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The Chimpanzees (*Pan troglodytes*) of the Yoko Council Forest in Cameroon: Abundance, Activity Pattern and Threats

Serge Alexis Kamgang[1, *], Ervis Manfothang Dongmo[2, *], Iris Kirsten[3], Pop Moadomb Jacques Jefferson[2], André Mveimané[3], Didier Bastin[3], Neba Estherbel Bih[2], Bakwo Fils Eric-Moise[4]

[1]Garoua Wildlife College, Ministry of Forestry and Wildlife, Garoua, Cameroon

[2]Department of Forestry (FASA), University of Dschang, Dschang, Cameroon

[3]Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Forest and Environment Project (ProFE), Yaoundé, Cameroon

[4]Department of Biological Sciences, University of Maroua, Maroua, Cameroon

Email address:

sergekamgang@yahoo.fr (Serge Alexis Kamgang), manfothang@yahoo.com (Ervis Manfothang Dongmo)

[*]Corresponding authors

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Abstract: Successful conservation and management of chimpanzees (*Pan troglodytes*) in Yoko Council Forest (YCF), Centre Cameroon, requires reliable estimates of their population size and density, habitat use and threats. Our study offers the opportunity to improve the knowledge on the population density, distribution and threats of the chimpanzee in this area. We used indirect survey methods using nest counts to estimate the decay rate of the nests. This approach consisted of locating and marking fresh nests (less than 48 hours old) at different periods of time and revisiting them at the end of the inventories to verify whether they had deteriorated or not. Human activities, habitat types, and nesting tree species were also assessed. The mean nest decay rate estimated using a logistic regression analysis was 77.53 days with a nest density of 69.3 [95% CI 54.9-86.7] nests/km^2, for an estimated population of about 113 [95% CI 45-280] chimpanzees. In YCF, chimpanzees nest in Marantaceae forests and swampy forests, especially on *Khaya grandifolia* and *Uapaca guineensis* trees. Transhumance was the greatest threat in the area (75.33%), followed by hunting (13. 66%), wild sawing (8.81%) and fishing (2.2%). These anthropogenic perturbations were most observed in the south-west sector of the YCF. The area with the greatest density of nests occurred at a site least impacted by human activities. It is essential to regulate these activities in order to guarantee the sustainable management of this precious chimpanzee population.

Keywords: YCF, Anthropogenic Perturbations, Chimpanzee, Nest Decay Rate, Sustainable Management

1. Introduction

The biodiversity of the Congo Basin forest is of global significance because of the sheer number of species found in the region [15, 40]. They harbor the most diverse assemblage of plants and animals in Africa including over 400 mammal species, more than 1,000 bird species, and over 10,000 plant species of which some 3,000 are endemic [17, 60, 65]. This forest plays an important role in the preservation of genetic resources, the protection of ecosystem functions, ecotourism and safeguarding of natural and cultural heritage [15, 17, 81]. Nonetheless most serious degradations are underway in the forest of the Congo Basin. Large blocks of the forest in this area are already unable to support wildlife which are dependent on forest resources [17, 70]. Moreover, the forest faces a lot of pressure with its increasing population principally for agriculture, Non-Timber Forest Product (NTFPs) collection, illegal wood exploitation and bush meat

hunting. In the Congo Basin, degradation, illegal hunting, wildlife trafficking, and bush meat trade pose a serious threat as they lead to the overexploitation of wildlife species to meet the demand of urban and international markets [50, 66]. Furthermore, about 34 million people in this area still depend on wildlife as a direct source of protein [84]. Hunting by humans for bushmeat, is one of the primary threats to large-bodied vertebrates in many African forests [4, 5, 38, 60]. Overhunting can have cascading effects through an ecosystem, altering forest structure and composition, and affecting nongame species [1, 21, 77, 83]. Human activities have been changing forest diversity and composition, and some forests have not been recovering after being faced with human disturbance. For example, the vegetation of the western region of Cameroon was originally described as moist semi-deciduous Guinean rainforest [30, 41], currently, the vegetation cover of this area is dominated by a mosaic of crops [71], and very little of the region's native biota remained, a consequence of decades of deforestation to make way for agriculture and urbanization [44, 45].

Chimpanzees (*Pan troglodytes*) as a species are classified as Endangered by IUCN [55], and in the last decades, populations in Africa are rapidly declining from about 1 million in 1900 to 300,000 in 2000 [9, 13, 51], as well as a pronounced reduction in an area with suitable environmental conditions [32]. They are rapidly declining as a result of epidemic diseases, commercial bushmeat hunting, wildlife trafficking, deforestation associated with logging and agricultural activities, the introduction of exotic plant species and natural changes [24, 27, 29, 64, 78]. Also, a serious reduction in suitable habitat between the 1990s and 2000s [13], and human proximity to settlements make a large contribution to the loss of the suitable niche for chimpanzees [15]. Suitable ecological conditions for chimpanzees in many forests where there is a higher human population size are widely fragmented by agricultural and agro-forestry areas [14], common for human-primate conflicts to occur consequently [26], as well as transmission of diseases and pathogens between humans and chimpanzees [14], and limiting large home ranges for chimpanzees [58]. However, some of these human activities, such as illegal hunting and bushmeat trade [55] affect primate populations directly, while others, such as deforestation, agricultural activities and fragmentation, indirectly [15, 19].

YCF is located in a transition zone in the Centre Region of Cameroon, and precise baseline studies on apes are not available and the extent of their declines unknown [12, 71]. This study aimed to assess population density and distribution, habitat use, and threats to chimpanzees in this area. This study offers the opportunity to improve the knowledge, protection and conservation of the chimpanzee in this area. We hypothesized that there was a variation in the density of nests across the vegetation types. Therefore, we predicted that the greatest density of nests occurred in territories that were the least impacted by anthropogenic activities. Mammalian species show higher abundance and species richness where anthropogenic activities are limited and decrease continuously with a gradient of disturbance [45, 73]. Species richness and abundance of chimpanzees are limited in an area where human pressure is stronger [61], especially in landscapes dominated by slash-and-burn agriculture [74].

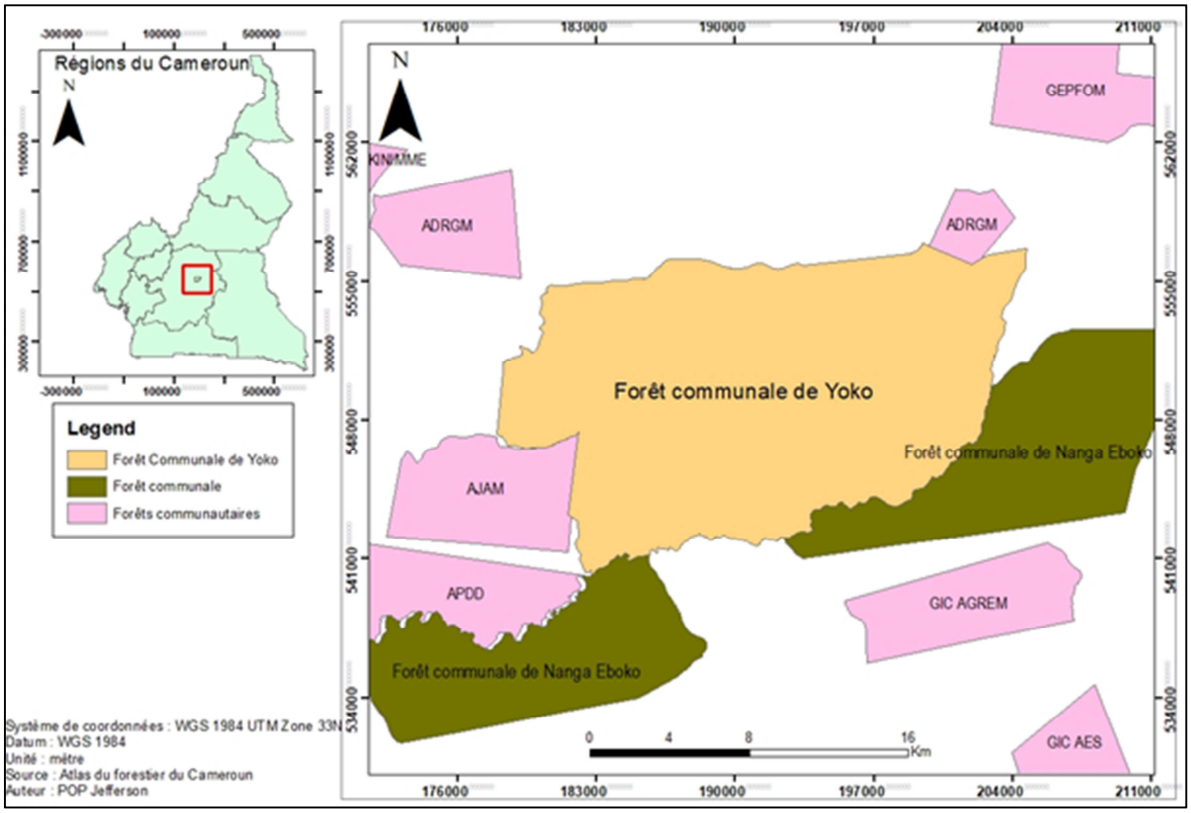

Figure 1. *Map of Cameroon showing the study area, and others forests types.*

2. Materials and Methods

2.1. Study Site

The study was conducted in the Yoko Council Forest from February to July 2022. This area is situated between 180 703.18 and 554 795.63 537,033 North latitude, and 198 626.31 and 544 009.34 East longitude (UTM Zone 32N) in the Centre Region of Cameroon and covers a total surface area of 29500 ha (Figure 1). It is characterised by four seasons: two rainy seasons alternating with two dry seasons (a long rainy season from mid-September to mid-November and a short rainy season from mid-March to mid-June; a long dry season runs from mid-November to mid-March and the short dry season runs from mid-June to mid-September). The average temperature ranges from 27°C to 28°C [2]. This station displays average annual rainfall greater than 1500 mm, which would lead to the conclusion that water is not the limiting factor of biomass production in the region [2].

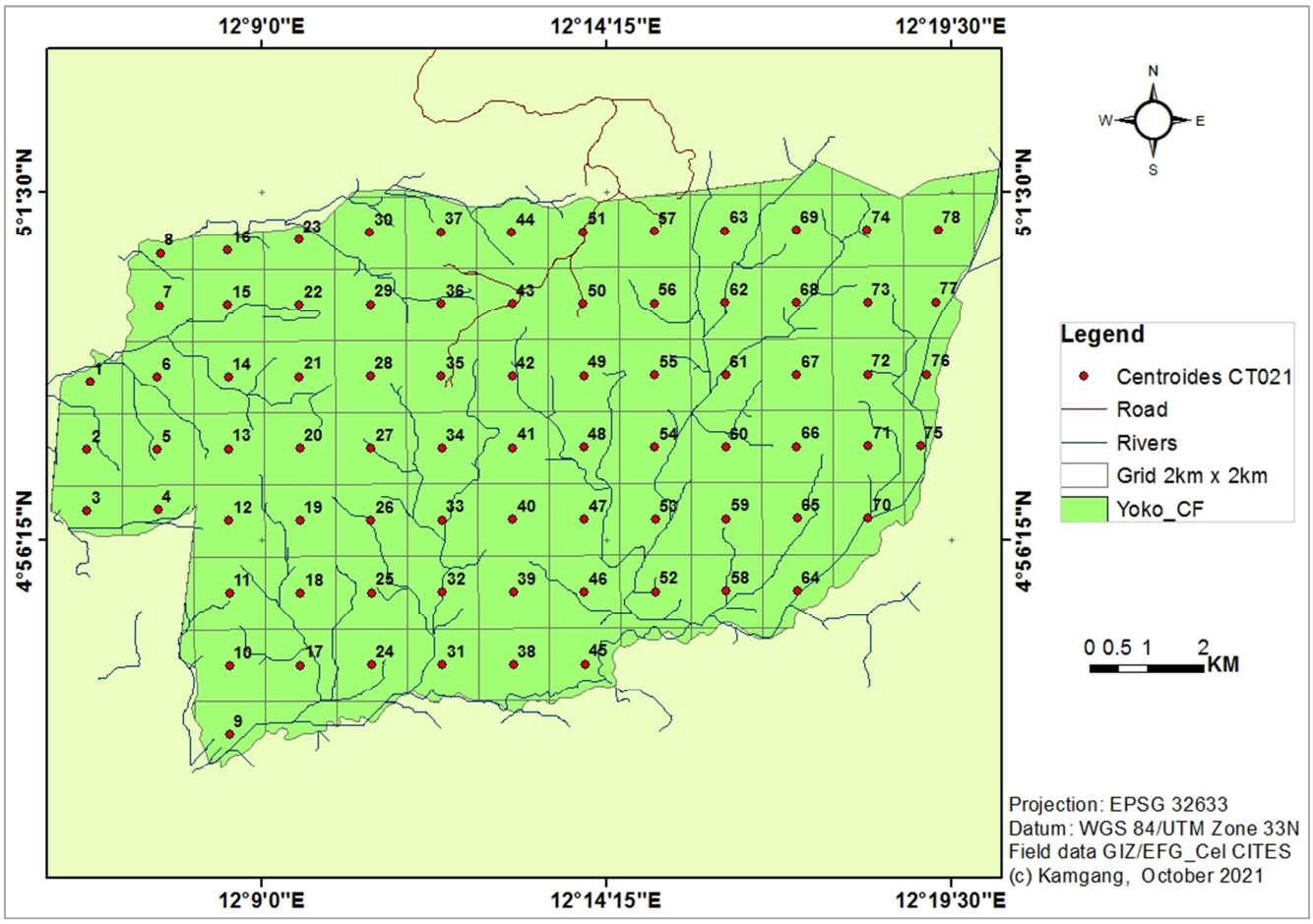

Figure 2. *Installation map of trap cameras in the FCY.*

2.2. Data Collection

2.2.1. Chimpanzee Nest Surveys

In contrast to all other nonhuman primates, great apes like chimpanzees build a nest every night for sleeping or resting during the day [3]. Thus, nest abundance become a useful tool for estimating densities and population sizes of chimpanzees [11, 15, 19]. Nest or dung surveys have been used to estimate the population density of several mammals [33]. However, the process of nest decay varies temporally and spatially, resulting from various factors such as vegetation type and climatic variables [11, 37], providing a large variation in its estimates between areas. It became necessary to estimate the nest decay rate for each study site. In this study, the retrospective method was used. This approach consists of marking fresh nests at different periods and revisiting them only once to verify whether or not they have decayed and with which speed [33]. Using this approach, a period of time for a visit is preselected and the mean decay rate of the nests already present can be estimated [48]. We conducted monthly marked nest count surveys and revisited marked nests from February to July 2022 the 27 transects (54 km) and recorded only newly-built night nests (less than 48 hours old) and marked them to avoid subsequent re-counting. In the study area, the following parameters were collected: nest-group size, nest age class, habitat types, human activities, nesting tree species, and nest decay. Identification of plant species on which the chimpanzees nest was made in the field by the local guides

through the vernacular names. The samples were collected and taken to the Cameroon National Herbarium (HNC) for scientific identification. The daily nest site locations of chimpanzees were recorded in the field using a Global Positioning System (Garmin).

2.2.2. Estimation of Nest Age Class

According to the classification of [75], four nest age classes were defined namely: fresh (1): the nest has green leaves that are not sunken, presence of fresh feces, urine, or traces of food at the site; recent (2): the nest has green but faded leaves; old (3): the nest still has leaves but which have a brown color, with sometimes the presence of some faded green leaves and the nest structures still intact; very old (4): nest with holes showing few or no leaves. All that remains are the skeleton of the nest made of branches and twigs.

2.2.3. Nest Marking

We used a GPS and a compass monthly to locate the surveyed areas with activity (data of the trap cameras installed) for chimpanzees at two weeks intervals, and mark fresh chimpanzee nests. The survey was made from centroids to quadrats 2km^2 of centroids, and a systematic search was made in a radius of 500m for a total of 27 transects (2 km transect length). When the next or a group of next is seen, we marked by putting the codes referring, noted M1, M2,… M5 (Mission/survey number); G1, G2, …. G5 (nest group), and N1, N2,….. N5 (nest). We walked each transect with a mean speed of 1km/2 hours to ensure detection of all chimpanzee nests. We disturbed the habitat as little as possible, and did not cut the vegetation, although we bent some branches when necessary, to mark our path.

2.2.4. Revisit Marked Nests

During fieldwork in July 2022, all marked fresh nests were revisited. A nest was considered degraded when its structure no longer allowed it to be identified as a nest. We marked nests that were present as (1) and those that were absent as (0). A nest was considered absent when it had either brown or yellow leaves piled up, or dry branches at the same position as the initially marked fresh nest [33]. We used the software program QGIS 3.2 Bonn to map the geographic location of all marked fresh nests in the study area (Figure 3).

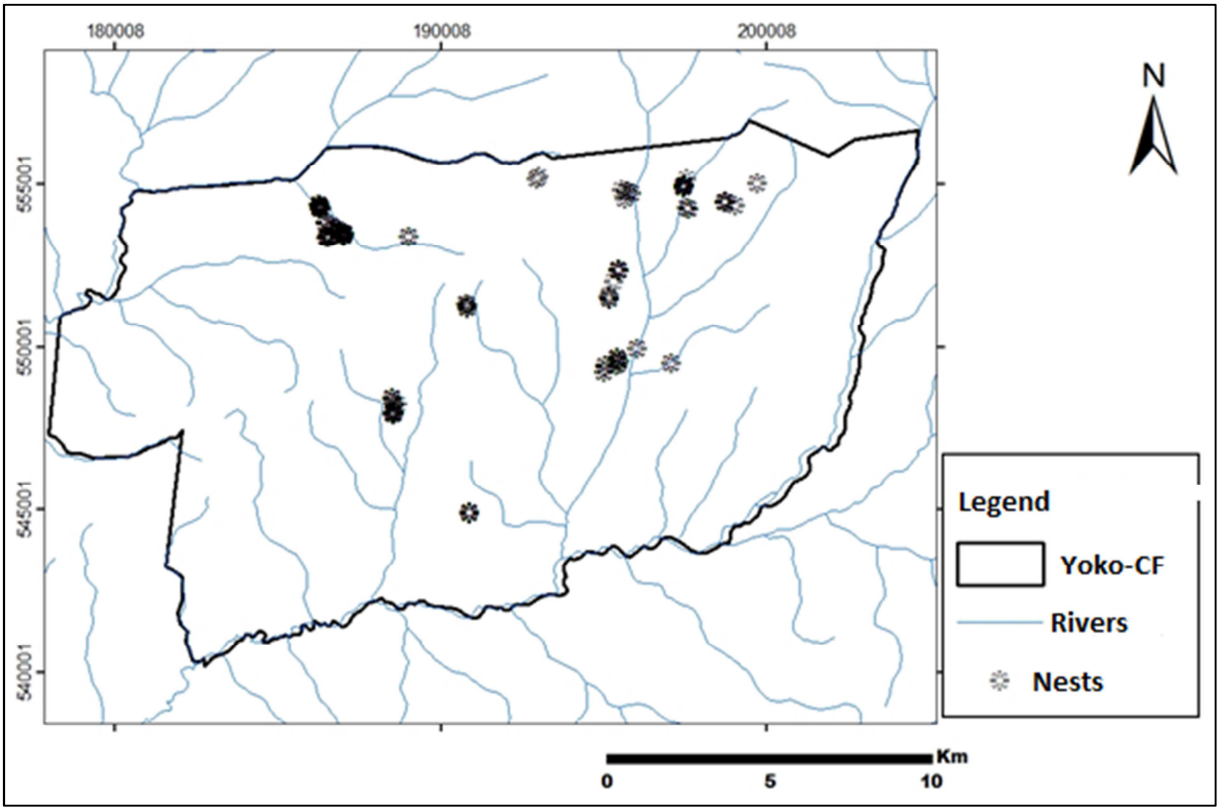

Figure 3. *Distribution of the fresh nests in the YCF.*

2.2.5. Human's Activities

During a survey in the area, the signs of human activities were collected, namely poaching clues (traps, shell casings, hunting camps), pastoral transhumance clues (cattle droppings, Mbororos camps, burning or degraded areas, cattle, and illegal logging) and fishing clues (fishing barriers, fishing camps). The distribution maps of various anthropogenic activities were made with the QGIS 3.2 software.

2.3. Data Analysis

The data was entered and compiled in the Microsoft Office Excel 2013 software. Before statistical analysis, we collapsed

some levels of some categorical data to ensure adequate sample size within each level or category and to meet assumptions for some statistical tests. We used Pearson's chi-squared statistic (χ^2) of homogeneity to compare the occurrence of chimpanzee's nests concerning age and to compare the frequencies of encountered human activities potentially harmful to primates. All statistical tests were set at a 5% significant level. Only two variables were considered in this analysis: the predictor variable "age" and the response variable "absence/presence". To estimate the rate of nest decay, the logistic regression model [54] was used with R software version 3.6. The model allowed us to plot the logistic regression model of the nest age and helps to determine the number of days in a probability of survival noted P = 0.5 (equation 1). Then, the alpha (α) and beta (β) parameters are estimated using the R for Windows statistical software.

$$P\,(Y = 1/\,Xi) = \frac{e^{\alpha+\beta\,X+\,\alpha i}}{1+e^{\alpha+\beta\,X+\,\alpha i}}$$

With *(α)* as a constant and *(β)* the coefficient of time, and *X* represents the time (days) [33, 34].

We derived the mean nest decay rate and the confidence interval by isolating the *X* factor from equation 1 using the coefficients *α* and *β* from each logistic regression (equation 2).

$$X = \frac{log\left(\frac{1}{y}-1\right)+\alpha}{-\beta}$$

The Distance 7.0 program [10] was used to derive nest and chimpanzee density estimates. This program implements a series of detection function models with their expansion series acquired from the dataset to estimate chimpanzee density by inference from nest density. Different models are then compared based on Akaike's information criterion with the 95% confidence interval (CI). Single nests will be used to estimate chimpanzee nest density. Chimpanzee density is then derived from nest density using conversion parameters (nest production rate, nest decay rate, and proportion of nest builders) [34].

3. Results

A total of 255 nests were encountered during the study from 35 colonies of chimpanzees. Nest counts per colony ranged from one to 45 nests ($\overline{x} = 15.10 \pm 0.193$). The distribution of nests per square meter, per colony of chimpanzees is shown in Figure 4.

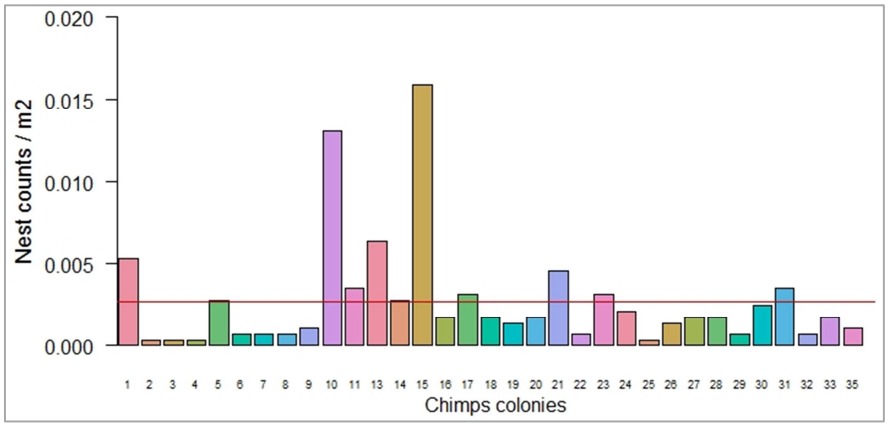

Figure 4. *Nest density (number of nests per m^2) according to colonies of chimpanzees. The red horizontal line represents the mean density.*

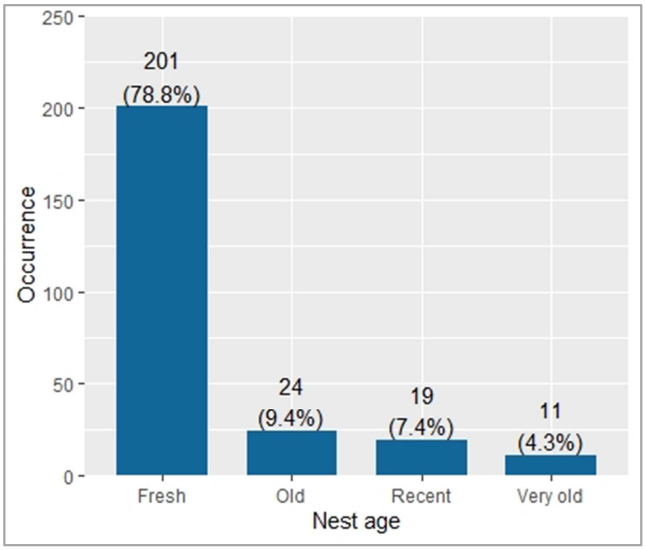

Figure 5. *Nests class frequencies in YCF.*

We marked 201 (78.82%) fresh nests, 24 (9.41%) old nests, 19 (7.45%) recent nests, and 11 (4.31%) very old nests during the study (Figure 4). It was observed that in the YCF, the chimpanzees prefer to build nest in Marantaceae forests (92.16%) and swampy forests (7.84%), contrary to the forest-savannah mosaics, and galleries forest observed in the area. Between these forest types, 24 nesting tree species of chimpanzees were recorded. *Khaya grandifolia* (Meliaceae) (28.24%) was the most used following the *Uapaca guineensis* (Euphorbiaceae) (27.06%).

3.1. Density Estimation

The nests of the first 03 missions (February, March, and April) have deteriorated (absent), and only the nests of the last 02 missions (May and June) were present. For a survival rate of 24.38% of all nests marked and revisited (Table 1). The mean nest decay rate estimated using a logistic

regression analysis was 77.53 days for a choice of the probability of survival of 0.5.

Table 1. *State of nests revisited (5 months after nest marking) in the study area.*

Missions (M)/season	Number of nests marked and revisited	Number of nests absent	Number of nest present	Survival percentage (%)
M1 (dry)	62	62	0	0
M2 (dry)	69	69	0	0
M3 (rainy)	21	21	0	0
M4 (rainy)	22	0	22	100
M5 (rainy)	27	0	27	100
Total	201	201	49	24.38%

Among the 27 transects (54 km) planned, 24 (48 km) were covered, thus arriving at a completion rate of 88.88% in the YCF. Using the Distance Sampling 7.0 statistical software, an average chimpanzee nest density of 69.3 [95% CI 54.9 86.7] nests/km^2 was obtained for YCF, corresponding to the 0.38 [95% CI 0.15-0.94] individuals/km^2, and N 113 [95% CI 45-280] chimpanzees. Figure 6 shows the survival curve of these nests.

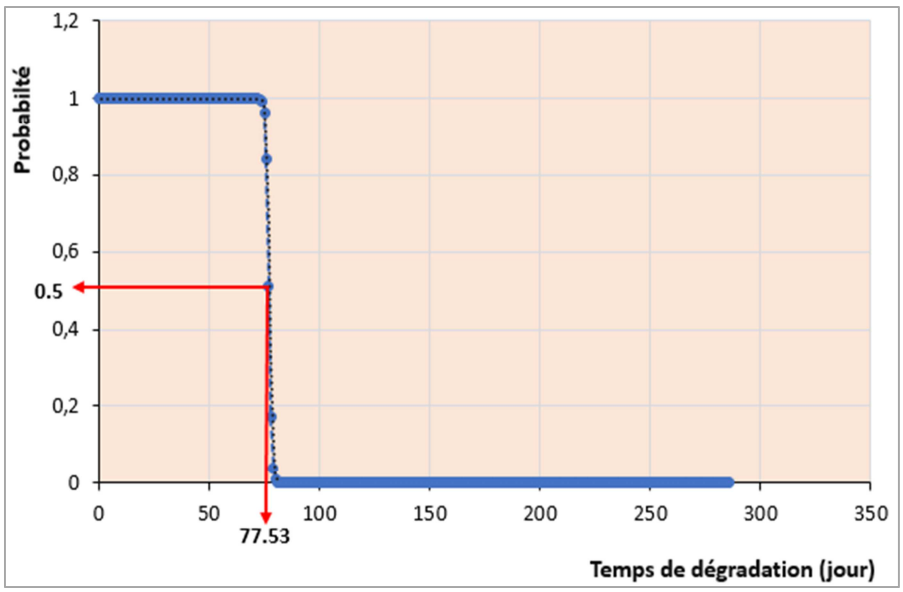

Figure 6. *Determination of the duration of degradation of chimpanzee nests in the FCY.*

3.2. Abundance and Distribution of Human Activities

The distribution of human activities in the study area proves that anthropogenic pressure is present almost everywhere. However, We identified four anthropogenic activities (Figure 7) potentially harmful to chimpanzees in the study area: transhumans (n=171), poaching (n=31), illegal logging (n=20) and Fishing (n=5). Transhumance was the most practised human activity while we collapsed the other activities together ($X^2 = 58.26, \mathrm{df} = 1, \mathrm{P} < 0.001$). We observed a very strong presence of human activities in the south-west part of the YCF. This area is impacted by transhumance activities, hunting and illegal logging. An area with moderately significant human activities located in the north-west and north-east parts. In this area we observed significant transhumance activities, followed by moderated hunting and low fishing activities (Figure 8). Indeed, from November to April in the YCF, there exist significant activities of transhumance occupying a totality of the savannah forest. It is perceptible in the area through the occupation of all savannah spaces by herds of cattle, sheep, Mbororo tracks and burns to facilitate the movement of herds and the renewal of pastures.

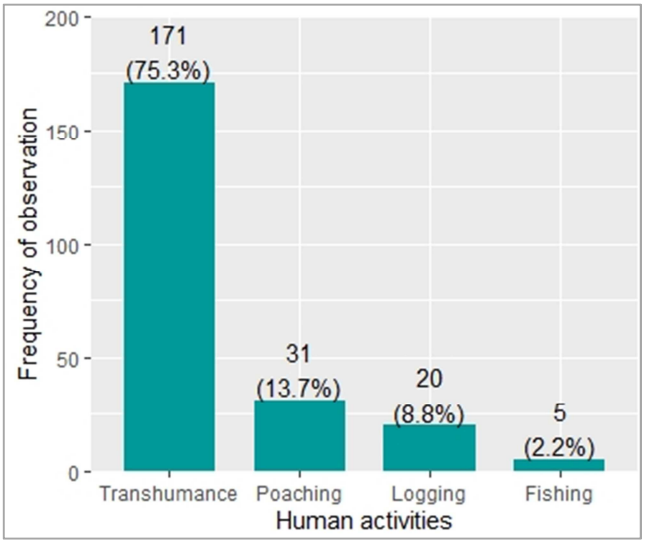

Figure 7. *Frequency of encountering human activities.*

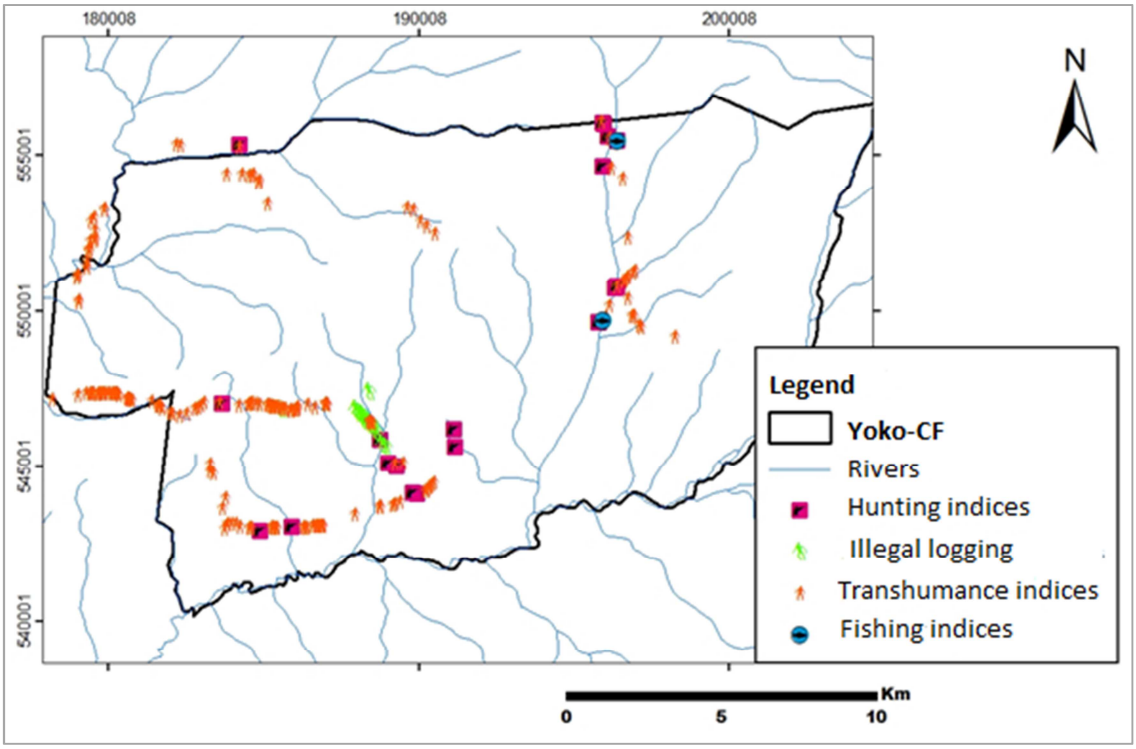

Figure 8. *Distribution of human activities in YCF.*

3.3. Relationship Between Human Activities and the Presence of Chimpanzees

The relationship in Figure 9 reflects the negative influence of human activities on the presence of chimpanzees in the study area. This confirms that the greatest density of nests occurred at a given site are were the least impacted by human activities. In other words, the higher the human activities indices, the lower the density of nests at a given point.

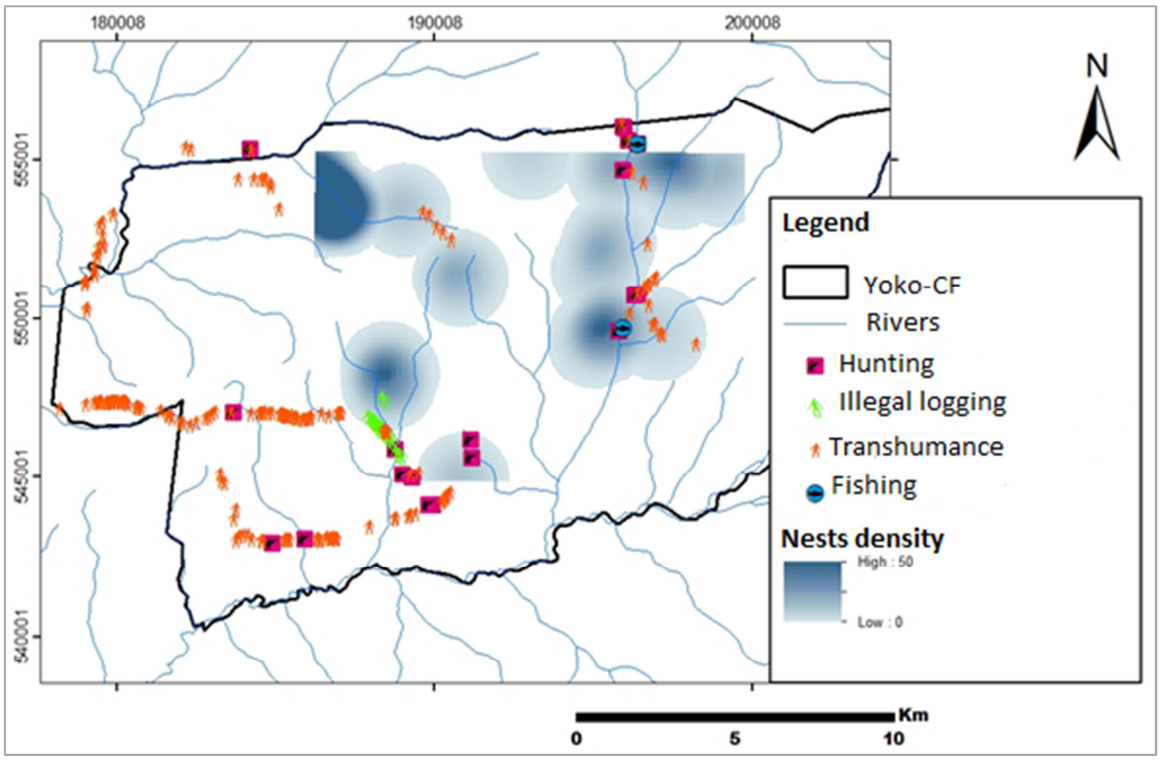

Figure 9. *Negative influence of human activities on the chimpanzees nest density in the study area.*

4. Discussion

Different methodologies were used for population size estimates of primates [8]. The presence, density and abundance of chimpanzees in an area are indirectly used by nest count methods [74], due to the difficulty of observing chimpanzees in the forest [39]. Nest production rates are usually taken for long-term monitoring of these mammals [39, 33] and in this study, we assessed the nest decay rate for chimpanzees and human disturbances to obtain values that permit us to estimate the density, abundance and population status of chimpanzees in the YCF.

Our results show the mean decay rate of 77.53 days which is very small compared to the 127 days estimated in the Mbam‐Djerem National Park by [33], 130 days estimated in Campo Ma'an National Park, south-western Cameroon by [49], and 114 days estimated in Lopé National Park, central Gabon by [75]. However, this decay rate is close to 73.3 days obtained by [46], 88 days by [52] in Ebo Forest, Cameroon, and 90 days at Nouabalé-Ndoki National Park (Republic of Congo) by [51]. Such variations in nest decay rates of chimpanzees are dependent on the specific area. The process of nest decay varies temporally and spatially and is the result of a complex interaction between vegetation type and climatic variations [37]. Thus, [33] showed that rainfall increases the probability of the nest decay rate. These effects of rainfall on dung and nest have long-time been reported in many studies [37, 52, 80]. Moreover, in this study, it was observed that the nests marked during the dry season (February, and March) degraded more slowly than those marked during the rainy season (April, May and June), which strengthens our hypothesis that rainfall intensity plays an important role in nest decay time in the area.

Nest encounter rates were 69.3 [95% CI 54.9 86.7] nests/km^2 in the territories for a total of 201 fresh nests. Chimpanzee density in the area was 0.38 [95% CI 0.15-0.94] individuals/km^2, and N 113 [95% CI 45-280] chimpanzees. Our results are very few compared to the 0.59 [95% CI (0.41–0.86)] with an abundance of 987 [95% CI (683–1427)] obtained in Mbam‐Djerem National Park by [33] for 127 decay days estimated. However, this density is higher than those of 0.22 nest-building chimpanzees/km^2 (95% CI 0.08-0.62), corresponding to 137 (95% CI 51.0-390.0) chimpanzees for Lagoas de Cufada Natural Park, Guinea-Bissau for 293.9 days 'nest decay rate by [15]. This different chimpanzee density estimated in a given area depends on the availability of floristic richness, diversity and composition, tree size and density, and human interference [18, 42, 63, 69]. Further, the abundance of food items in a habitat minimizes the competition for food and increases the chances of survival and colonization of mammals [44]. Nest tree species selection habitat choices have also been reported for other great apes [16, 22, 62]. In the YCF, chimpanzees nest essentially in Marantaceae forest, especially on tree species such as *Khaya grandifolia*, *Uapaca guineensis*, *Berlina grandifera.* These trees species are close to the results of [34] in the Mbam and Djerem National Park (PNMD) which showed that in this protected area, chimpanzees' nest on *Berlina* sp. *Diospyros* sp. and *Uapaca guineensis*, nonetheless are found in gallery forests. In contrast to Lagoas de Cufada Natural Park, Guinea-Bissau where authors identified 23 tree species harboring chimpanzee nests at different proportions, of which *D. guineense, A. africana, D. senegalense, E. guineensis, P. biglobosa* were more preferred. Chimpanzee's selectivity in the choice of nest tree species was also reported in African forest sites [24, 35, 53, 67, 68]. [15] underlying two possible causes of the tree species preference: suitable ecological conditions offered by dense forests such as resource availability, topographical features, or climatic conditions [24, 35, 68]; and certain physical characteristics of trees [25, 59].

In central Africa as everywhere in the world, the major obstacles to the great apes' conservation have been poaching, habitat destruction, infectious diseases and logging [36]. Chimpanzees have a long time been hunted by humans, however in recent years bushmeat trade has greatly intensified the exploitation of great apes and other wildlife [19, 15, 55]. Hunting by humans for bushmeat is one of the primary threats to large-bodied vertebrates in many African forests [4, 38, 60]. Anthropogenic pressures, particularly hunting for the bushmeat trade, and wild sawing are driving wildlife species toward extinction in West and Central African forests [1, 21]. Another threat and not the least has been identified in many African forests, it is pastoral transhumance which results in the regular movement of herds. Transhumance intensifies conflicting relationships between herders, farmers and conservation agents, around issues of access to resources, degradation of wildlife habitats and poaching [5-7]. Indeed, the high transhumance activity observed in the south-west of this forest corroborates with the result of [76] who showed that the impacts of transhumance on the biophysical environment affect several components of the environment, including protected areas, leading to negative socio-economic impacts, threats, pressures and alarming consequences on the preservation of the rich biodiversity in Central Africa. Moreover, the recent intensification of the flow of transhumant people from the Sahel to the south in search of grazing resources has exacerbated the current problematic coexistence between mobile herders and local farmers and raised new concerns for the protected area network in the Congo Basin [31, 43]. It, therefore, seems essential to regulate this phenomenon to guarantee the sustainable management of chimpanzees in this forest.

5. Conclusion

In the present study, we estimated the nest decay rate of 77.3 days, for an estimated abundance of about 113 [95% CI 45-280] chimpanzees in YCF. In the area, chimpanzees are nesting in Marantaceae forests and swampy forests contrary to savannah, mosaics-savannah forests, and

galleries forests. 24 nesting tree species of chimpanzees have been recorded with *Khaya grandifolia* and *Uapaca guineensis* being the most used trees. However, we observed four main threats (transhumance, hunting, illegal logging and fishing) which are affecting this species in the area. These activities influence negatively the presence of chimpanzees in YCF.

Data Availability Statement

Data analysed during this study are included in this published article.

Author Contributions

Didier Bastin, Serge Alexis Kamgang, Ervis Manfothang Dongmo and Iris Kirsten designed the research study. Pop Moadomb Jacques Jefferson and André Mveimané conducted the field study. Serge Alexis Kamgang, Ervis Manfothang Dongmo, Iris Kirsten, Neba Estherbel Bih and Bakwo Fils Eric-Moise analyzed the data and wrote the manuscript. The authors contributed to the article declare no conflicts of interest regarding the publication of this article.

ORCID

Serge Alexis Kamgang: OrcidID: 0000-0001-5422-7794.

Ervis Manfothang Dongmo: OrcidID: 0000-0002-2581-9624.

Iris Kirsten: OrciID: 0000-0001-7884-0649.

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