EJSIT
European Journal of Science, Innovation and Technology
ISSN: 2786-4936
www.ejsit-journal.com
Volume 6 | Number 3 | 2026

Diversity of Primates in the Mukingiti and Kingombe Gorilla Reserve in Lubutu Territory, Bitule Sector (Maniema Province, D.R. Congo)

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ABSTRACT

Our study focused on the Mukingiti Gorilla Reserve (REGOMUKI), a buffer zone of Maiko National Park in the Democratic Republic of the Congo. This reserve is managed directly by local communities through the Bitule and Omate Local Community Forest Concessions (CFCL). However, increasing human pressure is observed, including poaching, agricultural clearing, and mining activities. Despite this, the area has maintained remarkable ecological integrity.

Our field inventories recorded no fewer than nine primate species. These include the Chimpanzee and Grauer's Gorilla, an endemic species of the region that is critically threatened. Chimpanzees were the most frequently observed. In contrast, colobus monkeys, which are more sensitive to hunting pressure, are becoming increasingly rare.

This forest, with its high species diversity and apparently stable populations, proves to be an essential refuge. It undoubtedly constitutes a true sanctuary, a biodiversity center of exceptional value that must be preserved.

Keywords: Diversity, Distribution, Primates, Mukingiti and Kingombe Gorilla Reserve, Lubutu, Maniema

INTRODUCTION

Hunting for consumption or trade is considered one of the greatest threats to mammals in tropical rainforests (Fa et al., 2002a,b; Poulsen et al., 2011). In Central Africa, bushmeat demand is high (Wilkie et al., 2016), and hunting intensity is particularly severe (Hegerl et al., 2018). In the D.R. Congo, severe wildlife depletion has been documented in protected areas (Linchant et al., 2015; Van Vliet et al., 2023a,b), mainly attributable to unsustainable hunting practices (Van Vliet et al., 2017; Nathalie et al., 2021).

Under such pressure, large and medium-sized mammals with slow growth and low reproductive rates are generally the first to become locally extinct (Poulsen et al., 2011). This is the case for the Mukingiti and Kingombe Gorilla Reserve, one of the buffer zones of Maiko National Park, which is not spared from this phenomenon.

Commercial and subsistence hunting constitute major activities for surrounding populations (Nyange, 2014; Ngabinzeke & Tongo, 2019). It even extends into the core zone, which is theoretically strictly protected from human activities (Cizungu et al., 2021). However, very little information currently exists regarding the state of wildlife and animal offtake within this reserve.

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Problematic

Humanity is highly dependent on the natural ecosystems it occupies and exploits, as well as on the immense animal and plant biodiversity these ecosystems support (Ibouroi, 2017).

The tropical forests of the Congo Basin constitute one of the world's most important biodiversity centers. Despite ongoing efforts to conserve this valuable region and its natural resources, threats of wildlife extinction involving great apes (gorillas, chimpanzees, baboons), small monkeys (red colobus, *Cercopithecus spp*.), and other large mammals, along with habitat loss, forest degradation, deforestation, and climate change threats, are increasing at an alarming rate.

The Mukingiti and Kingombe Gorilla Reserve, one of the buffer zones of Maiko National Park, is not spared from these ecological damages, including threats affecting mammals, particularly primates.

Today, Maiko National Park, in its buffer zone, faces multiple threats to biodiversity, including traditional and armed poaching, artisanal mining, deforestation due to human settlement through armed group camps, village establishment, and agricultural expansion (Koto-te-Nywa et al., 2014).

Besides the threats they face, primates play an important role in seed dispersal through fruit consumption (Chapman, 1995; Refisch, 1998; Chapman & Perez, 2001). Seeds may retain their germination capacity after passage through primate feces (Cyrille et al., 2001).

However, they are also subject to strong anthropogenic pressures that may compromise long-term conservation (Caspary et al., 2001; Yéo et al., 2013).

The major causes of primate decline worldwide are directly linked to increasing anthropogenic pressures on primates themselves and their natural habitats, associated with demographic growth, agricultural expansion, logging, road construction, large-scale deforestation, and habitat loss.

This research aims to address questions related to primates in the REGOMUKI forest massif concerning primate composition, relative abundance, and spatial distribution.

This study was conducted in the southern sector of the buffer zone of Maiko National Park, within the REGOMUKI Community Reserve (Mukingiti Gorilla Reserve).

With an area of 116,100 hectares, this reserve is located in five groupings of Lubutu Territory (Mandimba/Osso, Batikamwanga, Babongena, Okoku, and Babute) along the Osso axis, in Bitule Sector, Maniema Province.

This community reserve supported the process of establishing Local Community Forest Concessions (CFCL), in accordance with Decree No. 14/018 of August 2, 2014, establishing procedures for allocating local community forest concessions.

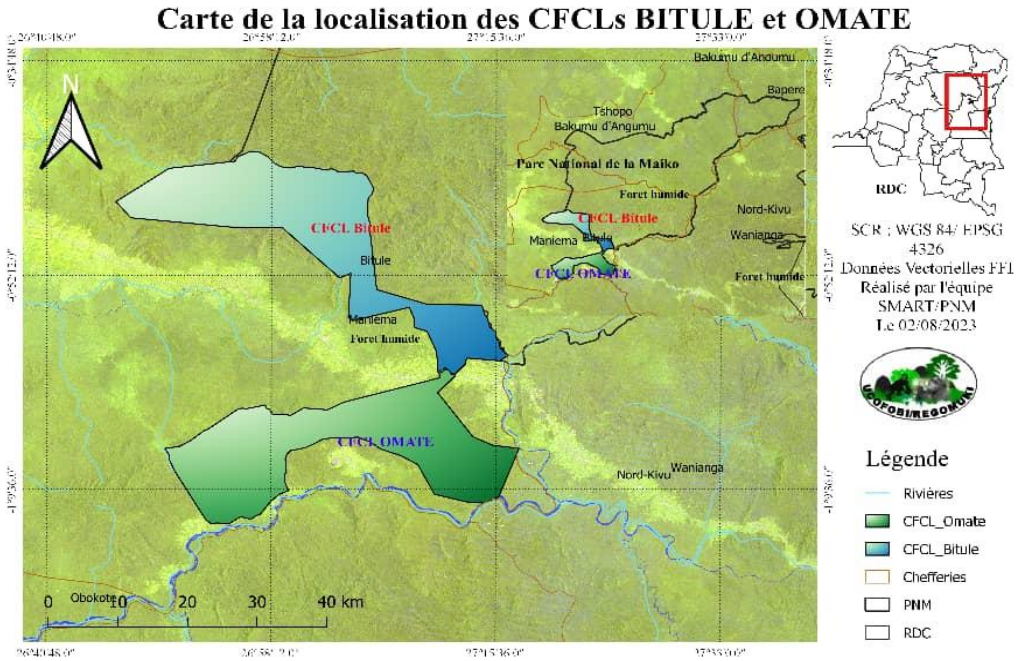

Figure 1. Map of CFCL Bitule and Omate

Being contiguous with Maiko National Park and due to its position straddling the Equator, REGOMUKI (Mukingiti Gorilla Reserve) experiences an equatorial climate characterized by two rainfall minima (January and July) and two maxima (April and October) during the year. Maiko National Park lies within the humid intertropical zone and receives regular precipitation with relatively constant warm temperatures.

REGOMUKI is drained by an important hydrographic network comprising the Kiti, Lubutu, Osaka 3, Amaokota, Gboto, Amaeboma and Osabende rivers. All of these rivers are tributaries on the right bank of the Congo River and contribute to regulation of its hydrological regime and global climate.

MATERIALS AND METHODS

Materials

The biological material used in this study consisted of primates recorded through direct and indirect observations in REGOMUKI during patrol activities. Observations were conducted monthly from January 2020 to August 2023, with 10 patrol days per month.

The technical equipment used for large mammal inventories included a GPS Map64S, a compass, a camera, binoculars, camera traps, and the Mammals of Africa guide (Kingdon, 2017). The use of camera traps contributed to improving observations of primate populations in REGOMUKI. These traps were placed in locations where signs of primate presence (nests, feeding remains, etc.) had been recorded.

Methods

Field Data Collection

Data were collected using the reconnaissance walk method known as 'Recce', within a radius of 5 kilometers (Maisels, 2004a,b). This method consists of recording wildlife or other observations while moving along paths of least resistance (animal trails, human paths, open understory, etc.).

This 'Recce' method is relatively low-cost and allows teams to cover larger areas within a short period while minimizing environmental disturbance (Walsh and White, 1999; White and Edwards, 2000).

For data collection, a team composed of three groups was established:

1. Local guides with expertise in recognizing signs (feeding signs, footprints, food remains, feces, nests, etc.) indicating the presence of different animal species. For efficiency, successive isolated camps were established inside the forest.

2. Patrol staff responsible for researcher safety and with strong knowledge of the study area to facilitate forest access.

3. One person responsible for recording all field observations on data sheets.

Inventories were based on direct and indirect signs of animal presence in the study area. Direct observations included live animals (monkeys) and their vocalizations. Indirect observations included feces, footprints, trails, nests, feeding remains, and other signs.

a. Detection of Presence Indicators

Each reconnaissance line was numbered, and each team selected a number, one even and the other odd. Observations were made progressively along transects established by guides, following pre-selected compass bearings. Ground observations were recorded within a width of 1 m on either side of the line traced by the compass bearer and tracker.

The presence of great apes (gorillas and chimpanzees) was confirmed through detection of nests, individuals, feces, vocalizations, footprints, feeding traces, and other indicators.

b. Counting and Observation of Primates

In particular, nests were counted individually rather than using group or nest-site counting techniques, in order to avoid overestimation through counting nests not belonging to the focal group.

Data on small primates were primarily based on individuals observed visually and identified through vocalizations. Each species was recorded separately and the number of individuals counted, even when polyspecific groups were observed.

All signs indicating human presence or activities (individuals, vocalizations, motor noise, transit signs, extraction, exploitation, roads, tracks, traps, cartridge cases, camps, etc.) were recorded.

Data Processing and Analysis

Statistical analyses were conducted using PAST software (PAST 2.17.c). Three indices were used to study community structure. To analyze changes in species biodiversity in REGOMUKI, Shannon diversity, Simpson diversity, and evenness indices were used.

RESULTS

We present the tables derived from the synthesis of our field sampling results. These are divided into two major parts: one presenting results on sampled primate diversity, wildlife potential, relative abundance of observed ecological indicators, and indicators of anthropogenic activities threatening wildlife in REGOMUKI.

Primate Diversity in the Mukingiti and Kingombe Gorilla Reserve (REGOMUKI)

Signs of primate presence were recorded in all CFCLs (Local Community Forest Concessions) of REGOMUKI, although at different frequencies (Table 1).

Table 1. Observation effort for primate signs in REGOMUKI

Family	Species	Total number	Frequency (%)
Cercopithecidae	*Cercopithecus ascanius whitesidei*	881	21,43
	Cercopithecus mitis stuhlmani	476	11,56
	Cercopithecus mona denti	418	10,15
	Allocrocebus lhoesti	226	5,44
	Cercopithecus hamlyni	306	7,43
	Lophocebus albigena	49	1,19
	Piliocolobus langi	1	0,02
Hominidae	*Pan troglodytes schweinfurthii*	1310	31,83
	Gorilla beringei graueri	449	10,91
Total	9	4116	100

Results from Table 1 indicate that the presence of nine primate species was confirmed through direct and indirect observations in the Bitule and Omate CFCLs. The observation frequency of Pan troglodytes was the highest (31.83%), followed by Cercopithecus ascanius whitesidei (21.43%). Species rarely observed in the two CFCLs (Bitule and Omate) were colobines: Lophocebus albigena (1.19%) and Piliocolobus langi (0.02%).

Primate Diversity Indices by Sampled CFCL

Analysis of data collected in Bitule and Omate enabled calculation of diversity indices, providing an overview of the structure and richness of primate communities in these two CFCLs. These results are presented in Table 2.

Table 2. Results of primate diversity indices in the Bitule and Omate CFCLs

Indices des présences		
Factors	**CFCL Bitule**	**CFCL Omate**
Number of species S	9	8
Dominance	0,18	0,20
Simpson (D)	0,81	0,79
Shannon (H)	1,86	1,77
Evenness (E)	0,84	0,85

Caption : D= indice of Simpson ; H= indice of Shannon ; E= Evenness

The results presented in Table 2 show that these two CFCLs (Bitule and Omate) exhibit robust ecological health. These results suggest that community-based management in these two CFCLs is yielding positive conservation outcomes for primates. The identical evenness value (0.84) indicates that both forests function under a similar ecological model, despite a slight difference observed in Bitule.

Wildlife Potential of the Study Area

Biological inventories conducted in REGOMUKI confirm the richness of local wildlife heritage. In this results section, we present a detailed analysis of relative abundance and major structural indices of primate communities.

The assessment of wildlife potential was based on 11 distinct ecological indicators: two direct indicators (vocalization and observation) based on visual detection of primates, and nine indirect indicators based on signs of presence (nests, calls, feces, tools, browsing signs, footprints, carcasses, and food remains).

Observed Ecological Indicators in REGOMUKI and Their Relative Abundance

As indicators of primates, we considered 11 ecological indicators including indirect indicators (nests, feces, tools, browsing signs, footprints, carcasses and food remains) and direct indicators (vocalization and observation).

Table 3. Frequency of primate signs in the Mukingiti and Kingombe Gorilla Reserve

Ecological indicators	Category	%
D.E.I (65,9%)	Voice	38,5
	Visual Observation	27,4
I.E.I (34,1%)	Nest	12,82
	Fecal	5,46
	Tools	1,04
	Grazing	8,57
	Fingerprints	6,12
	Carcass	0,07
	Food rest	0,02

Caption : D.E.I : Direct ecological indicators ; I.E.I : Indirect ecological indicators

The results in Table 3 highlight a predominance of direct ecological indicators (65.9%) over indirect indicators (34.1%) within REGOMUKI. Primate identification primarily relied on vocalization (38.5%) and visual observation (27.4%). Among indirect signs, nests were the most represented (12.82%), followed by feces (5.46%) and, more marginally, food remains (0.02%).

Indicators of Anthropogenic in REGOMUKI

To assess the degree of habitat disturbance, we present results related to indices of anthropogenic pressure recorded in Bitule and omate, highliting the main threats affecting wildlife in REGOMUKI

Table 4. Anthropogenic indices in the two CFCLs

Activity	CFCL Bitule	CFCL Omate	%
Agriculture	0,98	3,61	4,59
Gold mining	2,95	7,57	10,52
PFNL extraction	-	0,33	0,33
Mining 3T : cassitérite and coltan)	2,30	3,25	5,55
Illicit fishing	1,31	1,64	2,95
Traditionnal traps	21,31	22,95	44,26
encampment	8,85	4,59	13,44
Cartridge sleeve	11,15	5,25	16,39
Poachers	1,31	0,33	1,64
Tools	0,33	-	0,33
%	50,49	49,51	100

The inventory of anthropogenic activities within REGOMUKI identified ten key indicators summarized in Table 4. Spatial analysis reveals that human pressure is higher in the Bitule CFCL (59,48%) than in Omate (40,52%). The most frequent indicators were traditional traps (44,26%) and cartridge sleeve (16,39%), highlighting intense hunting activity. In contrast, NTFP extraction (Non-timber Forest Products) and the presence of tools (0,33%) represented the lowest anthropogenic indicators in both concessions.

DISCUSSION

In view of the 4116 observations recorded in the field, this study provides a solid basis for discussing primate diversity, relying on a significant distribution between direct observations and indirect signs of presence.

Species Diversity and Relative Abundance of Primates Sampled in REGOMUKI

Studies conducted in REGOMUKI allowed us to inventory nine primate species in the two CFCLs (Bitule and omate). The observation frequency of *Pan troglodytes* is the highest (31,83%), followed by *Cercopithecus ascanius* (21,43%). The least frequently observed species in both CFCLs are Colobines : *Lophocebus albignena* (1,19% and *Piliocolobus langi* (0,02%).

These results can be explained by the fact that primates are still the zoological group with viable populations in this sector, due to the rarity of near disappearance of other groups such as Proboscideans and Artiodactyls, which are threatened by poaching (Nebesse, 2022). The presence of *Cercopithecus ascanius* suggest a primary or slightly fragmented forest structure where more sensitive species such as Colobines can maintain stable populations. *Cercopithecus ascanius* shares its ecosystem with more sensitive species such as the eastern lowland gorilla (*Gorilla gorilla graueri*) and/or the chimpanzee (*Pan troglodytes*), which is an indicator of high conservation value forest. The presence of these species (notably the Grauer's gorilla, endemic and threatened, and the chimpanzee) demonstrates that these CFCLs play a critical refuge role for regional biodiversity.

The low abundance of *Piliocolobus langi* and *Lophocebus albigena* in these forests is likely due to their high vulnerability to hunting (Koné, 2004 a et b ; Koné , 2028 ; Béné *et al.,* 2013).

Bshary & Noé, (1997) also showed that red colobus monkeys are highly vulnerable to hunting because they are not very skilled at detecting hunters and predators. Once a hunter spots a group of red colobus, these monkeys often show curiosity or even aggression. They rarely adopt a "hide and wait" strategy like other monkeys, making them easy target (Refisch, 1998).

In the Luki Biosphere reserve, studies based on indirect signs and camera trapping (excluding arboreal animals) have repeatedly shown that *Cercopithecus cephus, perodictus potto*, *Pan troglodytes* and *Cercopithecus spp*. Are the most frequently observed primates (Enganga, 2015; Djami et al., 2023).

This difference may be due to the methodology used as well as the sampling protocol. In our case, we conducted reconnaissance walks based on both direct and indirect observations of primate presence. It should be noted that nocturnal primates (prosimians) were not observed due to the methodology used, as observations were carried out only during the day.

The analysis of diversity indices within the Bitule and Omate CFCLs demonstrates remarkable ecological integrity, characterized by high species diversity (H′) and an even distribution of populations (J′ = 0.84). The simultaneous presence of nine primate species, including highly threatened and endemic taxa such as the Grauer's gorilla (*Gorilla gorilla graueri)* and the chimpanzee (*Pan troglodytes*), confirms that these forest blocks are not merely transition zones but true biodiversity sanctuaries. The absence of dominance by opportunistic species, reflected by high Simpson index values, indicates a stable community structure where ecological niches are preserved.

These results highlight the crucial effectiveness of community-based management in protecting primate habitats. The stability of indices between the two concessions suggests functional forest connectivity, essential for the survival of wide-ranging species such as great apes. Therefore, maintaining these diversity parameters constitutes a key performance indicator for long-term monitoring of these CFCLs. The protection of this wildlife heritage, reinforced

by the presence of rare species such as Cercopithecus hamlyni, must remain a strategic priority to ensure the resilience of forest ecosystems in the region in the face of increasing anthropogenic pressures (Nasi et al., 2011; Nasi & Van Vliet, 2012; Nasi et al., 2018).

Observed Ecological Indices

In the REGOMUKI reserve, we recorded 11 types of indices to assess primate presence. These indices include direct signs such as vocalizations and visual observations, and indirect signs such as nests, feces, feeding traces, footprints, carcasses, food remains, or possible tools.

Direct indices accounted for approximately 65.9% of detections. Among them, vocalizations were the most frequent (38.5%), followed by direct observations (27.4%). Indirect indices accounted for 34.1% of recorded signs. Nests were the most commonly found (12.82%), followed by feces (5.46%), while food remains were rarely observed (0.02%). The distribution of these indices varies between the two community forest concessions studied.

Determining the age of primate nests can provide valuable information to better understand local population dynamics, as highlighted by White & Edwards (2000). These authors propose a classification into four categories: fresh nests (with recent droppings and/or noticeable odor), recent (vegetation still mostly green, reduced odor, sometimes some droppings), old (structure intact but vegetation dry, no droppings), and very old (advanced decomposition). In our case, due to time constraints during sampling, we were unable to perform this dating. Nevertheless, the repeated presence of nests and feces in REGOMUKI confirms regular and current occupation by primates in the reserve. For other indirect indices, precise dating is less crucial since they are ephemeral signs that disappear relatively quickly.

Indicators of Anthropogenic Activities

Among the causes of primate decline, human activity is by far the most significant (Zadou et al., 2011). During this study, various indices indicated the presence of human activities in the forests of the two CFCLs.

Indicators of human pressure in the two CFCLs (Bitule and Omate) were more frequently observed in Bitule (50.49%) than in Omate (49.51%). The presence of traditional traps (44.26%), followed by cartridge shells (16.39%), was recorded. However, regular human presence in these forests may disturb primates and increase harvesting pressure. Activities such as agriculture, logging, gold mining, mineral extraction, and hunting directly threaten their survival. Not only do these activities destroy habitats, but substances such as mercury used in mining contaminate water bodies. When ingested by primates drinking from these sources, such pollutants can cause severe neurological disorders.

Logging also has major consequences: it rapidly reduces primates' home ranges, limiting movement and shortening lifespan. In response, the Congolese state must act to mitigate the impacts of human activities and preserve these concessions. Without strong measures, this relict population could disappear locally.

Human presence may also disrupt primate behavior and increase hunting pressure. These species could otherwise thrive if not for the most threatening factors, namely poaching and agriculture through deforestation (Béné et al., 2012). Deforestation driven by agricultural expansion is a global reality (Moussa & Amadou, 2014; Moussa, 2014; Moussa et al., 2014).

Hunting tools are non-selective and therefore do not allow sustainable wildlife management (Béné et al., 2015). Logging also has numerous negative impacts on primate populations, accelerating the reduction of their home ranges and shortening their lifespan. In Lopé, Gabon, White (1994) showed that chimpanzee groups displaced by logging experienced lethal conflicts with other groups when attempting to settle in already occupied territories.

Moreover, this activity leads to the opening of access roads, allowing farmers and hunters to reach previously inaccessible areas (Zeta & Kragbé, 2012).

Mining and gold panning are also dangerous for primates (Bebbington & Williams, 2008). In addition to habitat destruction, chemicals such as mercury used in these activities contaminate water bodies. Once ingested by primates, these substances can cause neurological disorders (Bwenda, 2013).

CONCLUSION

During our field study, we surveyed several areas within the two forest concessions of the reserve. We identified nine primate species. Unlike other animal groups whose populations are declining, monkeys and other primates appear to be thriving here. Their presence is evident: we encountered numerous nests and fecal traces, indicating an established and active population.

These observations confirm that REGOMUKI plays an essential refuge role for these species. They also demonstrate that the community-based management model can be effective in preserving biodiversity. However, this success remains fragile. Human pressures are still strong: poaching using traps and firearms, forest fragmentation… all of which pose serious threats to the future of great apes.

The long-term sustainability of this exceptional ecosystem largely depends on the commitment of the Congolese authorities. It is urgent to strengthen existing laws and strictly regulate human activities. Without such measures, these already vulnerable populations could disappear forever.

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