PRIMATES, 36(4): 591–607, October 1995

RESEARCH REPORT

Census and Distribution of Chimpanzees in Côte D'Ivoire

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ABSTRACT. Most methods of estimating chimpanzee population densities rely on nest counts. We tested the most frequently used techniques on a known chimpanzee community living in the rainforest of the Taï National Park, Côte d'Ivoire. The best density estimates are given by counts that assume groups of nests to be distributed randomly and that use the mean group size for homogenous habitat but the median for heterogenous habitats. Correction for real forest cover within the region should be made because chimpanzees make nests only in forested regions. This method gave the exact chimpanzee density for the Taï population, i.e. 1.7 nest builders/km^2. For the nationwide survey, we first estimated the chimpanzee density for different types of habitat (e.g. intact primary forest: 1.64 chimpanzees/km^2; degraded forests: 0.4 chimpanzees/km^2; human encroached forests and mosaic habitats: 0.09 chimpanzees/km^2). Second, we estimated the total forest cover of the country with satellite pictures. This gave an estimated chimpanzee population in Côte d'Ivoire of about 11,676 ± 1,168 individuals, which equals the number of spectators at a soccer game in an average European town. Sadly, only three National Parks may have chimpanzee populations large enough to be viable, whereas the rest are scattered and isolated small populations that are already threatened in their survival.

Key Words: *Pan troglodytes*; Census; Distribution; Côte d'Ivoire; Method; Conservation.

INTRODUCTION

In the past, chimpanzees were present in 25 African countries and they numbered over several millions (TELEKI, 1989). In the last decades, disappearance of their natural forest habitat, hunting for meat, and capture for biomedical researches have threatened their prospect of survival. Chimpanzees have disappeared in five countries and are on their way to disappearing in five others. Their total number today is believed to be about 230,000 individuals of which about 17,000 may live in West Africa (LEE et al., 1988; TELEKI, 1989; ADAM, 1990), the majority of them (about 7,000) being in Guinea (SUGIYAMA & SOUMAH, 1988). TELEKI (1989) estimated the Côte d'Ivoire population not to exceed 1,000 individuals.

In reality, current distributions in the various nations are poorly known and detailed census still need to be carried out in these countries before making any accurate estimation (LEE et al., 1988) in order to propose adequate solutions to increase their prospects for surviving. Most information has been based on interviews with different authorities or

villagers (SUGIYAMA & SOUMAH, 1988; TELEKI, 1989; HOPPE-DOMINIK, 1991), by controlling at most some of the statements. Such methods rely completely on the accuracy of these indirect information. More direct census work on chimpanzees, using nest counts as a direct measure of the population density, has been done in Uganda by GHIGLIERI (1979) and more recently in Gabon by TUTIN and FERNANDEZ (1983, 1984).

Our study was undertaken in order to obtain a reliable picture of the present situation of the chimpanzee populations remaining mainly in the forest regions of Côte d'Ivoire. Before starting a nationwide count, we calibrated the different census methods on a chimpanzee population of known size (BOESCH & BOESCH, 1989). Simultaneously, we collected data on nut cracking behaviour, known so far to be restricted to the West African chimpanzees (*Pan troglodytes verus*). This topic is treated elsewhere (BOESCH et al., 1994).

GENERAL DESCRIPTION OF THE CÔTE D'IVOIRE

The Côte d'Ivoire is situated in West Africa between 5° and 10° of latitude North. It is a vast quadrilateral of 322,500km^2 bordered by Liberia, Guinea, Mali, Burkina Faso, and Ghana and possesses a 550-km long littoral along the Atlantic Ocean. The relief is generally flat with some isolated mountains not exceeding a few hundred meters. Only the far west and north-west along the Guinean border possess about ten picks exceeding 1,000m. The highest point is the Mont Nimba reaching 1,752m.

The country is divided into two principal vegetation zones (Fig. 2):

1) The Guinean belt: Area covering about 110,000km^2 in the southern part of the country (Fig. 2), comprising the evergreen and semi-deciduous forests. In the north, a "preforested Guinean belt" can be added, which constitutes a buffer zone of semi-deciduous forests and Guinean type of savanna, between the Guinean and Soudanese belts.

2) The Soudanian belt: Area covering the northern and drier part of the country, comprising the open and the dense dry (deciduous) and the gallery forests, and the soudanesen type of savanna and savanna woodland.

The estimated human population in 1988 was about 10,180,000 inhabitants (mean density: 31.6 inhab./km^2), of which about 40% are urban populations. The mean annual population increase is 4.3% (M.C.A.C., 1989). The state economy is mainly agricultural; in 1986 three main agricultural products (coffee, cocoa, and wood) represented 70% of the exportations. The rural population also practices a traditional shifting slash-and-burn cultivation. This type of agriculture destroys large tract of forest each year. Together with wood exploitation, agriculture practices have destroyed 73% of the forest cover of the Guinean belt, since the end of the last century. Officially only 30,000km^2 of forest remain today (AKE ASSI & BONI, 1990). Our results show that this is still an overestimate of the forest surface. The permanent plantations monopolize about 23%, and the towns, the villages, the crop plantations, and particularly the fallow lands (probably more than half of the cultivated area) about 50% of the previous forests of 110,000km^2 (AKE ASSI & BONI, 1990).

Bush meat hunting provides the villagers with most of the animal proteins in the forested areas. Organized commercial hunting also supplies the big cities with meat. In 1979, 77,000 tons of bush meat was consumed in the country, including 23% of primates (SEDES, 1984). The disappearance of the fauna is an important limitation for the human populations in many places today (pers. obs.)

CENSUS METHODS

A nationwide census of chimpanzees, based on nest densities to estimate the total remaining chimpanzee population, would represent a tremendous enterprise. To make this enterprise feasible, we adopted the following procedure: (1) We tested the different formulas used in census studies in other countries, on a known chimpanzee population, to select the most accurate one; (2) Detailed measures were made on selected sites of the most common habitats in which chimpanzees are found in Côte d'Ivoire; (3) We visited all National Parks to obtain the best evaluation from well protected areas; and (4) We used satellite pictures of the country to obtain the most recent estimation of the remaining surface of all types of habitats existing in Côte d'Ivoire.

Training of the field workers was conducted at the BOESCH's long-term study site in the Taï National Park, where a habituated chimpanzee community allowed us to test the different methods for evaluation of population density. This census was conducted from September 1989 to December 1990 by PAUL and NATHALIE MARCHESI with the help of BARBARA FRUTH in 1989, DENIS LIA throughout the study and various local guides.

1. TRANSECTS

To estimate the density of chimpanzees, we employed a classical line transect method (ANDERSON et al., 1983; GHIGLIERI, 1979; TUTIN & FERNANDEZ, 1983, 1984). One of the side effects of using this method is that the opening of a transect with the use of local helpers may give them or local hunters the opportunity to use it afterwards as a new hunting trail. The transects varied in length from 9 to 15km and they were cut in shape of a T or a cross. A 10-m strip on each side of the transect line was always recorded, whatever the density of the habitat. A local guide cut the vegetation using a compass to keep a straight direction. Another person followed with a hipchain to measure the distances and marked each 100m with a red plastic tape. This person also took all the scientific notes. Two more observers were looking carefully for nests on each side of the transect line. The speed of progression was about 1 to 2km per day, depending on the number of nests and the density of the vegetation. All transects were covered two to three times to minimize the number of nests overlooked.

2. HABITATS

The changes of type of habitats were noted along the transects. The ten different types of habitats used are not defined by their botanical composition but by their structural particularities: presence and importance of the different vegetation stratum (emergent, canopy, undergrowth...). The definition of these types of habitats are close to those given by TUTIN & FERNANDEZ (1983) and can be found in the Table 1.

We have considered as primary forest the forests which were intact or relatively undisturbed by human activities, in contrast to the degraded forests which are much more affected in their structural aspect by such activities. The bushy-forest type indicates primary forest which differs by a very dense undergrowth (bush and lianas) and has fewer emergent or canopy trees. However, this is not due to any human activity but rather to particular pedological conditions (poor slope grounds and surfacing rocks on inselbergs) or past phenomena such as bush fires or dryness.

Table 1. Description of the habitat types according to structural characteristics.

	Emergent	Canopy	Small trees	Grass	Liana	Special characters
Wet primary forest	Common	Common	Rare	Absent	Common on the crown	Easy walking
Dry primary forest	Rare	Common	Common	Absent	Common	
Gallery forest	Rare	Common	Common	Rare	Common	
Bushy forest	Rare	Rare to common	Abundant	Absent	Common	See text
Secondary forest	Absent	Common	Common to abundant	Common to abundant	Rare to common	
Degraded forest	Rare to common	Rare to common	Rare to common	Common to abundant	Common to abundant	Secondary trees-bush
Bush	Absent	Absent	Abundant	Abundant	Abundant	Rather impenetrable
Farmland	Absent	Absent to rare	Abundant crops	Abundant crops	Absent	
Savanna woodland	Absent	Absent	Common	Common	Abundant	
Savanna	Absent	Absent	Absent	Common	Absent	

3. NESTS

We recorded for each nest: The distance from the beginning of the transect; the perpendicular distance from the transect line to the trunk of the tree with the nest; the height of the nest and of the tree supporting it, using classes of 5m, the diameter and, when possible, the species of the tree; and the age of the nest, using the four age classes given by TUTIN and FERNANDEZ (1983): 1) fresh: leaves still totally green; 2) recent: leaves drying, changing colour; 3) old: dead leaves, nest still entire; and 4) very old: no more leaves but nest still identifiable by broken branches for example.

Following TUTIN and FERNANDEZ (1983) we considered a group of nests to include all the nests that are at most 20m of one another. However, contrary to these authors, we did not distinguish between different age classes, because we have observed that nests made on the same day by a group of chimpanzees may age differently, so that they look as if they belong to different age classes, although they were built for the same night.

4. AGING OF NESTS

To get an idea on the aging speed of nests, 26 fresh nests in the Taï forest were observed each week from the day of their construction on (from December 1, 1988 to August 28, 1989). The mean lifetime of these nests was 73.3 ± 4 days (SD=49.84, range=7−290). By comparison, GHIGLIERI (1979) found in Kibale forest a mean of 110.8 days ($N=29$), and TUTIN and FERNANDEZ (1983) in Gabon 113.6 ± 5 days ($N=49$, range=35−151).

5. ESTIMATION OF THE DENSITY OF CHIMPANZEES

Two similar formulas have been used to estimate the density of chimpanzees. One is given by GHIGLIERI (1979):

$$\frac{\text{No. chimpanzee}}{\text{km}^2} = \frac{\text{No. nests}}{\text{km}^2} \times \frac{1}{\text{mean nest duration}} \times \frac{1}{\text{observator efficiency}} \times \frac{\text{No. total chimpanzee}}{\text{No. weaned chimpanzee}}.$$

This formula rests on the assumption that individual nests are placed randomly throughout the home range of a chimpanzee community: therefore, GHIGLIERI counts only the nests found within the transect. However, we know that this is not commonly the case, as chimpanzees regularly nest with other group members. That is why TUTIN and FERNANDEZ use the notion of "group" of nests (an individual nest belongs to a group of nests when it is within 20m from another one), and employ the median instead of the mean in their calculations to correct for this sampling problem. They propose the assumption of a random distribution of group of nests throughout the home range of a chimpanzee community. TUTIN & FERNANDEZ's formula (1983) is as follows:

$$\frac{\text{No. weaned chimpanzee}}{\text{km}^2} = \frac{\text{No. group nests}}{\text{km}^2} \times \frac{1}{\text{x group nest duration}} \times \text{Median size of nest groups.}$$

As they presume their observation efficiency to be optimal and because they did not know the structure of the chimpanzee population in Gabon, they have neglected the two last factors of GHIGLIERI's formula.

We tested the different alternatives on the habituated community of chimpanzees of C. and H. BOESCH at Taï Audrenisrou which was composed in 1988 by 79 individuals of which 44 were nest builders (this gives 1.795 for the last fraction of GHIGLIERI's formula). The size of their territory was of about 26km^2. For Taï, this gives a density of three individuals/km^2 or 1.7 nest builder (weaned chimpanzee)/km^2.

Nests were counted along a 15-km transect made by one of us in 1988 (B. FRUTH) at Taï Audrenisrou. Table 2 gives the results obtained by using the two different formulae with the different variables. The TUTIN & FERNANDEZ formula with the Taï nest duration and the mean instead of the median (Table 2, *N*: 1) gives the best approximation for the density of chimpanzees in the Taï area. The straight use of their formula, with the median and the number of groups, which takes into account the age classes (*N*: 4) gives a density of 41.2% too low compared to the reality (1.7 chimpanzee/km^2).

Table 2. Evaluation of the population density of the Taï chimpanzee community by using TUTIN and FERNANDEZ (1983), and GHIGLIERI (1979) formulas for the Taï Audrenisrou site.

N	Formula	No. of nests	Age classes	Group nest size		No. of nest group	No. of weaned chimpanzees/km^2
				Mean	Median		
1	TUTIN & FERNANDEZ	38	Without	1.9		20	**1.72**
2	TUTIN & FERNANDEZ		Without		1	20	0.91
3	TUTIN & FERNANDEZ	38	With	1.73		22	1.72
4	TUTIN & FERNANDEZ		With		1	22	1
5	GHIGLIERI	28					1.26

The life duration of the nests is 73.3 days. Using GHIGLIERI's methods (calculation N: 5) gives only 28 nests inside of the 20-m width of the transect.

We shall, therefore, use the TUTIN & FERNANDEZ formula but with the mean, and without considering age classes for the nests. However, before using such a formula on a nationwide census, four points have to be considered in regard to problems inherent to the assumption of random distribution of group of nests:

1) The homogeneity of the environment strongly affects the distribution of the nests: The calculation in Table 2 is made in the homogeneous habitat of Taï. In a heterogeneous environment including a mosaic of forest and open habitats (bush, savanna etc.), chimpanzees have been observed to make their nests only in wooded habitat, never in a savanna (TUTIN & FERNANDEZ, 1983; this study, Table 5). In these cases, the group of nests are not randomly distributed. The consequence of such an irregularity in the distribution of the nests is that the chance to find close and indistinguishable groups increases and as a consequence the number of nests in one group increases. Figure 1 shows the size of groups for a homogeneous (Taï) and a heterogeneous (Marahoué) environment. Heterogeneity of environments shifts the distribution towards more extreme values, so that the mean is more affected by the asymmetry of the distribution then in a homogeneous habitat.

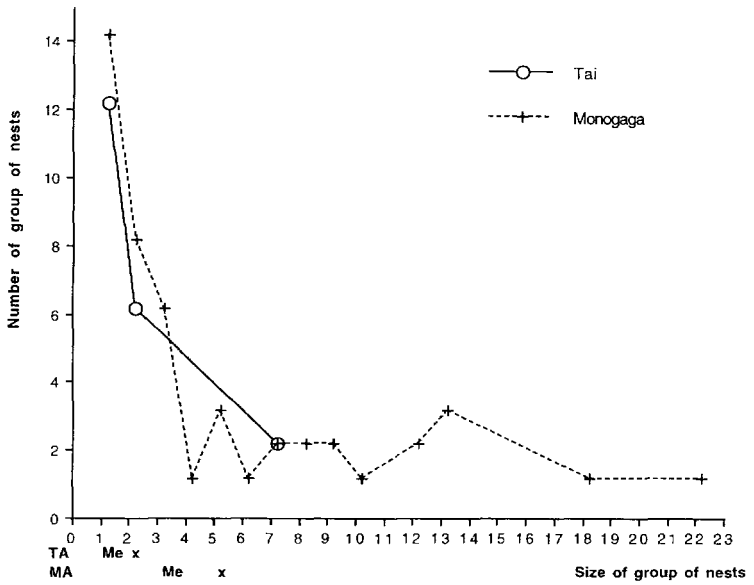

Fig. 1. Effect of homogeneous (Taï) and heterogeneous (Monogaga) environments on the size of group of nests. Me: Median; x: mean.

2) In addition, homogeneous habitats with high poaching or with high risk of being attacked by strangers (peripheral area of territories) may be irregularly employed by chimpanzees as they avoid unsafe places for nesting. Long transects allow to decrease the bias of this factor. For regions with high poaching, we shall also use the median for the calculations as poaching makes the habitat unevenly suitable for chimpanzees (heterogeneous effect).

3) GHIGLIERI, and TUTIN and FERNANDEZ assume that each weaned individual makes one nest only for the night. However, day-nests in Taï can be common, representing sometimes up to 65% of the nests. Some of these day-nests may disappear rapidly, i.e. after a few hours, because they are not done as well as the night-nests and, for the same reason, their lifetime may be much shorter. But others remain visible for weeks and the fact that night- and day-nests are not differentiated has the effect of over-estimating the chimpanzee density in a site. We shall thus correct for those day-nests.

4) Corrections should be made when the habitat proportion along the transects does not correspond with the one found within the area inhabited by the chimpanzees.

In summary we shall use the TUTIN & FERNANDEZ formula without the use of age classes for the groups of nests, and take the mean value for group of nests within undisturbed homogeneous habitat, and the median for group of nests within heavily poached and heterogeneous environments.

Finally, although our observator efficiency may not be optimal, we have not calculated this factor. We estimate it to be probably lower than the 20% given by GHIGLIERI, because the transects were checked several times in search of nests. The consequence of missing nests would be to lower the density values.

6. ESTIMATION OF THE FOREST COVER

To calculate the total surface of the forests, the topographical maps of 1:200,000 of the Institut Geographique National (IGN) of Côte d'Ivoire (which were made in the 60th) were not useful. Since that time, more than two thirds of the forest cover of the Guinean belt have disappeared. Fortunately, we were able to consult and use the satellite pictures (Landsat TM 1986-88, Spot 1988-89, scale: 1:100,000) at the "Direction Centrale des Grands Travaux" office in Abidjan and proceeded as follows: The outer limits of the forests were drawn on tracing papers (limits were easy to see when not a mosaic habitat), and each surface weighed with a micro-balance (Mettler H20T). The estimated technic error is $\pm 3\%$. For the very patchy forests, we superposed a grid on the sketching and counted the squares covering the forest areas.

The well delimited surfaces of fallow lands and of plantations situated inside the forests have been eliminated, and the small isolated forests of the guinean belt covering less than $1km^2$ and the very narrow gallery forests have not been taken into account, because we assumed them to be meaningless in regard to chimpanzee populations.

RESULTS

1. TRANSECT

During this study 154.4km of transects have been made in 14 sites (Table 3). In only one of them (Comoé Gansé) no evidence of chimpanzee presence was found. Seven of these sites are situated in National Parks, six in Classified Forests and one outside protected areas. Furthermore, we have surveyed, without making transects, 21 other sites and saw nests in only 11 of them. The geographical situation of all these sites is shown in Figure 2. Exactly 611 nests were found within the transects, 236 (38.6%) of them were outside of the 20m width but were counted because they were part of a group of nests.

The detailed data and the estimation of chimpanzee density for each site are given in Table 3. Both estimations of density, using either the mean or the median of nests and group of nests are given. These data confirm the relation between the heterogeneity of the environments and the distribution of groups of nests. Only in the sites of Taï Audrenisrou, Taï Nipla, and Mt Kopé, the primary forest represents more than 75% of the habitat (Table 4), and the level of poaching remains low. For the other sites, we shall use the median (see Census Methods 5:1 and 2).

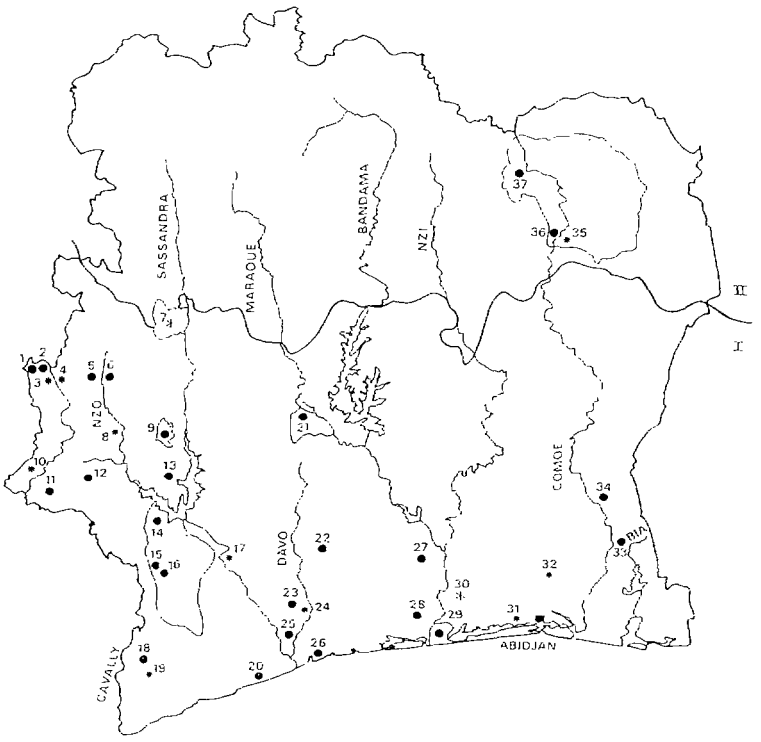

Fig. 2. Geographic distribution of the visited sites in Côte d'Ivoire. ●: Sites with chimpanzee presence; ✱: sites without indications of chimpanzee presence; *: two other sites where chimpanzees have been mentioned recently by credible observers; —: northern limit of the Guinean belt; I: Guinean belt; II: Soudanian belt; NP: National Park; CF: Classified Forest. 1: Mt Nimba NP; 2: Gbapleu (Tiapleu CF); 3: Tiapleu CF; 4: Mt Nieton CF; 5: Blépleu (Sangouiné CF); 6: Mt Tonkoui CF; 7: Mt Sangbé NP; 8: Tyonlé CF; 9: Mt Péko NP; 10: Goulaleu CF; 11: Mt Bétro CF; 12: Mt Zoa (Scio CF); 13: Duékoué CF; 14: Nzo reserve; 15: Taï NP-Audrenisrou; 16: Taï NP-Nipla; 17: Mt Kourabahi CF; 18: Mt Kopé; 19: Haute Dodo CF; 20: Monogaga CF; 21: Marahoué NP; 22: Nizoro CF; 23: Guiniadou (Niegré CF); 24: Davo; 25: Kouadiokro (Niegré CF); 26: Dagbégo (Dassiékro CF); 27: Mopri CF; 28: Gô CF; 29: Azagny NP; 30: Irobo CF; 31: Agnéby; 32: Yapo CF; 33: Songan CF; 34: Bossematié CF; 35: Comoé NP-Gansé; 36: Comoé NP-Amaradougou; 37: Comoé NP-Kolonkoko.

In addition, we correct for the irregular use of habitat types mentioned in Census Methods 5:4. This correction increases the Marahoué density to 6.92, as the transects include only 81.2% of forest, whereas in reality the Park contains 87.9% of it. For Comoé (C. Amaradougou plus C. Kolonkoko), it decreases to 0.93 (transect has 75.6% of forest, whereas the western part of the National Park has 21.1% of forest).

2. Utilization of Habitats for Nesting

Table 5 shows that almost no nests have been found in the open type of habitat, including the wooded savanna. This does not mean that chimpanzees do not travel or forage in these habitats, for they are sometimes heard or seen there. In addition, we have never seen a nest in an exposed isolated tree surrounded by an open area, such as can be seen in bush

Table 3. Estimation of chimpanzee densities obtained with the modified TUTIN and FERNANDEZ (1983) formula.*

	National Parks							Classified Forests						Other Forests
	Guinean belt				Soudanian belt			Guinean belt						
	Taï Audr.	Taï Nipla	Mt Nimba	Mara-houé	Comoé Gansé	Comoé Amar.	Comoé Kolon.	Mono-gaga	Dag-bégo	Dué-koué	Nizoro	Gô	Bosse-matié	Mt Kopé
Transect (km)	15	9	10.4	15	12	15	3	9	9	12	12	12	12	9
Trails/10km	0.7	2.7	1.8	0	0	0	0	13.3	7.8	21.7	35	39.2	33.3	20
No. of nests	38	14	31	234	0	122	20	7	63	35	1	5	18	22
No. of group nests	20	11	8	47	0	36	8	6	9	12	1	2	9	13
Density (mean)	**1.72**	**1.06**	2.03	10.3	0	5.52	4.53	0.53	4.76	1.99	0.06	0.28	1.0	**1.67**
Density (median)	0.91	0.83	**1.31**	**6.39**	0	**3.26**	**2.72**	**0.45**	**1.02**	**0.68**	**0.06**	**0.28**	**0.51**	0.98

*Modification with the help of the mean or the median of the number of nests per group. The bold figures are those used for the census.

Table 4. Proportion (%) of the different habitats in the studied sites.

	National Parks							Classified Forests						Other Forests
	Guinean belt				Soudanian belt			Guinean belt						
	Taï Audr.	Taï Nipla	Mt Nimba	Mara-houé	Comoé Gansé	Comoé Amar.	Comoé Kolon.	Mono-gaga	Dag-bégo	Dué-koué	Nizoro	Gô	Bosse-matié	Mt Kopé
Transect (km)	15.0	9.0	10.4	15.0	12.0	15.0	3.0	9.0	9.0	12.0	12.0	12.0	12.0	9.0
Wet primary forest	100	99.4	67.5	19.1	—	—	—	61.7	44.7	5.0	8.8	1.8	—	76.5
Dry primary forest	—	—	—	—	—	25.9	64.9	—	—	—	—	—	—	—
Gallery forest	—	—	—	1.5	94.6	11.3	—	—	—	—	—	—	—	—
Bushy forest	—	—	—	54.5	1.3	23.7	15.0	8.6	4.6	1.0	—	—	—	4.3
Secondary forest	—	0.3	15.1	—	—	—	—	1.8	5.6	0.6	2.7	1.9	—	0.8
Degraded forest	—	0.2	4.6	4.6	—	1.3	8.4	14.6	28.3	67.5	25.1	56.3	80.6	5.8
Bush	—	—	5.3	1.5	0.3	10.3	2.8	7.2	0.3	21.2	29.4	14.9	17.5	5.8
Plantation	—	—	—	—	—	—	—	6.1	1.9	4.7	34.1	25.0	1.9	6.8
Savanna woodland	—	—	—	8.6	2.7	8.3	8.9	—	—	—	—	—	—	—
Savanna	—	—	7.5	10.2	1.1	19.3	—	—	—	—	—	—	—	—
Other	—	0.1	—	—	—	—	—	—	14.4	—	—	—	—	—

habitats. However, nests can sometimes be found close to the forest edges or on isolated trees in small clearings. The tree cover density plays, therefore, an important role for the choice of the sleeping site (see also Census Methods 5:2).

Table 5. Number of nests found in each type of habitat.

Habitats	Number of nests
Evergreen primary forest	268
Dry primary forest	66
Evergreen bushy forest	142
Dry bushy forest	30
Gallery forest	47
Degraded forest	55
Secondary forest	0
Bush	2
Savanna woodland	0
Savanna	0
Plantation	0
Other	0

3. Relations Between Chimpanzee Density and Human Activities

Human activities have an important negative effect on the chimpanzee populations: the chimpanzee density observed decreases with the surface of plantations and fallow land in each site (Kendall rank correlation coefficient: $\tau = -0.71$, $Zt = -3.05$, $N = 11$, $p < 0.001$), as it does with increasing numbers of hunting trails/km (Kendall rank correlation coefficient: $\tau = -0.75$, $Zt = -3.19$, $N = 11$, $p < 0.001$). The degree of association between these two variables [plantation (x) and hunting (z)] with the density (y) can be controlled with a Kendall partial rank correlation coefficient. Since the obtained value ($\tau_{xy.z} = -0.255$) is much smaller than the value of $\tau_{xy} = -0.71$ (SIEGEL, 1956), the relation between the plantations and chimpanzee density is not independent of the influence of hunting. This makes sense as the planters are often the hunters as well.

4. Estimation of Chimpanzee Population in Côte D'Ivoire

The overall mean density for the Guinean forests belt is 1.64 for the National Parks. Because of its somewhat excessive density value, the data of the Marahoué National Park have been excluded from these calculations. This problem will be examined below. The mean density calculated for the Classified Forests is 0.4.

As we know that human pressure is higher in Classified Forests than in National Parks, we can measure the impact of human activities on chimpanzee populations by comparing the two density values for these regions; a reduction of 75.6% of the chimpanzee density is observed from National Parks to Classified Forests. The 0.4 mean density will be used later for the general population estimation of the Classified Forests of the Guinean forest belt. Because there are no detailed and recent vegetation maps of Côte d'Ivoire, we have no information about the distribution and surface covered by each type of habitat in this country. Therefore, we assume that our transects are a sufficiently representative sample of

the actual state of the Classified Forests. However, for habitats that we know to include at least a mosaic habitat with degraded forests and more than one third of cultivated surface, we shall use the mean density of 0.09, given by the results obtained in two such forests in the Nizoro and Gô regions, to account for the higher human pressure.

For the Soudanian belt the value obtained for the Comoé National Park cannot be used directly, because the proportion of savanna in another region can be very different. As we expect savanna far from any forest to be never or very rarely used by chimpanzees and because we know that chimpanzees make their nests only in forest types of habitat, we shall only take into account the surface of the forests, to obtain a more accurate estimation of chimpanzee populations. For this we add, from satellite pictures, only the dry forest surfaces for the Soudanian belt. The Comoé value of 3.32 chimpanzees per km^2 was obtained from a transect with 75.6% of forest, which gives a value of 4.39 for a 100% forest. If we apply the 75.6% reduction due to human activities impact to the 4.39 forest density of the Comoé National Park, we obtain a mean density of 1.07 for populations within the forested part of the Soudanian belt being outside the National Parks. As we have no data for the Classified Forests of this belt, we will arbitrarily use a density of 1.07 for them.

National Parks

Table 6 gives an estimation of chimpanzee populations for National Parks and Reserves of Côte d'Ivoire. Follows a brief description of the chimpanzee situation within each of the National Parks and some reserves in Côte d'Ivoire.

Table 6. Estimation of weaned chimpanzee populations in the National Parks and Reserves of Ivory Coast.*

Regions[1)]	Biotope[2)]	Total area (km^2)	Forested area (km^2)	Density/km^2	Estimated weaned chimpanzee population
Azagny NP	CF	217.4	35	1.64	57
Banco NP	EF	30	30	0	0
Comoé NP	DF	11500	?		
Western part		(500)	(107)	4.39	470
Iles					
Ehotiles NP		5.5	?	0	0
Marahoué NP	SF	1010	858.2	1.64	1407
Mt Péko NP	SF	340	195	0.4	78
Mt Sangbé NP	SF	950	41		
Southern part			(33.6)	1.64	55
Mts Nimba NP	EF	50	45.2	1.31	59
Taï NP PPR	EF	4260	2620	1.47	3851
Taï CTR	EF		1640	0.4	656
Ht Bandama RSV	DF	1230	280.3	1.07	300
N'Zo fauna RSV	EF	730	730	0.4	292
Lamto RSV	RS	25	?	0	0
Total		20577.9	6581.7		7225

*Obtained by the multiplication of the densities by the forested surfaces. 1) NP: National Park; PPR: peripherical area; CTR: central area; RSV: reserve. 2) CF: Coastal forest; EF: evergreen forest; DF: dry forest; SF: semi-deciduous forest; RS: Ronnier savanna. As for the numbers in brackets, see Results: National Parks, p. 602.

Azagny National Park: Coastal marshy area with few upland forests (periodically inundated forests = 35km^2) partly replaced in some areas by former plantations. Nests have been seen and chimpanzees heard but no transect was made, so we take for this region the mean density calculated for the National Parks of the Guinean belt. Six out of 20 chimpanzees from Liberia introduced for a rehabilitation project in 1985 still remain on a small island on the Bandama river.

Banco National Park: The chimpanzees were still present in the 60th (AESCHLIMANN, 1965). Because of the high level of poaching, we presume that they have now disappeared.

Comoé National Park: In spite of an intense prospection in the southwestern part of the park, we have only noted the presence of chimpanzees west of the Comoé river. The numbers in brackets indicate therefore only the western forest surfaces including the Kolonkoko forests in which lives the northern population of chimpanzees of Côte d'Ivoire (Fig. 2, point 37). One chimpanzee has been very recently observed on the eastern side of the Comoé river near the Kolonkoko site (POILECOT, pers. comm.). In the dry season, the chimpanzees can probably cross the very low river. It would be interesting to control if a population exists there.

Marahoué National Park: As mentioned above, the density number obtained for this park seems, for unknown reasons, incredibly high (6.92). We went back to test whether we face a concentration effect of the chimpanzees in the middle of the park due to heavy poaching and logging around the park. Two new areas were visited in the southwestern and western part of the park. However, we found an equally high number of nests in both sites. Thus, this high density seems to be typical for the entire park.

Mont Péko National Park: The two-thirds of the forested area of this mountainous park are very degraded because it has burned completely three times, in 1983, 1984, and 1986. We still found some chimpanzee nests during one week of intense investigation. Because it looks like many degraded Classified Forests, we give it the same mean density number.

Mont Sangbé National Park: We have not visited this park but the presence of chimpanzees is reported in its southern forests (numbers in brackets in Table 6).

Mont Nimba National Park: The chimpanzees are probably less poached in the ivorian than in the guinean (pers. obs.) or liberian part of this park.

Taï National Park: Chimpanzees are reported from many places in this park. We have divided this park in two zones: (1) A stretch of land of 5km inside the 328km of the outer limit of the park, where the poaching is much higher and where parts of land have been cultivated. We give it the mean density obtained for the Classified Forests. (2) A central area with a mean density calculated on the Taï Audrenisrou and Taï Nipla sites.

Haut Bandama Reserve: We were there for only one day without having found any chimpanzee nests, although the apes are reported by local people. The poaching level is high. As we have not done any transect in this kind of dry forests we gave it the mean density calculated for the Classified Forests of the Soudanian belt.

N'Zo Reserve: This Reserve is officially open for industrial timbering. A lot of hunting trails have been observed. Nests were found and three chimpanzees were seen crossing the road.

Lamto Reserve: The chimpanzees have not been seen there for many years.

Classified and Other Forests

Of the 183 Classified Forests reported in the SODEFOR listing (unpubl.), 129 (70.5%) are situated in the Guinean belt. Of those Guinean forests, 54 (41.9%) were almost totally or even completely replaced by agricultural lands (Table 7). Of the 75 forests for which we have recalculated the surface, only 57 could be found on satellite pictures. Their surfaces represent 58.7% ($N=57$) of the ones given by the SODEFOR report. So, we have reduced by a same proportion the surfaces given by the SODEFOR report for the 18 forests we did not find on satellite pictures, which include 2 of the 7 forests where chimpanzees are certainly missing (Table 7, No. 4 in Guinean belt). For some forests, our estimations were higher than the official ones, because we have taken into account forest plots remaining around the Classified ones.

Table 7. Estimation of weaned chimpanzee populations in the Classified Forests and Other non-protected Forests of Ivory coast.*

	Forests	*N*	Official surfaces	Calculated surfaces	Density/km^2	Estimated population
Guinean belt						
Classified Forests	1	54	4,627	0	0	0
	2	68	23,097	10,652	0.4	4,260
	3			2,856	0.09	257
	4	7	404	280	0	0
Sub total 1)		129	28,128	13,788		4,517
Other Forests	2			1,154	0.4	462
	3			89	0.09	8
Mt Kopé	2			180	1.67	301
Sub total 2)				1,423		771
Soudanian belt						
Classified Forests	1	39	5,718	0	0	0
	2	15	6,302	1,098	1.07	1,175
Other Forests	2			45	1.07	48
Sub total 3)		54	12,020	1,143		1,223
Total 1)+2)+3)		183	40,148	16,354		6,511

*Obtained by the multiplication of the densities by the calculated forest surfaces. Forests 1: Forests replaced by plantations or non-forested habitats; 2: remaining forests for which the surfaces have been recalculated; 3: same forests as for 2, but the calculated surfaces represent mosaic habitat of more than 35% of forest and less than 65% of plantation; 4: forests without chimpanzees.

The calculation is a slightly different for the Soudanian belt because: 1) Some "Classified Forests" were always savanna woodland; 2) the official surfaces take into account not only the dry forests but also a big part of savanna habitats; and 3) the factor of reduction used for two Classified Forests (not found on satellite pictures) is 17.4%.

The estimated population for the Soudanian belt should be considered with parsimony because the chimpanzee density value is not supported by transect data.

Finally, the total number of weaned chimpanzees in Côte d'Ivoire is presented in Table 8, but it still needs to be corrected for three errors we pointed out before (see Census Methods): 1) We have to correct for day-nest building by chimpanzees. Recent observations made during several weeks with the habituated chimpanzee community of Taï show that the number of day-nests can be quite high (BOESCH, in prep.). Even if this behaviour could be influenced by many ecological factors such as seasonal variations in rains, predation, hunting, and harassment by insects (ants) or, maybe, also by social fashions, it should not be neglected. We judge that the number of nests counted, i.e. the weaned chimpanzee estimation, should be reduced by an average of 20% (decreases the Côte d'Ivoire estimation by 20%). 2) The overall observer efficiency should not be lower than 95% (increases the Côte d'Ivoire estimation by 5%). 3) Error of calculations and technics is in the order of ±10%.

In conclusion, the overall population of Côte d'Ivoire is estimated to be about 11,676 ±1,168 individuals.

Table 8. Total number of weaned chimpanzees in Côte d'Ivoire.

	Calculated forest surface (km^2)	Number of weaned chimpanzees
Guinean belt	21,405.4	11,743
Soudanian belt	1,530.3*	1,993
Total	22,935.7	13,736
After correction Côte d'Ivoire	22,935.7	11,676 ± 1,168

See text for explanation about the correction used. *Eastern forests of the Comoé National Park not included.

DISCUSSION

This study shows that an accurate census of chimpanzee populations is not an easy task. Field conditions in Africa are usually difficult, and the transect method, the only reliable method, is very time consuming, especially in degraded forests. It often takes many days, sometimes up to one week, just to find a specific forest. Researchers should be aware of this and should find reliable, updated maps, if possible satellite pictures, before starting a nationwide survey.

HOPPE-DOMINIK (1991) provided an estimate of the chimpanzee populations in 1988, that was close to ours. However, the methods used were arbitrary and not based on nest counts. Presence of chimpanzees was judged on the bases of interviews with villagers, which were controlled in less than 10% of the case. Chimpanzee densities were based on nest counts from only six regions. In addition, chimpanzees were supposed to occur in 298,499km^2 of the country, without any reference to the real forest surface, an estimation simply 13 times higher than ours. Therefore, even if the nationwide result coincide, we have different estimations for all sites and no conclusion about any trend in the chimpanzee population in Côte d'Ivoire could be done.

As mentioned by TUTIN and FERNANDEZ (1983), the census of chimpanzees by counting their nests is actually the most efficient method to use for a nationwide survey, but it is not free of potential errors. We have tried, in this paper, to correct the estimation by taking

into account some of the most important ones (see Census Methods 3). Our mean chimpanzee densities for different habitats [1.64 (primary forests); 0.4 (degraded forests); 0.09 (mosaic habitat)] exemplify the impact of human activities on chimpanzee populations. Our findings correspond to data obtained by other authors (see TUTIN & FERNANDEZ, 1983) for tropical forests. The lower densities found by TUTIN and FERNANDEZ for the least disturbed forests could be explained either by the possible competition between chimpanzees and gorillas in Gabon and/or the use of the median in the formula (see Census Methods 5).

As explained by MITTERMEIER and CHENEY (1987) for nonhuman primates, three major factors contribute to the decline of chimpanzee populations: habitat destruction, hunting, and live capture for export or local trade. In Côte d'Ivoire, *loss of habitat* appears to be the most important threat. Our results show that for the Guinean belt only 19.5% of the previous 110,000km^2 primary forest remain. In addition, about 75% of these remaining forests are degraded by timber exploitation and agriculture. Thus, a major problem in Côte d'Ivoire today is the shortage of agricultural lands, due to the population growth (birth and immigration), and to the traditional slash and burn farming, which needs large surfaces of land. Today there is often no other choice for farmers than to settle into the Classified Forests or National Parks. It is very difficult to remove them from these lands after a few years. Many Classified Forests have been, or still are devoted to industrial crops (cocoa, palm oil, and rubber trees) or to exotic wood plantations (Teck, Terminalia sp., Cedrella sp....). Usually these plantations are inhabited by an extremely poor fauna, but we have been surprised to observe a small population of chimpanzees in one of them (Mopri Classified Forests). In such badly degraded forests, surprisingly even some large mammals such as duikers, chimpanzees, and elephants can survive as the visibility and walking ease of the poachers is prevented by the very dense undergrowth. This protection is often given by an exotic grass of Central America (*Chromolaena odorata*) invading most of the ground surface of the Classified Forests. *This grass* is also a real pest for agricultural lands.

Hunting is the second main threat influencing the chimpanzees. Even if illegal since 1974 in Côte d'Ivoire, hunting and snaring bush animals, such as primates, for food is a normal practice in all the country. We have found and destroyed up to hundreds of snares in some forests (Niegré Classified Forest, Tiapleu Classified Forest, Marahoué National Park...). Annual bush meat consumption in the Côte d'Ivoire represents the same amount as that of beef meat (SEDES, 1984). But, chimpanzees are not only killed for food. When plantations exist contiguously with wild chimpanzee populations, the animals learn within five to six years to eat the cocoa beans, as these have a very similar structure and taste to the wild occurring fruits of an abundant vine, *Landolphia dulcis*. Planters protect their crops and kill the chimpanzees. But as these plantations are often placed today at the limit or even inside the Classified Forests or National Parks, where the chimpanzees were always living, this resembles a provocation. These cocoa plantations should be at least replaced by coffee, rubber trees, or other products not eaten by the wild mammals.

The *live capture* of chimpanzees for pets or research does not seem very developed in Côte d'Ivoire, but we have seen a dozen of captive chimpanzees during this study and suspect many Europeans living in Abidjan to keep some as pets. There is no regular market but it is still quite easy to buy young apes in places close to the forest. We were offered a baby chimpanzee in Monogaga for about $100 US and two adults for $200 US in San Pedro. We have personally checked that it is rather easy, with some money, to export a chimpanzee through the airport border.

Finally, this study shows that chimpanzees can survive despite a significant deterioration of their habitat when the poaching is moderate. This species seems to be relatively habitat tolerant if the non-cultivated forest islands are large enough (see UHLENBROEK, 1990). This situation, still relatively frequent in Côte d'Ivoire, explains why chimpanzees can be found in many places throughout the country. However, this situation is very *deceptive* because deforestation and poaching are often recent, and isolated populations of chimpanzees may have only survived thus far.

Such small populations face three main problems for their survival, even if deforestation and poaching is low: 1) Adult males are often the first ones to be killed by farmers, as they protect group members from danger (BOESCH, pers. obs). These individuals are not only essential for the reproduction but also for the social cohesion of a chimpanzee community. With the reproductive unit disturbed, survival chances decrease accordingly. 2) Due to the low rate of reproduction of this species, these small populations will be very rapidly exterminated by even a low level of hunting, as they cannot compensate for these losses. 3) Finally, the isolation of these small populations make them very susceptible to inbreeding depression and genetic drift in a close future.

Therefore, most of the 10,000 to 13,000 actual living chimpanzees of Côte d'Ivoire are highly endangered. Only chimpanzee populations of National Parks of Taï, Comoé, and Marahoué might be viable in the long term.

CONCLUSIONS

This survey study shows that the chimpanzee population of Côte d'Ivoire is larger than thought before. Although pleased by this result, we cannot be optimistic because this situation is very fragile. More than half of the chimpanzees are threatened to more or less *close extinction*, due to their extremely patchy and discrete distribution.

We strongly recommend the conservation of this fascinating ape in Côte d'Ivoire, not only by improving the protection of the National Parks, but also by trying to conserve chimpanzee populations living in less protected, but fauna-rich forests like the Monogaga Classified Forest, Dassiékro (Dagbégo) Classified Forest, Songan-Tamin-Mabi-Yaya Classified Forest, Gô Classified Forest, Haut Bandama Classified Forest, Goin-Cavally Classified Forest and finally, situated south of Taï National Park, the mountain chain of Mont Kopé — Mont Bodélé which belongs to the richest forests of the country.

Acknowledgements. We are very grateful to the following people and organizations for their efficient support: The "Ministère de la Recherche Scientifique de Côte d'Ivoire," "The Ministère des Eaux et Forêts de Côte d'Ivoire," particularly Dr. K. E. BONNY director of the National Parks, P. MENGIN-LECREULX director of the "Aménagement de la forêt naturelle" at the SODEFOR, Mr. FOFANA director of the "Section Autonome de la Télédétection à la Direction et Contrôle des Grands Travaux" in Abidjan, and Dr. F. LAUGINIE director of the Abidjan Zoological Garten. Dr. L. ORTEGA director of the "Centre Suisse de Recherches Scientifiques," Adiopodoumé, H. BOESCH for critical reading of the manuscript, T. ZOROA TIEPKAN and his staff of the IET Scientifique Station of Taï, and D. LIA our faithful helper during this study. Drs. A. AESCHLIMANN, C. MERMOD, G. TELEKI, and J. GOODALL for helping during different phases of the project. We thank for their financial support the "Fonds National Suisse pour la Recherche Scientifique" which gave a one-year postdoctoral grant to P. MARCHESI, the D.A.A.D. (Deutsche Akademische Austauchdienst) that supported B. FRUTH, the Leakey Foundation, Oakland, U.S.A., and the Jane Goodall Institute, Tucson, U.S.A.

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—— Received: *May 8, 1993*; Accepted: *March 25, 1995*

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