

Evaluation of the role of Guenons and Mangabeys in seed dispersal in Moukalaba-Doudou National Park, Gabon

MANGAMA-KOUMBA Lilian Brice^{1*}, MINDONGA NGUELET Fred Loïque¹, EBANG ELLA Ghislain Wilfried¹, AKOMO-OKOUE Etienne François¹, MOUNIOKO Franck², ZINGA KOUMBA Christophe Roland¹, MAVOUNGOU Jacques François¹ and MINTSA NGUEMA Rodrigue¹

¹Institut de Recherche en Ecologie Tropicale (IRET-CENAREST), BP : 13354, Gabon

²Université des Sciences et Techniques de Masuku (USTM), BP : 901, Gabon

Corresponding author: E-mail address: mangamalilian@yahoo.fr

Abstract

In order to gain knowledge on the quantity of seed dispersed and the contribution of small diurnal primates in the ecosystem, a preliminary study on four species of monkeys was carried out in the northeastern part of the Moukalaba-Doudou National Park in Gabon. The aim was to identify the species of fruits which are dispersed and the animal biomass in two large groups of monkeys namely mangabeys (*Cercocebus torquatus* and *Lophocebus albigena*) and guenons (*Cercopithecus cephus* and *Cercopithecus nictitans*). Using the reconnaissance walking method, we followed old tracks and dung piles were collected after direct observation of the little monkeys and in the sleeping site. The dung piles were washed, and the seeds collected were identified. A total of 104 fecal samples from the four species of monkeys were collected. Seeds from 19 species of plants were found in the dung piles. The majority of the seeds found in droppings were seeds of *Cissus dinklagei* and *Musanga cecropioides*. *Cercopithecus nictitans* dispersed seeds of more plant species than the others. All the results obtained show that the monkeys disperse an average of 1,114 seeds per day. In this study guenons disperse more fruit than the mangabeys who have a more varied diet. These results suggest that monkeys of Moukalaba-Doudou disperse fewer seeds compared to monkeys in other sites in Africa.

Keys word: guenons, mangabeys, seed, dispersal, dung pile

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Résumé

Afin d'avoir une connaissance sur la quantité de graine dispersée et la contribution des petits primates diurnes dans l'écosystème, une étude préliminaire sur quatre espèces de singes a été réalisée dans la partie nord-est du Parc National de Moukalaba-Doudou au Gabon. L'objectif était de connaître les espèces de fruits dispersées et la biomasse animale chez deux grands groupes de singes à savoir les mangabeys (*Cercocebus torquatus* et *Lophocebus albigena*) et les guenons (*Cercopithecus cephus* et *Cercopithecus nictitans*). En utilisant la méthode de la marche de reconnaissance, nous avons suivi d'anciennes pistes et les tas de fumier ont été ramassés après observation directe des petits singes et dans les dortoirs. Les crottes ont été lavées et les graines récoltées ont été identifiées. Un total de 104 échantillons fécaux des quatre espèces de singes a été collectés. Les graines de 19 espèces de plantes ont été trouvées dans les excréments. *Cercopithecus nictitans* a dispersé plus d'espèces de graines que les autres. La majorité des graines trouvées dans les déjections étaient des graines de *Cissus dinklagei* et *Musanga cecropioides*. L'ensemble des résultats obtenus montre que les singes dispersent en moyenne 1114 graines par jour. Dans cette étude les guenons dispersent plus de fruits que les mangabeys qui ont une alimentation plus variée. Ces résultats suggèrent que les singes de Moukalaba-Doudou dispersent peu de graines en comparaison aux singes d'autres sites en Afrique.

Mots-clés : cercopithèques, mangabeys, graine, dispersion, crotte

INTRODUCTION

Seed dispersal by animals contributes significantly to demographics, dynamics and succession of plant communities (Gautier-Hion *et al.*, 1985 ; Janson, 1983 ; Jordano and Schupp 2000 ; Muller-Landau, 2007 ; Wright *et al.*, 2007 ; Beaune *et al.*, 2013a ; Petre *et al.*, 2013 ; Chen *et al.*, 2017). Indeed, in tropical forests, most trees produce fruit suitable for consumption and seed dispersal by animals (Beaune *et al.*, 2013a). Among the different agents of seed dispersal, guenons and mangabeys (Cercopithecines) are important, but considered weak dispersers relative to other mammals such as elephants, gorillas chimpanzees and bonobos, leading to conflict over priority in conservation projects for the management of forest ecosystems (Chapman and Chapman, 1995; Gross-Camp *et al.*, 2009; Chanthorn *et al.*, 2017; Corlett, 2017). Furthermore, many primate species feed on fruits, and the large majority of neotropical primates play roles as seed dispersers (Fuzessy *et al.*, 2018). Moreover, in African and Asian tropical forests, these animals are an important part of the fruit-eating biomass and thus are seed dispersers (Kaplin and Moermond, 1998; Slater and Du Toit, 2002). While their fundamental impact on forest regeneration and maintenance of tropical biodiversity is accepted (Beaune, 2012; Garcia *et al.*, 2020), the specific contributions of some species of these groups (guenons and mangabeys) in the forests of the Congo Basin are not well known (Tarnaud and Negeshi, 2009). Yet these animals play an important role in seed dispersal in the forested areas of the Congo Basin, especially in protected areas (Schupp, 1993). Moreover, they could play a role of regular seed disperser in microhabitats, marked by the opening of the canopy, in which they are present (Beaune, 2012).

In Gabon, very few studies on seed dispersal by guenons and mangabeys, particularly in protected areas have been undertaken. The earliest studies

were done in north-eastern Gabon and focused on seed dispersal by cercopithecines (Gautier-Hion, 1984). The next study was on fruit selection and seed dispersal by a vertebrate community in the Ipassa area (Gautier-Hion *et al.*, 1985). The most recent studies have focused on fruit dispersal by large mammals (Poulsen *et al.*, 2021), Moreover, despite many studies conducted on primates, there have been few studies on the monkey groups (guenons and mangabeys). Also, knowledge of the seed disseminating role of these animals remains necessary to the preservation of biodiversity and the value of protected areas in the Congo Basin. Indeed, the ecological services provided by seed dispersers have considerable consequences for the existence and dynamics of forests in the Congo Basin (Beaune, 2012; Rogers *et al.*, 2021a). The Congo Basin forests are under increasing pressure of deforestation and degradation, that threaten the integrity of forest ecosystems (Petre *et al.*, 2013).

It is in this context that a study on seed dispersal by guenons and mangabeys was carried out in Moukalaba-Doudou national park in order to understand the role of each of these species of monkeys belonging to these two groups. The objective was to assess the ecological importance of cercopithecines in the ecosystem by studying the plant species whose seeds are dispersed, the number of seeds deposited and biomass of monkeys.

METHODS

Study site

This study was conducted in the Moukalaba-Doudou National Park (S02°20'49.0"; E010°34'19.0") located in the province of Nyanga in southwestern Gabon (Figure 1). This park covers an area of 5,028 km² and is located 700 km from Libreville, Gabon's capital city (Ando *et al.*, 2008; Takenoshita and Yamagiwa, 2008; Mangama-Koumba *et al.*, 2016). It includes several types of habitats including wetlands,

savannahs, old secondary forests, floodplain forests, young secondary forests dominated by *Musanga cecropioides* and *Aframomum spp.*, rock formations and caves (Mounioko *et al.*, 2015; Dibakou *et al.*, 2016). The main village in this region is Doussala.

The floristic landscape of the region includes many species, the most dominant of which are *Musanga cecropioides*, *Aframomum sp.*, *Cissus dinklagei*, *Myrianthus arboreus*, *Irvingia gabonensis*, *Dichostemma glaucescens*, *Meiocarpidium lepidotum* and *Diospyros spp.* (Yumoto *et al.*, 2015; Tamura and Akomo-Okoue, 2021). The forest canopy is approximately

35-45 m high, and is dominated by species within the *Caesalpinaceae* and *Mimosaceae* (Sosef *et al.*, 2004). As for wildlife, it consists of several species namely *Syncerus caffer nanus* (African forest buffalo), *Loxodonta africana cyclotis* (forest elephant), *Pan troglodytes* (chimpanzee), *Gorilla gorilla gorilla* (western lowland gorilla), *Hippopotamus amphibius* (hippopotamus), *Tragelaphus speki* (sitatunga) and *Cephalophus spp.* (duikers) (Iwata and Ando, 2007; Nakashima, 2015). The avifauna is very rich in species, of which one species the black-winged red bishop (*Euplectes hordeaceus*) is a species that is not found everywhere in Gabon (Vande, 2012).

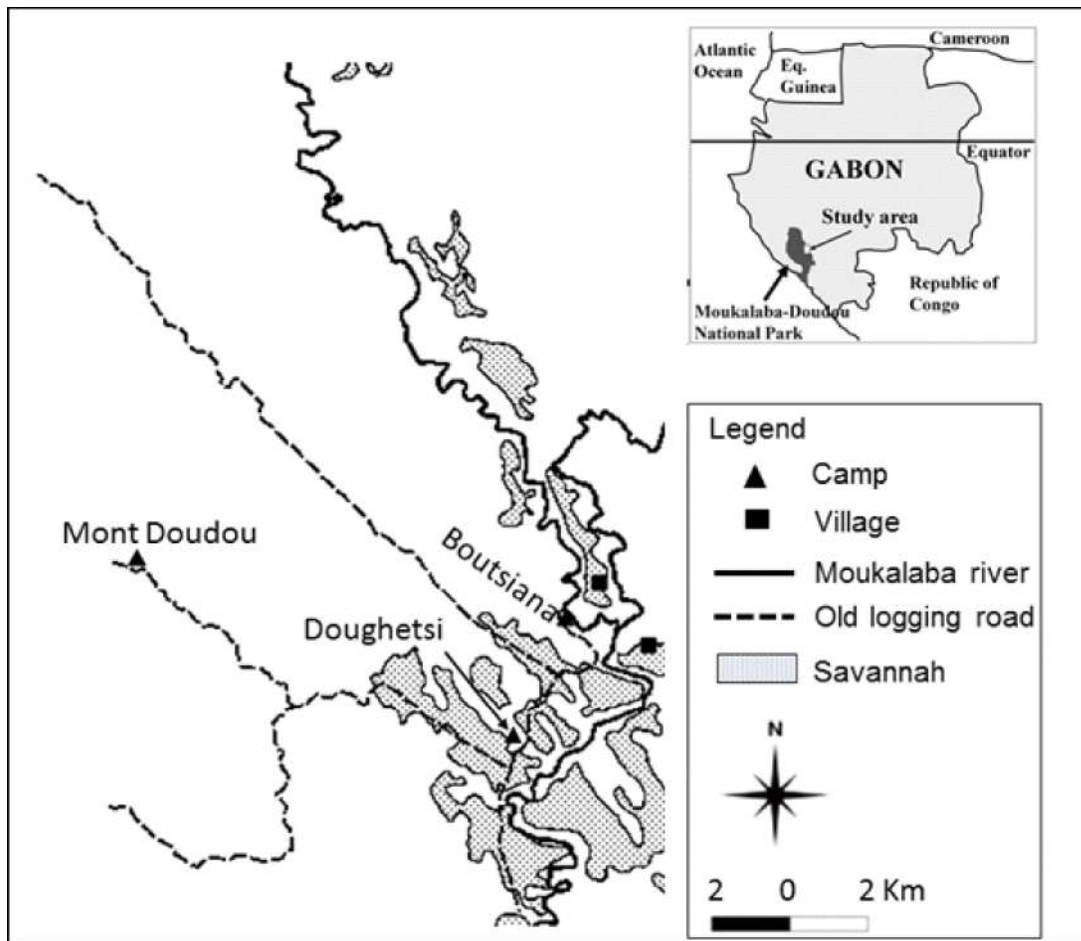


Figure 1: Location (S02°20'49.0"; E010°34'19.0") of study site of Northern part of Moukalaba-Doudou National Park.

Moukalaba River is the main tributary of Nyanga. It winds through a plain covered with a mosaic of forest and savannah. The region's climate is equatorial, with four seasons. The dry seasons are from May to August and from December to February for the long and short seasons respectively. The rainy seasons run from August to November for the short season and from March to May for the long season (Takenoshita *et al.*, 2008; Ebang and Juichi, 2014; Tamura and Akomo-Okoue, 2021). The average annual rainfall of the park is 2,000 mm rainfall in the far north and only 1,600 mm in the south. The variation of temperature is a function of season. The difference between the cooler and warmer month's (March and April) is of the order of 3 to 4 ° C. It should also be noted that in this region the daily minimum and maximum temperatures can change depending on the altitude.

Choice of primate species

A total of four primate species comprising two guenons (*Cercopithecus cephus* and *Cercopithecus nictitans*) and two mangabeys (*Lophocebus albigena* and *Cercocebus torquatus*) was selected for study in Moukalaba Doudou National Park. The choice to focus on these animals was determined by their diet. Indeed, these four species are the most observed in our surveys and they differ from each other by their diet and habitat preference.

Data collection

Seed dispersal by primates was determined by direct observations of these animals on the trees with binoculars along existing tracks at a speed of about 2,5 km h⁻¹. Information was recorded on each primate group encountered (species, group size and distance). All observations were made from 6:00 to 11:00 in the morning for 9 months for 15 days per month from June 2013 to June 2014 except the months of September and December 2013, and January 2014. All dung and droppings of these species were collected in

plastic bags and brought to the laboratory for identification.

In the laboratory, the samples were washed in a sieve of 1 mm mesh, then placed in a paper towel and dried in a traditional smokehouse. All seeds were identified to species level using a guide to the vegetation of the Lopé Reserve (White and Abernethy, 1997) and Flora of Gabon (Aubreville *et al.*, 1961).

Data analysis

The density of each primate species was calculated using the program Distance sampling 6.0 (Buckland *et al.*, 2001; Mangama-Koumba *et al.*, 2016). Data for detection functions were sequentially adjusted with half-normal key functions; uniform rate risks associated cosine, Hermite polynomials and simple terms of polynomial adjustment (Buckland *et al.*, 2001). The best model was selected on the base of the Akaike information criterion (AIC).

Body masses were taken from the Smith and Jungers (1997). The mass of an average individual was calculated as follows. For the monkeys (guenons and mangabeys), an average individual was assumed to weigh 75% of the mass of an adult female (Oates *et al.*, 1990).

The biomass was calculated from the data on the masses of each primate species and their densities in study area by according to the following formula:

$$\text{Biomass} = \text{Mass of each individual} * \text{Density of each species}$$

The number of seeds deposited was calculated on the base of density of each species of defecation rate according to Poulsen *et al.* (2001) and the average number of seeds in each dung piles. The defecation rate was estimated as the average rate of the four monkey species in our seed passage trials

Number of seed deposited by each monkey = density of each species * defecation rate * Average number of seed by dung piles.

A principal component analysis was performed to understand the correlation between different monkey species studied and the spatial distribution of different species of fruit eaten by the animals.

RESULTS

A total of 104 dung piles were collected from the four monkey species *Cercopithecus cephus*, *Cercopithecus nictitans*, *Cercocebus torquatus* and *Lophocebus albigena* in the study area. The seeds of 19 different plant species were identified from these dung piles.

Table 1 presents the lists of plant species eaten by the four species of primates. This table shows

that all seed species are not consumed by the same monkey species. Although the seeds of *Aframomum leptolepis* and *Cissus dinklagei* were found in faecal samples of the four monkey species, seeds of *Sterculia tragacantha*, *Duboscia macrocarpa* and *Santiria trimera* were identified only in *Cercocebus torquatus* and *Cercopithecus cephus*. These results suggest that *Cissus dinklagei* and *Aframomum spp* are important food for all four species. Furthermore, the results show that the dung heaps of *Cercopithecus nictitans*, *Cercocebus torquatus*, *Cercopithecus cephus* and *Lophocebus torquatus* contained 12, 15, 11 and 7 seeds of these two plant species respectively

Table 1 : The number of seeds of each species by dung piles .

Seed species	<i>Cercopithecus nictitans</i>	<i>Cercocebus torquatus</i>	<i>Lophocebus albigena</i>	<i>Cercopithecus cephus</i>
<i>Aframomum leptolepis</i>	1	3	1	5
<i>Caloncoba welwitschii</i>	3	-	-	6
<i>Cissus dinklagei</i>	11	12	6	6
<i>Dialum sp</i>	-	2	6	-
<i>Diospyros mannii</i>	6	-	-	2
<i>Duboscia macrocarpa</i>	-	1	-	-
<i>Ficus sp</i>	5	8	2	-
<i>Indetermined</i>	1	-	-	1
<i>Indetermined1(mousoni cocu)</i>	2	-	1	1
<i>Lannea welwitschii</i>	5	6	3	-
<i>Macaranga spinosa</i>	2	2	-	1
<i>Musanga cecropioides</i>	12	-	-	10
<i>Myrianthus arboreus</i>	-	1	-	-
<i>Plagiostyles africana</i>	-	1	-	4
<i>Pseudospondias longifolia</i>	3	-	1	-
<i>Santiria trimera</i>	-	-	-	1
<i>Sterculia tragacantha</i>	-	1	-	-
<i>Synsepalum dulcificum</i>	2	1	5	-
<i>Uapaca guineensis</i>	6	10	-	-
Total	59	48	25	37

The overall density of four species of monkeys chosen was 140 primates / km² with a total biomass 906 kg.km⁻². *Cercocebus torquatus* (Collared mangabey) was the monkey species with the highest density followed by *Cercopithecus nictitans* (white nose) and *Cercopithecus cephus* (the Moustached). *Lophocebus albigena* (gray mangabey) was the species with the lowest density (Table 2). The results obtained on biomass suggest that small diurnal primates in Moukalaba-Doudou National Park represent an important part of the total organic matter of animal origin in this area.

Table 2: Density and biomass of monkeys at the Moukalaba-Doudou National Park.

species of monkeys	Mass (Kg) ¹	Density (individuals per km ²)	Average group size	Biomass (Kg per km ⁻²)
<i>Cercocebus torquatus</i>	8.125 (9.75-6.5)	62.37	22.95	506.76
<i>Lophocebus albigena</i>	7 (8.5-5.5)	15.72	10.85	110.04
<i>Cercopithecus nictitans</i>	5.5 (6.7-4.3)	33.26	6.28	182.93
<i>Cercopithecus cephus</i>	3.6 (4.3-2.9)	29.38	7.48	105.77
Total		140.37		905.5

¹ Body masses were taken from the Smith and Jungers (1997).

Abundance of seeds dispersed by monkeys

The abundance of seeds dispersed by primates varied depending on the species of monkey (Figure 2). *Cercopithecus nictitans* was the species that dispersed the largest number of seeds, followed by *Cercocebus torquatus*. *Cercopithecus cephus* and *Lophocebus albigena* dispersed less seeds.

Tableau 3: Seeds number deposited per km² per day by monkeys in Moukalaba-Doudou National

Species	Defecation rate.d ⁻¹	Density (individuals per km ⁻²)	Seeds number by dung piles mean ± SD	Seeds.km ⁻² .d ⁻¹
<i>Cercocebus torquatus</i>	5	62.37	1.7 ± 1.21	530.14
<i>Lophocebus albigena</i>	5	15.72	1.6 ± 1.6	125.76
<i>Cercopithecus nictitans</i>	5	33.26	1.7 ± 1.3	282.71
<i>Cercopithecus cephus</i>	5	29.38	1.4 ± 1.4	205.66
Total				1,144.27

Analysis of variance (ANOVA) showed that there was no significant difference in the consumption of fruits by different primate species (F = 1.137; P-value = 0.34). Furthermore, correspondence analysis (ACP) showed a high correlation between *Lophocebus albigena* and *Cercocebus torquatus* concerning some seeds (figure 3). Similarly, *Cercopithecus nictitans* and *Cercopithecus cephus* have an affinity for many species of seeds. This result suggests that guenons have an affinity for certain fruits, while the mangabeys have affinity for other fruits. However, we also observe a difference in correlation between the four monkey species. *Cercocebus torquatus* and *Lophocebus albigena* are well represented on both components, whereas *Cercopithecus cephus* and *Cercopithecus nictinans* are well represented on only one component (figure 3a).

The distribution of species of fruits eaten by these animals varied according to the species of monkey studied. *Lophocebus albigena* and *Cercocebus torquatus*, both mangabeys, showed a preference for fruits produced by *Dialium* sp, *Ficus* sp, *Uapaca guineensis* and *Lannea welwitschii*. In contrast, *Cercopithecus cephus* and *Cercopithecus nictitans* showed a preference for *Musanga cecropioides* and *Caloncoba welwitschii*, respectively. However, *Duboscia macrocarpa* and *Santiria trimera* fruits do not seem to be attractive to the different monkeys studied.

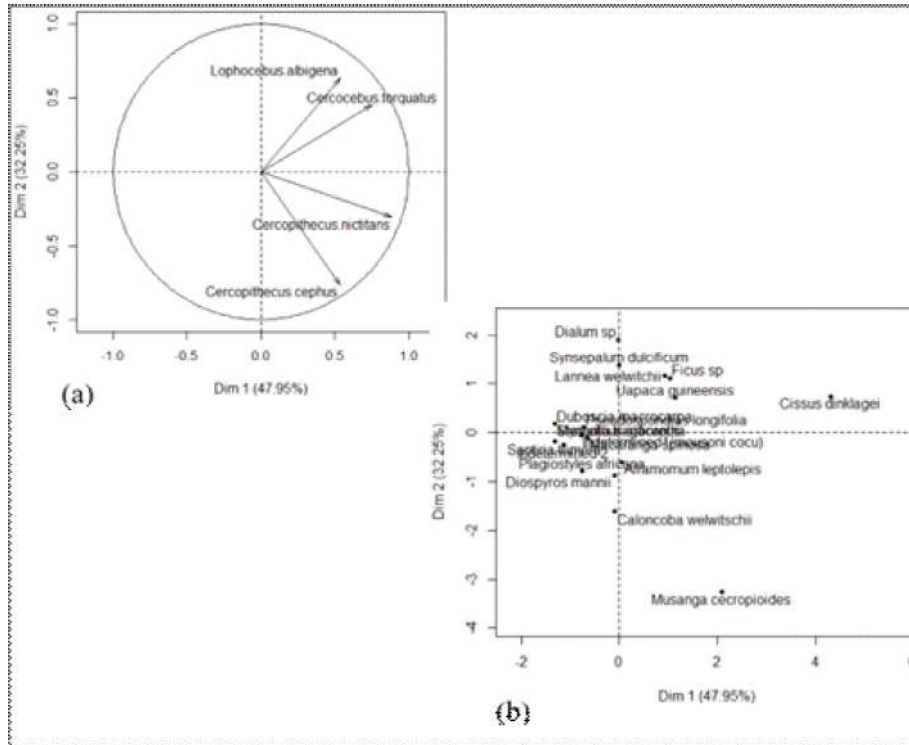


Figure 3: Correspondence analysis: (a) Graphic of variable correlation (monkey species); (b) graphic of seed distribution.

DISCUSSION

The results obtained in this study constitute the first limited data on the role of primates in seed distribution in protected areas in Gabon, in particular in the Moukalaba Doudou National park located in southwestern Gabon. The target taxa *Cercopithecus cephus*, *Cercopithecus nictitans*, *Cercocebus torquatus* and *Lophocebus albigena* presented the advantage of understanding the role of monkeys in seed dispersal and therefore in the dynamics of some forest types in the Congo Basin. Thus, this study has shown the ecological service of primates in seed dispersal in this protected area. In addition, this study also provides a list of fruit species and / or seeds eaten by these four monkey species. This list could serve as a baseline for further studies. Also, the methodology used

in this study could be used in most parts of protected areas in the Congo Basin.

However, only seeds from 19 plant species were identified in 104 dung piles of these primates. These results are similar to those obtained by Otani (2003) on a one-year study on Japanese macaques in the Kashima region. This low seed diversity could be explained by the size of seeds consumed. Indeed, in Cercopithecidae the seeds swallowed are small size (Lucas and Corlett, 1998; Lambert, 1999; Almazán-Núñez, 2021). In addition, the fruit whose seeds are large are not ingested by the monkeys. Large fruits can only be ingested by large animals such as gorillas, chimpanzees and elephants, which consume more seeds than any other mammal species (Beirne *et*

al., 2020; Poulsen *et al.*, 2021). Therefore, these animals (guenons and mangabeys) tend to swallow less seeds due to their smaller intestinal tract (Kaplin and Lambert, 2002; Kaplin and Moermond, 1998; Otani, 2010; Poulsen *et al.*, 2001; Yumoto *et al.*, 1998). These results are similar to those obtained by Gautier-Hion (1984) who showed that monkeys swallow the seeds with an average length not exceeding 3cm. The majority of seeds found in the faeces of monkeys were *Cissus dinklagei* and *Musanga cecropioides*. Both species have seeds with relatively small diameters and therefore can be easily ingested by Cercopithecines. Thus, the low rate endozoochory recorded during our study by these animals could well be explained by the size of the seeds contained in fruits they consume.

The abundance and variety of seeds dispersed by monkeys vary depending on the structure of the fruit and availability but also the eating habits of these animals (Kaplin and Moermond, 1998; Lambert and Garber, 1998; Tsujino and Yumoto, 2009; Albert, 2012). Indeed, *Cissus dinklagei* is a tree whose fruit is pulp and succulent. These fruits are strongly attached to the core fiber. They represent an essential element in the diet of monkeys (Gautier-Hion, 1980; Mangama-Koumba *et al.*, 2016). Takenoshita *et al.* (2008) defines this fruit species as keystone species. Also, the results suggest that the seeds of this species were frequently found in the dung pile of these monkeys. These results show that Guenons and Mangabeys are important disseminators of *Cissus dinklagei* in the National Park Moukalaba Doudou.

Similarly, *Aframomum leptolepis* was also found in the excrement of these four species but with relatively low levels compared to *Cissus dinklagei*. This difference could be explained by the nature and ecology of this plant species. Indeed, *Aframomum leptolepis* is a herbaceous plant in the lower layer and especially present in young secondary forests. Thus, the possibility that this

species is frequently used by monkeys, is sometimes reduced. Therefore, the results obtained in this study may explain the fact that the seeds of *Aframomum leptolepis* are found in large quantities in the dung pile of *Cercopithecus cephus* and *Cercocebus torquatus*. These observations are similar to those made by Gautier-Hion *et al.* (1999) who showed that *Cercopithecus cephus* prefers middle and lower strata of the forest and is observed within 15 m high in 60% of cases. *Cercocebus torquatus* is a semi-terrestrial species and frequently uses disturbed forest sites in the search for food (Kaplin and Moermond, 1998). Therefore, it plays an important role in seed dispersal of *Aframomum leptolepis*. *Cercopithecus nictitans* and *Cercocebus torquatus* presented the most abundant quantity of seeds in their dung pile. These results could be explained by the fact that the number of faecal samples collected in the field for these two species was more important than the other two species. These results confirm the work carried out by Poulsen *et al.* (2001) on seed dispersal by diurnal primates in the Dja reserve in Cameroon, which showed that the higher the number of droppings sampled, the higher the number of seeds present. Moreover, *Cercopithecus nictitans* and *Cercocebus torquatus* were two species of monkeys with high densities in this park, which has the consequence of finding a significant number of their dungs pile in the study site. Also, these two species played a major role in the dispersion of some plant species in this ecosystem.

The data collected on the biomass (90-6 kg.km⁻²) of small monkeys in this study show that small monkeys represent a significant proportion of the medium-sized mammals in this area. They also show that they were superior to others in northeastern Gabon (Gautier and Gautier-Hion, 1969; Gautier-Hion and Gautier, 1974; Sourd, 1983, summarised in Harrison and Hladik, 1986), and for another site in the Lopé National Park (Harrison and Hladik, 1986), where the estimated total primate biomass was 445-615 and 575-875

kg.km⁻² respectively. These differences can be explained by the methods used for density estimates, but also by the number of monkey species that were taken into account. In Moukalaba-doudou National Park, we considered four species, including *Cercocebus torquatus*, which are very numerous in this area and form very large groups of up to 80 individuals (Mangama-Koumba, obs pers). This could increase the biomass. However, the biomass estimates of the other species (*Cercopithecus cephus*, *Cercopithecus nictitans* and *Lophocebus albigena*) would be similar to those of other study sites in Gabon. In Africa and elsewhere, most of the variation in primate biomass is due to differences in the abundance of Colobine species (Oates et al., 1990), which reach a biomass of 1875-2948 kg.km⁻² in Kibale, Uganda (Struhsaker, 1975). At Moukalaba-doudou there are no colobines, and the densities of species present do not approach those of other Colobines in some African forests (Struhsaker, 1975; Bourlière, 1985; Oates et al., 1990; White, 1994).

The number of seeds dispersed by the four species seems to be low compared to other sites where it has been noticed that monkeys disseminate on average 2 to 3 seeds by pile dung (Kaplin and Moermond, 1998). According to the work conducted by Kaplin and Moermond (1998) on the effectiveness of seed dispersal by cercopithecine monkey, monkeys disperse on average between 2.52 and 2.95 seeds per dung pile, depending on the size of the seeds ingested. In our study, monkeys dispersed a lower number (1.4 and 1.7) of seeds per dung. This low average could be explained by sampling effort was relatively low (104 dungs pile for all species) and the time was relatively short. Guenons and Mangabeys of Moukalaba-Doudou disperse nearly 1,114 seeds.d⁻¹. However, other studies have shown that fruit-eating species disperse a small percentage (12%) of seeds in African

rainforests (Clarck *et al.*, in press). Between 1997 and 2000, Refisch and Koné observed frugivorous monkeys to consume 25 species of Taï forest trees. But for The Taï Monkey Project database contributed another 75 (61%) seed species dispersed by six monkey species present (Koné *et al.*, 2008). Similarly, in Kibale National Park, Lambert and Garber (1998), showed that some species of monkeys including *Cercopithecus ascanus*, *Lophocebus albigena* and *Cercopithecus mitis* disperse over 22% of the seeds of species they consumed by endozoochory. In this like, it is impossible to compare seed dispersal by fruit-eating community. But, by focusing on the seed dispersion quality by a primate community Poulsen *et al.* (2001) found that the primate community, including four species of monkeys and two apes in Dja National Park could disperse nearly 1,146 seeds per day. No significant difference observed with our results. This could be explained by the fact that total density of the four species of Moukalaba-Doudou is higher than that of the diurnal primate community in Dja National Park in Cameroon. This confirms the importance of these monkeys in seed dispersal.

Our study showed that mangabeys (*Cercocebus torquatus* and *Lophocebus albigena*) are positively correlated to certain fruit species and the guenons also have a positive correlation to other species. Indeed, mangabeys and guenons generally form polyspecific groups. Gautier-Hion et al (1985) have shown that *Cercopithecus nictitans* and *Cercopithecus cephus* tend to share the same distribution areas and thus formed polyspecific groups and consume the same food resources. Mangama-Koumba (pers obs) observed that *Cercocebus torquatus* also associates with *Lophocebus albigena*. Despite some differences in the vertical stratification and diet of the associated species, it appears that the association is based on a high degree of interlocking ecological needs (Gautier and Gautier-Hion, 1974). Even in swampy areas

hostile to *Lophocebus albigena*, *Cercocebus torquatus* will follow this species to take advantage of resources especially in times of fruit scarcity. Our results show that the favourite fruits (*Dialium sp*; *Ficus sp*; *Uapaca guineensis*) of mangabeys were found in the old secondary forests while *Musanga cecropioides* and *Caloncoba welwitschii* are young secondary forest species in which the guenons are inferred.

CONCLUSION

This study is a first approach to animal-plant relationships but also the role of primates in seed dispersal in protected areas in Gabon. This work has allowed drawing up a basic list of plant species eaten by guenons and mangabeys. These plants are dispersed throughout the forest by zoochory. Also, it appears from this study that the guenons and mangabeys play an important role in the dissemination of certain species especially *Cissus dinklagei* and *Aframomum leptolepis* and they represent an important part of the animal biomass in Moukalaba-doudou National Park.

However, it is essential to deepen our study by studying the dynamics of these four species for a relatively long time to list all species in their diet. In addition, the results will ensue and will include these animals in the list of protected species in Gabon.

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BIBLIOGRAPHY

Albert, A. 2012. Feeding and ranging behavior of northern pigtailed macaques (*Macaca leonina*): impact on their seed dispersal effectiveness and ecological contribution in a tropical rainforest at Khao Yai National Park, Thailand. Département de Biologie, Ecologie et Environnement, Université de Liège, Liège, Belgium, p. 220.

Almazan-Nunez, R.C., Alvarez-Alvarez, E.A., Sierra-Morales, P. Rodriguez-Godinez, R., 2021. Fruit size and structure of zoochorous trees: identifying drivers for the foraging preferences of fruit-eating birds in a Mexican successional dry forest. *Animals* doi.org/10.3390/ani11123343

Ando, C., Iwata, Y., Yamagiwa, J. 2008. Progress of habituation of western lowland gorillas and their reaction to observers in Moukalaba-Doudou National Park, Gabon. *African. Studies. Monographs.* 39:55–69.

Aubreville, A., Leroy, J.F., and Morat. P. 1961. Flore du Gabon. Paris: Museum national d'histoire naturelle.

Beaune, D. 2012. Latest news from the bonobos: *Pan paniscus* myths and realities. *Rev. Primatol.* 4, DOI:10.4000/primatologie.1090.

- Beaune, D., Bretagnolle F., Bollache, L., Hohmann, G., Surbeck, M. Fruth, B. 2013a.** Seed dispersal strategies and the threat of defaunation in a Congo forest. *Biodiversity and conservation*, 22, 225-238.
- Beirne, C., Meier, A.C., Brumagin, G., Jasperse-Sjolander, L., Lewis, M., Masseloux, J., Myers, K, Fay, M, Okouyi, J, White, L.J.T, Poulsen J.R 2020.** Climatic and resource determinants of forest elephant movements. *Front. Ecology Evolution*. 8:96. doi: 10.3389/fevo.2020.00096.
- Bourliere F. 1985.** Primate communities: their structure and role in tropical ecosystems. *Int J Primatol* 6:1–26.
- Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L, Thomas, L, 2001.** Introduction to Distance Sampling. Oxford University Press, Oxford.
- Chanthorn, W., Wiegand, T., Getzin, S., Brockelman, W.Y., Nathalang, A. 2017.** Spatial patterns of local species richness reveal importance of frugivores for tropical forest diversity. *Journal of Ecology*, 00, 1–11. <https://doi.org/10.1111/1365-2745.12886>.
- Chapman, C.A., and Chapman, L.J. 1995.** Survival without dispersers: seedling recruitment under parents. *Conservation Biology*. 9:675–678.
- Chen, Y, Wang, Z, and Xiang, Z, 2017.** Seed dispersal. *Biodiversity Science*, 25(3): 325-331.
- Corlett, R.T. 2017.** Frugivory and seed dispersal by vertebrates in tropical and subtropical Asia: An update. *Global Ecology and Conservation*, 11: 1–22.
- Dibakou Ely S., Mounioko., F., Zinga-Koumba., C.R., Mbang Nguema., O.A, Acapovi-Yao G.L. and Mavoungou J.F. 2015.** Distribution des Glossines vecteurs de la Trypanosomose humaine africaine dans le Parc National de Moukalaba Doudou (Sud-ouest Gabon), *Journal of Applied Biosciences* 86, p. 7957-7965.
- Ebang-Ella, G.W., and Yamagiwa, J. 2014.** Use of tool sets by chimpanzees for multiple purposes in Moukalaba-Doudou National Park, Gabon. *Primates* 55(4): 467-472.
- Fuzessy, L.F, Janson, C., Silveira, F.A. 2018.** Effects of seed size and frugivory degree on dispersal by Neotropical frugivores. *Acta Oecologica*, 93: 41-47.
- Garcia, C., Espelta, J.M., Hampe A. 2020.** Managing Forest regeneration an expansion at a time of unprecedented global change. *Journal of applied Ecology*, 57:2310-2315. Doi: 10.1111/1365-13797.
- Gautier, J.P. and Gautier-Hion, A. 1969.** Les associations polyspécifiques chez les Cercopithèques du Gabon. *La Terre et la Vie*, 23 : 164-201.
- Gautier-Hion., A., and Gautier, J.P. 1974.** - Les associations polyspécifiques de Cercopithèques du plateau de M'Passa (Gabon). *Folia Primatologica*, 22: 134- 177.
- Gautier-Hion., A. 1980.** Seasonal variation of diet related to species and sex in a community of Cercopithecus monkeys. *Journal of Animal Ecology*, 49, 237–69.
- Gautier-Hion., A. 1984.** La dissemination des graines par les cercopithecides forestiers Africains. *Terre. Vie.* 39 :159–165.
- Gautier-Hion, A., Duplantier, J.M., Quris, R., Feer, F., Sourd, C., Decous, J.P., Doubost, G.,**

- Emmons, L., Erard, C., Hecketsweiler, P., Mougazi, A., Roussilhon, C., & Thiollay, J.M. 1985.** Fruit characters as a basis of fruit choice and seed dispersal in a tropical forest vertebrate community. *Oecologia* 65 :324–337.
- Gautier-Hion, A., Colyn, M, and Gautier, J.P. 1999.** Histoire naturelle des primates d’Afrique Centrale. Libreville, Gabon: ECOFAC.
- Gross-Camp, N.D, Masozera M., and Kaplin B.A. 2009.** Quantité de dispersion des graines de chimpanzé dans une forêt tropicale montagnarde du Rwanda. *American Journal of Primatology* 71: 901–911.
- Harrison. M.J.S., and Hladik C.M. 1986.** Un primate Granivore : Le colobe noir dans la forêt du Gabon, potentiel d’évolution du comportement alimentaire. *Terre Vie* 41:281-298
- Iwata, Y., and Ando. C. 2007.** Nest and nest-site reuse by western lowland gorillas (*Gorilla g.gorilla*) in Moukalaba-Doudou National Park, Gabon. *Primates*, 48: 77-80.
- Janson, C.H. 1983.** Adaptation of Fruit Morphology to Dispersal Agents in a Neotropical Forest. *Science*, 219, 187-189.
- Jordano, P., and Schupp, E.W. 2000.** Seed disperser effectiveness: The quantity component and patterns of seed rain for *Prunus mahaleb*. *Ecological Monographs* 70: 591–615.
- Kaplin, B.A., and Moermond, T.C. 1998.** Variation in seed handling by two species of forest monkeys in Rwanda. *American Journal of Primatology*. 45, 83–101.
- Kaplin, B.A., and Lambert, J.E. 2002.** Effectiveness of seed dispersal by *Cercopithecus* Monkeys: implications for seed input into degraded areas. In: Levey, D.J., Silva, W.R., Galetti, M. (Eds.), *Seed-Dispersal and Frugivory: Ecology, Evolution and Conservation*. CABI Publishing, New York, pp. 351–364.
- Koné, I., Lambert, J.E., Refisch, J., Bakayoko, A. 2008.** Primate seed dispersal and its potential role in maintaining useful tree species in the Taï region, Côte-d’Ivoire: implications for the conservation of forest fragments. *Tropical Conservation Science* 1 (3):293-306.
- Lambert, J.E., and Garber, P.A. 1998.** Evolutionary and ecological implications of primate seed dispersal. *American Journal of Primatology*. 45: 9–28.
- Lambert, J.E. 1999.** Seed handling in chimpanzees (*Pan troglodytes*) and redtail monkeys (*Cercopithecus ascanius*): implications for understanding hominoid and cercopithecine fruit-processing strategies and seed dispersal. *American Journal of Physiology and Anthropology*. 109, 365–386.
- Lucas, P.W., and Corlett, R.T. 1998.** Seed dispersal by long-tailed macaques. *American Journal of Primatology*. 45, 29–44.
- Mangama-Koumba L.B., Nakashima., Y., Mavougou., J.F., Akomo-Okoue, E.F., Yumoto, T., Yamagiwa., J., M’batchi., B. 2016.** Estimating diurnal primate densities using distance sampling method in Moukalaba-Doudou National Park, Gabon. *Journal of Applied Biosciences*. 99: 9395 – 9404.
- Mangama-Koumba L.B., Ebang Ella G.W., Akomo-Okoue., E.F., Mindonga Nguelet., F.L., M’batchi B., Mavougou J, F. 2016.** Vegetarian diet in Guenon and Mangabey monkeys of Moukalaba-Doudou National Park, Gabon:

Similarities and Differences. *Inter Jour Biol Che Sci.* 10(6) : 2435-2446

Mounioko., F., Dibakou E.S., Zinga-Koumba., C.R., Mbang-Nguema., O.A., Acapovi-Yao., G, Mutambwe., S, Mavoungou J.F. 2015. Rythme d'activité journalière de *Glossina fuscipes fuscipes*, vecteur majeur de la trypanosomiase humaine africaine dans le parc national de Moukalaba Doudou (Sud-Ouest Gabon). *Int. J. Biol. Chem. Sci.*, 9(1): 419-429.

Muller-Landau H.C. 2007. Predicting the Long-Term Effects of Hunting on Plant Species Composition and Diversity in Tropical Forests. *Biotropica* 39(3): 372–384.

Nakashima. Y., 2015. Inventorying medium- and large-sized mammals in the African lowland rainforest using camera trapping. *Tropics.* 23(4): 151-164.

Oates., J.F., Whitesides., G.H., Davies., A.G., Waterman., P.G., Green., S.M, Dasilva., G.L, Mole., S. 1990. Determinants of variation in tropical forest primate biomass: new evidence from West Africa. *Ecology* 71:328–343.

Otani, T. 2003. Seed dispersal and predation of fleshy-fruited plants by Japanese macaques in the cool temperate zone of northern Japan. *Mammal Study* 28: 153–156.

Otani, T. 2010. Seed dispersal by Japanese macaques, In: N. Nakagawa, M. Nakamichi, H. Sugiura (Eds.), *The Japanese macaques*, Tokyo, Japan, pp. 129–142.

Petre, C.A., Tagg, N.B., Haurez. B., Beudels-Jamar, R., Huynen. M.C., Doucet, J.L. 2013. Role of the western lowland gorilla (*Gorilla gorilla gorilla*) in seed dispersal in tropical forests and implications of its decline. *Biotechnol. Agron. Soc. Environ.* 17(3), 517-526.

Poulsen, J.R., Clark, C.J., Smith, T.B. 2001. Seed dispersal by a diurnal primate community in the Dja Reserve, Cameroon. *Journal of Tropical Ecology.* 17, 787–808.

Poulsen J.R, Beirne C, Rundel C, Baldino M, Kim S, Knorr J, Minich T, Jin L, Núñez C.L, Xiao S, Mbamy W, Obiang G.N, Masseloux J, Nkoghe T, Ebanega M.O, Clark C.J, Fay M.J, Morkel P, Okouyi J, White L.J.T Wright J.P. 2021 Long Distance Seed Dispersal by Forest Elephants. *Front. Ecol. Evol.* 9:789264. doi: 10.3389/fevo.2021.789264.

Rogers, H.S., Donoso, I., Traveset, A., Fricke, F.C. 2021a. Cascading impacts of seed disperser loss on plant communities and ecosystems. *Annu. Rev. Ecol. Evol. Syst.* 52, 641–666 doi: 10.1146/annurev-ecolsys-012221-111742.

Slater, K., and Du Toit, J.T. 2002. Seed dispersal by chacma baboons and syntopic ungulates in southern African savannas. *South African Journal of Wildlife Reserve.* 32, 75–79.

Schupp, E.W. 1993. Quantity, quality and the effectiveness of seed dispersal by animals. *Vegetation* 108:15–30.

Smith, R.J., and Jungers, W.L. 1997. Body mass in comparative primatology. *Journal of Human Evolution* 32:523–559.

Sosef M.S.M., Issembe, Y., Bourobou, H.P.B., Koopman, W.J.M. 2004. Botanical diversity of the Pleistocene forest refugia Mounts Doudou. In: Fisher BL, editor. *Monts Doudou, Gabon: Floral and faunal inventory with reference to elevational distribution.* San Francisco, CA: California Academy of Science. P 17–92.

Sourd., C. 1983. - Etude des modes d'exploitation des ressources fruitières par *Cercopithecus cephus*

au cours d'un cycle annuel. *Thèse 3^{ème} Cycle*, Université de Rennes 1.

Struhsaker, T.T. 1975. The Red Colobus Monkey. *Chicago University Press*. Chicago

Takenoshita., Y., and Yamagiwa, J. 2008. Estimating gorilla abundance by dung count in the northern part of Moukalaba Doudou National Park, Gabon. *African Study Monographs* 39:41–54.

Takenoshita., Y, Ando., C., Yamagiwa J. 2008. Fruit phenology of the great ape habitat in the Moukalaba Doudou National Park, Gabon. *African Study Monographs* 39:23–39.

Tamura., M., and Akomo-Okoue., E.F. 2021. Hand preference in unimanual and bimanual coordinated tasks in wild western lowland gorillas (*Gorilla gorilla gorilla*) feeding on African ginger (Zingiberaceae). *Am J Phys Anthropol.* 2021; 1–15. <https://doi.org/10.1002/ajpa.24227>

Tarnaud L, and Negishi., Y 2009. Intérêt précoce des jeunes macaques (*Macaca fuscata yakui*) âgés de 0 à 11 mois pour les nourritures rares sélectionnées par les mères en milieu naturel. Conférence : Société Francophone de Primatologie. p. 20

Tsujino, R., Yumoto, T. 2009. Topography-specific seed dispersal by Japanese macaques in

a lowland forest on Yakushima Island, Japan. *Journal of Animal Ecology.* 78, 119–125.

Vande, W.J.P. 2012. Moukalaba Doudou. Agence National des Parcs Nationaux (ANPN), Libreville, Gabon. 296 p.

White L.J.T. 1994. Biomass of rain forest mammals in the Lope. Reserve, Gabon, *Journal of Animal Ecology.* 63 : 499-512.

White., L.J.T., and Abernethy K. 1997. Guide de la Végétation de la Réserve de la Lopé [A Guide to the Vegetation of the Lopé Reserve, Gabon]. 2e éd. Libreville, Gabon : ECOFAC.

Wright, S.J., Hernandez, A., Condit, R. 2007. The bush meat harvest alters seedling banks by favoring lianas, large seeds, and seeds dispersed by bats, birds, and wind. *Biotropica* 39: 363–371.

Yumoto, T., Noma, N., Maruhashi, T. 1998. Cheek-pouch dispersal of seeds by Japanese monkeys (*Macaca fuscata yakui*) on Yakushima Island, Japan. *Primates* 39, 325–338.

Yumoto, T., Terakawa, M., Terada, S., Boupoya, A., Nzabi, T. 2015. Species composition of a middle altitude forest in Moukalaba-Doudou National Park, Gabon. *Tropics.* 23(4):205-213.