Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2022; 10(5): 181-186

Received: 05-06-2022
Accepted: 08-07-2022

Djaha André Koffi
Laboratoire de Biologie et Ecologie Tropicale, Université Jean Lorougnon Guédé Dalo. Groupe de Recherches Conservation et Valorisation des Ressources Naturelles, Centre Suisse de Recherches Scientifiques, Abidjan, Côte d'Ivoire

Eloi Anderson Bitty
Laboratoire des Milieux naturels et Conservation de la Biodiversité, Université Félix Houphouët Boigny Abidjan, Côte d'Ivoire. Groupe de Recherches Conservation et Valorisation des Ressources Naturelles, Centre Suisse de Recherches Scientifiques, Abidjan, Côte d'Ivoire

Jean Modeste Kouassi
Laboratoire des Milieux naturels et Conservation de la Biodiversité, Université Félix Houphouët Boigny Abidjan, Côte d'Ivoire

Daniel Alempijevic
Department of Biological Sciences, Florida Atlantic University, USA

Kate Detwilerand
Department of Biological Sciences, Florida Atlantic University, USA. Department of Anthropology, Florida Atlantic University, USA

Inza Koné
Laboratoire des Milieux naturels et Conservation de la Biodiversité, Université Félix Houphouët Boigny Abidjan, Côte d'Ivoire. Groupe de Recherches Conservation et Valorisation des Ressources Naturelles, Centre Suisse de Recherches Scientifiques, Abidjan, Côte d'Ivoire

Corresponding Author:
Djaha André Koffi
Laboratoire de Biologie et Ecologie Tropicale, Université Jean Lorougnon Guédé Dalo. Groupe de Recherches Conservation et Valorisation des Ressources Naturelles, Centre Suisse de Recherches Scientifiques, Abidjan, Côte d'Ivoire

Association rates between the monkeys of the Tanoé-Ehy swamp forest in Côte d'Ivoire using arboreal camera traps

Djaha André Koffi, Eloi Anderson Bitty, Jean Modeste Kouassi, Daniel Alempijevic, Kate Detwiler and Inza Koné

Abstract
The Tanoé-Ehy Swamp Forest is a critical site for the conservation of West African primates. This study aims to understand a behavioral aspect of these monkeys: their tendency to form polyspecific associations. Direct observation is difficult because of high water levels in the swamp, so we used camera traps for this purpose. We set 62 camera traps in the canopy at eight sites for 16 months. Analysis of the recorded videos confirmed the presence of six species of monkeys. Among these species of monkeys, only the olive- Colobus (*Pro* Colobus verus) showed a significant tendency to associate with heterospecifics. *Roloway*'s monkey (*Cercopithecus roloway*) also showed a strong association trend, although this trend was not significant. In contrast, few polyspecific associations were detected among the other species. These results may be explained by the absence of non-human predators at this site, but the limited detection zone of the camera traps in relation to group spread must be taken into consideration.

Keywords: polyspecific associations, tanoé-ehy forest, camera-traps, cercopithecidae

Introduction
Social living is known in several taxa of animals. This phenomenon is widespread in fish where some species live in schools of several thousand individuals (Masse *et al*., 1996) [28] as well as in migratory birds and insects (Ben, 2015) [5]. Group living is also observed in some mammals (Averbeck *et al*., 2009) [2]. In primates, group life coincided with the transition from nocturnal to diurnal activity (Van Schaik and Van Hooff, 1983) [36]. Indeed, it is generally accepted that the ancestors of modern primates were nocturnal and solitary (Eisenberg *et al*., 1972) [15]. Living in a group provides several advantages to its members. For example, members of a large group benefit from the dilution effect. (Williams, 1966; Hamilton, 1971) [37, 22]. The dilution effect is the fact that the probability of an individual being captured by a solitary predator decreases rapidly with increasing group size (Turner and Pitcher, 1986; Inman and Krebs, 1987) [35, 23]. Members of large groups also benefit from the confusion effect (Cott, 1940; Edmunds, 1974; Milinksi, 1990) [10, 14, 31], when the predator is unable to concentrate on a specific individual. Another advantage is that due to its large size, the group has higher vigilance and therefore a greater probability of detecting the predator before it attacks (Kenward, 1978; Dunbar, 1988) [25, 13], each member ensuring the safety of the group. In addition, a large group has the advantage of defending resources from a smaller group.
All of these advantages are valid for both monospecific and polyspecific groups. The ultimate causes of polyspecific groups have been widely documented (Hamilton, 1971; Edmunds, 1974; Milinksi, 1990; Bshary and Noë, 1997b) [22, 14, 34, 9]. Bshary and Noë (1997b) [9] have shown that this behavior in primates is a strategy to increase vigilance while reducing food competition among conspecifics. In this study, we investigate the use of camera traps to estimate rates of associations between the monkeys of the Tanoé-Ehy Swamp Forest.

Materials and Methods
Study area
The Tanoé-Ehy Swamp Forest is located in the extreme south-east of Côte d'Ivoire between West longitudes 2° 45' and 2° 53' and the north latitudes 5° 05' and 5° 15' (Figure 1). The average rainfall in the region was 1,925 mm per year (Avenard *et al*., 1971) [1] but it has

considerably decreased in recent years. It fluctuates between 1400 and 1600 mm per year and the temperatures vary from 22 °C to 30 °C with an average of 26 °C. The Tanoé-Ehy swamp is covered with evergreen forest with many areas submerged year-round. The site has recently received status as a community nature reserve, through conservation initiatives that are supported by local people.

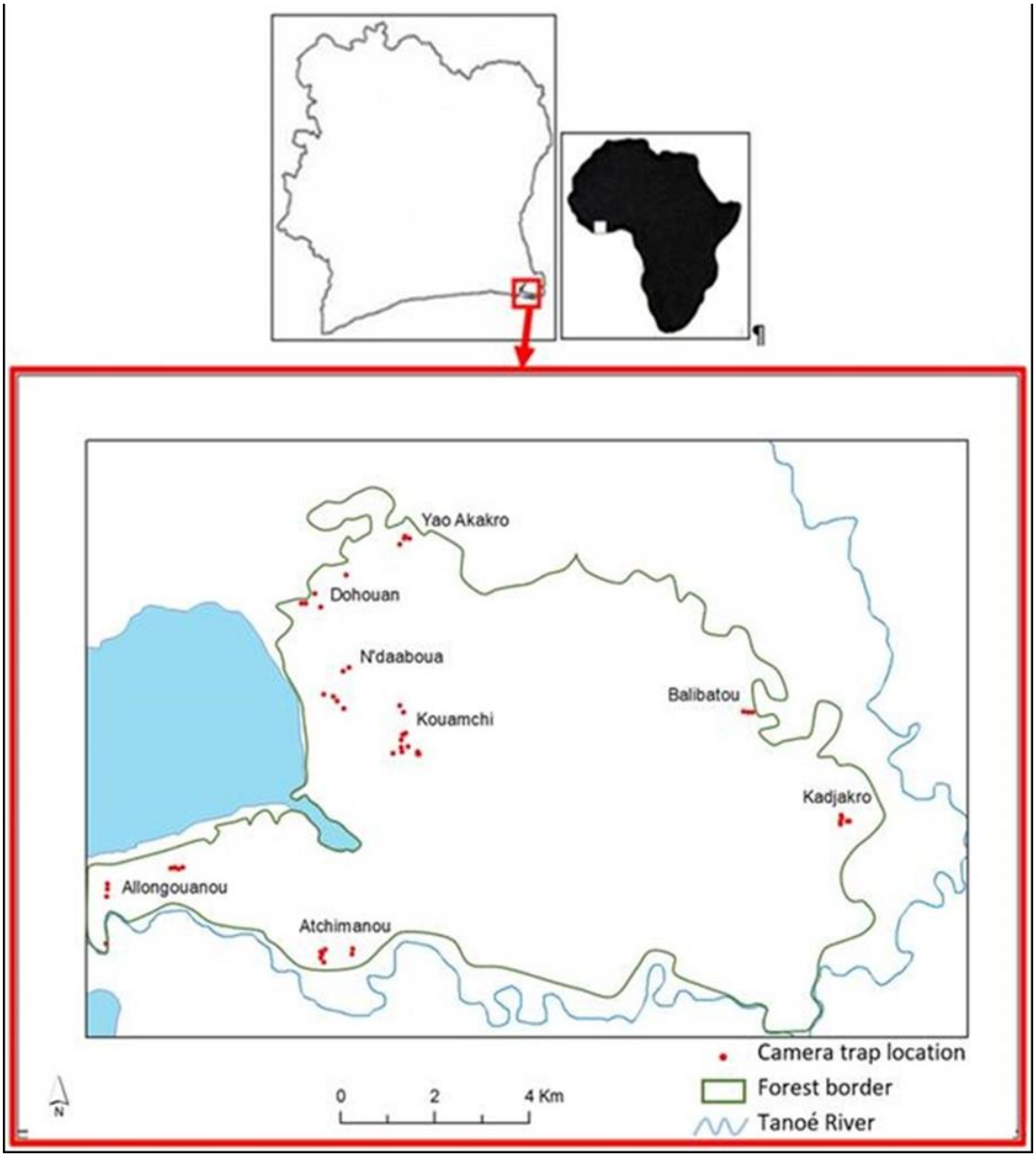

Fig 1: Camera trap locations in the Tanoé-Ehy Swamp Forest

Data collection

We held interviews with village guides (Converted hunters) to determine sites for setting up camera traps. Sites were chosen strategically using local knowledge of primate habitat use, the presence of fruit trees, and the intensity of human activities. From this preliminary survey, eight sites were selected: Allangouanou, Atchimanou, Balibatou, Dohouan and Yao-Akakro (high human use), Kadjakro and N'daaboua (moderate use) and Kouamtchi (rare use).

In the forest, 62 camera traps (Bushnell Trophy Cam HD Essential) were installed in the canopy at 51 trapping points throughout the eight sites. DA accessed the canopy using the single-rope climbing technique (Gregory *et al.*, 2014) [21]. The cameras were set to record 60-s videos with a one-second minimum interval between two consecutive videos. Data collection lasted 16 months over three survey rotations, when camera traps were serviced and moved between the eight sites.

Data analysis

Species identification and determination of association types

Species identification was carried out using Kingdon's field guide (2015) [26] but also with the support of experts in primatology.

To determine the different types of associations, we binned all the videos taken at the same trapping point during a period of ≤ 30 minutes into an event (Rovero *et al* Zimmermann, 2016) [32]. When only one species of monkey was observed in an event, we considered it to be a mono specific association. If two or more species were recorded in an event, we recorded the species to be in a poly specific association. These

associations included bispecific associations when two species were present or trispecific when there were three species in the same event.

Duration and tendency to associate calculations

We calculated the duration of an association by summing the durations of all the events during which the association occurred.

We calculated the absolute specific tendency to form an association following the method of Gautier and Gautier-Hion (1969) [18], taking into account the numbers of encounters where the species is found alone and the numbers of polyspecific encounters, without considering the types of association.

$$Ta = \frac{Rp}{Rp + Rm}$$

Ta = Tendency to associate
Rp = number of polyspecific encounters
Rm = number of monospecific encounters

Results

Diversity and observation frequencies

Six monkey species belonging to two subfamilies (Cercopithecinae and Colobinae) and distributed in four genera (*Cercocebus*, *Cercopithecus*, Colobus, *ProColobus*) were identified. The Lowe's guenon (*Cercopithecus lowei*) and the lesser-spot nosed monkey (*Cercopithecus petaurista*) were the most frequently observed and were found at almost all surveyed areas (Figure 2). The Lowe's guenon was detected most frequently at the Kadjakro, Kouamtchi and Dohouan sites.

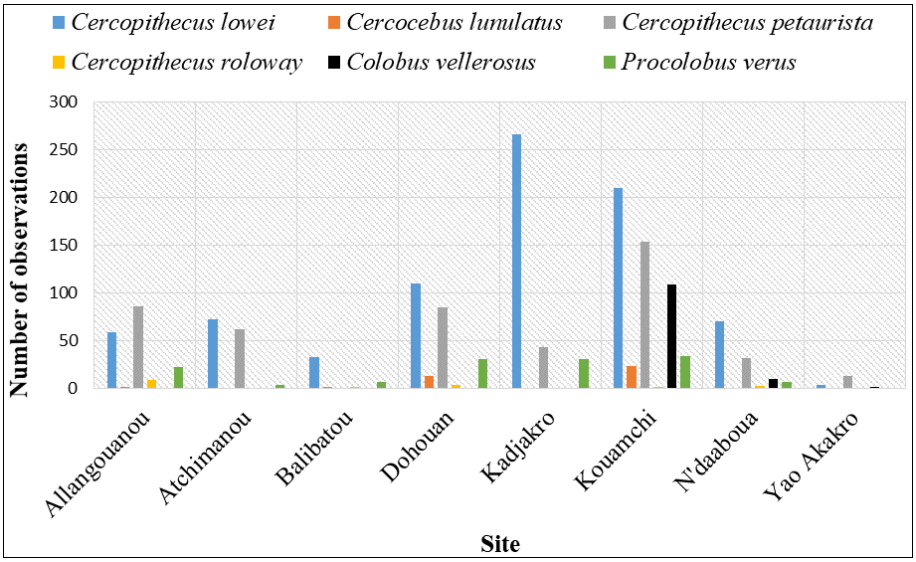

Fig 2: Monkey observation frequencies by site.

Different types of association

We identified 15 different combinations of associations including six monospecific and nine polyspecific associations (bispecific: 8, trispecific: 1). The proportion of monospecific associations (96%) was much higher than that of polyspecific associations (4%) (Table 1).

Trispecific associations were rarely detected (0.2%) compared to bispecific associations (3.8%). The only trispecific association detected was composed of *Cercopithecus lowei*, *Cercopithecus petaurista* and *ProColobus* verus.

Table 1: Importance of different types of association

Type of association	Species involved	Number of observations	Proportion of type of association (%)
Monospecific	*Cercocebus lunulatus*	42	96
	Cercopithecus lowei	826	
	Cercopithecus petaurista	476	
	Cercopithecus roloway	20	
	Colobus *vellerosus*	121	
	ProColobus verus	137	
Bispecific	*C. lowei-Cer. lunulatus*	4	3,8
	C. lowei-C. petaurista	19	
	C. lowei-C. roloway	1	
	C. lowei-Col. vellerosus	3	
	C. lowei-Procol. verus	23	
	C. petaurista-Procol. verus	9	
	C. petaurista-C. roloway	4	
	Procol. verus-*Col. vellerosus*	1	
Trispecific	*C. lowei-C. petaurista-Procol.* verus	4	0,2
Total		1690	100

Of the six monkeys detected, only *Procol.* verus showed a significant tendency towards polyspecific association (Table 2). *C. petaurista* and *C. lowei*, the most frequently observed monkeys, showed the least tendency to associate. *C. roloway* showed a tendency to form polyspecific associations, although this trend was not statistically significant.

Table 2: Absolute tendency of species to associate

Species	Ma	Pa	Ta	χ^2	Significancy	Rank (Ta)	
Procol. verus	137	37	0,21	38,85	S	1	
C. roloway	20	5	0,20	4,57	NS	2	
Cer. lunulatus	42	4	0,09	0,03	NS	3	χ^2 (5%) = 11,07
C. petaurista	476	36	0,07	0,54	NS	4	
C. lowei	826	54	0,06	3,63	NS	5	
Col. vellerosus	121	4	0,03	3,54	NS	6	

Ma= Monospecific association, Pa= Polyspecific association, Ta=Tendency to associate, NS= Not Significant, S= Significant.

The sites of Kouamtchi and Dohouan had the highest number of association combinations with seven and six different combinations respectively (Figure 3)

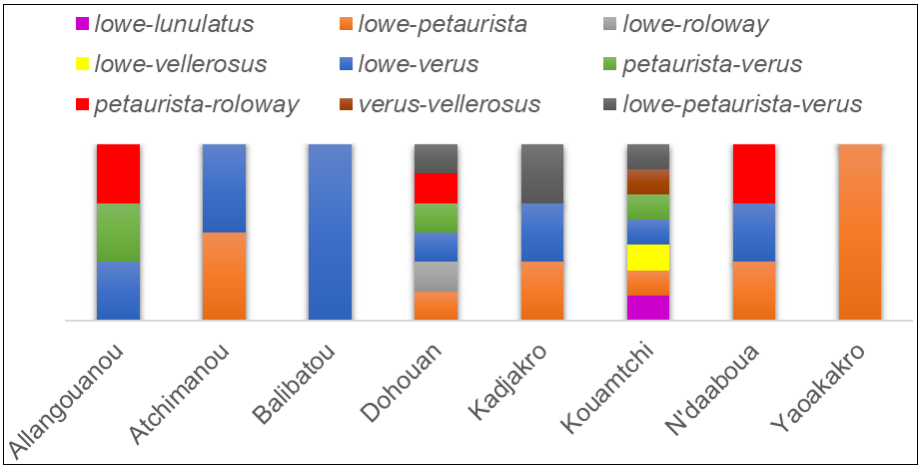

Fig 3: Different association combinations per site

Duration of associations

The monkeys were observed for a total duration of 61,300 minutes. During this period, they were in polyspecific associations only 4% of the time (figure 4)

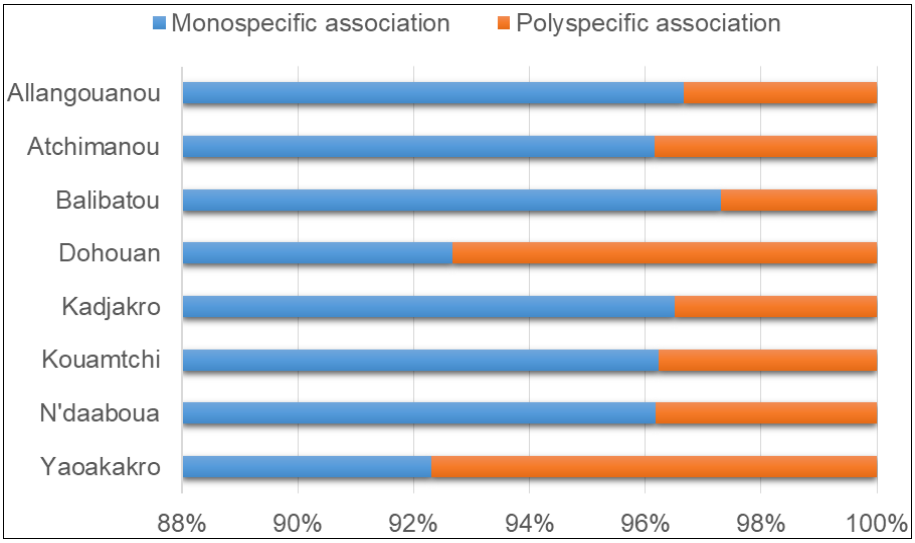

Fig 4: Proportion of association time

Although polyspecific associations appeared to be of short duration, they were formed at all sites. However, the length of time devoted to these associations varied. Indeed, the G^2 test or Wilks' likelihood ratio revealed significant differences in association time between sites (ddl = 56, α = 0, 05, $p<$ 0,0001). Polyspecific associations were formed longer at the Dohaoun and Yao-Akakro sites than at the other sites.

Discussion

Our study confirmed six species of diurnal primates in the Tanoé-Ehy Swamp Forest, as have previous studies (McGraw, 1998; McGraw and Oates, 2002; Gonédélé Bi *et al.*, 2008; Béné *et al.*, 2012; Bi *et al.*, 2013; Koffi *et al.*, 2019) [29, 30, 20, 4, 27]. These species were found almost everywhere, except for Colobus *vellerosus* which was detected only at the

sites of Kouamtchi and N'daaboua, suggesting that this species is sensitive to disturbance and avoids areas of high human activity. Colobus *vellerosus* is a cryptic species that prefers high canopy forest (Teichroeb *et al*., 2003; Djègo-Djossou *et al*., 2015) [34, 12] and therefore is difficult to detect. Lowe's guenon *(Cercopithecus lowei)* and lesser-spot nosed monkey *(Cercopithecus petaurista)* were particularly common. These species were found in all environments of the study site and appeared tolerant of human activity. Indeed, these two species often approach agricultural plots or fallow land to feed on exotic plant items such as seeds of palm oil *Elaeis guineensis* (Arecaceae) (Kambiré *et al*., 2021) [24].

While camera traps were an excellent tool to detect arboreal primates, they rarely detected polyspecific associations. Indeed, 96% of detections were of monospecific groups, while it is widely documented that monkeys form polyspecific associations for foraging (Erin and McGraw, 2017) [16] and to defend themselves against predators (Bshary and Noë, 1997a; 1997b) [8]. This could be explained by the fact that the monkeys from this site showed a weak tendency to associate, unlike their congeners from the Taï national park (Galat and Galat, 1985) [17] and from the Ogooué-Ivindo basin in Gabon (Gautier and Gautier, 1969) [18]. Indeed, of the six species of monkeys observed, only the olive Colobus showed a significant tendency to associate (Ta = 0.21; χ^2 =38.85 with χ^2 (5%) = 11.07). However, this species was rare at the site, as was *Roloway*'s monkey, which also had a strong, although not significant, tendency to associate. Moreover, in a study conducted by Béné *et al*., 2012 [4], *Roloway*'s monkey was the species that associated most frequently with White-napped mangabey and olive Colobus. But since then, this monkey has become very rare and cryptic due to poaching. Since the most frequent species such as *C. lowei* and *C. petaurista* were rarely observed in polyspecific associations, the overall frequency of polyspecific associations was low in this study. During the 16 months of the study, camera traps only detected trispecific associations during four events. These associations included *C. lowei, C. petaurista and Procol.* verus. However, quadrispecific, pentaspecific and even hexaspecific associations have been observed in Taï National Park (Galat and Galat, 1985) [17].

Anthropogenic pressure on the forest includes poaching, agriculture, fishing and illegal logging. However, these activities are mostly practiced on the periphery of the swamp because it is difficult to traverse the high water. Moreover, unlike the Taï National Park where chimpanzee (*Pan troglodytes* verus), crowned eagle (*Stephanoaetus coronatus*) and leopard (*Panthera pardus*) are formidable predators (Boesch and Boesch, 1989; Shultz and Noé, 2002; Zuberbühler and Jenny, 2002) [7, 33, 38] there are few non-human predators in Tanoé swamp. The lack of non-human predators may be reducing the likelihood of forming polyspecific associations.

However, a few cases of polyspecific associations (4%) have been observed in all survey sites, regardless of the intensity of human activities. The greatest number of combinations of associations was observed in the Kouamtchi area in the swamp' s interior. The Kouamtchi site experiences less disturbance than the peripherial sites. It is possible that more primates occur here, thereby increasing the likelihood of detecting monkeys in polyspecific association. Also, many camera traps were installed in the crowns of fruiting trees such as *Nauclea diderrichii* (Rubiaceae) where monkeys were often recorded eating, which may have influenced the likelihood of detection. However, in areas of high anthropogenic pressure, polyspecific associations were formed over a relatively longer period (more than 7% of the observation time). This is particularly the case in Dohouan and Yao-Akakro. In these two sites, deforestation and poaching is high. However, the monkeys at these sites take advantage of the wide availability of *Elaeis guineensis* (oil palm) and *Raphia hookeri* (Arecaceae) seeds. By forming polyspecific associations of longer duration, the monkeys may benefit from the vigilance of each member of the group (Dunbar, 1988; Beauchamp, 2001) [13, 3] but also from the dilution effect (Hamilton, 1971; Dehn, 1990) [22, 11] with respect to human predation. The dilution effect being the fact that the probability of an individual being captured decreases rapidly with increasing group size.

While camera traps are an excellent tool to detect individual primates, further research is needed to determine their effectiveness in detecting enough members of a social group to make inferences regarding group composition. Camera traps can only record individuals that pass through its detection zone. Monkeys in a polyspecific association can travel across several tree crowns, resulting in a group spread that is greater than the camera trap's detection zone. Therefore, it is likely that the rate of polyspecific association was greater than what was detected by the camera trap footage.

Conclusion

The use of camera traps made it possible to identify six species of monkeys living in the Tanoé-Ehy Swamp Forest: *Cercopithecus lowei, Cercopithecus petaurista, Cercopithecus roloway, Cercocebus lunulatus,* Colobus *vellerosus* and *ProColobus* verus. Among these species, *Cercopithecus lowei* and *Cercopithecus petaurista* were detected most frequently and were found throughout the forest. Although camera traps occassionally recorded polyspecific associations, most recordings were of individiual monkeys or of monospecific associations. Most species showed a weak tendency to associate except for *ProColobus* verus, which expressed a significant tendency to associate.

Acknowledgments

We sincerely thank Re:wild for its financial support in accomplishing this work. Our thanks also go to each of the members of the village team who help us set up the camera traps in this hard-to-reach forest. We thank the local communities for their ongoing support and collaboration. We thank the students and volunteers at Florida Atlantic University for screening videos and entering data on animals detected.

References

1. Avenard JM, Eldin M, Girard G, Sircoulon J, Touchebeuf P, Guillaumet JL, *et al*. Le milieu naturel de la Côte d'Ivoire. Paris OSTROM 50; c1971.
2. Averbeck C, Apio A, Plathe M, Wronski T. Hunting differentially affects mixed-sex and bachelorherds in a gregarious ungulate, the impala (*Aepyceros melampus*: Bovidae). African Journal of Ecology. 2009;48:255-264.
3. Beauchamp G. Should vigilance always decrease with group size? Behavioral Ecology and Sociobiology. 2001; 51:47-52.
4. Béné JCK, Koné I, Gonédélé Bi S, Bitty EA, Ouattara K, Akpatou KB, *et al*. The diurnal primate community of the

Tanoé Forest: species composition, relative abundance, distribution, polyspecific associations and conservation status. International Journal of Biological and Chemical Sciences. 2012;6(1):51-64.
5. Ben Z. Parlons d'abeilles et d'oiseaux: la théorie des essaims et le processus décisionnel militaire. Revue militaire canadiennel. 2015;15(3):29-36.
6. Bi SG, Bené JCK, Bitty EA, Kassé BK, Guessan AN, Koffi DA *et al*. *Roloway* Guenon (*Cercopithecus diana roloway*) and White-Naped Mangabey (*Cercocebus* atys lunulatus) Prefer Mangrove Habitats in Tanoé Forest, South-Eastern Ivory Coast. Journal of Ecosystem and Ecography. 2013;3:1-6.
7. Boesch C, Boesch H. Hunting Behavior of Wild Chimpanzees in the Taï National Park. American Journal of Physical Anthropology. 1989;78:547-573.
8. Bshary R, Noë R. Anti-predation behaviour of red Colobus monkeys in the presence of chimpanzees. Behavioral Ecology and Sociobiology. 1997a;41:321-333.
9. Bshary R, Noë R. Red Colobus and Diana monkeys provide mutual protection against predators. Animal Behaviour. 1997b;54:1461-1474.
10. Cott, HB. Adaptive Coloration in Animals. London: Methuen; c1940.
11. Dehn MM, Vigilance for predators' detection and dilution effects Behavioral Ecology and Sociobiology 1990;26:337-342.
12. Djègo-Djossou S, Koné I, Fandohan AB, Djègo JG, Huynen MC, Sinsin B. Habitat Use by White-Thighed Colobus in the Kikélé Sacred Forest: Activity Budget, Feeding Ecology and Selection of Sleeping Trees. Primate Conservation. 2015;29:97-105.
13. Dunbar RIM. Evolution of grouping patterns. In: Primate social systems. Croom Helm. London, Sydney; c1988. p. 106-150.
14. Edmunds M. Defence in Animals: A Survey of Anti-Predator Defences. London: Longmans; c1974.
15. Eisenberg JF, Muckenhirn NA, Rudran R. The relation between ecology and social structure in primates. Science. 1972;176:863-874.
16. Erin EK, McGraw SW. Dietary variation in diana monkeys (*Cercopithecus diana*): The Effects of Polyspecific Associations. Folia Primatol. 2017;88:455-482.
17. Galat G, Galat-Luong A. La communauté de primates diurnes de la forêt de Taï, Côte d'Ivoire. Terre et Vie. 1985;40:3-32.
18. Gautier JP, Gautier-Hion A. Polyspecific associations in the Cercopithecidae of Gabon. Review of Ecology, Earth and Life. 1969(2):164-201.
19. Gautier-Hion A, Quris R, Gautier JP. Monospecific vs. polyspecific life: A comparative study of foraging and antipredatory tactics in a community of *Cercopithecus* monkeys. Behavioral Ecology and Sociobiology. 1983;12:325-335.
20. Gonédélé Bi S, Koné I, Béné JCK, Bitty AE, Akpatou KB, Zoro GB, *et al*. Tanoé forest, south-eastern Côte-d'Ivoire identified as a high priority site for the conservation of critically endangered Primates in West Africa. Tropical Conservation Science. 2008;1(3):265-278.
21. Gregory T, Carrasco Rueda F, Deichmann J, Kolowski J, Alonso A. Arboreal camera trapping: Taking a proven method to new heights. Methods in Ecology and Evolution. 2014;5(5):443-451. https://doi.org/10.1111/2041-210X.12177
22. Hamilton WD. Geometry for the selfish herd. Journal of Theorical Biolpgy. 1971;31:295-311.
23. Inman AJ, Krebs J. Predation and group living. Trends in Ecology &. Evolution. 1987;2:31-32.
24. Kambiré SB, Ouattara K, Kouakou JL, Koné I. Variabilité saisonnière et disponibilité des ressources alimentaires végétales consommées par les Mones de Lowe *Cercopithecus* lowei Thomas, 1923 dans la forêt de l'Université Nangui Abrogoua, Abidjan- Côte d'Ivoire. International Journal of Biological and Chemical Sciences. 2021;15(5):2023-2037.
25. Kenward RE. Hawks and doves: factors affecting success and selection in goshawk attacks on woodpigeons. Journal of Animal Ecology. 1978;47:449-460.
26. Kingdon J. The Kingdon field guide to African mammals. Ed. Princeton University Press; Second edition. New Jersey, USA; c2015.
27. Koffi DA, Kassi NJJD, Bene JCK, N'guessan KA, Kouakou YC. Diversity and abundance of terrestrial mammals in the northern periphery of Tanoe-Ehy forest in rainy season (South-eastern of Côte d'Ivoire). Journal of Biodiversity and Environmental Sciences. 2019;15(5):61-68.
28. Masse J, Koutsikopoulos C, Patty W. The structure and spatial distribution of pelagic fish schools in multispecies clusters: an acoustic study. ICES Journal of Marine Science: Journal du Conseil. 1996;53(2):155-160.
29. McGraw WS. Three monkeys nearing extinction in the forest reserves of eastern Côte d'Ivoire. Oryx. 1998;32:233-236.
30. McGraw WS, Oates JF. Evidence for a surviving population of Miss Waldron's red Colobus. Oryx. 2002;36:223-226.
31. Milinksi M. Information overload and food selection. In: Hughes RN Editor. Behavioural mecanism of food selection. Berlin Springer-Verlag; c1990. p. 721-736.
32. Rovero F, Zimmermann F. Camera trapping for Wildlife Research. F. Rovero & F. Zimmermann eds. Pelagic Publishing. Exeter, UK; c2016.
33. Shultz S, Noé R. The consequences of crowned eagle central-place foraging on predation risk in monkeys. Proceedings of the Royal Society B: Biological Sciences. 2002;269(1502):1797-1802.
34. Teichroeb JA, Saj TL, Paterson JD, Sicotte P. Effect of group size on activity budgets in Colobus *vellerosus* in Ghana. International Journal of Primatology 2003;24:743-758.
35. Turner GF, Pitcher TJ. Attack Abatement: A model for group protection by combined avoidance and dilution. The American Naturalist. 1986;128:228-240.
36. Van-Schaik CP, Van-Hooff JRAM. On the ultimate causes of primate social systems. Behaviour. 1983;85:91-117.
37. Williams GC. Adaptation and Natural Selection. Princeton: Princeton University Press, New Jersey USA; c1966.
38. Zuberbühler K, Jenny D. Leopard predation and primate evolution, Journal of Human Evolution. 2002;43(6):873-886.