


Diet of the mona monkey *Cercopithecus mona* in the Gnanhouizounmè community forest in Southern Benin

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Abstract

Diet of the mona monkey Cercopithecus mona in the Gnanhouizounmè community forest in Southern Benin. The mona monkey *Cercopithecus mona* Schreber, 1774 is an arboreal and diurnal species occurring in some forests in Benin. The present study determined the feeding ecology of the species in the Gnanhouizounmè community forest, a forest fragment in Southern Benin. The *ad libitum* observation method was used to collect data during the minor wet and the major dry seasons. Descriptive statistics, proportion comparison tests, and diversity indices were used to analyse data. Results showed that the mona monkey foraged on 22 plant species in the study forest, with *Ceiba pentandra*, *Dialium guineense*, *Elaeis guineensis* and *Spondia monbin* constituting its major diet. Three species of leguminous plants were the most common food type. Fruits, both mature and immature, were the top food item in the diet, while other items were leaves, buds, tubers, stalks and flowers. Dietary diversity was low ($H = 2.09$ in the wet season, $H = 1.74$ in the dry season) with a low similarity between the two seasons (Morisita–Horn's index = 0.31). In forest fragments, the mona monkey has adapted to feed on few plant species and adjusts its diet to resources available each season. Plants consumed by this species should be taken into account in future tree-planting campaigns for the sustainable conservation of these monkeys in the study area.

Key words: *Cercopithecus mona*, Diet overlap, Feeding ecology, Forests islands

Resumen

Régimen alimenticio del cercopiteco mona Cercopithecus mona en el bosque comunitario Gnanhouizounmè en el sur de Benin. El cercopiteco mona, *Cercopithecus mona* Schreber, 1774 es una especie arbórea diurna presente en algunos bosques de Benin. En este estudio se determinó la ecología alimentaria de la especie en el bosque comunitario Gnanhouizounmè, un fragmento forestal en el sur de Benin. Se utilizó el método de observación *ad libitum* para recopilar datos en las dos estaciones secas, una más larga y otra más corta. Para analizar los datos, se utilizaron la estadística descriptiva, pruebas de comparación de proporciones y algunos índices de diversidad. Los resultados mostraron que el cercopiteco mona se alimentaba de 22 especies vegetales en el bosque del estudio, aunque la mayor parte de su alimentación estaba compuesta por *Ceiba pentandra*, *Dialium guineense*, *Elaeis guineensis* y *Spondia monbin*. Las plantas leguminosas fueron las más representadas en el régimen alimenticio con tres especies. El principal producto alimenticio fueron los frutos, tanto maduros como inmaduros, aunque también se alimentaba de hojas, yemas, tubérculos, tallos y flores. La diversidad alimentaria fue baja ($H = 2,09$ en la estación húmeda, $H = 1,74$ en la estación seca) y la similitud entre ambas estaciones también lo fue (índice de Morisita–Horn = 0,31). En los fragmentos forestales, el cercopiteco mona está adaptado a consumir pocas especies vegetales y ajusta la alimentación a los recursos disponibles en cada estación. Las plantas consumidas por esta especie deberían tomarse en consideración en futuras campañas de plantación de árboles dirigidas a la conservación sostenible de estos simios en la zona de estudio.

Palabras clave: *Cercopithecus mona*, Solapamiento del régimen alimenticio, Ecología alimentaria, Islas forestales

Introduction

Benin is an African country located in the Dahomey gap, a Guinean forest-savanna mosaic separating the zonal West African rain forest into two blocs, the western Guinea zone and the Central African Congo zone (Salzmann and Hoelzmann 2005). Despite this situation, the country has a huge and diversified biodiversity where non-human primates are encountered in various ecosystems, mainly in forests. The country harbours eleven species of primates belonging to four families (Nobimè et al 2010). The Cercopithecidae family has the highest representation with six species, including the mona monkey (*Cercopithecus mona* Schreber, 1774). This species is an arboreal and diurnal Old World monkey that has a small to medium-sized body. Its natural range includes Benin, Cameroon, Ghana, Nigeria and Togo (Matsuda Goodwin et al 2020). The species is also found on the Caribbean Island of Grenada where it was introduced between the 17th and 18th centuries (Glenn 1997). The mona monkey is a social animal that lives in groups of up to thirty-two individuals (Glenn 1997). It is a forest species, although it can adapt to degraded habitats (Oleru 2016). The species was formerly classified as Least Concern status on the IUCN Red List, but is currently classified as Near Threatened as it is confronted with anthropogenic threats such as habitat degradation, hunting, and poaching (Matsuda Goodwin et al 2020).

The mona monkey has been the subject of several studies in its occurrence areas. Many of these studies have focused on population size, activity budget, and feeding ecology of the species in Nigeria and the island of Grenada (West Indies). Assessment of group size and group composition of the species in Grenada (Glenn 1997) shows there are all-male groups of two to four individuals and bisexual groups of up to 32 individuals. The activity budget has shown that the species spends most of its time moving, feeding, and resting during both the dry and wet seasons (Okekedunu et al 2014). The mona monkey eats mainly fruits, but also seeds, nuts and leaves (Ejidike and Salawu 2009, Oleru et al 2020). It has been reported in several forest ecosystems of southern and central Benin, where it primarily faces anthropogenic threats (Nobimè et al 2010).

Little is known about the feeding ecology of the species in Benin. A study was conducted on the feeding ecology of the species in the Lama Forest, a large continuous forest (Matsuda Goodwin 2007). However, the diet of the species has not been well documented in other habitats, especially in forest fragments where it still lives. Previous studies highlighted dietary variation between seasons and forests in guenons (Chapman et al 2002, Pazol and Cords 2005). It is therefore important to fill this knowledge gap concerning the species, because nutrition is a key factor which determine survival, growth and reproduction of wild animals (Rode et al 2006), particularly in fragment forests, which are fragile habitats. Besides, such knowledge is of particular importance for the sustainable conservation of the mona monkey in view of the degradation of its habitats and the consequent reduction in diversity of its diet. This study examined the diet of the mona

monkey in the Gnanhouizounmè community forest, a forest fragment located in the Ouémé valley, an area in Benin that has a high concentration of the species. We aimed to determine the species of food plants and items consumed and preferred by the mona monkey according to seasons.

Material and methods

Study area

The study was carried out in the Gnanhouizounme community forest in south-east of Benin (West Africa). This forest covers an area of 26 ha and comprises two forest fragments (Gbetoho 2020): Zindji (6 ha) and Kassiagbonou (20 ha). The forest is mainly composed of semi-deciduous rainforests and savannah ecosystems. A part of the forest is marshy and flooded by the Ouémé river watercourses. The forest has a diversified flora and wildlife comprising animal species such as *Dendrohyrax dorsalis sylvetris*, *Tragelaphus scriptus*, *Cercopithecus mona*, *Cercopithecus erythrogaster erythrogaster*, and plant species such as *Azelia africana*, *Ceiba pentandra*, *Milicia excelsa* and *Parkia biglobosa* (Gbetoho 2020).

The Gnanhouizounme forest (6° 51' 30" N, 2° 27' 50" E) is located in the district of Bonou in the Guineo-Congolese biogeographical zone of Benin. This region is characterized by two wet seasons (major: April to mid-July; minor: Mid-August to November) and two dry seasons (major: November to March; minor: from mid-July to mid-August). The average annual rainfall of the region is about 1,123.5 mm and the average monthly temperature is between 25 °C and 29 °C (Adjakpa et al 2016). The main activities of communities in this commune are agriculture, fishing and petty trading.

Data collection

Data were collected during the minor wet season (late August to October 2021) and the major dry season (January to mid-March 2022). Each season, mona monkey groups of 8 to 22 individuals were located and observed between 7:00 am and 7:00 pm for 31 days. The group to observe was generally identified on the eve of the observation day, between 6:00 and 7:30 pm on dormitory trees such as *Ceiba pentandra*, *Cola gigantea* and *Dialium guineense*, or searched on the observation day between 6:00 and 7:00 am. On each observation day we followed only individuals of the same group. Mona monkeys were observed by the principal investigator and a local helper using binoculars, at a distance of about 20-30 m to avoid disturbing the animals. Feeding events (i.e. when monkeys put a plant part in the mouth) were recorded following the ad libitum observation method (Oates 1988). We recorded as many feeding events and as many plant species and parts consumed as possible until the group moved out of the observers' sight. These records were collected through direct observation with the binoculars and from food remnants. Feeding events correspond to feeding of an individual on different plant species or different parts of the plant (fruit, leaves, buds, etc). Plant food items consumed

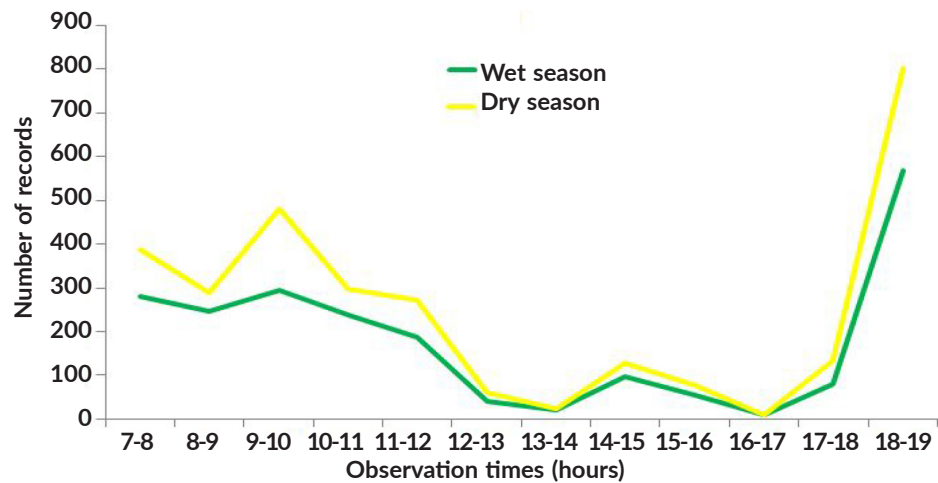


Fig. 1. Total number of feeding events at different times.

Fig. 1. Número total de episodios de alimentación en diferentes momentos.

by the species were categorized into seeds, leaves, buds, mature fruits, immature fruits, tubers and others (stalks, flowers) (Djogo-Djossou et al 2018, Bempah et al 2021). Samples of plant species unknown by the principal investigator were collected and later identified at the Laboratory of Forestry and Conservation of Bioresources of the National University of Agriculture (Benin) using the Analytical Flora of Benin (Akoègninou et al 2006). Families of plant consumed by the mona monkey were searched in the literature.

Data analyses

Data collected were computed on an excel sheet which was used to conduct descriptive statistics. The numbers of feeding events at different times of the day were summed, and the proportions of plants in the diet and the proportions of plant parts in the diet were calculated. Proportions of the different plant parts consumed were compared between the two seasons via proportion comparison tests. Analyses were performed using SigmatStat 3.5 statistical software, and graphs were drawn in Excel 2010. The diversity and evenness of plant species consumed were assessed via the Shannon-Weaver index of diversity (*H*) and the Pielou Equitability Index (*J*) using the equations 1 and 2 respectively (Kane and Scott McGraw 2017).

$$H = - \sum_{i=1}^S p_i \ln p_i \quad \text{Equation 1}$$

$$J = H / \ln S \quad \text{Equation 2}$$

where *H* is Shannon-Weaver index of diversity, *p_i* the proportion of the species *i* in the diet, *S* the number of species consumed by mona monkeys, and *J* the Pielou Equitability Index

The similarity in diet composition between the dry and wet seasons was accessed by calculating the simplified Morisita-Horn index (*C_H*) using the equation 3 (Krebs 1999).

$$C_H = 2 \sum_{i=1}^S x_i y_i / \sum_{i=1}^S x_i^2 + y_i^2 \quad \text{Equation 3}$$

where *C_H* is the simplified Morisita–Horn index, *x_i* is the proportion of species *i* in the diet of mona monkeys in the wet season, *y_i* is the proportion of species *i* in the diet of mona monkeys in the dry season and *S* the number of species consumed by mona monkeys. *C_H* ranges from 0 (no similarity) to 1 (high similarity).

Life forms of plants following the classification of Raunkiaer (1934) were mainly obtained in Adomou (2005): MPh, megaphanerophyte (> 30 m tall); mPh, mesophanerophyte (8 to 30 m); mph, microphanerophyte (2 to 8 m); npH, nanophanerophyte (0.5 to 2 m); Ch, Chamephyte; G, Geophytes; HC, hemicryptophyte; Th, Therophyte; L, liana; and Ep, epiphyte.

Results

Feeding events according to the observation times

The monitoring of feeding activities of mona monkeys yielded a total of 2,114 records during the wet season and 2,964 records during the dry season (fig. 1). The highest feeding records were obtained between 7:00 and 12:00 h in the morning (~59%) and between 17:00 and 19:00 in the evening (~27%).

Plant species and plant parts consumed by mona monkeys

We identified 22 plant species from 18 families that were eaten by mona monkeys during the dry

Table 1. Plant species consumed by mona monkeys in dry and wet seasons: Leg, Leguminosae; IFr, immature fruits; MFr, mature fruits; Se, seeds/nut; Le, leaves; Bu, buds (leave and floral); Fl, flowers; Tu, tuber; St, stalks.

Tabla 1. Especies vegetales consumidas por el cercopiteco mona en las estaciones secas y húmedas: Leg, leguminosas; IFr, frutos inmaduros; MFr, frutos maduros; Se, semillas y frutos secos; Le, hojas; Bu, yemas (foliares y florales); Fl, flores; Tu, tubérculos; St, tallos.

Plant species	Family	Parts eaten	Percentage of total records	
			Wet season	Dry season
<i>Elaeis guineensis</i> Jacq.	Arecaceae	IFr, MFr, Se, Bu	31.55	2.09
<i>Ceiba pentandra</i> (L.) Gaertn.	Bombacaceae	Le, IFr, MFr, Bu, Fl	14.00	31.36
<i>Spondias mombin</i> L.	Anacardiaceae	IFr, MFr, Se	18.54	2.63
<i>Dialium guineense</i> Willd.	Leg-Caesalpinioideae	IFr, MFr, Se	0.95	29.14
<i>Mangifera indica</i> L.	Anacardiaceae	IFr, MFr, Se	8.33	3.04
<i>Diospyros mespiliformis</i> Hochst. ex A.DC.	Ebenaceae	IFr, MFr, Se	5.35	2.63
<i>Rourea coccinea</i> (Thonn. ex Schum.) Benth.	Connaraceae	IFr, MFr, Se	6.29	0.37
<i>Cola gigantea</i> A. Chev.	Sterculiaceae	IFr, MFr	0.14	0.91
<i>Azalia africana</i> Smith ex Pers.	Leg-Caesalpinioideae	MFr	-	0.34
<i>Pleioceras barteri</i> Baill.	Apocynaceae	IFr, MFr, Se	-	2.30
<i>Albizia zygia</i> (DC.) J.F. Macbr.	Leg-Mimosoideae	IFr, MFr	-	0.74
<i>Cola laurifolia</i> Mast.	Sterculiaceae	IFr, MFr, Se	-	0.88
<i>Morinda lucida</i> Benth.	Rubiaceae	IFr, MFr, Se	-	22.11
<i>Synsepalum brevipes</i> (Baker) Pennington	Sapotaceae	IFr, MFr, Se	-	1.45
<i>Ipomoea batatas</i> (L.) Lam	Convolvulaceae	Tu, St	1.37	-
<i>Manihot esculenta</i> Crantz	Euphorbiaceae	Tu	0.38	-
<i>Psidium guajava</i> L.	Myrtaceae	IFr, MFr	1.32	-
<i>Zea mays</i> L.	Poaceae	Le, IFr, MFr	1.56	-
<i>Ficus exasperata</i> Vahl	Moraceae	IFr, MFr, Se	3.55	-
<i>Myrianthus arboreus</i> P. Beauv.	Moraceae	IFr, MFr, Se	4.40	-
<i>Salacia pallescens</i> Oliv.	Celastraceae	IFr, MFr	2.03	-
<i>Piper guineense</i> Schum. and Thonn.	Piperaceae	MFr	0.24	-

and wet seasons (table 1). Each season, the diet was dominated by three to five plant species. In the dry season, the top three species, *Ceiba pentandra*, *Dialium guineense* and *Morinda lucida*, accounted for 82.6% of the diet, while in the wet season the top five species (*Elaeis guineensis*, *Spondia monbin*, *Ceiba pentandra*, *Mangifera indica* and *Rourea coccinea*) accounted for 78.71%. Leguminous plants were those most highly represented in the diet with three species (13.64%), followed by Anacardiaceae, Moraceae, and Sterculiaceae, each of which was represented by two species (9.09%). Mona monkeys foraged mainly on large trees as 63% of their food came from mesophanerophyte and megaphanerophyte (fig. 2). Sometimes, the monkeys ate cultivated crops such as potato, cassava and maize in farms bordering the study forest. Mona monkey ate mainly fruits (67 to 75% depending on seasons) and seeds/nuts (16 to 25%) (fig. 3). No difference was found between the dry and wet seasons regarding the proportions of the various parts consumed ($p > 0.05$).

Seasonal variation in the diversity of plant species consumed

The mona monkey consumed 16 plant species during the wet season and 14 species during the dry season (table 2). Its diet was not greatly diversified in either season ($H < 2.5$). However, evenness of their diet was higher in the wet season. Similarity between the two seasons regarding plant species consumed was low (Morisita–Horn index < 0.5).

Discussion

The mona monkey foraged on different plant species, both wild and cultivated. During both the dry and wet seasons, most feeding records were reported in the mornings and evenings. This observation suggests that their feeding activity occurs mainly during these periods. Similar observations were reported by Olaleru et al (2020). This pattern could be due to the fact that the species is more active during the morning (Uloko

and Lameed 2019). The high number of feeding events observed in the late afternoon was due to individuals meeting around water sources to drink and dormitory trees to sleep, facilitating observation of groups of individuals.

The mona monkey consumed parts of 22 plant species during both dry and wet seasons. The species richness found in this study was lower than the 31 species reported by Olaleru et al (2020) in Okomu National Park, Nigeria. Some species, such as *Pycnanthus angolensis*, *Raphia hookeri*, *Xylopia aethiopica*, etc. consumed by mona monkeys in that park were also recorded in our study area. The monkeys accessed other plant species, such as *Ceiba pentadra*, *Morinda lucida* and *Dialium guineensis*, found in the Gnanhouzounmè community forest. Additionally, the lower species richness reported in this study may be related to the type of habitat as the result of fragmented landscapes reducing food availability (Arroyo-Rodríguez et al 2007).

The diet was more diversified in the wet season than in the dry season because of the availability of more resources during the former. During the wet season, several trees flourished and fruited. During both the dry and wet seasons, the mona monkey mainly consumed parts of three to five key species. For example, in the wet season, the species mainly fed on almost all edible parts of *Elaeis guineensis* (immature and mature fruits, leave buds, nuts), *Ceiba pentandra* and *Spondias mombin*. In the dry season, when the monkey had fewer plants to feed on (such as *Ceiba pentandra*: both immature and mature fruits, leaves, floral buds, flowers; and *Dialium guineense*), they adjusted their diet to available food resources in the fragmented forests. Similar results were also reported in the Lama Forest in southern Benin, where

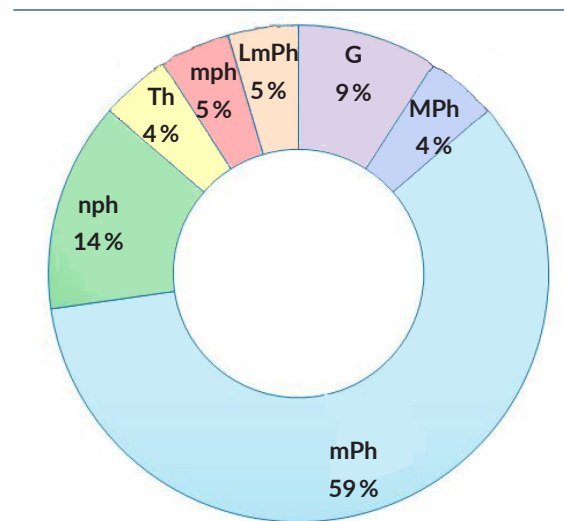


Fig. 2. Life forms of plant species on which mona monkeys foraged: mPh, mesophanerophyte; MPh, megaphanerophyte; G, Geophytes; LmPh, liana-megaphanerophyte; mph, microphanerophyte; Th, Therophyte; nph, nanophanerophyte.

Fig. 2. Formas biológicas de las especies vegetales de las que se alimenta el cercopiteco mona: mPh, mesofanerófito; MPh, megafanerófito; G, geófito; LmPh, liana megafanerófito; mph, microfanerófito; Th, terófito; nph, nanofanerófito.

the most common species *Dialium guineense* and *Diospyros mespiliformis* contributed to approximately 40% of the diet (Matsuda Goodwin 2007). This aptitude contributes to the monkeys' adaptation to fragmented habitats (Ogunyebi et al 2018). The low similarity in

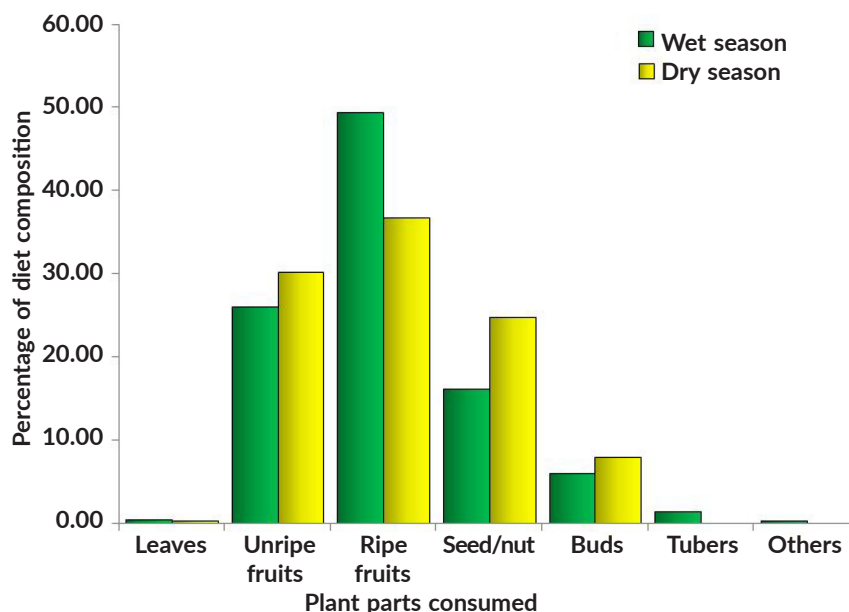


Fig. 3. Plant parts consumed by mona monkeys according to seasons.

Fig. 3. Partes vegetales consumidas por el cercopiteco mona en cada estación.

Table 2. Dietary diversity indices of plant foods consumed by mona monkeys: N, number of plant species; H, Shannon-Weaver index; J, Evenness index; Ch, Morisita-Horn index.

Tabla 2. Índice de diversidad alimentaria de los alimentos vegetales consumidos por el cercopiteco mona: N, número de especies de plantas; H, índice de Shannon-Weaver; J, Índice de uniformidad; Ch, índice Morisita-Horn.

Seasons	N	H	J	Ch
Wet	16	2.09	0.76	0.31
Dry	14	1.74	0.66	

plant species consumed between the two seasons also confirms this assumption (adaptation to few available foods), and may be explained by the low overlap in fruit production phenology of plant species between both seasons (Vayssières et al 2010). Leguminous plants were the most frequently represented in the diet with three species.

From time to time, and mainly in the wet season, mona monkeys moved to farms bordering the study forest where they ate items such as potato (*Ipomoea batatas*) stalks and tubers, cassava (*Manihot esculenta*) tubers and corn (*Zea mays*) leaves and seeds. This behaviour may be a means to complete the limited resources in the forest fragment. Zoffoun et al (2019) reported that local communities at Togbota -in the same area as our study- considered that the mona monkey (*C. mona*) and the red-bellied monkey (*Cercopithecus erythrogaster erythrogaster*) were responsible for great damage on farms. Crop-raiding is a source of primate-human conflict and may reduce willingness of local communities to contribute to the conservation of mona monkeys. Results of the present study suggest that conservation efforts should be increased to ensure a good availability of plant species consumed by the species in this habitat in order to reduce depredation on farms. This would avoid conflicts with humans and favour the growth of populations of the mona monkey in the study area. Our results contributes to achieving the Sustainable Development Goal 15 related to life on land since it provides knowledge necessary for conservation of biodiversity.

The mona monkeys' diet in the dry and wet seasons is mainly made up of fruits (mature and immature), followed by seeds. This finding supports previous studies about the frugivorous diet of the species (Matsuda Goodwin 2007, Ejidike and Salawu 2009; Olaleru et al 2020). Fruits provide mainly carbohydrates and energy to primates (Riba-Hernandez et al 2003). Other nutrients, such as proteins and lipids, are supplied by other plant parts such as leaves, seeds and buds. At times, the species was also seen eating insects. However, we did not count or identify these because they were difficult to identify with the methods used due to their small size and the fact that they did not fall out of the monkeys' hands (Olaleru 2016). Insects are a source of proteins to complete those supplied by plants. The

feeding strategy of mona monkeys in the study forest, consisting of feeding mostly on fruits of a few plant species available each season, seems to meet the optimal foraging theory. They likely move to the most closely available species, avoiding spending energy to search for other less available resources that they could also eat. We observed no statistically significant difference between the dry and wet seasons regarding the proportions of plant parts eaten. Nonetheless, further studies are necessary to assess nutrient intake during these seasons due to the low similarity of plant species in the diet during both seasons. Mona monkeys are arboreal and primarily picked their foods on large trees. However, they also collected foods on the ground when they got down from the trees to drink water and to play, especially when the forest was not flooded.

Primates are dispersers of a large number of plant species. According to seed size classes (small: < 3 mm; medium: 3–12 mm and large: > 12 mm) used by Bufalo et al (2016), the majority of plant species consumed by mona monkeys in the Gnanhouzounmè community forest were medium-seeded and large-seeded. Accordingly, the mona monkey likely contributes to the dispersal of these plant species in the study area. Plant species bearing small seeds which can be swallowed easily and voided intact, such as *Psidium guajava* and *Morinda lucida*, may be transported away from parent plants and to greater distances as reported for the tamarins *Leontocebus nigrifrons* (Heymann et al 2022). An important aspect of endozoochorous dispersal that could merit investigation is the viability of these seeds after passing through the mona monkey gut. Contrarily, species with large seeds such as *Mangifera indica* may be mostly dispersed when mona monkeys move short distances during feeding.

Conclusion

Our findings show that the mona monkey foraged on 22 plant species in the Gnanhouzounmè community forest in the dry and wet seasons. However, during both seasons the diet basically consisted of only a few species. The monkeys consumed different parts of the plants, including mature and immature fruits, seeds, buds, tubers, stalks and flowers. Fruits were the main food item of the diet. The species foraged mainly on large trees in the forest, but also sometimes moved to farms bordering the forest, where it ate cultivated crops. This situation is a source of human-wildlife conflicts. For a sustainable conservation of the mona monkey in this forest fragment, managers should increase availability of plant species consumed by the species through planting activities, and develop strategies to reduce illegal wood harvesting by local communities in the forest.

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Conflicts of interest

No conflicts declared

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