

Confirmed Presence of a Small, Isolated Population of *Cercopithecus mitis* on Idjwi Island, Democratic Republic of Congo

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Abstract: The blue monkey (*Cercopithecus mitis*) was presumed extirpated from Idjwi Island, Lake Kivu, eastern Democratic Republic of Congo (DRC) due to widespread deforestation and habitat fragmentation in recent decades. This study confirms the presence of a small, isolated, population of at least 50 *C. mitis* individuals using camera traps and direct observation. Scan sampling was used to assess *C. mitis* feeding and vigilance behaviors in the remnant Bulolero Forest and adjacent agricultural fields. We also conducted Knowledge-Attitude-Practice (KAP) surveys with smallholder farmers affected by *C. mitis* crop raiding. *C. mitis* exhibited higher vigilance during crop sowing and harvesting periods due to the presence of farmers. KAP surveys suggested that community attitudes towards *C. mitis* are generally negative, with the primates perceived as crop predators and opportunistically hunted for bushmeat. This study sets the stage for developing community-based conservation strategies to enhance the conservation of *C. mitis* and its habitat on Idjwi Island.

Key words: Vigilance, Feeding, Human-wildlife Conflict, Guenon

INTRODUCTION

The blue monkey (*Cercopithecus mitis*) is a highly polytypic species, with a complex and extensively debated taxonomy (Dandelot 1974; Napier 1981; Groves 2001; Grubb *et al.* 2003; Kingdon 2013, 2015; Lawes *et al.* 2013; Butynski & De Jong 2019). There are currently 16-18 subspecies are recognized, some of which lack accuracy on their geographic distribution (Stuart & Stuart 2017). Because few molecular studies including *C. mitis* have been conducted (e.g., Zinner *et al.* 2022), classification of *C. mitis* subspecies are largely based on phenotypic traits such as coloration and fur patterns and on geographic distributions (Butynski & De Jong 2022).

C. mitis on Idjwi Island in Lake Kivu, eastern Democratic Republic of Congo may represent one of three subspecies, *C. mitis schoutedeni*, *C. m. stuhlmanni*, or *C. m. doggetti*, which differ in coloration and geographic distribution. *C. m. stuhlmanni* has a short, very dark dense coat, grizzled back, black cap with sharply defined blue-grey grizzled diadem while *C. m. doggetti* is grizzled grey or golden back, black cap with sharply defined, grizzled diadem (Kingdon 2015). Phenotypically, *C. m. schoutedeni* has been distinguished from the two nearest subspecies of *C. mitis* (*C. m. stuhlmanni* and *C. m. doggetti*) based on color variation (Stuart

& Stuart 2017; Butynski & De Jong 2022). *C. m. schoutedeni* exhibits broad color variation spanning from gray to silver gray, with a notably dark dorsal region and a predominantly dark coat variably speckled with lighter patches (Schouteden 1948; Kingdon 2015). The silver-gray coloration of *C. m. schoutedeni* is the taxon's defining characteristic among the *Cercopithecus mitis* group. According to the geographic distribution of the 3 subspecies, *C. m. stuhlmanni* has an expansive range in eastern DRC, Ethiopia, and East Africa to the great Rift Valley (Kingdon 2015). There is uncertainty in the distribution of *C. m. doggetti* and the degree of overlap with neighbouring subspecies (Kingdon *et al.* 2008). *C. mitis schoutedeni* is still a poorly understood taxon. Thus, the subspecies of the *C. mitis* whose presence has been confirmed at Idjwi Island remains to be clarified.

Although *C. m. schoutedeni* had been classified as a subspecies of *C. mitis* (Kingdon 2013; Lawes *et al.* 2013; Butynski & De Jong 2019), the IUCN SSC African Primate Specialist Group currently treats the taxon as a synonym of *Cercopithecus mitis stuhlmanni* (e.g., Butynski & De Jong 2019). This taxonomic arrangement for *C. mitis* was adopted at the IUCN SSC African Primate Red List Assessment Workshop in Rome in April 2016 (Butynski & De Jong 2019). However, more molecular studies are needed to further understand the evolutionary history and taxonomy of *C. mitis* (Butynski & De Jong 2022; Zinner *et al.* 2022). Recognizing that further investigation is warranted on the validity of *C. m. schoutedeni* as a separate subspecies, we will use *C. mitis* hereafter to describe the population of guenons recently reconfirmed to be present on Idjwi Island in Lake Kivu, eastern DRC.

Since the 1980s, Idjwi Island has experienced unprecedented deforestation due to rapid human population growth and saw an influx of refugees from neighboring countries around 1994 (Kabonyi 2004; Buchekabirhi 2010; Habakaramo *et al.* 2015). The growing population was estimated at 320,000 inhabitants as of 2016 (Akilimali *et al.* 2022) and relies heavily on subsistence farming and forest resources for timber and charcoal production. These pressures have disrupted the island ecosystem and its wildlife (Thomson *et al.* 2012; Habakaramo *et al.* 2015). In particular, the Nyamusisi Forest has nearly disappeared, once having covered about 17 percent of the island's surface area (RDC-MECNT 2012; Akilimali 2017; Amani 2018). Surveys in the remnant forest indicated that several species had vanished from the ecosystem, including primates (e.g., Kabonyi 2004; Safari 2016). In fact, *C. mitis*

was widely presumed extirpated from the island (Basabose 2015).

This study provides evidence that a small, isolated population of *C. mitis* persists on Idjwi Island in the Bulolero Forest, a remnant of the Nyamusisi Forest (Figure 1). We examined feeding activity, and vigilance of *C. mitis* in the forest and adjacent agricultural fields. We also surveyed landowners to understand community knowledge, attitudes, and practices (KAP) regarding *C. mitis* and forests. Finally, we propose community-based conservation action to secure the population of *C. mitis* and its habitat on Idjwi Island.

METHODS

Study area

The study was conducted in the Bulolero Forest, which straddles the Ntambuka and Rubenga Chiefdoms, on Idjwi Island in Lake Kivu, eastern Democratic Republic of Congo (Figure 1). The Bulolero Forest is a degraded relic of the Nyamusisi Forest, formerly the largest forest on Idjwi Island (RDC-MECNT 2012; Akilimali 2017; Amani 2018). Following massive deforestation on Idjwi Island, the remaining animal species have taken refuge in forest fragments and rocky sites, such as that of Bulolero Forest (~25 ha). The people of Idjwi Island are mostly smallholder farmers. Due to population growth and the tradition of inheritance, small farms are regularly broken up into smaller plots that are insufficient for family needs.

Idjwi Island is the second largest inland island (680 sq. km of which 310 sq. km is terrestrial and 370 sq. km is territorial waters) of the African continent (Safari 2016; Amani 2018). Geographic data place Idjwi Island between 1°59' and 2°28' S and between 29°05' and 28°26' E. Idjwi remains dominated by mountainous terrain including the Muganzo mountains in the center of the north (1,829 m above sea level) and especially Nyamusisi in the center of the island, the highest peak at 2300 m altitude (Kalala *et al.* 2019) (Figure 2).

Data collection

To confirm the presence of *C. mitis* on Idjwi Island, we installed 14 infrared camera traps (Bushnell Trophycam HD aggressor, Bushnell Trophycam HD trail camera) across the study area where higher presence probability of *C. mitis* was confirmed by fresh trails, food remains, and droppings (Tobler *et al.* 2008; Xiao 2014; You *et al.*

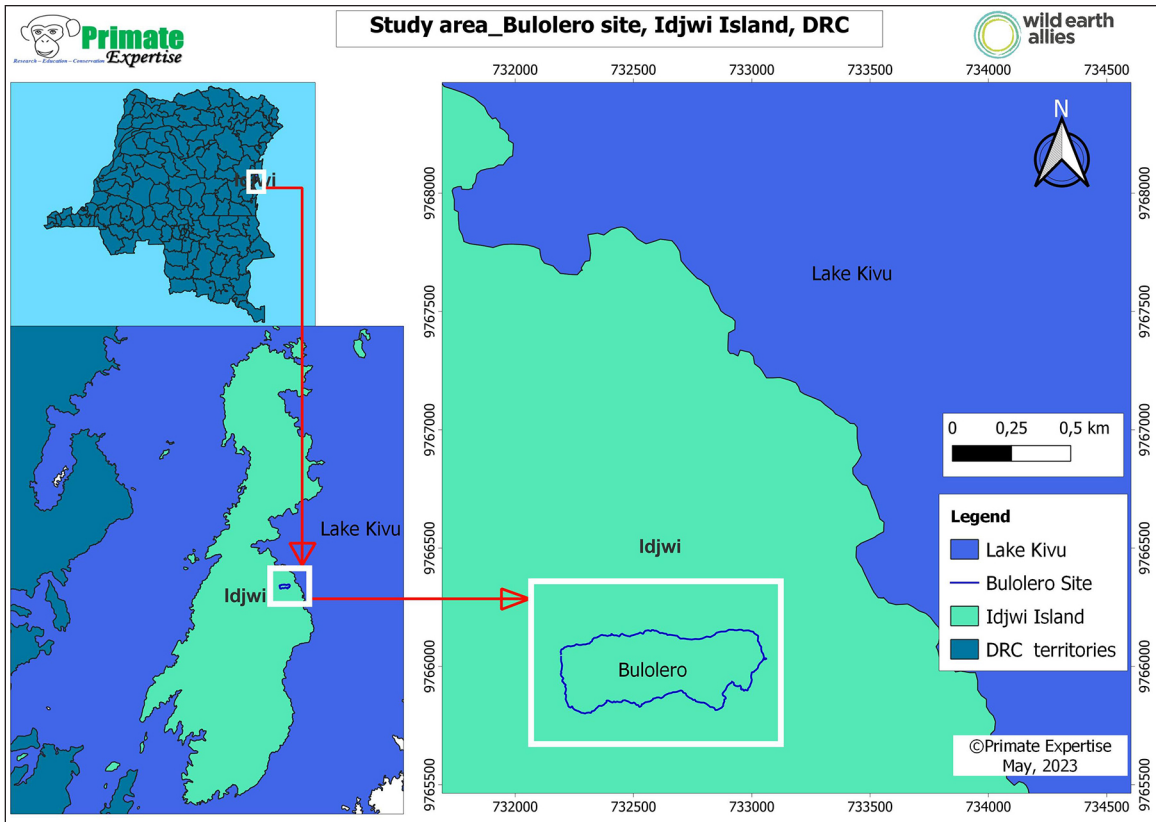


Figure 1. Location of a small, isolated population of *C. mitis* in Bulolero Forest on Idjwi Island, eastern Democratic Republic of the Congo.



Figure 2. Representative image of the rugged terrain and patchy forests of in Bulolero Forest, Idjwi Island, eastern Democratic of Congo. Photograph by Augustin Basabose.

2022). At each installation station, cameras were oriented at 0° or 180° (North-South direction) to avoid solar rays affecting the camera lens, often with a deviation ($\pm 20^\circ$) to compensate for visual obstacles (e.g., windfalls, dense vegetation, and streams) (N'goran *et al.* 2020; Monket *et al.* 2021). The cameras were attached to trees at heights of 40-60 centimeters above the ground (Figure 3). All camera traps functioned properly and remained operational for 15 days in April 2019. The cameras were set to hybrid mode (video and photo) taking three photos followed by a 60-second video. Our overall sampling effort represented 210 camera trap days.

We assessed the vigilance and feeding behavior of *C. mitis* in their core range to understand how the primate responds to human presence during periods of farming activity. The monkeys in this study were afraid of the human presence and it was very difficult to observe the behavior of the troop members. The only activity in which the monkeys engaged that could be easily observed from a distance, and during which their vigilance behavior was observed, was feeding. Feeding included ingesting, processing, harvesting or searching for food.

Vigilance was defined as a visual scan beyond the range of the troop members, with the entire face turned towards the observers. The vigilance event was noted when a feeding individual abruptly stops eating and fixes its gaze on the observers for a moment before continuing to eat or fleeing. Vigilance and feeding behaviors of *C. mitis* were recorded using the scan sampling method (Altmann 1974) during a three-month period in 2019 (April-June), resulting in 339 5-minute observation sequences. The number of times a monkey subject exhibited vigilance in each 5-minute scan was recorded.

Finally, we conducted Knowledge-Attitude-Practice (KAP) surveys with 24 smallholder farmers whose lands were located within the core of the *C. mitis* range in Bulolero Forest. Semi-structured interviews covered community perceptions of – and interactions with – *C. mitis* and forests.

Data analysis

A one-way ANOVA was performed to compare the effect of month on *C. mitis* feeding and vigilance behaviors. Linear regression was used to assess the relationship between behavioral activity (i.e., vigilance and feeding) and human presence. R software and Jamovi software were used for analysis of behavioral data. KAP survey data were analyzed using Microsoft Excel.



Figure 3. Team researcher installs a camera trap in Bulolero Forest, Idjwi Island, eastern Democratic Republic of Congo. Photograph by Augustin Basabose.

RESULTS

Cercopithecus mitis presence confirmed on Idjwi Island

The camera traps produced a total of 1,872 images and videos with wildlife, domestic animals, and people. *C. mitis* was the most documented wildlife species, representing 2.1 percent of total captures ($n = 39$), including footage of infants and juveniles. Other wildlife captures included species of birds ($n = 27$) and rats ($n = 13$). The remaining footage captured people ($n = 1,778$) and domestic goats ($n = 15$), together representing about 96 percent of total captures. Overall, these results confirm the presence of *C. mitis* on Idjwi Island (Figure 4) and indicate high levels of human activity in *C. mitis* habitat.

Vigilance and feeding behaviors

During April-June 2019, *C. mitis* exhibited different levels of vigilance ($F = 4.77$, $p < 0.001$) and feeding activity ($F = 2.94$, $p = 0.003$) across months (Figure 5). Across all months, *C. mitis* spent more time exhibiting vigilance than feeding behaviors. Highest vigilance and lowest feeding activity occurred in May (Figure 5), which may be explained by increased human presence in agricultural fields during harvesting season.

We found a weak correlation between *C. mitis* vigilance and distance to people (Figure 6). Though



Figure 4. *C. mitis* recorded by camera traps in Bulolero Forest, Idjwi Island, eastern Democratic Republic of Congo.

C. mitis exhibited higher vigilance as people approached, the trend was not statistically significant ($r = -0.33$; $p > 0.05$). Group size had little effect on vigilance.

The time of day influenced *C. mitis* vigilance and feeding behaviors, with most activity occurring in the morning (08:00–12:00). Highest frequencies of vigilance and feeding were observed during 10:00–12:00, followed by the period 08:00–10:00 (Figure 7). Increased vigilance during late morning was likely explained by increased human activity; morning is the preferred time for cultivation by smallholder farmers in the area. In addition, there was an increase in the number of *C. mitis* during this time as they searched for food.

Community knowledge, attitude, and practices (KAP)

KAP survey respondents demonstrated good knowledge about *C. mitis* and its natural habitat. All 24 respondents confirmed that *C. mitis* is a wild animal. Seventeen respondents (70.8%) said they regularly observe *C. mitis* in Bulolero Forest, while six respondents (25%) were surprised to learn that monkeys still exist on Idjwi Island. Seven people (29.2%) knew that monkeys are primates and closely related to humans.

Overall, respondent attitudes towards *C. mitis* were negative. Of the 24 respondents, twenty people (83.3%) reported that *C. mitis* and humans

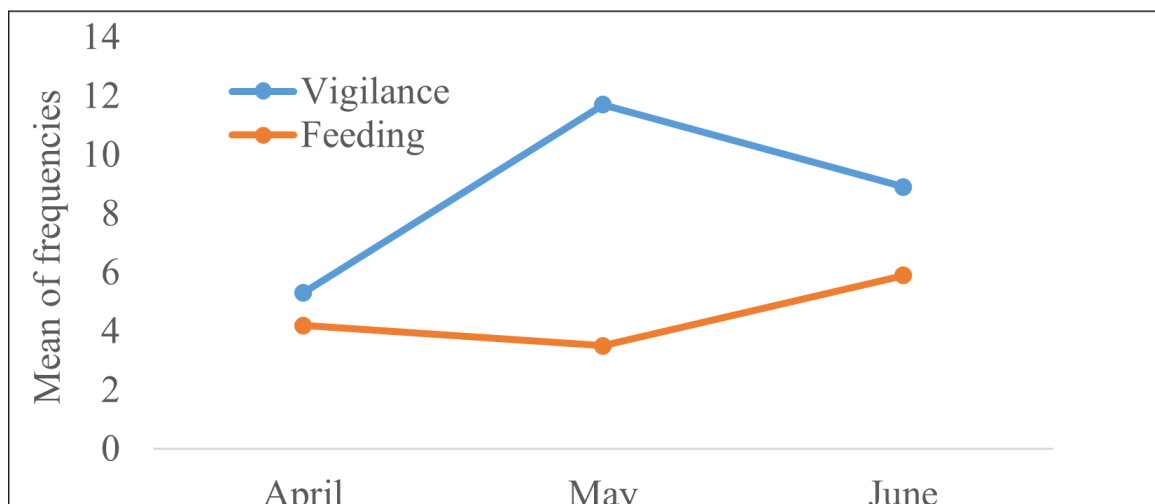


Figure 5. Frequency of *C. mitis* vigilance and feeding during April–June 2019 in Bulolero Forest, Idjwi Island, eastern Democratic Republic of Congo.

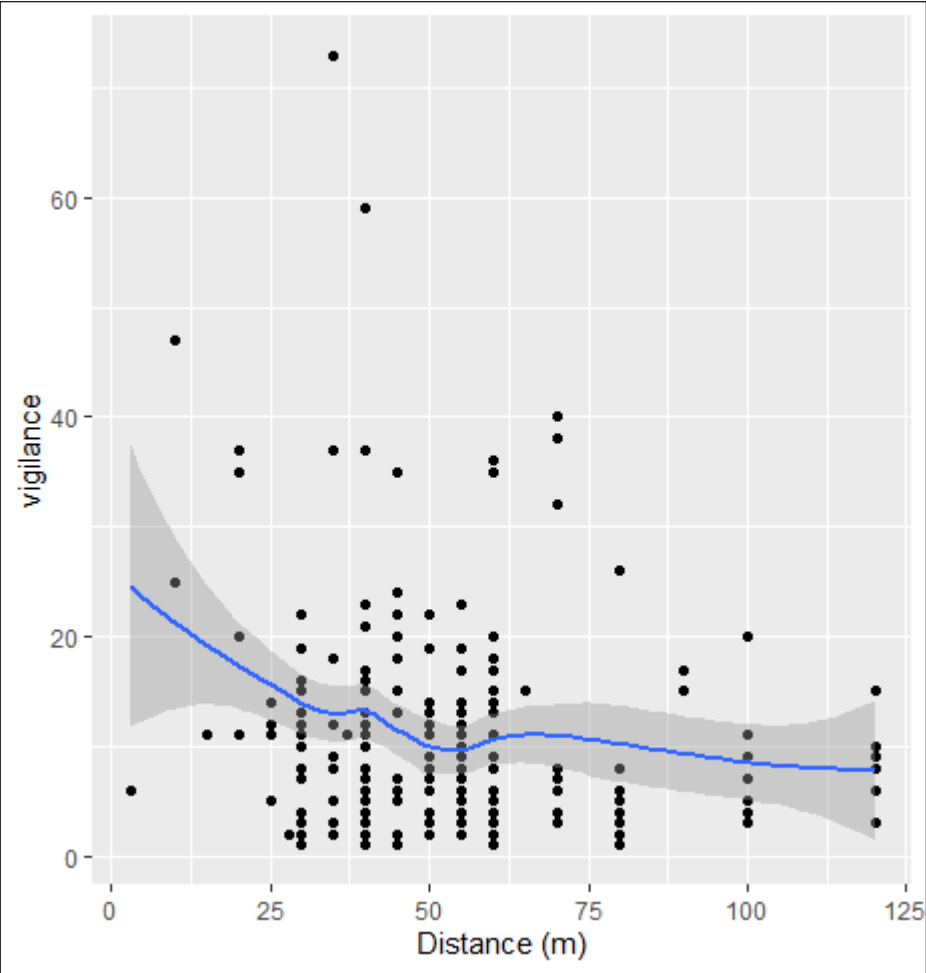


Figure 6. *C. mitis* vigilance decreased as distance to humans increased in Bulolero Forest, Idjwi Island, eastern Democratic Republic of Congo.

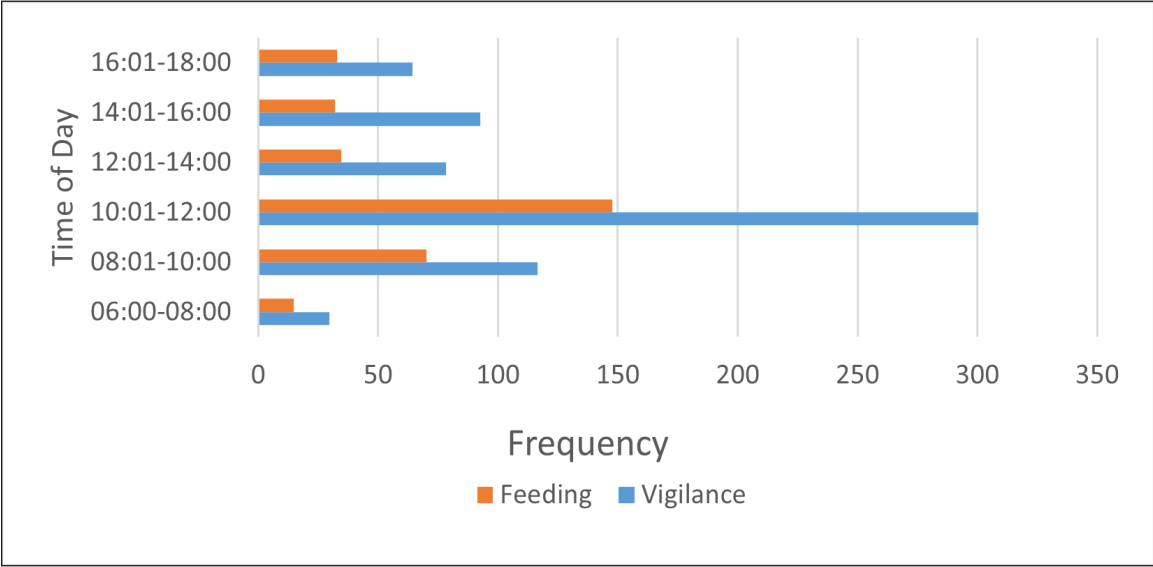


Figure 7. Frequency of *C. mitis* vigilance and feeding throughout the day (06:00-18:00) during April-June 2019 in Bulolero Forest, Idjwi Island, eastern Democratic Republic of Congo

negatively impact one another, while only four (16.7%) agreed that *C. mitis* may live near humans without issue. Ten respondents (41.6%) said that *C. mitis* raid agricultural fields.

Eleven people (45.8%) said monkeys are edible, while five (20.8%) said monkeys are considered edible only in certain Indigenous communities, such as Batwa. Eight people (33.33%) said monkeys are not edible. Most respondents (75%) reported that people hunt *C. mitis* for meat or in retaliation for crop raiding, while 10 of 24 respondents (41.6%) reported to have consumed *C. mitis*.

Landowners also demonstrated relatively good knowledge about forests and related ecosystem services. Most respondents (83.3%) considered the natural forest to be unsustainable though 75% recognized forests as a source of goods and services, such as firewood and non-timber forest products (e.g., mushrooms).

DISCUSSION

This study reconfirms the presence of *C. mitis* on Idjwi Island in eastern Democratic Republic of the Congo (DRC), following the species' presumed extirpation after decades of forest loss and fragmentation. Camera traps installed in the small, fragmented Bulolero Forest captured 39 independent photographs of individual guenons identified as *C. mitis*. Rough preliminary estimates based on camera trap footage and direct observation indicate at least 50 individuals in the population, including infants and juveniles.

This new evidence confirming the presence of *C. mitis* on Idjwi Island now warrants further study to identify the population to subspecies. While previous reports and studies (Kingdon *et al.* 2008; Kingdon 2013; Lawes *et al.* 2013) have suggested that *C. mitis* on Idjwi Island belong to the subspecies *C. mitis schoutedeni*, more recent reports treat the taxon as a synonym of Stuhlmann's blue monkey (*Cercopithecus mitis stuhlmanni*) (e.g., Butynski & De Jong 2019). Thus, genetic studies are necessary to clarify the taxonomy of *C. mitis* on Idjwi Island and its conservation status.

Regardless of taxonomic designation, the *C. mitis* population of Idjwi Island is highly vulnerable to local extirpation. Idjwi Island has undergone massive deforestation in recent decades, leaving the remaining forest habitat highly degraded and fragmented (Thomson *et al.* 2012; Habakaramo *et al.* 2015). The *C. mitis* population has taken refuge in a rocky escarpment within the Bulolero Forest, a relic of the larger Nyamusisi Forest which once

covered about 17% of the island (RDC-MECNT 2012; Akilimali 2017; Amani 2018). Our camera traps revealed high levels of human activity in the Bulolero Forest where *C. mitis* range.

This finding is unsurprising given that most of Bulolero Forest has been converted for agriculture, despite the steep, rocky slopes which characterize the landscape.

Our study also documented vigilance and feeding behaviors of *C. mitis* on Idjwi Island to understand how human activity might be affecting the population. In primates, vigilance plays an important role in survival strategies (i.e., protection from predators) and in reproductive strategies (i.e., detection of mates and competitors) (Elgar 1989; Kutsukake 2007; Busia *et al.* 2016). As predator avoidance is prioritized, vigilance behaviors may include detecting predators, monitoring group members, and sometimes assessing escape routes (Bednekoff & Lima 1998; Treves 2000).

In this study, *C. mitis* spent more time on vigilance than feeding, regardless of time of day or month. This trend was especially apparent in May when more smallholder farmers were present nearby cultivating and harvesting crops. Feeding activity decreased as vigilance increased, indicating that feeding and vigilance does occur simultaneously in this population. *C. mitis* group size had little effect on vigilance. These results indicate that *C. mitis* exhibit predator avoidance in the form of vigilance when people approach. Heightened vigilance in this population may also suggest elevated stress levels, which have negative impacts on reproduction, neurophysiological activities, and many other biological processes (Balzamo 1980; Cords 1995; Cowlshaw 1998; Busia *et al.* 2016). Therefore, the prioritization of vigilance over feeding in this population may have important implications for the long-term survival of *C. mitis* on Idjwi Island.

Knowledge, attitude, and practices (KAP) surveys conducted with smallholder farmers active in the core *C. mitis* habitat offered insights regarding the interactions between *C. mitis* and people. Though landowners generally had good knowledge of *C. mitis*, negative attitudes and practices towards the primate prevailed. Notably, many respondents regarded *C. mitis* as crop predators (41.6%), and most respondents (75%) reported that people hunt monkeys for meat or in retaliation for crop raiding. Nearly half of respondents had reportedly eaten *C. mitis* meat. Negative interactions with *C. mitis* may be attributed to two primary reasons: (1) severe poverty and food insecurity which characterize these communities, and (2) weak involvement of local

communities in primate conservation. Community awareness and engagement in conservation action will be essential to ensuring that *C. mitis* remain on Idjwi Island.

Historically, *C. mitis* inhabited Idjwi Island's natural forests and enjoyed protection from local conservation-centric tradition, including the belief that consuming primate flesh was taboo; however, intergenerational knowledge transmission has waned over time (Rahm 1966). Socioeconomic hardships and recurring social conflicts have catalyzed a paradigm shift in societal norms, prompting a surge in bushmeat hunting and deforestation, which has, in turn, precipitated habitat fragmentation and decimated the *C. mitis* population. While poverty may elucidate prevailing adverse attitudes towards natural resources, including nonhuman primates, the dearth of knowledge among younger cohorts presents a formidable impediment to conservation endeavors.

CONCLUSION AND RECOMMENDATIONS

This study confirms the presence of a small, isolated population of *C. mitis* on Idjwi Island after its presumed extirpation. Our preliminary research also identifies existential threats facing the population and underscores the urgent need for developing community-based conservation strategies to avert the extirpation of *C. mitis* on Idjwi Island. We recommend immediate implementation of the following conservation strategies:

- Promote alternative livelihood projects in and around Bulolero village to improve community well-being and reduce human-induced pressures on *C. mitis* and its habitat.
- Restore degraded forests to provide suitable habitat for *C. mitis*.
- Promote behavior change campaigns through sustained education and outreach projects.
- Launch health projects and other social services to improve community health and well-being.
- Develop a community-based *C. mitis* monitoring system that integrates community participation in conservation activities and delivers benefits to the people of Idjwi island.
- Conduct a baseline census to estimate the population size of *C. mitis* on Idjwi Island.
- Conduct DNA analyses to clarify taxonomy and assess genetic diversity of the *C. mitis* population on Idjwi Island.

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