Status and conservation of primates in Odzala National Park, Republic of the Congo

Magdalena Bermejo

Abstract A survey of diurnal primate populations was carried out in Odzala National Park, Republic of the Congo, over 3 months in 1994 and 2 months in 1995. The park contains a high diversity and species-specific abundance of primates, and has the highest number of diurnal primates (10 species) in the forest block of Central Africa. Eight species of monkey: greater white-nosed monkey *Cercopithecus nictitans*, moustached monkey *Cercopithecus cephus*, crowned guenon *Cercopithecus pogonias*, De Brazza's monkey *Cercopithecus neglectus*, talapoin *Miopithecus talapoin*, white-cheeked mangabey *Cercocebus albigena*, agile mangabey *Cercocebus galeritus* and guereza *Colobus guereza*, as well as gorilla *Gorilla g. gorilla* and chimpanzee *Pan t. troglodytes* were sighted in the survey. Monkey species richness was highest in dense inundated forest and thicket, with all eight species occurring in these habitats, whereas only four species were found in *terra firma* forest (consisting of the park's two main habitats, open-canopy Marantaceae forest and closed-canopy primary forest). Three of the four species (*C. nictitans*, *C. cephus* and *C. albigena*) present in *terra firma* forest were most abundant in closed-canopy primary forest (1.4, 1.0 and 0.6 groups per km, respectively) while the fourth (*C. pogonias*) was most abundant in open-canopy Marantaceae forest. Gorilla nests were most abundant in open-canopy Marantaceae forest (12.1 nests per km), while chimpanzee nests were mostly found in closed-canopy primary forest and Marantaceae forest (14 and 12 nests per km, respectively). Odzala has the highest recorded densities of western lowland gorilla (mean = 5.4 individuals per sq km) and chimpanzee (mean = 2.2 individuals per sq km) in Central Africa. The high densities of gorillas and chimpanzees may be a result of the high productivity of the forest and low poaching pressure. Conservation measures to ensure the maintenance of conditions in the area, such as educational programmes, are suggested.

Keywords Congo, conservation, density, primate diversity, surveys.

Introduction

Primate populations in the Republic of the Congo (Congo) have received little attention, although some information on their distribution and population densities has been recorded (Regusters, 1983; Fay *et al.*, 1990; Kuroda, 1990; Mitani, 1990, 1992; Nishihara, 1990; Oko, 1990; Fay & Agnagna, 1992; Blake, 1995). Since 1992 the regional programme 'Conservation and Rational Utilization of Tropical Forest Ecosystems in Central Africa' (ECOFAC), which is funded by the European Union and implemented by AGRECO-CIRAD Forêt, has undertaken a variety of surveys in the subregion to collect information on biodiversity, and ensure its conservation through the sound management of protected areas and the development of sustainable activities for the local people. To this end, surveys of primate populations have been conducted in several protected areas in Central Africa (Garcia & Mba, 1997; this study). Since 1992 ECOFAC has been responsible for overseeing the management of Odzala National Park (ONP), and in 1994 a survey of the diurnal primate populations in the park was conducted over a 5-month period in order to assess their relative abundance and conservation status.

Study area

The Republic of the Congo is a large country (342,000 sq km) with forests covering nearly two-thirds (222,300 sq km) of the area. Human population density is low (*c.* 6 people/sq km) with approximately 50 per cent of the population in towns and cities, leaving the countryside relatively unpopulated. The contiguous ONP, Lékoli-Pandaka Faunal Reserve and M'boko Hunting Reserve cover nearly 5000 sq km (Hecketsweiler *et al.*, 1991). The 2848 sq km of ONP is north of the equator (0°23'–1°10'N; 14°39'–15°11'E) on the north-western fringe of the Congo River watershed, at an altitude of between 300 and 600 m (Fig. 1). The western and northern areas of Odzala are hilly with steep slopes and a dense network of watercourses. There

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are two wet seasons, from October to December and from March to May. The average annual rainfall is 1509 mm (M'boko data, 1994). Temperatures vary little over the year but are lowest during the dry season when there is constant cloud cover during the daytime.

Odzala National Park is characterized by a rich diversity of habitats (primary forest, both on *terra firma* and inundated soils, Marantaceae forest (evergreen forest with a dense understorey of Marantaceae species), clearings and savannahs (Hecketsweiler *et al.*, 1991; Lejoly, 1996). Two major habitat types, *terra firma* forest and riparian forest, were surveyed and these were divided into five subtypes depending on canopy structure, plant species and moisture content of the soil (Dowsett-Lemaire, 1995; Maisels, 1995; Lejoly, 1996).

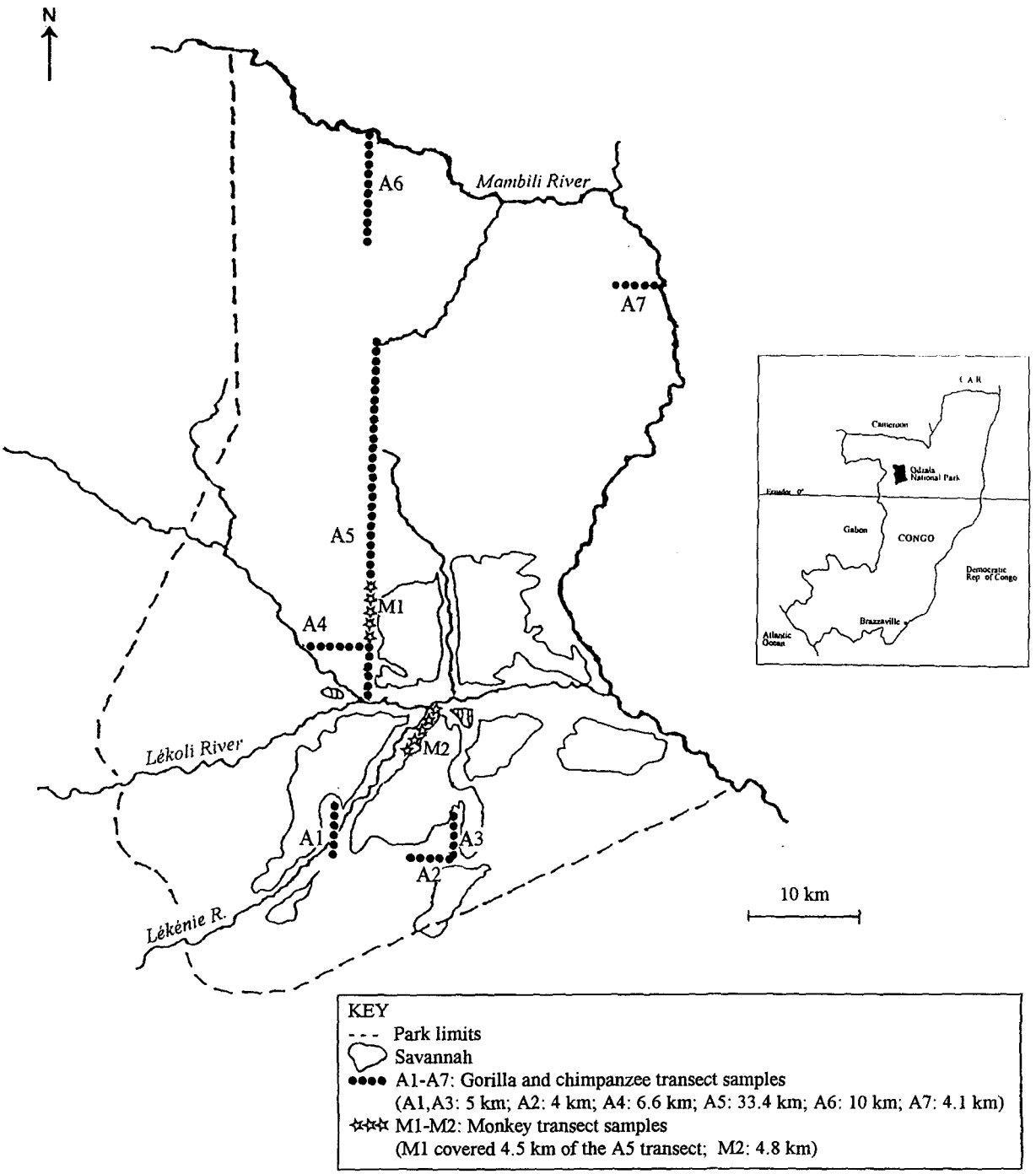

Fig. 1 Location of transects for the primate survey, Odzala National Park, north Congo.

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Terra firma forest consisted of areas of open-canopy Marantaceae forest (the dominant vegetation to the north of the Lékoli River, particularly in the north-eastern part of the park) and closed-canopy primary forest (abundant in the western part of the park). Riparian forest (well represented along the Lékoli and Mambili rivers) consisted of areas of thicket, swamp and dense inundated forest occurring on perpetually waterlogged and often seasonally inundated soils. Two other habitat types were not surveyed: clearings, which are swampy areas distributed patchily and mostly situated near rivers with sedges (Cyperaceae) such as *Rhynchospora* sp. as the dominant species (Vanleeuwe *et al.*, 1998); and savannah areas (the dominant vegetation type to the south of the Lékoli River), dominated by Graminae (*Andropogon schirensis*) with scattered fire-resistant shrubs (*Hymenocardia acida* and *Annona senegalensis*).

The major distinguishing features and dominant species of each vegetation type after Dowsett-Lemaire (1995), Maisels (1995) and Lejoly (1996) are listed below.
1 Open Marantaceae forest, in which the canopy is discontinuous, allowing light to penetrate to the forest floor. The middle-storey canopy cover is particularly sparse. Characteristic species are *Erythrophleum suaveolens, Pentaclethra macrophylla, Milletia laurentii, Santiria trimera, Diospyros* sp. nov., *Vernonia brazzavillensis, Markhamia tomentosa, Croton mayombense, Sapium cornutum, Pausinystalia* spp. and *Caloncoba welwitschii*. An almost impenetrable thicket of Marantaceae species—*Haumania liebrechtsiana, Megaphrynium macrostachyum* and *Sarcophrynium* sp.—dominates the ground vegetation.
2 Closed-canopy forest, in which the canopy cover is more continuous than in open Marantaceae forest, especially in the middle storey (10–20 m). The understorey is sparse. *Erythrophleum suaveolens, Lophira alata, Pentaclethra macrophylla, Milletia laurentii, Isolona hexaloba, Chaetocarpus africanus, Santiria trimera, Strombosia pustula, Pausinystalia macrophylla* and *Camptostylus mannii* are the most common species.
3 Thicket forest along streams or rivers is dominated by *Dichostemma glaucescens, Homalium africanum* and *Baphia laurifolia*, with often a high incidence of rattan palms (*Calamus* spp. and *Ancistrophyllum* spp.).
4 Swamp forest is characterized by permanently flooded or waterlogged soils, with *Xylopia* spp., *Raphia* sp. and *Klaineanthus gaboniae* as the most common species.
5 Dense inundated forest is a low closed-canopy formation with very little understorey and with a *Gilbertiodendron ogoouense/Cryptosepalum congolaneum/Baphia laurifolia* association.

Open-canopy Marantaceae forest, which often has a canopy density of less than 10 per cent and resembles savannah when observed from the air (Fay, 1997), is the dominant vegetation over an area of about 20,000 sq km, including the area of ONP (Rollet, 1964; Letouzey, 1968).

Methods

Monkey census

The monkey census was conducted between March and June 1995. The census methodology followed Struhsaker (1981) and Whitesides *et al.* (1988). In accordance with the terms of reference for the surveys, transects approximately 5 km long were used in the park (Fig. 1). Transect M1, which was previously used for vegetation studies, in the central area of the park's forest block, had an even mix of the two main forest types of Odzala (2.86 km of open-canopy Marantaceae forest and 1.64 km of closed-canopy primary forest). Transect M2 was set up in the Lékénie riparian forest, where the major forest types are thicket and dense inundated forest (1.94 and 1.81 km, respectively), with some patches of swamp forest (1.1 km), and followed a prescribed transect direction adjusted to follow an important drainage course (Fig. 1).

Three observers (M. Bermejo, G. Illera and the guide R. Ngounga) conducted 39 single-observer transect samples, 14 along transect M1 and 25 samples along transect M2. Surveys started between 06.00 and 06.50 hours, only when light and weather conditions were favourable for observation, and ended between 12.00 and 13.00 hours. Transects were walked at a rate of between 0.9 and 1.5 km/h depending on trail conditions and brief stops were made regularly to listen and increase the probability of detecting cryptic primate groups. Special care was taken to ensure that no group was counted twice. The number of groups of monkeys seen were the accumulated totals recorded over the period of the surveys. The following information was recorded for all monkey groups encountered on each transect: species; group size; date and time detected; observation duration; transect position; habitat type; perpendicular distance from the transect trail to the estimated geometric centre of the group; and vertical position of the group in forest strata. To determine the proportion of each habitat type along the transects, a habitat classification using the categories above was assigned every 50 m along each trail.

The size (n) of the sample is an important consideration in survey design. To fulfil statistical requirements, n should usually be 60–80 encounters for a given target species, although a sample size of 40 may be adequate for some purposes (Buckland *et al.*, 1993).

Along transect M2, where eight monkey species were observed, there was great variation in the number of

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groups observed each time the transect was walked. Therefore, in order to provide a sample size that would be adequate for statistical analysis, transect M2 was censused more often than transect M1.

Data collection should be carried out throughout the year, with transects being walked every month until $n = 60–80$ for each species in each habitat. This was planned at Odzala, but was not possible because of logistical problems. However, Maisels (1995) conducted a 5-month observational study, based on the identification of all groups of monkeys in a given area of the Lékénie riparian forest (ONP). Both studies (Maisels, 1995; this study) showed similar indices of abundance for the species concerned.

Gorilla and chimpanzee census

The methods for a quantitative census of gorilla and chimpanzee populations used in this study followed Tutin & Fernandez (1984). The census of gorillas and chimpanzees was conducted between April and July 1994 along seven transects that covered three habitat types (closed-canopy primary forest, open-canopy Marantaceae forest and swamp forest (Fig. 1). Because of the short duration of our study, the number of transects established was limited to forested areas, despite the fact that gorillas have been shown to nest occasionally along the savannah/forest edge or in the savannah itself in other study areas (Carroll, 1988; Tutin *et al.*, 1995).

Except for transect A5, which had been used previously for vegetation studies, the route of each transect was decided in advance by plotting the direction and distance on a 1:2000 map (Fig. 1). Seven routes totalling 68.1 km were drawn on a map, on a compass bearing crossing the drainage in order to include a representative sample of the main vegetation types. In the field, a compass was used to maintain the predetermined course, and the distance covered was measured with the aid of a thread measuring device. Transects were walked only once, on the day that the census was carried out, to eliminate bias resulting from disturbance of gorillas. Three or four local people were employed to search for nests from the transect line. Walking speed, when looking for nests in areas dominated by a complex tangle of Marantaceae overhead, averaged 0.3 km/h. Along transect lines all signs of gorillas and chimpanzees were recorded, including: feeding sites; tracks; trails; dung; and nests. At each nest site observed from the transect line, we recorded data following Tutin & Fernandez (1984): species; location and distance along the transect line; perpendicular distance of the nest from the transect line; habitat type; age class; height; plant species used in construction; construction type for each nest; and nest group size. We recorded gorilla and chimpanzee sign encounters, in addition to broad habitat classes. When a qualitative change in vegetation type occurred, the vegetation type and distance along the transect were recorded.

Gorilla nests were distinguished from chimpanzee nests by: construction type; height distribution of nests within the nest group (gorilla nest groups often have one or more nests on the ground and are rarely found above 15 m); and gorilla scent, dung or hair in tree nests. Therefore, nest sites were considered to be those of gorilla when, (i) at least one ground nest was present, or (ii) an obvious gorilla sign, e.g. dung of the same age as the nest site, was on the ground below the site. A nest group was defined as a collection of nests of the same age not more than 25 m apart.

Structural differences in the habitat affected the visibility of nests and so reliable visibility limits were calculated by recording the shortest distance between the transect line and each nest, i.e. the perpendicular distance. This allowed *post-hoc* determination of the limits of reliable visibility for the nests of each species in each habitat type and hence calculation of the area sampled by the transect.

Gorilla and chimpanzee densities were calculated and compared with results from other sites in Central Africa. We used the following formula to calculate the population density of weaned (nest-building) individuals (Tutin & Fernandez, 1984): (number of nest groups within reliable visibility limits/area sampled) $\times$ ($1/x$, where x = number of days a nest remains visible) $\times$ (median nest group size). The strip width sampled for gorilla nest groups was 20 m (because visibility is limited beyond 10 m on either side of the transect), while the strip width for chimpanzees was 40 m in closed-canopy primary forest and swamp forest, and 50 m in open-canopy Marantaceae forest.

The short duration of this study meant that it was not possible to estimate the length of time that chimpanzee and gorilla nests remained visible. Therefore, data from other studies were used to complete the density calculations. Tutin & Fernandez (1984) found that chimpanzee nests in Gabon were visible for 113.6 days and we used this figure in our calculations. Data on duration of gorilla nests are more problematic. Tutin & Fernandez (1984) monitored 223 gorilla nests at Belinga, north-east Gabon, and found a mean nest duration of 53.6 days. However, mean duration of gorilla nests at the Lopé reserve in Gabon was 78 days (Tutin *et al.*, 1995), 32 per cent longer than in the previous study. The species and methods used for nest construction were different in the two studies, with most nests at Belinga being in *Musanga cecropioides*, a fast growing softwood species, and where nest decay

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Table 1 Relative abundance of guenon, mangabey and colobus groups observed on transects M1 and M2 in Odzala National Park, Congo, between March and June 1995

	M1		M2	
Species	No. of groups	Relative abundance (per cent)	No. of groups	Relative abundance (per cent)
Guenons				
Cercopithecus nictitans	65	49.6	24	21.8
Cercopithecus cephus	37	28.3	21	19.1
Cercopithecus pogonias	10	7.6	12	10.9
Cercopithecus neglectus	–	–	16	14.5
Miopithecus talapoin	–	–	10	9.1
Mangabeys				
Cercocebus albigena	19	14.5	9	8.2
Cercocebus galeritus	–	–	7	6.4
Colobus				
Colobus guereza	–	–	11	10
Total	131	100	110	100

was rapid because branches were broken rather than bent during nest construction. Most nests at Odzala were in *Camptostylus mannii*, also a softwood species, and we used the nest degradation rates of 53.6 days determined at Belinga in our calculation of gorilla densities.

The census method used in these studies has been reappraised recently for two major reasons: first, up to 26 per cent of gorilla nest-sites can be mistakenly recorded as chimpanzee nest-sites when only tree nests remain visible (Tutin *et al.*, 1995); second, some individuals do not build a nest while others make more than one (Remis, 1993). As a result, surveys using these methods give only a partial insight into population structure (Fay, 1997). However, using data based on the nest counts as well as accessory data sets (observation of animals), it is possible to document population trends with greater precision.

Results

Monkey census

During our survey we found eight species of monkey: greater white-nosed monkey *Cercopithecus nictitans*, moustached monkey *Cercopithecus cephus*, crowned guenon *Cercopithecus pogonias*, De Brazza's monkey *Cercopithecus neglectus*, talapoin *Miopithecus talapoin*, white-cheeked mangabey *Cercocebus albigena*, agile mangabey *Cercocebus galeritus* and guereza *Colobus guereza*. Carpaneto (1993) collected a skin of a black colobus *Colobus satanas* from a hunter a few kilometres outside the western border of the park. This is the first record of this species in the Odzala area and represents the eastern limit of their known distribution. This species, however, was not sighted during this survey.

Species richness

Monkey species richness was highest in the riparian forest, with all eight species occurring in dense inundated forest and thicket and six of the eight species (*C. nictitans*, *C. cephus*, *C. pogonias*, *Cercocebus albigena*, *Cercocebus galeritus* and *Colobus guereza*) occurring in swamp forest, whereas only four species (*C. nictitans*, *C. cephus*, *C. pogonias* and *Cercocebus albigena*, were found in the *terra firma* forest (consisting of open-canopy Marantaceae and closed-canopy primary forest).

Species abundance

Table 1 shows the total number of groups and the relative abundance of species found on the two transects. The most commonly sighted species on both transects were *C. nictitans* (49.6 and 21.8 per cent of sightings, respectively) and *C. cephus* (28.2 and 19.1 per cent, respectively).

Table 2 indicates species abundance (groups per km) in the different habitat types: *C. nictitans* was the most commonly seen species in four different habitats: closed primary forest, Marantaceae forest, dense inundated forest and swamp forest (1.4, 0.82, 0.28 and 0.20 groups per km, respectively). However, the most commonly sighted species in thicket forest was *C. neglectus* (0.24 groups per km) followed by *C. cephus* (0.20 groups per km).

Three species of the four—*C. nictitans*, *C. cephus* and *Cercocebus albigena*—present in *terra firma* forest were most abundant in closed-canopy primary forest (1.4, 1.0 and 0.6 groups per km, respectively) while the

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fourth, *C. pogonias*, was most abundant in open-canopy Marantaceae forest (0.2 groups per km). Six of the eight species present in riparian forest (*C. nictitans*, *C. pogonias*, *M. talapoin*, *Cercocebus albigena*, *Cercocebus galeritus* and *Colobus guereza*) were most abundant in dense inundated forest (0.09–0.28 groups per km), while *C. neglectus* was most abundant in thicket forest (0.24 groups per km) and *C. cephus* was equally abundant in both habitats (0.20 groups per km). Odzala appears to have one of the highest abundances of guenons of the *terra firma* forests in Central Africa.

Gorilla and chimpanzee census

Species abundance and density

A total of 68.1 km was censused along seven transects, 33 km in closed-canopy primary forest, 30.5 km in open-canopy Marantaceae forest, and 4.5 km in swamp forest. We found 630 gorilla nests, of which 427 (67.7 per cent) were visible from the transect line. Gorilla nests were most abundant in open canopy Marantaceae forest (12.1 nests/km; Table 3) and 81.6 per cent of the nests had been made on the ground using herbaceous material, in particular *Haumania liebrechtsiana*. The remaining nests were in trees 1–14 m above ground level, with a mean nest height of 5.5 m.

The 427 gorilla nests were found in 65 groups, with a mean size of 6.6 nests per group (range 1–26), and a median size of seven nests in open-canopy Marantaceae forest and 3.5 nests in closed-canopy primary forest. Gorilla densities were high in Marantaceae forest (Table 3). The maximum density estimate of 11.3 nesting gorillas/sq km in Marantaceae forest in this study is the highest recorded for any vegetation type surveyed, and is comparable with estimates from the Central African Republic (10.96 gorillas per sq km; Carroll, 1988) in secondary forest. The mean density estimate of 5.4 nesting gorillas per sq km in Odzala is the highest recorded anywhere. The most commonly observed gorilla feeding remains were *Haumania liebrechtsiana*, *Megraphrynium* sp., *Palisota* sp. and *Aframomum* sp.

We found 966 chimpanzee nests, 860 (89 per cent) of which were visible from the transect line. All chimpanzee nests were between 2 and 35 m above the ground with the majority (66.3 per cent) between 5 and 10 m (mean, 14 m). Chimpanzee nests were most abundant in closed-canopy primary forest (14 nests per km; Table 3) followed by open-canopy Marantaceae forest (12 nests per km).

The 860 chimpanzee nests were found in 378 groups with a mean of 2.3 (range 1–14), and a median size of 2. The park contains one of the highest densities of chimpanzees recorded, with a maximum of three individuals per sq km, which is comparable with estimates from Kalinzu forest, Uganda (2.8–4.7 individuals per sq km; Hashimoto, 1995), where the forest is also characterized by a mosaic structure.

Factors affecting gorilla nest construction

Nest counts are powerful tools for population censuses and demographic studies of great apes, but problems exist in interpreting data on lowland gorilla nests. Habitat type, group size and season all affect nest construction type. Baseline data on nests, in addition to documenting aspects of gorilla behaviour and ecology, have important implications for census work in tropical forest habitats. In order to assess the effect of these factors, we compared data on gorilla nests from nest- sites recorded during a 24-month study on the ecology of lowland gorillas at the Lossi forest study site (50 km to the east of Odzala National Park), where nine gorilla groups have been intermittently followed in a 25-sq km study area:

Table 2 Abundance (groups/km) of mangabeys, guenons and colobus by habitat type on transects M1 and M2 in Odzala National Park, Congo, between March and June 1995

		No. groups								Groups per km							
Habitat	Distance (km)	Cn	Cc	Cp	Ce	Mt	Ca	Cg	Co	Cn	Cc	Cp	Ce	Mt	Ca	Cg	Co
MI (*terra firma* forest transect)																	
Marantaneceae forest	40.0	33	14	9			4			0.82	0.30	0.20			0.10		
Closed primary forest	23.0	32	33	1			15			1.40	1.00	0.04			0.60		
Total	63.0	65	37	10			19										
M2 (Riparian forest transect)																	
Thicket	48.7	6	10	4	12	3	2	1	1	0.10	0.20	0.08	0.24	0.06	0.04	0.02	0.02
Dense inundated forest	45.6	13	10	7	4	7	5	4	10	0.28	0.20	0.10	0.10	0.15	0.10	0.09	0.22
Swamp forest	27.5	5	1	1			2	2	1	0.20	0.04	0.04			0.07	0.07	0.04
Total	121.8	24	21	12	16	10	9	7	12								

Cn, *Cercopithecus nicitans*; Cc, *C. cephus*; Cp, *C. pogonias*; Ce, *C. neglectus*; Mt, *Miopithecus talapoin*; Ca, *Cercoebus albigena*; Cg, *Cerocebus galeritus*; Co, *Colobus guereza*.

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Table 3 Nest abundance index and densities of gorillas *Gorilla g. gorilla* and chimpanzees *Pan t. troglodytes* by habitat type along transects surveyed in Odzala National Park, Congo, between April and July 1994

Habitat type	Distance (km)	Nests/km		Individuals/sq km	
		Go	Ch	Go	Ch
Closed-canopy primary forest	33.05	1.2	14.0	1.1	3.0
Open-canopy Marantaceae forest	30.52	12.1	12.0	11.3	2.1
Swamp forest	4.53	3.9	7.1	3.7	1.5
Mean abundance and density		5.7	11.0	5.4	2.2
Total	68.10				

Go, gorilla; Ch, chimpanzee.

group sizes 32, 20, 20, 18, 17, 12, 10, 7, and 4 solitaries (M. Bermejo, unpublished data), and data from Lopé reserve, Gabon, with results from our nest-count census. In ONP 18.4 per cent of gorilla nests were in trees at heights of 1–14 m compared with 11.7 per cent of those built by gorilla groups in Lossi and 35 per cent of gorillas nesting in Lopé at heights of 1–35 m. The location of gorilla nests (on the ground or in trees) varied between different study sites. At Lopé 8.3 per cent of the nest-sites had only tree nests and a further 10.2 per cent consisted of tree nests with a single ground nest. However, at Lossi (204 fresh gorilla nest-sites, $n = 3432$ nests from six different groups) we found no gorilla nest-sites consisting of only tree nests or of mainly trees with only a single ground nest.

At Lopé, most tree nests were built in wet months and in habitats where herbaceous plants were scarce, suggesting that gorillas chose to nest in trees rather than travel long distances to find herbaceous plants for ground nests. Odzala is characterized by a rich variety of habitats, including forests dominated by the densest formations of Marantaceae known to date. At Odzala and Lossi, gorillas often stay close to a concentration of particularly limited resources such as fruiting trees and they do not need to travel to find an ideal ground nesting site.

Variability in nest construction by different populations may be the result of variation in vegetation types and densities at different sites, producing differences in terms of available nesting materials in the habitats that gorillas exploit. Furthermore, the sampling problems presented by gorilla nests may make accurate census difficult, but if standard methods are employed at the same time of year, nest counts along transect lines can doocument population trends with greater precision because deviations from the assumptions of line transects will be similar (Tutin *et al.*, 1995).

Census data are essential for the conservation and management of protected areas. It is important to estimate numbers but probably more important to monitor trends to establish whether populations are stable, declining or increasing over time, and to document responses to habitat alteration.

Discussion

Odzala National Park has the richest primate fauna of Central Africa, with 10 taxa of diurnal primates confirmed in the park. Furthermore, the forests in Odzala, and those to the east and north, probably hold the largest population of gorillas in Africa today. Magliocca *et al.* (in press) studied western lowland gorillas visiting a clearing of *c.* 18 ha in the north of ONP where 420 gorillas (36 groups and 18 solitaries) were identified. This suggests that gorilla densities are very high in this region with the author concluding that gorilla densities are probably close to 11 individuals per sq km.

It has been suggested that variations in primate densities between sites may result from the presence or absence of competitive species (Harrison & Hladik, 1986), historical events (such as disease; Butynski, 1990), variation in plant species composition, structural heterogeneity of the habitat and patterns of seasonal change in the availability of food (Oates *et al.*, 1990). The abundance of primates at ONP may be a result of the high productivity of the forest, a complex mosaic of vegetation types and low poaching pressure. However, more comparative data are required (on primate diets and biomass, and on plant species composition and fruiting phenology) before conclusions can be reached. Tutin *et al.* (1997) suggested that the most likely explanation of low primate biomass at Lopé is the occurrence of an ecological 'catastrophe' in the fairly recent past from which populations have not yet recovered.

The results of this study suggest that riverine forests are important for conserving the diversity of monkey species in the region. These forest types are therefore of particular importance when considering management options for the area. At Odzala, the abundance of *C. nictitans*, *C. cephus* and *C. albigena* is particularly high and the abundance of *C. neglectus* and *M. talapoin* is similar to that in north-east Gabon (Gautier-Hion, 1971, for *M. talapoin*; Gautier-Hion & Gautier, 1978, for *C. neglectus*).

Odzala National Park contains the largest area of open-canopy Marantaceae forest known to date (Hecketsweiler *et al.*, 1991). Because of its structure and

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dense undergrowth, Marantaceae forest is often misclassified as secondary vegetation and, as such, tends to be assigned a low conservation priority. However, both Marantaceae forest and clearings are known to be attractive sites for gorillas that range in search of herbaceous plant food (Rogers & Williamson, 1987; Fay & Agnagna, 1992; White, 1994; Nishihara, 1995) and frequent the clearings to feed on abundant herbaceous vegetation (Olejniczak, 1996; Fay, 1997; Magliocca *et al.*, in press).

Although large groups of gorillas (> 26 individuals) are known from montane forests, this study is the first that observed such large groups in lowland tropical forests. It is difficult to draw conclusions, but it seems likely that maximum group size is not constrained by within-group competition for fruit. Activities of sympatric forest elephants, which create the herbaceous vegetation by opening up the forest, may also have a large influence on habitats and thus the densities of gorillas (Nishihara, 1991). White (1994) estimated densities of mammals in five sites in lowland semi-evergreen tropical rain forest in the Lopé Reserve, central Gabon. Two of the sites were located in Marantaceae forest, where densities of these important foods were high and this probably explained the higher biomass of gorillas and elephants in these areas. However, data from vegetation surveys at Ndakan, in the Central African Republic (Fay, 1997) indicate that Ndakan has more terrestrial herbaceous vegetation available to gorillas than is found at Lopé. If the difference in densities and group size found at the two sites could be attributed to one variable, then the amount of terrestrial herbaceous vegetation would rank highest. The evidence from ONP follows this trend. In the Likouala region in northern Congo calculated gorilla densities are high (5.8 nesting gorillas per sq km) where *Raphia* is present (Fay *et al.*, 1990).

Despite the high numbers of gorillas and their widespread distribution in Congo, gorilla populations should still be considered to be Vulnerable because of the continuing expansion of logging and associated hunting (Wilkie *et al.*, 1992). It is possible that the Vulnerable criterion rate of decline of 50 per cent within 100 years will be reached, because so many gorillas in the two countries that harbour most of the world's population (Gabon and Congo) live outside conservation areas (Harcourt, 1996). We have been studying the ecology of lowland gorillas and chimpanzees at Lossi (50 km south-west of ONP) since 1994. Lossi forest is an example of gorillas living at unusually high densities outside a conservation area. We are currently developing a pilot western lowland gorilla tourism programme, which will channel benefits back to local communities and thus encourage long-term conservation. The public awareness activities associated with this programme will contribute to the preservation of Odzala's exceptional primate fauna.

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