community estimated by the Shannon index (H') and its maximum diversity (Log2 S). It is used to detect the effect of human pressure on biodiversity. This index varies from 0 to 1 [52, 51], being close to 1 when all species tend to have the same abundance in an undisturbed natural environment (optimal regularity) [53] and below 0.80 when one species, more resistant to environmental conditions than the others, predominates [54]. It is obtained by the following mathematical formula:

$$J' = H'' / H \max = H'' / \log2 (S)$$

- J: equitability index
- H': Shannon index
- H max: maximum diversity

3. Results

3.1. Specific richness of game fauna in the study area

A total of 4,356 carcasses were inventoried in the course of the study, including 3,177 (72.93%) in the Bandama valley district, 731 (16.79%) in the Savannah district and 448 (10.28%) in the Denguélé district.

Analysis of these carcasses enabled them to be grouped into three classes, 12 orders, 22 families and 36 animal species (Table 1). The Mammals class is the most diverse, with nine (8) orders and 26 species (72, 22% of the total number of animal species). It is followed by the Reptiles class with three (3) orders and seven (7) species (19.44%). The Birds class has one order with three (3) species (8.33%) (Table 1).

The orders encountered include Carnivores, Artiodactyla, Rodents, Squamates, Galliformes, Primates, Chiroptera, Pholidotes, Hyracoides, Lagomorphs, Crocodilians and Testudines. The most represented orders, with seven (7) species each, are the Carnivores (*Herpestes sanguineus, Crossarchus obscurus, Canis adustus, Nandinia binotata, Civettictis civetta, Genetta genetta, Genetta tigrina*) and Artiodactyla (*Cephalophus dorsalis, Phacochoerus africanus, Tragelaphus scriptus, Cephalophus rufilatus, Kobus kob, Neotragus pygmaeus, Philantomba maxwellii*). They represent 19.44% of each order (Figure 2a and 2b). They are followed by the order of Rodents (*Thryonomys swinderianus, Cricetomys gambianus, Xerus erythropus, Atherurus africanus, Anomalurus beecrofti*) and Squamates (*Varanus niloticus, Varanus exanthematicus, Python sebae, Bitis arietans, Bitis gabonica*) each represented by five (5) species, i.e. 13.89% per order (Figures 2c and 2d). Galliformes represent 8.33% with three (3) species encountered (*Pternitis bicalcaratus, Pternitis ahantensis, Numida meleagris*) (Figure 2e). Primates (*Erythrocebus patas, Chlorocebus sabaeus*) and chiropterans (*Eidolon helvum, Hypsignathus monstrosus*) accounted for two (2) species each, or 5.56% per order (Figures 2f and 2g). The orders Pholidotes (*Manis tricuspis*), Hyracoides (*Dendrohyrax dorsalis*), Lagomorphs (*Lepus spp*), Crocodilians

(*Osteolaemus tetraspis*) and Testudines (*Kinixys belliana*) are each represented by a single species, i.e. 2.78% each (Figures 2h, 2i, 2j and 2k).

In the Bandama valley district, 3,177 carcasses were inventoried. These carcasses were divided into 11 orders, 18 families and 31 animal species (Table 1). In this district, the orders encountered are Artiodactyla, Carnivora, Squamata, Rodentia, Galliforma, Primata, Chiroptera, Pholidota, Hyracoides and Lagomorpha. The most representative order is the Artiodactyla, with seven species. This order is followed by the Carnivora and Squamata orders, each with five species. Next come the Rodents and Galliformes orders, with four and three species respectively. Primates and Chiroptera have two species each. The other orders, Pholidotes, Hyracoides and Lagomorphs, are each represented by one species (Table 1).

In the Savannah district, the carcasses inventoried were divided into 10 orders, 18 families and 26 species. In this district, the order with the most species is Carnivores, with five species. Rodents and Artiodactyla in this district are represented by four species. They are followed by the orders Squamates and Galliformes with three species each. These orders are followed by the Primates with two species. The orders Chiroptera, Pholidotes, Lagomorphs and Crocodilians are represented by one species per order (Table 1).

In the Denguélé district, the carcasses inventoried are divided into 12 orders, 19 families and 24 animal species. The orders with the most species are Rodents and Carnivores, with four species each. The Squamates order in Denguélé is represented by three species. The Galliformes, Artiodactyla and Primates orders have two species each. The least represented orders are Hyracoides, Crocodilians, Testudines, Chiroptera, Pholidotes and Lagomorphs, with one species each (Table 1).

Table 1 Specific diversity of hunted wildlife in the savannah zone of Côte d'Ivoire

Classes	Order	Family	Species	Common name	VB	Sav	Den
Mammalia	Carnivora	Viverridae	*Civettictis civetta*	African Civet	X	X	X
			Genetta genetta	Common genet	X	X	X
			Genetta tigrina	Tiger genet		X	
		Herpestidae	*Crossarchus obscurus*	Brown mongoose	X	X	X
			Herpestes sanguineus	Red mongoose	X		
		Nandiniidae	*Nandinia binotata*	African Palm Civet	X		
		Canidae	*Canis adustus*	Striped jackal		X	X
	Artiodactyla	Bovidae	*Cephalophus dorsalis*	Black-banded Duiker	X	X	X
			Phacochoerus africanus	Common warthog	X	X	X
			Tragelaphus scriptus	Bushbuck	X	X	
			Cephalophus rufilatus	Red-flanked Duiker	X		
			Kobus kob	Buffalo cob	X		
			Neotragus pygmaeus	Royal antelope	X		
			Philantomba maxwellii	Maxwell's Duiker	X	X	
	Rodentia	Tryonomidae	*Thryonomys swinderianus*	Greater Cane Rat	X	X	X
		Nesomyidae	*Cricetomys gambianus*	Gambian Giant Rat	X	X	X
		Sciuridae	*Xerus erythropus*	Striped ground squirrel	X	X	X
		Hystricidae	*Atherurus africanus*	African Brush-tailed Porcupine	X	X	
		Anomauridae	*Anomalurus beecrofti*	Flying squirrel			X
	Chiroptera	Pteropodidae	*Eidolon helvum*	African straw-coloured fruit-bat	X	X	X

			Hypsignathus monstrosus	Monstrous hypsignathe	X		
	Primates	Cercopithecidae	*Erythrocebus patas*	Red monkey	X	X	X
			Chlorocebus sabaeus	Vervet	X	X	X
	Lagomorpha	Leporidae	*Lepus ssp*	Hare	X	X	X
	Hyracoidea	Procaviidae	*Dendrohyrax dorsalis*	Tree Daman	X		X
	Pholidota	Manidae	*Manis tricuspis*	Small-scaled pangolin	X	X	X
Aves	Galliformes	Phasianidae	*Pternitis ahantensis*	Ahanta Francolin	X	X	X
			Pternitis bicalcaratus	Double-spurred Francolin	X	X	X
		Numididae	*Numida meleagris*	Wild guinea fowl	X	X	
Reptilia	Squamata	Varanidae	*Varanus niloticus*	Nile Varan	X	X	X
			Varanus exanthematicus	Savannah Varan	X	X	X
		Viperidae	*Bitis arietans*	Common viper	X	X	X
			Bitis gabonica	Gabonese viper	X		
		Pythonidae	*Python sebae*	Seba python	X	X	X
	Crocodilia	Crocodylidae	*Osteolaemus tetraspis*	Dwarf crocodile		X	X
	Testudines	Testudinidae	*Kinixys belliana*	Tortoise			X

VB : Bandama Valley district ; Sav : Savannah district ; Den : Denguélé district ; X : Presence in the district

Crossarchus obscurus

Civettictis civetta

Nandinia binotata

Herpestes sanguineus

Canis adustus

a : Some representatives of the order of Carnivores

Kobus kob

Phacochoerus africanus

Tragelaphus scriptus

Cephalophus dorsalis

Cephalophus rufilatus

b : Some representatives of the Artiodactyla order

<table>
<tr><td> 
Xerus erythropus</td><td> 
Cricetomys gambianus</td><td> 
Atherurus africanus</td><td> 
Thryonomys swinderianus</td><td></td></tr>
<tr><td colspan="4">c : Some representatives of the order of Rodents</td><td></td></tr>
<tr><td> 
Bitis arietans</td><td> 
Bitis gabonica</td><td> 
Python sebae</td><td> 
Varanus exanthematicus</td><td> 
Varanus niloticus</td></tr>
<tr><td colspan="5">d : Some representatives of the Squamate order</td></tr>
<tr><td> 
Pternitis ahantensis</td><td> 
Pternitis bicalcaratus</td><td> 
Numida meleagris</td><td> 
Chlorocebus sabaeus</td><td> 
Erythrocebus patas</td></tr>
<tr><td colspan="3">e : Some representatives of the Galliformes order</td><td colspan="2">f : Some representative of the order of Primates</td></tr>
<tr><td> 
Eidolon helvum</td><td> 
Hypsignathus monstrosus</td><td> 
Manis tricuspis</td><td> 
Lepus ssp</td><td></td></tr>
<tr><td colspan="2">g : Some representatives of the chiropteran order</td><td>h : A representative of the order of Pholidotes</td><td>i : A representative of the order of Lagomorphs</td><td></td></tr>
</table>

 *Osteolaemus tetraspis*	 *Kinixys belliana*			
j : A representative of the order of Crocodilians	**k:** A representative of the Testudine Order			

Figure 2 Species found in markets and restaurants in the savannah area of Côte d'Ivoire

3.2. Abundance of hunting fauna in the study area

In terms of abundance of specimens, Mammals were the most hunted, with 3,372 specimens divided into nine (9) orders, i.e. 77.41% of the specimens inventoried. They are followed by the Birds and Reptiles classes, which represent 18.57% (N=809) and 4.02% (N=175) respectively (Table 2).

The orders with the highest number of slaughtered specimens are Rodents (N=1991; 45.71%) and Galliformes (N=809; 18.58%). The orders Artiodactyla (10.27%; N=449), Lagomorpha (8.49%; N=370), Chiroptera (7.96%; N=347), Squamata (3.75%; N=163) and Carnivora (2.32%; N=101) were moderately slaughtered. Primates (1.70%; N=74), Pholidotes (0.60%; N=26), Hyracoids (0.35%; N=15), Crocodilians (0.18%; N=8) and Testudines (0.09%; N=4) were the least culled (Figure 3).

Specifically, the most hunted species was *Thryonomys swinderianus*, with 1,392 specimens collected, representing 31.96% of all specimens. This species is followed by *Pternitis bicalcaratus* (N=440; 10.10%) and *Cricetomys gambianus* (N=403; 9.25%). The species *Neotragus pygmaeus* (N=4)*, Kinixys belliana* (N=4), *Bitis gabonica* (N=1), *Genetta tigrina* (N=1) and *Anomalurus beecrofti* (N=1) were the least observed (Figure 4).

Considering the districts independently, in the Bandama Valley district, the most hunted species is *Thryonomys swinderianus* with 1234 specimens, i.e. 53.51%. In the Savannah district, the most hunted species are *Lepus spp*., *Cricetomys gambianus* and *Thryonomys swinderianus* with 147 (20.11%), 138 (18.88%) and 118 (16.14%) specimens respectively. In the Denguélé district, *Phacochoerus africanus* and *Cricetomys gambianus* were the most collected species, at 16.39% and 16.96% (60 and 76 specimens respectively).

Table 2 Abundance of game in markets and restaurants in study cities

Class	**Order**	**Familly**	**Scientific name**	**Locality**					
					Bandama Valley	**Savannah**		**Denguélé**	**Total**
				Bouaké	**Katiola**	**Korhogo**	**Tengréla**	**Odiénné**	
		Carnivora	Viverridae	*Civettictis civetta*	5	3	9	1	7	25
				Genetta genetta	2	2	1	2	3	11
				Genetta tigrina	-	-	1	-	-	1
			Herpestidae	*Crossarchus obscurus*	10	8	1	-	14	33
				Herpestes sanguineus	4	7	-	-	-	10
			Nandiniidae	*Nandinia binotata*	5	-	-	-	-	5
			Canidae	*Canis adustus*	-	-	1	-	15	16

Mammalia	Artiodactyla	Bovidae	*Cephalophus dorsalis*	132	29	31	-	-	195
			Phacochoerus africanus	15	6	6	1	63	91
			Tragelaphus scriptus	32	7	6	-	-	45
			Cephalophus rufilatus	16	4	-	-	-	20
			Kobus kob	11	1	-	-	-	12
			Neotragus pygmaeus	4	-	-	-	-	4
			Philantomba maxwellii	51	19	11	-	-	81
	Rodentia	Tryonomidae	*Thryonomys swinderianus*	912	322	110	8	40	1392
		Nesomyidae	*Cricetomys gambianus*	125	64	88	0	76	403
		Sciuridae	*Xerus erythropus*	60	38	28	5	25	156
		Hystricidae	*Atherurus africanus*	24	11	4	-	-	39
		Anomauridae	*Anomalurus beecrofti*	-	-	-	-	1	1
	Chiroptera	Pteropodidae	*Eidolon helvum*	246	-	60	-	27	333
			Hypsignathus monstrosus	14	-	-	-	-	14
	Primates	Cercopithecidae	*Erythrocebus patas*	5	4	4	5	22	40
			Chlorocebus sabaeus	6	3	4	-	21	34
Aves	Lagomorpha	Leporidae	*Lepus ssp*	123	94	119	28	6	370
	Hyracoidea	Procaviidae	*Dendrohyrax dorsalis*	9	-	-	-	6	15
	Pholidota	Manidae	*Manis tricuspis*	12	2	11	-	1	26
	Galliformes	Phasianidae	*Pternitis ahantensis*	131	27	46	-	7	211
			Pternitis bicalcaratus	234	157	16	-	33	440
		Numididae	*Numida meleagris*	108	27	21	2	-	158
Reptilia	Squamata	Varanidae	*Varanus niloticus*	1	15	2	4	28	46
			Varanus exanthematicus	5	9	5	50	22	45
		Viperidae	*Bitis arietans*	-	7	27	3	10	47
			Bitis gabonica	1	-	-	-	-	1
		Pythonidae	*Python sebae*	3	5	6	2	8	24
	Crocodilia	Crocodylidae	*Osteolaemus tetraspis*	-	-	2	-	6	8
	Testudines	Testudinidae	*Kinixys belliana*	-	-	-	-	4	4
	Total			2306	871	620	111	448	4356

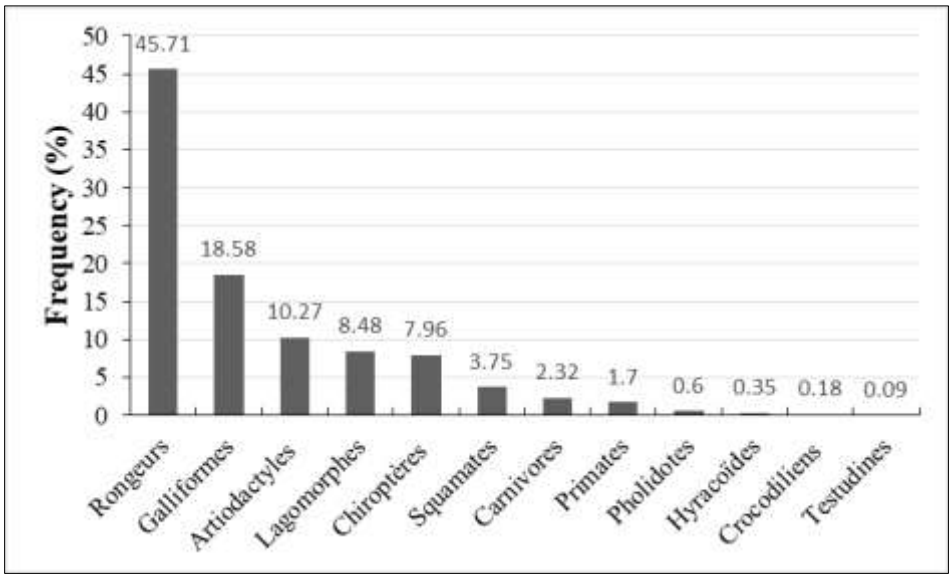

Figure 3 Relative abundance of hunting fauna orders in the savannah zone of Côte d'Ivoire

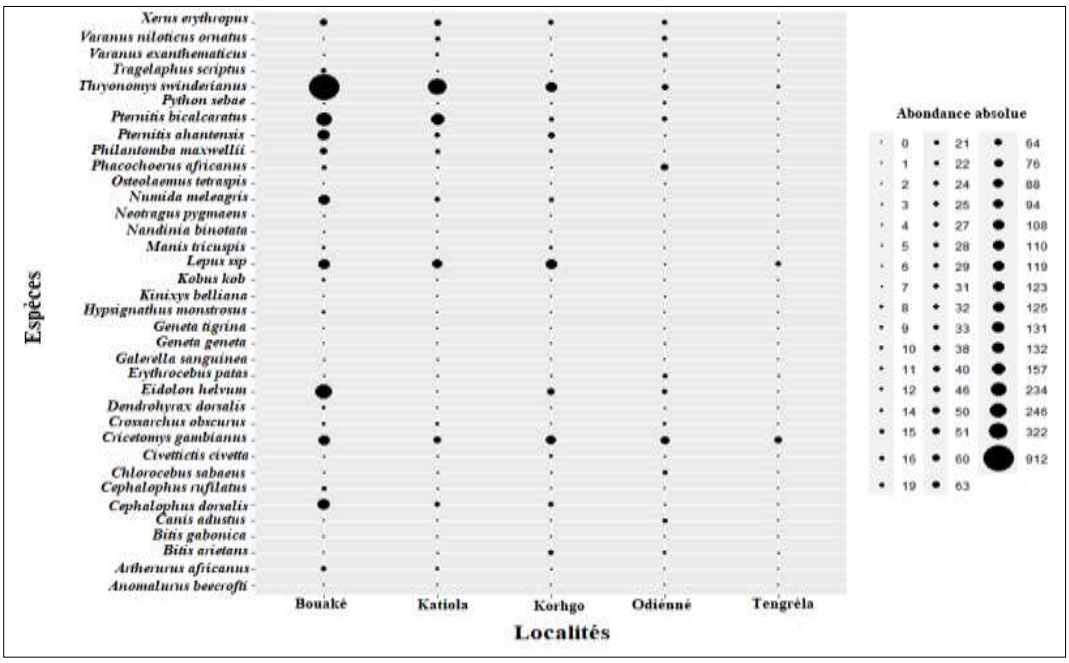

Figure 4 Absolute abundances of hunting fauna in the savannah zone of Côte d'Ivoire

3.3. Hunting diversity indices in the study districts

Generally speaking, the diversity index values recorded in all localities show a high diversity of hunted species. Indeed, the specific richness obtained is 36 animal species with a Shannon index value equal to 2.5 (Table 3).

The Shannon diversity values (H') obtained in this study are around 2.6, with an average value of 2.52. The Denguélé district has the highest Shannon diversity index (H'=2.74). This is followed by the Savannah district with a Shannon diversity index of 2.57. The lowest Shannon index value was recorded in the Bandama valley, with a value of H'=2.26 (Table 3).

Equitability index values were roughly equal in all localities, ranging from 0.65 to 0.86. The value of the equitability index obtained in the Bandama valley district (0.65) shows that there is no identical distribution between the species

felled and their numbers. On the other hand, the savannah and Denguélé districts have an index value close to 1. Such values reveal that there is a good distribution of felled species (Table 3).

Table 3 Indices of diversity of wildlife hunted in the study area

Districts	S	H’	E
Bandama Valley	31	2,26	0,65
Savannah	26	2,57	0,79
Denguélé	24	2,74	0,86
Study area	36	2,5	0,70

S: Species richness; H' : Shannon-Weaver index ; E: Piélou's equitability index

3.4. Origin of game inventoried

The results of the inventories carried out in the study area showed that the game came from several towns and villages in the vicinity of the inventory locations. Occasionally, animals also come from more distant towns. In view of the large number of villages supplying bushmeat to markets in towns in central, northern and north-western Côte d'Ivoire, we have grouped them according to their sub-prefectures (S/P).

In the Bandama Valley district, the sub-prefectures of Bouaké, Béoumi, Botro, Djébonoua, M'bahiakro, Fronan, Niakara and Katiola supplied markets and restaurants in the towns of Bouaké and Katiola (Figure 5). In this district, the majority of game comes from the Bouaké sub-prefecture (N= 2162; 68.05%). This is followed by the Sub-prefecture of Katiola (N= 918; 28.89%). The Sub-prefectures of Botro, M'bahiakro, Niakara, Béoumi, Djébonoua and Fronan have respectively 0.78% (N= 25), 0.66% (N= 21), 0.28% (N=9), 0.15% (N= 5), 0.09% (N= 2) and 0.06% (N= 3) ranked in order. In addition to these sub-prefectures, hunters from more distant towns (Dabakala 0.66% (N= 21), Odiénné 0.12% (N= 4), Yamoussoukro 0.09% (N= 3) and Korhogo 0.09% (N= 3)) delivered game to markets in Bouaké and Katiola.

In the Savannah district, the villages from which game is sourced have been grouped into nine (9) sub-prefectures (Korhogo, Tengréla, Boundiali, Kouto, Katiola, Odiénné, Niakara, Ferkéssédougou and Tafiré) (Figure 5). The Korhogo sub-prefecture leads with 74.82% (N= 547) of game meat supplies, followed by Tengréla with 11.62% (N=85). Localities such as Boundiali (1.5%; N=11) and Kouto (0.27%; N=2) also supplied game at a low frequency. Other districts, such as those in the Bandama and Denguélé valleys, also supplied the towns of Korhogo and Tengréla with bushmeat. These are the towns of Katiola (0.95%; N=7), Odiénné (0.95%; N=7) and Niakara (0.41%; N=3). The more distant towns of Ferkéssédougou (5.33%; N=39) and Tafiré (4.10%; N=30) also supplied the towns of Korhogo and Tengréla.

In the Denguélé district, game comes exclusively from the Sub-prefecture of Odiénné (Figure 5). In this area, a particular case of exchange was observed between hunters. Hunters from localities in this sub-prefecture (Gbéléban N=22; 4.91%), Léguésso (N=5; 1.11%), Sarana (N=5; 1.11%), Koudougou (N=5; 1.11%), Madinani (N=2; 0.44%), and Toureni (N=2; 0.44%)) also delivered hunting meat to those from the town of Odiénné (09.15%; N=41). Odiénné hunters contributed 83.25% (N=373). The locality of Minignan contributed 4.46% (N=20) to the supply of game. The origin of 14 game animals (3.12%; N=14) was not determined.

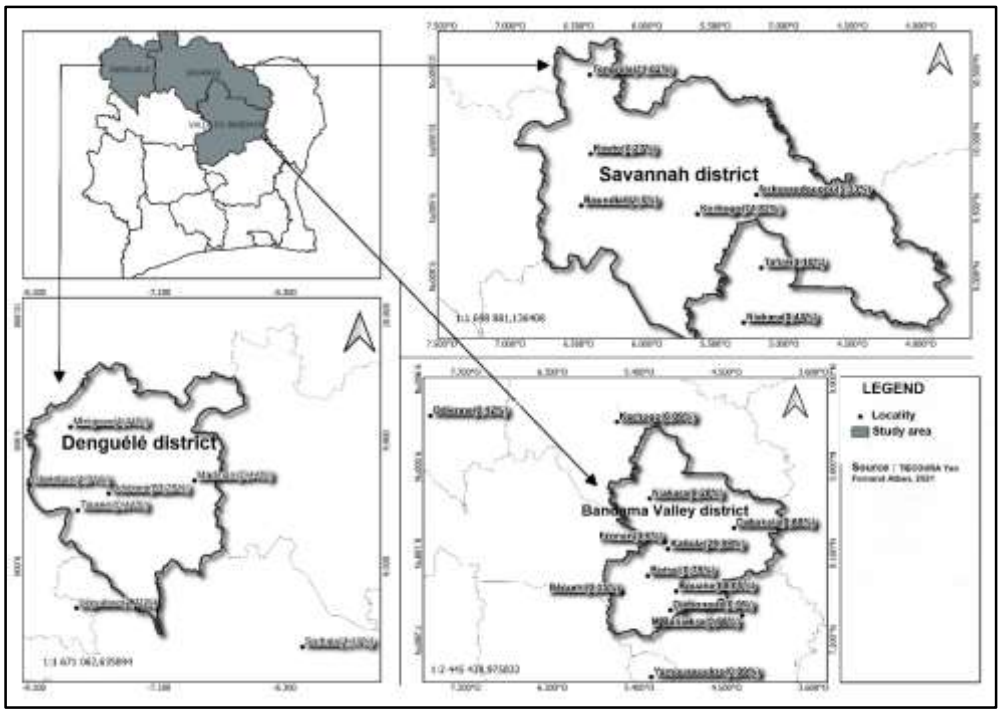

Figure 5 Frequency of game supply by Sub-prefecture

4. Discussion

The results of the study showed that 36 animal species were inventoried in all the localities visited. This species richness is close to the 34 species obtained by [55], in a study conducted in the periphery of the Pendjari biosphere in northwest Benin. The species richness obtained in our study could be due to the extent of our study area and the time devoted to carrying it out. In other studies carried out in Dassioko, in southwest Côte d'Ivoire, 17 species of Mammals were inventoried [29]. This low richness may be due to their relatively shorter sampling period than in the present study.

A large proportion of the animal species traded in markets and restaurants in the localities visited were Mammals, in particular the order Rodents. This trend could be explained by their wide distribution due to their prolificity and adaptation to different natural and disturbed habitats. Similar results have been observed in Congo [56], Benin [55] and Côte d'Ivoire [29]. This large number of Mammalian means encountered during our study would be related to their abundance in the different environments or habitats [57, 55].

These authors assert that small and medium-sized animals are slaughtered more frequently because they are found in abundance in the vicinity of fields, fallow land and village dwellings. Indeed, as in most regions of Côte d'Ivoire, the Bandama Valley, Savannah and Denguélé districts are suffering the consequences of human activities. Thus, natural areas are increasingly used for intensive cultivation [25, 58]. At the same time, rodents and galliformes are found in large numbers around fields, making it easier to capture them with dogs and traps, but also with shotguns and machetes [59].

During this study, the most hunted species was the Greater Cane Rat (*Thryonomys swinderianus*). This high rate of encounters with the Greater Cane Ratin markets and restaurants in our study area can be explained by the fact that its meat is prized by customers from a gustatory point of view. These results are in line with studies by [60] in Ghana. Indeed, this study revealed that the Greater Cane Rat was the most consumed animal species.

In all three districts, the average Shannon index value is 2.5. This high specific diversity of wild species killed in the Central, Northern and North-Western zones of Côte d'Ivoire reflects a significant loss of wild fauna richness in this part of the country. This could be explained by the fact that the demand for game meat from the big cities in the study districts is growing. From a taste point of view, bushmeat is increasingly prized over domestic meat [55]. The possibility of quickly generating income from the sale of bushmeat is a common incentive for hunting. During our study, it emerged that the Sub-prefectures of Bouaké and Katiola were the localities that provided a significant diversity of bushmeat carcasses. This may be explained by the fact that these areas are home to numerous forest islands, the largest of which

is the Haut Bandama fauna and flora reserve [23]. In this collection process, forest areas seem to act as a reservoir for the surrounding hunting zones. Studies carried out in the Congo have shown that localities surrounding natural areas produce more game, as populations practice several types of hunting [61, 62, 63].

5. Conclusion

The aim of this study is to contribute to the sustainable management of biodiversity in Côte d'Ivoire. In doing so, we looked at the specific diversity of hunting fauna on display in markets and restaurants in the northern part of the country. A total of 4356 carcasses were inventoried in the course of this study. Based on morphological characteristics, 36 animal species were identified, divided into 13 orders and 22 families. The order Carnivora is the most diverse.

The mammal class was the most hunted, with 3,372 specimens. The Rodent order is the most represented, with 1991 carcasses counted, and *Thryonomys swinderianus*, the most commercialized species (N=1234; 31.96%).

In addition, the Bouaké and Katiola sub-prefectures provided a wide variety of bushmeat carcasses

Compliance with ethical standards

Disclosure of conflict of interest

The author declares that there is no conflict of interest.

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