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DENSITIES OF APES' FOOD TREES AND PRIMATES IN THE PETIT LOANGO RESEARVE, GABON

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ABSTRACT Preliminary surveys were conducted to estimate primate densities and forest structure in the Petit Loango Reserve, Gabon. The tropical forest of the Reserve consisted mainly of primary vegetation characterized by poor Marantaceae or Zingiberaceae undergrowth, which are regarded to be important (keystone) foods for apes in other habitats. Despite the absence of such herbs, seven diurnal primate species were found at relatively high densities. In comparison with Lopé Reserve in central Gabon, some important food tree species for apes were found at higher densities in Petit Loango Reserve, which may provide suitable habitats for frugivorous primates.

Key Words: Forest structure; Ape food; Density; Primates.

INTRODUCTION

Many primate species live sympatrically in tropical forests of Central Africa having formed complex interactions with each other and with other mammals (Gautier-Hion et al., 1980). The composition of tropical forest and the abundance of food may influence these interactions and play a role in determining the range of primate group or individual density, through intra or interspecific competition (Oates, 1987; Waser, 1987). However, few surveys have been conducted on density or biomass of primates in relation to their habitat quality and carrying capacity in African tropical forests (Gautier-Hion & Gautier, 1974; Struhsaker, 1975; Harrison & Hladik, 1986; Tutin et al., 1994; White, 1994b).

Tutin and Fernandez (1984) conducted a nationwide survey on gorillas and chimpanzees in Gabon, and found both apes widely distributed throughout the country. They noted that gorillas occurred at highest densities in secondary forests and thickets, while chimpanzees occurred at highest densities in primary forests. They suggested that terrestrial herbaceous vegetation (THV), such as Marantaceae or Zingiberaceae, may constitute staple foods of gorillas in the lowland tropical forest (Tutin & Fernandez, 1985). THV has also been regarded as a keystone food (Leighton & Leighton, 1983) for other larger mammals (Rogers & Williamson, 1987; White et al., 1993).

The Petit Loango Reserve is located in the southwestern Gabon. This area has been proposed by both IUCN (International Union for Conservation of Nature

and Natural Resources) and WWF (World Wide Fund for Nature) to be integrated into a Protected Areas Complex of 11,000 km^2 with several surrounding hunting areas (Wilks, 1990). At Cette Cama near the Reserve, the estimated densities of gorillas (0.22 individuals/km^2) and chimpanzees (0.42 individuals/km^2) were relatively high in comparison with those estimated in other areas of Gabon (Tutin & Fernandez, 1984). However, we found that the Researve was characterized by poor THV undergrowth during the first survey in 1994. Why and how do gorillas and chimpanzees live in higher densities in this area with poor THV condition? Which components of forest structure differ from other habitats of apes? What primate communities are constituted in this type of forest?

In order to answer these questions, we conducted the second survey in 1995. We used the belt-transect method to estimate densities of primates and forest structure. Composition of the forest and abundance of apes' foods in the Petit Loango Reserve were compared with those at the Lope Reserve, located in central Gabon and where a long-term survey on gorillas and chimpanzees has been conducted. Densities of apes and other primate species are discussed in relation to forest types found in other habitats.

METHODS

Two censuses were carried out in and around the Petit Loango Reserve, Gabon in 1994 and 1995. The reserve is located on the western coast of Gabon at 2°15′S, 9°30′E (Fig. 1). It covers an area of 500 km^2, which constitutes a complex mosaic of forests, swamps and savanna surrounded by three hunting areas. The reserve faces the Atlantic Ocean to the west and contacts with lagoons in the north and south. Dense mangrove forests have developed along the lagoons. A forestry road forms the eastern border of the reserve.

The climate of this area is equatorial of transition. The mean temperature is 25–26°C and the annual rainfall is 1,800–2,200 mm (Wilks, 1990). Two dry seasons (minor, January-February; major, July-September) are recognizable from the monthly rainfall records.

Vegetation of this area is a complex mosaic of primary forest, secondary forest, swamp forest and open savanna. Mangrove forest is seen along lagoons. High tree stands of *Aucoumea klaineana*, *Sacoglottis gabonensis* and *Desbordesia glaucescens* are frequently found with scarce undergrowth in the primary forest. Dominant plant species in swamp are *Cyperus papyrus*, *Pandanus candelabrum*, *Alstonia congensis*, *Mitragyna ciliata* and *Raphia* spp. Open savanna vegetation is constituted mainly of Graminea, such as *Pleiadelphia gossweileri*, *Pobeguinea arrecta* and *Rhynchelytrum* spp. (Wilks, 1990).

The censuses were made during one week each in February 1994 and 1995. In the first census, an investigator (J. Yamagiwa) walked c. 48 km with a pace counter on the foot path, on the elephant trails, and randomly in the forest with two field assistants in the daytime. During this census, average rate of travel was 0.5–1.0 km/h. The investigator recorded vegetation types, fresh (up to 2 days old) feeding signs and feces of larger mammals, and day or night beds of great apes.

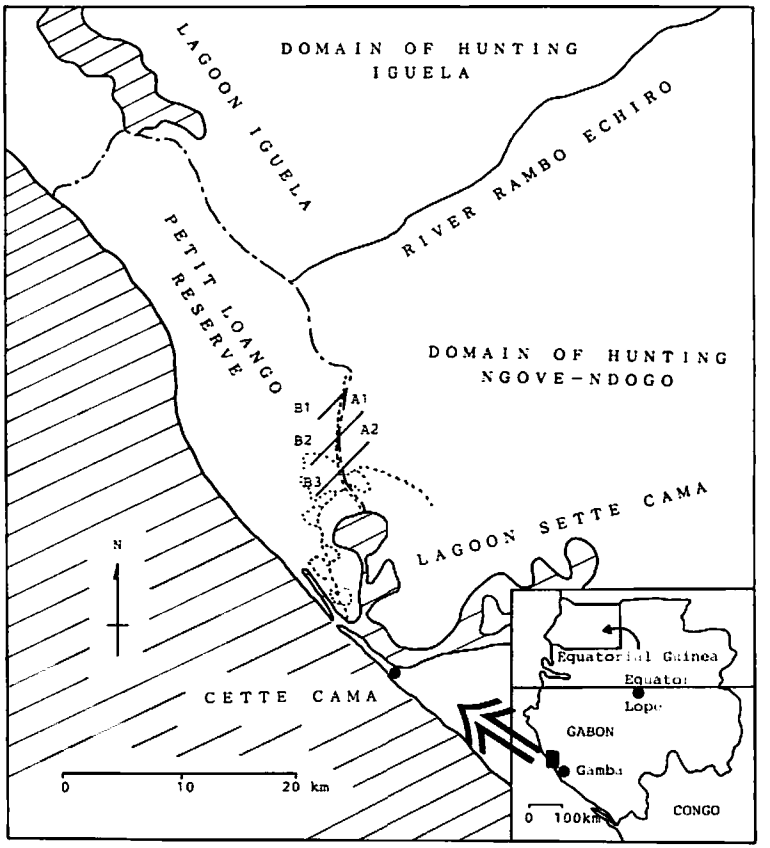

Fig. 1. Map of the study area.
A1–B3: Transect lines (each 3 km in length).
Dotted line: Survey route in the 1994 census. Station of the Reserve is located near Cette Cama and is organized by Direction de la Fane et de la Chasse and WWF.

When investigator sighted primates, he carefully followed them and counted the number of individuals within the groups.

In the second census, the belt-transect methods (Burnham et al., 1980) were used to estimate primate densities. We cut five transect lines (each 3 km in length), northeast to southwest, and walked carefully along the line using a 100 m measure to sight primates and to record vocalizations on both sides of the line. Transects A1/B2 and A2/B3 started at the same points. Three parallel lines were made 2 km from each other. We completed 3 km in the four transects when we cut short at 2.7 km on the B1 transect, having encountered a group of elephants. During this census, average rate of travel was 0.2–0.5 km/h.

The diurnal primates usually live in groups, but occasionally travel alone. Therefore, when we counted more than two individuals or heard more than two vocalizations from different directions within 30 seconds, we recorded a group. Visual range was defined as 0–50 m and auditory range as 0–150 m from the tran-

sect.

Gorillas and chimpanzees build one bed each night per independent individual. Such beds were used to estimate their density (Ghiglieri, 1984). Density (D) was calculated as follows;

$$D = \frac{\text{Number of beds counted}}{\text{Area sampled (km}^2\text{)}} \times \frac{1}{\text{Observer efficiency}} \times \frac{1}{\text{Average (durability life span) of bed}}$$

We defined the visual range of beds as 5 m to either side of the transect line and observer efficiency as 100%, because we only found ape beds within 5 m from the line. The average (durability life span) of beds was estimated to be approximately 114 days for chimpanzees and 54 days for gorillas (Tutin & Fernandez, 1984).

All the large trees of more than 30 cm in DBH (diameter at breast height) were identified and counted within 5 m of either side of the transect line. Trees bearing fruits were recorded, and the number of fruit species was counted on each transect line.

RESULTS

I. Forest Structure and Densities of Apes' Food Trees

The primary or secondary forest of the Petit Loango Reserve was characterized by poor undergrowth. No Marantaceae or Zingiberaceae harb was found along the route of the first census. Only a small patch of *Halopegia azuela* (Marantaceae) was found in one of nine swamps along the transect line during the second census.

The transect lines span 12,869 m in primary forest with many small swampy areas, 1,478 m in secondary forest and 353 m in a open plain. The lines made outside the Reserve (A1 and A2) included more secondary forest than the lines inside the Reserve (B1 and B2). This reflects recent (until about 10 years ago) deforestation by logging companies and local people both outside and inside the Reserve.

The number of tree species and their overall density were similar between five transect lines (Table 1). The density of large trees (more than 70 cm in DBH) was slightly higher inside the Reserve (B1, B2, B3) than outside (A1, A2). Density of

Table 1. Number of species and density of trees along the transect line.

Transect line	length (m) Primary forest	Secondary forest	No. of species	Density(individual/ha) >30 cm	>70 cm (in DBH)
A1	2870	130	28	21.3	18.0
A2	2714	286	27	29.0	12.3
B1	2550	450	29	24.0	19.3
B2	2088	612	36	27.4	18.1
B3	2647*		26	33.2	24.9

*: Open plain (353 m) was excluded.

Table 2. Number of tree species (more than 30 cm DBH) found along the transect line.

Species name		Density (ind./ha) Primary forest		Secondary forest		Possible food	
		>30	>70	>30	>70	G	C
Monopetalanthus pellegrinii	CAESALPINIACEAE	5.1	2.0				
Irvingia gabonensis	IRVINGIACEAE	3.9	1.1	6.8	3.4	+	+
Coula edulis	OLACACEAE	3.0	0.4	2.0			
Strombosia glaucescens	OLACACEAE	3.0	0.4	0.7	0.7		
Anthostema anbryanum	EUPHORBIACEAE	2.7	0.3				
Calpocalix heitzii	MIMOSACEAE	2.1	1.6				
Berlinia bracteosa	CAESALPINIACEAE	1.9	1.4				
Poga oleosa	RHIZOPHORACEAE	1.8	0.5	1.4			+
Pterocarpus soyauxii	PAPILIONACEAE	1.6	1.0	2.7	0.7	+	
Hexalobus crispiflorus	ANNONACEAE	1.6	0.5	1.4	0.7	+	+
Klainedoxa gabonensis	IRVINGIACEAE	1.6	1.0			+	+
Nauclea trillesii	RUBIACEAE	1.5	1.0	4.7	2.0	+*	+*
Staudtia stipitata	MYRISTICACEAE	1.5	0.6	2.0	2.0	+	+
Berlinia confusa	CAESALPINIACEAE	1.3	0.4			+*	
Tieghemella africana	SAPOTACEAE	1.2	0.3				
Lecomtedoxa heitzana	SAPOTACEAE	1.1	1.0				
Sacoglottis gabonensis	HUMIRIACEAE	0.9	0.5	0.7		+	+
Panda oleosa	PANDACEAE	0.8	0.2	0.7			
Aucoumea kleineana	BURSERACEAE	0.8	0.6			+	+
Vitex pachyloba	VERBENACEAE	0.7	0.4	1.4	1.4	+*	+*
Strombosiopsis sp.	OLACACEAE	0.7		0.7		+*	
Mitragyna ciliata	RUBIACEAE	0.5	0.1			+	
Cola lateritia	STERCULIACEAE	0.5				+*	+
Canarium schweinfurthii	BURSERACEAE	0.4	0.3	1.4	1.4		+
Danielia soyauxii	CAESALPINIACEAE	0.4	0.2				
Steculia sp.	STERCULIACEAE	0.3	0.3	0.7			+*
Entandrophragma utile	MELIACEAE	0.3					
Irvingia glandifolia	IRVINGIACEAE	0.3	0.2			+	+
Hylodendron gabunense	CAESALPINIACEAE	0.3				+	
Ficus sp.	MORACEAE	0.2	0.1	0.7		+*	+*
Anthocleista nobilis	LOGANIACEAE	0.2	0.2	0.7	0.7	+*	
Fagara sp.	RUTACEAE	0.2		0.7	0.7		
Terminalia sperba	COMBRETACEAE	0.2		0.7			
Desbordesia glaucescens	IRVINGIACEAE	0.2	0.2	1.4	1.4		
Uapaca sp.	EUPHORBIACEAE	0.2	0.2			+*	+*
Enantia chlorantha	ANNONACEAE	0.2				+	+
Chlorophora excelsa	MORACEAE	0.1	0.1				
Bridelia sp.	EUPHORBIACEAE	0.1		0.7			
Anthonatha fragrans	CAESALPINIACEAE	0.1					
Diospyros crassiflora	EBENACEAE	0.1				+	+*
Plagiostyles africana	EUPHORBIACEAE	0.1				+	+
Symphonia globulifera	GUTTIFERAE	0.1					+
Dialium sp.	CAESALPINIACEAE	0.1				+*	+*
Omphalocarpum sp.	SAPOTACEAE	0.1					
Pterygota bequaertii	STERCULIACEAE	0.1					
Ricinodendron heudelotii	EUPHORBIACEAE	0.1	0.1				
Lovoa trichilioides	MELIACEAE	0.1					
Pentaclethra eetveldeana	MIMOSACEAE	0.1				+	+
Dacriodes buttneri	BURSERACEAE	0.1	0.1			+*	+*
Xylopia aethiopica	ANNONACEAE			0.7	0.7	+	+

Possible food is defined as the plant species or genus (*) used for food by gorillas (G) or chimpanzees (C) at Lopé in Gabon (Tutin et al., 1994), at 8 regions (gorillas) and Mt. Okorobiko (chimpanzees) in Equatorial Guinea (Sabater Pi, 1977, 1979) or at Ndoki in Congo (Nishihara, 1995).

medium-sized trees (more than 30 cm in DBH) was highest on the B3 line, where all *Aucoumea klaineana* trees were found. The highest diversity of tree species was found on the B2 line, which included the longest line in secondary vegetation. These observations suggest that the percentage of different vegetation types, rather than the degree of present protection, may influence the diversity of tree species.

The most frequent tree species in primary forest were *Monopetalanthus pellegrini*, *Irvingia gabonensis*, *Coula edulis* and *Strombosia glaucescens* (Table 2). The top 10 most frequent species in primary forest constituted 60% of the total number of 49 tree species, and included four possible food species of *G. g. gorilla* or *P. t. troglodytes* in the other habitats (Sabater Pi, 1977, 1979; Tutin & Fernandez, 1993; Nishihara, 1995). The most frequent species in secondary forest were *Irvingia gabonensis*, *Nauclea trillesii*, *Pterocarpus soyauxii*. The top 10 most frequent species in secondary forest constituted 79% of the total number of 21 tree species, and included seven possible food species of the apes. We found 25 and 22 possible food tree species for gorillas and chimpanzees, respectively, in primary forest, and 11 species for both apes in secondary forest.

The number of possible food trees (more than 30 cm in DBH) was 299 for gorillas and 246 for chimpanzees within the transect. Possible food tree densities

Table 3. Density of large possible food tree species (more than 70 cm DBH) in Petit Loango and Lopé Reserve, Gabon.

Scientific name	Density (individual/km²)			Plant part eaten				
	Petit Loango	Lopé		Gabon Lopé		E. Guinea		Congo Ndoki
		MF	CCF	G	C	G	C	G
*Irvingia gabonensis**	129	20	4	F	F,S	F	F	F
Berlinia bracteosa	122	8		L				
Pterocarpus soyauxii	95	68	20	S,L,Fl		F		
*Klainedoxa gabonensis**	88	32		F	F			F
Staudtia stipilata	75				F			L
Aucoumea klaineana	54	570	312	Fl	Fl			
Hexalobus crispiflorus	48			F	F			
Sacoglottis gabonensis	48			F	F	F	F	
*Canarium schweinfurthii***	41	10	20		F		F	
Irvingia glandifolia	20	12	4	F	F,S			
Mitragyna ciliata	7	2	16	L,B				
Xylopia aethiopica	7			F	F			
Hylodendron gabunense		28		F				
Enantia chlorantha				F	F			
Plagiostyles africana		2		F	F	F		
Symphonia globulifera					F			
Pentaclethra eetveldeana		14	12	L	L			

*: Indicates important food for both gorillas and chimpanzees, and
**: Indicates important food for chimpanzees at Lopé.
Plant part (F, fruit; S, seed; L, leaf; B, bark; Fl, flower) indicated is eaten by gorillas (G) and chimpanzees (C) at Lopé in Gabon (Tutin & Fernandez, 1993), at 8 regions (gorillas) and Mt. Okorobiko (chimpanzees) in Equatorial Guinea (Sabater Pi, 1977, 1979) and at Ndoki in Congo (Nishihara, 1995). At Lopé (Tutin et al., 1994), trees more than 70 cm DBH were enumerated in a strip 50 m wide (25 ha) in each MF (Marantaceae Forest) and CCF (Closed Canopy Forest).

in primary forest were 20.7 (individual/ha) for gorillas and 16.7 for chimpanzees, and those in secondary forest were 22.3 for gorillas and 21.7 for chimpanzees. The possible food tree density was slightly higher in the secondary forest than in primary forest for both gorillas and chimpanzees.

Table 3 compares the densities of large trees reported as possible food trees of apes in the Petit Loango and the Lopé Reserves. Plant parts eaten by gorillas and chimpanzees at Lopé (Tutin & Fernandez, 1993), in Equatorial Guinea (Sabater Pi, 1977, 1979) and in Congo (Nishihara, 1995) are also indicated. Among 17 species, 10 species appeared at higher densities in Petit Loango than Lopé. The lower density of *Aucoumea klaineana* in Petit Loango was caused by selective logging in the past. *Irvingia gabonensis*, *Klainedoxa gabonensis* and *Canarium schweinfurthii*, regarded as important foods at Lopé (Tutin & Fernandez, 1993), were found at higher densities in Petit Loango. *Pterocarpus soyauxii*, *Staudtia stipilata* and *Sacoglottis gabonensis*, which are used for foods by the apes in Equatorial Guinea or Congo, were also found at higher densities. These suggest that the larger number of large food trees for gorillas and chimpanzees may be available in our study site than the Lopé Reserve, with a few exceptions.

II. Density of Primates

In the first census, we confirmed the presence of seven diurnal primates, such as *Cercopithecus nictitans*, *C. cephus*, *C. pogonias*, *Cercocebus albigena*, *C. torquatus*, *Pan troglodytes* and *Gorilla gorilla*, within Petit Loango Reserve through direct observation.

We walked about 48 km within the Reserve and encountered various primate groups. Despite the difficulty of counting group sizes due to poor visibility in the dense forest and nervous responses of primates, we partly succeeded in identifiying the individuals within groups (Table 4). We sighted all the primate species both inside and outside the Reserve. The frequency of encounters with each species was not markedly different between inside and outside, except for *Cercocebus*

Table 4. Number of individuals counted by direct observations and the estimated density for each primate species in the first census.

Primate species	No. of observations (within the Reserve)	Group size N	Mean (range)
Cercopithecus nictitans	27 (21)	11	11.6 (5–21)
cephus	29 (24)	10	11.2 (3–33)
pogonias	4 (3)	1	9
Cercocebus torquatus	5* (1)	3	9.3 (7–11)
albigena	6 (5)	2	10.5 (8, 13)
Pan troglodytes	3** (2)	3	4.0 (3–6)
Gorilla gorilla	3** (3)	2	2.5 (2, 3)

*: *C. torquatus* was observed only once in the study area. Group size was counted near the Cette Cama Station.

**: Party size of chimpanzees was counted by direct observations in one case and by bed counts in two cases. Solitary male gorilla and a group of gorillas were directly observed in one case, and a group was indirectly obseved (measurements of foot prints and feces on the ground) in one case.

torquatus, which was rarely observed inside the Reserve.

C. nictitans and *C. cephus* were the most frequently encountered. Directly observed group sizes widely varied within species, but the mean group size of Cercopithecine monkeys fell in the range of 9–12. The largest group counted had 33 individuals for *C. cephus*.

Among 25 contacts with *Cercopithecus* and *Cercocebus* monkeys which we tried to follow and count, nine contacts were polyspecific groups (more than two primate species fed, traveled or rested less than 10 m from each other). *C. nictitans* and *C. cephus* formed mixed group in seven cases, *C. cephus* and *C. albigena* in one case, and *C. nictitans*, *C. cephus* and *C. pogonias* in one case. *C. torquatus* was observed to form a mixed group twice with *C. cephus* near the Cette Cama Station, outside the Reserve.

We counted six chimpanzees (one adult male, two adult females, one young female and two juveniles) in trees and on the ground during an encounter with a group of chimpanzees. Although not all the individuals were visible, the party may have consisted of more than six chimpanzees. On the same day, two fresh bed sites were found, separated by more than 2 km from each other and from the site where we saw chimpanzees. Both sites consisted of three beds, constructed at a height of 7–20 m in the trees.

We identified at least two groups of gorillas and one solitary male gorilla along our travel route. We encountered a solitary male and a pair consisting of an adult male and an adult female. They were frightened away when they noticed our presence. But it was not likely that they were accompanied by other individuals, judging from fecal samples collected in their fresh trails. We found evidence that another group consisted of an adult male, a medium sized individual (probably an adult female) and an infant, from fecal samples and foot prints remaining in the sandy ground.

In the second census, we identified the presence of five primate species from visual or auditory contact along the transect lines. Neither *Cercocebus torquatus* or gorillas were seen or heard. We heard chimpanzee pant hoots from at least three directions.

We heard vocalizations of three primate species outside the Reserve (A1 and A2 transect lines) and four species, inside (B1, B2 and B3 lines) the Reserve (Table 5). We found a day-old gorilla bed site on the A1 transect line. It consisted of three beds (one was large and the others were medium-sized) on the ground. We also

Table 5. Estimated density of primates from direct observation in the second census.

Species	No of auditory contact					Estimated density	
	A1	A2	B1	B2	B3	N(individual/km^2)	
Cercopithecus							
nictitans	2*	1	3*	3*	1	4	31.6
cephus	1	1*	2*	1*		3	22.9
pogonias				1*		1	6.1
Cercocebus							
albigena		2*			1	1	7.1

*: The contacts in which we also made visual contacts with each species.

found a day-old chimpanzees bed site on the B1 transect line and two older bed sites on the A2 and B3 lines. The fresh bed site consisted of three beds, and the older ones, of two (A2) and three (B3) beds. These observations suggest that the monkeys and apes may be distributed evenly both inside and ouside the Reserve.

Since we did not follow primate groups seen nor count group-sizes in the second census, we used the mean group-size calculated in the first census for each primate species in order to estimate their density. *Cercopithecus nictitans* was the most frequently found in auditory and visual ranges, and their density was estimated to be the highest among four species. Estimated density of gorillas and chimpanzees (bed-builders) from bed counts were 0.40 and 0.48 individual/km^2, respectively.

DISCUSSION

The Petit Loango Reserve is characterized by poor undergrowth of Marantaceae and Zingiberaceae. These herbaceous vegetation are important foods for larger mammals in the tropical forests of Africa and are regarded as keystone foods in many habitats of great apes (Jones & Sabater Pi, 1971; Kano, 1984; Wrangham, 1986; Rogers & Williamson, 1987; Malenkey & Stiles, 1991; Tutin et al., 1991; Yamagiwa et al., 1994). The present study shows, however, that gorillas and chimpanzees survive despite the scarcity of such vegetation. We also found other larger mammals, such as elephants (*Loxodonta africana*), buffalo (*Syncerus caffer*), bush pigs (*Potamochoerus porcus*) and duikers (*Cephalophus* spp.), surviving probably in higher density in the Reserve, from dung counts (unpublished data). The presence of hippopotamus, at least three species of crocodiles and about 400 species of birds have been confirmed within the reserve (WWF, Gabon, unpublished information). Petit Loango is one of the Reserves which maintains the richest fauna in terms of species diversity within Gabon.

The tropical forest of the Petit Loango Reserve, consisting mainly of primary forest, included many possible food trees for gorillas and chimpanzees. More than half of tree species (>30 cm in DBH) were reported to be used for food by *G. g. gorilla* and *P. t. troglodytes* in Equatorial Guinea (Sabater Pi, 1977, 1979), in Gabon (Tutin et al., 1994) and in Congo (Nishihara, 1995). Tutin et al. (1994) listed a total of 25 tree species (>10 cm in DBH) as top 10 most frequent species in terms of basal area and stem density in Marantaceae forest and closed canopy forest at Lopé. These included 15 food species for gorillas and chimpanzees. In Petit Loango, we listed a total of 15 tree species as top 10 most frequent species in the highest density in primary or secondary forest, which included 10 possible food species. Large trees (>70 cm in DBH) of *Irvingia gabonensis* and *Klainedoxa gabonensis*, important foods for apes at Lopé (Tutin & Fernandez, 1993) or Ndoki (Nishihara, 1995), occurred at far higher density in Petit Loango. White (1994a) reported that the fruiting period of *Sacoglottis gabonensis*, *Klainedoxa gabonensis* and *Staudtia gabonensis* extended over eight months of the year at Lopé. These fruits are eaten by the apes in at least two countries (Gabon, Equatorial Guinea or Congo), and the large trees of these species occurred at higher densities in Petit Loango. These fruits may probably play the role of keystone foods for apes and

may compensate for the scarcity of Marantaceae and Zingiberaceae in the Petit Loango Reserve.

We found a relatively high density of apes and other primates in the Reserve. White (1994b) set up five transect lines in different types of forest (Marantaceae forest, closed canopy forest, *Sacoglottis gabonensis* forest and colonizing forest) at Lopé and calculated the individual density for each primate species using the same methods as the present study (1.4–23.7 individual/km^2 for *Cercopithecus nictitans*, 0.46–6.2 for *C. cephus*, 2.0–6.4 for *C. pogonias* and 2.5–12.4 for *Cercocebus albigena*). The results of our study show that the density of each primate species falls within the range or even exceeds those reported at Lopé.

To calculate primate density, we used the mean group-size from incomplete counts through direct observations. The range of group-size was reported to be 13–20 for *C. nictitans*, 5–10 but sometimes 30–35 for *C. cephus*, 13–18 for *C. pogonias* and 13 for *C. albigena* (Gautier & Gautier-Hion, 1969; Gautier-Hion & Gautier, 1974; Wolfheim, 1982; Gautier-Hion et al., 1983). We used smaller group-sizes for each primate species for calculating density estimates than these reports and, therefore, may have underestimated population size. Although our results are far from complete, it is likely that these four primate species live in a higher density in the Petit Loango Reserve.

Densities of apes estimated in this study are almost similar to that (0.22 gorillas/km^2 and 0.42 chimpanzees/km^2) estimated at Cette Cama (Tutin & Fernandez, 1984) and other areas using the transect methods. The density of *G. g. gorilla* was reported to be 0.1–1.2 individual/km^2 in five different areas of Congo (Fay & Agnagna, 1992) and 0.89–1.45 in Central African Republic (Carroll, 1988). Tutin and Fernandez (1984) made a nation-wide census in Gabon and estimated the density of gorillas to be 0.008–0.44. In comparison with these figures, the density of gorillas (0.4) in Petit Loango is rather higher than those of other habitats.

White (1994b) compared the densities of gorillas between different types of forest and found the highest density (1.0) in Marantaceae forests. Nishihara (1994) also reported a far higher density (2.29–2.61) in the Ndoki forest, Congo, where Marantaceae and Zingiberaceae are densely distributed. These observations and the results of our study suggest that the presence of such herbaceous vegetation is not necessary for gorilla survival but may support higher density.

The density of chimpanzees (0.48 individual/km^2) estimated in our study was also in the range for *P. t. troglodytes* reported in other habitats. It was higher than 0.01–0.13 in Central African Republic (Carroll, 1986), 0.26 or 0.3 in Congo (Ihobe, 1993; Kano & Asato, 1994) and 0.32 in Gabon (Nation-wide, Tutin & Fernandez, 1984), and lower than 1.30 in Ndoki forest, Congo (Mitani, 1992). In Uganda, far higher densities (1.96 in Kibale by Ghiglieri, 1984; 2.5 in Karinzu by Hashimoto, 1993) for *P. t schweinfurthii* were estimated using the transect methods. These suggest that the density of chimpanzees in tropical lowland forests of Central Africa may be lower than those in medium altitude forests of Uganda, and that chimpanzees may live in relatively higher density in the Petit Loango Reserve.

No marked differences in the diversity and density of tree species, the number of primate species and the frequency of encounters were found between inside and

outside the Reserve. These suggest that the past logging history and disturbance of human activities may not have seriously influenced the fauna and flora of the Petit Loango Reserve. This is probably due to few human activities outside the Reserve at present. Jones (1986) reported that primates quickly returned to their past home range after selective logging in the tropical forests of West Malaysia. Around the Petit Loango Reserve, primates may also have returned to the disturbed forest and dispersed widely during the roughly 30 years after selective logging.

Although the carrying capacity for primates in tropical forest is difficult to assess, due to marked seasonal or annual changes in the production of plant food (Tutin & Fernandez, 1993; Tutin et al., 1994), this study suggests that the tropical forest of Petit Loango Reserve may provide suitable habitats for primates and may support their high densities. Detailed studies on the ecology should be conducted in the near future.

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