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Density and distribution of bongos (*Tragelaphus eurycerus*) in a high forest zone in Ghana

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This research was undertaken at Kakum Conservation Area (KCA) in the Central Region of Ghana, from October 2011 to September 2012. The aim was to determine the population density and factors affecting distribution of bongos *(Tragelaphus eurycerus)* for management planning and conservation of the bongo as well as tourism promotion. The methodology involved a field study of sampled plots that represented three habitat types, namely closed forest, open forest and thickets and habitat classification based on canopy coverage and locations of these habitats, whether marginal or deep inside the forest within each of the nine ranges. It was observed that encounters with bongos in KCA were more likely to be during early hours of the day, from 05.00 to 07.00 h GMT and later in the day, from 17.30 to 18.00 h GMT. The usual location was in their preferred thickets at four out of the nine ranges of KCA, and their distribution was not affected by seasonality or habitat utilization. About 5.3 bongos/km^2 currently occupy the KCA, which can be said to be currently under severe pressure as evidenced by the presence of hunting tools and human activities all over. The results of Pearson's correlation coefficient regarding bongo densities and water availability suggested that sources of water affected the distribution of the bongos in the KCA since more bongos were encountered closer to water sources. This underscores the importance of sources of water in the KCA for the conservation of the bongos, and the need to ensure adequate protection of the rivers and rivulets in KCA and off-reserve areas. These results have implications for the formulation of adaptive management plans that would protect the secretive, charismatic and largest antelopes in the KCA, thereby promoting tourism.

Key words: Population density, distribution, bongos, secretive, forest margins, Kakum Conservation Area, hunting pressure, water availability, tourism.

INTRODUCTION

The bongo (*Tragelaphus eurycerus* Ogilby, 1837) is the largest social forest-dwelling antelope in Africa, with geographical distribution within three discontinuous parts: East, Central and West (Bosley, 2003) (Figure 1). The species has been classified as Low Risk or Near Threatened with extirpations occurring in some African countries such as Benin, Togo and Uganda (IUCN, 2002). The species inhabits tropical jungles with dense under-growth up to altitude of 4000 m in Ghana, with exacer-bated loss of habitat for mammals due to agriculture and

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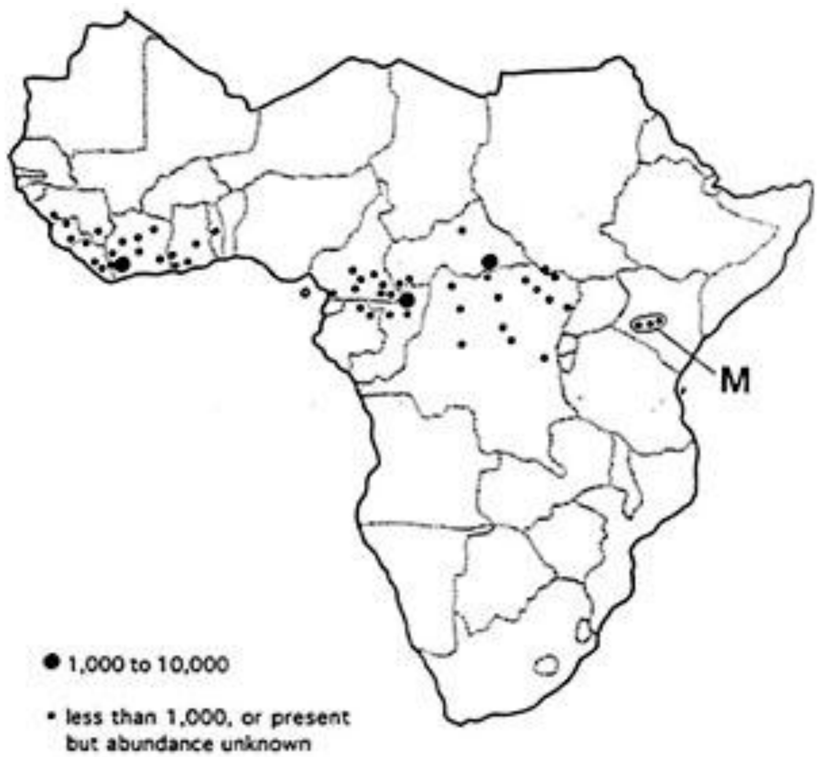

Figure 1. Distribution of bongos in Africa (Bosley, 2003).

deforestation. As expanding human populations compete with mammals for habitat, few forests including Kakum Conservation Area (KCA) remain for the bongo and; the future of bongos depends entirely on protected areas. Proper management of protected areas is thus very important and requires useful information from research studies as guide to the implementation of management schemes, specifically for the conservation of species, and more so for those endangered or near threatened such as the bongo. The bongo is a spectacular species with a relatively high touristic value. Yet, very few studies have been undertaken on wild bongos (Hillman, 1986; Hillman and Gwynne, 1987; Klaus-Hugi et al., 2000) with most information coming from captive populations in zoos. In the KCA, the bongo is second to the elephant in terms of size of the large mammal species, and its range in West Africa is limited as compared to elephants. Whilst the threatened status of elephants and some primates like the western chimpanzee *(Pan troglodytes)* and Miss Waldron's red colobus monkey *(Procolobus badius waldron)* has been given wide publicity (Oates et al., 1997), little is known about the bongos (East, 1990). Hiking expeditions for bongo sighting at the KCA have not been successful in many cases, even though this charismatic mammal would be interesting to view. In this study, the factors affecting the density and distribution of the bongo in KCA were assessed for management planning and action towards the conservation of the species, as well as tourism promotion. The study also investigates effects of water availability, habitat utilization and hunting pressure on the distribution of bongos in the study area.

Study area

KCA is located in a fragmented moist evergreen high forest zone in Southern Ghana (Figure 2), and consists of the Kakum National Park and its adjacent Assin Attandanso Resource Reserve, and occupies a 366-km^2 land area. Both areas were originally Forest Reserves but were legally gazetted in 1992 as wildlife conservation areas under the Wildlife Reserves Regulations (Ll 1525). This transferred administrative jurisdiction to the then Wildlife Department, following recommendations based on an initial faunal survey (Hawthorne and Abu-Juam, 1993; Nchanji, 1994). The general climatic conditions of the country characterized by bimodal rainfall and two dry seasons (Durand and Skubich, 1982) prevail in the park. A heavy rainy season from April to July is followed by a light dry season from August to September. A light rainy season from October to early December is then followed by a heavy dry harmattan season from December to March (Kouadio et al., 2008). The fauna may concentrate in and around the few water spots available in the park during the dry harmattan from December to March.

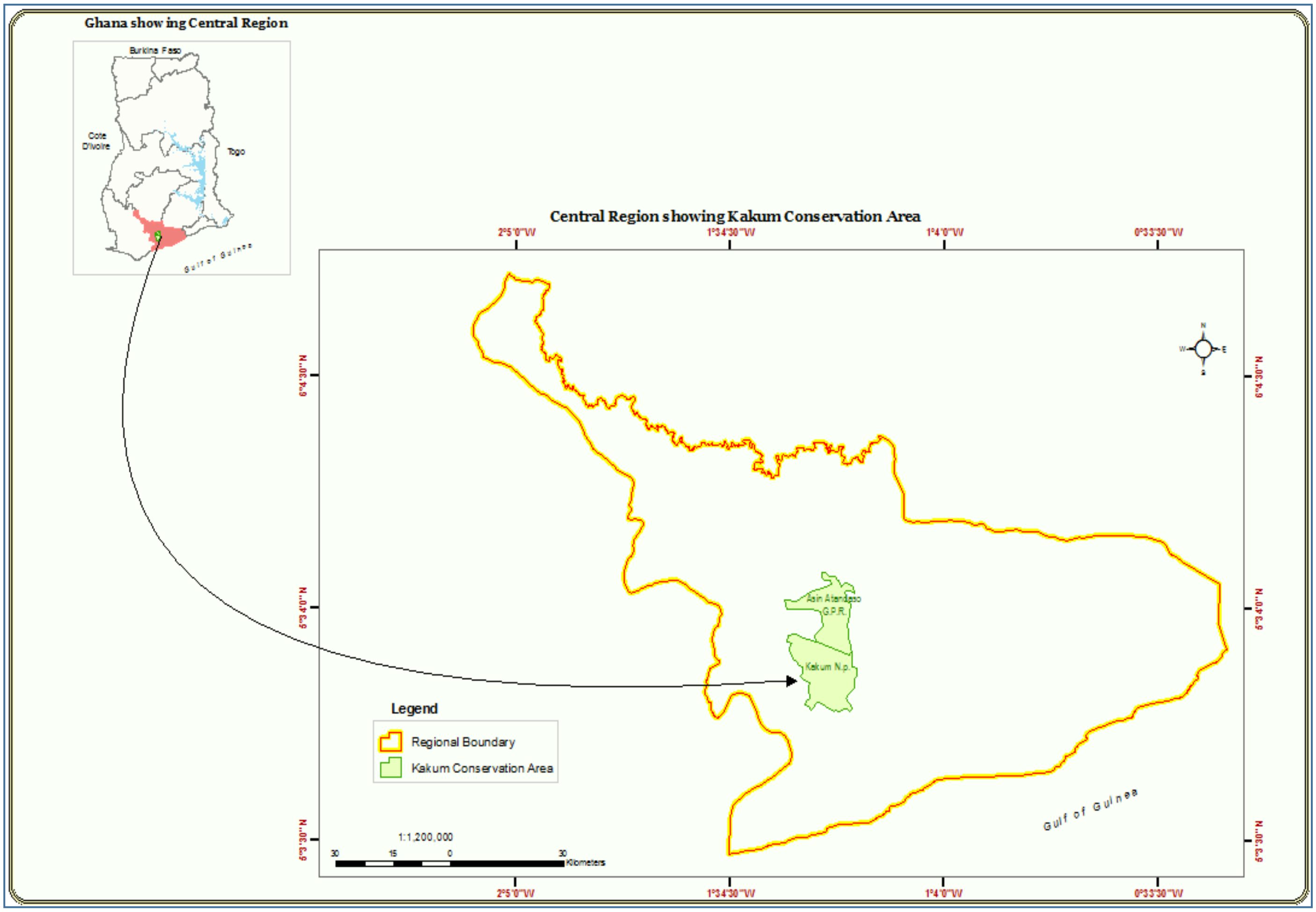

Figure 2. Location map of Kakum Conservation Area in the Central Region, Ghana.

The average annual rainfall is about 1600 mm (Forestry Commission, 2007). The average relative humidity is about 80% throughout the year while temperature ranges from 18.2 to 32.1°C. The terrain is flat to slightly undulating with an elevation of between 15 to 250 m above sea level (asl) (Forestry Commission, 2007). Most of the elevations occur in the south-western portion of the park. Light south westerly winds blow over the area almost throughout the year. The KCA is surrounded by about 52 local communities with a population of about 40,000 people who are mainly peasant farmers cultivating various food and cash crops, often close to the park boundaries (Monney et al., 2010).

About 105 species of vascular plants (Wildlife Department, 1996), 69 species of mammals (Yeboah, 1996) and about 266 species of birds (Dowsett-Lemaire and Dowsett, 2005) have so far been identified in KCA. Mammals include the potto (*Perodicticus potto*), Demidoff's galago (*Galagoides demidoff*), bongo, African forest elephant (*Loxodonta cyclotis*), and leopard (*Panthera pardus*). Many herpetofaunal species (Yeboah, 1996; Monney et al*.*, 2011) and a great number and diversity of butterflies (at least 405 species) (Larsen, 1994, 1995) have been recorded in the KCA, which, for effective patrol and monitoring is divided into nine ranges, namely Abrafo, Kruwa, Briscoe II, Adiembra, Homaho, Aboabo, Afiaso, Antwikwaa and Mfuom. Field staff are deployed from their camps adjacent to their ranges, and tourists led by tour guides use traditional routes in the park for hiking.

MATERIALS AND METHODS

Habitat classification

This study was undertaken from October 2011 to September 2012 using the nine ranges of KCA as study blocks, and camping at some vantage points from 04:00 to 08:00 h GMT and 16:00 to 18:30 h GMT. This became necessary because feasibility studies failed to sight the animal during the day to confirm reports by the staff. The study relied on a field study of sampled plots which were representative of three habitat types (closed forest, open forest and thickets) within each range. Habitat types were classified according to canopy coverage (Wiafe et al., 2010). In the closed forest, light penetration to the forest floor was less than 25%, and tree canopy coverage was more than 75%. In the open forest, light penetration to forest floor was more than 25% with tree canopy coverage less than 75%. In the thickets, light penetration was less than 25% and the canopy consisted of underbrush with coverage of more than 75%.

Sample plots, herd sizes and sighting times

To equalize sampling effort, two 200 m square plots were studied in different locations at each habitat type in each range, one at forest margin and another deep in the forest, and these locations were at least 1 km apart. In all 54 plots were surveyed over the period of study and each one was surveyed by eight people working in pairs and each pair taking charge of a portion of the plot to increase efforts. GPS coordinates at the centre of each plot were recorded. At each range plot surveys were conducted in each of eight months including both rainy and dry months and; from hideouts, including tree tops, hill tops and observation platforms, the number of bongos sighted, herd sizes and sighting times were recorded. Binoculars were used to facilitate viewing where necessary.

Mean bongo densities

Bongo densities were estimated by counting the number of individuals of bongo in each plot as follows: (1). The number of individuals of bongo in any plot divided by the plot area gave the bongos' plot density; (2). The number of individuals of bongo in the same habitat type were summed up and the result divided by the total area of all the plots in that habitat type to give the bongos' density for a specific habitat type; (3). The number of individuals of bongo in each habitat location were summed up and the result divided by the total area of all the plots in the same habitat location to give the bongos' density for a specific habitat location; (4). The number of individuals of bongo in each range were summed up and the result divided by the total area of all the plots in the same range to give the bongos' density for a specific range and; (5). The number of individuals of bongo in all plots in the study area were summed up and the result divided by the total area of all the plots to give a bongo density in the study area. As surveys were replicated eight times all densities were divided by eight to give mean densities.

Population densities and distribution of bongos

Distribution of bongos was measured in terms of the presence and absence of bongos, and their population densities in survey plots, in the different habitat types and their locations, and ranges of the Park during both rainy and dry seasons.

Habitat use

There was also daytime searching for signs of the presence of the bongos in each plot. The presence of bongo spoors (scats, footprints, etc.) was used as evidence of their presence. The degree of habitat use by the bongos was measured by signs of bongos' presence or absence, coded as follows: 0 = no sign of presence; 1 = signs of presence (footprints, dung), but no evidence of browsing; 2 = signs of presence and < 50% browsing; 3 = signs of presence and ≥ 50% browsing of the area.

The codes scored in each plot in the respective habitat types were ranked (1st for habitat that had the highest, 2nd for the next and 3rd for habitat that recorded the least number).

Water availability and hunting pressure

To find out whether water availability affected the distribution of bongos in KCA, the distance of each plot from the nearest source of available water was recorded using the nearest-features extension method in ArcView GIS (v 3.2), based on the GPS coordinates of the plots and geospatial data on the parks water bodies obtained from the Centre for Remote Sensing and Geographic Information System (CERSGIS), Accra. A correlation between distances of plots from water and the bongos' plot densities was then determined. Hunting pressure on bongos was measured by counting any sign of hunting activity in each plot, notably traps, spent cartridges, poachers' camping sites and footprints. Each tool or activity sighted was recorded as 1 and removed from the study area. Correlation between bongos' density and hunting pressure was determined.

Analysis of data

We used IBM's SPSS version 16.0 to calculate descriptive statistics including mean densities and their standard errors to analyze all data. To assess habitat use of bongos at KCA, Levene's test of homogeneity of variance (Zar, 2010) was used to test the null hypothesis that population variances were equal. A two-factor ANOVA was conducted twice to evaluate the: (i) seasonal differences in bongo densities with habitat type (closed forest at Park margins, closed forest deep inside the Park, open forest at margins, open forest deep inside, thickets at margins or thickets deep inside), and (ii) seasonal differences in bongo densities among the nine study ranges (Aboabo, Abrafo, Adiembra, Afiaso, Antwikwaa, Briscoe II, Homaho, Mfuom and Kruwa). The data were transformed using the log (base 10) function in order to convert it into a normally-distributed one. Where differences were statistically significant, a post-hoc analysis of the variances by either non-parametric Games-Howell multiple comparisons or parametric Tukey's HSD multiple pairwise comparisons test (Kleinbaum et al., 1988) was conducted. Descriptive statistics of ANOVA were used to evaluate the population densities as a function of the distribution of the bongos in the various habitat types and locations, and the ranges in the Park in both rainy and dry seasons. Descriptive statistics of ANOVA were used also to assess the differences in habitat use in the three habitat types and in the two different locations of habitat types and; Chi-square was used to test for the significance of the differences. In order to determine the association between bongo densities and water availability or hunting pressure, total bongo densities for habitats in all ranges for both rainy and dry seasons were log-transformed to obtain a linear relationship and also to meet the assumption of normality. A bivariate correlation between the density of bongos and distances from sources of water or hunting pressure was computed and Pearson's correlation coefficient (Cohen and Cohen, 1975) was calculated.

RESULTS

Sighting times and herd sizes

We observed bongos during early hours of the day, from 05:00 to 07:00 h GMT and in the evening between 16:00 and 18:30 h GMT (Figure 3) meaning that this species is likely crepuscular. There was no significant difference between morning and evening periods of encounter with the bongo ($t=0.7806$, $p=0.4575$). Of all the bongo herds encountered throughout the study, herd sizes ranged from one to eight individuals, with two as the modal size,

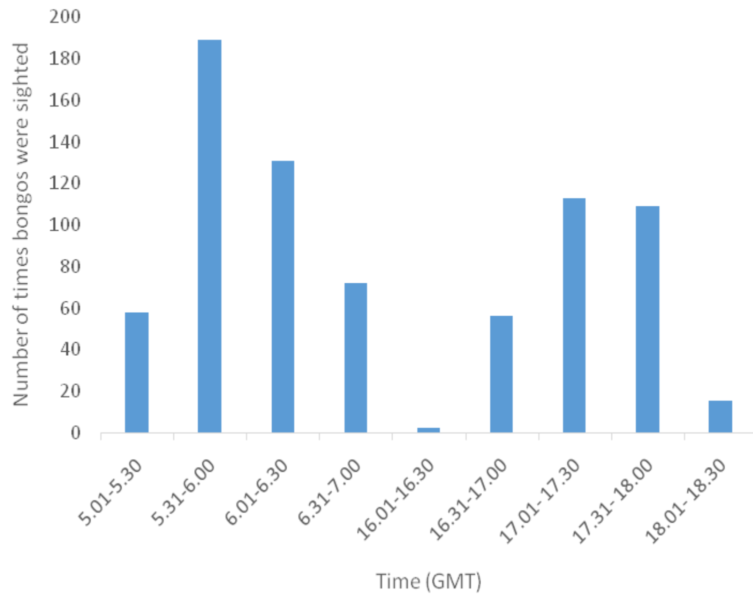

Figure 3. Time of encounter with bongos in the Kakum Conservation Area

though sizes as high as 15 individuals have been reported by field staff.

Mean bongo densities

ANOVA for the various combinations of the factors (season and habitat) and the dependent variable (bongo densities) indicated that in both the rainy and dry seasons, the highest bongo densities were recorded in thickets at the Park margins (Table 1). The mean was 0.9219 (σ=0.59056) per 100,000 m^2 in the rainy season and 1.0005 (σ=0.54398) per 100,000 m^2in the dry season. The next highest bongo density was also recorded in the thickets deep inside the Park. The mean values in the rainy and dry seasons were 0.6002 (σ = 0.59056) and 0.6213 (σ = 0.55254) respectively per 100,000 m^2. At the margin's closed forests, means of 0.4451 (σ = 0.1387) and 0.4370 (σ = 0.10544) were recorded for the rainy and dry seasons respectively per 100,000 m^2 estimates while deep inside closed forests were 0.3574 (σ = 0.22486) and 0.4863 (σ = 0.7325), respectively per 100,000 m^2. Also, mean bongo density for deep inside open forests was higher (μ/100,000 m^2 = 0.3548; σ = 0.44697) in the dry season than in the rainy season (μ/100,000 m^2 = 0.1995; σ = 0.41140). At margin's open forest, mean bongo density of 0.4478/100,000 m^2 (σ = 0.23199) was recorded during the rainy season, and 0.3028/100,000 m^2 (σ = 0.37707) during the dry season.

Overall, mean bongo population density per 100,000 m^2 was 0.5252 (σ = 0.45819) ranging from μ = 0.5495 (σ = 0.44841) in the dry season to μ = 0.5009 (σ = 0.46807) in the rainy season. The bongo population density per 100,000 m^2 was highest (μ = 0.9612; σ = 0.58670) in the thickets at the margins and lowest (μ = 0.2616; σ = 0.40872) in the open forests deep inside. The test for homogeneity of variance was highly significant (Levene'stest statistic = 3.820; $p < 0.05$). This indicates variances were not equal across groups, and therefore an assumption of ANOVA is violated. Games-Howell's post-hoc analysis which is free of assumptions of normality indicated a significant difference in bongo population densities between the open forests deep inside and the margins thickets in the Park. The estimated marginal mean for margins thickets was 0.961 ± 0.123, while that for open forests deep inside was 0.277 ± 0.138. It could therefore be concluded that margins thickets have the highest bongo density in the park.

Descriptive statistics of ANOVA for the independent variables (season and range) and the dependent variable (bongo densities) revealed interesting results. While the population densities were zero for three ranges, representing 33% of all the ranges or plots surveyed in the park in both rainy and dry seasons, others showed different results for the different seasons. At Abrafo, the population density of the bongo community during the rainy season was very low, with a mean of 0.02258 (σ = 0.15051), but shot up slightly to a mean of 0.0587 (σ = 0.10167) in the dry season. A similar trend was recorded at Kruwa, with mean 0.1910 (σ = 0.35236) in the rainy season and 0.894 (σ = 0.45189) in the dry season. Three of the four remaining sites recorded marginal increases in population density from the rainy to the dry season. At Adiembra, the mean population densities for the rainy and dry seasons were 0.6191 (σ = 0.38158) and 0.7131 (σ = 0.35374) respectively. Values for Afiaso were 0.7765 (σ = 0.36413) and 0.8112 (0.35088), while those for Antwikwaa were 0.6926 (σ = 0.37644) and 0.6919 (σ =0.35788). Mfuom recorded 0.7095 (σ = 0.38268) and

Table 1. Means, standard deviations, and the number of observations (N) of the factors affecting bongo densities (response).

Season	Habitat Type	Mean	Standard Deviation	N
Rainy	CF-M	0.4451	0.13872	5
	CF-D	0.3574	0.22486	5
	OF-M	0.4478	0.23199	6
	OF-D	0.1995	0.41140	6
	TH-M	0.9219	0.67651	6
	TH-D	0.6002	0.59056	6
	Total	0.5009	0.46807	34
Dry	CF-M	0.4370	0.10544	5
	CF-D	0.4863	0.07325	5
	OF-M	0.3028	0.37707	6
	OF-D	0.3548	0.44697	4
	TH-M	1.0005	0.54398	6
	TH-D	0.6213	0.55254	6
	Total	0.5495	0.44841	32
Total	CF-M	0.4410	0.11624	10
	CF-D	0.4218	0.17166	10
	OF-M	0.3753	0.30793	12
	OF-D	0.2616	0.40872	10
	TH-M	0.9612	0.58670	12
	TH-D	0.6108	0.54536	12
	Total	0.5244	0.45577	66

CF-M = closed forest margin; CF-D = closed forest deep; OF-M = open forest margin; OF-D open forest deep; TH-M = thickets margin and; TH-D = thickets deep.

0.7145 (σ = 0.34998). Overall, the highest bongo population density was recorded during the dry season at Afiaso (mean = 0.7938; σ = 0.34141) and the lowest at Aboabo, Briscoe II and Homaho (all recording zero in both seasons) followed by Abrafo during the rainy season (μ = 0.01039; σ = 0.19466). The means recorded at four stations, namely Adiembra, Afiaso, Antwikwaa and Mfuom were always much higher than at Abrafo and Kruwa, and there was not much difference in the mean bongo population densities between Abrafo and Kruwa. Again, it could be said that the population distributions of bongos in the various ranges were not uniform. They were absent from Aboabo, Briscoe II and Homaho, low in Abrafo and Kruwa and relatively high in Adiembra, Afiaso, Antwikwaa and Mfuom.

Population density and distribution of bongos

Bongos were present in six of the nine ranges and 36 of the 54 sample plots (representing 67% of all the ranges surveyed) in both seasons. They were absent from all the 18 plots in three ranges, namely Aboabo, Briscoe II and Homaho in both seasons. Bongos were present in both seasons in the same habitat type or absent in both seasons from the same habitat type, but never present in one habitat type during one season and absent during the other.

The 2*6 factorial ANOVA to determine the possible interaction between the distribution of the bongos in various habitats of the study area and the season of the year on the population densities of the bongos also revealed interesting results for all possible combinations of the analyses. There was no significant interaction between seasons and population distribution of bongos in the various habitats {F (5, 54) = 0.181, p>>0.05, Table 2}. From the partial ETA computed the interaction effect only accounted for 1.7% of the total variance in bongo densities between season and distribution of bongos in the habitats (Table 2). The profile plots of interaction (Figure 4) gives a pictorial representation of the interaction. It is observed that the lines are almost all parallel. The main factor (season) was not significant {F (1, 54) = 0.132, p>>0.05, Table 2}, only accounting for 0.2% of the variations in the population densities of the bongos. However, the habitat main effect was found to be significant {F (5, 54) = 0.005, p <0.05, Table 2}. This means that bongo population densities for the various habitats were different and Games-Howell's post-hoc analysis (Table 3) revealed the difference existed between open forests deep inside (with low population distribution) and margins thickets (with high population

Table 2. Test of subject effects for season and habitat type.

Source	df	Mean square	F	Significance	Partial Eta squared
Season	1	0.024	0.132	0.717	0.002
Habitat	5	0.681	3.750	0.005	0.258
Season x Habitat	5	0.033	0.181	0.968	0.017
Error	54				

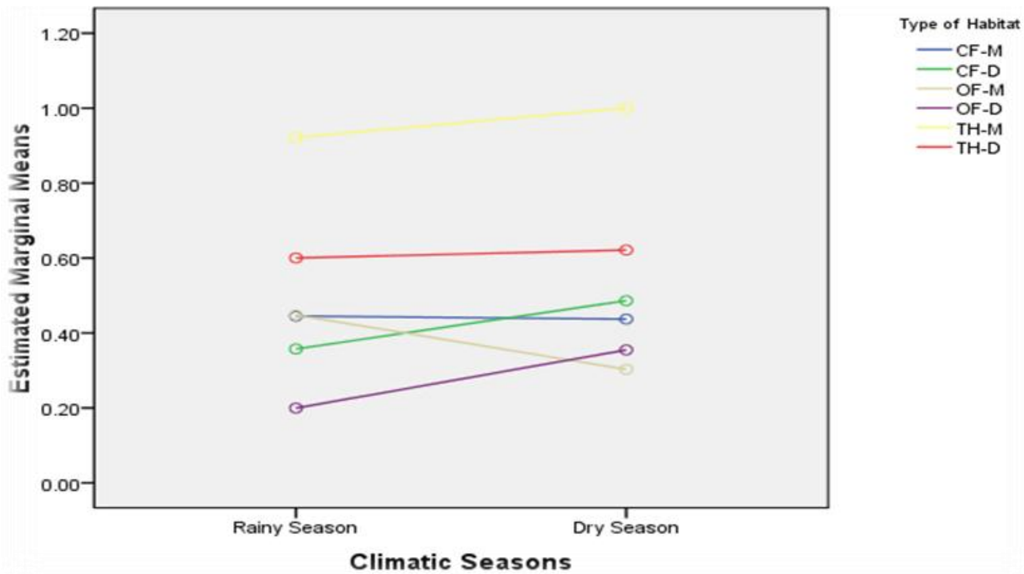

Figure 4. Comparing estimated marginal means of bongo densities in different types of habitats in the rainy and dry seasons during the study.

distribution). Bongos' population densities however did not differ between all other possible pairings of habitats (Table 3).

Also, there was no significant interaction between season and distribution of bongos in the various ranges of the park {*F* (5, 54) = 0.278, *p*>>0.05, Table 4}. Only 2.5% of the total variance in the bongos' densities was accounted for by the interaction between season and range of occurrence of the bongos in the park. The main effect by the season on the population distribution of the bongos in the ranges was also not significant {*F* (1, 54) = 0.562, *p* >>0.05, Table 4} and the season main effect accounted for less than 1% of the total variance in the bongos' densities. However, there was a highly significant {*F* (5, 54) = 9.591, *p* <<0.05, Table 4} main effect by the range factor. In other words, the bongos' population densities were statistically different across the different ranges of the bongos in the park. As the ratio of the highest to least recorded population densities was 7:1, variances across groups were expected to be small, which was confirmed by the test of homogeneity of variance {*F* (11, 54) = 1.090, *p*>>0.05}. However, Tukey's post-hoc analysis revealed significant differences (Table 5) in bongos' population densities between Abrafo and each of four ranges namely Adiembra, Afiaso, Antwikwaa, and Mfuom, but not Kruwa and; also between Kruwa and each of the four ranges. Between pairs of Adiembra, Afiaso, Antwikwaa and Mfuom, the differences were not significant (Table 5). This means that population densities varied across the ranges, but with Abrafo and Kruwa having similarly low densities and Adiembra, Afiaso, Antwikwaa and Mfuom similarly high densities. Bongos were absent from Homaho, Briscoe II and Aboabo.

In summary, the population densities of the bongos were not dependent on the time of climatic season (rainy or dry). On the other hand, the population densities of the bongos depended on the habitat in which they lived, particularly in four of the nine ranges of the park.

Habitat use

The results of cross-tabulation among degrees of habitat use are presented in Table 6. The figure in each cell indicates the number of times that degree of use was assigned in that habitat. For example, 24 in cell 1 implies

Table 3. Tukey's HSD post-hoc multiple comparisons of the various levels of the factor range.

Range(I)	Range(J)	Mean Difference (I-J)	Std. Error	Sig.
Abrafo	Kruwa	-0.2441	0.17039	0.707
	Adiembra	-0.7657*	0.17322	0.001
	Afiaso	-0.8977*	0.17039	0.000
	Antwikwaa	-0.7961*	0.17039	0.000
	Mfuom	-0.8158*	0.17039	0.000
Kruwa	Abrafo	0.2441	0.17039	0.707
	Adiembra	-0.5216*	0.14955	0.012
	Afiaso	-0.6536*	0.14626	0.001
	Antwikwaa	-0.5521*	0.14626	0.005
	Mfuom	-0.5718*	0.14626	0.003
Adiembra	Abrafo	0.7657*	0.17322	0.001
	Kruwa	0.5216*	0.14955	0.012
	Afiaso	-0.1320	0.14955	0.949
	Antwikwaa	-0.0305	0.14955	1.000
	Mfuom	-0.0502	0.14955	0.999
Afiaso	Abrafo	0.8977*	0.17039	0.000
	Kruwa	0.6536*	0.14626	0.001
	Adiembra	0.1320	0.14955	0.949
	Antwikwaa	0.1015	0.14626	0.982
	Mfuom	0.0818	0.14626	0.993
Antwikwaa	Abrafo	0.7961*	0.17039	0.000
	Kruwa	0.5521*	0.14626	0.005
	Adiembra	0.0305	0.14955	1.000
	Afiaso	-0.1015	0.14626	0.982
	Mfuom	-0.0197	0.14626	1.000
Mfuom	Abrafo	0.8158*	0.17039	0.000
	Kruwa	0.5718*	0.14626	0.003
	Adiembra	0.0502	0.14955	0.999
	Afiaso	-0.0818	0.14626	0.993
	Antwikwaa	0.0197	0.14626	1.000

*The mean difference is significant at the 0.05 level.

Table 4. Test of subject effects for season and ranges.

Source	df	F	Significance	Partial Eta squared
Season	1	0.340	0.562	0.006
Range	5	9.591	0.000	0.470
Season * Range	5	0.278	0.923	0.025
Error	54			

that in the closed forest, the degree of use of that habitat assigned a "no use" was coded 24 times. It appears that the degree of use coded 'no use', 'low use' or 'moderate use' was always least in the thickets while 'high use' was highest in the thickets (Table 6). In other words, it appears that the bongos used the thickets more than other habitat types. However, the trend was not clear between the closed and open forests and as Chi-square statistic at an alpha level of 0.05 was not significant (χ = 3.2121, df = 3, p = 0.36006), none of them could be said

Table 5. Mean differences of pair-wise comparisons of the types of habitats and their significance.

Habitats	CF-M	CF-D	OF-M	OF-D	TH-M	TH-D
CF-M						
CF-D	-0.01919					
OF-M	-0.06573	-0.04654				
OF-D	-0.17939	-0.16021	-0.11367			
TH-M	0.52016	0.53935	0.58589	0.69956**		
TH-D	0.16971	0.18890	0.23544	0.34911	-0.35045	

CF-M: closed forest margins; CF-D: deep inside closed forest; OF-M: open forest margin; OF-D: deep inside open forest; TH-M: thicket margins; TH-D: deep inside thicket. **Mean difference is significant at 0.05 by Games-Howell multiple comparisons test.

Table 6. Cross-tabulation between degree of habitat use and habitat type.

Degree of habitat use	Habitat type		
	Closed forest	Open forest	Thicket
No use	24	20	20
Low	5	6	3
Moderate	6	5	3
High	1	5	10

Table 7. Cross-tabulation between degree of habitat use and habitat location.

Degree of habitat use	Habitat location	
	Margin	Interior
No use	32	32
Low	4	10
Moderate	10	4
High	8	8

to be used more than the other. Also, in the case of habitat locations, scores for both forest margin and deep forest were the same for ‘no use’ and ‘high use’ and it appeared that margins were used more than deep forests judging from the results of low and moderate uses (Table 7). However, the difference in the degree of use between forest margins and deep forests was not significant (χ = 5.143, df = 3, p = 0.162).

Water availability and hunting pressure

Pearson’s correlation coefficient for bongo densities and water availability was -0.468 and this was statistically significant (p = 0.005), suggesting a moderate and inverse correlation between bongo density and water availability. Thus bongo densities were lower when water was scarcer or farther away from bongo locations, and this affected bongo distribution in the KCA, with bongo occurring in areas closer to water sources.

A correlation coefficient of -0.267 suggested an inverse relationship between bongo densities and hunting pressure that could also suggest that higher hunting pressure reduced bongo densities and vice-versa; but as the correlation was found to be not significant at an alpha level of 0.05 (p = 0.127) hunting pressure could not therefore be said to have any effect on the distribution of bongos at KCA. Evidence of hunting activities included spent cartridges, traps of different types, poachers’ camps, and matchboxes and reports from field staff confirmed that poaching was rampant with the use of dogs, guns and traps at all ranges and habitats.

DISCUSSION

Mammals of the tropical moist forest are not easy to see and count, as in the case of bongos, which are particularly secretive, making it difficult to encounter especially during daytime. Considering the total survey effort in this study, however, the results could be considered reliable. Spinage (1986) and Estes (1991) described bongos as nocturnal and Hillman (1986) observed most activity of the species from dusk to early morning; but Bosley (2003) described bongos as diurnal. This study found virtually no direct activity during the day, but there was no opportunity to obtain evidence of night activity since there were no surveys at night. It appears that the bongos in KCA are active in low light during the day.

Apart from direct encounter with the bongos, critical examination of footprints and feeding activities further support the hypothesis that intense activity occurred during the early and late hours of the day, rest by lying under dense cover during high light in the day and sleep at night. The explanation could be that poachers return home in the early and late hours after night and day duty respectively. Also leopards, the historical predators of calves of bongos (An Ultimate Ungulate Fact Sheet, 2004), are exclusively nocturnal and may find it difficult to locate the bongos when they are asleep at their hideouts under dense cover in the night. This may also account for the higher use of thickets by bongos in both forest margins and forests deep inside the park than other habitat types, as observed in this study. The thickets normally comprise slow and low-growing regenerating plants used as hideouts for the bongos as well as food sources, unlike the primeval or less-disturbed areas in the interior parts of the reserve where leaves and twigs of tall trees cannot be reached for consumption.

East (1990) reported crop-raids by bongos and though this study did not investigate field staff's reports on crop raids, it is suggested that location of bongos near forest margins, and therefore crop fields just after the boundary of the conservation area sometimes, is one possible benefit which may account for the use of thickets at forest margins by bongos. Dense thickets might offer good hiding places for bongos to raid nearby crop farms bordering the KCA. As there was a significant difference in densities among the ranges of occurrences of bongos, other factors than chance may account for the distribution of bongos in the ranges. For instance, the chance of encountering bongos at KCA is high at the margins of Afiaso, Adiembra, Antwikwaa and Mfuom ranges perhaps because of the abundance of thickets in these areas, which are re-growths of extensively logged forests.

There were very few bongo encounters at the Kruwa and Abrafo ranges and no encounters at Briscoe II, Homaho and Aboabo. These five ranges had evidence of severe human interference in the form of direct poaching and noise due to increased human populations or visitor influx. For example, Aboabo shares boundary with the Park; Kruwa and Briscoe II harbour the most notorious hunters, according to Park Management and; Abrafo experiences noise due to regular influx of visitors to the canopy walkway. For the purpose of bongo viewing, observation platforms would be more useful if they were erected at Afiaso, Antwikwaa, Mfuom and Adiembra near the forest margins as tourists have failed to view bongos from existing platforms at Briscoe II and Abrafo (Monney and Dakwa, 2014).

The results also indicated that water sources were necessary for the distribution of the bongos, since even thickets were avoided if they were farther away from water sources. This underscores the importance of conserving water bodies (rivers and rivulets) in the KCA and off-reserve.

Large herd sizes of up to 15 have been recorded in field reports and; elsewhere, Klaus-Hugi et al. (2000) encountered 10-20 bongo herd sizes in the Dzanga National Park, Central African Republic. This study did not however record herd sizes larger than eight. Even though large herds may split temporarily (Klaus-Hugi et al., 2000) or permanently, it is possible that threats to bongos in KCA in the form of poaching and predation may have reduced the herd sizes. There was no significant difference between bongo densities and hunting pressure in the various habitat types, habitat locations and ranges, suggesting that the mammals were equally exposed to hunting pressure, which could not therefore account for the distribution of the bongos. It is noteworthy that factors including illegal hunting and predation affect the abundance and distribution of bongos as they do to other mammals, notably elephants. However, Ottow et al. (1996) reported that bongo populations in a predominantly secondary forest in Bangassou in the Central African Republic were stable even though there was hunting pressure.

This study was not extensive enough to find evidence of reducing bongo populations in the KCA, yet patrol staff reported reducing bongo encounter rates. Estes (1991) reported a drastic decline of some isolated bongo populations in Africa and in Kenya, bongo populations are declining throughout their range as a result of over-hunting, habitat loss and rising exploitation through safari hunting and have been nearly extirpated (Kingdon, 1997; East, 1999). The field staff reported active hunting with guns, traps and dogs, inside KCA, as evidenced by the spent cartridges and traps (wire snares and gin traps) found all over the reserve in this study. There was however no evidence of predation in this study, even though field staff reported that pythons *(Python sebae)* and leopards preyed on young bongos.

The elusive nature of bongos, coupled with difficulties in detecting over-exploitation of bongos, makes more reliable population estimates difficult, leading to 'sudden' drops in bongo numbers. This study estimated bongo populations at approximately 0.53 bongos per 100,000 m^2 (5.3/km^2) within an area of about 360 km^2 at the KCA. Estimated bongo density in the about 150 km^2 Dzanga National Park in the Central African Republic was 0.25/km^2 (Klaus-Hugi et al., 2000). This is an indication that bongo population densities in Africa's protected areas are low, and that there is need for institution of measures to ensure the adequate protection of bongos (East, 1990). The results of this study suggest that the bongo population at KCA is currently under severe pressure.

Protected area management requires information about species distribution, trends in species population densities and knowledge about the impact of potential threats on the population, such as hunting pressure (Carrillo et al., 2000) and logging (Frumhoff, 1995). Also,wildlife monitoring is essential for assessing the success of implemented management actions such as law enforcement strategies and the establishment of research and tourist sites (Hockings et al., 2006). The results of this study have implications for the formulation of adaptive management plans to protect the secretive, charismatic and largest antelope in the Kakum Conservation Area.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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REFERENCES

An Ultimate Ungulate Fact Sheet (2004). *Tragelaphuseurycerus*, Bongo. Proc. Zool. Soc. Lond.1836:120 [1837]. West Africa.

Bosley LF (2003). International Studbook for Bongo Antelope (*tragelaphus eurycerus isaaci*, Vol. XVIII, Fort Worth Zoo, Fort Worth, TX.

Carrillo E, Wong G, Cuaro´n AD (2000). Monitoring mammal populations in Costa Rican protected areas under different hunting restrictions.Conserv. Biol. 14:1580-1591.

Cohen J, Cohen P (1975).Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences,1st Edition, Lawrence Erlbaum Associates, Mahwah (2nd Edition, 1983; 3rd Edition, with West, S.J. & Aiken, L.S., 2003).

Dowsett-Lemaire F, Dowsett RJ (2005). Ornithological surveys in Kakum National Park. WDSP Report No. 50-s. Unpublished.

Durand JR, Skubich M (1982). Lagoons of Ivory Coast. Aquaculture 27: 211-250

East R (1990). Antelope's global survey and regional action plans. Part 3.West and Central Africa.171 pp.

East R (1999). African Antelope Database 1998.Occasional Paper of the IUCN Species Survival Commission No. 21.IUCN, Gland, Switzerland and Cambridge, U.K.

Estes D (1991). The Behavior Guide to African Mammals. University of California Press,London.

Forestry Commission (2007). Monitoring staff deployment, patrol effort, illegal activity and wildlife trends to facilitate adaptive and performance management in nine protected areas in Ghana. Second Evaluation, Accra, p. 55.

Frumhoff P (1995). Conserving wildlife in tropical forests managed for timber. Bioscience 45:456-464.

Hawthorne W, Abu-Juam M (1993). Forest protection in Ghana.Unpublished Report, ODA and Forest Inventory and Management Project Planning Branch, Forestry Department, Kumasi.

Hillman JC, Gwynne MD (1987). Feeding of the bongo antelope *Tragelaphuseurycerus*(Ogilby, 1837) in southwest Sudan. Mammalia 51:1.

Hillman JC (1986). Aspects of the biology of the bongo antelope *Tragelaphuseurycerus* (Ogilby 1837) in South West Sudan.Biol.Conserv. 38(3):255-272.

Hockings M, Stolton S, Leverington F, Dudley N, Courrau J (2006).Evaluating Effectiveness: A Framework for Assessing Management Effectiveness of Protected Areas,2nd Edn.IUCN, Gland, Switzerland and Cambridge, UK, xiv + 105 pp.

International Union for Conservation of Nature and Natural Resources (IUCN) (2002).IUCN Red List of Threatened Species. Available online at http://www.redlist.org/

Kingdon J (1997). Field Guide to African Mammals. Academic Press, London.

Klaus-Hugi, C, Klaus, G, Schmid, B (2000). Movement patterns and home range of the bongo *(Tragelaphuseurycerus)* in the rain forest of the Dzanga National Park, Central African Republic. Afr. J.Ecol. 38: 53-61.

Kleinbaum DG, Kupper LL, Muller KE (1988). Applied regression analysis and other multivariable methods.2nd Ed. Duxbury Press in Pacific Grove.

Kouadio KN, Diomande D, Ouattara A, Koné YJM, Gourène G (2008). Taxonomic diversity and structure of benthic macroinvertebrates in Aby Lagoon (Ivory Coast, West Aftrica). Pak. J. Biol. Sci. 11:2224-2230.

Larsen TB (1994). *Diopeteskakumi*, a new hairstreak from Kakum National Park, Ghana.Trop.Lepid. 5:83-84. (WA 5).

Larsen TB (1995). Butterflies in Kakum National Park, Ghana. Part 1: Papilionidae, Pieridae&Lycaenidae. Bulletin of the Amateur Entomological Society, 54:3-8, Part 2: Nymphalidae, Hesperiidae, *ibid*. 54:43-46. (WA 11).

Monney KA, Dakwa KB (2014). Prospects and potentials of the Kakum Conservation Area. J. Ecol. Nat. Environ. 6: 140-153.

Monney KA, Dakwa KB, Wiafe ED(2010). Assessment of crop raiding situation by elephants (*Loxodontaafricanacyclotis*) in farms around Kakum Conservation Area, Ghana. Int. J. Biodiver. Conserv. 2(9): 243-249.

Monney KA, Darkey ML, Dakwa KB (2011). Diversity and distribution of amphibians in Kakum National Park and its surroundings.Int.J.Biodivers.Conserv.3(8):358-366.

Nchanji AC (1994). Preliminary survey of the forest elephant, *Loxodontaafricanacyclotis* crop damage situation around the Kakum National Park. Conservation International, Cape Coast, Ghana.Unpublished.

Oates JF, Struhsaker TT, Whitesides GH (1997). Extinction faces Ghana's red colobus monkey and other locally endemic subspecies. Primate Conservation 17:138-144.

Ottow K, Jean-Bosco K, Bloom A (1996). A survey of the BangassouForest.Gnusletter 16:23-25.

Spinage CA (1986). Natural History of Antelopes.London: Croom Helm. 224pp.

Wiafe ED, Dakwa KB, Yeboah S (2010). Assemblages of avian communities in forest elephant *(Loxodontacyclotis)* range in Ghana. Pachyderm 48: 41- 47.

Yeboah S (1996). Small mammals and the herpetofauna of the Kakum National Park.Facing the Storm, Proceedings of the Kakum Conservation Area Research Colloquium)Consvervation International, Washington D.C. pp. 37-45.

Zar JH (2010). Biostatistical Analysis.Prentice Hall.944 pp.