MASTER 2 APPLIED ETHOLOGY

FIELD OF STUDY: SCIENCE, TECHNOLOGY, HEALTH

Human - Vervet monkeys interactions in a semi-urban environment

by

Manon Desaivres

Urban Vervet Project

Dr. Sofia Forss
Dr. Stephanie Mercier

January - June 2023

SORBONNE PARIS NORD UNIVERSITY - UFR LLSHS

ABSTRACT :

Vervet monkeys (*Chlorocebus pygerythrus*) are widely distributed primates across Africa, including urban areas. Urbanisation has increased interactions between humans and vervet monkeys, posing challenges for both. In this study, we collected data on two vervet monkey groups in Simbithi Eco-Estate, a semi-urban environment. We used observational data (henceforth focal data) to analyse their behavioural patterns. In addition, ad libitum observations were conducted to capture spontaneous interactions with anthropogenic elements of the environment urbanisation. Additionally, we employed a citizen science approach, using questionnaires to gather insights from the local community. Although the monkeys feed mainly on natural fruit, our results indicate that all individuals have equivalent frequencies of human food-stealing behaviour. We also found that the presence of fruit trees near dwellings tended to reduce intrusion by vervet monkeys. We also found that the presence of fruiting trees near residences reduces vervet monkeys' intrusions into houses. These results deepen our understanding of the complex dynamics between vervet monkeys and urbanisation.

Keywords : Human-Vervet Conflict, Urbanisation, Natural Observation, Citizen Science

RÉSUMÉ :

Les singes vervets (*Chlorocebus pygerythrus*) sont des primates largement répandus en Afrique, y compris dans les zones urbaines. L'urbanisation a accru les interactions entre les humains et les singes vervets, posant des défis pour les deux parties. Dans cette étude, nous avons collecté des données sur deux groupes de singes vervets dans Simbithi Eco-Estate, un environnement semi-urbain. Nous avons utilisé des données focales pour analyser leurs comportements. Des observations ad libitum ont été collectées pour capturer les interactions spontanées avec l'environnement urbain. De plus, nous avons utilisé la science citoyenne à travers des questionnaires pour recueillir les impressions de la communauté locale. Bien que les singes se nourrissent principalement de fruits naturels, nos résultats indiquent que tous les individus ont des fréquences de comportement de vol de nourriture humaine équivalentes. Nous avons aussi trouvé que la présence d'arbres fruitiers à proximité des habitations a une tendance à réduire les intrusions des singes vervets. Ces résultats approfondissent notre compréhension des dynamiques complexes entre les singes vervets et l'urbanisation.

Mots clés : Conflit Homme-Vervet, Urbanisation, Observation naturelle, Science citoyenne

Table of contents

1. INTRODUCTION **4**
2. MATERIAL AND METHODS **5**
2.1. Location of study 5
2.2. The studied species 6
2.3. Data collection 6
2.3.1. PART I – Vervet monkeys' perspective 7
Focal data to unveil the daily routine of vervet monkeys 7
Ad libitum data to determine their interactions with urbanisation 8
2.3.2 PART II – Humans' perspectives 8
2.4. Statistical analyses 9
Focal data 9
Ad libitum data 9
Questionnaire 10
3. RESULTS **10**
3.1. PART I – Vervet Monkeys' perspective 10
Focal data 10
Ad libitum data 11
3.2. PART II – Humans' perspectives 15
3.2.1. Participant characteristics 15
3.2.2. Statistical analysis of vervet monkey presence around houses 16
3.2.3. Statistical analysis of vervet monkeys' entry into houses 16
4. DISCUSSION **17**
5. CONCLUSION **21**
6. ETHICAL NOTE **22**
7. ACKNOWLEDGMENTS **22**
8. REFERENCES **22**

1. INTRODUCTION

Urbanisation is a growing landscape transformation around the world, with a constant growth in population and an increasing demand for living space. As a result, cities are expanding rapidly, encroaching on formerly wild or rural areas. Anthropogenic activities, such as deforestation, urbanisation, and pollution, are also causing a decline in species diversity on a global scale (Pimm et al., 2014). Animals must adapt to these new environments to survive.

However, Bateman and Fleming (2012) reported that some animal species do successfully adapt to human-altered environments, such as the red fox (*Vulpes vulpe*s), coyote (*Canis latrans*), Eurasian badger (*Meles meles*), and raccoon (*Procyon lotor*), thanks to their remarkable resilience and behavioural flexibility. By capitalising on a diverse range of newfound resources, these species have managed to navigate and exploit the opportunities presented in urban landscapes (Bateman & Fleming, 2012).

Vervet monkeys are highly social primates that live in complex social groups and are one of the few primate species that have successfully adapted to urban habitats (Patterson, 2017; Thatcher et al., 2019). Vervet monkeys occupy an opportunistic omnivorous feeding niche spanning a high variety of food sources, including human waste, compost, vegetable garden, and pet food (Contesse et al., 2004) and are reportedly using man-made structures for shelter (Bateman & Fleming, 2012). The generalist foraging niche facilitates adaptation and persistence in urban environments (Patterson et al., 2019c ; Baker & Harris, 2007).

Conflict management between vervet monkeys and humans depends on the conservation of natural habitats and sufficient food resources. Reducing the dependence of these animals on anthropogenic food sources can help minimise conflicts between the two (Patterson et al., 2019). Another way to mitigate conflicts is the presence of pets. While cohabitation between vervet monkeys and cats appears to be possible without aggression (Chipangura et al., 2020), dogs can be particularly aggressive and are often chasing the monkeys away from human properties (Chapman et al., 2016).

In this study, we focused on the interactions between semi-urban vervet monkeys and human residents of the Simbithi Eco-Estate, Kwazulu-Natal, South Africa. In the first part, we used focal and ad libitum data from natural observations to investigate if and how the presence of humans and anthropogenic

elements influenced the behaviours and movements of vervet monkeys. In the second part, we used citizen science data to explore the factors that attract and/or repel vervet monkeys to residential areas using a questionnaire answered by 100 residents. Furthermore, we examined the effect of preventive measures reported by the residents to mitigate conflicts. By understanding the underlying causes of the vervet monkeys' attraction or aversion to residential areas and the factors that influence their behaviours and movements, we can implement targeted preventive measures that might help to improve peaceful coexistence between vervet monkeys and residents.

In terms of interactions with humans, we anticipated adults and juveniles to exhibit different patterns. Adults, who are bigger and have likely developed more efficient foraging strategies, may engage in more food-related interactions. On the other hand, juveniles, being in a stage of exploration and learning, may show a higher inclination to interact with human artefacts as they investigate their environment and learn from their surroundings. In this study we predicted following factors to be potential "attractors" for the monkeys: the presence of food sources, such as fruiting trees or garbage bins as well as people feeding them, and other factors that potentially could repel the monkeys and link to conflicts with humans, the presence of dogs, or the use of preventive measures.

2. MATERIAL AND METHODS

2.1. Location of study

Simbithi Eco-Estate, located in Ballito, South Africa, is an unique residential community that strives to coexist with nature and wildlife. The estate covers 430 hectares and was conceptualised in 2003 as a response to the growing concern over environmental degradation caused by rapid urbanisation and unsustainable land use practices.

Fig. 1 Map of South Africa showing the study location at Simbithi Eco-Estate, KwaZulu Natal

2.2. The studied species

Within the eco-estate, several vervet monkeys' groups coexist, but so far not all of them have been thoroughly individually identified and studied. Therefore for this study, only two groups (Acacia N=21 and Savanna N=25) were examined. In order to create a comprehensive record for each individual in each group, detailed descriptions, photographs, and unique names were assigned to each individual. We defined adults as all females that had a baby and all males that have been dispersed from their natal group. We considered subadults as individuals that have reached sexual maturity but have not yet reproduced or dispersed from their natal group. Juveniles, on the other hand, were defined as individuals that are still in the process of development and have not reached sexual maturity yet. Dispersal among vervet monkeys is costly, particularly for adult males, as they disperse to neighbouring groups when reaching sexual maturity to avoid incestuous relationships (L'Allier et al., 2022). In contrast, female vervet monkeys remain in their natal group throughout their lives.

Table 1. Group size and composition of the studied population

	Adult and subadult male	Adult and subadult female	Juvenile male	Juvenile female	**Total**
Acacia	2	7	7	5	**21**
Savanna	2	8	9	6	**25**

2.3. Data collection

For this study, we used a multi-method approach, collecting data from March to May 2023. The data collection methods included focal observations, ad libitum observations, and questionnaires with residents. The data collection process involved four trained observers, who were rigorously prepared to ensure the accuracy and reliability of the collected information. To ensure data were collected in a standardised and consistent manner, each observer underwent an identity test to verify their ability to accurately recognize and distinguish individual vervet monkeys. Moreover, the observers successfully

completed an inter-observer reliability test, which assessed the level of agreement among them (proportion of agreement > 80%).

2.3.1. PART I – Vervet monkeys' perspective

Focal data to unveil the daily routine of vervet monkeys

We used 20-minute focal data on each adult of the Savanna group collected in May 2023 to study their natural behaviours in an urban environment. We collected a total of 90 focal observations distributed across three different time zones to ensure a balanced dataset across individuals throughout the day. The specific observation periods were determined based on the sunrise and sunset times. Time zone one corresponded to the early morning hours, time zone two encompassed the midday period, and time zone three represented the late afternoon hours.

For each focal session, we collected data on the "micro habitat" in which the focal individual was observed. The micro habitat categories included nature, road, fence, outside of houses, inside houses, and community centre. The term "nature" referred to any vegetated area outside of the properties and gardens, encompassing all trees, including those surrounding the houses. The category "road" referred to the roads where vehicular traffic was permitted. The category "fence" represented the fences around the Simbithi Eco-Estate. The "outside of houses" category encompassed the areas outside the houses but restricted to the private space of each respective dwelling, including courtyard, patios, stairs and roofs. The "inside houses" category referred to the interior spaces of the houses. Lastly, the "community centre" category denoted the designated communal gathering spaces within the Simbithi Eco-Estate. These micro habitat categories were used to contextualise the observations and analyse how vervet monkeys distributed their behaviours across different environmental settings.

In addition to the location, we recorded the monkeys' behaviours in a continuous way to get the duration of all their agonistic, sexual, affiliative, vigilant, feeding, resting, movement behaviours, as well as all their interactions with humans, pets or human artefacts. As soon as a focal was no longer visible, we recorded it as "out of sight". We aborted a focal if an individual was out of sight for more than 5 minutes in a row (see table 1 and 2 in the Appendix 1).

Ad libitum data to determine their interactions with urbanisation

To examine if there were any differences in the frequency and type of interactions between different groups of monkeys and according to their age-sex class, we collected ad libitum data throughout the day on all interactions observed from vervet monkeys with humans, pets and human artefacts. Therefore, the Acacia group was monitored for a cumulative duration of 330.76 hours, while the Savanna group was observed for 256.34 hours, considering the presence of multiple observers throughout the monitoring period. Consequently, we collected data on the time, location, identity of the monkey and the interaction that happened.

We defined a human-related encounter as any occasion where at least one human, and at least one vervet monkey interacted. We defined negative encounters if interactions involved any form of aggression by humans towards the vervet monkeys, usually with the goal of chasing them away from their properties. These encounters were terminated when either party broke eye contact. In contrast, encounters were defined as positive if interactions involved any food consumed by the monkeys. These interactions began when a monkey started feeding and ended when no monkeys were feeding on the food item anymore. In addition to human-monkey interactions, we also recorded instances of monkey interactions with any human artefacts. These artefacts included all those that could be manipulated, but also various urban elements such as roofs, balconies, street lamp and other elements of urban infrastructure.

2.3.2 PART II – Humans' perspectives

For this second part of the study, a questionnaire was developed to assess the perceptions and experiences of residents and workers within Simbithi Eco-Estate regarding their interactions with vervet monkeys. The questionnaire was designed to gather information about respondents' demographics, housing characteristics, perceptions of vervet monkeys, their interactions with the monkeys, as well as the preventive measures they employ to mitigate conflicts.

A total of 100 questionnaires, primarily conducted door-to-door within the home ranges of the Savanna and Acacia groups, were used in this study. We aimed to assess the impact of eight factors to see whether they will attract or repel the monkeys: the presence of fruiting trees, bird feeders, water pond, garbage bin clips, dogs, the provisioning of food to vervet monkeys, the human chasing behaviour, and preventive measures implemented to prevent monkeys from entering human dwellings. We tested the

influence of these factors on two response variables related to vervet monkeys' behaviours but perceived by the residents: the frequency of visit in the vicinity of houses and their entry into houses.

2.4. Statistical analyses

All analyses were performed using R version 4.1.1.

Focal data

In this part, we conducted a descriptive analysis of focal data collected from vervet monkeys to examine their spatial distribution and behavioural patterns across the three time zones. We compared the monkeys' locations within each time zone to assess their spatial distribution. Additionally, we compared the monkeys' behavioural patterns across the different time zones, including their feeding behaviours.

To analyse the spatial distribution, we recorded the locations where the monkeys were observed within each time zone and calculated the frequency and percentage of observations in different habitat types. This allowed us to determine if there were any significant differences in the monkeys' spatial distribution across the various time zones.

Furthermore, we conducted comprehensive comparisons of the monkeys' behaviours across the different time zones. We examined a range of behaviours, including social interactions, locomotion, vocalisations, and foraging activities. This analysis provided insights into any variations or similarities in the monkeys' behaviours across the different time zones.

After analysing the overall behavioural patterns, we then focused specifically on the feeding behaviours of the vervet monkeys. We compared the frequencies of feeding on natural food sources versus human-provided food within each time zone. This analysis aimed to understand the monkeys' dietary preferences and their potential interactions with human resources.

Ad libitum data

For this analysis, we used 692 natural observations collected by four trained researchers during 330.77 hours of observations in Acacia and 256.35 hours of observations in Savanna. Beta regression models (using "betareg" package) were used to investigate the influence of the groups and the age-sex class of the monkeys on three different response variables: for each positive (N=46), negative (N=25) and human artefacts interactions (N=40). We checked that all assumptions were met, i.e. that data were

collected independently, that all values ranged between zero and one, that the variables were not correlated (all VIF <5). Furthermore, we used graphs of the residuals to check for the linearity and homoscedasticity of the data.

Questionnaire

To investigate which factors attract or repel the monkeys from the houses, we used a generalised linear model fitted with a binomial distribution (using "survival" package) and a logit link function. We used the presence around houses (yes or no) and whether the monkeys were reported as raiding the houses (yes or no) as response variables of the following predictors (yes or no) around each house: bird feeders, fruiting trees, water pond, food, dog, chasing behaviours from humans, garbage bins, and the use of preventive measures. We first checked that all assumptions were made, i.e. that the data were independent, and that the variables were not showing any sign of multicollinearity (all VIF < 3). A null model and a full model were then created, using anova to check the relevance of our factors. For the variable "presence around houses," we obtained a non-significant result (X^2_8 = 4.3733, P = 0.822), suggesting that our factors may not have been the most pertinent for our analysis. However, we proceeded to examine the results using the "summary" function on our full model to determine if any of our factors of interest had a potential influence on the presence behaviours of the monkeys around houses. Similarly, for the variable "raiding houses," we found a significant result (X^2_8 = 17.727, P = 0.02336), which indicates that our factors may have been relevant, but that they still need to be studied in more detail.

3. RESULTS

3.1. *PART I – Vervet Monkeys' perspective*

Focal data

In our results, we observed that vervet monkeys spent more time in natural areas regardless of the time zone, with a noticeable increase in midday. The second most frequented location was around houses, showing higher presence in the morning and evening. However, they exhibited slightly more time in community centres during midday.

Regarding their behavioural patterns, differences were observed. The use of objects was more prevalent in the early and late hours of the day. Human interactions, although infrequent, occurred more frequently during the early and late hours as well. Additionally, affiliative behaviours were more prominent during midday.

On the other hand, resting behaviour decreased throughout the day, while feeding behaviour increased.

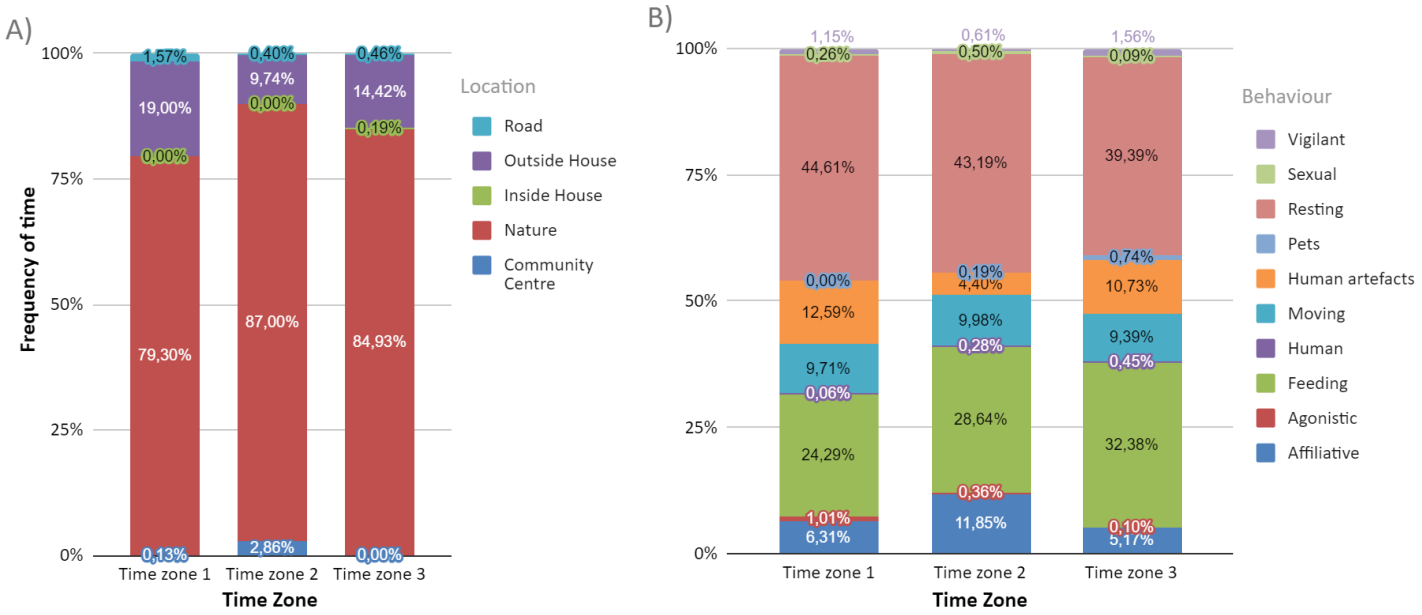

Fig. 2 Stacked histograms of frequency averages by time zone for A) Behavioural categories, B) Locations in the Savanna group

In addition, we investigated the frequency of feeding behaviours to examine the distribution between "Human food" and "Natural food" categories. Results revealed that the majority of feeding behaviours (93.3%) were associated with "Natural food," while a smaller proportion (6.72%) was related to "Human food".

Ad libitum data

For this analysis, we used a dataset consisting of 692 natural observations of vervet monkeys to investigate and compare the differences in positive interactions, negative interactions, and interactions involving human artefacts between two groups: the savanna group and the acacia group. We also examined these differences across different age classes and between sexes, aiming to determine if there

are any prevailing patterns or preferences in these interactions. The results indicated that the highest percentage of interactions occurred in the Outside houses (50.98%), followed by the Nature habitat (16.67%). The Garden habitat accounted for 13.73% of the interactions, while the Centers, Fence, and Road habitats showed relatively lower percentages at 10.78%, 0.98%, and 2.94%, respectively. Interestingly, the Inside habitat had a moderate percentage of interactions at 3.92%. Out of the total of 692 interactions recorded, 74 were classified as negative, indicating that the monkeys had been chased away by the humans, 124 interactions were classified as positive, indicating that the monkeys stole human food or were fed and 494 occurrences were classified as interactions with human artefacts in both groups.

Results from the GLM on the negative interactions indicated a significant difference for the interaction between "age class" and "sex", with adult females being chased away by humans more often than juveniles females while juveniles males were more often chased away than adult males. While not strictly significant, the Savanna group seem to have a tendency of having less negative interactions than the Acacia group.

Table 2. Results of the Betareg model of the negatives interactions

	Estimate	**Stand error**	**CI**	***Z* value**	***P* value**
Intercept	-4.422	0.156	-4.729 to -4.116	-28.279	<2e-16
Group	-0.364	0.196	-0.748 to 0.020	-1.858	0.063
Age class	**-0.647**	**0.296**	**-1.228 to -0.065**	**-2.180**	**0.029**
Sex	-0.109	0.301	-0.699 to 0.480	-0.365	0.715
Age class * Sex	**0.850**	**0.425**	**0.016 to 1.684**	**2.000**	**0.045**

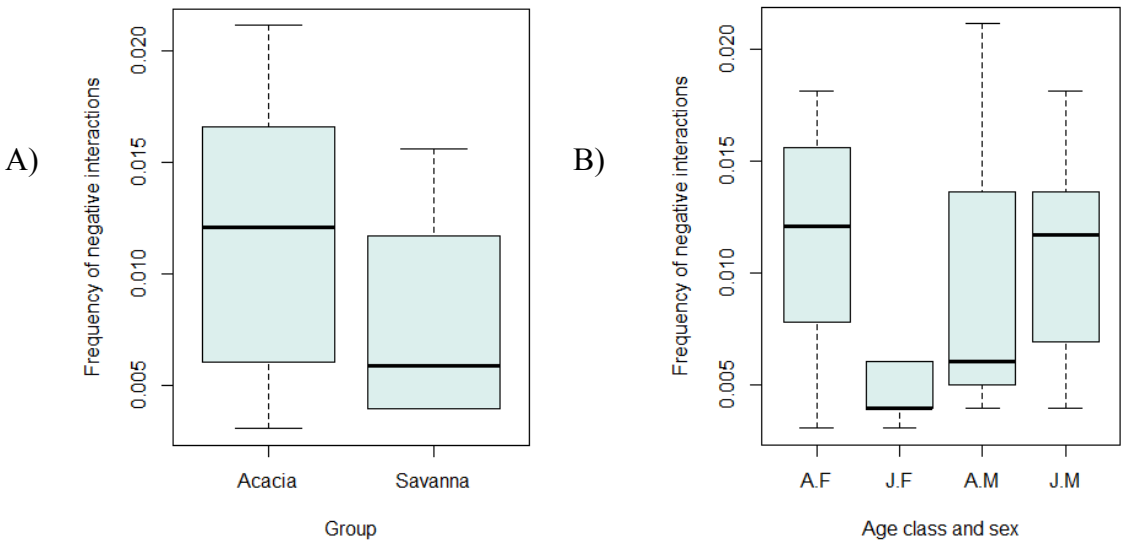

Fig. 3 Graphs of negative interactions frequencies per hour based on A) groups and B) age class / sex

Results from the GLM on the frequencies of positive interactions revealed that both groups had a similar level of positive interactions and age-sex class of the individuals did not influence these interactions.

Table 3. Results of the Betareg model of the positive interactions

	Estimate	**Stand error**	**CI**	***Z* value**	***P* value**
Intercept	-4.28164	0.21527	-4.703 to -3.859	-19.889	< 2e-16
Group	-0.05893	0.22530	-0.500 to 0.382	-0.262	0.794
Age class	0.13236	0.34282	-0.539 to 0.804	0.386	0.699
Sex	0.31231	0.32023	-0.315 to 0.939	0.975	0.329
Age class * Sex	-0.46997	0.49115	-1.432 to 0.492	-0.957	0.339

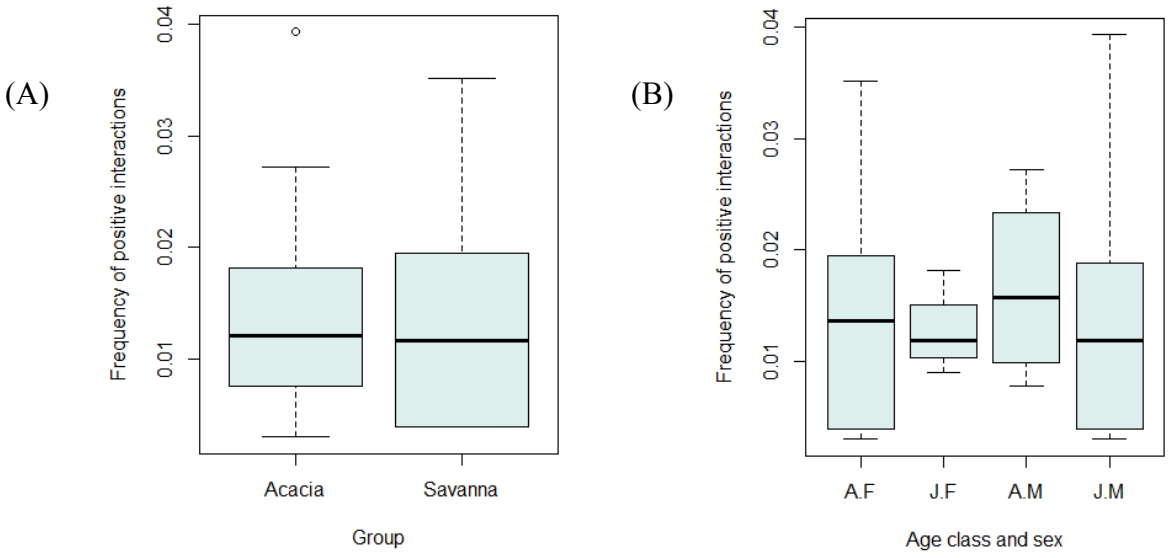

Fig. 4 Graphs of positive interaction frequencies per hour based on A) groups and B) age class / sex

Results from the GLM on the frequencies of interactions with human artefacts revealed that none of the factors "Group" , "age class" , "sex" , and the interaction between "age class" and "sex", had a statistically significant effect on the variable.

Table 4. Results of the Betareg model of the human artefacts' interactions

	Estimate	**Stand error**	**CI**	***Z* value**	***P* value**
Intercept	**-3.052**	**0.188**	**-3.422 to -2.682**	**-16.189**	**<2e-16**
Group	0.002	0.192	-0.375 to 0.381	0.015	0.988
Age class	-0.421	0.275	-0.961 to 0.117	-1.532	0.125
Sex	0.278	0.307	-0.323 to 0.881	0.907	0.365
Age class * Sex	0.135	0.418	-0.684 to 0.956	0.324	0.746

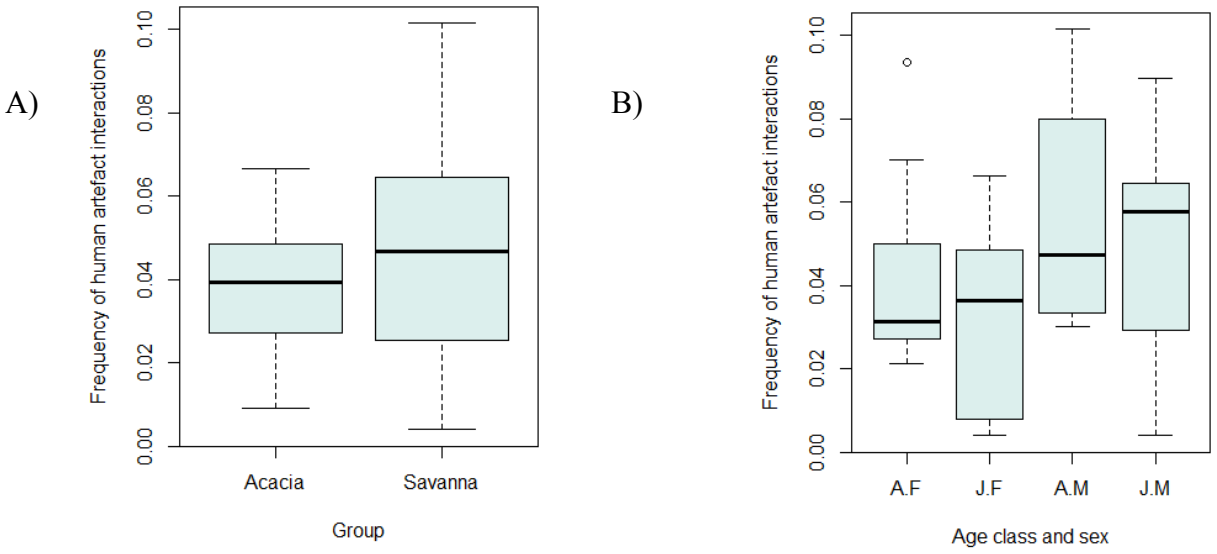

Fig. 5 Graphs of human artefacts interaction frequencies per hour based on A) groups and B) age class / sex

3.2. PART II – Humans' perspectives

3.2.1. Participant characteristics

All participants ranged in age from 21 to over 70 years, with a majority of participants being over 40 years old. Regarding the sex distribution, out of the total respondents, 25 identified as men, while 73 identified as women. The participants had diverse nationalities, with the most common being South African (English 40: Zulu 19; and Afrikaans ; 9). The participants' status varied, with 65 being homeowners, 4 renting their accommodation, and 29 being workers. Furthermore, the number of inhabitants in the households ranged from 1 to 9. Regarding the presence of children, 38 participants reported having children, while 57 did not.Lastly, the participants' perception of monkeys was assessed using different categories. The distribution of responses showed that 25 participants expressed to dislike the monkeys, 2 expressed hate, 20 expressed liking, 10 expressed love, 1 had no opinion, and 40 responded with being 'OK' with them.

3.2.2. Statistical analysis of vervet monkey presence around houses

In the generalised linear model (GLM) for the binomial response variable "Daily" indicating whether monkeys visited the houses daily or not (Yes = 1 / No = 0), none of the factors included showed a statistically significant effect. The results of the generalised linear model analysis revealed that the presence of a bird feeder, fruiting trees, water pond, the provision of food, the presence of dogs, the act of chasing monkeys, the presence of a cover to close the bin, and the implementation of preventive measures did not exhibit statistically significant associations with the frequency of daily monkey visits.

Table 5 Results of the GLM model of the factors studied in the influence of visits by urban vervet monkeys around houses, Simbithi eco-domain, KwaZulu-Natal, South Africa

	Estimate	**Stand error**	**CI**	***Z* value**	***P* value**
Intercept	0.071	1.143	11.824 to 15.862	0.063	0.950
Bird feeder	-0.794	0.683	12.128 to 13.467	-1.163	0.245
Fruiting trees	0.092	0.661	-1.771 to 3.499	0.140	0.889
Water pond	-0.556	0.503	-3.815 to 1.128	-1.106	0.269
Food	-0.080	0.647	-3.422 to 1.930	-0.124	0.901
Dog	0.330	0.561	-3.045 to 2.005	0.588	0.557
Chase	-0.554	0.781	-13.378 to -9.737	-0.710	0.478
Bin	-0.160	0.497	-1.869 to 2.666	-0.322	0.748
Preventive	0.116	0.575	-3.033 to 1.938	0.202	0.840

3.2.3. Statistical analysis of vervet monkeys' entry into houses

Based on the results of the generalised linear model (GLM) analysis, investigating the factors influencing the occurrence of monkeys raiding houses in Simbithi, none of the factors, including the presence of bird feeders, water ponds, additional food sources, waste bins, chasing the monkeys, preventive measures, and the presence of dogs, showed a significant impact on raiding behaviour. However, it is worth noting that the presence of fruiting trees around houses exhibited a marginal

significance, suggesting that the monkeys were less likely to raid houses if there were fruiting trees in the vicinity.

Table 6. Results of the GLM model studying the raiding behaviours

	Estimate	**Stand error**	**CI**	***Z* value**	***P* value**
Intercept	-1.124	1.441	-4.487 to 1.516	-0.781	0.435
Bird feeder	-1.155	0.776	-2.847 to 0.271	-1.489	0.136
Fruiting trees	-1.524	0.794	-3.157 to 0.012	-1.919	0.055
Water pond	0.474	0.632	-0.731 to 1.776	0.749	0.453
Food	0.467	0.737	-1.015 to 1.923	0.635	0.525
Dog	1.138	0.632	-0.073 to 2.430	1.802	0.071
Chase	1.313	1.209	-0.742 to 4.406	1.086	0.277
Bin	-0.363	0.592	-1.555 to 0.797	-0.612	0.540
Preventive	-1.177	0.745	-2.745 to 0.237	-1.580	0.114

4. DISCUSSION

The aim of this study was to investigate the interactions between vervet monkeys and anthropogenic disturbance, focusing on their behavioural patterns, occurrence data, and responses to human presence. Results from focal data showed that vervet monkeys, despite being in a semi-urban environment, were still significantly feeding more on natural food rather than on human food. Analyses from ad libitum observations revealed a potential tendency of group difference for the frequency of the negative interactions with humans, with Acacia being chased away more often than Savanna. However there were no group differences for both positive interactions and interactions with human artefacts. Similarly, the age-sex class of the monkeys also influenced the negative interactions but not the positive ones or interactions involving human artefacts. While adult females were chased more often than juvenile females, we found the opposite for males with juveniles being chased away more often

than adults. Finally, results from the citizen science data revealed that one factor could potentially play a role in the raiding behaviour of the vervet monkeys: the presence of fruiting trees around the houses.

Feeding behaviour

Our findings revealed distinct patterns of behaviour throughout the day, providing valuable information about the typical daily routine of vervet monkeys in Simbithi Eco-Estate. During the daytime, feeding behaviours were prominent, with vervet monkeys dedicating a significant portion of their time to consuming natural food sources. This can also be attributed to the greater abundance and accessibility of such food, as well as the lower risk associated with interactions with humans.

Community centres

One possible explanation for the increased presence of vervet monkeys in community centres during midday is the correlation with meal times. It is likely that these locations correspond to the hours when humans gather to have their meals, making it easier for the monkeys to engage in food theft. The midday period provides an opportune time for the vervet monkeys to exploit the availability of food and potentially acquire sustenance through pilfering. This behaviour suggests an adaptation to the human-centric environment, where the monkeys take advantage of the predictable patterns of human activity to secure additional food resources.

Movements and resting times

Movement behaviours were also prevalent, indicating the utilisation of different areas within the estate. Vervet monkeys exhibited regular patterns of movement, potentially driven by the need to access feeding sites, locate resting areas, and respond to environmental cues. Additionally, resting behaviours were observed, suggesting periods of relaxation and recuperation during the day.

Social behaviours

The social dynamics within the vervet monkey group were evident through affiliative and agonistic behaviours. These behaviours play a crucial role in maintaining social cohesion and establishing dominance hierarchies.

Influence of groups on negative interactions

The observed differences in the levels of negative interactions between the Acacia and Savanna monkey groups could potentially be attributed to their distinct home ranges. It is possible that the residents within the Acacia home range are more inclined to chase the monkeys compared to those in the Savanna home range. Additionally, the data indicate that the Acacia monkey group exhibits a slightly higher tendency for food theft compared to the Savanna group. This increased food theft behaviour may contribute to a higher occurrence of negative interactions with humans in the Acacia group, further reinforcing the hypothesis that they have more negative interactions with humans.

Influence of age-sex class on negative interactions

One possible explanation is related to the size and physical appearance of adult male monkeys. Adult males are typically larger, more imposing, and may appear more intimidating to the human population. This may act as a deterrent for inhabitants, as they might perceive adult males as potentially more aggressive and dangerous. Therefore, they may be less targeted to avoid any potential conflict or aggression from adult male monkeys. On the other hand, adult females may be chased more than juvenile females because they have a tendency of more positive interactions, such as stealing food. This also increases their chances of being chased by humans who will try to interrupt the theft of food.

No factor influenced positive interactions

This suggests that individuals from all age-sex classes accessed human food by either being fed or by stealing food from the outside and/or inside the houses, indicating that they all make attempts to obtain human food.

No factor influenced interactions with human artefacts

Interestingly, the results did not show any significant differences among the groups, age classes, and sexes in relation to interactions with human artefacts. This could be explained by the nature of the interactions with human artefacts, such as roof crossings or other human structures, which are likely utilised by individuals of all age classes and sexes for various purposes, including travel and exploration. It is possible that the study focused on a broader range of human artefacts rather than specifically manipulable objects. Further research specifically targeting the use of manipulable objects could explore potential differences among age classes and investigate the curiosity and playfulness often observed in juvenile vervet monkeys during fieldwork.

Citizen science

The voluntary participation of residents in this study provided valuable insights into the factors influencing human-monkey interactions. It is important to note that the findings are based on self-reported data and should be interpreted with caution, considering potential biases and limitations. Participants' perceptions and behaviours towards monkeys, as well as their presence at home throughout the day, may contribute to the variability of the results. Therefore, the study results should be viewed as indicative and not necessarily fully representative of the entire population. Additionally, the sample size of completed questionnaires may be considered relatively small, limiting the generalizability of the findings.

Fruiting trees

Moreover, the statistical analysis revealed some interesting findings regarding the factors influencing the likelihood of monkeys raiding houses. One of the factors identified as a tendency, was the presence of fruiting trees, which had a negative effect on this behaviour. This suggests that when there are ample natural food sources available, such as fruiting trees, the monkeys may be less inclined to raid houses in search of food. This finding highlights the importance of considering the local environment and the availability of natural resources when studying human-monkey interactions.

Dogs

On the other hand, the presence of dogs was found to have a positive tendency on the likelihood of monkeys raiding houses. This suggests that the presence of dogs may actually contribute to an increased probability of raiding incidents. However, it is important to note that there may be other factors related to the dogs that should be considered in the analysis and their effectiveness in deterring monkeys. For example, the size of the dog, the behaviour, whether it barks and chases the monkeys or not, whether it has direct access to the monkeys or is confined to another area, and its activities such as sleeping, all could potentially impact the dynamics between dogs and monkeys. However, these factors were not specifically examined in the analysis of the collected data. Further research is needed to explore these additional factors and their potential influence on monkey behaviour and interactions with dogs.

Understanding the factors that influence monkey raiding behaviour is crucial for developing effective management strategies. However, it's important to note that these findings should be interpreted with caution and further research is needed to explore additional variables to gain a deeper understanding of the complexities involved in human-monkey interactions in the context of house raiding incidents. During the analysis of questionnaires filled out by residents, several additional important pieces of information were gathered. Firstly, residents reported aggressive behaviour from the monkeys when they felt threatened or chased away. Theft was a major concern, with monkeys successfully stealing personal belongings such as clothing and telephones. Additionally, monkeys have caused damage to gardens by uprooting plants and digging for food. Residents have expressed concerns about public health, fearing the transmission of diseases or parasites by the monkeys. Furthermore, the monkeys were blamed for the decline in the bird population, as they destroyed nests and consumed eggs, much to the distress of bird lovers. To address these issues, residents discovered that securing rubbish bins with ties prevented monkeys from stealing and scattering the rubbish. Moreover, the installation of 'monkey screens' significantly reduced the number of intrusions into houses, despite statistical analyses not showing significant differences. These screens acted as a preventive measure, allowing air circulation while keeping monkeys out. It is essential to note that future studies should consider long-term monitoring and the potential effects of seasonal variations, as well as the impact of specific landscape features within Simbithi Eco-Estate. Such investigations will provide a more comprehensive understanding of vervet monkey behaviour and enhance conservation initiatives aimed at maintaining the ecological balance within human-altered environments.

5. CONCLUSION

In this study, the results highlighted distinct behavioural patterns of vervet monkeys in Simbithi Eco-Estate with differences found according to the groups and between age-sex classes.

Furthermore, the questionnaire conducted with the residents of Simbithi Eco-Estate provided valuable insights into human-wildlife interactions and perceptions. Understanding the perspectives of local communities is crucial for developing effective management strategies and fostering harmonious coexistence between humans and vervet monkeys. The questionnaire responses revealed important information about residents' attitudes, experiences, and concerns regarding vervet monkeys, providing a valuable foundation for future conservation efforts. By integrating the results of behavioural observations and the perspectives gathered from the questionnaire, this study offers a comprehensive

understanding of the day-to-day lives of vervet monkeys in Simbithi Eco-Estate. These insights can inform decision-making processes, guide the development of targeted conservation initiatives, and support sustainable management practices in similar human-dominated landscapes.

6. ETHICAL NOTE

This study was conducted at Simbithi Eco-Estate in South Africa with ethical permissions and approvals, including the Number of our ethical Permit, Ethical permit Nr. AREC/00004821/2022 approved by the ethics committee of University of Kwazulu Natal. The research focused on studying vervet monkeys through observational and questionnaire-based methods. The University of Zurich authorised the study, ensuring confidentiality and data protection for participants. We prioritise upholding ethical standards and animal welfare in our research.

7. ACKNOWLEDGMENTS

I would like to express my heartfelt gratitude to Sofia Forss, my internship supervisor, for providing me with this opportunity and for her consistent support and guidance throughout my study. I am also thankful to Stephanie Mercier for her valuable contributions to the study's design and implementation. Special thanks go to Zonke Mbutho for her dedication and hard work in data collection and collaboration. I sincerely appreciate the support and encouragement from my university and academic advisor. Lastly, I acknowledge the financial support from CROUS and the Ile-de-France region, which made this internship possible.

8. REFERENCES

Baker, P. N., & Harris, S. J. (2007). Urban mammals: what does the future hold? An analysis of the factors affecting patterns of use of residential gardens in Great Britain. *Mammal Review*, *0*(0), 070611094052001-??? https://doi.org/10.1111/j.1365-2907.2007.00102.x

Bateman, P. W., & Fleming, P. J. (2012). Big city life: carnivores in urban environments. *Journal of Zoology*, *287*(1), 1–23. https://doi.org/10.1111/j.1469-7998.2011.00887.x

Chapman, C. A., Twinomugisha, D., Teichroeb, J. A., Valenta, K., Sengupta, R., Sarkar, D., & Rothman, J. M. (2016b). How Do Primates Survive Among Humans? Mechanisms Employed by

Vervet Monkeys at Lake Nabugabo, Uganda. *Springer EBooks*, 77–94. https://doi.org/10.1007/978-3-319-30469-4_5

Chipangura, J. K., Ganswindt, A., & Naidoo, V. (2020b). A report on the housing vervet monkeys adjacent to domestic cats as a means of environmental enrichment. *Onderstepoort Journal of Veterinary Research*, *87*(1). https://doi.org/10.4102/ojvr.v87i1.1870

Contesse, P., Hegglin, D., Gloor, S., Bontadina, F., & Deplazes, P. (2004). The diet of urban foxes (Vulpes vulpes) and the availability of anthropogenic food in the city of Zurich, Switzerland. *Mammalian Biology*, *69*(2), 81–95. https://doi.org/10.1078/1616-5047-00123

García, M. a. L., De Guinea, M., Bshary, R., & Van De Waal, E. (2022). Drivers and outcomes of between-group conflict in vervet monkeys. *Philosophical Transactions of the Royal Society B*, *377*(1851). https://doi.org/10.1098/rstb.2021.0145

L'Allier, S. K., Schwegel, M. A., Filazzola, A., Mastromonaco, G. F., Chapman, C. A., & Schoof, V. a. M. (2022). How individual, social, and ecological conditions influence dispersal decisions in male vervet monkeys. *American Journal of Primatology*, *84*(9). https://doi.org/10.1002/ajp.23426

Patterson, L., Kalle, R., & Downs, C. (2017). A citizen science survey: perceptions and attitudes of urban residents towards vervet monkeys. Urban Ecosystems, 20(3), 617-628.

Patterson, L., Kalle, R., & Downs, C. T. (2019b). Living in the suburbs: Space use by vervet monkeys (Chlorocebus pygerythrus) in an eco‐estate, South Africa. *African Journal of Ecology*, *57*(4), 539–551. https://doi.org/10.1111/aje.12629

Pimm, S. L., Jenkins, C., Abell, R., Brooks, T., Gittleman, J. L., Joppa, L., Raven, P. B., Roberts, C. J., & Sexton, J. B. (2014). The biodiversity of species and their rates of extinction, distribution, and protection. *Science*, *344*(6187). https://doi.org/10.1126/science.1246752

R Core Team. (2021). R: A language and environment for statistical computing (version 4.1.1) [Logiciel]. R Foundation for Statistical Computing. Récupéré de https://www.R-project.org/

Thatcher, H. R., Downs, C. T., & Koyama, N. F. (2019). Positive and negative interactions with humans concurrently affect vervet monkey (Chlorocebus pygerythrus) ranging behavior. International Journal of Primatology, 40(4), 496-510.

APPENDIX 1

Table 1 Ethogram for focal observations: Behavioural categories and definitions

Behaviour	Description
Vigilant	
If the focal is clearly vigilant, having a straight posture and staring in specific directions	
Posture	If the focal is sitting, bipedal, or quadrupedal
Height	The height of the focal (0m, <2m, 3-5m, 6-10m, >10m)
Position	If the focal central or at the periphery of the group, or unknown if not sure
Feeding	
Forage	When feeding on the ground and walking at the same time, picking up random items every now and then, not walking in a straight line but going rather slowly to different directions
Eat (Human food / Natural food)	Actively putting food in the mouth, usually collected in a specific food patch that can be on the grounds or in trees, considering 1 tree as 1 food patch
Drink	If the focal is drinking usually water, but any other liquid too
Regurgitate	If the focal is vomiting
Chewing	If the focal is moving his/her jaws
Moving	
Whenever the focal is walking in a straight line, going from A to B	
Walk	If the focal is moving slowly
Run	If the focal is moving quickly
Climb	If the focal is moving vertically up and/or down, both in trees or on buildings/roof
Arboreal movement	If the focal is moving horizontally in trees
Jump	If all legs up in the air at the same time, jumping from A to B
Chewing	If the focal is walking while still having some food in mouth,

Behaviour	Description
	moving jaws
Resting	
Whether the focal is doing nothing else (no feeding/moving/socialising)	
Inactive	Can be either sitting or quadrupedal
Auto-groom	When the focal is removing parasites from own body
Self-scratching	When the focal is rubbing hands and/or foots on the same place quickly and repeatedly, either due to an itchy spot or when feeling nervous
Sleeping	When both eyes closed
Auto-smell	When the focal is rubbing hands on genitals and bringing it to nose
Auto-play	Either alone or with an object, jumping, rolling, running, lying..
Sunbathing	When the focal is resting inactive facing the sun
Urinating	When the focal is peeing
Defecating	When the focal is having a poo

Table 2 Other variables used in focal observations

Humans	
Whenever the focal is having an interaction with a human	
Positive active	When the focal is being directly fed by humans
Positive passive (inside)	When the focal is stealing food from inside the house
Positive passive (outside)	When the focal is stealing food from outside the house, either from the bins, braai area, compost or vegetable gardens…
Negative	When the focal is being chased by humans, specifying the methods used by humans to chase the monkeys away
Pets	
Whenever there is an interaction between the focal and a pet, most likely a dog (only if focal are reacting/interacting with a pet)	
Number of pets	Which pets and how many

Dog breed	Whenever possible, the breed
Positive	If the interaction is affiliative, friendly, playful
Negative	If the interaction is hostile, chasing, barking, biting
Pet behaviour	Describe here all the behaviours performed by the pet using codes from the ethogram
Monkey behaviour	Describe here all the behaviours performed by the focal only
Human artefacts	
Whenever the focal is interacting with human artefacts	
Artefacts used	Objects used in the list proposed
Behaviour	Describe the behaviour of your focal, what does he do with the artefact, how does it manipulate it, does he/she try to eat it, to play with it, does he/she use it for a specific reason such as to climb somewhere, to open something…
Other	
If you see the focal doing anything interesting that can't fit in any of the previous category	
OOS	
Whenever the focal is out of sight and you can't observe its behaviour	