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Diversity and Structure of Wildlife in the Nafadji Community Forest, Circle of Kita, Mali

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Abstract: ***Mali still has a few difficult to access areas with natural relics rich in wildlife, such as the Nafadji forest, indigenous protected by populations. The objective of the study is to count the wildlife resource of this forest and to analyze their condition. Kings method has been used to wildlife inventory. A survey was conducted among the populations and the technical services to understand the fauna situation and the management difficulties. In total, 366 individuals divided between 14 species, 10 families and 5 orders were identified with a female's proportion of 55% of higher than that of males. Adult species represent 51%, subadults 27%, young 10%. The Papio anubis species (25.37%) and Erythrocebus patas (17.91%) are the most abundant, followed by Phacochoerus aethiopicus, Canis adustus, Sylvicapra grimmia and Gazella dorcas. The analysis also reveals that habitat and food factors play an important role in the wildlife distribution. Controlling these factors is therefore essential for the effective management of wildlife and its habitat. The involvement of the Nafadji population and hamlets alone is not enough to ensure the wildlife protection, but it will require close collaboration with communities, technical services and other stakeholders in the forest.***

Keywords: Diversity, density, fauna, Nafadji forest, Mali

1. Introduction

Mali once had a rich and varied faunal diversity made up of: 136 species of mammals, 647 birds, 106 reptiles including one endemic, 30 amphibians/amphibians with 2 endemics, and 160 fish with 24 endemics and insects/invertebrates including 6 Sphinx Butterflies. To protect this diversity, it has focused its policy on the creation and implementation of protected areas, currently 26 in number, totaling an area of 9 172 757 ha, or 8% of the territory [1] compared to 12% required by [2].

These areas, despite their protection regime, are not immune, like other forest areas, to the combined effect of man and climate [3], [4], [5]). Numerous studies [6], [7], [8], [9]) carried out in these natural spaces in Mali have shown that the natural resources (flora, terrestrial and aquatic fauna) have declined in Mali due in particular to poaching, illegal and abusive exploitation and the long drought of the 1970 and 1980.

Indeed, the assessment to establish the situation of wild livestock in 1986 by the [10] and the IUCN [2], reveals that after eight years of hunting closure, large wildlife has still struggling to develop, only birds and the smallest mammals have seen their numbers increase slightly. The results of research and inventories in Mali on the degradation factors of wildlife and its habitat carried out within the framework of [6], [11], [12] highlighted the regression or even the disappearance of a large number of wild animals and the vulnerability of certain large spectacular mammals such as the Elephant, the Derby Elk, the Buffalo, the Giraffe, the Chimpanzee. On the other hand, primates and sedentary birds showed growth. This situation of regression of fauna has been confirmed by studies carried out by the [2] and which continues to grow with the extension of crops, transhumant livestock and illegal logging [8], [13], [14], [15]. These studies have attributed declines in animal population densities to high mortality rates caused by overexploitation by Malian and Moorish poachers in Mauritania.

The impacts of transhumant herding, illegal logging [16] and especially poaching have always led to ecological changes in the distribution and habits of wild animal species. Within the animal community, these changes have caused not only the disruption of their reproductive capacities, but also the degradation of natural habitats. Today, it must be recognized that the wildlife potential is seriously reduced and certain species are on the verge of extinction and the current method of managing forest resources does little to promote the conservation and development of wildlife resources hard hit in its diversity [8], [14]) and this despite the start of the development of Public/Private partnership initiatives as an alternative to the involvement of populations and the financial mobilization resources [13].

However, despite the various threats, Mali still has some natural areas rich in wildlife that can still be saved. These are difficult - to - access relics of classified forests and protected areas located in the south - west of the territory and which are of particular importance from a national and

global point of view [17]. These isolated areas and difficult access areas such as the Nafadji forest still contain most of the diversity of mammals [17].

This study is part of the perspective of deepening knowledge of the wildlife resources of the Nafadji ecosystem. This specifically involves: (1) making the current state of wildlife biodiversity in the community forest of Nafadji, (2) determining the distribution by age and sex of the fauna species recorded and their natural increase in this forest.

2. Materials and method

2.1 Study environment

Located in the Senegal River basin between the Sahelian zone in the North and the Sudanian zone in the South, the Nafadji forest bearing the name of the village of Nafadji (Figure 1) is located in the rural commune of Séfeto ouest, Kita circle, region of Kayes covering an area of approximately 10 000 ha. According to the [18] studies (1982), Nafadji is located in the agro - ecological zone of upper Kaarta, the mountain range in particular: the Sangarou, the Kouroufing and the extension of the Galla Kourou. Distant about 360 km northwest of the capital Bamako, it is limited between latitude 13.54° to 14.24° North and longitude 9.97° to 10.17° West. The mountains also form the administrative boundary between the Diallan rural commune (Bafoulabé circle) to the north and Séfeto Ouest (Kita circle) to the south. The villages and hamlets bordering the study area are: Nafadji, Seramissé (Sefeto Ouest commune), Samine and Sobé (Diallan commune).

The climate is northern Sudanese type with alternating dry and rainy seasons with a general downward trend. The rainy season begins in the area from the May month to reach its peak in August where the heights of rain can be greater than or equal to 250 mm. This period of heavy rain corresponds to the high humidity period and mild temperature (25°C). The hot weather rages during the dry season between March and May and gradually fades from June. It is also during this period that evapotranspiration is high and would correspond to a sunshine duration of around 2969 hours [19].

The relief is made up of a plateaus set with an altitude of 200 m to 500 m dotted with residual reliefs such as the "Kita Kourou" which culminates at 500 m from the central plain and serves as refuges for wildlife.

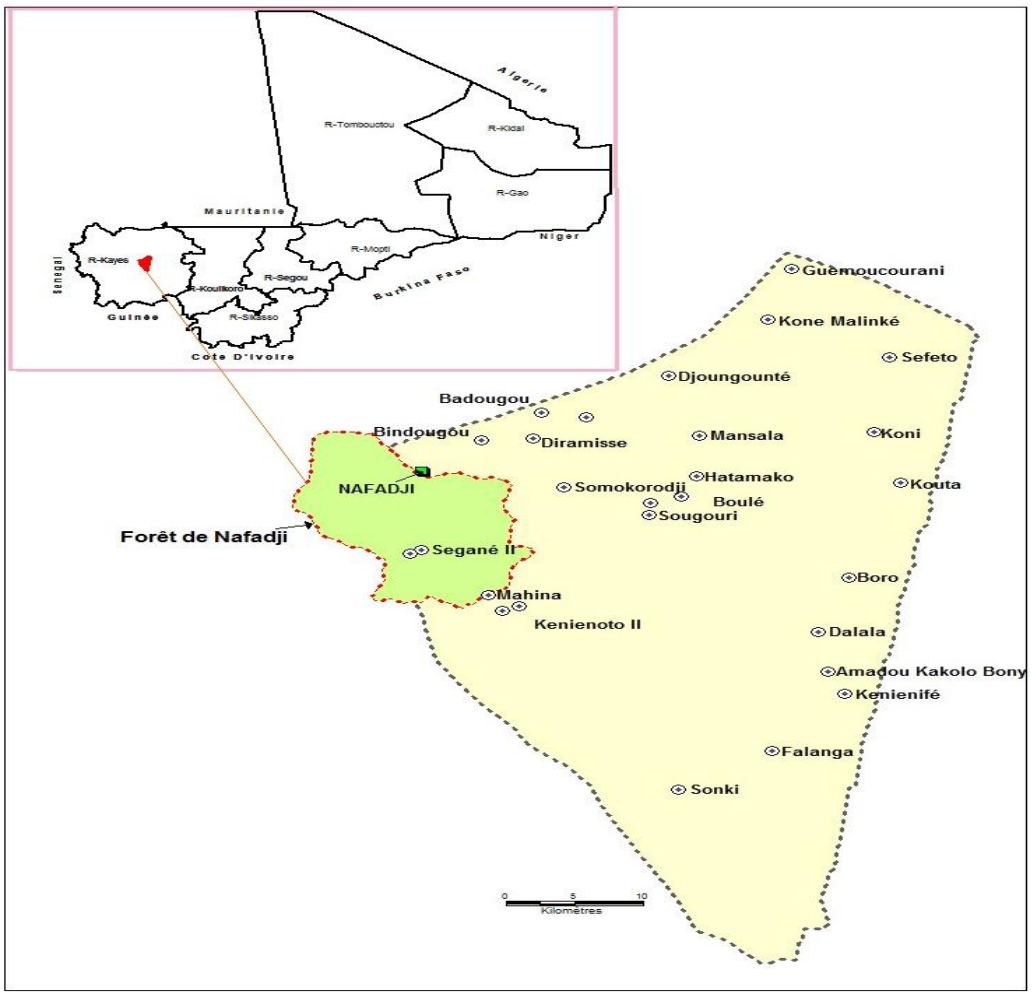

Figure 1: Geographic location of the area

It is flat on the south side and very uneven towards the north and west part of the forest and the soil is of Tc4 type (Armoured Earth) whose soils are characterized by a moderate depth before reaching the armor according to [18] which corresponds to armored terrain whose soils are characterized by a moderate depth before reaching the

armor. The Nafadji forest is entirely located on this type of soil. The surface texture is loamy, often sandy with fine silt. Below the surface, it becomes clay silty with the gravels presence. The structure is weak and subangular blocky or granular. The soil is friable when moist throughout the profile. The pH ranges from moderately to strongly acidic at depth.

The hydrographic network is marked by small streams that originate at the hills top of Kouroufing, Sagarou, Galla kourou and Naliokourou. The most important is the Kouaga river with its tributaries which flow into the Bagoue at the Badoumbé level.

The forest contains at least six (6) permanent water points Malandji, Gnonketo, Dialanikorodji, N'Gagnadji, Kitora, Wontimé which are very important for wildlife and livestock resources in the area. The area also contains large streams that dry up as soon as the rains end. However, it is influenced by the Bakoye River course which constitutes the natural limit to the north.

The population of the study area is 4 084 inhabitants for the two major villages in the area, including 3 000 inhabitants for the village of Nafadji and 1 084 inhabitants for that of Siramissé with a number of women (50.4%) slightly higher than that of men (49.6%). In addition to this permanent workforce, the village of Nafadji includes five cultivation hamlets (Kéniénoto I and II, Mahina, Segané I and II) which are only inhabited during the rainy season to set up crop fields there.

Agriculture is the population main activity. It is extensive with basic equipment and revolves around cereal crops (sorghum, maize, pearl millet, cowpea, lowland rice) mainly intended for local consumption and cash crops (peanuts and cotton) and production market gardening (onion, shallot, sweet potato, papaya, okra, carrots, pepper, tomato, cucumber, and cabbage) which contribute significantly to the local and regional economy. Livestock is developing gradually (1, 371 cattle, 1, 375 sheep/goats, 256 donkeys and 12 horses) and constitutes a more or less secure means of saving, especially for women.

2.2 Method

The tools used to collect the data are composed of maps, satellite images and field tools. National topographic maps were used to identify the topography of the study area, the link with the Baoulé loop reserve. The survey sheets (interview guides) and wildlife inventories were used to report the information collected. Two tapes of 50 m and 100 m were used to measure the viewing distance of wildlife. A SUUNTO brand compass was used to measure the angles of view of the animals and two (2) binoculars for distant visions, a high resolution Nikon digital camera was used for shooting to illustrate the thesis. The global positioning system (GPS) was used for the georeferencing of the forest and all phases of wildlife inventories (photo 1).

Photo No. 1: Some materials used for the works.

2.2.1. Collection of data

Socio - economic surveys

The so - called "participatory mapping" method [20] consists of using the knowledge of local actors to map their land. With the help of the Nafadji population, a sketch on paper of the various land use zones that they recognize on their land is made. These areas, as well as the limits of the land following the natural limits (watercourses, hills), were then surveyed using a Garmin 90 GPS, circumscribed on the spot with the collaboration of the villagers.

Beforehand, documentary research was carried out to summarize the work and studies carried out in the Baoulé reserve (Block of Badinko), the Social and Economic Development Programs of the Kita circle and other documents (annual reports of the Kita Cantonment Waters and Forests). This work served to deepen knowledge of the environment and especially of the wildlife resources of the study zone.

Individual interviews and group meetings based on an interview guide developed for this purpose are organized with institutional actors, associative structures and resource persons. The approach taken is much more semi - structured leaving a large part to the discussion and exchange with the interlocutors. The purpose of these meetings was to exchange views in order to identify the different wildlife species in the current environment, endangered species, potential habitats, the site's natural water points, human pressure on wildlife resources, conservation of wildlife resources at the local level, etc. The villages and hamlets bordering the Nafadji forest were covered by the interviews.

Wildlife inventory work

The environment nature and the means available were the determining criteria in the choice of the inventory method. After reading the Topo funds to 200 thousandths (Sandaré ND_29 XIV and Bafoulabé ND_29 VIII) and prospective field visits, the transect sampling method King, 1933 described by [21] was used. It consists of by pedestrian counting to cover a restricted area in order to provide clues to the animals presence [22], [23]. In the field, the chosen route is traveled by counting fauna by visual or auditory contact on either side of the progression line. The the transect length, defined beforehand on a map with the coordinates of the entry and exit points, varies from 8 to 11

km, and in East - West direction and 2 to 5 km apart between them to minimize the risk of double counting. The census in the transects was done early in the morning and in good weather when the animals showed up more vigorously.

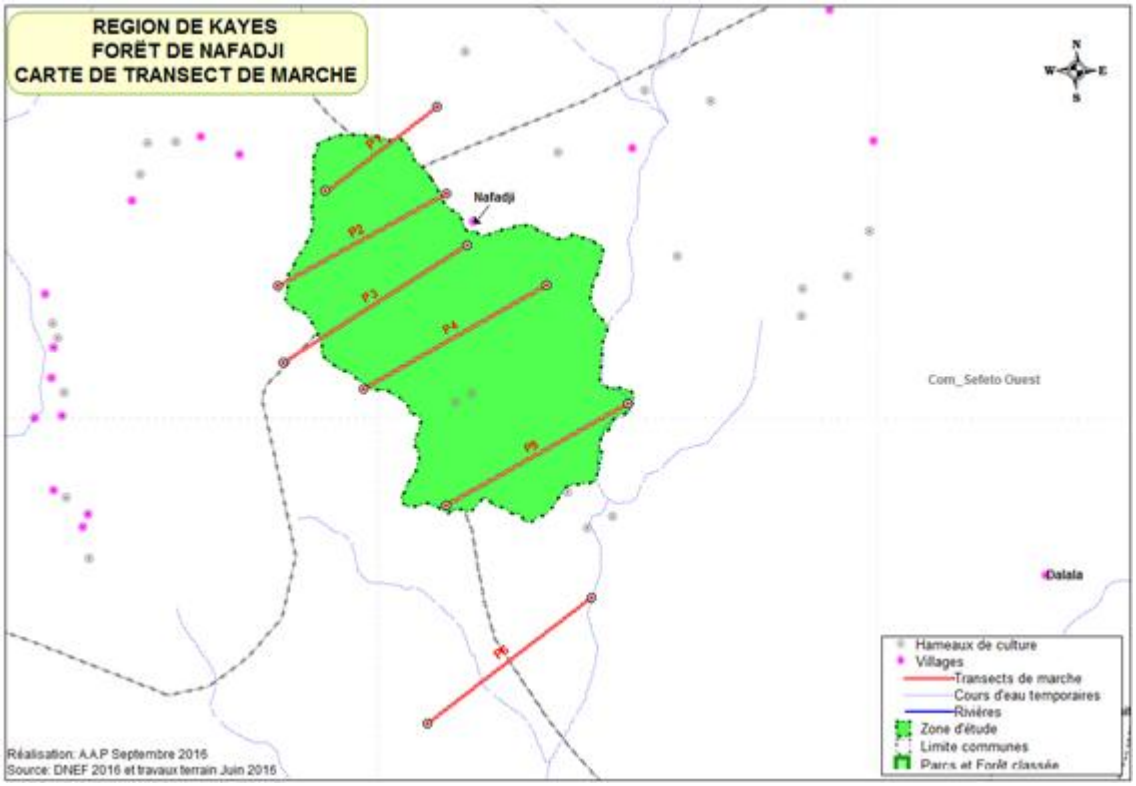

Figure 2: Carte de transects de la faune de la forêt de Nafadji.

2.2.2. Data collection and processing

Statistical and cartographic analyzes were performed by specific objective.

Global faunal diversity was made by counting all the species encountered, their traces (droppings, prints, carcasses, etc.). The individuals of species counted were distributed by sex and age category. The determination of sex and age category was made with the support of two operators (hunters) during the fieldwork.

Global density D_t is calculated from the formula:

$$D_t = \frac{\left\{\sum_{i=1}^{n} (Ni)\right\}}{\left\{\sum_{i=1}^{n} (S_i)\right\}} \leftrightarrow Dt = \frac{Nt}{St}$$

Ni: number of animals of the species counted in sample unit i; Si: area of sample i; n: number of sample units counted; Dt: Total density; Nt: total number of animals of the species; St: total area.

Population growth or the increase was calculated ignoring the limiting factors or specific intrinsic factors (food, space, etc.) both to the environment and to the species (predation, disease, lack of food, epidemic, poaching, bush fires, transhumance, etc. . .). Indeed, a natural environment with a natural population never lacks limiting factors, better still, the growth of a population in a natural environment with limited resources cannot be exponential in nature for long, because the resistance offered to it by this environment is shows more intensely that the densities are stronger.

For a given population of a stable environment sheltered where all limiting factors, among others, are artificially eliminated, the numbers of this population will grow indefinitely according to an exponential law as a function of time. Suppose that **No** is the size of the population at time to, **Nt** the number of individuals at time **t**, **r** the rate of natural increase specific to the species (intrinsic rate of increase) and e the exponential, we has for this population the relation:

$$Nt = No^{ert}$$

This function according to the method gives a J - shaped exponential curve.
The intrinsic rate of natural increase r is conditioned by the birth rate and the death rate.
If b is the intrinsic birth rate and m the intrinsic death rate, we have:

$$r = b - m$$

A population increases when **r** is positive and the expected increase **I** is calculated by multiplying the natural growth rate by the current size **N** of the population.

$$I = r\,N$$

Data processing and analysis

The counting, processing and analysis of the data collected were carried out using Word and Minitab 16 (2010) programs used respectively for data entry and processing. MapInfo 10.5 software was used to produce the maps and also to generate the boundary coordinates of the study area.

The document "Guide to Mammals - Reptiles and Birds [24]" was used to identify the mammals and determine, with the support of the hunting guide, the sex of the species either by the difference in size, or by peeling, etc.

3. Results

3.1 Wildlife diversity

It was counted in the forest of Nafadji (Table 1), a total number of 366 individuals divided between 5 orders, 10 families, and 14 species. For all the species observed, *Papio anubis* (25.37%) and *Erythrocebus patas* (17.91%) are the most abundant and with the highest densities per km². These two species are followed by: *Phacochoerus aethiopicus*, *Canis adustus*, *Sylvicapra grimmia* and *Gazella dorcas*. The kilometric density varies from 0.47 to 0.03. It is very low, less than one faunal individual per km².

Table 1: Inventory of individuals species identified and density per Km²

Order	Familly	Species	effective	%	Density/km²
Primates	Cercopithecidae	*Papio anubis*	66	17.91	0.33
Artiodactyls	Bovidae (Cephalophinae)	*Sylvicapra grimmia*	22	5.97	0.11
Carnivores	Canidae	*Canis adustus*	27	7.46	0.14
Carnivores	Viverridae	*Viverra civetta*	5	1.49	0.03
Artiodactyls	Bovidae (Gazelophinae)	*Gazella dorcas*	22	5.97	0.11
Artiodactyls	Bovidae (Tragelaphinae)	*Tragélaphus scriptus*	5	1.49	0.03
Carnivores	Hyenidae	*Hyena hyena*	16	4.48	0.08
Artiodactyls	Bovidae (Hippotrague)	*Hippotragus equinus*	11	2.99	0.06
Tubilidentes	Oryctéropidae	*Orycteropus afer*	16	4.48	0.08
Artiodactyls	Suidae	*Phacochoerus aethiopicus*	44	11.94	0.22
Rodents	Hystricidae	*Hystrix cristata*	16	4.48	0.08
Carnivores	Mustelidae	*Mellivora capenssis*	16	4.48	0.08
Primates	Cercopithecidae	*Erythrocebus patas*	93	25.37	0.47
Artiodactyls	Bovidae (Reduncinae)	*Redunca redunca*	5	1.49	0.03
Total (5)	**(10)**	**(14)**	**366**	**100**	

3.2 Distribution by sex and age of individual's species listed

Table 2 shows that, of the 224 observations for a total of 366 individuals, the sex of 20 could not be determined. The proportion of females is higher than that of males, 55% and the sex not determined 8%. This superiority of females is an interesting prospect for the wildlife manager because it is synonymous with the possibility of increasing the population and therefore of biological recovery.

Table 2: Distribution by sex of individual's species listed.

Espèces	NO	SND	Male	Female	Sex ratio
Papio anubis	16	0	22	44	0.5
Sylvicapra grimmia	22	1	5	16	0.33
Canis adustus	27	0	11	16	0.66
Viverra civetta	5	0	5	0	0
Gazella dorcas	22	0	11	11	1
Tragélaphus scriptus	5	0	0	5	0
Hyena hyena	16	0	5	11	0.5
Hippotragus equinus	11	1	5	5	1
Orycteropus afer	16	0	5	11	0.5
Phacochoerus aethiopicus	11	0	11	33	0.33
Hystrix cristata	16	0	11	5	2
Mellivora capenssis	16	5	0	11	0
Erythrocebus patas	33	13	33	49	0.66
Redunca redunca	5	0	0	5	0
Total	**224**	**20**	**124**	**222**	**8, 06**

NO: Number of Observations; SND: Gender not identified.

The analysis of the observations on the age distribution (Table 3) focused on adults who are at 51%, sub - adults 27%, young people estimated at 10% of the workforce.

Table 3: Distribution by age of individual's species identified

Scientific Species	Number	Adult	Subadult	Young	ANI
Papio anubis	66	22	22	5	19
Sylvicapra grimmia	22	11	5	0	6
Canis adustus	27	16	5	5	1
Viverra civetta	5	5	0	0	0
Gazella dorcas	22	22	0	0	0
Tragélaphus scriptus	5	5	0	0	0
Hyena hyena	16	5	5	0	6
Hippotragus equinus	11	11	0	0	0
Orycteropus afer	16	5	5	5	1
Phacochoerus aethiopicus	44	16	11	16	1
Hystrix cristata	16	11	5	0	0
Mellivora capenssis	16	11	5	0	0
Erythrocebus patas	93	38	38	16	1
Redunca redunca	5	5	0	0	0
Total	**366**	**186**	**104**	**49**	**36**

NO: number of observations; SA: subadult; ANI: age not identified.

3.3 Population increase

In a natural environment where resources are available for each individual such infinite growth is possible in this scenario of growth in the absence of limiting factors. From the birth numbers given during surveys for large mammals in the Nafadji forest, an annual intrinsic growth rate is calculated for each species. This rate varies from 50% to 5% depending on the species.

Table 4: Population increase

Species	POP 2016	ARI in %	POP 2017	POP 2018	POP 2019	POP 2020	POP 2021	Accroissment in 5 years
Papio anubis	66	14	76	87	100	116	133	67
Sylvicapra grimmia	22	15	26	30	35	40	47	25
Canis adustus	27	50	45	73	121	200	329	46
Viverra civetta	5	50	8	14	22	37	61	9
Gazella dorcas	22	50	36	60	99	163	268	38
Tragélaphus scriptus	5	50	8	14	22	37	61	9
Hyena hyena	16	5	17	18	19	20	21	17
Hippotragus equinus	11	25	14	18	23	30	38	15
Orycteropus afer	16	10	18	20	22	24	26	18
Phacochoerus aethiopicus	44	50	73	120	197	325	536	75
Hystrix cristata	16	10	18	20	22	24	26	18
Mellivora capenssis	16	14	18	21	24	28	32	19
Erythrocebus patas	93	14	107	123	142	163	187	111
Redunca redunca	5	50	8	14	22	37	61	9

NB. The growth rate is given from the percentage of births and deaths from the forest management committee. POP: Population; POT: Population totale; ARI: Annual rate of increase

Figure 3 below shows an exponential increase of two species, one of which is the most abundant and the second rare and threatened with extinction in the area. This figure shows an increase in the population, especially of the species *Erythrocebus patas*, which is under less human pressure (poaching), unlike *Orycteropus afer*, which is disappearing in the area.

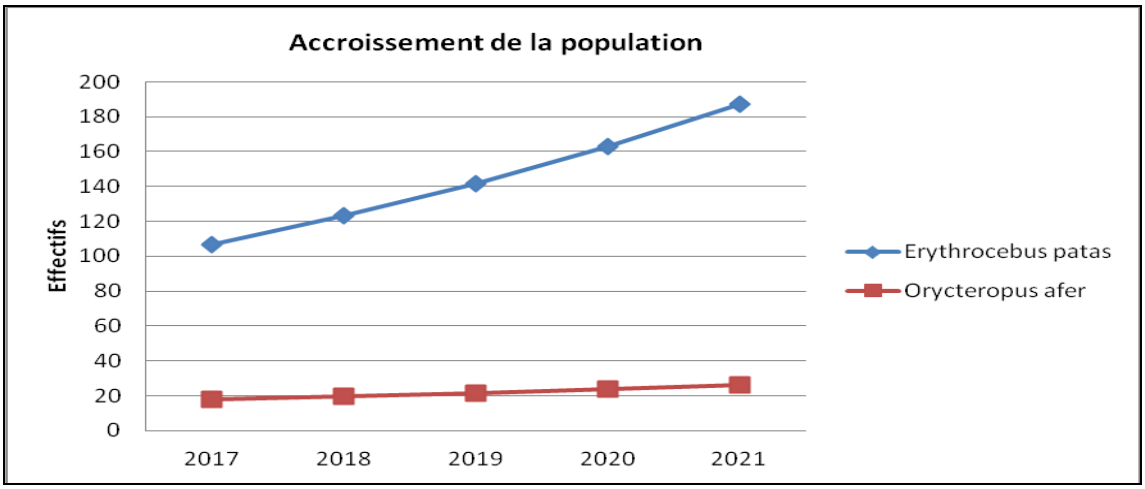

Figure 3: Population growth of *Erythrocebus patas* and *Orycteropus afer*

4. Discussion

The faunal inventories made it possible to count on a forest surface of 10 000 ha, 14 species of mammals, 10 families and 5 orders with a low density per km². In terms of diversity, the *Bovidae* species of the Artiodactyle order are the most represented. The weakly observed species are among others *Redunca redunca*, *Tragelaphus scriptus* and *Viverra civetta*. But in terms of numbers, it is the *Cercopithecidae* of the order of primates that are the most abundant in this forest. Overall, the number of species at 14 is very low compared to that of the 70 terrestrial mammal species listed by the IUCN [25] in Mali, which, according to [26], [8] once had an extraordinary faunal capital but today it has become one where practically all faunal species are considered to be in danger. According to the hunter [27], the low number is explained by the season (May - July) of the inventories which corresponds to the period of calving which is not very favorable for observing the wild animals which hide in their shelter to shelter from predators in order to secure their offspring as much as possible.

Notwithstanding the low number of species, in view of the favorable conditions of the current habitat of the Nafadji forest according to the populations, a biological increase is perceptible in terms of species and individuals. Compared to our results, the very first inventory study carried out by [28] which was limited to the northern part contiguous to the Nafadji forest (Sangourou hill) identified with the same inventory device, a total of 10 species out of a population of 239 individuals. The case, for example, of our *Hyena hyena* study, which was 10 individuals in the ecosystems of the Sangourou hill, has increased to 16.

The inventory studies carried out by [29] and the [14] in the Baoulé reserve clearly indicated a certain biological increase, especially in species of the genus *Hippotragus*, *Redunca* and *Papio*, but had emphasis on their great vulnerability to threats linked to the fragmentation of their natural habitats and to anthropogenic pressures (transhumant herding, poaching). Fragmentation accelerates the degradation of wildlife habitats [30]) resulting in the gradual decline of wildlife populations [26], [31]. As in Mali, in many African countries, wildlife is decimated due to difficult living

conditions marked by their overexploitation and the destruction of their habitat [32].

The determination of the sex was laborious especially during the nocturnal inventories where the visibility was really low. The experience of hunters was a vitally important contribution to sex determination. The analysis of the results indicate a clear dominance of the female sex, which is in favor of reproduction, growth of the wildlife population and augurs for a possible biological recovery in the community forest. The studies of [6] and [12] had made the same observation of the superiority of females and also reported the low density per km² and a worrying regression of large fauna following a strong poaching pressure from populations.

The low percentage of young (27%) against 57% for adults and 27% for subaldults is explained by the inventory period (September - October) which corresponds to the reproduction period of large and medium - sized fauna with environmental protection conditions more favorable due to the low visibility linked to the tall grasses. These same observations were made by [33] in the Baoulé reserve who underline that the limits of direct observations in the field during this period are real due to the low visibility linked to the high density of the biomass. Herbaceous, but above all to the apparently nocturnal behavior of many of the species of fauna which, by nature, are diurnal.

The current behavior of the species in the fairly disturbed environment (human and pastoral pressure) constitutes one of the difficulties for their direct photography during the inventories. To this end, some hunters point out that more and more species are hiding in inaccessible places and others seem to be more active at night (nocturnal) than during the day (diurnal) to protect themselves against poaching. Currently, given the isolation of the Nafadji forest and the awareness of the populations on the need to protect wildlife, should we believe that diurnal species are having nocturnal behaviors to ensure their survival and would be the cause of their low observation during the inventories? This assertion remains to be verified because it seems to indicate a life adaptation strategy of species to different threats.

In general, large ungulate mammals have seen their chances of survival considerably reduced in the Baoulé Reserve due to the strong disturbance of the environment. This pushes them to take refuge in places that are difficult to access, such as the Nafadji forest, which offers them conditions of tranquility.

5. Conclusion and Perspectives

The study contributes to the knowledge of the baseline situation of wildlife resources in the Nafadji forest, studies of which are rare.

The device used for the inventory (transects) offers more visibility of large fauna in fairly open natural formations. However, the nature of the terrain (escarpment) and the rainy season for the second phase (September) constitute limits in the estimation of individuals in the middle. Also, the inventory period was considered not conducive to identify all the species. The ideal would be the period (November - January) or (May - June) which would respectively correspond to the departure and return of the large fauna from the Badinko reserve to the Guinean part in transit in the Nafadji forest.

It should also be recognized that the lack of sufficient reference data on the size of wildlife populations constitutes a limit to the objective analysis of the dynamics of wildlife resources in this forest.

In perspective, this study is an important start to the development of a forest management plan and the planning of monitoring activities at the ecosystem level. Good wildlife management requires a better knowledge of population dynamics, their movement, behavior and spatial distribution or distribution, the different modes of harvesting, use and their impacts on the natural resources of the area concerned. A study would be necessary in this direction with in addition that relating to the pastures as well as their carrying capacity.

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