Journal of Tropical Ecology

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Growing population of the critically endangered white-thighed colobus monkey (*Colobus vellerosus*) from forest fragments in Ghana

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Short Communication

Cite this article: Kankam BO, Antwi-Bosiako P, Addae-Wireko L, and Dankwah C (2023). Growing population of the critically endangered white-thighed colobus monkey (*Colobus vellerosus*) from forest fragments in Ghana. *Journal of Tropical Ecology*. **39**(e33), 1–6. doi: https://doi.org/10.1017/S0266467423000214

Received: 5 September 2022
Revised: 19 April 2023
Accepted: 27 June 2023

Keywords:
Boabeng-Fiema Monkey Sanctuary; *Colobus vellerosus*; population trends; forest fragments; census

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Abstract

The population of critically endangered white-thighed colobus monkeys (*Colobus vellerosus*) at Boabeng-Fiema Monkey Sanctuary (BFMS) is possibly the only growing population of this species in West Africa. We assessed the current population status of *C. vellerosus* in BFMS and the surrounding fragments in Ghana. We undertook a complete count of the population in 2020, and this data was combined with previously conducted complete counts from 1990 to 2014. Results show that the total population growth rate of colobus monkeys at BFMS and the surrounding forest fragments was 353.9% between the 1990 and 2020 censuses (at a rate of 11.8% annually). In the BFMS alone, the total population growth rate was 252.3% between 1990 and 2020 (i.e., at a rate of 8.4% annually). The total population growth rate in the surrounding forest fragments was 97.0% between the first census year of 1997 and the 2020 census (i.e., at a rate of 4.2% annually). The mean group size in the BFMS was 16.7 individuals (SD = 4.0; range = 9–25), while that of the surrounding forest fragments was 14.4 individuals (SD = 4.6; range = 9–23). The overall mean group size was 16.1 individuals (SD = 4.3; range = 9–25). An approximate ratio of one adult male to three adult females (1:3.4) and one adult female to one immature (1:1.2) is an indication that the population of *C. vellerosus* still has the potential to increase further when new suitable forest fragments are explored in the future. *C. vellerosus* has the potential to increase further in population in small, suitable fragments if habitat destruction and settlement expansion are managed with primate conservation intentions.

Introduction

It is estimated that on average, 69% of the global wildlife population has been lost in just under 50 years (WWF 2022), and 60% of all primate species are threatened with extinction as a result of human activities and behaviour (Estrada *et al.* 2017). Numerous land-use practises lead to habitat degradation and the formation of forest fragments in the tropical forest regions of the world where primates live (Didham 1997; Foley *et al.* 2005; Onderdonk & Chapman 2000; WWF 2022). Such anthropogenic activities affect plant species richness, and change the forest structure, diversity, and biomass (Arroyo-Rodríguez *et al.* 2007; Martin & Asibey 1979; Spracklen *et al.* 2015). As a result, primate food resources may be reduced, which has the potential to modify group size, group composition, and population size (Clarke *et al.* 2002; Eppley *et al.* 2011; Onderdonk & Chapman 2000). When primate populations become completely isolated, especially in small fragments, they are likely to be threatened by localised extinctions (Benchimol & Peres 2013; Lovejoy *et al.* 1986).

The critically endangered white-thighed colobus (*Colobus vellerosus*) is resident only in Benin, Côte d'Ivoire, Togo, and Ghana (Matsuda *et al.* 2020). In Boabeng-Fiema Monkey Sanctuary (BFMS), in Ghana, *C. vellerosus* population lives in fragmented habitats (Kankam 1997; Saj *et al.* 2005). Current evidence suggests that in addition to the Boabeng and Fiema communities, *C. vellerosus* also inhabits fragmented habitats within the forests of seven other communities (Kankam 1997; Kankam & Sicotte 2013).

The population of *Colobus vellerosus* at BFMS and the surrounding communities has increased over the years (Kankam *et al.* 2010) from 128 individuals in 1990 (Fargey 1991) to 163 individuals in 1997 (Kankam 1997), excluding the small populations in the surrounding forest fragments. Furthermore, it increased from 200 individuals in 2005 (Saj *et al.* 2005) to 275 individuals in 2010 (Kankam & Sicotte 2013), making it possibly the only growing population of *C. vellerosus* in West Africa (Saj & Sicotte 2013). However, there are fluctuations in the population trend in the surrounding communities (Kankam & Sicotte 2013). Monitoring

the colobus population is critical to understanding the population dynamics of *C. vellerosus* at the BFMS and the surrounding forest fragments (Kankam & Sicotte 2013).

The population trend in the sanctuary and the surrounding communities has not been monitored for over a decade to determine its current status. Regular monitoring and provision of information on the population status are very important to assess the success of primate conservation programmes (Kankam 2010). Therefore, the objective of the research was to examine current population trends of *Colobus vellerosus* in the BFMS and surrounding forest fragments. Specifically, we undertook a complete count of the population of *C. vellerosus* in the BFMS and the surrounding fragments in 2020, and this data was compared with previously conducted counts from 1990 to 2014.

Study site

The study was carried out at BMFS and surrounded forest fragments (7º 43' N, 1º 42' W). It is a 1.9 km^2 area within a 4.5 km^2 sacred grove, situated around the twin villages of Boabeng and Fiema in the Nkoranza District in Ghana (Wong & Sicotte 2007). The sanctuary is surrounded by communities that have pockets of forest owned by the communities (Kankam 1997; Kankam & Sicotte 2013; Wong & Sicotte 2006). The area lies within the southern rainforest–dry northern grassland transition zone, with a mean annual temperature and rainfall of 26ºC and 1,250 mm, respectively (Kankam & Sicotte 2013). The sanctuary is home to the endangered white-thighed colobus (*Colobus vellerosus*), which is endemic to the Upper Guinean Forest, and Lowe's monkeys (*Cercopithecus campbelli lowei*) (Fargey 1991). The vegetation comprises a mosaic of original forest, degraded forest, woodland, and savannah (Kankam 2010).

Materials and methods

To determine the current population of *C. vellerosus* in BFMS and the surrounding fragments ($n = 11$), the complete count method (Jarman *et al.* 1996; Onderdonk & Chapman 2000) was adopted for consistency and comparability with the methods previously used by other researchers at the site (Fargey 1992; Kankam 1997; Kankam & Sicotte 2013; Saj *et al.* 2005; Wong & Sicotte 2006). It is perhaps the most accurate primate census technique to assess group size and population size (Plumptre & Cox 2006), although it cannot be generalised (Ross & Reeve 2003). In the pre-census period, the colobus groups were identified and their general location was assessed by trained research assistants ($n = 42$) for two weeks. This exercise was very important to identify all groups and where they could possibly be found. To gain access to various parts of their ranges to locate the groups of *C. vellerosus,* several transects were cut, and existing trails, footpaths, and roads were also used (estimated total distance covered: 88.2 km). The length of transects was averaged at 0.05 km (range: 0.02–0.1 km). The population survey was conducted over three days in October 2020. On each census day, research assistants located a group assigned to them in the morning before the census began at 10:00 h. The censuses were carried out on the same day and at the same time (from 10:00 h to 15:00 h) to avoid counting moving individuals or groups that may be moving between fragments during the census period. Research assistants were rotated to get an independent count for each group and also minimise biases in the counts. For each census, a 'good count' was used. A 'good' count was characterised by the fact that the group either crossed an opened area during counting, which made the monkeys more visible and easier to count, or when they were in a tree with good visibility (Baker *et al.* 2009, Kankam & Sicotte 2013). The absence of groups in a fragment was also recorded. For each group encountered, we recorded the total number of individuals by sex and age-class. The age-class was classified into adults (this category included sub-adults), immature, and infants (Kankam & Sicotte 2013; Wong & Sicotte 2006). Estimation of age-class was based on the relative size of the monkeys and our knowledge of each group's history (Kankam 2010).

Data analyses

The population density (number of individuals/km^2) was calculated by dividing the total number of monkeys in each forest fragment by the size of the fragment. A good count of the number of individuals in each fragment was used to estimate the colobus population density in each community (Kankam & Sicotte 2013; Wong & Sicotte 2006). The population growth rate from one period to another (Table 2) was calculated from the formula PR = [(Vpresent –Vpast)/Vpast × 100]/N, where PR is the percentage growth rate, Vpresent is the present population, Vpast is the past population, and N is the number of years (Organization for Economic Cooperation and Development 1997).

The size of the fragments was obtained by traversing the defined pillared boundaries of some communities. Other communities have planted trees with fire resistant characteristics, such as teak (*Tectona grandis*), to demarcate the forest boundaries. For communities with no defined boundaries, the elders and chiefs elected some community members who had knowledge of the proposed boundaries of the areas to accompany the first author to take the Global Positioning System points. A map was generated from this data, which allowed documentation of the fragment sizes (Kankam 2010).

Results

Thirty-six white-thighed colobus monkey groups with a total of 581 individuals inhabited the BFMS and the surrounding forest fragments, for a population density of 148.6 ind/km^2 and group density of 9.0 groups/km^2 (Tables 1 and 2). In BFMS alone, the population was 451 individuals (density: 234.9 ind/km^2) in 27 groups (density: 14.1 ind/km^2). The colobus population of the surrounding forest fragments was composed of 130 individuals (density: 65.3 ind/ km^2), divided into nine groups (density: 4.5 groups/km^2) (Table 2). Overall, the total population growth rate of colobus monkeys at BFMS and the surrounding forest fragments was 353.9% in the 30 years between the 1990 and 2020 censuses (at a rate of 11.8% annually). In the BFMS alone, the total population growth rate was 252.3% between 1990 and 2020 (i.e., at a rate of 8.4% annually). The population growth rate from 1990 to 2000, 2000 to 2010, and 2010 to 2020 was 5.6%, 3.8%, and 6.4%, respectively, in the BFMS. The total population growth rate in the surrounding forest fragments was 97.0% in the 23 years between the first census years of 1997 and the 2020 census (i.e., at a rate of 4.2% annually). However, the population growth rate from 1997 to 2010 and 2010 to 2020 was 7.5% and 3.8%, respectively, in the surrounding forest fragments. The mean group size of colobus in BFMS was 16.7 individuals (SD = 4.0; range = 9–25), while that of the surrounding forest fragments was 14.4 individuals (SD = 4.6;

https://doi.org/10.1017/S0266467423000214 Published online by Cambridge University Press

Table 1. *C. vellerosus* population characteristics and density in the BFMS and surrounding forest fragments in 2020

Community	Area (km^2)	Age-sex composition				No. of groups	No. of monkeys	Density (ind/ km^2)
		Adult Female	Adult Male	Immature	Infants			
BFMS	1.92	137	43	174	97	27	451	234.9
Konkrompe	0.39	6	1	7	5	1	19	48.7
Bonte	0.33	7	2	6	3	1	18	54.5
Bomini	0.31	5	1	4	4	1	14	45.2
Busunya	0.54	14	3	12	7	2	36	66.7
Akrudwa Kuma	0.34	8	2	5	6	2	21	61.8
Akrudwa Panyin	0.03	4	1	6	2	1	13	433.3
Tiger Krom	0.05	3	1	3	2	1	9	180.0
Total		184	54	217	126	36	581	

Table 2. *C. vellerosus* population trends in the BFMS and surrounding fragments between 1990 and 2020. The numbers of monkey groups are shown in brackets

Community	Area (km^2)	Total number of individuals in census year						
		1990[a]	1997[b]	2000[c]	2006[d]	2010[e]	2014[f]	2020*
BFMS	1.92	128 (8)	163 (10)	200 (14)	229 (15)	275 (19)	332 (25)	451 (27)
Konkrompe	0.39	–	0 (0)	–	0 (0)	22 (2)	16 (1)	19 (1)
Bonte	0.33	–	15 (1)	–	17 (1)	24 (2)	14 (1)	18 (1)
Bomini	0.31	–	0 (0)	–	0 (0)	4 (1)	7 (1)	14 (1)
Busunya	0.54	–	45 (2)	–	27 (4)	24 (3)	42 (3)	36 (2)
Akrudwa Kuma	0.34	–	6 (1)	–	16 (1)	17 (2)	11 (1)	21 (2)
Akrudwa Panyin	0.03	–	0 (0)	–	0 (0)	0 (0)	13 (1)	13 (1)
Tiger Krom	0.05	–	0 (0)	–	0 (0)	0 (0)	0 (0)	9 (1)
Total	3.91	128 (8)	229 (14)	200 (14)	289 (21)	366 (29)	435 (33)	581 (36)
BFMS density (ind/km^2)		66.7	84.9	104.2	119.3	143.2	172.9	234.9
Forest fragments density (ind/km^2)		–	54.5	–	49.6	47.6	53.1	65.3
Overall density (ind/ km^2)		–	58.6	–	73.9	93.6	111.3	148.6

Source: Fargey (1991)[a]; Kankam (1997)[b]; Saj *et al.* (2005)[c]; Wong and Sicotte (2006)[d]; Kankam *et al.* (2010)[e]; Sicotte and Kankam (unpublished report)[f]; this survey*, (-) means census was conducted only in BFMS.

range = 9–23). The overall mean group size was 16.1 individuals (SD = 4.3; range = 9–25) in BFMS and surrounding forest fragments (Table 1). There was an approximate ratio of one adult male to three adult females in both BFMS and in the surrounding fragments, as deduced from Table 1. However, the ratio of adult individuals (adult females and adult males) to immature individuals, including infants, was skewed towards immature individuals at BFMS (1:0.7) and the surrounding forest fragments (1:0.8). On average, there was a ratio of one adult female to one immature individual (1:1.2).

Discussion

We detected an impressive growth of colobus monkeys at BFMS and the surrounding fragments, about 354% in a 20-year period (1990–2020; at a rate of 11.8% annually). In the BFMS alone, the total population growth rate was 252.3% between 1990 and 2020 (i.e., at a rate of 8.4% annually).

The *C. vellerosus* density in BFMS was higher (density: 14.1 groups/km^2) for a small fragment than that of *Colobus guereza* in Kakamega Forest in Kenya (estimate of 11.5 groups/km^2), which was described as high for a rainforest site (Fashing & Cords 2000). Also, the smaller fragments of the surrounding communities support a relatively higher population density (Irwin 2008). The average ratio of one adult female to one immature (1:1.2) is an indication that the population in the fragments is growing with births (Emmel 1976; Kankam 2010).

The colobus population in BFMS continues to increase, as seen in successful stories of primate conservation in fragments (e.g., the golden lion tamarin *Leontopithecus rosalia* in Brazil: Kierulff *et al.* 2012; the howler monkey populations in Mexico: Estrada *et al.* 2002; and the black-and-white colobus *Colobus guereza* in Kibale National Park: Chapman *et al.* 2018). Conversely, the population of the black-and-white colobus *Colobus guereza* and the red colobus *Procolobus pennantii* decreased in Western Uganda due to habitat loss and forest degradation in small and unprotected forest fragments (Chapman *et al.* 2007). The construction of large infrastructures affected the population of the black howler monkey *Alouatta pigra* in Mexico (Pozo-Montuy & Bonilla-Sánchez 2022). Moreover, primate habitat fragmentation also decreased the

https://doi.org/10.1017/S0266467423000214 Published online by Cambridge University Press

population of the black-fronted titi monkey *Callicebus nigrifrons* in Brazil (Berthet *et al.* 2021); and in India, of the western hoolock gibbon *Hoolock hoolock*: ICIMOD 2021; Sharma *et al.* 2014).

We do not completely understand the causes of this population increase in BFMS; however, it suggests some degree of success for the community-based primate conservation programme (Kankam *et al.* 2010). Although we did not specifically investigate the cause of the increase in population over the past thirty years, it is likely that, first, the success of protecting the monkeys using traditional systems or cultural beliefs infused with the biological conservation management goal of the Wildlife Division of Ghana to assist communities in managing natural resources is a contributing factor (Saj *et al.* 2006). At BFMS, the monkeys are revered by the communities as the 'children of the gods' and protected as such (Fargey 1992). Second, improved stakeholder inclusion through the formation of a monkey sanctuary management committee comprised of representatives from Boabeng-Fiema and the surrounding communities with fragments occupied by colobus monkeys could be another factor. This committee includes a wildlife officer-in-charge of the sanctuary who is tasked with assisting in educating the communities about primate conservation, protecting biodiversity, and enhancing the site's tourism potential. The participating communities get financial support from monies accrued from the eco-tourism project (Kankam 2010). Third, the monkey's ability to cope well in smaller fragments (at least for the time being) may be due to their ability to broaden their diet to include low-quality plants when limited food resources are available (Kankam & Sicotte 2013; Marsh *et al.* 1987; Saj & Sicotte 2007; Saj *et al.* 2005; Tutin 1999), as seen in other colobus species (*Colobus polykomos*: Davies *et al.* 1999, *Colobus guereza*: Fashing 2001, *Procolobus badius, Procolobus verus,* and *Colobus satanas*: McKey *et al.* 1981). For example, in 2007, the colobus monkeys at the BFMS were found eating the leaves and green pods of an exotic and invasive species (*Leucaena leucocephala*) for which we have no records at the site as colobus food trees (Bright O. Kankam, pers. obs.). A similar behaviour is reported for black howler monkeys (*Alouatta caraya*) and brown howler monkeys (*Alouatta guariba clamitans*) in Rio Grande do Sul State, southern Brazil (Bicca-Marques & Calegaro-Marques 1994; Chaves & Bicca-Marques 2016). We argue that the conservation of the monkeys at the site should include planting food trees for the monkeys to increase the fragment size and food resources of the monkeys (Anderson *et al.* 2007; Chapman *et al.* 2020).

The existing threats in the area run counter the success of increasing populations of the monkeys, thus questioning the long-term conservation of the monkeys in the fragments at the BFMS (Kankam *et al.* 2010). Habitat disturbance (e.g., bushfire, farming activities, cutting of fuelwood, burning of charcoal in the fragments, and settlement expansion) has occurred and still occurs in the small fragments and the patches in between the fragments (Amankwah *et al.* 2021; Kankam 2010; Yeboah 2020). The colobus habitat is consistently becoming smaller due to the high level of anthropogenic disturbance (Amankwah *et al.* 2021; Kankam & Sicotte 2013; Kankam *et al.* 2010). For example, some large trees in the Busunya community have been removed to pave way for infrastructure expansion because it has been elevated to the district capital status of the Nkoranza South Municipal (Robert Koranteng, pers. comm.). Also, part of the core forest of BFMS was gutted by fire, which led to the death of 49 *C. vellerosus* in early 2020 (Samuel Amponsah, pers. comm.). The long-term persistence of the colobus species is at risk because of the shrinkage of forest fragments (Kankam *et al.* 2010; Yeboah 2020). Given that active farming activities and the burning of charcoal are still going on in the agricultural lands in-between fragments, the long-term conservation of *C. vellerosus* at BFMS is at risk because the removal of trees will reduce the food resources (Medley 1993), destroy the forest structure (Chapman & Chapman 1999), and reduce the possibility of arboreal movements for colobus in small fragmented landscapes (McGraw *et al.* 2007; Medley 1993). Revenue sharing from the conservation effort is also motivating the stakeholders to protect the monkeys and the forest fragments (Samuel Amponsah, pers. comm.). We believe that the lack of collaborative effort from stakeholders (e.g., the chiefs and leaders of all communities and the Ghana Wildlife Division), as a result of any non-transparent revenue-sharing and accountability plan (Kankam *et al.* 2010), would become one of the future potential threats to the protection and better management of the ecotourism programme at BFMS.

We suggest that *C. vellerosus* populations have the potential to increase further in small, suitable fragments if habitat destruction and settlement expansion are managed with primate conservation intentions.

Acknowledgements. We thank the chiefs and elders of all the fragments and the Wildlife Division officer-in-charge of BFMS (Samuel Amponsah) for granting permission to conduct this research at BFMS. Thanks to all the research assistants, especially Robert Koranteng and Charles Kodom, for training research assistants and helping in the censusing of the monkeys.

Financial support. This research received no specific grant from any funding agency or not-for-profit sector.

Competing interests. The authors declare none.

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