POLYSPECIFIC ASSOCIATIONS FROM CAMERA TRAPPING DATA OF THE LESULA MONKEY (CERCOPITHECUS LOMAMIENSIS) IN THE LOMAMI NATIONAL PARK AND BUFFER ZONE IN THE DEMOCRATIC REPUBLIC OF THE CONGO

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Abstract

Polyspecific associations are common among African Cercopithecus monkeys in the forest canopy and may provide benefits by maximizing foraging success and reducing predation risk. The ground dwelling lesula monkey (Cercopithecus lomamiensis) is endemic to the Congo Basin in Central Africa and provides a unique opportunity to study interspecies interactions on the forest floor. The objectives of our study were to investigate the type and frequency of associations between lesula and heterospecifics, and if variation in patterns of association occurs among survey sites. We also assessed lesula's behavior when in association. Camera trap videos containing lesula with heterospecifics were organized into events. We scored behaviors in an ethogram using continuous focal sampling. We found that lesula occurred in polyspecific associations with multiple sympatric species and were observed most often with the blue duiker (Philantomba monticola). Results indicated that relaxed behaviors were the most common responses of lesula when in polyspecific associations.

Introduction

Biodiversity monitoring has revealed a diverse animal community in the Lomami National Park (LNP) in the Democratic Republic of the Congo (DRC) (Hart et al., 2012). The lesula monkey (Cercopithecus lomamiensis) is found only in the LNP and buffer zone making it endemic to the area. The species was first documented in 2012 after intense field observations in the LNP area. Due to the relatively recent discovery of the lesula monkey, camera traps were placed in its range to learn more about its behavioral ecology and unique terrestrial niche among the Cercopithecus genus, a group of African monkeys commonly referred to as the guenons.

In the past decade, the use of camera traps has exponentially increased in wildlife field studies as a tool for monitoring unhabituated and cryptic species that would have been inaccessible otherwise (Pebsworth & LeFleur, 2014; Boyer-Ontl & Pruetz, 2014). Camera traps have provided new insight into surveying rare species, monitoring remote primate populations, and documenting elusive primate behavior, such as resource use and mixed species interactions (Pebsworth & LeFleur, 2014; Tisovec et al., 2014; Boyer-Ontl & Pruetz, 2014). For example, Prasad et al. (2010) documented through camera traps the ecological interaction between arboreal primate species and terrestrial frugivores by confirming which species consumed the fruit dropped by the primates. This type of association contributes to natural forest regeneration through seed dispersal and the health of an ecosystem (Prasad et al., 2010).

In this study, the use of camera traps provided a unique opportunity to study mixed-species associations between the elusive lesula monkey and sympatric terrestrial mammals. Arboreal guenons typically form interspecies associations among one another (Buzzard, 2010; Cords, 1990; Noe & Bshary, 1997). Lesula is one of the rare guenon species that spends most of its time on the forest floor, which makes this study important by providing insight on which sympatric species lesula may associate with (Arenson et al.,2020). Additionally, this study contributes to the limited number of publications regarding the LNP and buffer zone and even fewer that report on lesula's ecology.

Primate studies involving associations between multiple species, or polyspecific associations, typically focus on overlapping (sympatric) tree dwelling (arboreal) primate species; however, this study has a unique opportunity to record associations between the ground dwelling lesula monkey species and heterospecifics. Furthermore, the lesula monkey is relatively understudied and no study has investigated mixed species group behavior. The objectives of our study were to use ground camera trap data to: (1) document polyspecific associations between lesula and sympatric species, (2) report the frequency of these associations, (3) investigate if variation in association patterns exists among survey sites, and (4) analyze the behavioral responses of lesula individuals when found in close proximity associations with heterospecifics.

Methods

Study site

LNP is an 8,874 km2 area of undeveloped lowland rainforest that lies within the 21,000 km2 TL2 landscape (named after the Tshuapa, Lualaba, and Lomami Rivers bordering the area) (Figure 1). This area of the Congo Basin is relatively understudied, and little is known beyond the knowledge of local hunters. Since 2007, members of the Frankfurt Zoological Society's TL2 Project have surveyed the area and found a biodiverse ecosystem with a number of endemic animal species. The project documented bonobos (Pan paniscus), confirmed the presence of okapi in the park (Okapia johnstoni), documented the threatened and commonly hunted African forest elephant (Loxodonta cyclotis),

and discovered the lesula monkey (Cercopithecus lomamiensis), which is a unique species that spends most of its time on the forest floor, unlike other guenons. Through collaborations with the Congolese Institute for the Conservation of Nature (ICCN), local hunters and villagers, and regional governments, the LNP was established in 2016. The TL2 Project is ongoing, and patrol teams regularly survey the park and buffer zone for illegal hunting, document species, and contribute to the conservation of its biodiversity.

Camera trap surveys

The Florida Atlantic University (FAU) Primatology Lab has an ongoing collaboration with the TL2 Project of the Frankfurt Zoological Society in the DRC (Hart, 2020). Our study is part of the Lesula Project, a larger project on the lesula monkey based on camera trap surveys that were conducted along the forest floor over a three-year period in the LNP and buffer zone in the DRC. We used both Moultrie and Bushnell cameras of similar standards and they were programmed to take videos at a resolution of 1280x720 pixels. Camera models consisted of Bushnell trophy cam, Moultrie M100, and Moultrie M880. The lesula species was recorded at three survey sites, Losekola, Okulu, and E15, located between the Lomami and Tshuapa Rivers (Figure 1). Two survey sites (Losekola and E15) were located inside the protected park area, and one site (Okulu) was located in the buffer zone, where mammals are heavily hunted (Figure 1). Forty-one cameras were placed in Okulu between October and December 2013, 41 cameras in Losekola between January and November 2014, and 20 cameras in E15 between August 2015 and January 2016. We recorded the sampling effort as the total number of days the camera traps were running. The video length for each camera varied from 20 to 90 seconds, the difference in video durations were caused by camera trap models used and its deterioration of quality after extensive exposure outdoors. The Primatology Lab at Florida Atlantic University (FAU) received the camera trap videos from the TL2 Project (Hart, 2020).

Species analysis

After receiving camera trap data, we watched all videos using VLC format v. 3.0.8 along with QuickTime player 7 v. 10.5 software (n = 1,885 in Okulu, n = 9,179 in Losekola, n = 3,570 in E15) and logged all species captured into a database (Fournier Korchia, 2020). Throughout the project, the lab recruited FAU undergraduate and high school students to input camera trap data. We created a biological inventory with the known species and listed a description of each species' physical characteristics accompanied with a video. Lab volunteers used this inventory as a reference list to provide a visual aid for identifying species. We organized the videos in an excel database by survey site and camera trap station and in chronological order by date and time of day. After input, we cross checked the data with an excel database completed by TL2 Project field biologists in the DRC. We then created a cumulative excel database by correcting inaccuracies and inconsistencies in species identification.

Polyspecific association events

For the Lesula Project, researchers organized lesula videos into 30-minute events from the same camera, defined as a series of chronological videos where a cluster of activity was observed (Fournier Korchia, 2020). In this study, we used the same event duration for comparison purposes. We differentiated two types of polyspecific associations (close and distant proximity) and recorded an association event when at least one video displayed lesula monkey(s) in close proximity with individual(s) from another species (Table 1). Event data sheets were organized by species, survey site, and in chronological order. We calculated the percentage of polyspecific association events compared to the total lesula events calculated in the Lesula Project. We also compared the number of polyspecific associations between species and survey sites.

Behavioral Analysis

Looking at each event, we counted the total number of lesula monkeys recorded in associations along with the total number of lesula monkeys in close proximity to heterospecifics. We determined if the same individual occurred in consecutive videos if it was in the same spot or if multiple videos tracked their activity pattern (i.e., an individual started walking in one video and in the next video a monkey, presumably the same individual, continued to walk in the same direction). We recorded the time (in seconds) each lesula monkey was in a close proximity association with heterospecifics. We then compared the percentage of time lesula monkeys spent in close proximity versus distant proximity within all polyspecific associations.

To understand behaviors of lesula during associations with each species, we sampled all lesula individuals during close proximity using continuous focal sampling. Focal animal sampling is typically done with one animal at a time; however, with camera trap videos, multiple animals can be sampled by replaying the video and selecting a new focal animal until all individuals are sampled. We recorded behaviors following the ethogram in Table 2. During observations, behaviors were scored using a one-zero sampling method. To determine the type of association, we organized each behavior into one of the two categories: relaxed or aroused (Table 2).

Results

Camera trap surveys

The camera traps ran for a total of 5,960 camera trap days (n = 1,551 in Okulu, n = 2,430 in Losekola, n = 1,979 in E15) (Fournier Korchia, 2020). Researchers recorded a total of 598 lesula events out of the three surveys, which represents a capture rate of 10 events/100 camera trap days (Fournier Korchia, 2020). Here, we recorded 34 events of lesula associating with one species and one event

of lesula associating with two species (Cercopithecus mitis and Philantomba monticola), which represents 5.9% of all lesula events and an association capture rate of 0.6 events/100 camera trap days.

Polyspecific Association Events

We recorded lesula in polyspecific associations with multiple bird species (crested guinea fowl, Guttera pucherani, and two unidentified species), one primate species (blue monkey, Cercopithecus mitis), two duiker species (Weyns' duiker, Cephalophus weynsi, and blue duiker, Philantomba monticola), and one species of mongoose (long snouted mongoose, Xenogale naso) (Table 3).

Lesula was found to be in association more often with the blue duiker (68%) than any other species across all three surveys (Figure 2a & b). We recorded higher rates of polyspecific associations inside the LNP (E15 followed by Losekola) than in the buffer zone (Okulu) (Figure 3).

Association types

We recorded a total of 130 lesula monkeys in association events, of which 43% (n = 56 lesula) were in close proximity with sympatric species. Out of the total time of polyspecific associations (n = 2962 seconds), lesula was in close proximity with heterospecifics 21% (n = 626 seconds) of the time. When in close proximity associations, lesula individuals displayed relaxed behaviors at least once across all species. However, aroused behaviors (n = 6 behavioral scores) were observed with only three of the five species captured in association with lesula: C. mitis, P. monticola, and X. naso (Figure 4). Overall, relaxed behaviors occurred in 93% (n = 69 behavioral scores) of the close proximity associations (Figure 4).

Discussion

Similar to arboreal Cercopithecus monkeys, our results confirmed that the lesula species forms polyspecific associations on the forest floor. Of all sympatric species, the blue duiker was found to associate most often with lesula and was the only species captured in association with lesula through all three surveys. Studies on interspecies interactions have discussed driving factors behind polyspecific associations, which include an increase in foraging efficiency and a decrease in predation risk (Heymann & Hsia, 2015; Cords, 1990). One species may exploit the other to locate resources, or both species may collaboratively increase their foraging efficiency. Ungulates have been found to co-occur with primates to benefit from their foraging habits (Heymann & Hsia, 2015; Newton, 1989; Desbiez et al., 2010; Newton, 1989; Tsuji et al., 2007; Koda, 2012). Some primate species are known to leave behind and drop unfinished food items to the forest floor, which are exploited by ground dwelling species, such as antelope and deer (Heymann & Hsia, 2015; Prasad et al. 2010). Similarly, individuals may reduce predation risk by benefiting from antipredator strategies of another species or by having a shared defensive strategy. In a larger mixed-species group, species may gain protection from increased vigilance, dilution, and through primate alarm calls (Rainey et al., 2004; Isbell & Bidner, 2016; Cords, 1990).

The blue duiker species may utilize lesula for protection and foraging purposes. As lesula lives in larger groups than the monogamous blue duiker, it may be an opportunity for the blue duiker to increase vigilance and dilution effect. Additionally, relaxed behaviors were the most common category scored during associations. This suggests that neither species views each other as a threat or as potential competition. Duikers were observed initiating play with lesula or playing while lesula was present. Further analysis should look at possible dietary or home range overlap to find possible explanations of the high association pattern (Waser, 1982; Erinjery et al., 2016).

Associations were mostly captured between two species; however, we observed one association event composed of three species (blue monkey, blue duiker, and lesula). This event displayed lesula and blue monkey individuals in a close proximity interaction; whereas, one duiker appeared at the end of the event in a distant proximity association. This is the only event recorded with lesula interacting with another guenon species and it contained aroused behaviors. This may suggest a potential competitive interaction for food resources or territory between arboreal guenon species.

When comparing the three survey sites (Okulu, Losekola, and E15), Okulu had the smallest number of association events, which is likely due to the impact of hunting on the mammal population in the buffer zone. Overall, interspecies events were rare, making up less than 6% of all lesula events, which may be due to the use of camera traps as a detection tool. While camera traps are beneficial to study unhabituated species, some limitations may be reported. We expect undocumented associations to have occurred outside of the camera trap detection zone. Additionally, the duration of an association was also limited by the camera detection zone, where animals moving out of sight could no longer be scored.

The understudied lesula monkey is a unique species as it is the only guenon to mostly occupy the forest floor in the Lomami National Park and thus provided us with the opportunity to investigate its interspecies interactions. This study generated new knowledge about the sympatric species that lesula associates with. Future studies that set cameras in the canopy will expand our knowledge on the multiple species in association with lesula. Understanding their mixed species associations provides new insight into lesula's behavior and ecology and the overall community ecology of the Lomami National Park.

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References

Arenson, J. L., Sargis, E. J., Hart, J. A., Hart, T. B., Detwiler, K. M., & Gilbert, C. C. (2020). Skeletal morphology of the lesula (Cercopithecus lomamiensis) and the evolution of guenon locomotor behavior. American Journal of Physical Anthropology, 172(1), 3–24.

Boyer-Ontl, K. M., & Pruetz, J. D. (2014). Giving the forest eyes: The benefits of using camera traps to study unhabituated Chimpanzees (Pan troglodytes verus) in Southeastern Senegal. International Journal of Primatology, 35(5): 881-894.

Buzzard, P. J. (2010). Polyspecific associations of Cercopithecus campbelli and C. petaurista with C. diana: What are the costs and benefits? Primates, 51(4): 307-314.

Cords, M. (1990). Mixed-Species association of East-African guenons: General patterns or specific examples? American Journal of Primatology, 21(2): 101-114.

Desbiez, A., Rocha, F., & Keuroghlian, A. (2010). Interspecies association between an ungulate and a carnivore or a primate. Acta Ethologica, 13(2): 137-139.

Erinjery, J., Kumara, H., Kavana, T. S., & Singh M. (2016). Are interspecific associations of primates in the Western Ghats a matter of chance? A case study of the lion-tailed macaque. Journal of Tropical Ecology, 32: 41-49.

Fournier Korchia, C. S. (2020). Behavioral ecology of Cercopithecus lomamiensis in the Lomami National Park and buffer zone, Democratic Republic of the Congo. Master Thesis. Florida Atlantic University. Boca Raton, FL.

Hart, T. B. Searching for Bonobo in Congo. Field notes from Dr. Terese Hart. https://www.bonoboincongo.com/the-project/. Downloaded on May 29, 2020.

Hart, J., Detwiler, K., Gilbert, C., Burrell, A., Fuller, J., Emetshu, M., Hart, T., Vosper, A., Sargis, E., Tosi, A. (2012). Lesula: A new species of Cercopithecus monkey endemic to the Democratic Republic of the Congo and implications for conservation of Congo's Central Basin. PlosOne, 7(9).

Heymann E. W., & Hsia S. S. (2015). Unlike fellows - a review of primate-non-primate associations. Biological Reviews, 90(1), 142–156.

Isbell, L. A. & Bidner L. R. (2016). Vervet monkey (Chlorocebus pygerythrus) alarm calls to leopards (Panthera pardus) function as a predator deterrent. Behavior, 153(5): 591-606.

Koda, H. (2012). Possible use of heterospecific food-associated calls of macaques by sika deer for foraging efficiency. Behavioural Processes, 91(1): 30-34.

Newton, P. N. (1989). Associations between Langur monkeys (Presbytis entellus) and Chital deer (Axis axis): Chance encounters or a mutualism? Ethology, 83(2): 89-120.

Noe, R. & Bshary R. (1997). Red colobus and Diana monkeys provide mutual protection against predators. Animal Behaviour, 54: 1461-1474.

Pebsworth, P. A., & LaFleur, M. (2014). Advancing primate research and conservation through the use of camera traps: Introduction to the special Issue. International Journal of Primatology, 35(5): 825-840.

Prasad, S., Pittet, A., & Sukumar, R. (2010). Who really ate the fruit? A novel approach to camera trapping for quantifying frugivory by ruminants. Ecological Research, 25(1): 225-231.

Rainey, H., Zuberbühler K., & Slater P. (2004). Hornbills can distinguish between primate alarm calls. Proceedings of the Royal Society B – Biological Sciences, 271(1540): 755-759.

Tisovec, K. C., Cassano, C. R., Boubli, J. P., & Pardini, R. (2014). Mixed-species groups of Marmosets and Tamarins across a gradient of agroforestry intensification. Association for Tropical Biology and Conservation, 46(2): 248-255.

Tsuji, Y., Shimoda-Ishiguro, M., Ohnishi, N., & Takatsuki, S. (2007). A friend in need is a friend indeed: Feeding association between Japanese macaques and sika deer. Acta Theriologica, 52(4): 427–434.

Waser, P. M. (1982). Primate polyspecific associations: Do they occur by chance? Animal Behaviour, 30: 1-8.

Tables

Table 1. Definitions of the two type of associations captured between lesula and other species.

Type of association	Definition
Close proximity	Lesula co-occurs with another species within the detection zone of the camera at the same time (i.e. observer sees animals together on the computer screen).
Distant proximity	Lesula occurs with another species within the same event (i.e. observer sees another species in the event but not together at the same time).

Table 2. Ethogram of the different behaviors displayed by lesula separated in two categories: relaxed and aroused.

Behaviors	Definition
Relaxed behaviors	Focal animal displays a behavior of relative un-alertness.
Following	Individual walking in the same direction, in close or distant proximity or walking towards the same side of the camera frame.
Foraging	Individual searching surroundings for food items, such as leaves or fruits.
Playing	Individual performing non-aggressive chasing, grabbing, and/or wrestling.
Walking	Individual displaying forward locomotion on four legs at a slow gait.
Stationary	Individual not moving (sitting, standing, or clinging).
Aroused behaviors	There is an increased sense of alertness by the focal animal.
Fleeing	Individual involved in flight behavior, movement in the opposite direction in response to chasing and/or viewing or interacting with another individual.
Chasing	Individual running rapidly or leaping toward another individual.
Running	Individual displaying forward locomotion on four legs at a rapid gait.

Table 3. Number of associations between lesula and other species captured during a lesula event at the three camera trap sites.

Category	Species	Number of associations			
		Okulu	**Losekola**	**E15**	**Total**
Bird	N/A	1	0	2	3
Primate	*C. mitis*	0	1*	0	1
Duiker	*P. monticola*	1	9*	15	25
	C. weynsi	0	3	2	5
Mongoose	*X. naso*	0	1	1	2
Total		2	14	20	36

* The one event where lesula was captured with two heterospecific species (*C. mitis* and *P. monticola*) was counted in separate categories in this table (one association with *C. mitis* and one association with *P. monticola*).

Figures

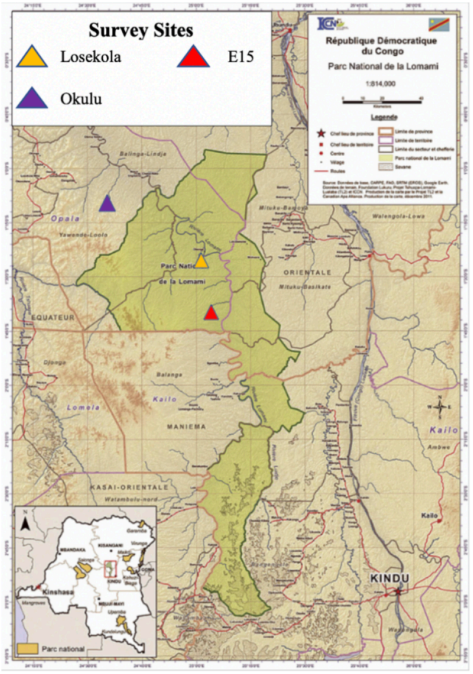

Figure 1. Map inset: Lomami National Park in the Democratic Republic of the Congo. Enlarged map: The three camera trap survey sites in the Lomami National Park and its buffer zone (Okulu, Losekola, and E15).

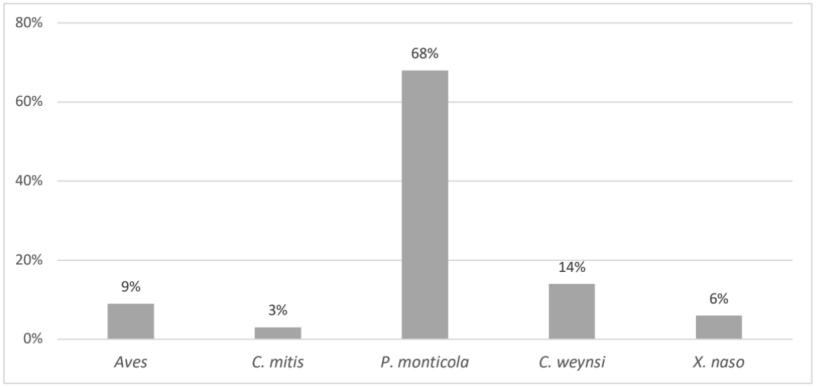

Figure 2a. (top) Still frame of lesula (*Cercopithecus lomamiensis*) standing in front of the blue duiker (*Philantomba monticola*) in close proximity. Figure 2b. (bottom) Frequency of polyspecific associations between lesula and other species at the three sites combined.

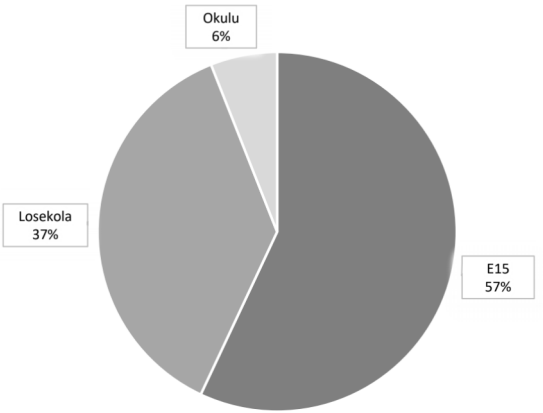

Figure 3. Percentage of polyspecific events between lesula and other species at the three survey sites: Okulu (n = 2), Losekola (n = 13), and E15 (n = 20).

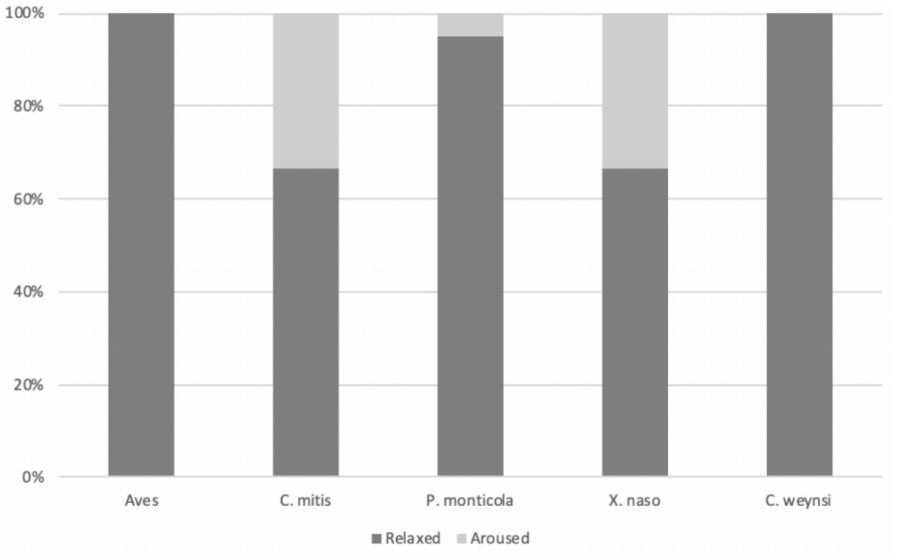

Figure 4: Frequency of the two types of polyspecific associations (relaxed and aroused) based on the analysis of lesula behaviors in close proximity with heterospecifics at the three survey sites (n = 75 behavioral scores).