

The Nesting of Grauer's Gorillas (*Gorilla beringei graueri*) and the Management of Wildlife Tourism at High Altitude in Kahuzi-Biega National Park (DRC): The Case of the Sylverblack Chimanuka Family

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Abstract

Kahuzi-Biega National Park, in the eastern Democratic Republic of the Congo, currently hosts only 3,815 eastern lowland gorillas (Grauer's gorillas) according to a recent survey conducted by the Wildlife Conservation Society (WCS) led by Dr. Andrew Plumptre. At higher altitudes, there are approximately 170 individuals of Grauer's gorilla (*Gorilla beringei graueri*, Hominidae, Primates), including 143 regularly monitored as follows: 10 adult males, 58 adult females, 9 blackbacks, 20 sub-adults, 17 juveniles, and 29 infants, grouped into 9 semi-habituated families and 2 habituated families (the Chimanuka family and the Banonane family). The Chimanuka family consists of 1 dominant silverback male, adult females, blackbacks, sub-adults, juveniles, and infants. Visitor satisfaction also results from observing fresh nests built by the gorillas before their visit. Grauer's gorillas build nests every night on the site.

Our study aims to: (i) identify fresh nests built by Grauer's gorillas in the different sectors of high altitude areas; (ii) characterize the dominant vegetative materials by layer and by season that show preference in the construction of nest types; (iii) determine the part of vegetative material most used in nest construction; (iv) assess the regenerative aspect of fruit trees at terrestrial nest sites by season; (v) identify the heights used in constructing different types of aerial nests and their pattern of habitat use by season.

Using the method of reconnaissance walks, direct observation, and measuring the height of nests built on trees with a measuring tape by climbing the trees with a rope to assess the vertical distance between the base and the nests. EXCEL software was used to represent diagrams of nest types and the averages of the strata. The study was able to identify the areas visited by the Chimanuka family gorillas by season, with more areas visited during the rainy season than in the dry season. The categories of terrestrial and aerial nests showed that there were more terrestrial nests in the rainy season than in the dry season. Herbaceous strata were more visited during the rainy season, while in the dry season, gorillas more frequently slept in the shrub strata. Terrestrial nests are built in several categories; during the rainy season, they are mostly constructed from grasses (59%), and in the dry season, they are mostly made from shrub foliage (50%).

55% of ground nests are built by a dominant species, *Mimulopsis solmsii*, during the rainy season, and in the dry season, it is the species *Chassalia subochreatea* (60%).

Air nests are also built during both seasons: In the rainy season, gorillas construct nests at heights of 6 to 10 m, accounting for 55% of nests, and 40% of nests are built at heights of 1 to 5 m. The species *Dombeya torrida* is the most used tree for constructing aerial nests, followed by the shrub *Galiniera coffeoides*. In the dry season, 55% of nests are built at heights of 4 to 6 m and 40% at heights of 1 to 3 m. The shrub species *Xymalos monospora* is the most used, followed by *Chassalia subochreatea* and the tree *Trichilia volkensii*.

Keywords: sector, shrub layer, herbaceous layer, ground nests, aerial nests

1. Introduction

Kahuzi-Biega National Park (PNKB), located in the eastern Democratic Republic of Congo, is a critical biodiversity hotspot that is home to 3,815 Eastern lowland gorillas (*Gorilla beringei graueri*), with 170 of these gorillas inhabiting the park's high-altitude areas (WCS, 2021; ICCN, 2024). Among these, nine families are semi-habituated to human presence, and two families—the Chimanuka and Bonane families—are fully habituated (ICCN, 2025). These gorillas are a keystone species in their ecosystem, and their nesting behavior plays a significant role in shaping the park's ecological dynamics, particularly in terms of vegetation structure and regeneration.

Gorillas are primarily herbivorous and construct nests each night from local plant materials, either on the ground or in trees (Tutin & Fernandez, 1984; Mühlenberg et al., 1994; Halford, 2003; Gauthier-Hion, 2006). This nesting behavior not only reflects their daily and seasonal movements in relation to food availability but also has a profound impact on the plant communities in their habitat (Yumoto et al., 1994; Yamagiwa et al., 2005). The materials used to build nests can vary based on the season, which correlates with the changing distribution of food resources. For instance, during the rainy season, gorillas may prefer herbaceous species, while in the dry season, they may rely more heavily on shrubs (Wils et al., 1976; Wilson & Castis, 1990). These seasonal shifts are important for both ecological and agricultural science because they influence plant regeneration, biodiversity, and the structure of the park's various vegetative strata.

From an ecological standpoint, the gorillas' nest-building behavior influences the composition and regeneration of plant species in the park. For example, certain plant species, such as *Mimulopsis solmsii* and *Chassalia subochreatea*, are preferentially used in nest construction, and this selection could have implications for the regeneration of these species and their role in the ecosystem. Additionally, the height and location of nests—whether terrestrial or aerial—are indicative of the gorillas' interaction with the park's vertical stratification of vegetation, which is of particular interest to both ecological and agricultural scientists. Understanding these nesting preferences can shed light on broader questions about habitat use, food availability, and the role of gorillas as ecosystem engineers, influencing the structure and function of the park's habitats.

Moreover, this nesting behavior is not only significant from an ecological perspective but also holds implications for sustainable wildlife tourism management. As the park is a vital source of ecotourism revenue, particularly through the observation of habituated gorilla families like Chimanuka, understanding the interplay between gorilla behavior and their habitat can help to mitigate human-wildlife conflict and enhance visitor experiences, while also contributing to conservation efforts.

In this study, we seek to understand the nest-building behavior of the Chimanuka family of gorillas in high-altitude areas of PNKB. Specifically, we aim to identify seasonal patterns in nest construction, characterize the plant species and vegetative strata used in nest building, and assess the ecological implications of these behaviors for plant regeneration. By linking gorilla behavior with ecological and agricultural processes, this research will contribute to the effective conservation and management of PNKB, ensuring both biodiversity preservation and the sustainable development of the region's ecotourism potential. Figure 1 shows tourists in front of the fresh nests built by the gorillas of the Chimanuka family in the Ifukiro sector at high altitudes.



Figure 1. Tourists visiting the freshly constructed nests of the Chimanuka family gorillas

2. Study Area

According to Mangambu et al. (2010), Kahuzi-Biega National Park (PNKB) is located in the east of the Congo and covers an area of 6,000 km². The park is named after two mountains that dominate its high-altitude section: Mount Kahuzi, with an altitude of 3,308 m, and Mount Biega, which stands at 2,790 m.

The extreme geographic coordinates define its boundaries: to the west, it is bordered by the Ezeza River (27°33'E); to the east, by Lemera (28°46'E); to the south, by Lulimbe (2°37'S); and to the north, by Mount Kamengele (1°36'S). The altitude within the park ranges from 600 m to 3,308 m (Masiala et al., 2020; Masiala et al., 2022; Mangambu et al., 2013).

The park is subdivided into four stations: one high-altitude station called Tshivanga and three low-altitude stations located at Nzovu, Luliungu, and Itebero (Masumbuku, 2011). We present the map of Kahuzi-Biega National Park, indicating the high-altitude area (Figure 2).

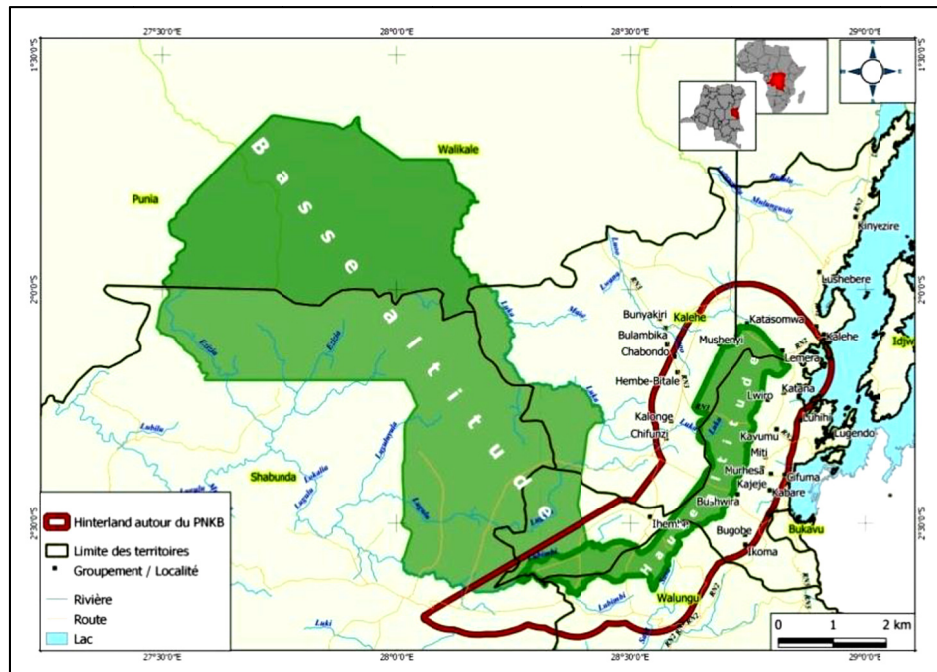


Figure 2. Map of Kahuzi-Biega National Park (Mangambu et al., 2014) and location of the PNKB on the map of the DRC. The red frame indicates the high-altitude area and the green area shows the Tshivanga station

3. Materials and Methods

3.1 Materials

Our study focuses on individuals from the Chimanuka gorilla family, which are habituated to human presence, for which tourism activities are organized. The composition of the family was established based on data from the Monitoring and Research Program of the Tshivanga station. In 2014, the Chimanuka family consisted of 31 individuals, including 1 silverback (28 years old), 9 adult females, 3 blackbacks, 4 subadults, 5 juveniles, and 10 infants (ICCN, 2014).

3.2 Methods

3.2.1 Detection of Nesting Sites

We used reconnaissance walks, following animal tracks starting from the site where they had spent the previous night. This site was located using the GPS coordinates from a MAP 60 CSX device used by the animal trackers. From this site, we continued to follow the gorilla tracks until we discovered fresh nests.

The study was conducted over two seasons, during a period of three years from 2012 to 2014: the rainy season and the dry season.

For each nesting site (Figures 3 and 4), we first recorded the sector, the plant species used in the construction of the nests, whether they were on the ground or in trees, the parts of the plants used in building the ground nests, the identification of the species whose seeds were found in the feces, and the height measurements of the nests constructed in trees.

It is important to note that in this study, we consider "sectors" as areas of vegetation with natural boundaries (rivers and hills) or artificial ones, such as roads that cross or end within the park. These sectors are named after rivers, landforms, or notable park rangers. Figure 3 shows a nest of an adult female and her baby. Figure 4 illustrates the dominant male in a nest at 6:30 AM near the Tshivanga station in the Mbuli sector during the rainy season.



Figure 3. Feces of an adult female and her baby

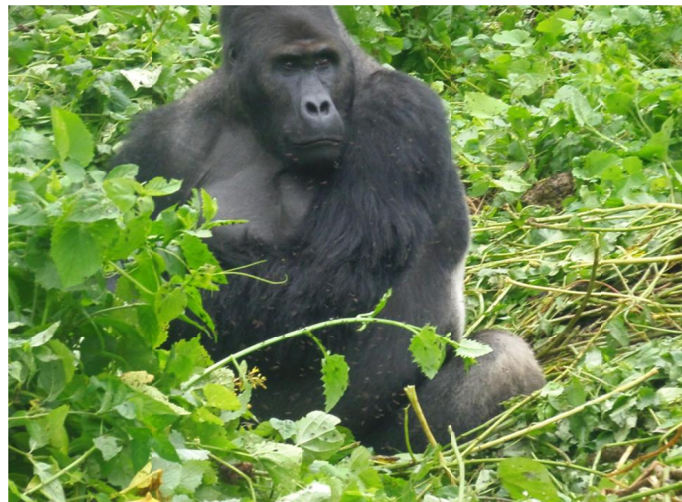


Figure 4. Dominant male sitting in the nest

In the dry season, there is a dominance of shrubs. Figure 5 shows the branching or foliage of the shrub *Tricalysia kivuensis*. Figure 6 illustrates the adult female sitting in the nest at 9:30 AM after a heavy rain. Figure 7 shows the aerial nest on *Xymalos monospora*.



Figure 5. Branches of the *Tricalysia kivuensis* nest

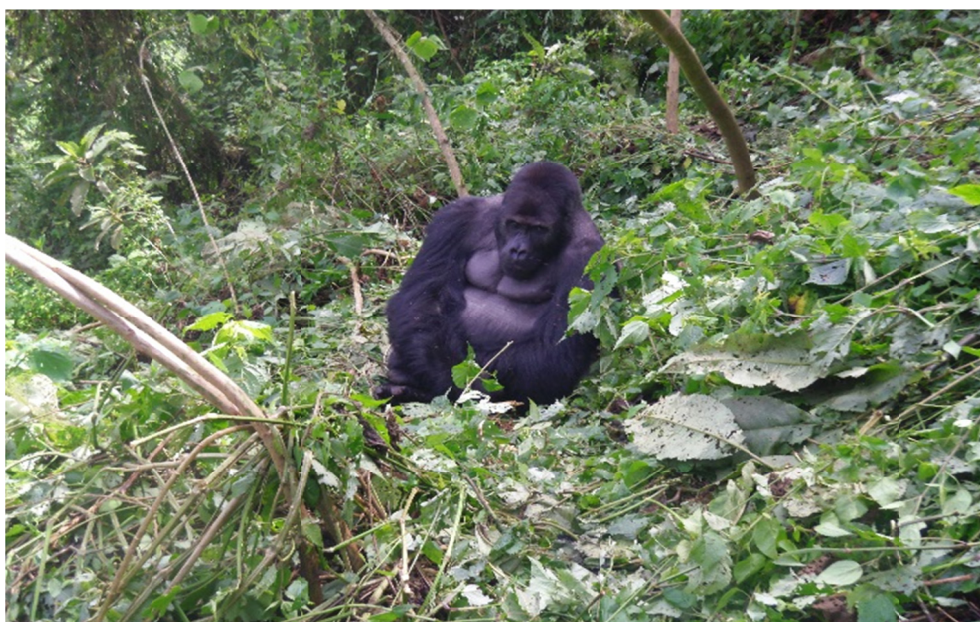


Figure 6. Adult female in a nest made of *Dombeya torrida* leaves



Figure 7. Aerial nest made of *Xymalos monospora* shrub branches (3 m)

For the identified plant species, we recorded their scientific names and morphological types. This allowed us to classify them into four categories: herbaceous layer, shrub layer, vines, and tree layer. These different layers were categorized according to the number of nests built by the gorillas in the morning (very fresh) and distributed across the various sectors visited.

Our observations were conducted in the late mornings, from 8 AM to 12 PM, which are the hours allowed for visits, to avoid finding the gorillas in the nests and to take advantage of the very fresh state of the nests. During the rainy season, gorillas can remain in their nests until 9:30 AM.

3.2.2 Identification of Species Used in Nesting

The identification of species used in nest construction began in the field. Samples were then collected and compared with reference specimens stored in the herbarium of the Center for Research in Natural Sciences of Lwiro (CRNL). We used various floras by Lebrun and Stork (1991, 1992, 1995, 1997) and data from molecular systematic botany (APG II, 2003; APG III, 2009; APG IV, 2016).

3.2.3 Measurement of Nest Heights

We measured the heights of nests built in trees by using a measuring tape and climbing the trees with ropes, measuring from the base of the tree to the location of the constructed nests.

3.2.4 Data Processing

Based on the number of nests per sector and the number of nests in each layer, we calculated the average using EXCEL software to determine the most frequently used layers in the gorillas' home range during both the rainy and dry seasons.

4. Results

4.1 Visited Sectors

During the rainy season, the gorillas exploited 15 sectors of the park, as listed below, and even a zone outside the park boundaries. We counted 591 nests, which represent more than half of the total number of ground nests in the herbaceous layer. However, it is in the sectors of Ifukiro and Mbuli where the gorillas spent the most nights (38%). It is also noted that the animals built fewer nests in the vine-dominated layers. In descending order, the layers are as follows: herbaceous layer, tree layer, shrub layer, and vines (Table 1).

Table 1. Visited sectors, number of nests, and types of vegetation layers (Rainy Season)

No.	Visited Sector	Herbaceous Layer	Shrub Layer	Liana	Tree Layer	Total
01	Bungulumiza	26 nests	3 nests	0 nests	13 nests	42 nests
02	Chanderma	17 nests	10 nests	0 nests	16 nests	43 nests
03	Ifukiro	125 nests	12 nests	2 nests	56 nests	195 nests
04	Kamano	0 nests	1 nest	0 nests	6 nests	7 nests
05	Katsumbwe	87 nests	11 nests	2 nests	8 nests	108 nests
06	Kakumbukumbu	27 nests	13 nests	0 nests	26 nests	66 nests
07	Kahimbiri	15 nests	7 nests	0 nests	3 nests	25 nests
08	Kasie (outside the park)	17 nests	1 nest	0 nests	1 nest	19 nests
09	Lulimbi	10 nests	2 nests	1 nest	19 nests	32 nests
10	Lushingu	64 nests	13 nests	3 nests	26 nests	106 nests
11	Mbuli	104 nests	46 nests	6 nests	37 nests	193 nests
12	Munga	12 nests	2 nests	0 nests	2 nests	16 nests
13	Muandagalo	2 nests	6 nests	0 nests	12 nests	20 nests
14	Ngalabuleti	18 nests	0 nests	0 nests	4 nests	22 nests
15	Tshamukenge	49 nests	19 nests	0 nests	15 nests	83 nests
16	Tshishakata	18 nests	12 nests	0 nests	3 nests	33 nests
Total		591 nests	158 nests	14 nests	247 nests	1,010 nests

During the dry season, gorillas change their behavior and nesting sites. In fact, we only encountered nests in 11 sectors, with just one sector also used during the rainy season. The sectors of Nyamuhambanza and Muandagalo were the most visited, accounting for more than half of the nests. The gorillas primarily exploited the shrub layer (60%). The vine layer was not visited (Table 2).

Table 2. Visited sectors, number of nests by type of vegetation layer (Dry Season)

No.	Visited Sector	Herbaceous Layer	Shrub Layer	Tree Layer	Total
01	Bungulumiza	2 nests	1 nest	6 nests	9 nests
02	Chanderma	0 nests	12 nests	5 nests	17 nests
03	Ifukiro	2 nests	5 nests	2 nests	9 nests
04	Langa	0 nests	10 nests	1 nest	11 nests
05	Lushingu	10 nests	3 nests	0 nests	13 nests
06	Marhale	20 nests	9 nests	7 nests	36 nests
07	Muandagalo	11 nests	55 nests	19 nests	85 nests
08	Mulunga	6 nests	20 nests	4 nests	30 nests
09	Nkhakala	1 nest	8 nests	7 nests	16 nests
10	Nyamuhambanza	5 nests	69 nests	13 nests	87 nests
11	Shantinga	13 nests	16 nests	4 nests	33 nests
Total		70 nests	208 nests	68 nests	346 nests

4.2 Frequency of Vegetative Strata Used (During the Rainy Season)

The gorillas of the Chimanuka family primarily exploit the herbaceous layer, with an average of 36.9 nests across 11 sectors where they spend the night (Figure 8). This indicates that these animals prefer sites that are denser in edible grasses, where they find plant species suitable for nest construction.

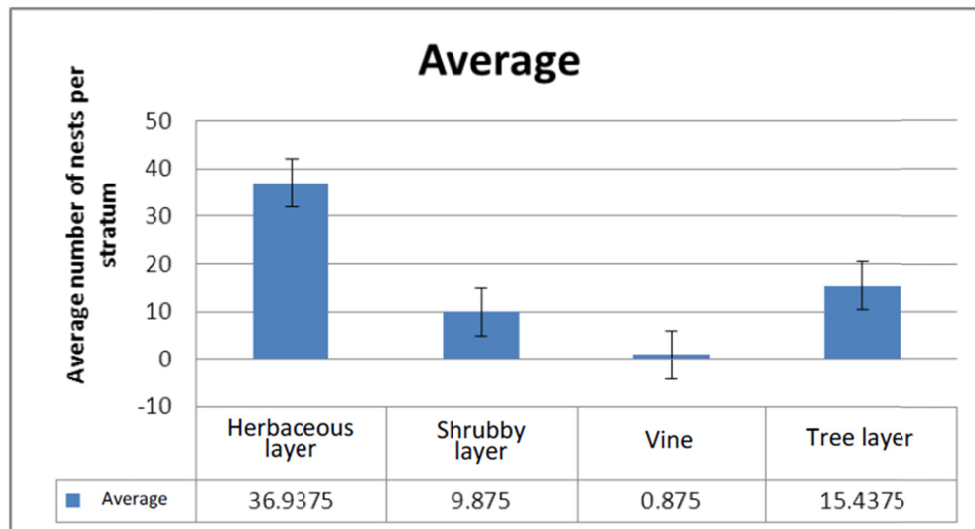


Figure 8. Marked frequency of the herbaceous layer among the vegetative strata used in nest construction

4.3 Frequency of Vegetative Strata Used (During the Dry Season)

The gorillas of the Chimnuka family most frequently visited the shrub layer, with an average of 18.72 nests, compared to the other strata (Figure 9). The gorillas find plenty of food in closed environments, which are favored habitats for fruit-bearing trees, such as *Myrianthus holstii*. They find available plant materials there as night falls and tend to compact the shrubs more.

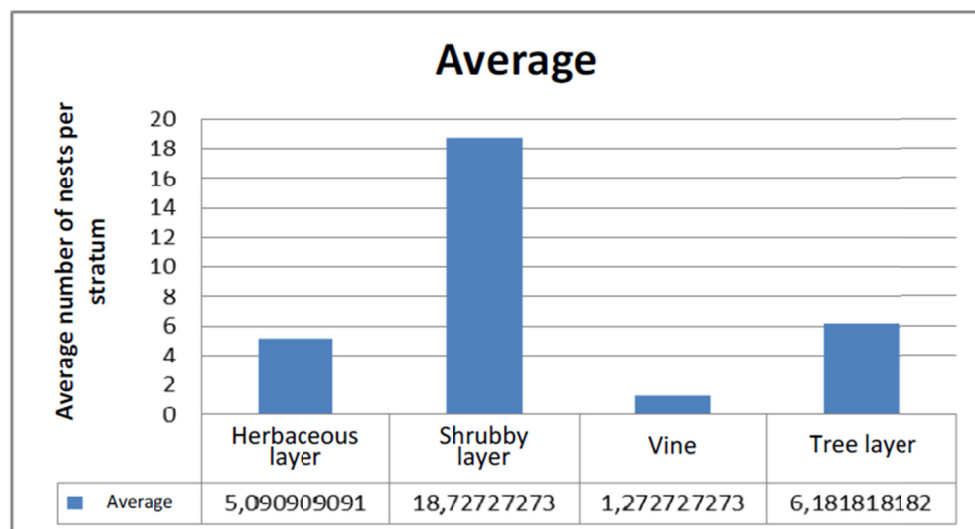


Figure 9. Marked frequency of the shrub layer during the dry season

4.4 Frequency and Composition of Materials for Ground Nest Construction (During the Rainy Season)

We identified 9 categories of ground nests. We found that grassy nests make up 59% of the materials used for ground nests (Figure 10). Additionally, some individuals from the Chimnuka family sleep on the ground, where their nests are made of dry leaves.

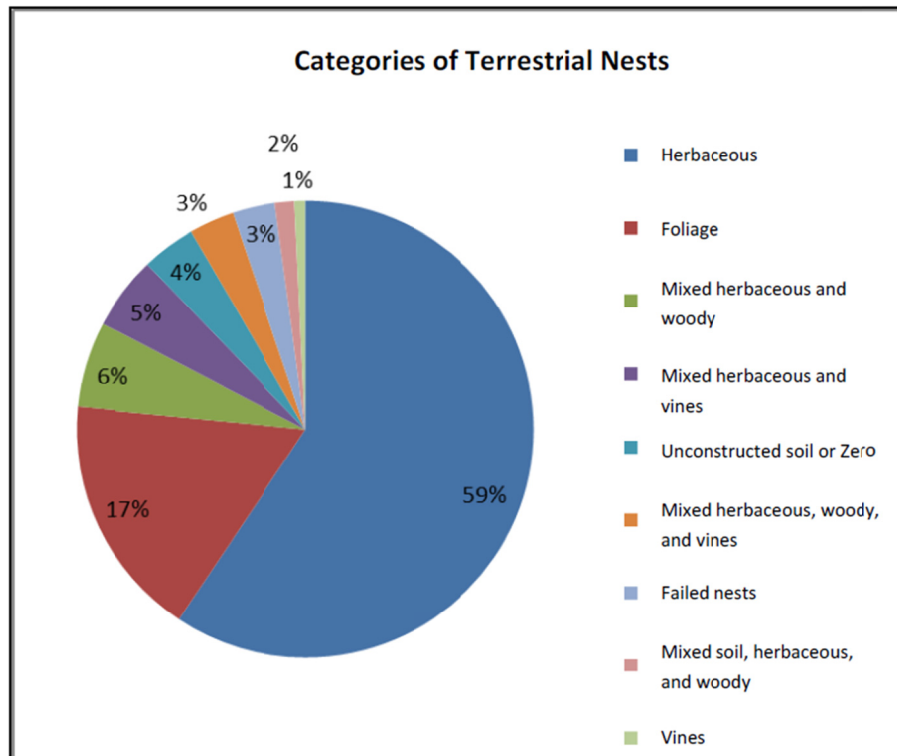


Figure 10. Frequency and composition of ground nests during the rainy season

Note. Unbuilt Ground or Zero: The nest is located on the ground surface and is not constructed, enriched by fallen dead leaves from the understory. Typically, feces are found, occasionally urine and hair.

Mixed Herbaceous, Woody, and Vines: The nest is compacted with a dominant grass that forms the perimeter and base, combined with a shrub or young tree and a vine. Typically, feces are found, occasionally urine and hair.

Mixed Zero Herbaceous and Woody: The nest is compacted with grass or a shrub that forms the perimeter, and the base is made on the ground. Typically, feces are found, occasionally urine and hair.

Vine: The nest is compacted entirely by a vine.

4.5 Frequency and Composition of Ground Nest Construction Materials (During the Dry Season)

Ground nests are more frequently built with foliage (branches) from shrubs (50%). Gorillas use fewer grasses during this season (Figure 11).

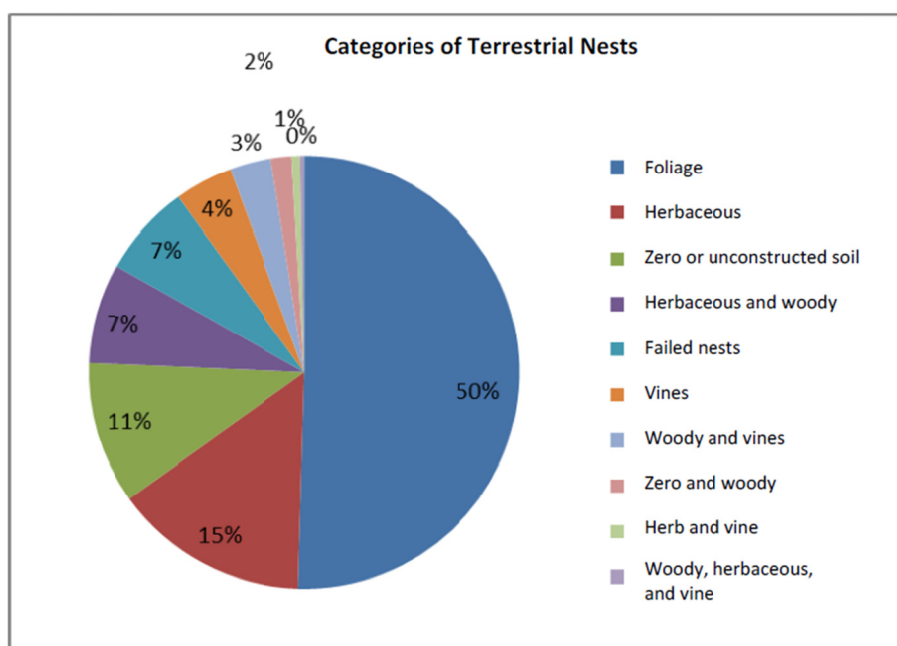


Figure 11. Frequency and Composition of Foliage Nests in Ground Nest Construction

Note. Foliage or Branch Nest (50%): The nest is compacted with a broken or bent shrub, with the foliage or branches forming the base. The trunk, or occasionally a branch, provides support. Feces are generally found, and occasionally food scraps, urine, and hair (Figure 7).

Grass Nest (15%): The nest is compacted with a dominant grass from the site, with the grass leaves forming the base, supported by the stems. Feces are generally found, and occasionally food scraps, urine, and hair.

Unbuilt Ground or Zero Nest (11%): The nest is located on the ground surface and is not constructed, enriched by fallen dead leaves from the understory. Feces are generally found, and occasionally urine and hair.

Mixed Grass and Woody Nest (7%): The nest is compacted by a dominant grass, which is reinforced by a woody species, either a tree or shrub. Feces are generally found, and occasionally food scraps, urine, and hair.

Failed Nest (7%): The failed nest is compacted by grass or a shrub from the site, but the gorillas do not spend the night there. No signs (feces, food scraps, urine, or hair) are present.

Vine Nest (4%): The nest is compacted solely by a vine, with its leaves forming the base and supported by the stems. Feces are generally found, and occasionally food scraps, urine, and hair.

Mixed Woody and Vine Nest (3%): The nest is constructed from a shrub combined with a vine. The shrub's foliage forms the base of the nest, reinforced by the vine, which provides leaves and stems. Feces are generally found, and occasionally food scraps, urine, and hair.

Mixed Zero and Woody Nest (2%): The base of the nest is made on the ground, with the perimeter supported by a shrub or young tree. Feces are generally found, and occasionally food scraps, urine, and hair.

Mixed Grass and Vine Nest (1%): The gorillas compact a grass from the site, with its leaves forming the base, combined with vine leaves supported by the stems. Feces are generally found, and occasionally food scraps, urine, and hair.

Mixed Grass, Woody, and Vine Nest (1 nest or 0%): The nest is compacted with a dominant grass that forms the perimeter and base, combined with the foliage of a shrub or young tree, with the vine adding its leaves and stems to reinforce the nest's structure. Feces are generally found, and occasionally urine and hair. These nests are rare.

4.6 Plant Species Used in the Construction of Ground Nests (Rainy Season)

For nest construction, we cataloged 5 species belonging to 5 different families. A total of 55% of the ground nests were solely constructed with *Mimulopsis solmsii*, 18% of nests were built with *Mimulopsis solmsii* in association with another species, and 1.5% of nests were constructed with *Mimulopsis solmsii* in association with

more than two species. Additionally, 10% of the ground nests were built with *Triumfetta cordifolia* and *Pilea bambuseti*. These three herbaceous species dominate the herbaceous layer at high altitudes (Table 3).

Table 3. Herbaceous species, parts used, and frequency of nests built

No.	Herbaceous Species	Families	Parts Used		Number of Nests (%)
			Leaf (base)	Stem (support)	
01	<i>Dryopteris calolepis</i>	Dryopteridaceae	Fe	Ti	32 (3.2%)
02	<i>Mimulopsis solmsii</i>	Acanthaceae	Fe	Ti	560 (55%)
03	<i>Mimulopsis solmsii</i> & <i>Pteridium aquilinum</i>	Acanthaceae, Dennstaedtiaceae	Fe	Ti	69 (7%)
04	<i>Mimulopsis solmsii</i> & <i>Triumfetta cordifolia</i>	Acanthaceae, Malvaceae	Fe	Ti	60 (6%)
05	<i>Mimulopsis solmsii</i> & <i>Pilea bambuseti</i>	Acanthaceae, Urticaceae	Fe	Ti	50 (5%)
06	<i>Mimulopsis solmsii</i> , <i>Triumfetta cordifolia</i> , & <i>Pilea bambuseti</i>	Acanthaceae, Malvaceae, Urticaceae	Fe	Ti	15 (1.5%)
			Fe	Ti	
			Fe	Ti	
07	<i>Pilea bambuseti</i>	Urticaceae	Fe	Ti	105 (10%)
08	<i>Triumfetta cordifolia</i>	Malvaceae	Fe	Ti	107 (10%)
09	<i>Triumfetta cordifolia</i> & <i>Pilea bambuseti</i>	Malvaceae, Urticaceae	Fe	Ti	23 (2.3%)
Total			Fe	Ti	1,010

Note. Fe = Leaf; Ti = Stem.

4.7 Plant Species Used in the Construction of Ground Nests (Dry Season)

During the construction of ground nests, the gorillas associate several plant species. The gorillas of the Chimanuka family construct two types of nests: nocturnal nests and diurnal nests. Diurnal nests were not part of our study. In the dry season, the gorillas travel long distances in search of food, with fruits becoming the main source of nutrition, and they also build nests to rest.

The gorillas construct their nocturnal nests each evening between 6:00 PM and 6:30 PM for sleep. For nest construction, we cataloged species from 18 different families. It is important to note that the diversity of species involved in nesting is an indicator of the high-altitude ecosystem's quality, which is crucial for the success and effectiveness of wildlife tourism. This diversity allows the Chimanuka family gorillas to fulfill a very important physiological function: sleep.

As shown in Table 4, the gorillas used a variety of 28 woody species. *Chassalia subochreatea* is the most used species during the dry season (Table 4). This species can be associated with other species. It is followed by *Dracaena laxissima* and *Cyathea manniana*. Among the parts used, the leaves are the primary component. The trunks of shrubs or young trees are also sometimes included.

Table 4. Woody species, parts used (Branches and Trunk), and number of nests built

No.	Species used	Families	Parts used		No. of nests
			Branches (Br)	Trunk (Tr)	
01	<i>Allophylus kivuensis</i>	Sapindaceae	Br	Tr	2
02	<i>Bersama abyssinica</i>	Melanthaceae	Br	Tr	3
03	<i>Chassalia subochreata</i>	Rubiaceae	Br	Tr	180
04	<i>Chassalia subochreata</i> , <i>Tabernaemontana johnstoni</i> & <i>Albizia gummifera</i>	Rubiaceae, Apocynaceae & Fabaceae	Br	Tr	1
05	<i>Chassalia subochreata</i> & <i>Xymalos monospora</i>	Rubiaceae & Monimoniaceae	Br	Tr	4
04	<i>Cyathea manniana</i>	Cyatheaceae	Br	Tr	39
05	<i>Cyathea manniana</i> & <i>Chassalia subochreata</i>	Cyatheaceae	Br	Tr	2
06	<i>Dracaena laxissima</i>	Dracaenaceae		Tr	42
07	<i>Dracaena laxissima</i> & <i>Chassalia subochreata</i>	Dracaenaceae & Rubiaceae	Br	Tr	17
08	<i>Dracaena laxissima</i> & <i>Rutidea syringoides</i>	Dracaenaceae & Rubiaceae	Br		1
09	<i>Dracaena laxissima</i> & <i>Xymalos monospora</i>	Dracaenaceae	Br	Tr	4
10	<i>Dracaena laxissima</i> & <i>Piper capens</i>	Dracaenaceae & Piperaceae		Tr	1
11	<i>Dracaena laxissima</i> & <i>Pavetta forinacea</i>	Dracaenaceae & Rubiaceae	Br	Tr	1
12	<i>Eurytrococca abyssinica</i>	Euphorbiaceae	Br	Tr	1
13	<i>Galiniera coffeoides</i>	Rubiaceae	Br	Tr	1
14	<i>Lindackeria kivuensis</i>	Flacourtiaceae	Br	Tr	1
15	<i>Macaranga neomildbraediana</i> & <i>Dracaena laxissima</i>	Euphorbiaceae & Dracaenaceae	Br	Tr	1
16	<i>Maessa lanceolata</i> & <i>Keertia rwandais</i>	Maesaceae & Rubiaceae	Br	Tr	1
16	<i>Microglossa densiflora</i>	Asteraceae	Br		1
17	<i>Mimulopsis arborescens</i>	Acanthaceae	Br	Tr	12
18	<i>Mimulopsis excellens</i>	Acanthaceae		Tr	1
19	<i>Mimulopsis excellens</i> & <i>Chassalia subochreata</i>	Acanthaceae	Br	Tr	1
20	<i>Neobutonia macrocalyx</i>	Euphorbiaceae		Tr	12
21	<i>Pavetta bagshawei</i>	Rubiaceae	Br		1
22	<i>Pavetta rwandensis</i>	Rubiaceae	Br		1
23	<i>Pavetta volkensii</i> & <i>Microglossa densiflora</i>	Rubiaceae & Asteraceae	Br	Tr	1
24	<i>Polycias fulva</i> & <i>Embela liberiana</i>	Araliaceae & Myrsinaceae	Br		1
25	<i>Sinarundinaria alpina</i>	Poaceae	Br		1
26	<i>Tabernaemontana johnstoni</i> & <i>Albizia gummifera</i>	Apocynaceae	Br		6
26	<i>Trichilia volkensii</i>	Meliaceae	Br	Tr	1
27	<i>Tricalysia kivuensis</i> & <i>Lindackeria kivuensis</i>	Rubiaceae & Flacourtiaceae	Br	Tr	1
28	<i>Xymalos monospora</i>	Monimoniaceae	Br	Tr	6
Total					346

4.8 Heights of Aerial Nests

The individuals of the Chimnuka gorilla family choose trees or shrubs suitable for the construction of aerial nests. They climb to the level where they can reach the leaves, which they pick and gather to form the nest's base. If the leaves are supported by branches, they break or bend them to reinforce the nest's stability. They may also construct several nests in a tree with multiple branches. *Dombeya torrida* is the most commonly used tree for constructing aerial nests, while *Galiniera coffeoides* is the most commonly used shrub. These species reflect the state of the woody layer in the high-altitude ecosystem.

The heights of the aerial nests indicate that the gorillas stay close to other members of the family to maintain family cohesion. A total of 55% of the nests are between 6-10 meters in height, 40% are between 1-5 meters, 3% are between 11-15 meters, and 1% are between 16-20 meters and 21-25 meters. It is mainly sub-adults, juveniles, and, in extreme cases, adult females who have recently reached maturity that climb to heights between 21-25 meters. The heights of the aerial nests reflect the characteristics of the high-altitude trees, where branches are not far from the ground, facilitating visits to higher levels (Table 5).

Table 5. Host woody species, heights used, parts used, and number of nests (Rainy Season)

No.	Species used	Families	Height					Part used		No. of nests
			1-5	6-10	11-15	16-20	21-25	Br	Tr	
01	<i>Afrocania volkensii</i>	Cornaceae	7	24	0	0	0	Br	Tr	31 (12%)
02	<i>Chassalia subochreatea</i>	Rubiaceae	6	2	0	0	0	Br		8 (3.2%)
03	<i>Dombeya torrida</i>	Malvaceae	28	65	5	1	1	Br	Tr	100 (40%)
04	<i>Galieniera coffeoides</i>	Rubiaceae	22	18	0	0	0	Br	Tr	40 (16%)
04	<i>Hagenia abyssinica</i>	Rosaceae	5	3	0	0	0	Br	Tr	8 (3.2%)
05	<i>Macaranga kilimandschari</i>	Euphorbiaceae	11	4	1	1	1	Br	Tr	14 (5.6%)
06	<i>Maesa lanceolata</i>	Maesaceae	4	10	0	0	0	Br	Tr	14 (5.6%)
07	<i>Milletia dura</i>	Fabaceae	2	3	0	0	0	Br	Tr	5 (2%)
08	<i>Neoboutonia macrocalyx</i>	Euphorbiaceae	8	3	1	0	0	Br		12 (4.8%)
09	<i>Syzygium guineense</i>	Myrticaceae	5	3	0	0	0	Br	Tr	8 (3.2%)
08	<i>Tabernaemontana johnstonii</i>	Apocynaceae	2	3	0	0	0	Br	Tr	4 (2%)
Total										244

Note. Aerial Nests Formed by Host Woody Species: The nest is typically formed by the leaves of the tree or shrub and may be associated with surrounding species at a certain height from the ground.

Aerial nests are also built on grassy canopies formed by grasses such as *Mimulopsis solmsii*, *Triumfetta cordifolia*, or by a combination of *Mimulopsis solmsii* and *Urera hypselodendron*. The gorillas construct the nests on the grass, which has formed a canopy supported by various solid stems (Table 6).

Aerial nests are either built on a grassy canopy, with the heights measured, the parts used, and the number of nests summarized below (Table 6). In Table 6, 61% of the aerial grassy nests are built on grassy canopies of *Mimulopsis solmsii*, with heights ranging from 1 to 3 meters (99%). This reflects a mature secondary forest, and tourism visits are difficult in these habitats because the gorillas tend to hide in these grassy canopies. These areas should be avoided during tourist visits because the trackers and guides end up clearing the vegetation to satisfy visitors.

Table 6. Host herbaceous species, heights, number of nests, and percentage (Rainy Season)

No.	Host herbaceous species	Families	Heights of the nests		No. of nests
			1-3	4-6	
01	<i>Mimulopsis solmsii</i>	Acanthaceae	63		64 (61%)
02	<i>Mimilopsis excelsa</i> & <i>Dryopteris callolepis</i>	Acanthaceae & Dryopteridaceae	4	1	4 (3.8%)
04	<i>Piper capense</i> & <i>Acalypha bipartita</i>	Piperaceae & Euphorbiaceae	3		3 (2%)
04	<i>Triumfetta cordifolia</i>	Malvaceae	34		34 (32 %)

Note. Aerial nests formed by host herbaceous species: The nest is typically formed by the leaves of a dominant grass species, which creates a vault capable of supporting the nest at a height from the ground. Some species may be associated with other species in the construction of the nest.

4.9 Aerial Nests (During the Dry Season)

In addition to ground nests, gorillas also build aerial nests in the evening before sleeping. A total of 27% of the nests are aerial. For constructing these nests, the gorillas choose a shrub or tree, and the nests are built at a height. The gorillas typically use most of the leaves and small branches of the tree, and they also add the trunk for shrubs. Other materials from surrounding species may also be incorporated into the nest construction. The shrub *Xymalos monospora* is the most commonly used species for building aerial nests (Table 7), followed by *Chassalia subochreatea*. Among trees, *Trichilia volkensii* is the most frequently used species.

The heights of the nests vary. The most common heights for aerial nests are between 4 to 6 meters (33 nests), followed by heights between 1 to 3 meters (22 nests). The highest nests are located between 13 to 15 meters, with 10 nests (Table 7).

Table 7. Host Tree Species, Heights Reached, Parts Used, and Number of Nests Built

No.	Host Species	Families	Height (m)					Parts used		No. of nests
			1-3	4-6	7-9	10-12	13-15	Branches	Trunk	
01	<i>Alchornea hirtella</i>	Euphorbiaceae	5	2				Br		7
02	<i>Albizia gummifera</i>	Fabaceae		1				Br		1
03	<i>Allophylus kivuensis</i>	Sapindaceae			1	1				2
04	<i>Bersama abyssinica</i>	Melanthaceae			1					1
05	<i>Chassalia subochreatea</i>	Rubiaceae	2	2	3	2		Br	Tr	9
06	<i>Dombeya torrida</i>	Malvaceae		2				Br		2
07	<i>Galiniera coffeoides</i>	Rubiaceae	4	3	1			Br	Tr	8
08	<i>Lindackeria kivuensis</i>	Flacourtiaceae	1	1	2			Br		4
09	<i>Macaranga neomildbreadiana</i>	Euphorbiaceae		1			1	Br		2
10	<i>Maessa lanceolata</i>	Maesaceae				4		Br		4
11	<i>Mimulopsis excellens</i>	Acanthaceae	1					Br		1
12	<i>Neoboutonia macrocalyx</i>	Euphorbiaceae		2				Br		2
13	<i>Symphonia globulifera</i>	Clusiaceae			1			Br		1
14	<i>Sinarundinaria alpina</i>	Poaceae		2	1			Br	Tr	3
15	<i>Syzygium guineense</i>	Myrtaceae		2		1	1	Br		4
16	<i>Tabernaemontana johnstoni</i>	Apocynaceae				3		Br		3
17	<i>Tricalysia kivuensis</i>	Rubiaceae	1					Br		1
18	<i>Trichilia volkensii</i>	Meliaceae	2	1			2	Br		5
19	<i>Xymalos monospora</i>	Monimoniaceae	6	13	1			Br	Tr	20
Total			22	32	11	11	4			80

5. Discussion

Previous studies by Mühlenberg et al. (1994), Gauthier-Hion (2006), and Masiala et al. (2024) have reported that, before nightfall, gorillas stop and each individual starts to construct a simple nest using some herbaceous plants or small branches. Only the infant sleeping with its mother does not build a nest. If the ground vegetation is abundant, it provides building material, and the nests are mainly constructed on the ground; otherwise, up to 80% of them may be perched in trees. The nesting site changes depending on their movements.

During our study, we found that the nesting behavior of the Chimanku family gorillas contributes to the high-altitude eco-tourism in Kahuzi-Biega National Park. The park is divided into different sectors where the gorillas spend the night and build nests during both the rainy and dry seasons. During the rainy season, the most visited sectors are Ifukiro and Mbuli. These sectors have the densest herbaceous layers, which provide dominant ground-based food sources, especially the species *Urera hypselodendron*, which is consumed 98% for its leaves (Yamagiwa et al., 2005; Masiala et al., 2024). Maldague (1994) states that vegetation serves different purposes (i) providing essential food substances for many species; (ii) offering animals shelter, and (iii) providing suitable places for reproduction. Our observations confirm that the Chimanku family gorillas change their nesting sites primarily in search of food during both seasons. Gauthier-Hion (2006) mentions that a gorilla can eat up to 18 kg of food per day. Barhakaziga (2010) shows that the search for food is also seasonal. The Mbuli sector has 195 nests built, and dividing this by 21 adult individuals in the Chimanku family means they spend 9 days in this sector, which benefits the vision tourism, allowing visitors to discover the Chimanku gorillas and understand the nesting habits of Grauer's gorillas. Yamagiwa et al. (2006) confirm that gorillas can spend up to 7 days in the same sector in Kahuzi-Biega National Park.

During the dry season, nesting activity is less intense. Yamagiwa et al. (2005) confirm our observations, as previous studies emphasize how food availability and distribution strongly influence various aspects of primate behavior, particularly gorillas. Yamagiwa and Mwanza (1994) and Yamagiwa et al. (2008) confirm that the eastern lowland gorilla (*Gorilla beringei graueri*) is a very difficult species to study, with a highly varied diet, being both frugivorous and herbivorous. Masiala et al. (2024) report that gorillas consume more fruit from *Myrianthus holstii*. Fewer sectors are visited during the dry season, with the Nyamuhambanza and Muandagalo sectors being the most visited, where we found 87 nests in the Nyamuhambanza sector. Gorillas construct fewer nests in these sites, staying only 4 days per sector. This makes it more difficult for visitors to discover nesting sites and reduces their chances of observing fresh nests during this season.

The frequency and types of terrestrial nests also depend on the season. Gorillas use different vegetation layers: herbaceous, shrub, vine, and arboreal layers. Clutton-Brock and Harvey (1997) support the idea that vegetation distribution creates a socio-ecology for primates. If foliage is denser and more evenly distributed than fruits, folivorous primates, due to their body size, spend less time and energy searching for food compared to frugivores. Gauthier-Hion (2006) notes that the *Gorilla beringei graueri* subspecies is the largest and has an intermediate diet.

During the rainy season, it is the herbaceous layer, and during the dry season, it is the shrub layer. This is also linked to the intermediate diet of the Grauer gorilla (Barhakaziga, 2010). These differences in vegetation layers influence vision tourism. Macfie and Williamson (2010) note that visibility is poor in the forests of the western plains, and great apes often remain hidden even when within 10 meters of an observer. In contrast, mountain gorillas benefit from low vegetation and irregular topography that provide ideal observation conditions, sometimes from the opposite side of a ravine. Herbaceous and shrub layers facilitate vision tourism, and visitors can discover the hidden side of Grauer's gorillas through nesting behavior. Macfie and Williamson (2010) also mention that if the great apes are not easily visible upon initial approach, the guide should escort and move tourists to a distance of 200 meters to wait until the apes rest or move into a more open area, where the permitted observation period can begin.

The type of terrestrial nests also varies by season depending on the materials used. Gorillas in the Chimpanzee family utilize different construction materials depending on the vegetation layer. During the rainy season, the herbaceous layer is abundant, providing more grass nests. Vision tourism should be based on conservation principles (Plumptre and Williamson, 2001). The species *Mimulopsis solmsii* is the most used in nest construction, followed by *Triumfetta cordifolia* and *Pilea bambuseti*. The nesting behavior proves that the herbaceous layer in high-altitude areas is more colonized by *Mimulopsis solmsii*, whose leaves and stems are used as bedding by the gorillas. During the dry season, terrestrial nests are more commonly constructed with *Chassalia subochreatea*, with branches being the primary material. These findings complement the visitors' experience before observing the animals. Our study did not specify which categories of gorillas construct each type of nest. Sometimes, gorillas do not build nests and sleep on the ground using fallen leaves. There are also failed nests, where gorillas do not sleep at the site due to (i) imminent danger. Yamagiwa (2001) reports that leopards have been found in the mountain forests of Kahuzi-Biega, and local populations spotted them as recently as the 1970s, or (ii) because of food scarcity during the dry season, where fruits are the primary food source (Masiala et al., 2024). Visitors may encounter this type of nest and gain more insights into vision tourism. Maldague (1994) and Puig (2001) emphasize that it is crucial to further examine the various roles of vegetation cover, as its relationship with climate, soil, and fauna is fundamental. Weghe (2004) indicates that fauna can serve as an indicator of ecosystem quality.

Aerial nests are also constructed during both seasons. During the rainy season, gorillas build aerial nests on either trees or shrubs. The tree *Dombeya torrida* is the most colonized for aerial nests, while the shrub *Galiniera coffeoides* is the most used. They reflect the state of the woody vegetation in high altitudes. The species *Dombeya torrida* is found in human-made secondary formations (Mühlenberg et al., 1994). For nest heights, 95% of the nests are between 1 and 10 meters high. In the montane ombrophile forests and secondary vegetation, where the altitude ranges from 1,600 to 2,700 meters, the vegetation is lower than that in lowland forests, and size tends to decrease slightly as altitude increases (Masiala et al., 2024). These heights allow for better visibility of nests by visitors. The shrub layer, dominated by *Galiniera coffeoides*, is characteristic of the understory.

There are also aerial nests built on the herbaceous layer, where the species *Mimulopsis solmsii* forms herbaceous vaults with heights ranging from 1 to 3 meters (61%). Some species, such as *Triumfetta cordifolia* and *Urera hypselodendron*, may be associated with these aerial nests. Gauthier-Hion (2006) mentions that adult males weigh between 160 to 200 kg and have an average height of 180 cm, while females weigh between 70 to 114 kg and measure 150 cm. It is the younger individuals who build nests at these heights, such as juveniles (3–6 years) and sub-adults (6–8 years). These nest heights help tourists better understand the nature of aerial nests.

During the dry season, nests are more often built in shrubs than in trees. The shrub *Xymalos monospora* is the most colonized, and the tree *Trichilia volkensii* is the most used. The most common nest heights are between 4 to 6 meters. This also promotes vision tourism within this layer. Macfie and Williamson (2010) note that the success of visits to a given site will depend on the type of tourist, the habitat, the species or subspecies involved, and the activity offered. Nesting also contributes to this experience.

6. Conclusion

Our study on the contribution of nesting to vision tourism management in Kahuzi-Biega National Park revealed that gorillas move across different sectors during both the rainy and dry seasons. The sectors of Ifukiro and Mbuli were the most visited during the rainy season, while Nyamuhambanza and Muandagalo were the most visited during the dry season. They also move outside the park and spend the night there.

Gorillas can stay for up to 9 days in one sector, which makes it easier to locate them during tourism activities in the rainy season. They build fewer nests during the dry season, making them harder to find. The herbaceous layer was more commonly used in nest construction during the rainy season, indicating that the Chimanku family gorillas require a natural, undisturbed habitat rich in vegetation.

Gorillas build more terrestrial nests than aerial ones, suggesting that they find more vegetation materials on the ground to meet their needs. This also confirms the abundance of the herbaceous layer in their home range, which is favorable for both animal observation and vision tourism.

Among the aerial nests, the dominant heights range from 1 to 10 meters. This shows that, at higher altitudes, trees do not grow very tall, which facilitates the observation of gorillas while feeding at height. The species *Mimulopsis solmsii* is the most used in nest construction and is the most dominant species in the gorillas' home range. It is also part of their diet.

For shrubs, the species *Chassalia subochreatea* is the most used, followed by *Mimulopsis arborescens* for terrestrial nest construction. The shrub *Galiniera coffeoides* is the most commonly used for aerial nests. For trees, *Dombeya torrida* is the most colonized for aerial nests, followed by *Neobutonia macrocalyx*. Three species dominate in terms of fruit consumption: *Africana kivuensis*, *Myrianthus holstii*, and *Maessa lanceolata*. These findings emphasize the educational aspect that vision tourism should play, while also highlighting the importance of preserving the natural habitat for the stability of the Chimanku family gorillas.

The tourism service should indicate in the guide that visitors can see fresh gorilla nests, reinforcing the educational aspect of the gorillas' natural habitat and the importance of conservation.

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