

Nest-Building Behaviour by Chimpanzees (*Pan troglodytes verus*) in the Non-Protected Area of Diaguiri (Kedougou, Senegal): Implications for Conservation

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Keywords

Conservation · Diaguiri · Nesting behaviour · Nest decay rate · *Pan troglodytes verus* · Savanna chimpanzee

Abstract

Diaguiri is a non-protected area situated in south-eastern Senegal. Chimpanzees (*Pan troglodytes verus*) have been living here since 1999 but information on the characteristics of their nest sites have been lacking until now. Furthermore, we implemented nest survey methods recently standardised to arid landscapes during a national chimpanzee survey. Variations in nest decay rates are poorly understood in savanna-woodland mosaic habitats. This study aims to describe in Diaguiri: (1) the distribution of chimpanzee nests and the location of their core sleeping area, (2) the tree species used for nest building, (3) the association between nests and nesting tree heights, and (4) differences in nest decay rates between habitats. We surveyed 43 km of chimpanzee nesting habitats and recorded 871 nests in gallery forest and woodland habitats between March 2015 and June 2016. Diaguiri chimpanzees used at least 17 tree species for nest building, and 58.8% of nests were in only 3 tree species: *Pterocarpus erinaceus*, *Anogeissus leiocarpus* and *Diospyros mespiliformis*. Nest decay rate was faster in gallery forests than in woodlands. These data are of great value for understanding habitat use by a Critically Endangered subspecies of savanna chimpanzee, for population density estimates of the species and for conservation programmes in this region and in savanna biomes.

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Introduction

Chimpanzees (*Pan troglodytes*) are listed as an Endangered species under the International Union for Conservation of Nature (IUCN) Global Species Programme [Oates et al., 2008]. The West African chimpanzee (*P. t. verus*) is one of the most threatened subspecies [Kormos and Boesch, 2003]; it was relisted as Critically Endangered in 2016 due to significant regional-wide population declines [Humble et al., 2016; Kühl et al., 2017]. Conserving these great apes requires a detailed understanding of their population size, spatial distribution and demographic trends. Survey and monitoring programmes are designed to provide this information. However, it is generally difficult to observe wild great apes in their natural habitat. Thus, nest count surveys are commonly used by researchers (1) to estimate great ape population sizes and (2) to determine habitats used for nesting and related aspects of nesting behaviour, especially for unhabituated apes [Pruetz et al., 2002; Kühl et al., 2008; Hernandez-Aguilar, 2009; Ukpong et al., 2013; Hakizimana et al., 2015; Dutton et al., 2016; McGrew, 2017].

Nest building behaviour may be a learned pattern in all great ape species. Weaned individuals of all great ape species build nests in which they sleep at night or sometimes rest during the day. Typically a nest is constructed, immediately used and abandoned the next morning [Kühl et al., 2008; Hernandez-Aguilar et al., 2013]. Nests can remain visible in the habitat for several weeks or months after construction and use. New nests are built each night, they may also be made during a mid-day rest [Kühl et al., 2008].

Chimpanzees show great selectivity for nest tree species, as they use only a subset of the total available tree species for nesting. Although no single characteristic has been found sufficient for explaining preferences in terms of nest tree species, nest tree selectivity has been linked generally to physical characteristics of the trees [Furnichi and Hashimoto, 2004; Hernandez-Aguilar, 2006; Ndimuligo, 2007; Stanford and O'Malley, 2008; Koops et al., 2012; Hernandez-Aguilar et al., 2013; Carvalho, 2014]. In light of the tremendous variation in nesting tree characteristics, managers of natural resources need to take account of information on nesting tree preference by chimpanzee populations. This information is of great help for the formulation of efficient conservation action plans. Thus, researchers must provide local information on nesting tree species, relationships between nest heights and tree heights, physical characteristics of the trees and the habitat types that chimpanzees preferentially use for nesting [Basabose and Yamagiva, 2002; Furnichi and Hashimoto, 2004; Hernandez-Aguilar, 2006; Ogawa et al., 2007; Hernandez-Aguilar, 2009; Koops et al., 2012; Ndiaye et al., 2013a, b; Ogawa et al., 2014; Hakizimana et al., 2015]. Chimpanzees use particular tree species for nest construction [Brownlow et al., 2001]. In the Nimba Mountains (Guinea), chimpanzees use 53.2% of the available tree species for nesting [Koops et al., 2012]. The 10 most frequently used species, namely *Chidlowia sanguinea*, *Rinorea* sp., *Chrysophyllum africanum*, *Amanoa bracteosa*, *Santiria trimera*, *Ituridendron bequaertii*, *Bussea occidentalis*, *Synsepalum* sp., *Manilkara abovata* and *Drypetes afzelii*, contained 56% of the nests. In the Boé area (Guinea), chimpanzees preferred to make their nests in *Khaya senegalensis*, *Parkia biglobosa*, *Erythrophleum suaveolens* and *Cola cordifolia* [Hoogveld, 2013]. In Lagoas de Cufada Natural Park, in Guinea, chimpanzees made 52.7% of their nests in *Dialium guineense* [Carvalho et al., 2015]. In Bagnomba (Senegal), 63% of the chimpanzee nests were in *Diospyros mespiliformis* and *Pterocarpus erinaceus* [Badji et al., 2018]. Of the 123 available tree species in Mambilla Plateau in Tarabi State (Nigeria), the Nigerian/Cameroon chimpanzees

(*Pan troglodytes ellioti*) use only 28.45% of the tree species for nesting. The top 5 identified nesting tree species were *Anthonotha noldeae*, *Macaranga monandra*, *Strombosia scheffleri*, *Trichilia welwitschii* and *Isolona deightonii* [Dutton et al., 2016]. In Bwindi National Park (Uganda), chimpanzees make nests in 38 of 163 tree species, and 72.1% of nests ($n = 2,463$) were constructed in just 4 species: *Cassipourea* sp., *Chrysopyllum gorungosanum*, *Drypetes gerrardii* and *Teclea nobilis* [Stanford and O'Malley, 2008]. Studies in Kibira National Park (Burundi) have focused on the environment and the characteristics of the trees used by chimpanzees for nesting and the type of habitat where nest sites are located [Hakizimana and Huynen, 2013; Hakizimana et al., 2015].

The numerous publications devoted to the nesting behaviour of chimpanzees clearly show its importance for the welfare and survival of this species. Studies of methods used to assess chimpanzee nesting behaviour in Budongo, Uganda, showed that different measures can have large effects on the estimation of chimpanzee density [Plumptre et al., 2003]. The key to accurately estimating population densities based on nesting behaviour is nest decay rate. Nest decay should be monitored in several areas if a large-scale census is being carried out because variation may occur at different sites and in different seasons [Kühl et al., 2008].

In Senegal, chimpanzees have adjusted to a hot, dry and open habitat [Pruetz et al., 2002, 2008]. While some studies have focused on nesting behaviour here [Stewart et al., 2007; Pruetz et al., 2008; Ndiaye et al., 2013a, b; Badji et al., 2018], most research has been done in the Niokolo Koba National Park (NKNP) or on the single habituated group at Fongoli outside the NKNP, but there have been no studies in the non-protected area of Diaguiri, Senegal. The Diaguiri chimpanzees live in an open and dry ecosystem that is intensively used by the local human population. For this reason, we studied their nesting behaviour to obtain scientific information specifically for the implementation of a conservation programme. Here we present the first data from Diaguiri on the nesting sites used by a population of chimpanzees never previously studied, and, in this non-protected area, we show the tree species used to nest in, the vertical distribution of the nests and the nest decay rate. These data are necessary to improve the conservation and management of chimpanzees in Diaguiri, specifically to inform policy on protecting key ecological aspects of the chimpanzees' natural environment.

Material and Methods

Study Site and Subjects

Our study was conducted in the hot, dry and open savanna of Diaguiri (UTM Zone 28N: 823230 E, 1396425 N) between March 2015 and June 2016. It is a non-protected area situated in the Kedougou region, outside NKNP, in the south-eastern region of Senegal (West Africa) (Fig. 1). Diaguiri is about 70 km from NKNP and 60 km from Bagnomba, and it has Sudano-Guinean types of climate and vegetation. It is a woodland-savanna mosaic landscape, which is mainly comprised of open-canopy habitats (woodland, bamboo woodland, grassland with scattered trees, treeless grassland) but also has small patches of closed-canopy (gallery forest, ecotone forest) habitat [Pruetz et al., 2008]. Diaguiri receives some of the highest rainfall levels within the country. From 1995 to 2014, the annual rainfall ranged from 900 to 1,800 mm, and the mean annual temperature was 28.6 °C (t_{\max} 35.4 °C, t_{\min} 21.9 °C) [Agence Nationale de l'Aviation Civile et de la Météorologie de Sénégal (ANACIM), 2015]. The dry season occurs from November to April and the rainy season from June to October. During the rainy season, the gallery forests are flooded. The month of May is a transition point between the dry and the rainy seasons [Ndiaye et al., 2013b].

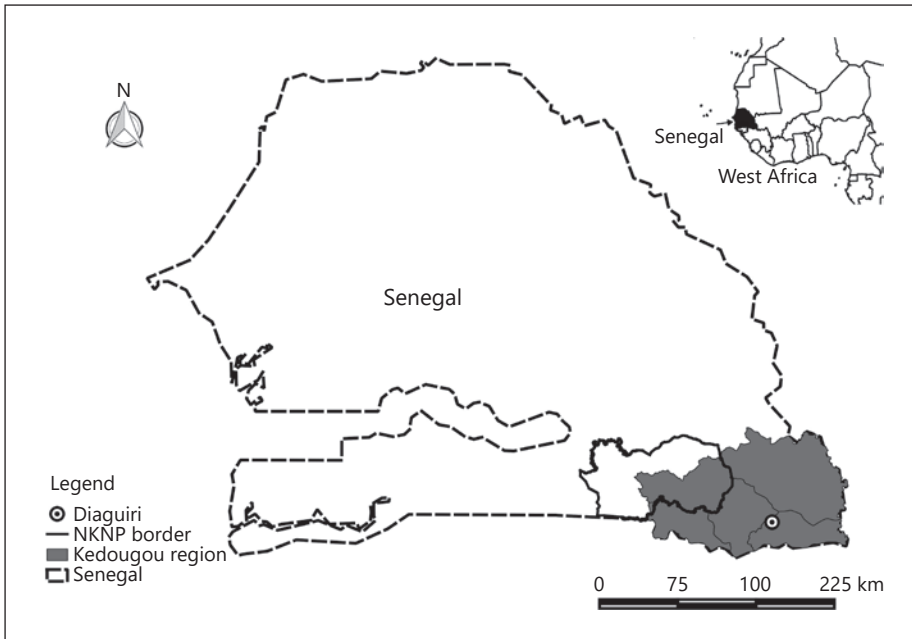


Fig. 1. Location of the study site.

Diaguiiri is situated close to the city of Kedougou, a major hub within the Kedougou region (Fig. 1, 2). The local human population is largely unaware of the importance of chimpanzees and their conservation [Ndiaye P.I., unpubl. observations]. Agricultural practices, hunting, poaching and gold mining are potential threats to the conservation of chimpanzees and their habitats at Diaguiiri, similar to other areas of the species' range across Africa [Kormos et al., 2004]. Today, the local human population of Diaguiiri is composed mainly of Muslims who do not eat primates, but the hunting of other wild animals constitutes a threat to the chimpanzees [Carter et al., 2003; Boyer-Ontl and Pruetz, 2014]. The Diaguiiri chimpanzee community has at least 11 individuals, based on camera trap images of identified chimpanzees and on the maximum number of fresh nests located at a single site on the same day [Ndiaye P.I., unpubl. data].

Data Collection and Analysis

Nesting data were collected during 14 months from March 2015 to June 2016. We conducted foot surveys along recce transects in habitats that were likely to have nesting tree species, namely woodland and forest habitats [Kühl et al., 2008]. We surveyed a total transect distance of 43 km within a 68-km² area. We recorded the geographic coordinates, date and time for each encounter with a chimpanzee nest or a group of nests. In addition, for each nest we recorded the habitat type, supporting tree species, tree height, height of nest from the ground and nest age class. Height was measured with a Tracker 670 laser rangefinder ($n = 393$ trees, mean \pm SD = 13.91 ± 2.5). Following Tutin and Fernandez [1984], nest age class was identified as fresh, recent, old or rotted. Fresh nests were judged to be used the night before and were identified by the presence of entirely green and unwilted leaves, with fresh faeces and/or urine sometimes present. Recent nests had wilted leaves that remained green. Old nests had a mixture of brown and dried green leaves, or consisted entirely of brown leaves. Rotted nests ranged from showing disintegrating brown leaves to leafless structures with only the supporting branches remaining. Ground nests were not observed in our study area.

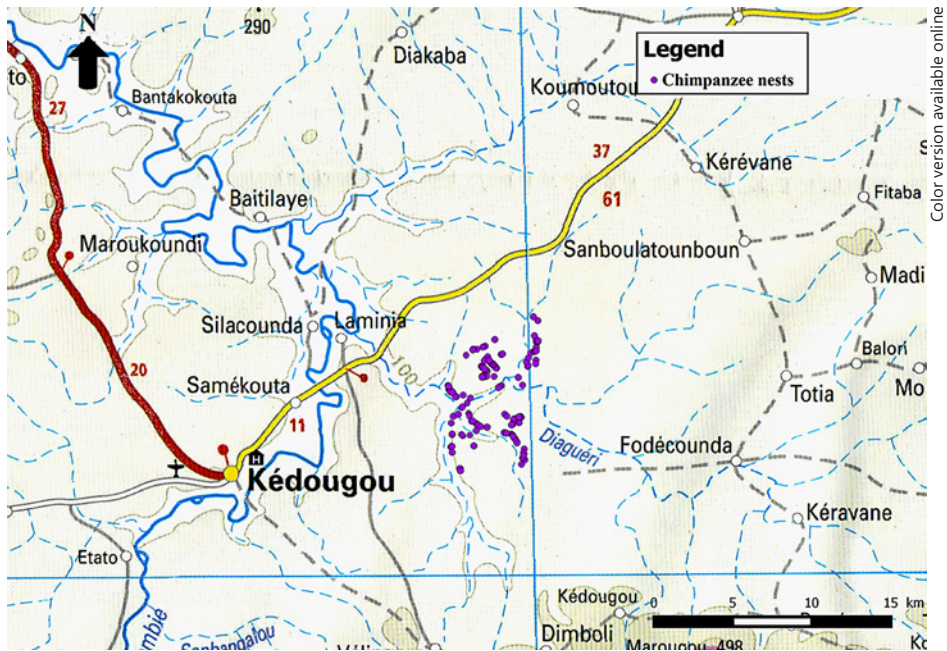


Fig. 2. Map of the study site and distribution of observed chimpanzee nests.

To assess the availability of nesting tree species and species preference by chimpanzees, we conducted vegetation surveys at nesting sites and along the recce transects. We identified and recorded all trees with a diameter at breast height ≥ 10 cm that could potentially support chimpanzee nests within a total of 21 quadrats each measuring 20×20 m (each quadrat area = 400 m^2 , $8,400 \text{ m}^2$ total quadrat area). All quadrats were located along recce transects where chimpanzee nests had been observed. The relative abundance of each species was calculated in order to identify common and rare tree species. We tested for a preference in nesting tree species by comparing the proportion of nests in each tree species with relative abundance using a regression analysis. A tree species was considered preferred when it was used at a significantly higher rate than its relative abundance.

To determine the nest decay rate at Diaguiri, we marked a total of 109 fresh nests ($n = 52$ in woodland, $n = 57$ in gallery forest) and monitored each one monthly for 7 months from December 2015 to June 2016. This monitoring period began during the early-middle dry season and ended during the early wet season after the nests had completely disintegrated.

We performed statistical tests in *R* (version 3.3.0) software to test for nesting tree preference and to evaluate the relationship between nest and tree heights using regression and correlation analyses.

Results

Location of Nests and Nesting Tree Species Preference

We recorded a total of 871 chimpanzee nests including 129 fresh (14.8%), 128 recent (14.7%), 398 old (45.7%) and 216 (24.8%) rotten nests. We encountered 20 nests/km of transect on average. Nests were often located on the edges of gallery forests and in woodlands near tributaries of the Gambia River (Fig. 2).

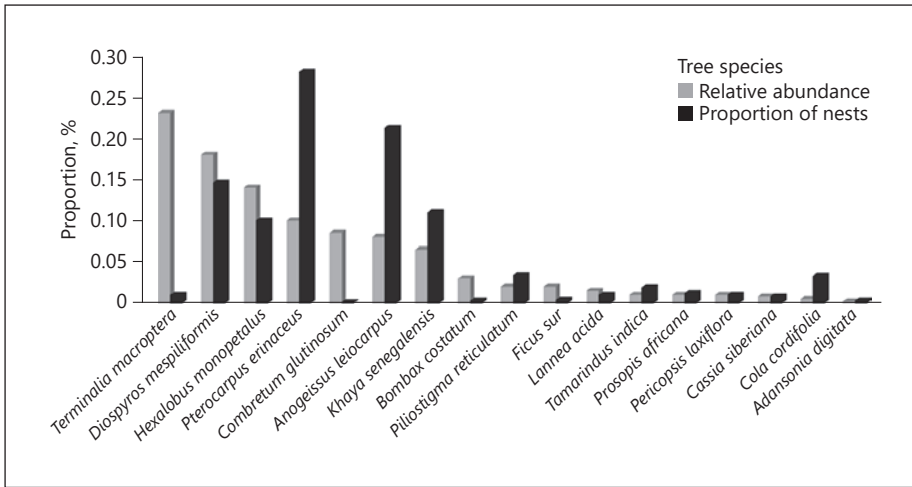


Fig. 3. Preferred tree species bearing chimpanzee nests in accordance with the abundance of the tree species in the study site.

Chimpanzees used at least 17 tree species to construct sleeping nests and 78.5% of nests were associated with 5 tree species, including the Proteaceae *Pterocarpus erinaceus* (26.1%), the Annonaceae *Anogeissus leiocarpus* (19.1%), the Dilleniaceae *Diospyros mespiliformis* (13.6%), the Hymenocardiaceae *Khaya senegalensis* (10.3%) and the Hernandiaceae *Hexalobus monopetalus* (9.4%). The remaining 21.5% of nests in our sample were associated with 12 other species (Fig. 3). We monitored 642 trees and vines within sample quadrats. Within this sample, we identified 40 tree species, and chimpanzee nests were observed in only 17 tree species (Fig. 3). Seven of these 40 tree species comprised 90.8% of the sample, namely *Terminalia macroptera* (25%), *Diospyros mespiliformis* (18%), *Hexalobus monopetalus* (14%), *Pterocarpus erinaceus* (10%), *Combretum glutinosum* (8.5%), *Anogeissus leiocarpus* (8%) and *Detarium microcarpum* (7.3%). The regression analysis showed no significant relationship between trees species preference and tree species abundance ($r = 0.39$; $df = 15$; $p = 0.1172$).

Nesting Height Classes

The majority of nests were between 6 and 15 m above the ground (78%). Mean nest height \pm SD was 10.9 ± 1.7 m with a range of 1–15 m. More than half of the nesting tree species (65.5%) were 11–20 m in height, while a quarter of these trees were between 6 and 10 m (Fig. 4). These data suggest that the chimpanzees of Diaguiri have a nesting height preference, as 43.3% of nests were made within the middle of the crown. Nest height was significantly correlated with tree height ($r = 0.874491$, $df = 391$, $p < 0.001$; Fig. 5).

Nest Decay Rate

We monitored 109 of the original 129 fresh nests until they completely deteriorated (Table 1). On average, 120–130 days passed before fresh nests transitioned to

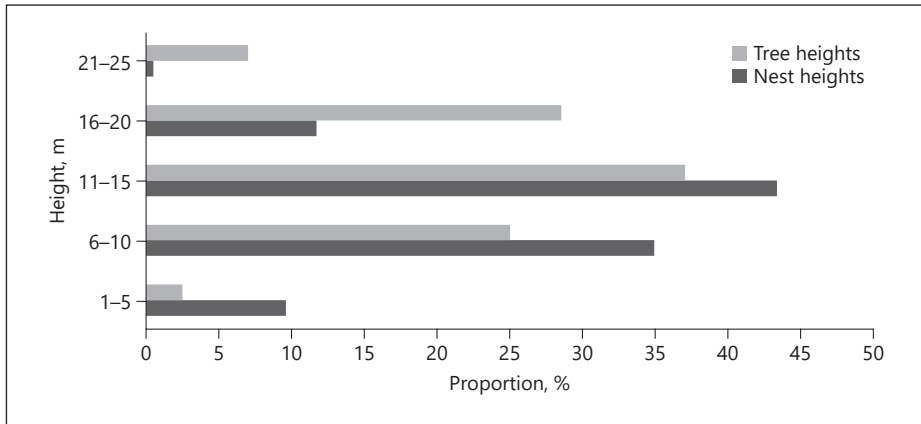


Fig. 4. Nest height classes in accordance with the height classes of the trees bearing nests.

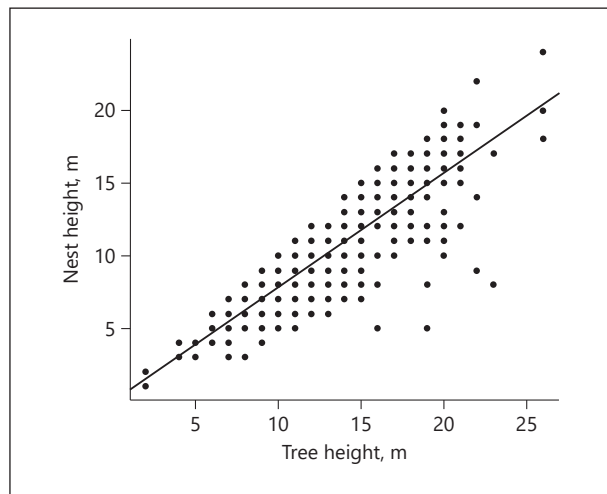


Fig. 5. Relationship between nest height and tree height.

the old stage, and 176–186 days passed before a fresh nest was reclassified as rotten. The interval from fresh to rotten was shorter in gallery forests (mean \pm SD: 176.5 \pm 0.71 days) than in woodlands (mean: 184 \pm 2.83 days).

Discussion

The presence of fresh and recent nests (29.5% of total nests) during the study demonstrates that chimpanzees regularly used the Diaguiri study area. The selection of nesting site, nest height and nest-bearing trees by chimpanzees described by several authors [Basabose and Yamagiwa, 2002; Furnichi and Hashimoto, 2004; Stanford

Table 1. Nest decay rate (number of days)

Site	Localisation (UTM)		Marked nests, <i>n</i>	Habitat type	Fresh nest	Old nest	Rotting nest
	longitude	latitude					
Parawol Manga 1	824692	1393692	30	Woodland	1 day	130 days	186 days
Parawol Manga 2	824200	1393551	24	Gallery forest	1 day	120 days	176 days
Diaguiri	175121	1394238	22	Woodland	1 day	124 days	182 days
Diabatama	824807	1391106	33	Gallery forest	1 day	121 days	177 days

The number of days indicates the time before fresh nests deteriorated to old nests or to rotting nests independent of tree species. UTM, Universal Transverse Mercator.

and O'Malley, 2008; Koops et al., 2012; Hernandez-Aguilar et al., 2013; Ndiaye et al., 2013b; Hakizimana et al., 2015] are also illustrated in the nesting behaviour of chimpanzees in Diaguiri. In this area, chimpanzees most often nested in woodland and grassland with isolated trees, while in Assirik, within the NKNP, chimpanzees nested less frequently in these habitats [Pruetz et al., 2008]. In Diaguiri, chimpanzees make their nests most often in the gallery forests, and the 5 most used nesting tree species are, in order of preference, *Pterocarpus erinaceus*, *Anogeissus leiocarpus*, *Diospyros mespiliformis*, *Khaya senegalensis* and *Hexalobus monopetalus*. These data provide important information for chimpanzee conservation programmes. According to the IUCN 2017 Red List of Threatened Species, *K. senegalensis* is a vulnerable species. *P. erinaceus*, *A. leiocarpus* and *D. mespiliformis* have not yet been assessed for the IUCN 2017 Red List but are in the catalogue of life (www.iucnredlist.org). Thus, the preference of these tree species by chimpanzees for nest building and their conservation status are good arguments for the authorities responsible for managing natural resources to revise the laws. The exploitation of these tree species in Senegal is permissible today (see www.eaux-forets.sn) and must be a threat to the conservation of chimpanzees in this region. Analysis of the abundance of the plant species likely to be selected by chimpanzee for nesting is consistent with a preference for *P. erinaceus* and *A. leiocarpus*. These two species bore about 45% of nests in our sample but represented 10 and 8% of the tree species in the study site, respectively. A similar result has been described in Kibira National Park in Burundi where most of the nests were constructed in *Parinari excelsa* and *Carapa grandiflora*, with the former being a tree species that occurred at a relatively low density (2 trees/ha), but bore 15.5% of all nests in this area [Hakizimana et al., 2015]. In contrast, the most abundant species (42 trees/ha), supported only 9.6% of all nests.

Nesting behaviour is associated with the physical characteristics of nesting trees. Nest and tree heights are positively correlated. The chimpanzees of Diaguiri show nesting height preferences. Nest height was significantly lower than the mean height of nesting trees. Diaguiri chimpanzees built most of their nests between 6 and 15 m height, below the top of the nesting tree crown. Thus, nest heights in Diaguiri (mean height = 10.9 m with a range of 1–25 m) exhibit some differences from Fongoli and Mont Assirik, Senegal [Pruetz et al., 2008]. Chimpanzees at Fongoli nest lower in trees (mean nesting height = 8.6 m). In Assirik, the mean nesting height was 13.55 ± 4 m. Pruetz et

al. [2008] think that the absence of predators in Fongoli accounts for the differences in nesting heights. Mean nest height is 12.11 m at Kibira National Park in Burundi, and the majority of nests occurred between 5 and 15 m in height [Hakizimana et al., 2015]. According to most authors, most nests are built in the middle segment of the crown [e.g., Hernandez-Aguilar, 2006; Koops et al., 2012; Hakizimana et al., 2015].

Nest decay rate varies with great ape species, nesting tree species, forest type and abiotic parameters such as rainfall, altitude, temperature, soil type and pH [Buij et al., 2003; Ancrenaz et al., 2004; Walsh and White, 2005; Marshall et al., 2006; Kühl et al., 2008; Mathewson et al., 2008]. The nest decay rate is 91.22 days at Taï (Côte d'Ivoire) [Kouakou et al., 2009], 90 days at Goualougo (Congo) [Morgan et al., 2006], 111 days in Kibale (Uganda) [Plumptre et al., 2003], 106 days at Lopé (Gabon) and 114 days at Belinga (Gabon) [Kühl et al., 2008], 221 days at Fouta Djallon (Guinea Conakry) [Kühl et al., 2008], 293.9 days in Guinea-Bissau [Carvalho et al., 2013] and in Issa (Ugalla, Tanzania) 139.2 days in woodland and 118 days in gallery forest [Stewart et al., 2011]. We report for the first time nest decay rates for Senegal. In the dry season, nests transition from fresh to old in about 4 months and become rotten at about 6 months after they have been first constructed. Furthermore, we found a slight difference in the nest decay rate between woodland and gallery forest. Nest decay rate is lower in woodland and higher in gallery forest. This difference could be associated with differences in nesting tree species between habitats, as *A. leiocarpus* and *P. erinaceus* occurred more often in woodland, and *Mytragina inermis* and *D. mespiliformis* were found more often in gallery forest. More research is needed in order to evaluate this hypothesis. In addition, all of the nests in our sample fully disintegrated after the rainy season, likely due to the forces of the rain and wind.

Conclusion

This work provides the first data on chimpanzee nesting behaviour and ecology in Diaguiri. In this site, chimpanzee nests are often located on the edge of gallery forests and in woodlands near tributaries of the Gambia River. Chimpanzees use at least 17 plant species to construct sleeping nests but 3 of them, namely *Pterocarpus erinaceus*, *Anogeissus leiocarpus* and *Diospyros mespiliformis*, are most used. They prefer to build nests within the middle of the crown. New data on nest decay rate are also provided. Nest decay rate is faster in gallery forests than in woodland habitats. Also, nest height is significantly correlated with tree height in Diaguiri, and the mean height in this site is 10.9 m. We think that these data are very useful for managing the habitat of the Critically Endangered subspecies of chimpanzee and to inform a local action plan for the conservation and management of the savanna chimpanzee.

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Disclosure Statement

There are no conflicts of interest.

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