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# Density and distribution of chimpanzee (*Pan troglodytes verus, Schwarz* 1934) In the forest zone of Mont Sangbe National Park, West of Cote d'Ivoire

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## Abstract

The loss of biodiversity mainly due to human activities is a global concern. The survival of wild mammals, including the West African chimpanzee (*Pan troglodytes verus*), which is considered a critically endangered species, is threatened. However, information on the status of the remaining populations of such a primate and its distribution is rarely available or out of date for some sites. This study aims at improving the knowledge of the west chimpanzee population density and distribution in Mont Sangbé National Park (MSNP), West Côte d'Ivoire, for conservation purposes. We counted chimpanzee sleeping nests along 64 line transects of one kilometer each in the forest area of the MSNP by following distance sampling methods. Then, we recorded the GPS coordinates of all signs of the presence of the species during transects and recce surveys. We observed 148 signs of the presence of chimpanzees including 94 nests counted along transects. The average density of chimpanzees in the forest area of MSNP was estimated at 0.25 individuals/km² and 0.48 individuals/km² when using a value of a lifetime of nests of 164.38 days and 84.38 days, respectively. In addition, the distribution map showed that the signs of the presence of chimpanzees are mainly observed in two areas: the southern and the north-eastern forest areas of the MSNP. We recommend the application of other survey methods (genetics, camera trapping, nest counts combined with the modeling of nest lifetime estimates) for a better understanding of the chimpanzee population ecology and for conservation management in the PNMS.

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## Introduction

The erosion of biodiversity is a growing concern globally (Norro, 2017). The loss of wild animal populations mainly due to human activities is becoming particularly alarming. The International Union for Conservation of Nature (IUCN) Red List indicates that 40% of amphibians, 14% of birds and 25% of mammals are globally threatened and are about extinction (IUCN, 2019).

The chimpanzee (*Pan troglodytes*) is one of the endangered mammal species. The West African subspecies, *Pan troglodytes verus* is now considered critically endangered as it is expected to decline by more than 80% by the next century (Humle *et al.*, 2016). Yet, the chimpanzee plays an ecological role (Chapman and Onderdonk, 1998) as well as in the study of human evolution (Boesch and Boesch-Achermann, 2000).

In Côte d'Ivoire, the population of *P. troglodytes verus* was estimated at 8,000 to 12,000 individuals in the early 1990s (Marchesi *et al.*, 1995). According to Campbell *et al.* (2018), this population has experienced an alarming decrease resulting in a 90% drop in the total nest encounter rate in less than two decades. Most of the remaining chimpanzee population in Côte d'Ivoire is confined to protected areas and a few fragmented forest habitats.

During the decade of the socio-political crisis in Côte d'Ivoire (2002-2011), the protected areas (PA) located to the north and west, including the Mont Sangbé National Park (MSNP), remained inaccessible to researchers, and managers (Normand *et al.*, 2010). This situation has led to a lack of information on the populations of chimpanzees inhabiting this park. To avoid the disappearance of the chimpanzee, it has been identified by managers as one of the target mammals for conservation. Thus, information relative to the density and distribution of populations is ofhigh priority for conservation and management (Nichols *et al.*, 2006; Bessone *et al.*, 2021; Ordaz-Németh *et al.*, 2021). Indeed, knowledge of the density and distribution makes it possible to provide reliable information in order to better monitor population trends and to know the areas of occurrence of those animals.

However, in the wild, the observation of individuals of chimpanzees is difficult and makes it almost impossible to reach the acceptable level of sample size for making population estimates (Plumptre and Reynolds, 1997). The count of nests built daily by chimpanzees and their average degradation time is therefore used to make population estimates (Baldwin *et al.*, 1981; Fruth and Hohmann, 1996; Kouakou, 2014). This work aimed at contributing to the conservation decision-making of these wild primates by determining the density and distribution of chimpanzees in the forest part of the MSNP.

## Material and methods

*Study site*

We conducted this study in the forest zone of Mont Sangbé National Park (MSNP) which is located between 7 ° 51 'and 8 ° 10' north latitude and 7 ° 03 'and 7 ° 23' west longitude. The PNMS covers an area of 97,554 ha (OIPR, 2017), with a rainfall of 1100 to 1600 mm, an average annual temperature of 25 ° C and with a relative humidity of 75% (Lauginie, 2007).

*Data collection*

We collected data from 11th February 2019 to 16th April 2019. We counted sleeping nests along line transects by following distance sampling methods and counted all other signs of the presence of chimpanzees during recce surveys and transects surveys (Buckland *et al.*, 2001; Kouakou *et al.*, 2009). The nests' counts on the line transects were carried out between 7 a.m. and 5 p.m. by a team of three observers. The observer ahead was equipped with GPS and a compass to ensure the team was walking on the virtual transect line. Indeed, during transects surveys, deviations are not authorized.

The three observers were looking for nests and other signs of the presence of chimpanzees (droppings, footprints, vocalizations, food scraps, etc.) on the line but also on both sides of the transects.

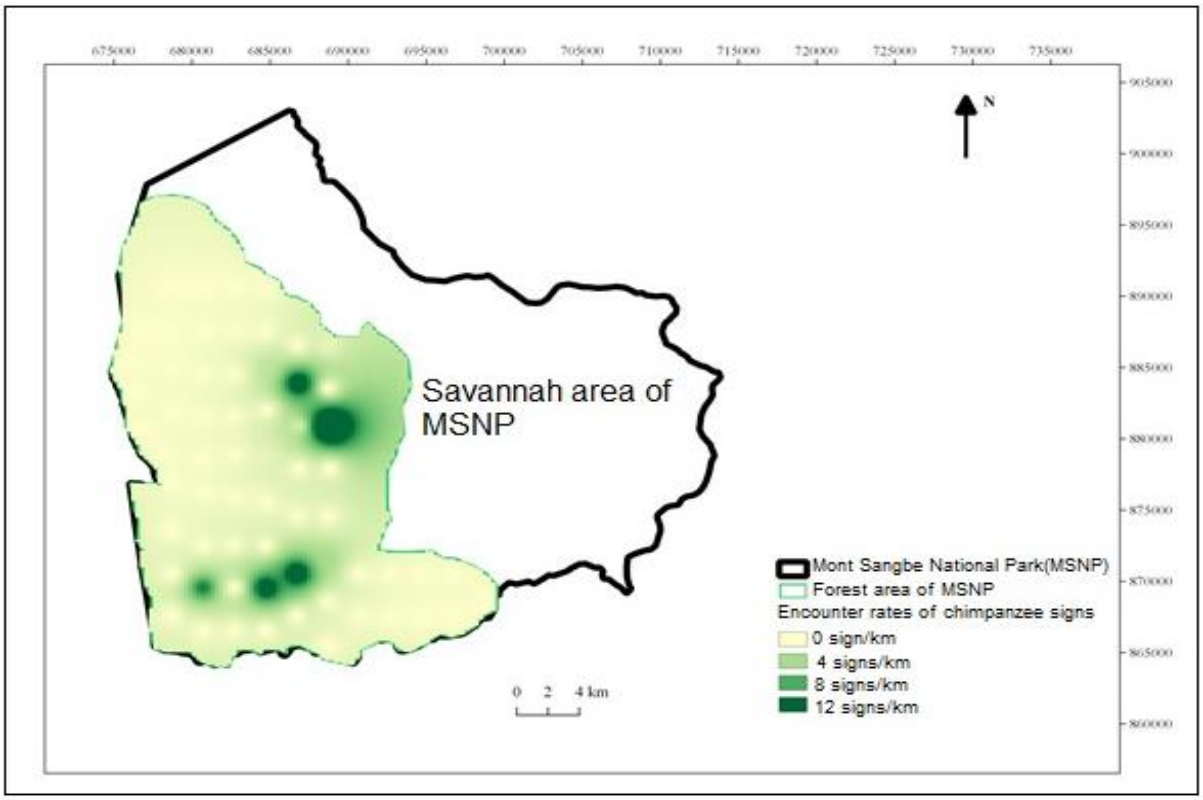


**Fig. 1.** Map showing the distribution of chimpanzee in the forest area of MSNP with indication of the observed variation of the species' signs enounter rates.

The number of observers, their arrangement and the travel speed, is estimated at about 0.6 km/h, had made it possible to increase the probability of detecting chimpanzee nests on the transect (Buckland *et al.*, 2001). Each transect had been surveyed only once and all detected nests were counted. This method is sometimes referred to as a standing nest count (Tutin and Fernandez, 1984; Marchesi *et al.*, 1995; Plumptre and Reynolds, 1996).

When a nest was detected, the following data were collected: the perpendicular distance from the position of the nest to the transect line, the distance travelled along the transect, the age class of the nest, the number of nests in the same location. In addition, the geographic coordinates of the position below the nest were noted. Four age classes or stages of nest degradation were defined according to Marchesi *et al.* (1995) and Kouakou *et al.* (2009): fresh, recent, old and very old. The nest is qualified fresh when the leaves that constitute it are green with the general smell of urine and the presence of chimpanzee droppings below the nest.

The recent nest is characterized by the presence within it of leaves in an advanced and varied state of wilting; therefore, leaves of various colors. Old nests are those that are generally intact in shape but in which the majority of the leaves are brown in color. Very old nests are those which have lost most or all of the leaves but which are identifiable as chimpanzee nests due to the bent branches (Kouakou, 2014). When other signs of the presence of chimpanzees were detected, the distance traveled, the type and number of clues were noted and then the geographical coordinates of these clues were recorded (Kouakou, 2014). The recce was applied to collect off-transect data for the spatial distribution of chimpanzees. It consisted of moving around the study area in a predetermined direction, following the passages of least resistance. Unlike surveys on the line transects, recce allows deviations. However, the angle of these deviations should not be greater than 40 degrees to avoid step backlash (Walsh and White, 1999). When a nest was observed, the same information as on linear transects was recorded, except the perpendicular distance.

*Data analysis*

To estimate the density of chimpanzees (Dc) at MSNP, we used data collected along transects and performed analysis by using the Distance 7.2 program. The calculations were made according to the formula below (Buckland *et al.*, 2001):

$D_{C=\frac{D_N}{r\times t}}$ Where t is the mean lifetime of nests and r is the mean of nests production rate. The detail on the formula for estimating the density of chimpanzee nests (Dn) provided by Distance 7.2 is described by Buckland *et al.* (2001).

In this study, the value of r used is 1.143 nest/day, as proposed by Kouakou *et al.* (2009). The values of t used are those of Kouakou *et al.* (2009), N'goran *et al.* (2011) and Tweh *et al.* (2014), which are respectively 91.22 days in the research area of the Taï National Park (TNP), 84.38 days for the entire TNP and 164.38 days for the Sapo National Park (SNP) in Liberia. These three values of t were used for the estimation of chimpanzee density because no nest degradation studies have been carried out within the MSNP.

In addition, the encounter rate or kilometric abundance index (KAI), which designates the number of presence indices per distance traveled, was also calculated according to the formula:

$$KAI = \frac{\text{obervation nomber}}{\text{Survey Distance}}$$

To establish the spatial distribution of chimpanzees, the geographic coordinates of the evidence of the presence of chimpanzees recorded both on the transects and during the recce were exported as QGIS 2.18 and projected on the map of the study area.

The spatial interpolation method was then used by estimating the value of the nest encounter rate at any point in the study area.

To estimate the point value at a location, the deterministic interpolation method of weighted inverse distance (IDW) was applied. It consists of using linear combinations and assuming that the influence of a known data point is inversely proportional to the distance between the unknown location that is being estimated (Li and Heap, 2008).

The mathematical model used to determine the densities of nests Z at an unsampled point j at a distance dij from a sampled point i is given by the equation:

$Z_j = \sum_i \lambda_i z_j$ with $\lambda_i = \frac{1/dij\alpha}{\sum 1/dij\alpha}$ (α is a constant or pow( ıeter)

**Results**

*The density of chimpanzees at MSNP*

The sampling effort during the present study was 61.829 km in the forest area of the MSNP. The chimpanzee nest encounter rate estimated from transect counts was 1.52 nests/km, with a total of 94 nests observed. The estimated nest density is 0.067nid/km² and does not vary regardless of the value of the mean nestlifetime (t).

The chimpanzee density varies depending on the value of t used. The chimpanzee density estimate is 0.25, respectively; 0.45 and 0.48 individuals /km2 using the mean nest lifetime of Tweh *et al.* (2014), Kouakou *et al.* (2009) and N'goran *et al.* (2011). Thus, the estimate of the average density of chimpanzees in the forest area of the MSNP is 0.39 individuals/km² (Table 1).

The coefficient of variation of all estimates is high, with a value which is about 44%.

*Spatial distribution of chimpanzees at MSNP*

Three types of signs indicating the presence of chimpanzees (nests, dung, vocalisation) were recorded during line transects surveys and recce surveys (Table 2). The majority (69.59%) of signs of the presence of the western chimpanzee have been observed during line transects surveys. In total, 148 signs of all three types were observed during the study.

**Table 1.** stimates of chimpanzees' density obtained from the counts of steeping nests in the forest zone of Mont Sangbe National Park.

| Nest degradation rate | Nest density (nid/km²) | Mean abundance estimated (individuals) | Estemated density (individuals/km²) | CV estemated density (%) | 95% Confidence interval of estemated density (individuals/km²) | |
|---|---|---|---|---|---|---|
| | | | | | Min | Max |
| 164.38[a] | 0.067 | 95 | 0.25 | 44.32 | 0.10 | 0.58 |
| 91.22[b] | 0.067 | 172 | 0.45 | 44.79 | 0.19 | 1.06 |
| 84.38[c] | 0.067 | 186 | 0.48 | 44.57 | 0.20 | 1.14 |

CV (%): coefficient of variation in percentage.

The nests production rate 1.143 (SE = 0.04) from Kouakou *et al.* (2009) was used for all the analyzes. a: mean lifetime of nests 164.38 days (SE = 0.32 days) (Tweh *et al.*, 2014); b: mean lifetime of nests 91.22 days (SE = 5.89 days) (Kouakou *et al.*, 2009); c: mean lifetime of nests 84.38 days (SE = 4) (N'goran *et al.*, 2011).

They allowed an estimate of the Kilometric Abundance Index (KAI) of 1.66 indices/km. Nests were the most observed signs of the presence of chimpanzees as they represented 91.22% (135 nests) of all signs counted, while dung piles were less observed. However, we observed varying numbers of nests with decay stages.

A total of 10 fresh nests (stage I), 38 recent nests (stage II), 61 old nests (stage III) and 26 very old nests (stage IV) were counted both on the transect and during the recce. Details are shown in Table 3. During recce surveys, we observed similar numbers of nests of stages I, II and IV.

The spatial distribution of signs presence of chimpanzees within the study area is presented in Fig. 1 and illustrates the wide distribution of this species in the forest area of MSNP. Indeed, the spatial interpolation of encounter rates illustrates the area of occupancy of this species within the study area. We found two main areas with the highest encounter rates (12 signs per km walked): the north-eastern and southern areas of the forested habitat of MSNP.

**Table 2.** Abundance of the signs of presence of chimpanzees in the forest zone at MSNP.

| Survey methods | Chimpanzee signs | | | |
|---|---|---|---|---|
| | Nests | Vocalisations | Dung | Total |
| Line transects | 94 | 6 | 3 | 103 |
| Recce | 41 | 4 | 0 | 45 |
| Total | 135 | 10 | 3 | 148 |

**Discussion**

This study provides the first estimate of the western chimpanzee population density and distribution at MSNP. The results indicate that chimpanzee density varies with the nest lifetime value used to make the estimate. Using the nest lifetime value from Tweh *et al.* (2014), the chimpanzee density at MSNP is estimated at 0.25 individuals/km². On the other hand, taking into account the values for the nest lifetime of the nests of the Taï National Park (TNP) provided by Kouakou *et al.* (2009) and N'goran *et al.* (2011), the density obtained is 0.5 individuals/km². Ultimately, the estimated average density of chimpanzees is significantly greater than that of the entire TNP, which is 0.087 individuals/km² (Kouakou, 2014). This difference in densities could be explained by low anthropogenic pressures on chimpanzees in the forest zone of the MSNP than on those of the TNP. On the other hand, compared to the densities of chimpanzees of the Sapo National Park (SNP) in Liberia and the Moyen-Bafing National Park (MBNP) of Guinea respectively of 0.86 individuals/km² and 0.42 individuals/km² (WCF, 2016), the density of chimpanzees in the MSNP forest area is lower. Indeed, the chimpanzee communities living within the SNP are revered by the Sapo people

who live in the region and, therefore, they are not hunted by them (William and Blue, 2005) while, although being formally prohibited in Côte d'Ivoire since 1974, hunting is a common practice in all regions, including in parks and reserves. As for the MNNP, it was selected on the basis of the results of the 2012 census, showing a high density of chimpanzees and the on-site presence of seven classified forests well respected by the populations (WCF, 2016), which would explain this difference in density. Between MSNP and MBNP. However, the value of the nest degradation time (t) could influence the precision of our estimate of densities. Indeed, for a high value of t (164.38), we have a smaller density (0.25 individuals/km²) and for smaller values of t (91.22 and 84.38), we have more densities. Large and approximately equal for these values (respectively 0.45 individual/km² and 0.48 individual/km²).

**Table 3.** Abundance of chimpanzee nests for different decay stages observedduring line transects and during the recce surveys in the forest zone of the MSNP.

| Survey methods | Abundance of nest per decay stage | | | | |
|---|---|---|---|---|---|
| | Stage I | Stage II | Stage III | Stage IV | Total |
| Line transects | 2 | 30 | 42 | 20 | 94 |
| Recce | 8 | 8 | 19 | 6 | 41 |
| Total | 10 | 38 | 61 | 26 | 135 |

This suggests that the density of chimpanzees would depend enormously on the value of t. The values used are those available for the sites (TNP and SNP) closest to our study area.

²Regarding the distribution of the chimpanzee in the forest part of the MSNP, the signs of the presence of the species are concentrated in two main areas: in the south and in the northeast of this forest of the park.

This type of distribution could be linked to the non-uniform distribution of food resources or the possible existence of different social groups. In fact, the survival of animals in the natural environment is strongly linked not only by their ability to efficiently locate potential food sources but also by the ability to escape predators or other threats by finding suitable shelter sites (Milton, 1981; Chapman and Wrangham, 1993; Inoue *et al.*, 1993). This arrangement of the presence indices according to the distribution map could indicate the presence of two social groups of chimpanzees within the forest zone of the MSNP. Indeed, given their territorial behavior, social groups of chimpanzees frequently repel each other in space (Wilson *et al.*, 2001; Wilson and Wrangham, 2003; Boesch *et al.*, 2008; Kouakou, 2014) which would explain the concentration of presence indices in the southern and north-eastern parts of the forest area of the park.

**Conclusion**

This study has provided information about the density and distribution of the western chimpanzee in the forest area of the PNMS. The maximum average density was estimated at 0.48 individuals / km² and 0.25 individual / km² for the average minimum density depending on the lifetime value of the nests used for calculations. Regarding the distribution, two main areas have been identified as the areas of occurence of the chimpanzee in the forest area of the PNMS. These are: the north-east and south areas.

We recommend the application of other population survey methods such genetic, camera trapping approaches and to undertake western chimpanzzee population monitoring for better management and conservation of the ape in PNMS.

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