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Eco-ethology of the primate population in the north-eastern periphery of the Dja Biosphere Reserve (South/East Cameroon)

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Abstract
Conserving the world's biodiversity is one of today's strategic challenges for sustainable development. Primates are increasingly threatened by habitat destruction, climate change and poaching. The aim of this article is therefore to study their behaviour in the wild as well as the ecological factors that influence this behaviour on the periphery of the Dja Biosphere Reserve, with the aim of improving their conservation. To do this, direct methods based on the counting of primates observed during reconnaissance walks along the transects and outside the transects in various vegetation facies (old secondary forest, young forest, riparian forest, swamp forest and forest gaps) made it possible to count 826 individuals divided into 6 species. The species *Cercopithecus pogonias* is the most abundant with 373 individuals, i.e. 45.16%, followed by *Cercopithecus cephus cephus* (228 individuals), representing 27.60% and finally *Cercocebus agilis* (133 individuals), i.e. 16.10%. The species with the lowest representation are *Pan troglodytes* (1.45%) and *Lophocebus albigena* (2.91%). This population of primates is made up mainly of adults (365 individuals) and juveniles (256 individuals). These primates are essentially frugivorous, which is why they are concentrated in the sectors where certain tree species are found, such as *Upaca* sp. which account for 30.60% of the primate population, followed by *Irvingia gabonensis* (8%), then *Landolphia* sp. (7.26%) and finally *Terminalia superba* (6.42%). Most primates in the periphery of the Dja reserve (35.42%) feed in the morning before noon, while only 14.58% do so in the afternoon. The majority of these primates also wander around in the morning (27.08%) more than in the afternoon (12.05%), certainly in search of food. These primates are found in young (62.11%) and old (27.97%) secondary forests. Very few frequent or inhabit raphias, riparian forests or forest gaps. However, there is a significant difference between the number of individuals in mature secondary forests and young secondary forests. Understanding the behavioural ecology of these primates is therefore important to improve their conservation.

Keywords: eco-ethology, primate, biosphere reserve, Dja, Cameroon

Introduction

The conservation of the world's biodiversity is nowadays one of the strategic challenges of sustainable development. Faced with the threats (deforestation, poaching) to biodiversity, a legal system has been implemented at the international and national levels to guarantee the sustainable conservation of biodiversity. These include the 1973 CITES on international trade in endangered species of wild fauna and flora and the 1992 Convention on Biological Diversity. At the national level, Cameroon has put in place law n°93/01 of 23 January 1993 on the regime of forests, wildlife and fisheries and the framework law of 5 August 1996 on environmental management.

According to IUCN (2014b), the majority of the world's gorillas and about one third of the world's chimpanzees live in the tropical rainforests of Western Equatorial Africa. These primates attract considerable conservation interest and funding due to their close relationship with humans and their status as a global symbol of species protection. As a result, they are often protected through strictly controlled and enforced conservation zones (IIED and CIFOR, 2012).

Among primates, chimpanzees are much more versatile than gorillas in terms of suitable habitat. They adapt to a variety of habitats including forest-savanna mosaics, woodlands and tropical rainforests.

However, chimpanzees are predominantly frugivorous and dependent on high fruit-producing forests, which underlines the importance of access to primary and secondary forests. Loss of large areas of forest and habitat degradation can reduce their numbers and lead to local extinctions in the medium to long term (IUCN, 2012). These apes are also in dramatic decline due to poaching, disease, habitat loss due to, among other things, the expansion of industrial agriculture and illegal logging encroachment in the south-eastern part of the reserve (IUCN, 2014a). In the same vein, it can be noted in the work of Galat-Luong and Galat (2000) that the increase in human pressure linked to recent modifications risked leading to the disappearance of species: *Procolobus badius* and *Cercopithecus diana* initially, *Pan troglodytes* and then *Cercocebus atys*. This situation has led to a relative decline in the gorilla population, although the chimpanzee population is showing signs of steady stability due to the changing interests of poachers and the quality of the habitat in and around the reserve (MINFOF/IUCN, 2015). Given the interest in conserving biodiversity and specifically primates, which are a natural heritage to be preserved for future generations, and in view of the threats they face, including their habitat, it was therefore important to study their ecological characteristics in order to be able to set up more effective conservation strategies.

Materials and method

1. Geographical framework of the study

The Dja Biosphere Reserve is located in the southern part of the country, straddling the East and South Regions in the Upper Nyong and Dja et Lobo Divisions respectively. It lies between 2° 40 and 3° 23 North latitude and 12° 25 and 13° 35 East longitude (Fig. 1). However, the area studied is located more precisely in the south-west of the 10047 Forest Management Unit, at the north-eastern periphery of the Dja Wildlife Reserve, between longitudes 13.11° and 13.17° E and latitudes 3.37° and 3.45° N (Fig.2).

The Dja Biosphere Reserve, now classified as a UNESCO World Heritage site, and its peripheral zone are home to a large number of these primates, which not only attract many tourists, but also constitute an ecological heritage to be preserved for future generations and the maintenance of ecosystem balance. It was created by decree n°2077/1029/PM of 9 July 2007, following the decree n°319 of 26 June 1950 creating a wildlife and hunting reserve in the Ntem and Upper Nyong regions. With an area of about 526,000 hectares, this reserve is one of the largest and best protected rainforests in Africa, with a large part of its area still virgin. It is especially remarkable for its biodiversity, with 107 species of mammals, including a wide variety of primates (14 species) living there, some of which are now endangered, such as the western lowland gorillas. On the strength of this exceptional biodiversity, it was set up in 1981 as a biosphere reserve and was later listed as a UNESCO World Heritage Site in 1987(Bahuchet and Leclerc, 2000).

At that time, however, 90% of the area is still considered to be intact and human pressure is still low. The reserve is home to a large number of animal and plant species, several of which are endangered. The most threatened primates at the global level are the western lowland gorilla and the chimpanzee.

The relatively favourable ecological conditions, the abundance of food resources and above all the natural character of the habitat explain the presence of primates in this protected area.

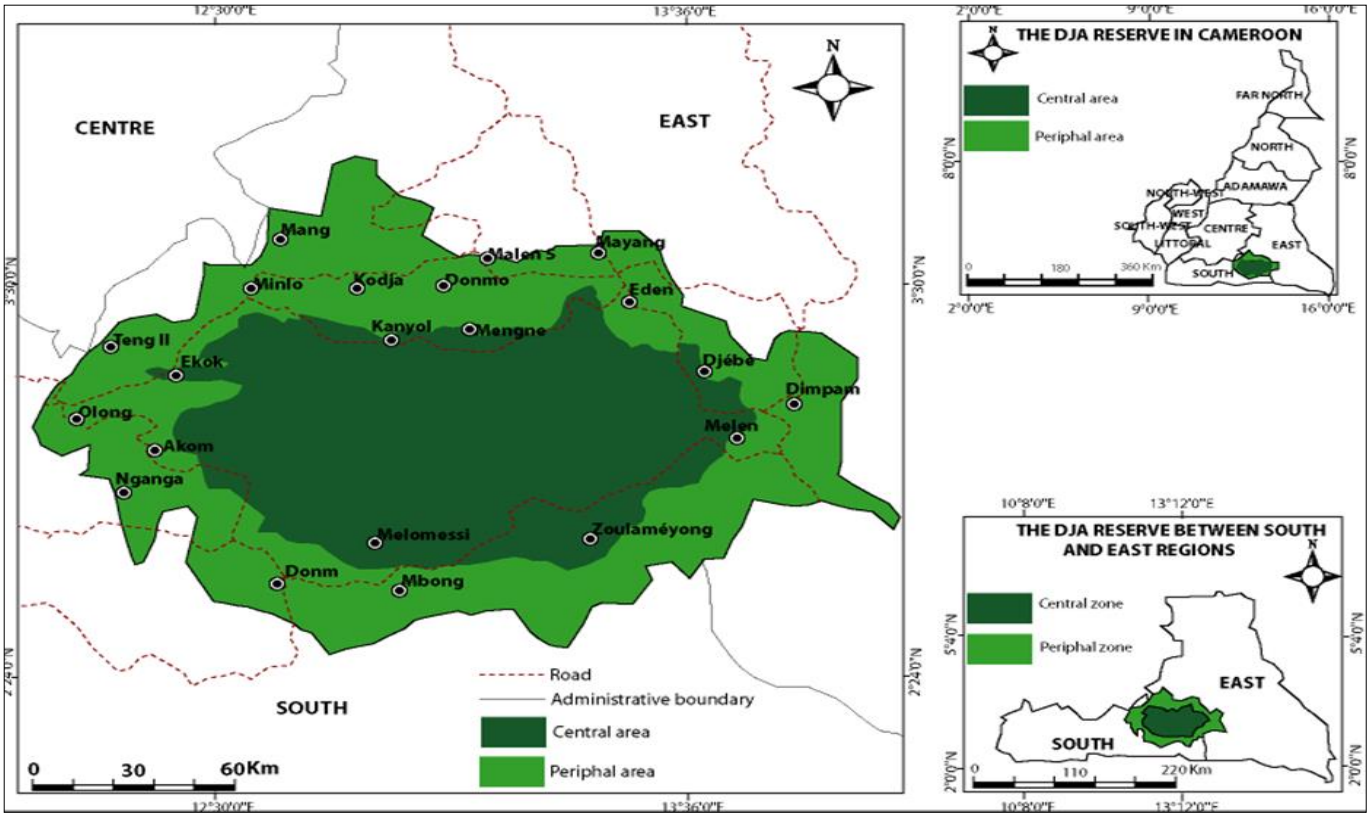


Fig 1: Location of Dja Biosphere Reserve

2. Tools and methods

2.1 Tools

Several tools were used to collect data in the field, including

- A NIKON digital camera for taking pictures in the field;
- A GARMIN GPS for geolocating sites or points;
- Survey sheets for recording observations;
- A notepad for collecting field data.

2.2 Method

This research work began with the collection of documentary data on the sociology of primates, their diet and their habitat from the library of the association for the protection of great apes.

Subsequently, further data was collected in the field on the northern periphery of the Dja reserve by direct counting methods through a reconnaissance walk during which direct observations and surveys of primate habitat types were made.

The reconnaissance walk consisted of daily walks in random directions along transects, between transects and into the forests beyond the area where the transects were marked (Fig. 2) with two local guides familiar with small primates (monkeys) to observe primates. Binoculars were used as much as possible during this operation. The guide's role was to identify trees and habitat types. The walks started early in the morning from 6.30 am and continued throughout the day until 5 pm in the evening. During the walks, efforts were

made to minimise noise as much as possible in order to observe as many small primates as possible and to collect relevant data. Whenever a group of small primates was encountered, the species name was determined and information on group size (number of individuals) and group composition (adults, sub-adults, juveniles and infants) was recorded as much as possible. In addition, activity patterns were studied and it was noted whether the monkeys were feeding, resting, playing/socialising or moving around at the time they were initially spotted. During the observations, the time spent by the monkeys performing any activity was recorded.

In addition, the type of vegetation present was determined each time a group of primates was encountered. Vegetation types included mature forest (KAA), old secondary forest (KA), young secondary forest (KJ), tree gaps (TA), riparian forest (RIP), and raffia or swamp forest (RAP). These data were recorded on a data collection sheet.

The data collected were analysed using Excel spreadsheets in order to produce dynamic cross-tabulations and graphs showing the frequencies of the different variables in the results obtained, as well as the relative abundance of primate species and plant species that serve as food or habitat for these primates.

Analyses of variance (ANOVA) were also carried out using SPSS software to compare the variances between the means of the number of primates distributed in different habitats.

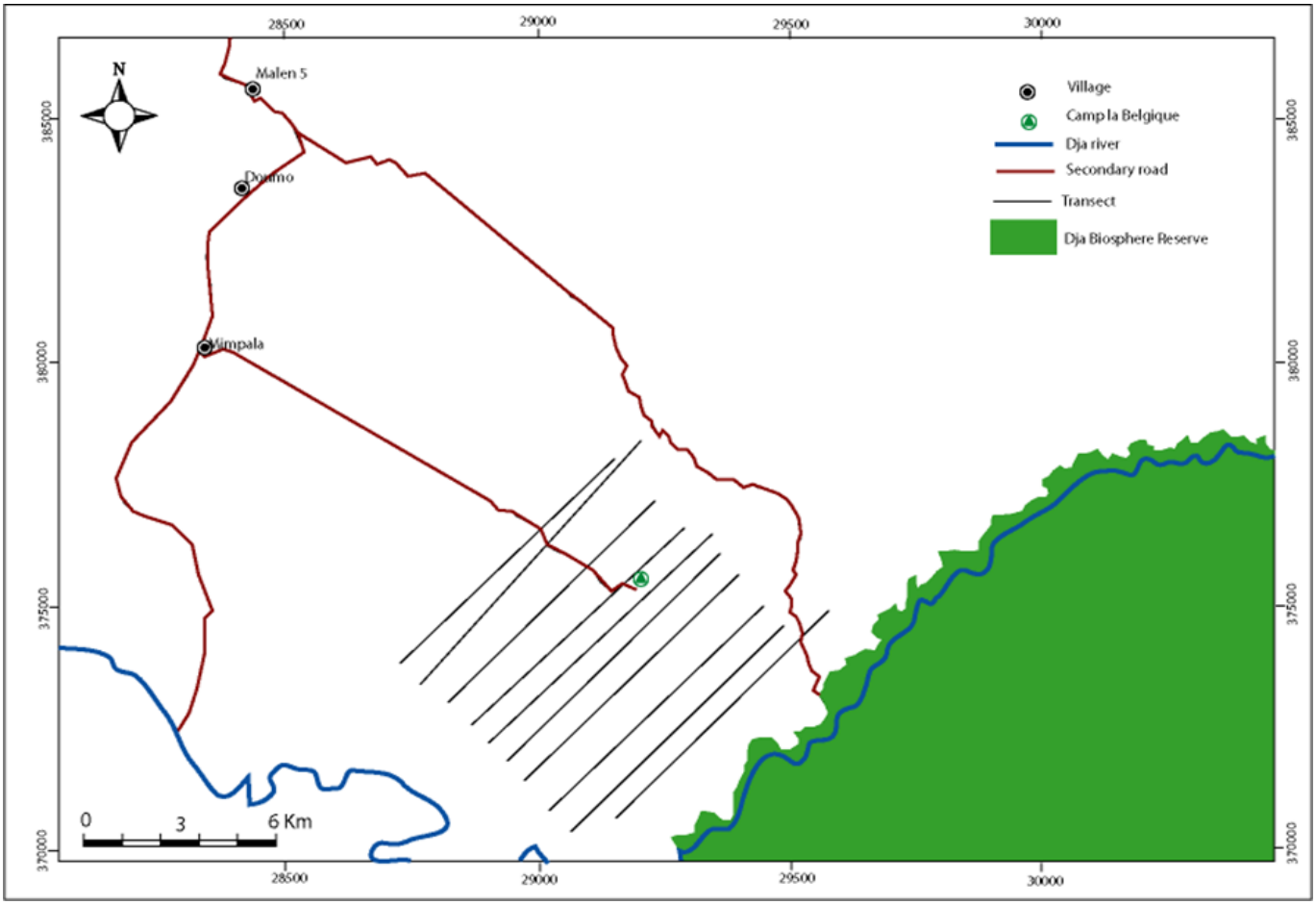


Fig 2: Layout of transects in the study site

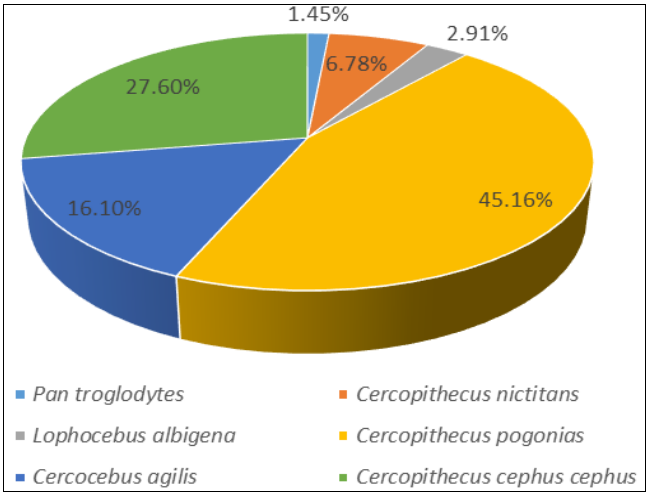
Results

1. Relative abundance of primates

The study of the relative abundance of primates on the periphery of the Dja reserve shows that out of the 826 individuals recorded and divided into 6 species, the species *Cercopithecus pogonia*s is the most abundant with 373 individuals, i.e. 45.16%, followed by *Cercopithecus cephus* (228 individuals), representing 27.60% and finally *Cercocebus agilis* (133 individuals), i.e. 16.10%. The species with the lowest representation are *Pan troglodytes* (1.45%) and *Lophocebus albigena* (2.91%) (Fig. 3). The low proportion of individuals of this species could be explained by the preferences of poachers for these species, leading them to exert strong pressure on their population.

This primate population is made up mainly of adults, with 365 individuals recorded, and juveniles, with 256 individuals. Furthermore, the populations with the lowest representation are *Pan troglodytes* (12 individuals) and *Lophocebus albigena* (24 individuals). Considering the level of maturity, the largest number of adults (171) and juveniles (138) is found in the *Cercopithecus pogonias* population.

This species is followed by *Cercopithecus cephus cephus* with 106 adults and 56 juveniles (Table 1). The analysis of the relative abundance of primates therefore shows that the high number of adults and juveniles in the population is indicative of low pressure on the primates and their high reproduction.



Source: Fieldwork, July 2022

Fig 3: Relative abundance of primates on the periphery of the Dja reserve

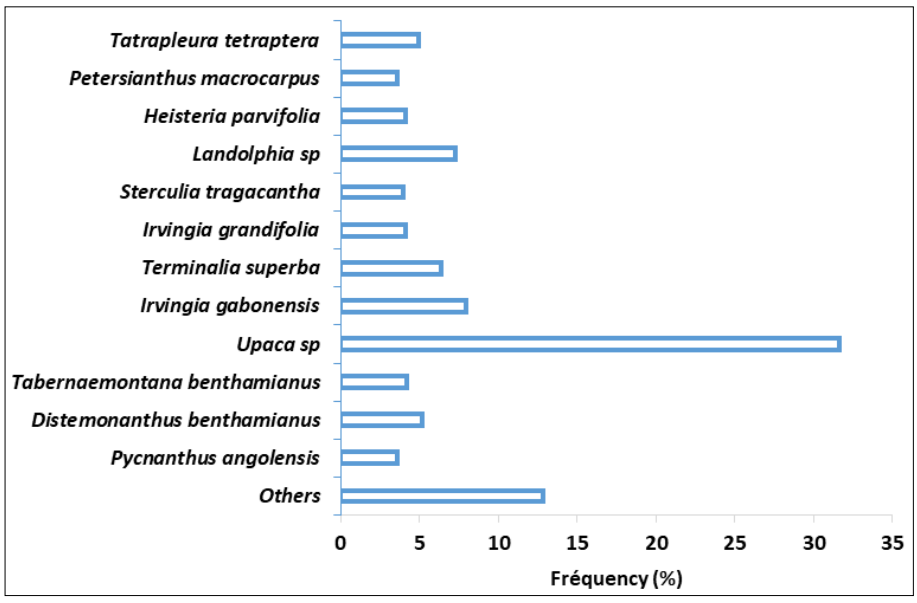
Table 1: Distribution of primates by maturity level

Maurity level Species	Adults	Sub-adults	Juveniles	Kids	Total
Pan troglodytes	6	1	4	1	12
Cercopithecus nictitans nictitans	21	12	13	10	56
Lophocebus albigena	8	6	8	2	24
Cercopithecus pogonias	171	34	138	30	373
Cercocebus agilis	53	21	37	22	133
Cercopithecus cephus cephus	106	37	56	29	228
Overall total	365	111	256	94	826

Source: Fieldwork, July 2022

Primate diet

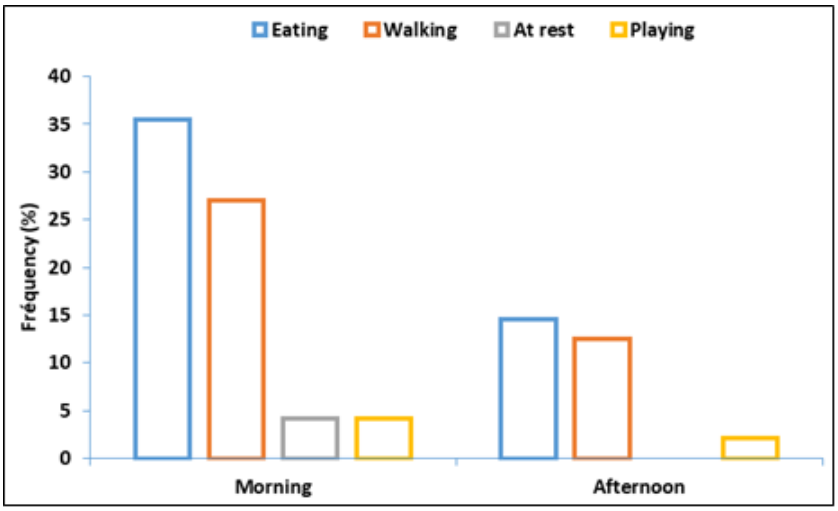
Primates on the periphery of the Dja reserve during the study period were mostly fruit-eaters. Among the tree species that populate the Dja reserve, some are particularly coveted by primates because they produce fruits that are consumed by them. As a result, the areas of the reserve where these fruit-bearing species are found concentrate a large population of primates. Among these species, the first is *Upaca* sp, whose areas where it is found account for 30.60% of the primate population. This species is followed by *Irvingia gabonensis* which attracts about 8% of primates, then *Landolphia* sp. (7.26%) and finally *Terminalia superba* (6.42%). The remaining species each attract less than 5% of primates (Fig. 4). The distribution of fruit trees on the periphery of the Dja reserve is therefore a determining factor in the distribution of the primate population. The areas marked by the presence of species whose fruit is prized by primates concentrate the majority of their population, unlike the areas where these fruit species are absent, which are less frequented by these primates.



Source: Fieldwork, July 2022

Fig 4: Distribution of primates by forest fruit tree species

Most of the primates in the periphery of the Dja reserve (35.42%) feed in the morning before noon, as opposed to only 14.58% who do so in the afternoon. These primates also wander around in the morning (27.08%) more than in the afternoon (12.05%), certainly in search of food. This means that the morning is the best time of day for these primates to feed (Fig. 5).



Source: Fieldwork, July 2022

Fig 5: Primate activity by time of day

The time of day is also a determining factor in the temporal distribution of primates around the Dja reserve. Indeed, the morning, i.e. the time interval between 6am and 12pm, is the best time to encounter primates around the reserve. To this end, 54.96% of primates are found between 6am and 9am, 30.63% between 10am and 12pm, while only14.41% are found in the afternoon, between 1pm and 2pm (Table 2). This unequal distribution can be justified by the fact that in the morning, primates are forced to leave their nests to look for food to eat, to take advantage of the sunlight and to play with each other. In general, very early in the morning, with daybreak, the populations are not yet circulating enough to pose a threat to these primates. As the hours go by, their population decreases because they are increasingly exposed to the danger of poaching due to the intensity of the sun's rays.

Moreover, these primates, having spent the morning eating and playing, start to rest and digest food in their hiding places from midday onwards, only to reappear late in the evening when the sun sets.

Table 2: Distribution of primates by time of day

Schedules	Number	Percentage (%)
6h-9h	454	54,96
10h-12h	253	30,63
13h-14h	119	14,41
Total	826	100

Source: Fieldwork, July 2022

As can be seen, the primates become less and less mobile as the sunlight intensifies. When the weather is mild and sunny, they remain mostly confined to their habitat (88.06%), but they are much more active when the weather is cloudy (11.94%) (Figure 6). Generally, when the weather is bad, poachers and other farmers are less active. They mostly flee from bad weather and to their homes. The primates therefore take advantage of the calm that prevails at this time to leave their nest.

Distribution of primates by habitat type

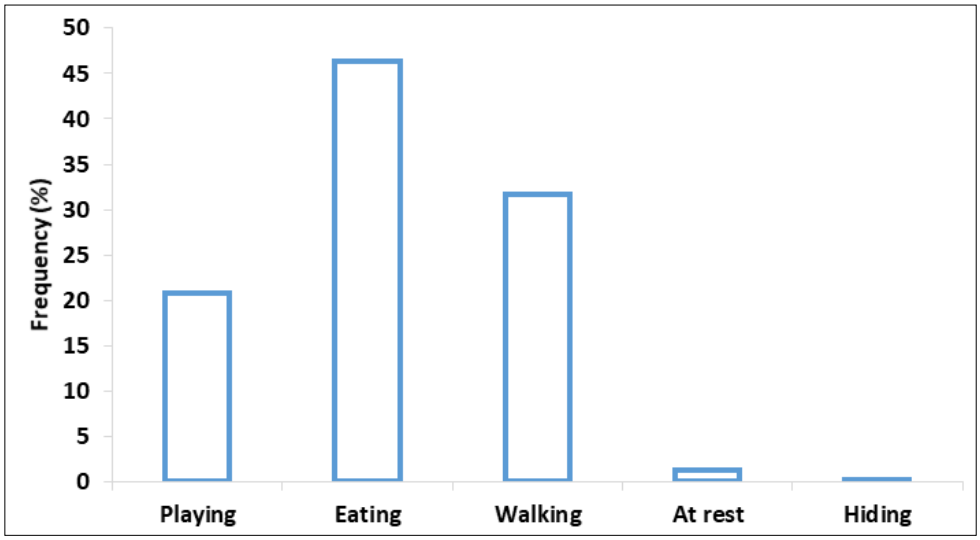
Habitat characteristics play an important role in the distribution of primates in the Dja reserve. Indeed, most primates are found in young (62.11%) and old (27.97%) secondary forests. Very few of these primates frequent or inhabit the raphias (3.63%), riparian forests (1.69%) or are found in forest gaps (4.60%) (Table 3). Regardless of the maturity level of these primates (child, juvenile, sub-adult or adult), young and adult secondary forests are their preferred habitat because their canopy is closed and the tree tops are contiguous, allowing them not only to move from tree to tree, but also to be less exposed or to hide in case of danger.

Table 3: Distribution of primates by habitat characteristics

Maturity level Habitat	Kids	Juveniles	Sub-adults	Adults	Total	Percentage (%)
Old growth secondary forest	25	87	28	91	231	27,97
Young secondary forest	64	151	61	237	513	62,11
Raffia	4	5	9	12	30	3,63
Riparian forest	1	2	1	10	14	1,69
Forest gaps	0	11	12	15	38	4,60
Overall total	94	256	111	365	826	100

Source: Fieldwork, July 2022

The distribution of the primate population around the Dja reserve is very uneven. It is particularly linked to a number of environmental conditions that must be met. Indeed, 46.37% of primates encountered around the Dja reserve were eating, 30.99% were moving, and 20.70% were playing (Fig 6). This shows that areas of the reserve where food is abundant attract and concentrate the primate population much more, as well as areas where trees are dense; allowing these primates to play easily by moving on the tops of trees or shrubs. The presence of food and suitable play areas therefore largely explains the uneven distribution of the primate population on the periphery of the Dja reserve.



Source: Fieldwork, July 2022

Fig 6: Main activities of primates

The one-factor ANOVA statistical test with Bonferoni to compare the differences between the means yielded the following results (Table 4)

Table 4: Difference in the number of individuals depending on the vegetation.

Vegetation	KA	KJ	RIP+RAP	TA	F	P
Number of individuals	2,39±1,67a	4,31±3,95a	3,14±2,48	2,5±1,22	3,058	,032

Source: Fieldwork, July 2022

Legend: KA= Old growth secondary forest; KJ =Young secondary forest; RIP: Riparian forest; RAP: Raphia; TA= Tree gaps Numbers with the same letter show a significant difference. (P=0.004). There is a significant difference between the number of individuals in KJ and KA but all other vegetations show no difference. Primates are found more in the KJs. Indeed, according to a study conducted by IUCN&MINFOF (2015), chimpanzees, which prefer less disturbed environments, are increasingly concentrated in the patch of primary forest that constitutes the "hard core" of the Dja Biosphere Reserve. Gorillas, which prefer secondary forest environments, prefer the edge of the reserve where logging is taking place.

The relative decline of gorillas in young forests can be explained by their natural preference to feed on young shoots from the secondary forest (IUCN, MINFOF, 2015).

Discussion

The relative abundance of primates in the Dja reserve identified a total of six (06) species including *Pan troglodytes, Cercopithecus nictitans nictitans*, *Lophocebus albigena, Cercopithecus pogonias*, *Cercocebus agilis* and *Cercopithecus cephus cephus*. The inventory report (2015) for the revision of the management plan instead identified eight (08) species including: *Pan troglodytes troglodytes*; *Gorilla gorilla gorilla*; *Cercopithecus nictitans*; *Cercopithecus cephus*; *Colobus satanas*, *Cercopithecus brazza*, *Colobus guereza* and an unidentified species. A similar study by Ngandjui and Blanc (2001) identified 4 species namely: *Cercopithecus cephus*, *Cercopithecus nictitans, Cercopithecus pogonias* and *Cercocebus albigena*. This disparity in the temporal distribution and presence/absence of some species can be explained by seasonal migrations, their disappearance due to poaching or the lack of census due to the short duration of the study. The most abundant species according to the results of our inventories is *Cercopithecus pogonias* which constitutes about 45% of the primate population in the periphery of the Dja Forest Reserve compared to the inventory report (2015) which identifies the species *Pan troglodytes* (Chimpanzee) as the most abundant, certainly due to the fact that the study was limited to the periphery where the forest has been degraded whereas the primary forests in the heart of the reserve constitute the preferred habitat of these species.

The secondary forests constitute the preferred habitat for the vast majority of these primates. Indeed, 62.11% were recorded in young secondary forests and 27.97% in old secondary forests. Contrary to the IUCN inventory report (2015), which identified the species *Gorilla gorilla gorilla* (693 observations) abundantly in these secondary forests, as it is particularly fond of this habitat, no primates belonging to this species were recorded during this study. This may be related to the observation season, which was not identical and did not take into account the seasonal migrations of the species.

The species *Upaca sp*. and *Irvingia gabonensis* are the most popular forest species for these primates because of their fruit, which they use for nutrition. However, the competition between humans and wildlife for these resources threatens the survival of the primates in their natural habitat. This was also noted by Tutin (1999) who showed that mandrills are

attracted to cassava plantations where they eat the tubers and destroy the plants. Gorillas sometimes eat banana stems in plantations, especially at times when little fruit is available in the forest, leading to real conflicts between villagers and primates, which can also occur in the forest when primates and humans are attracted to the same wild fruits. However, studies on the diet of these primates by Galat-Luong & Gala (1990) show that chimpanzees are omnivores.

Fruits, flowers, leaves and gum constitute the main plant foods. Animal prey consumed include mainly crustaceans (shrimps and possibly crabs), insects, fish and birds, with some hunting of pangolins.

Conclusion

This study on the distribution of primates on the periphery of the Dja reserve made it possible to characterise their population. It revealed that the 826 individuals recorded are divided into six (06) species, namely: *Pan troglodytes*, *Cercopithecus nictitans nictitans*, *Lophocebus albigena*, *Cercopithecus pogonias*, *Cercocebus agilis* and *Cercopithecus cephus cephus*. *Cercopithecus pogonias* is the most abundant species with 373 individuals, i.e. 45.16%, followed by *Cercopithecus cephus ce*phus (228 individuals), representing 27.60% and finally *Cercocebus agilis* (133 individuals) or 16.10%. The largest number of adults (171) and juveniles (138) are found in the *Cercopithecus pogonias* population. This species is followed by *Cercopithecus cephus cephus* with 106 adults and 56 juveniles. The distribution of these species depends on certain parameters such as the availability of food in an area, the characteristics of the habitat, the time of day and the weather conditions. In fact, the areas of the reserve where these fruit-bearing species are found are those with the highest concentration of primates. Among these species, the first is *Upaca sp*. whose sectors where it is found group together 30.60% of the primate population. This species is followed by *Irvingia gabonensis* which attracts about 8% of primates, then *Landolphia* sp. (7.26%) and finally *Terminalia superba* (6.42%). With regard to the time factor, the morning, i.e. the time interval between 6am and 12pm, is the best time to see primates around the reserve. To this end, 54.96% of primates are seen between 6 and 9 am, 30.63% between 10 and 12 am, while only 14.41% are seen in the afternoon, i.e. between 1 and 2 pm. When the weather is mild and sunny, these primates remain mostly confined to their habitat (88.06%), while they are much more likely to be seen when the weather is capricious and cloudy (11.94%).

In order to ensure better sustainable conservation of primates in the area, it is necessary to integrate primate conservation strategies into the management plan of the Dja reserve, to carry out regular ecological monitoring of the dynamics of primate populations in the reserve, and to supervise NTFP collection activities in order to limit as far as possible conflicts of interest between humans and wildlife regarding the consumption of these products.

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