A survey of the apes in the Dzanga-Ndoki National Park, Central African Republic: a comparison between the census and survey methods of estimating the gorilla (*Gorilla gorilla gorilla*) and chimpanzee (*Pan troglodytes*) nest group density

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Abstract

A survey of apes was carried out between October 1996 and May 1997 in the Dzanga sector of the Dzanga-Ndoki National Park, Central African Republic (CAR), to estimate gorilla (*Gorilla gorilla gorilla*) and chimpanzee (*Pan troglodytes*) densities. The density estimates were based on nest counts. The strip transect census and the line transect survey method (Standing Crop Nest Count) were used to estimate the gorilla nest group density. The strip transect has been most commonly used to date. It assumes that all nest groups within the width of the strip are detected, but as this assumption is easily violated in the dense tropical rain forest, the line transect survey was also used. In this method, only the nest groups on the transect line itself should be detected. This method proved to be an adequate and easy technique for estimating animal densities in dense vegetation. The gorilla density of 1.6 individuals km^{-2} (line transect survey method) found for the Dzanga sector is one of the highest densities ever reported in the literature for the Western lowland gorilla. The density estimate for chimpanzees was 0.16 individuals km^{-2} (census method). The results of this study confirm the importance of the Dzanga-Ndoki National Park for primate conservation.

Key words: chimpanzee, count, Dzanga-Ndoki, gorilla, rainforest, transect

Résumé

Entre octobre 1996 et mai 1997, on a étudié les grands singes du secteur de Dzanga dans le Parc National de Dzanga-Ndoki, en République Centrafricaine (RCA), pour évaluer les densités de gorilles (*Gorilla gorilla gorilla*) et de chimpanzés (*Pan troglodytes*). Les estimations de densité se basaient sur le comptage des nids. On a utilisé le recensement par bande transect et la méthode de contrôle par transect linéaire (comptage réel des nids) pour estimer la densité des groupes de nids de gorilles. C'est la bande transect qui est la plus communément utilisée à ce jour. Cela suppose que l'on détecte tous les groupes de nids inclus dans la largeur de la bande, mais comme cette supposition est facilement mise en défaut dans la forêt tropicale humide dense, on a aussi utilisé la méthode des transects en ligne. Avec cette méthode, seuls les groupes de nids qui sont sur la ligne de transect doivent être détectés. Cette méthode s'est révélée une technique adéquate et facile pour estimer les densités animales dans la végétation dense. La densité des gorilles (1,6 individus / km^2) relevée pour le secteur de Dzanga est une des plus élevées jamais repor-

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tées dans la littérature pour le Gorille de plaine occidental. On a estimé la densité des chimpanzés à 0,16 individus / km^2 (par la méthode de recensement). Les résultats de cette étude confirment l'importance du Parc National de Dzanga-Ndoki pour la conservation des primates.

Introduction

The Dzanga-Ndoki National Park (1222 km^2) and the Dzanga-Sangha Dense Forest Special Reserve (3159 km^2) in the extreme south-west of the Central African Republic (CAR) (Fig. 1) were designated in 1990. Their abundance of wildlife and range of pristine dense forest habitats have been described by Carroll (1986) and Fay (1989). The forest contains fifteen of the nineteen primate species recorded in the CAR, of which gorilla (*Gorilla gorilla gorilla*) and chimpanzee (*Pan troglodytes*) are of primary interest.

It is essential to have accurate data on the density of these animals in order to conserve and manage the CAR protected areas, and specifically to monitor trends in order to establish whether their populations are stable, declining or increasing. To design an appropriate system for monitoring gorilla and chimpanzee populations, we needed to establish an adequate survey technique based on indirect observations of animal presence, such as nest groups.

The usual methods of estimating mammal density in dense forest habitat are the strip transect census and the line transect survey. The strip transect (Burnham, Anderson & Laake, 1980) is the most commonly used method of estimating nest group densities. It assumes that all nest groups within the width of the strip are counted. However, this assumption is easily violated in the dense tropical rain forest. The line transect survey (Buckland *et al.*, 1993), also referred to as the Standing Crop Nest Count (e.g. Plumptre & Reynolds, 1996), assumes that all nest groups on the transect line are detected. A proportion of the nest groups on either side of this line may go undetected, but a detection function corrects for the decreasing probability of detecting a nest group further away from the transect line.

The data we collected will be used for an ongoing study (monitoring programme) of primates and other

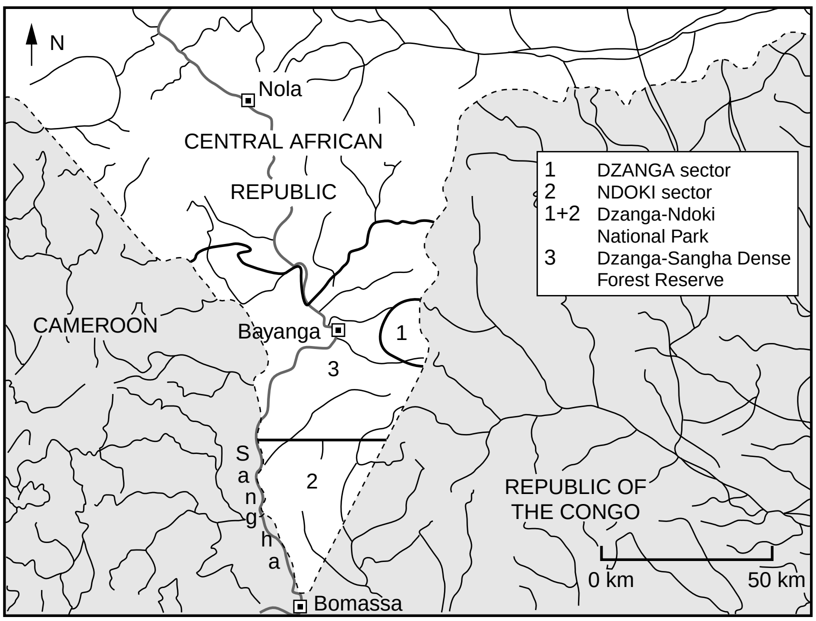

Fig 1 Study area in the Central African Republic

large mammals in the Dzanga sector, and to monitor the overall impact of project activities such as eco-tourism development and law enforcement.

Study area

This study was undertaken from the Mongambe research camp in the Dzanga sector (2°55′N, 16°20′E) of the Dzanga-Ndoki National Park. This sector covers an area of 495 km^2 (Fig. 1), which from 1972 until the 1980s was selectively logged, mainly for two species of hardwood.

The topography of the Dzanga sector is relatively flat. A few streams flow from east to west through the park, towards the Sangha River. There is a large marshy area in the north-western part of the park. The forest structure in the Dzanga sector is a patchwork of primary forest habitats and secondary forest with much herbaceous undergrowth. Light gaps created by natural tree fall or elephant activity (Carroll, 1986) account for almost 9.5% of the forest habitat. The selective logging has also created disturbed forest habitats: herbaceous plants are also abundant in the abandoned logging roads.

The climate is characterized by a dry season of three months (December–February) and a long rainy season with a drier period in June–July. The mean annual rainfall in Bayanga is 1365 mm (Carroll, 1986). Temperature varies little over the year, with an average of 26.4°C. Mean monthly minimum temperatures range from 20.6°C in December to 22.9°C in April, and mean monthly maximum temperatures range from 28.4°C in June to 35.7°C in March (Carroll, 1986).

The designated conservation area is managed by the Dzanga-Sangha project in an integrated manner, similar to the Biosphere reserve model (MacKinnon *et al.*, 1986). This means that limited traditional and safari hunting, agroforestry development and commercial logging are allowed in the reserve, while there is full protection of the natural forest ecosystem in the core area: the Dzanga-Ndoki National Park (Carroll, 1986).

Materials and methods

Direct counts along transects, the most commonly used technique for surveys of mammals, are of limited value for surveying gorillas and chimpanzees in the tropical rain forest because the dense understorey of the forest and the extreme wariness of the apes make direct observations rare (Tutin *et al.*, 1995). To overcome this problem of obtaining sufficient data, population studies must therefore rely on interpreting the signs of ape activity. We opted to estimate density from nest counts, as each individual of a group of gorillas/chimpanzees, except for suckling infants, usually builds a nest to sleep in each night, thereby leaving tangible signs of both their presence and their numbers (Tutin *et al.*, 1995). The transects could only be carried out once during the study period because of financial and time constraints, and so for practical reasons we opted to use the Standing Crop Nest Count, even though the marked nest count methods might have given better results (Plumptre & Reynolds, 1996). For a discussion of the limitations of the method used and the uncertainty caused by the variance in nest life-span and nest re-use, see Tutin *et al.* (1995) and Plumptre & Reynolds (1996).

Transects

Data were collected during 5 months of fieldwork, between October 1996 and March 1997. To estimate nest density, five 20-km transects were randomly laid across a map of the area, but at least 1 km apart and parallel to each other, across the drainage. Each transect was then walked once, following a fixed compass bearing; distances along the transect were measured by hip-chain. Each habitat type and topography change encountered along the transect was noted, with its distance along the transect, as well as all signs of ape and human activity. At least two BaAka assistants helped the observer search for signs and indications of ape and human activity. The BaAka are a tribe of forest-dwelling people with excellent knowledge of the forest. When a group of nests was encountered, the distance from each nest to the transect line was measured.

To overcome the problem of clumped distribution for the statistical analyses, the counted nests were analysed in terms of nest groups. All nests of the same age recorded within 20 m of each other were arbitrarily designated as one group.

Ape nests

The data collected on each nest were species, location, habitat type, age class of the nest, construction type and height above the ground. Four nest age classes were distinguished:

- fresh: moist dung present, sometimes with gorilla/chimpanzee odour;
- recent: vegetation still green, some flattened dung may be present;
- old: intact, but all vegetation dead;
- very old: decomposition advanced, vegetation is dead and the nest is not intact.

Six nest construction types were distinguished for gorillas:

- 'zero': flattened patch and gorilla odour and dung, indicating that the gorilla had slept on the ground;
- minimal: nest made from a few herbaceous stems;
- herbaceous: more complex structure made exclusively from herbaceous material;
- mixed: nest constructed from mixture of woody and herbaceous material;
- woody: nest constructed exclusively of woody material;
- tree nest: nest constructed in tree, mostly constructed exclusively of woody material.

Chimpanzees are only known to build tree nests in this area.

Gorilla nests were distinguished from chimpanzee nests by their construction, the height distribution of nests within a nest group (gorilla nest groups usually have at least one nest on the ground and are rarely constructed above a height of 15 m), and the presence of gorilla scent, dung or hairs in the nests. Even though the BaAka trackers probably identified most nest groups correctly, some gorilla nests might have been misidentified as chimp nests, which could have considerable implications for transect sampling (Tutin *et al.*, 1995).

Calculating nest group density

Both the strip transect census and the line transect survey method were used to estimate the nest group density. Both methods require the distance from each nest to the transect line to be measured. The distance of the geometrical centre of the nest group from the transect line was used to estimate nest group density (Fig. 2).

Strip transect census

This method calculates the nest group density by dividing the number of nest groups within the width of the strip by the total area of the strips:

$$\text{Nest group density} = \text{number of nest groups}/\Sigma[L_{ij} \times (2 \times w)] \quad (1)$$

L_{ij} = length transect line i–j, w = width of the strip transect.

A marked drop in the percentage of nests groups recorded beyond a particular strip width indicates the cut-off point for reliable counting (w). For gorillas the drop was detected at a distance of 4 m from the transect line, meaning that it was crucial to record all nests within this distance. The cut-off point for chimpanzees was established in a similar way to be 15 m.

It seems probable that the difference in transect width between gorillas and chimpanzees is a consequence of the distribution of nest groups over the various habitat types. Over 80% of gorilla nest groups were detected in a habitat type with dense understorey and low visibility, but 84% of the chimpanzee nest groups

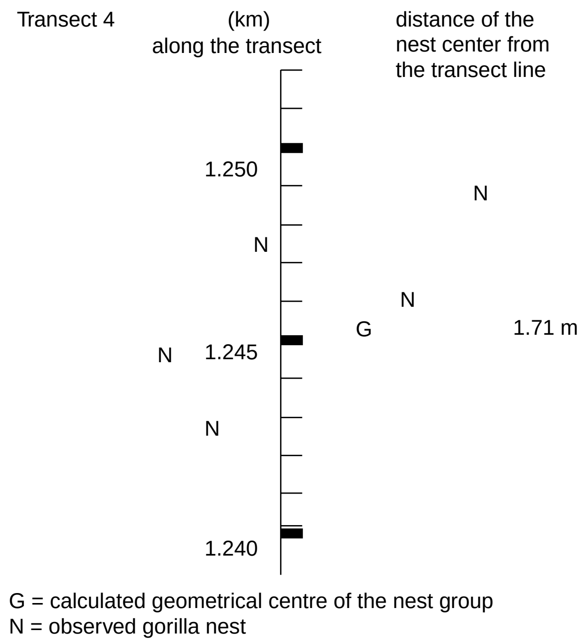

Fig 2 Calculation of the geometrical centre (G) of the nest group from the transect line

were situated in forest with little ground cover and good visibility.

Using the method described above, all nest groups that have their centres within the area of the strip should be detected. However, in dense tropical rain forest this assumption is easily violated. The application of this method is expected to yield reduced density, leading to underestimates of nest (i.e. gorilla) density.

Line transect survey

Unlike sampling methods based on fixed-width transects, the line transect method (Buckland *et al.*, 1993) does not assume that all nest groups within a specified width are detected. Instead, the assumption is that there is a 100% probability that the objects on the transect line are seen. The number of nest groups sighted away from the line decreases in some way. The detection function corrects for the lower probability of detecting a nest group as distances increase from the transect line. This method therefore considers only the nest groups that are seen from the transect line. Its assumption is more realistic given the conditions prevailing in our study area. Therefore we expected that it would yield higher and more reliable figures for nest group density than the strip transect method.

The DISTANCE sampling program (Buckland *et al.*, 1993) uses the perpendicular distances of the geometrical centre of the nest group from the transect line to estimate density. A rule of thumb is to truncate between 5% and 10% of the data to facilitate data modelling by deleting extreme data (Buckland *et al.*, 1993). Truncation at 7 m removed 7% of the data. We tested the influence of group size on detectability from the transect line ('size bias'), but found it to be insignificant.

Three key models were used to fit the detection function: the Uniform model with cosine adjustment, the Hazard rate model and the Half-Normal model. The Half-Normal model was selected by Akaike's Information Criterion to fit nest group data. We did not use the survey method to estimate chimpanzee nest group density because we counted only twelve nest groups.

Calculating the density of nest-building individuals

Equation 2 (Tutin & Fernandez, 1984) was used to estimate the density of nest-building individuals per km^2. We did not adjust the density figures to include non-nest-building individuals, because we had no data on the group structure of gorillas in CAR.

$$\begin{aligned}&\text{Nest group Density}\\&\times\ 1/\text{no. of nests built by a individual/day}\\&\times\ 1/\text{mean nest life span}\\&\times\ \text{Median nest group size}\\&=\ \text{number of nest building individuals per km}^2\end{aligned} \qquad (2)$$

$$L = \Sigma_1^5\ (l_i X p_i)$$

L = average life span of nest l_i = life span of type i nest I = nest construction type p_i = proportion of observations of nest types (see Table 1).

The mean nest life-span, i.e. the average number of days the nest remains identifiable as a nest, was obtained by multiplying the life-span of each nest type as determined by Tutin & Fernandez (1984) by the frequency of occurrence (Equation 3). This approach assumes that the nest decomposition factors are sufficiently similar in the Gabon study site and Dzanga to justify this extrapolation. We felt justified in making this assumption because the climate and the type of forest are similar in both study sites. The gorilla nest life-span was estimated to be 50 days (Equation 3, Table 1). Chimpanzees only build tree nests, so nest life-span has an average of 50.9 days (Table 1).

Table 1 Life-span of the nest types distinguished by Tutin & Fernandez (1984) and the number of observations of these nest types in this study

Nest construction type[a]	Mean nest life-span (days)[b]	No. of observations (%)
Zero	4.3	7 (9%)
Minimum	19.1	5 (6%)
Herbaceous	61.7	35 (43%)
Mixed	52.7	27 (33%)
Woody and tree	50.9	8 (10%)
Total number of nests		82

[a]For explanation, see text. [b]Data from Tutin & Fernandez (1984).

Results

Gorilla density

In total, 82 gorilla nests were counted in 29 nest groups, ranging from one to eight nests. Square root transformed data fitted a normal distribution. The mean group size was 2.6 (95% CI: 2.0–3.2).

The gorilla density calculated with the strip transect method was 1.5 gorilla km^{-2} (Table 2). The gorilla density calculated by the line transect survey method was 1.6 gorilla km^{-2} (95% CI: 1.1–2.3) (Table 3).

Despite sampling 100 km of transect, the data for gorillas in this study did not reach the required minimum number of 40 nest groups for the line transect survey method. Due to the small data set the coefficient of variation did not reach the desired accuracy of estimation of < 10% (Buckland *et al.*, 1993).

Chimpanzee density

We counted a total of 38 nests in twelve nest groups. The mean group size value was 2.8 (95% CI: 1.7–4.3, median = 2). Square root transformation was applied to fit the data to a normal distribution (Kolmogorov–Smirnov, $P > 0.05$). The density estimate as calculated by the strip transect method was 0.16 chimpanzee km^{-2} (Table 3). The line transect survey method was not applied because there were too few data to fit the detection function.

Table 2 Density of nest-building gorillas and chimpanzees estimated by the strip transect census method

Species	Width (m)	Area censused (km^2)	No. of nest groups	No. of weaned ind. km^{-2}
Gorilla	4	0.8	20	1.5
Chimpanzee	15	3.0	12	0.16

Table 3 Density of nest-building gorillas estimated by the line transect survey method

Species	Width (m)	No. of nest groups	No. of nest groups km^{-2} (95% CI)	No. of weaned ind. km^{-2} (95% CI)
Gorilla	7	29	26.7 (18.6–38.3)	1.6 (1.2–2.1)

Discussion

In a survey relying upon the estimation of traces left by animals (nests) rather than sightings of animals themselves, sources of error are introduced. On the other hand, sample size increases, thus improving statistical resolution (White, 1994). Plumptre & Reynolds (1996) favour the Marked Nest Count (repeated counts along the transects) above the line transect survey method (Standing Crop Nest Count) used in this study. Because the transects were walked only once for this study there was no possibility of using the Marked Nest Count method.

For a more detailed discussion of the accuracy of data collection and the correctness of Equations 1 and 2, see Tutin & Fernandez (1984). The high variance in life-span of nests, the influence of the season and the possible differences between the nest life-span in the Gabon and the Dzanga sites because of the climate differences are the major sources of uncertainty in the gorilla density estimate in this study. Furthermore, it is likely that some nest groups were wrongly attributed to gorillas instead of to chimpanzees (Tutin *et al.*, 1995) and that some nests were re-used or only used for the day (Plumptre & Reynolds, 1996). Unfortunately at this point in time no information from the area is available to address these issues adequately.

In this study, we found a gorilla density of 1.6 individuals km^{-2} for the Dzanga sector of the Dzanga-Ndoki National Park. The density calculations were based on nest group estimates, which were analysed by the survey method. The strip transect method yielded an estimate of 1.5 gorilla km^{-2}. In view of the assumptions underlying the latter method, we consider that this value represents a lower limit.

A possible reason for the good agreement between estimates is that the data were collected as the transects were being walked for the first time. The speed of progress was less than 500 m h^{-1}, with more than four BaAka assistants helping to cut the trail at the same time. This minimized the possibility of missing a nest group within the width of the strip transect.

The gorilla density in the Dzanga area is one of the highest densities recorded based on nest observations (Table 4), surpassed only by Mitani *et al*.'s (1993) estimate of 4–5 individuals km^{-2}. Their estimate was based on direct observation of gorilla groups in the Ndoki forest in Northern Congo. The high density of gorillas at their study site is expected to be a result of the presence of aquatic plants. Gorillas used these plants extensively without ecological competition from sympatric chimpanzees.

The high gorilla density in the Dzanga sector can be understood in view of the typical habitat of the Dzanga area. Moderately disturbed forest, such as that found in Dzanga, can be relatively rich in high quality folivore foods and can support higher densities of folivorous primates (Oates, 1996). Oates (1996) has demonstrated that gorilla density is correlated with the abundance of terrestrial herbaceous vegetation. Fay (1989) states that all monocotyledonous plants, but especially those belonging to the families *Marantaceae* and *Zingiberaceae*, are favourable for a high gorilla density. Not only are these herbs used for constructing most of the nests, but their pith is also an important gorilla food (Carroll, 1986).

Our density estimate of 0.16 chimpanzee km^{-2} is slightly higher than the figure of 0.01–0.13 chimpanzee km^{-2} that Carroll (1986) calculated in 1984 for the various sectors of the Dzanga-Ndoki National Park, and remains low compared to other sites in Africa. A possible explanation for the low chimpanzee density in the Dzanga sector is the proximity of the village of Bayanga. Tutin & Fernandez (1984) claim that chimpanzees are more seriously affected than gorillas by disturbances from poachers. Poaching occurs in the Dzanga sector, but poaching incidents involving apes are rare. It does not appear that poaching is a serious threat to the ape population. This may be because poachers usually hunt with cable snares because their chief prey is mainly duikers. It has also been reported that chimpanzees strongly prefer unlogged forests, even long after the logging event (Struhsaker, 1997). However just south of Dzanga, within the Ndoki sector of the park, researchers also report low densities of chimpanzees, even though this area has never been logged and poaching hardly ever occurs (A. Blom, personal observation; D. Doran & N. Shah, personal communication). Another more feasible explanation for the low density of chimpanzees could be the unavailability of suitable habitat or some form of competition with, for example, gorillas or elephants. Further studies are necessary to clarify this point.

The typical rainforest habitat in Dzanga, characterized by the frequent occurrence of natural secondary forest habitats containing abundant herbaceous regrowth, favours high gorilla densities. The high gorilla density we found confirms this and shows that the National Park plays an important role in the conservation of the Western lowland gorilla. Overall, the park

Table 4 Density estimates of Western lowland gorillas based on nest counts in various locations in Africa

Location	General class of habitat	No. of weaned ind. km^{-2}	Source
Equatorial Guinea	Tropical forest	0.58–0. 86[a]	Jones & Savage-Pi (1971)[c]
Gabon	Tropical forest	0.18 (0.008–0.44)[b]	Tutin & Fernandez (1984)
Northern Congo	Swamp forest	0.04 (0.01–1.2)[b]	Fay & Agnagna (1992)[c]
Dzanga-Ndoki CAR all sectors	Tropical forest	0.89–1.45[b]	Carroll (1986)
Dzanga-Ndoki CAR extreme south	Tropical forest	1.6 (1.1–2.0)[b]	Fay (1989)
Dzanga-Ndoki CAR Dzanga sector	Tropical forest	1.63 (1.18–2.14)[a]	This study (1996)

[a]95% confidence limits. [b]Overall mean density (minimum and maximum mean density values for complete sectors). [c]Data from Carroll (1986).

appears to offer sufficient protection to the gorilla and chimpanzee. We suggest that the research presented here be continued, using line transect surveys as the main tool for monitoring.

Acknowledgements

This work was supported by the Dzanga-Sangha Project, specifically by the World Wildlife Fund for Nature in Washington, and grants from the German World Wildlife Fund, the United States Fish and Wildlife Service, FONA Foundation, Lucie Burgers Foundation for Comparative Behaviour Research and the Wageningen Agricultural University Foundation. We would also like to thank the field team: K. Otto, E. Mbea and P. Godobo, and all the BaAka trackers for their assistance with the fieldwork. Furthermore, we would like to thank G. van der Kroon, Natasha Shah, Dr Diane Doran, Dr W. van Schaik and Ir. C. Sieler for their assistance. We are indebted to Ir. H. van Oeveren for his help with the map of the park. Finally, we would like to thank the entire Dzanga-Sangha Project staff and the World Wildlife Fund staff in Bangui, Frankfurt and Washington for their support. The anonymous reviewers helped to improve this paper.

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(Manuscript accepted 12 June 2000)