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## Behavioural adaptations and health threats in village-residing wild sacred Lowe's monkeys (*Cercopithecus lowei*)

Célestin Yao KOUAKOU<sup>1,2</sup>, Prince Dégný VALE<sup>1,2</sup>, Karim OUATTARA<sup>2,3</sup>, Yves Laure Carine KOUACOU<sup>1</sup>, Jean-Claude Béné KOFFI<sup>1</sup>

<sup>1</sup>Unité de Formation et Recherches en Environnement, Université Jean Lorougnon Guédé, Daloa, Côte-d'Ivoire

<sup>2</sup> Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire

<sup>3</sup>Université Félix Houphouët Boigny, Côte d'Ivoire

Corresponding Author email: Prince D. VALE [valeprince15@yahoo.fr](mailto:valeprince15@yahoo.fr)

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### ABSTRACT

*Objectives:* The protection of wildlife by local African communities through sacred sites for conservation and ecotourism has increased the proximity and interactions between animals and humans. Those interactions often result in challenging cohabitation scenarios, necessitating a comprehensive understanding and management of the ecological and health implications.

*Methodology and Results:* By combining animal behavioural observation and interviews, we focused on a group of Lowe's monkeys residing in a sacred forest near the village of Gbétitapéa in western Côte d'Ivoire. We reveal adaptive shifts in the monkeys' activity budget within the urban environment. In comparison to their wild counterparts feeding time (from 45% to 70%), Gbétitapéa monkeys allocate substantial time to travelling (40%) and resting (25%), with a reduced time spent on feeding (13%) as they receive food from humans. Furthermore, approximately 67% of their time is spent in the village, leading to frequent interactions with both humans and domestic animals.

*Conclusions and application of findings:* The intensified interaction observed between Gbétitapéa Lowe's monkeys and the local communities, frequently extending to tourists drawn to these sacred wild primates, underscores the risk of conflicts and, more critically, the heightened risk of zoonotic disease transmission. As human-wildlife interactions become more intricate, an integrated approach is essential to mitigate conflicts and reduce the transmission of zoonotic diseases. Tailored conservation initiatives (e.g., define a special statue for these sacred monkeys, raise awareness among the local community and tourists to avoid feeding the monkeys and touching them), shaped by a deep understanding of the unique cultural and ecological context, will play a pivotal role in ensuring the continued harmony between the sacred monkeys and the local community in Gbétitapéa.

**Keywords:** time activity budget, sacred monkey, human-wildlife interaction

## INTRODUCTION

The rapid growth of the human population is at the core of significant pressure on global biodiversity. This pressure is particularly intense in tropical forests, where urban expansion (Richards and VanWey, 2015), intensive exploitation of natural resources (Turubanova *et al.*, 2018), road construction (Laurance *et al.*, 2014), and the establishment of energy production infrastructures (Velastegui-Montoya *et al.*, 2022) increasingly reduce the surface area of tropical forests. Protected areas designed to isolate and safeguard these natural plant formations and thereby protect wild animal species from external threats, do not always guarantee these functions as these spaces are increasingly negatively impacted by anthropogenic activities (Romanillos *et al.*, 2018; Tranquilli *et al.*, 2014) although governmental institutions manage most of those protected. In Africa, designated protected areas encompass sacred natural sites established by traditional societies with the aim of safeguarding them from all forms of anthropogenic threats (Hartley *et al.*, 2000). These sacred sites, typically situated near villages for enhanced protection by local human communities, play a crucial role in biodiversity conservation and the promotion of local tourism. In this setting, certain wildlife species engage in interactions with humans, venturing into human-inhabited areas in search of food resources. This behaviour can give rise to potentially challenging encounters between wildlife and humans (Distefano, 2005). This once uncommon proximity between wild animal and humans is becoming more frequent, sometimes resulting in notable changes in animal behaviour as they adapt to using spaces dominated by humans (Llimona and Balasc, 2012; Wolf and Ripple, 2017). For instance, some species tend to reduce their movements during the day (Tucker *et al.*, 2018) and increase nocturnal activities (Gaynor *et al.*, 2018) to minimize contact with

humans. These behavioural changes raise crucial questions about animals' ability to adjust to changes induced by human activity while maintaining natural behavioural patterns. Beyond behavioural implications, the increased proximity between animal and human populations also exposes a major risk: the transmission of zoonotic diseases (Patz *et al.*, 2004). Pathogens, once confined to specific ecosystems, can now circulate between species, posing a potential threat to public health. This complex situation raises crucial questions about the coexistence between humans and wildlife, emphasizing the necessity of understanding and managing the ecological and health consequences of this growing proximity. From this perspective, it is necessary to explore certain aspects of this evolutionary dynamic to shed light on potential strategies to mitigate the risks associated with the emergence of stereotyped behaviours in wild animals and the transmission of zoonotic diseases in a rapidly changing world. Numerous studies worldwide, especially in sub-Saharan Africa, have already addressed the behavioural (Gaynor *et al.*, 2018; Tucker *et al.*, 2018), health-related (Asante *et al.*, 2019; Kasozi *et al.*, 2021), and economic (Brackowski *et al.*, 2023) consequences of the proximity between humans and wild animals, as well as the management of this proximity (Ouattara *et al.*, 2017). However, another component of this equation remains largely unexplored: it is about sacred wild animals, which are protected by tradition and relatively tolerated in humans living area. In Côte d'Ivoire, several villages house wild animals where conflicts are relatively rare due to the sacred nature of these animals such as the sacred monkeys of Soko in the northeast (Basma, 2017) and those of Gbétitapéa in the central west (Koffi *et al.*, 2019; Kouakou *et al.*, 2017) of the country. This work aims to analyse, the behaviour of a group of wild Lowe's monkeys, *Cercopithecus lowei*

(Thomas, 1923), living for decades in a sacred forest near the village of Gbétitapéa. Through daily observations, seek to understand the behaviour of these monkeys in proximity to humans by analysing their activity budget. Secondly, to evaluate the nature of the relationship between the villagers and these sacred monkeys and investigate the potential risks of zoonotic transmission. These sacred

monkeys, protected by tradition, interact frequently with the populations and tourists in this village. Due to their sacred nature and the fact that they are accustomed to human observers, the wild Lowe's monkeys of Gbétitapéa constitute suitable subjects for a deeper understanding of the relationships between humans and wild animals.

## MATERIAL AND METHODS

**Study Area:** Gbétitapéa village is in the Haut Sassandra region in the central-western part of Côte d'Ivoire. It is at 10 km from the city of Daloa between latitudes 7°06' and 7°07' North and longitudes 6°73' and 6°72' West. This village is in proximity to the sacred forest of Gbétitapéa, situated in a region with a humid tropical climate.

**Data Collection:** The study focused on 20 adults Lowe's monkey group observed over a four-week period in November and December 2020. Observations were conducted between 6:30 AM and 6:00 PM, with a stop between 10:00 AM and 2:00 PM, as during these hours, the monkeys remained in the sacred forest, to which we were prohibited from entering. We sampled the behaviours of the Lowe's monkeys individuals using scan sampling and Ad libitum methods (Altmann, 1974; Bateson and Martin, 2021). The scan sampling involved noting variations in the behavioural states of most adult individuals in the group at regular 30-minute intervals. Each scan recorded (1) the activity of the adult individuals in the group,

(2) the occupied stratum, and (3) the environment in which the group was located (inside the sacred forest, on the periphery of the sacred forest, in the village). A pre-established behavioural catalogue for Campbell's monkeys in the wild (Ouattara, 2009) and in captivity (Lemasson, 2003) was used to determine the main behaviours in the studied group. Moreover, the main activities considered in this study were adapted based on existing works (Fuller *et al.*, 2010; Nekaris, 2001). Then, six main activities were considered in this study: feeding, resting, grooming, movement, aggression, and play (Table 1). The use of different strata (vertical occupation) by these primates was estimated by considering four of the six vertical strata defined in the vertical stratification established by Buzzard (2006). The strata used in this study are as follows: stratum 0, which is below 1 m; stratum 1, ranging from 1 m to 5 m in height; stratum 2, beyond 5 m up to 10 m in height, and stratum 3 for heights exceeding 10 m.

**Table 1:** Activities considered in this study

Activity	Description
Feeding	Foraging, handling, and food consumption
Resting	Sitting or lying at rest without obvious movement
Grooming	Taking care of skin or fur (sitting or lying down)
Travelling	Walking or running on the ground
Aggression	Aggressive interaction with or without physical contact
Play	Activity or apparently purposeless interactions with other individuals or alone

The Ad libitum observation allowed for noting events of interactions between humans and the monkey group, as well as interactions between the monkeys and other domestic animals encountered in the village. Using an interview guide, we conducted a survey among the local population to gather their perceptions of these sacred monkeys in their village. The survey was conducted for one week alongside the group monitoring, based on voluntary participation. In total, 40 individuals, aged at least 21 years, representing various pre-identified socio-professional layers, were interviewed, comprising 19 men and 21 women.

**Data Analysis:** We calculated the frequencies of appearances for each behavioural by using the following formula:

$$y = (ny / N) \times 100$$

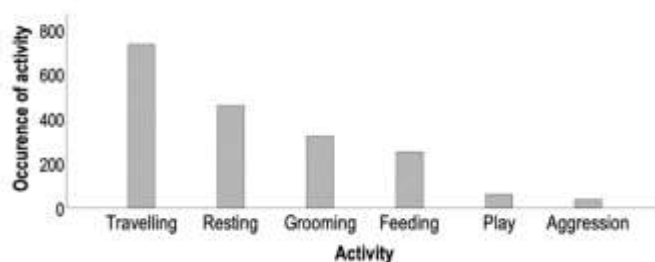
ny is the number of records of category y, N is the total number of records collected during the study period (Cullen and Valladares-Padua, 1997).

Subsequently, the frequencies of the recurrent variables were expressed based on the times of the day. We have considered two period in the day for data analysis. from 6:30 to 10:00 AM and from 2:00 to 6:00 PM. No data were recorded between 10:00 AM and 2:00 PM because the primates spend time in the heart of the forest where observer is forbidden to enter. We compared the proportions of observed activities per day using a Chi-square test ( $\chi^2$ ), and the distribution of activities based on the periods of the day was analysed using the Kruskal-Wallis' test (H). We performed the statistical analyses with the software IBM STATISTIC SPSS Version 25.

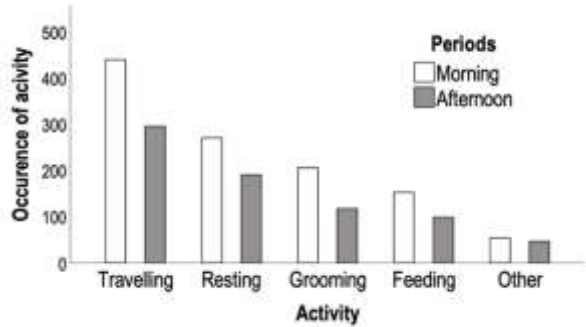
## RESULTS

**Activity budget:** The examination of the activity budget of sacred Lowe's monkeys individuals observed in the village of Gbétitapéa revealed a highly significant difference in the proportions of time allocated to each activity considered in this study ( $\chi^2 = 1418$ ; ddl = 6;  $P < 0.001$ ). Recorded were 1865 behavioural sequences using scan sampling. Among the recorded activities, four main behaviours stood out with relatively significant proportions. Ranked in order of importance these activities travelling, resting, grooming, and feeding (figure 1). Travelling was the most predominant activity, accounting for nearly 40% of appearances, followed by

rest observed in nearly 25% of recordings. Play and aggressions were rarely observed, each accounting for less than 4% of the recorded activities. The distribution of the four main activities of sacred Lowe's monkeys in the village of Gbétitapéa during the two periods of the day considered in this study showed similar trends to the overall distribution of these activities (figure 2), with a highly significant difference between proportions ( $H = 974.6$ ; ddl = 2 ;  $P > 0.001$ ). Travelling and rest remained the predominant activities, both in the morning and afternoon. Our results also indicate that our study subjects are much more active in the morning than in the afternoon.



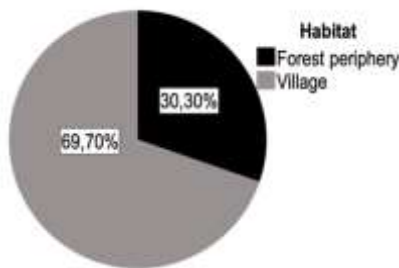
**Figure 1:** Occurrence of the activity observed in the sacred Lowe's monkeys of Gbétitapéa



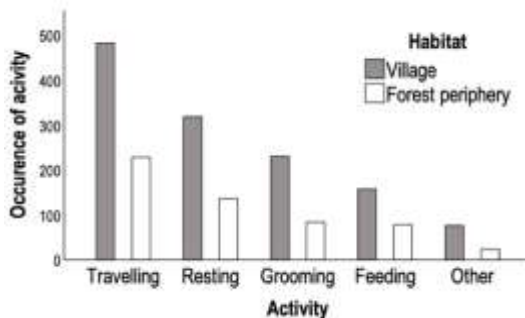
**Figure 2:** Occurrence of activities considering daily periods

**Habitat use and vertical stratification:** Regarding habitat use, the Lowe's monkeys were more frequently observed in the village of Gbétitapéa, accounting for almost 70% of cases. They were moderately seen at the periphery of the sacred forest (figure 3). Whether in the village or on the outskirts of the sacred forest, the activity budgets of Lowe's monkeys maintained the same configuration, with travelling and rest being the most

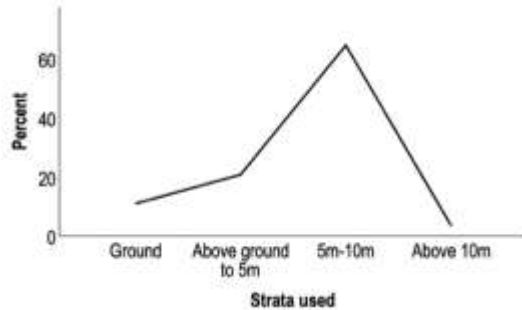
predominant activities, followed by grooming and feeding (figure 4). Play and aggressions remained the least frequent activities. In terms of the use of vertical strata, the followed Lowe's monkeys were mostly observed on the ground or in strata 1 and 2, i.e., below 10m, with individuals rarely (less than 4% of the time) observed at heights exceeding 10m (figure 5).



**Figure 3:** Use of habitat by the sacred Lowe's monkeys of Gbétitapéa



**Figure 4:** Occurrence of activities considering the habitat used



**Figure 5:** Strata used by the sacred Lowe's monkeys of Gbétitapéa

**Interactions with Domestic Animals and Humans:** The followed Lowe's monkeys were frequently observed in the village of Gbétitapéa inside residences, where various types of interactions with humans and domestic animals such as chickens, ducks, and dogs were observed. Interviewees reported occasional aggressive interactions between the monkeys and domestic animals, especially dogs, involving two-way and noisy aggressions, which we also observed during the study period. The monkeys also seized and consumed chicken or duck eggs. All interviewees affirmed that the monkeys frequently visited their homes. Generally, in

groups of 4 to 6 individuals, the monkeys visited these households at least twice a week. Nearly three-quarters of the interviewees claimed that the monkeys visited their homes every day of the week. According to 75% of those interviewed, the visits of Lowe's monkeys to their homes lasted more than an hour, and 12% of respondents asserted that the visits lasted between 30 and 60 minutes. Within the villages, residents and visitors frequently fed the monkeys. It was also reported on multiple occasions that individuals from the sacred Lowe's monkey group in Gbétitapéa had been hunted by outsiders of the village.

## DISCUSSION

The results of this preliminary study provide substantial data on the behavioural adaptations of the sacred Lowe's monkeys in Gbétitapéa. The study revealed that these monkeys dedicate most of their time to four main behavioural activities: travelling, resting, grooming, and feeding. Other activities, such as play and aggressions, were rarely observed. Among the primary activities of the studied Lowe's monkeys, travelling was the most practiced, while the proportions of time allocated to feeding and grooming were relatively low compared to the proportions observed by McGraw (1998) and Ouattara *et al.*, (2017) in groups of Campbell's monkeys and two other primate species belonging to the Cercopithecidae family (Table 2). Indeed, it appears that the time devoted to feeding is lower in the groups of monkeys living near

human populations, as was the case for the wild Campbell's monkeys living in the city of Taï, west of Côte d'Ivoire (Ouattara *et al.*, 2017), and in our study at Gbétitapéa. These monkeys, constantly in contact with humans, spend less time searching for food provided by humans. The time devoted to feeding by the sacred Lowe's monkeys of Gbétitapéa is significantly lower than normal because they are frequently fed by villagers due to their sacred nature. Moreover, they serve as an attraction to tourists, which, during their visit, result in more significant feeding of the monkeys by the persons responsible for presenting them, increasing the frequency of human feeding. It is also worth noting that some wild food requires a significantly slow search time and digestion, which would develop a preference for human-produced food



in animals that have access to it, fulfilling their nutritional needs in relatively short times (Hill, 2000; Kemnitz *et al.*, 2002; Warren *et al.*, 2007). As for the significant time devoted to traveling, it may be explained by the fact that these monkeys are frequently in the village, where they have frequent interactions with

humans and domestic animals. These monkeys engage in frequent chases, pursuits, escapes, and leaps from one house to another. However, this activity budget must be considered with caution because observations did not cover all days due to restrictions on tracking the monkeys when they entered the sacred forest.

**Table 2:** Comparison of activity budgets of 3 Cercopithecidae species

Scientific name	Living area	Activity (%)					Reference
		Feeding	Resting	Travelling	Social	Other	
<i>Cercopithecus lowei</i>	Sacred forest	13.40**	24.66	39.36	17.27*	5.31	This study
<i>Cercopithecus campbelli</i>	Rural forest	45.04**	6.72	20	25.38*	2.86	Ouattara <i>et al.</i> , 2017
<i>Cercopithecus campbelli</i>	Wild forest	70.8**	20.2	6.7	2.8	-	McGraw, 1998
<i>Cercopithecus diana</i>	Wild forest	61.5**	8.8	28.5	1.2	-	McGraw, 1998
<i>Cercocebus atys</i>	Wild forest	63.3	18.5	10.3	7.9		McGraw, 1998

\*Considering grooming only

\*\* Including foraging

We observed that, except for the third of the daily time spent by the monkeys in the sacred forest where we had no access, these primates spent the majority of their time in the village. This preference could be linked to the monkeys' ease in finding food resources in the village (Warren *et al.*, 2007), which may also contribute to an increase in the monkeys' activity in the morning compared to the afternoon. In the village, the monkeys frequently stayed at heights below 10 m, corresponding to a habit in their natural habitat where they commonly use lower and middle strata (Buzzard, 2006). The unchanged use of vertical strata by the Lowe's monkeys within human living area may indicate a relatively non-conflictual environment between the monkeys and humans and may also be due to the lower supports available to them for resting and travelling (house roofs, trees or electrical wiring). This preference for lower and middle strata might also influence the nature of interactions with domestic animals and

humans. The results regarding aggressive activities of the monkeys towards dogs raise ethical and safety questions for the cohabitation between these monkeys and the population of Gbétitapéa. The bidirectional aggressions (dog towards monkey and monkey towards dog) underscore the need for careful management of these interactions to prevent potential conflicts and even aggression against humans. Although the cohabitation with these sacred monkeys in Gbétitapéa appears harmonious, likely due to tradition (Koffi *et al.*, 2019; Kouakou *et al.*, 2017), it cannot be ruled out that there are risks to the survival of these monkeys. Feeding these monkeys may create a certain dependence on human food, leading to significant conflicts in the long term, as observed by Wiafe & Arku (2012) in a monkey sanctuary in Ghana. Therefore, if measures are not taken to reduce the frequency of feeding, the long-term survival of this monkey group is at risk. The report of some individuals of the sacred Lowe's monkey group

being killed by outsiders emphasizes the challenges of protecting these sacred animals and the need for actions to raise awareness of their special status. Another threat not only to this monkey group but also to the residents of Gbétitapéa is the significant risk of zoonotic transmission. The frequent visits of Lowe's monkeys to the humans' homes, as well as their feeding by humans, raise conservation and health concerns. Indeed, non-human primates and humans have such a significant phylogenetic proximity that they share a significantly similar microbial flora (Sharma *et al.*, 2020) and various pathogens (Gonzalez *et al.*, 2012). Due to this phylogenetic proximity

to humans, non-human primates are increasingly indexed as a source or reservoir of emerging zoonotic diseases. This is evident in the case of Ebola haemorrhagic fever, which has been linked to contact with primates (Rouquet *et al.*, 2005; Wittmann *et al.*, 2007). The risks of zoonotic transmission at Gbétitapéa should thus be examined in more detail, given the constant proximity between the sacred monkeys and the local populations. This study provides valuable information on the behavioural adaptations that primates living in proximity to human populations may undergo.

## CONCLUSION AND APPLICATION OF RESULTS

Urban wild animals serve as a tourism and educational asset for area where they live, opening avenues for scientific research to better understand wild species from a perspective other than their natural habitat. However, this proximity to humans, influencing both human and animal behaviour, reduces mutual distrust, thus facilitating the risk and spread of zoonoses through the regular interaction with food and play initiated by Human. Indeed, the case of the sacred Lowe's monkeys living near and in the village by

spending most of the time between 6.30 to 10 am and 2 to 6 pm (observations periods) in the village of Gbétitapéa presents a significant risk of disease contamination. Thus, in-depth research is necessary to conduct effective health associated with this proximity by analysing for instance the repertoire and distribution of parasites in shared by Human and Monkeys. That will be relevant to guide for a sustainable coexistence in this village, which receive more than more visitors.

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