African Primates 10: 1-12 (2015)

Characterization of Nest Sites of Chimpanzees (*Pan troglodytes schweinfurthii*) in Kibira National Park, Burundi

Dismas Hakizimana[1,2], Alain Hambuckers[1], Fany Brotcorne[1], and Marie-Claude Huynen[1]

[1]*Primatology Research Group, Behavioral Biology Unit, University of Liège, Liège, Belgium*
[2]*Department of Biology, University of Burundi, Burundi*

Abstract: Kibira National Park is the only site in Burundi that harbors a large number of chimpanzees (*Pan troglodytes schweinfurthii*). While information on factors influencing the selection of nest sites by chimpanzees is available for other locations of the species' range, this information is lacking for Kibira National Park. This is mainly due to the political troubles that prevailed in the country from 1993 until 2007, making study there difficult. To better protect this chimpanzee population, it is crucial to survey nest sites to identify the tree species, physical characteristics of the trees and habitat type that chimpanzees preferentially use for nesting. Therefore, in this study, we investigated: 1) the tree species used by chimpanzees for building their nests; 2) nest tree availability in the study area; 3) whether chimpanzee selection of a nest tree is based on physical characteristics such as diameter at breast height, lowest branch height, tree size and crown height; and 4) whether chimpanzees choose their nest sites according to topography and canopy types. We collected data monthly along 16 transects of 3 km each, from September 2011 to February 2013 (18 months). However, data related to the measurements of nests and nest trees were collected for only the last 12 months, from March 2012 to February 2013. We identified tree species used for nesting, and measured physical characteristics of trees used as opposed to surrounding trees unused. The results showed that chimpanzees select certain tree species to build their nests. Among the 32 species of trees bearing nests, chimpanzees used 12 species significantly more frequently than expected and 11 species significantly less frequently than expected. In addition, trees bearing nests were significantly larger and taller than the surrounding trees and had higher lowest branch and bigger canopies.

Key words: chimpanzees, nest sites, nesting behavior, Kibira National Park, *Pan troglodytes schweinfurthii*

Résumé: Le Parc National de la Kibira est le seul site au Burundi qui abrite un grand nombre de chimpanzés (*Pan troglodytes schweinfurthii*). Alors que des informations sur les facteurs influençant le choix des sites de nidification par les chimpanzés sont disponibles dans les autres parties de leur aire de distribution, ces informations manquent pour le Parc National de la Kibira. Ceci s'explique principalement par les troubles politiques qu'a connus le pays depuis 1993 jusqu'en 2007. Afin de mieux protéger cette population de chimpanzés, il est intéressant de mener des études sur les sites de nidification pour identifier les espèces, les caractéristiques physiques des arbres et le type d'habitat que les chimpanzés considèrent de préférence pour la construction des nids. Au cours de cette étude, nous avons cherché à déterminer: 1) les espèces d'arbres les plus utilisées par les chimpanzés pour la construction de leurs nids; 2) la disponibilité de ces espèces d'arbres dans la zone d'étude; 3) si la sélection d'un arbre de nidification est basée sur ses caractéristiques physiques telles que le diamètre à hauteur de poitrine, la hauteur au-dessus du sol de la première branche, la taille de l'arbre et la hauteur de la couronne; 4) si les chimpanzés choisissent leurs sites de nidification en fonction de

Correspondence to: Dismas Kakizimana, Primatology Research Group, Behavioral Biology Unit, University of Liège, Liège, Belgium
E-mail: hakdismas@yahoo.fr.

la topographie et du type de canopée. Nous avons collecté les données mensuelles sur 16 transects de 3 km de long chacun, de septembre 2011 à février 2013 (18 mois). Toutefois, les données relatives aux mesures des nids et des arbres nids sont celles des 12 derniers mois, de mars 2012 à février 2013. Nous avons identifié les espèces d'arbres dans lesquelles les nids étaient construits, et nous avons mesuré les caractéristiques physiques de ces arbres ainsi que celles des arbres environnants non utilisés. Nos résultats montrent que les chimpanzés sélectionnent préférentiellement certaines espèces d'arbres pour la construction de leurs nids. Parmi les 32 espèces d'arbres porteurs de nids, ils ont utilisé 12 espèces significativement plus fréquemment qu'attendu et 11 espèces significativement moins fréquemment qu'attendu. De plus, les arbres porteurs de nids étaient significativement plus gros et plus hauts que les arbres environnants, leur première branche était plus élevée et leur couronne plus grande que celle des arbres environnants.

INTRODUCTION

Nesting behavior has been observed in the four types of nonhuman great apes: chimpanzee (Koops *et al*. 2007; Samson *et al*. 2013), bonobo (Mulavwa *et al.* 2010; Serckx *et al*. 2014), orangutan (Ancrenaz *et al*. 2004; Prasetyo *et al.* 2009) and gorilla (Mehlman & Doran 2002; Matthews & Matthews 2004; Sanz *et al.* 2007). The choice of a nest site, i.e., any place containing one or more nests, is thought to be influenced by several environmental factors, including: predation avoidance strategies that reduce potential detection of the primates, decreased access of predators, improved early detection of danger (Anderson 1998; Kortlandt 1992; Pruetz *et al.* 2008), comfort and hygiene (Goodall 1962; Mackinnon 1974; Anderson 1998; Nunn & Heymann 2005; Stewart *et al*. 2007), habitat types (Baldwin *et al.* 1981; Basabose & Yamagiwa 2002; Furuichi & Hashimoto 2004), and climatic conditions (Kappler 1998; Koops *et al*. 2012).

In general, all weaned great apes build fresh nests every night (Plumptre & Reynolds 1996; Rothman *et al*. 2006), and occasionally during the day (Goodall 1962; Fruth & Hohmann 1994; Plumptre & Reynolds 1997; Stanford & O'Malley 2008), while nest reuse is rare (Goodall 1962; Plumptre & Reynolds 1997; Blom *et al.* 2001). If building nests aims at providing conditions favoring sleep (Stewart 2011), one can hypothesize that fresh foliage provides more warmth and comfort, and that building a new nest every day reduces the risk of predation by lowering the probability of detection by predators (Nissen 1931). Mackinnon (1974) proposed that building a new nest every night could also reduce ectoparasite exposure. Finally, Stewart (2011) and Koops *et al.* (2012) proposed that fresh plants used in nest building may release chemical compounds repelling insects or masking the odor of the ape, thereby lowering the probability of detection by predators.

Studies in Mount Assirik, Senegal (Baldwin *et al.* 1981), in Kahuzi-Biega, DRC (Basabose & Yamagiwa 2002), in Kalinzu, Uganda (Furuichi & Hashimoto 2004), in Ugalla, Tanzania (Hernandez-Aguilar *et al*. 2013), in the Goualougo Triangle, Republic of Congo (Sanz *et al*. 2007), in Bwindi, Uganda (Stanford & O'Malley 2008) and in Seringbara, Nimba Mountains, Republic of Guinea (Koops *et al*. 2012) showed that chimpanzees selected particular tree species for nest construction. Furthermore, other studies specified that nest tree species had particularly strong and elastic branches, with small and abundant leaves (Goodall 1962; Izawa & Itani 1966; Hernandez-Aguilar 2009). The choice of nest sites by chimpanzees is thought to be based on safety concerns (Baldwin 1979; Kortlandt 1992; Hernandez-Aguilar 2009). Others noted that chimpanzees tend to prefer primary forest for nesting, which can relate to their use of ecological resources such as food availability (Tutin & Fernandez 1984; Basabose & Yamagiwa 2002), or to a thermoregulation function such as humidity avoidance (Koops *et al.* 2012).

We conducted a survey on chimpanzee nest sites in Kibira National Park in Burundi. Prior to our study, data on environmental factors influencing nesting behavior of chimpanzees at this site were lacking. The park has been subject to many changes over the past two decades. The rebels who occupied the forest during the armed conflict (1994 – 2007) cut trees and extensively hunted large mammals. This occupation led to a deterioration of the habitat of the remnant chimpanzee population, potentially causing changes in nesting behavior. It is therefore important to provide information on the environment and the characteristics of the trees used by the chimpanzees in Kibira National Park, since it could change in the future with forest recovery.

Understanding which tree species are preferred for nest building and the type of habitat where nest sites are located can help in generating informed conservation plans about particular areas in the park where chimpanzees occur. The first objective of this study was to identify the tree species preferred by chimpanzees for nest building. As data on available tree density in the chimpanzee habitat are necessary to determine if chimpanzees choose nest trees randomly in relation to tree species abundance (Stanford & O'Malley 2008), the second objective was to assess nest tree species availability in the study area. The third objective was to investigate whether nest tree selection is based on physical tree characteristics such as diameter at breast height (DBH), lowest branch height (LBH), total tree height (TH) or crown height (CH). Finally, this study aimed to see if chimpanzees in Kibira National Park showed preference for specific topography and canopy types.

METHODS

Study Site

From 1933 to 1980, the Kibira forest was classified as a Forest Reserve. It was declared a National Park in 1980. Initially, Kibira forest covered an area of about 900 km², but this area is now reduced to 400 km² (FAO 2002). Indeed, in the 1970s, the Burundian government established a tea plantation extension program. As the climate surrounding Kibira National Park is particularly suitable for tea cultivation, hundreds of square kilometers of the forest were destroyed for the program. One portion was reserved for tea plantations, and another reforested with exotic tree species (e.g., eucalyptus and grevillea) to be used as fuel for processing tea plants (Dennison *et al.* 1989). The remaining park area is divided into four sectors, from south to north: Teza, Musigati, Rwegura and Mabayi, covering 57.94 km², 154.24 km², 124.23 km² and 63.59 km², respectively.

Kibira National Park is one of the two remaining tropical highland forests in Burundi. It is located in the northwestern part of Burundi (Figure 1) on the Congo-Nile Divide, between latitude 2°36'52" and 3°17'08" South and between longitude 29°13'31" and 29°39'09" East. The altitude varies between 1,600 and 2,666 m (Arbonier 1996). Kibira National Park's altitude gives it a temperate climate with an average yearly temperature of around 15°C. The temperature in the montane forest is relatively stable throughout the year ranging between 9 and 22°C although in some areas, particularly in the valleys, it may drop below 0°C (Trenchard, unpublished data). Relief, more marked on the western side, is characterized by steep slopes on both sides of the Congo-Nile Divide.

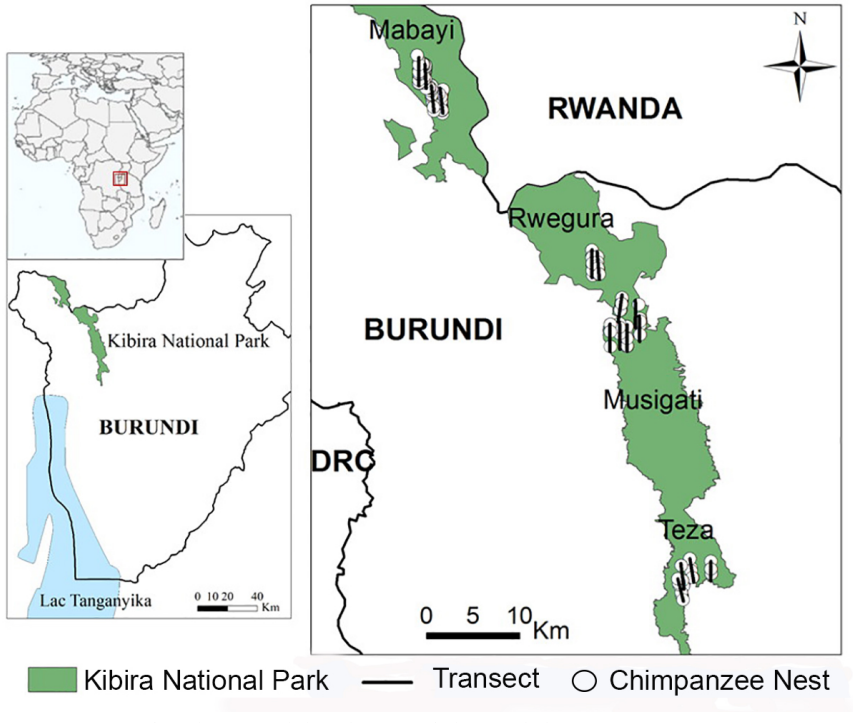

Figure 1. Map of study site and distribution of observed chimpanzee nests.

The forested zone receives the highest rainfall in the country with more than 2,000 mm per year. The rainy season occurs between September and May; November and April receive the heaviest rainfall. The main dry season is from June to August and a short dry season occurs in January and February. The diversity of the Kibira National Park biotopes, its primary forest relics, the richness of its fauna, and its hydrologic regulation role are of considerable importance for the country. The local human population does not yet fully appreciate the importance of the forest in this role, and promoting the awareness of its value should be a major component of any conservation program. Despite protection status, the surrounding human population, living in great deprivation, still uses the forest for firewood and timber collection, clears parcels of the forest for agriculture, poaches and hunts, all of which constitutes a significant threat for the remaining forest and wildlife.

Data Collection and Analysis

We studied nesting patterns of chimpanzees in Kibira National Park for eighteen months, between September 2011 and February 2013. We used 16 transects of 3 km each and running north-south, most having been part of the only previous census study in the area (Barakabuye *et al*. 2007). As the park was divided into 4 sectors (Teza, Musigati, Rwegura and Mabayi) (Figure 1), we chose 4 transects per sector, covering as much as possible all the habitat types present in the 4 sectors surveyed within the park. We travelled each transect 18 times (864 km in total). All nests visible from transects and built since previous visits were recorded and marked in order to avoid counting the same nest twice. We recorded the following variables for the nest trees and the nests using an adaptation of the methods in Hernandez-Aguilar (2006, 2009) and Koops *et al.* (2012):

Nest Trees

1. Tree species
2. Diameter at breast height (DBH): measured with DBH tape measure
3. Total tree height (TH): measured from the ground to the top of the tree with a clinometer
4. Lowest branch height (LBH): measured from the ground to the lowest branch, with a clinometer
5. Crown height (CH): calculated by subtracting the height of the lowest branch from the total height of the tree.

Nests

1. Nest age (Tutin & Fernandez 1984): a) fresh: all leaves still green and fresh; b) recent: leaves changing color; c) old: all leaves dead but nest still intact (Figure 2)
2. Nest height (NH): measured from the ground at the base of the tree to the base of the nest, with a clinometer
3. Nest position within the crown: calculated by dividing the distance between nest and lowest branch by the height of crown: (1) bottom: 0 – 0.33, (2) middle: 0.34 – 0.66, (3) top: 0.67 – 1.0
4. Number of nests per tree: the total number at the end of our study
5. Topography type recorded at a nest site: valley vs. slope vs. hill top
6. Forest type recorded at a nest site: open canopy vs. closed canopy

Figure 2. A fresh chimpanzee nest in Kibira National Park. Photograph by D. Hakizimana.

Nest Tree Selectivity

To assess the availability of nest tree species and preference by the chimpanzees, we conducted regular vegetation surveys in nest sites and along the 16 transects. We considered nests as being part of the same nest group when the maximum distance between two nests of the same age did not exceed 20 m (Tutin & Fernandez 1984). We set up vegetation plots of 20 m radius around a nest or group of nests (N = 118 nest sites or nest plots: NP), with the nest as the middle point if isolated, and with the central nest as the middle point in cases of groups of nests. We also established control plots (CP; N = 256) of 20 m radius at 200 m intervals along the 16 transects which had no nests. Within all vegetation plots (NP and CP), we sampled all trees of DBH ≥ 10 cm, assumed to be strong enough to support chimpanzees' weight.

To analyze preference for tree species, we compared the frequencies of species bearing nests in NP with the frequencies of the same tree species in the CP using the chi-squared test of independence and the analysis of standardized residuals (SR) for

post-hoc comparisons (Sheskin 2004). When the absolute value of SR is larger than 1.96, the observed frequency of the species is significantly different from the expected value at a probability level of 0.05. To analyze preferences of physical characteristics of the nest trees, we compared TH, DBH, LBH and CH of nest trees, with the mean values of the surrounding trees without nests present in the same NP. Since the assumption of normality, tested with a Kolmogorov-Smirnov test, was rejected for all the variables, we used the Wilcoxon rank test for paired samples for the mean comparisons (Sokal & Rohlf 1995).

Finally, to test site selection for nesting, we compared the class frequencies of plot characteristics between nest plots (2519 trees) and control plots (6504 trees) using the chi-squared test of independence and the analysis of standardized residuals for post-hoc comparisons. We tested the effects of tree size (DBH classes in cm: 0 – 5; > 5 – 10, > 10 – 15, > 15 – 20, > 20 – 25, > 25 – 30, > 30), local topography (hilltop vs. valley vs. slope) and canopy type (open vs. closed).

RESULTS

We recorded a total of 471 nests of chimpanzees at 118 nest sites throughout the study period. These nests were recorded in 365 trees belonging to 36 species, including four tree species (*Grewia mildbraedii, Alchornea hirtella, Trema orientalis* and *Croton megalocarpus*) not recorded in the control plots. These four tree species accounted for 8.9% (42/471) of all nests. Nest trees harbored a single nest in 73.6% (N = 347) of the cases, two nests in 23.4% (N = 110) and three or more nests in 3% (N = 14) of the cases.

Nest Tree Species Preference

Chimpanzees used 32 of the 70 tree species recorded in the control plots for nesting. Selection of species as nest trees was statistically significant (χ^2 = 1518.60, P < .0001, Figure 3). Chimpanzees used 12 tree species significantly more frequently than expected: *Parinari excelsa, Carapa grandiflora, Strombosia scheffleri, Ekebergia capensis, Beilschmiedia rwandensis, Aningeria adolfi-friderici,*

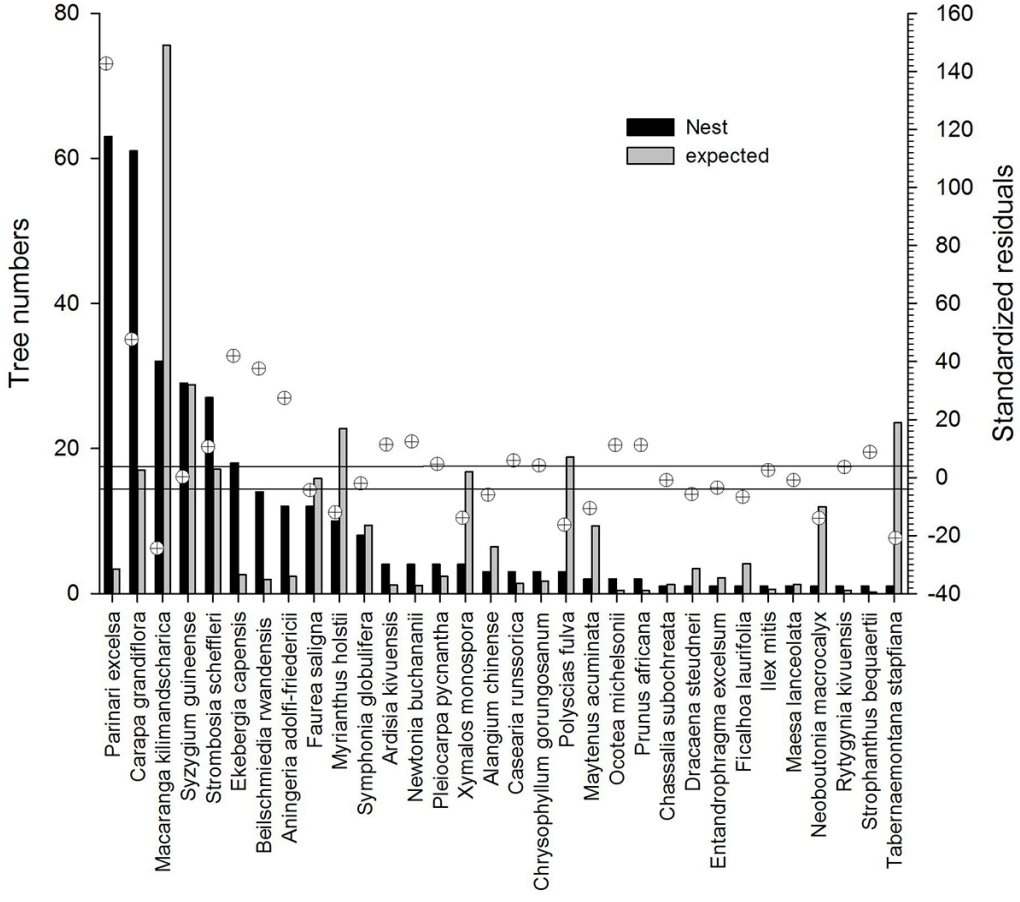

Figure 3. Preferred and less preferred nest tree species – observed and expected frequencies and post-hoc tests. Crossed circles give the standardized residuals: when they fall outside the space delimited by the horizontal lines, the difference are significant at the 0.05 level; if they are over the lines, the species are preferred, below, they are less preferred.

Ardisia kivuensis, Newtonia buchananii, Casearia runssorica, Ocotea michelsonii, Prunus africana and *Strophanthus bequaertii*. In contrast, 11 tree species, *Macaranga kilimandscharica, Faurea saligna, Myrianthus holstii, Xymalos monospora, Alangium chinense, Polyscias fulva, Maytenus acuminata, Dracaena steudneri, Ficalhoa laurifolia, Neoboutonia macrocalyx* and *Tabernaemontana stapfiana*, were used significantly less frequently than expected.

Physical Characteristics of Nest Trees and Nests Position

The measurements presented here represent 341 nests recorded during the last 12 months of the study, from March 2012 to February 2013. For nest trees with more than one nest, we measured only the lowest one, to save time on the task.

The mean height of the 341 nests measured was 12.11 m ± SD 5.8 m (range: 3 – 33.2). However, the fact that we measured only the lowest nest for nest trees bearing more than one nest may have led to an underestimated nest height. Chimpanzees built most of their nests (75.4%) between 5 m and 15 m above the ground, 19% of the nests between 15 and 25 m, 9.4% at a height ≥ 25 m, and only 0.9% of nests at a height less than 5 m (Figure 4). In this study, we did not find any nests on the ground.

Regarding the position of nests inside the tree crown, most nests (71.6%) were located in the middle third of the crown, 22.3% in the lower third, and 6.2% at the top third. We noted that nests at the top were built in small trees. The height of nests was significantly correlated with tree height (r = 0.9648, df = 339, p = .00001) (Figure 5). In addition to their preference for certain tree species, chimpanzees also selected trees of specific size. Trees bearing nests were significantly larger and taller than the surrounding trees and they had the highest lowest branches and the largest canopies (Table 1).

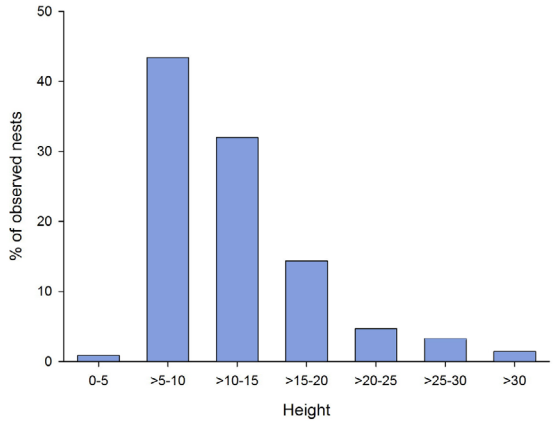

Figure 4. Nest height classes in Kibira National Park.

Nest Site Selection

Considering the DBH of all trees sampled along transects and trees used for nest construction, chimpanzees built nests in trees with mean DBH between 30 and 50 cm more frequently than expected based on availability (χ^2 = 114.99, df = 13, P < .0001; Figure 6). Chimpanzees preferred sites with a closed canopy (56.1% of nests) to an open canopy (43.9% of nests) to build their nests (χ^2 = 60.29, df = 1, P < .0001; SR = 14.75 for close canopy and SR = -11.67 for open canopy). The frequencies of nests located on slopes (77.3% of nests), hilltops (16.1% of nests) and valleys (6.6% of nests) were significantly different (χ^2 = 61.35, df = 2, P < .0001; SR = 20.48 for slopes, SR = -12.55 for hilltops and SR = -6.16 for valleys).

DISCUSSION

In Kibira National Park, chimpanzees were selective in their choice of nest trees. This is well

Table 1. Means (± SD) of physical characteristics of nest trees (N = 341) with the mean values of the surrounding trees (N = 2,519): diameter at breast height (DBH), tree height (TH), lowest branch height (LBH), crow height (CH) and results of the Wilcoxon rank test for paired comparisons: W, sample sizes (N) and P values.

Variables	Nest Trees	Surrounding Trees	W	N	P Value
DBH (cm)	36.3 ± 16.2	30.9 ± 8	3.12	118	.0018
TH (m)	17 ± 5	14.6 ± 3.7	4.87.	118	< .0001
LBH (m)	7.8 ± 3.1	6.6 ± 1.9	3.61	118	.0003
CH (m)	9.2 ± 2.3	8 ± 2.1	4.64	118	< .0001

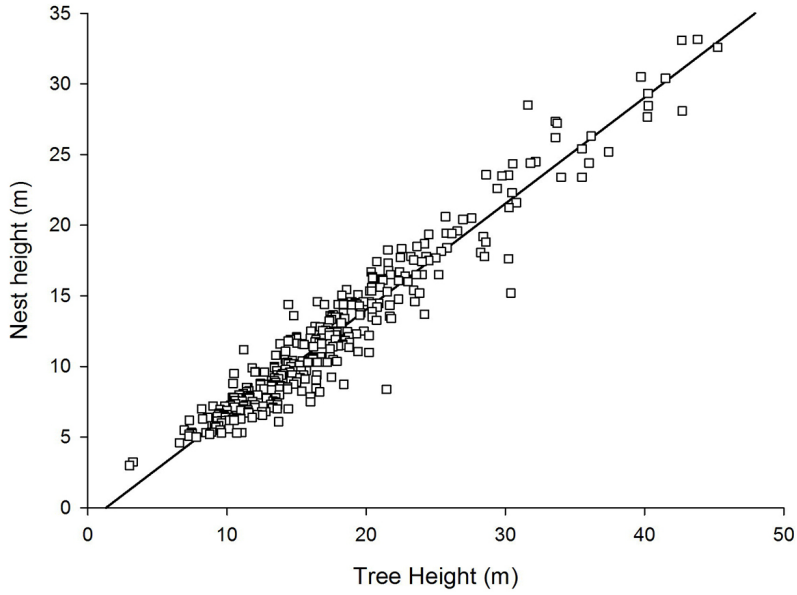

Figure 5. Relationship between nest height and tree height (r = 0.9648, df = 339, p = .00001).

illustrated by data from *Parinari excelsa*, a tree species which occurred at a relatively low density (2 trees/ha), but bore 15.5% of all nests. On the other hand, Macaranga kilimandscharica, the most abundant in Kibira National Park (42 trees/ha), supported only 9.6% of all nests. In agreement with previous studies (e.g., Hashimoto, 1995; Brownlow *et al.*, 2001; Koops *et al.*, 2012; Hernandez-Aguilar *et al.*, 2013), these results indicate that chimpanzees do not randomly use tree species to build their nest. However, the importance of factors influencing the choice of nest tree species may vary according to the study site. At Kahuzi-Biega National Park (Democratic Republic of Congo), Basabose & Yamagiwa (2002) reported that chimpanzees tend to build nests in fruiting trees that they used as food sources. Similarly, Fruth & Hohmann (1996) found that bonobos at Lomako (DRC) built nests close to fruiting trees. In Bwindi Impenetrable National Park (Uganda), the choice of nest tree species did not appear to strictly depend on their value as a food resource (Stanford & O'Malley, 2008). The authors suggested that *Cassipourea* sp. and *Drypetes gerrardii*, two out of the four tree species preferred for nest building, may have been chosen because of their density. In Budongo Forest (Uganda), chimpanzees preferred to nest in trees with small and dense foliage (Brownlow *et al.* 2001). Koops *et al.* (2012) showed that choice for specific tree species could not be explained solely based on physical properties. Finally, Furuichi & Hashimoto (2004) and Stanford & O'Malley (2008) reported that combined factors such as fruit abundance, size and physical characteristics of the tree, and tree species, all influenced the pattern of nest tree selection in variable proportions.

Our results showed that chimpanzees in Kibira National Park preferred to nest in trees with physical characteristics that can potentially make access difficult to predators able to climb. Nest trees had a significantly greater DBH and height, higher lowest branch height, and higher crown height than the surrounding trees not used for nesting. These findings are in accordance with those reported by Hernandez-Aguilar *et al.* (2013) for Ugalla, who argued that such preferences supported the hypothesis that elevated height of a sleeping place is a predator avoidance strategy.

Regarding the position of the nest within the crown, Hernandez-Aguilar (2006) noted that, in Ugalla, 17.8% of the nests were made at the top of the crown, 45.4% in the middle and 36.8% at the bottom. Data from Seringbara, Nimba Mountains, Republic of Guinea, showed similar results: most of the nests (50%) were built in the middle third of the crown, 27% at the bottom and 23% at the top (Koops *et al.*, 2012). Our findings in the Kibira National Park are in agreement with these, most nests being made mainly in the middle segment of the crown. The few nests atop the crown were built on trees smaller than the surrounding trees; this was also found by Goodall (1962) at Gombe National Park in Tanzania. Ultimately, as the height of the nests was highly correlated with the height of the nest trees, we can conclude that the choice of a place in the tree

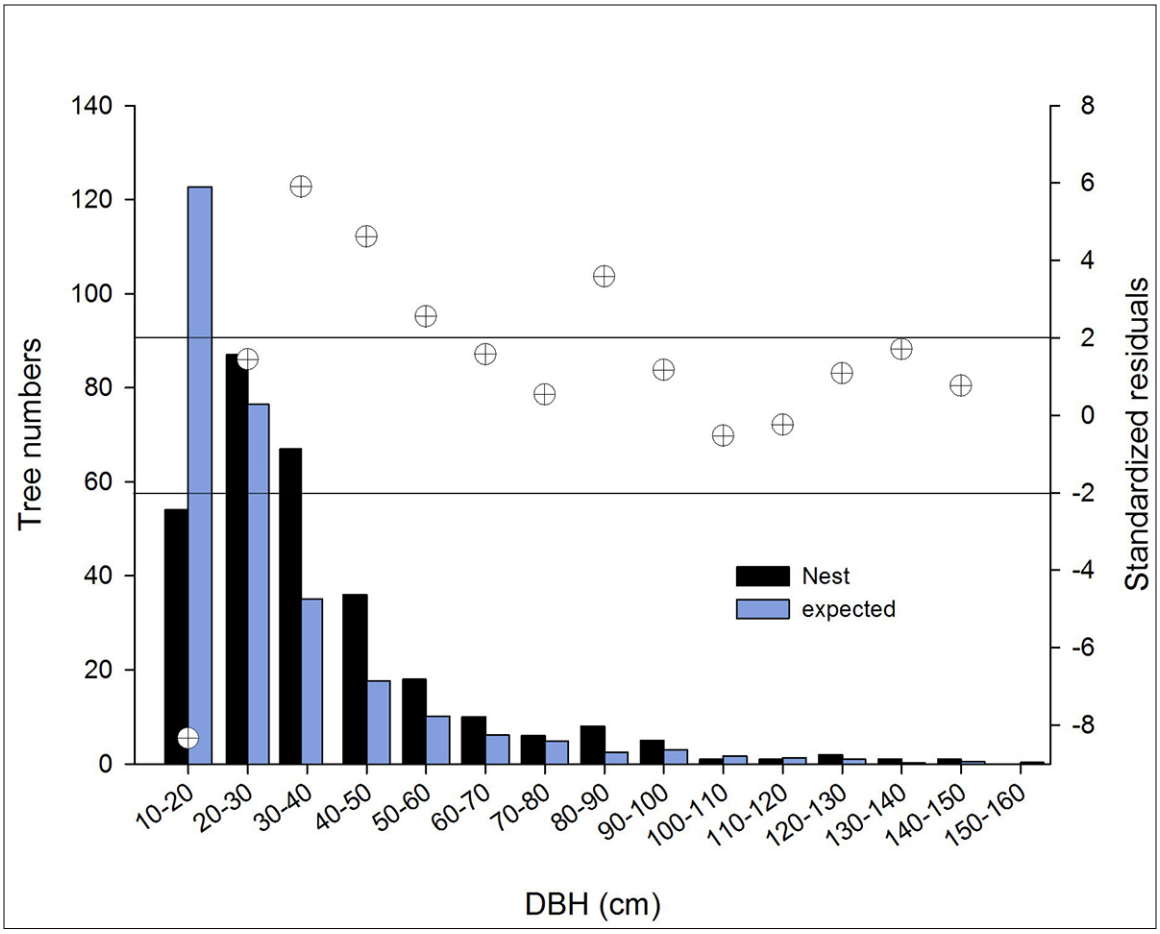

Figure 6. Preferred and less preferred classes of DBH in nest sites – observed and expected frequencies and post-hoc tests (crossed circles give the standardized residuals: when they fall outside the space delimited by the horizontal lines, the differences are significant at the 0.05 level; if they are over the lines, the classes are preferred, below, the classes are less preferred)

crown to build a nest is a compromise between the constraints of the habitat (high trees are not always available) and the necessity to make the access to the nest as difficult as possible for predators.

Chimpanzee nesting habits in the montane forest of Kibira National Park are similar to those observed in other sites, particularly in Ugalla (Hernandez-Aguilar *et al.* 2013). Data on both trees and nests are presented for comparison in Table 2.

Pruetz *et al.* (2008) suggested that if arboreal nesting by great apes evolved primarily to avoid predation, release from predation pressure should result in more frequent terrestrial nesting. In Kibira, we did not see any evidence of potential predators, except humans, during the 18 months of the study, yet all the nests we found were above the ground. Trenchard (unpublished data) indicated that leopards, the main predator of chimpanzees, had already disappeared from Kibira National Park. However, the disappearance of potential nonhuman predators might be too recent in Kibira National Park to have triggered a change in the nesting behavior, or the continued presence of a human threat might explain the subsistence of exclusive arboreal nesting. This behavior could also be related to the last armed conflict in this region, which subjected large mammals to heavy hunting pressure and ended in 2007. This assumption is supported by observations reported by Hicks (2010) on chimpanzees of Democratic Republic of Congo, where nest height increases with increasing human pressure.

Previous studies (Baldwin 1979; Furuichi & Hashimoto 2004; Hernandez-Aguilar 2009) showed that nests most often occurred on slopes. The results from our study are congruent with these earlier reports. Several factors that might explain the selection of slopes for nest building by chimpanzees have been proposed. Nishida (1989) argued that chimpanzees may prefer hilly terrain in Ugalla because of the abundance of *Brachystegia bussei,* a

Table 2. Physical characteristics of nests and nest trees of chimpanzees in different study sites.

Study Site	Nest Height (m)				Tree Height (m)				DBH of Tree (cm)				
	Mean	Median	SD	Range	Mean	Median	SD	Range	Mean	Median	SD	Range	Reference
Assirik[2]	11.3		5.16	2 - 40	14.22		5.46	2 - 40				41 - 60	Baldwin 1979
Sapo[1]		12				18				52			Anerson *et al.* 1983
Lope[1]	11.7	10		2 - 45					34.6	25		5 - 400	Wrogemann 1992
Petit Loango[1]	12.5												Furuichi *et al.* 1997
Budongo[1]	12.1												Brownlow *et al.* 2001
Kahuzi-biega[1]	9.8		3.2		12.6		4.3		35.3		21.9		Basabose & Yamagiwa 2002
Ugalla[2]	13.4		5.1	3 - 30	19.8		5.5	5 - 35	39.6		19.3	4.5 - 121.3	Ogawa *et al.* 2007
Goualougo Triangle[1]	17.3		7.4										Sanz *et al.* 2007
Fongoli[2]	8.33		4.13		11.15		4.42						Pruetz *et al.* 2008
Bwindi[1]	16.06	15	6.2										Stanford & O'Malley 2008
Seringbara[1]	11.3	10.5	6.3		16.3	15	7.3		24.5	18.9	19.5		Koops 2011; Koops *et al.* 2012
Issa[2]	12.15	11.93	4.19	1.17 - 33.02	17.69	17.39	5.66	3.14 - 43.76	35.6	33.4	15.8	8.3 - 147.4	Hernandez-Aguilar *et al.* 2013
Kibira[1]	12.11	10.6	5.8	3 - 33.2	17	16	5	3 - 45.24	36.3	31	16.2	9.5 - 200	This study

[1] Rainforest; [2] Savanna

tree species preferred for nesting, which happens to grow in hilly areas. However, Baldwin (1979) reported that nests were more frequently built on slopes both in woodland and in gallery forest despite the difference in vegetation composition, arguing that trees of these locations had similar characteristics. Hernandez-Aguilar (2009) proposed that an important factor leading chimpanzees to build nests on slopes may be a lower density of predators in these locations. In our study, we suggest that chimpanzees choose slopes for safety reasons, especially to keep a good view over wide areas and monitor for danger (e.g., Kortlandt 1992; Furuichi & Hashimoto 2004). Even though we could not find any sign of chimpanzee predator presence, human 'predation' (poaching activity) still occurs in the park.

Most nest trees (73.6%) in our study area carried only one nest (median = 1). This result is similar to findings by Hernandez-Aguilar (2006), who reported that the majority of trees (69.5%) had a single chimpanzee nest in Ugalla, western Tanzania, and by Baldwin *et al*. (1981) in Rio Muni, in Equatorial Guinea. Baldwin *et al*. (1981), however, obtained a median of 2 nests per tree in Assirik (Senegal). They explained this difference by the lower availability of suitable nest trees in Assirik, a drier site, in comparison with Rio Muni, in Equatorial Guinea. As the Kibira National Park is a rainforest, the density of suitable trees for nesting is high, which could explain the fact that most of the trees bore a single nest.

CONCLUSIONS

As in other sites surveyed, chimpanzees in Kibira National Park select particular tree species for nest building. Therefore, attention must be given to the conservation of the twelve preferred tree species (*Parinari excelsa, Carapa grandiflora, Strombosia scheffleri, Ekebergia capensis, Beilschmiedia rwandensis, Aningeria adolfi-friderici, Ardisia kivuensis, Newtonia buchananii, Casearia runssorica, Ocotea michelsonii, Prunus africana* and *Strophanthus bequaertii*) in any management plan of the Kibira National Park, because of the likely impact that changes in tree density may have for the long-term conservation of chimpanzees. This is illustrated by *Parinari excelsa*, a tree species selected for nesting by chimpanzees that occurred at a low density in the park, but is also overexploited for building materials, firewood and charcoal production.

As the first survey on chimpanzee nest sites in Kibira National Park, we report only preliminary information regarding the factors influencing nest tree selectivity. This study provides initial results on nest tree choice by chimpanzees, but further research needs to be done, for instance focusing on phenological studies and fruit availability, on feeding ecology and tree species consumed by chimpanzees, or on chemical characteristics of trees used for nest building. These and other characteristics, such as quality and quantity of leaves and elasticity of the branches, need to be assessed to better understand the factors influencing nest building by chimpanzees at Kibira National Park.

ACKNOWLEDGEMENTS

This work was supported by the Burundian Government, the University of Liège, the International Foundation for Science (IFS) and the Ecole Régionale Post-universitaire d'Aménagement et de Gestion Intégrée des Forêts Tropicales (ERAIFT) via WBI program. We are grateful to the following: E. Muhitira, E. Gabo, M. Niyonkuru, M. Ndikuriyo and W. Bindariye, guards of Kibira National Park, for their help in data collection. Finally, we would like to thank the anonymous reviewers and the Editor for their very constructive and helpful comments on earlier versions of this manuscript.

LITERATURE CITED

Ancrenaz, M., R. Calaque & I. Lackman-Ancrenaz. 2004. Orangutan nesting behavior in disturbed forest of Sabah, Malaysia: implications for nest census. *International Journal of Primatology* 2: 983-1000.

Anderson, J.R., E.A. Williamson & J. Carter. 1983. Chimpanzees of Sapo Forest, Liberia: density, nests, tools and meat-eating. *Primates* 24: 594-601.

Anderson, J.R. 1998. Sleep, sleeping sites, and sleep-related activities: awakening to their significance. *American Journal of Primatology* 46: 63-75

Arbonier, M. 1996. Parc National de la KIBIRA, Plan de Gestion. Unpublished report to INECN, Burundi.

Baldwin, P.J. 1979. The Natural History of the Chimpanzee (*Pan troglodytes verus*), at Mt.

Assirik, Senegal. Ph.D. thesis, University of Stirling, Scotland.

Baldwin, P.J., J. Sabater-Pi, W.C. McGrew & C.E.G. Tutin. 1981. Comparisons of nests made by different populations of chimpanzees (*Pan troglodytes*). *Primates* 22: 474- 486.

Barakabuye N., F. Mulindahabi, A.J. Plumptre, B. Kaplin, I. Munanura, D. Ndagijimana & O. Ndayiziga. 2007. Conservation of Chimpanzees in the Congo Nile Divide forests of Rwanda and Burundi: Unpublished Report. No 98210-G-GO95/GA 0282. Arlington VA: US Fish and Wildlife Service (USFWS).

Basabose, A.K. & J. Yamagiwa. 2002. Factors affecting nesting site choice in chimpanzees at Tshibati, Kahuzi-Biega National Park: influence of sympatric gorillas. *International Journal of Primatology* 23: 263-282.

Blom, A., A. Almaši, I.M.A. Heitkönig, J.B. Kpanou & H.H.T. Prins. 2001. A survey of the apes the Dzanga-Ndoki National Park, Central African Republic: a comparison between the census and survey methods of estimating the gorilla (*Gorilla gorilla gorilla*) and chimpanzee (*Pan troglodytes*) nest group density. *African Journal of Ecology* 39: 98-105.

Brownlow, A.R., A.J. Plumptre, V. Reynolds & R. Ward. 2001. Sources of variation in the nesting behavior of chimpanzees (*Pan troglodytes schweinfurthii*) in the Budongo Forest, Uganda. *American Journal of Primatology* 5: 49-55.

Dennison G., G. Murray & G. Booth. 1989. Burundi: biological diversity and tropical forest assessment. *World Directory of Country Environmental Studies,* 35 p.

FAO. 2002. Etude de cas d'aménagement forestier exemplaire en Afrique centrale: le parc national de la Kibira, Burundi. Par Cyriaque Nzojibwami, Octobre 2002. Document de travail FM/9F. Service de la mise en valeur des ressources forestières, Division des ressources forestières. FAO, Rome.

Fruth, B. & G. Hohmann. 1994. Comparative analyses of nest-building behavior in bonobos and chimpanzees. In *Chimpanzee Cultures*. R.W. Wrangham, W.C. McGrew, F.B.M. de Waal & P.G. Heltne, eds. Cambridge, Harvard University. Pp. 109–128.

Fruth, B. & G. Hohmann. 1996. Nest building behavior in the great apes: the great leap forward? In *Great Apes Societies*. W.C. McGrew, L. Marchant, T. Nishida, eds. Cambridge: Cambridge University Press. Pp. 225–240.

Furuichi, T., H. Inagaki & S. Angoue-Ovono. 1997. Population density of chimpanzees and gorillas in the Petit Loango Reserve, Gabon: employing a new method to distinguish between nests of the two species. *International Journal of Primatology* 18: 1029-1046.

Furuichi, T. & C. Hashimoto. 2004. Botanical and topographical factors influencing nesting-site selection by chimpanzees in Kalinzu Forest, Uganda. *International Journal of Primatology* 25: 755-765.

Goodall, J. 1962. Nest building behavior in the free ranging chimpanzee. *Annals of the New York Academy of Sciences* 102: 455-467.

Hashimoto, C. 1995. Population census of the chimpanzees in the Kalinzu Forest, Uganda: comparison between methods with nest counts. *Primates* 36: 477–488.

Hernandez-Aguilar, R.A. 2006. Ecological and nesting patterns of chimpanzees (*Pan troglodytes*) in Issa, Ugalla, Western Tanzania. PhD thesis, University of Southern California, USA.

Hernandez-Aguilar, R.A. 2009. Chimpanzee nest distribution and site reuse in a dry habitat: implications for early hominin ranging. *Journal of Human Evolution* 57:350-364.

Hernandez-Aguilar, R.A., J. Moore & C.B. Stanford. 2013. Chimpanzee nesting patterns in savanna habitat: environmental influences and preferences. *American Journal of Primatology* 75: 979-994.

Hicks, T.C. 2010. A chimpanzee mega-culture? Exploring behavioral continuity in *Pan troglodytes schweinfurthii* across northern DR Congo. Ph.D. thesis, Institute for Biodiversity and Ecosystem Dynamics.

Izawa, K. & J. Itani. 1966. Chimpanzees in Kasakati Basin, Tanganyka: ecological study in the rainy season 1963-1964. *Kyoto University African Studies* 1: 73-156.

Kappler, P.M. 1998. Nests, tree holes, and the evolution of primate life histories. *American Journal of Primatology* 46: 7-33.

Koops, K., T. Humle, E.H. Sterck & T. Matsuzawa. 2007. Ground-nesting by the chimpanzees of the Nimba Mountains, Guinea: environmentally or socially determined? *American Journal of Primatology* 69: 407-419.

Koops, K. 2011. Elementary Technology of Foraging and Shelter in the Chimpanzees (*Pan troglodytes verus*) of the Nimba Mountains, Guinea. Ph.D. thesis, University of Cambridge, UK.

Koops, K., W.C. McGrew, H. de Vries & T. Matsuzawa. 2012. Nest-building by chimpanzees (*Pan troglodytes verus*) at Seringbara, Nimba

Mountains: antipredation, thermoregulation, and antivector hypotheses. *International Journal of Primatology* 33: 356-380.

Kortlandt, A. 1992. On chimpanzee dormitories and early hominid home sites. *Current Anthropology* 33: 399-401.

Mackinnon, J. 1974. The behaviour and ecology of wild orangutans (Pongo pygmaeus). Animal Behaviour 22: 3-74.

Matthews, A. & A. Matthews. 2004. Survey of gorillas (*Gorilla gorilla gorilla*) and chimpanzees (*Pan troglodytes troglodytes*) in Southwestern Cameroon. *Primates* 45: 15-24.

Mehlman, P.T. & D.M. Doran. 2002. Influencing western gorilla nest construction at Mondika Research Center. *International Journal of Primatology* 23: 1257-1285.

Mulavwa, M.N., K. Yangozene, M. Yamba-Yamba, B. Motema-Salo, N.N. Mwanza & T. Furuichi. 2010. Nest groups of wild bonobos at Wamba: selection of vegetation and tree species and relationships between nest group size and party size. *American Journal of Primatology* 72: 575-586.

Nishida, T. 1989. A note on the chimpanzee ecology of the Ugalla area, Tanzania. *Primates* 30: 129–138.

Nissen, W.H. 1931. A field study of the chimpanzee. Observations of chimpanzee behavior and environment in western French Guinea. *Comparative Psychology Monographs* 8: 1-122.

Nunn, C.L. & E.W. Heymann. 2005. Malaria infection and host behavior: a comparative study of Neotropical primates. *Behavioral Ecology and Sociobiology* 59: 30-37.

Ogawa, H., J. Moore, L. Pintea & A. Hernandez-Aguilar. 2007. Sleeping parties and nest distribution of chimpanzees in the savanna woodland, Ugalla, Tanzania. *International Journal of Primatology* 28: 1397-1412.

Plumptre, A.J. & V. Reynolds. 1996. Censusing chimpanzees in the Budongo forest, Uganda. *International Journal of Primatology* 17: 85-99.

Plumptre, A.J. & V. Reynolds.1997. Nesting behavior of chimpanzees: implications for censuses. *International Journal of Primatology* 18: 475-485.

Prasetyo, D., M. Ancrenaz, H.C. Morrogh-Bernard, S.S. Utami Atmoko, S.A. Wich & C.P. van Schaik. 2009. Nest building in orangutans. In *Orangutans: Geographic Variation in Behavioral Ecology*. S.A. Wich, S.S. Utami Atmoko, T. Mitra Setia & C.P. van Schaik, eds. Oxford University Press, Oxford. Pp. 269-277.

Pruetz, J.D., S.J. Fulton, L.F. Marchant, W.C. McGrew, M. Schiel & M. Waller. 2008. Arboreal nesting as anti-predator adaptation by savanna chimpanzees (*Pan troglodytes verus*) in southeastern Senegal. *American Journal of Primatology* 70: 393-401.

Rothman, J.M., A.N. Pell, E.S. Dierenfeld & C.M. McCann. 2006. Plant choice in the construction of night nests by gorillas in the Bwindi Impenetrable National Park, Uganda. *American Journal of Primatology* 68: 361-368.

Samson, D.R., M.P. Muehlenbein & K.D. Hunt. 2013. Do chimpanzees (*Pan troglodytes schweinfurthii*) exhibit sleep related behaviors that minimize exposure to parasitic arthropods? A preliminary report on the possible anti-vector function of chimpanzee sleeping platforms. *Primates* 54: 73-80.

Sanz, C., D. Morgan, S. Strindberg & J.R. Onononga. 2007. Distinguishing between the nests of sympatric chimpanzees and gorillas. *Journal of Applied Ecology* 44: 263-272.

Serckx A., M.C. Huynen, J.F. Bastin, A. Hambuckers, R.C. Beudels-Jamar, M. Vimond, E. Raynaud & H.S. Kühl. 2014. Nest grouping patterns of bonobos (*Pan paniscus*) in relation to fruit availability in a forest-savannah mosaic. *PloS One* 9: e93742.

Sheskin, D.J. 2004. *Handbook of Parametric and Nonparametric Statistical Procedures (3rd Edition)*. Chapman & Hall/CRC, 1195 p.

Sokal, R.R. & F.J. Rohlf. 1995. *Biometry*. WH Freeman, New York. 887 p.

Stanford, C.B. & R.C. O'Malley. 2008. Sleeping tree choice by Bwindi chimpanzees. *American Journal of Primatology* 70: 642-649.

Stewart, F.A., J.D. Pruetz & M.H. Hansell. 2007. Do chimpanzees build comfortable nests? *American Journal of Primatology* 69: 930-939.

Stewart, F.A. 2011. Brief communication: why sleep in a nest? Empirical testing of the function of simple shelters made by wild chimpanzees. *American Journal of Physical Anthropology* 146: 313-318.

Tutin, C.E.G. & M. Fernandez. 1984. Nationwide census of gorilla (*Gorilla g. gorilla*) and chimpanzee (*Pan t. troglodytes*) populations in Gabon. *American Journal of Primatology* 6: 313–336.

Wrogemann, D. 1992. Wild chimpanzees in Lope, Gabon: Census -method and habitat use. Ph.D. thesis, Bremen University.

Received: 3 April 2014
Accepted: 14 July 2015