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Preliminary Survey of Chimpanzees and Threatened Monkeys in the Bia-Goaso Forest Block in Southwestern Ghana

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Abstract: We used line transects to survey chimpanzees (*Pan troglodytes verus*) and threatened monkeys in the Bia-Goaso Forest Block (BGFB) in Southwestern Ghana. Based on nest counts, we estimated a density of 0.26 chimpanzees per km² (SE = 0.25, CV = 111.7%) and an average nest encounter rate of 0.29 nests per km. We directly encountered 16 monkey groups (encounter rate of 0.12 groups per km), which included four species of diurnal monkeys: Lowe's monkey (*Cercopithecus campbelli lowei*), lesser spot-nosed monkey (*Cercopithecus petaurista petaurista*), black and white colobus (*Colobus vellerosus*) and olive colobus (*Procolobus verus*). More than half of our monkey encounters involved polyspecific groups. The distribution of chimpanzees was clumped and their range was restricted to only five out of the 14 reserves surveyed, while that of the monkeys was much extensive for the different species, extending from nine to eleven of the 14 reserves surveyed. We found signs of hunting activity throughout the BGFB, with the majority being wire snares.

Key words: chimpanzees, threatened monkeys, forest reserves, line transects, Ghana

Résumé: *Nous avons utilisé des transects linéaires pour enquêter sur les chimpanzés (*Pan troglodytes verus*) et sur les singes menacés dans le Block de Forêt de Bia-Goaso (BGFB) dans le Sud-Ouest du Ghana. En comptant les nids, nous estimons la densité des chimpanzés à 0,26 par km² (SE = 0,25, CV = 111,7%) et une fréquence de rencontre des nids de 0,29 par km. Nous avons rencontré directement 16 groupes de singes (fréquence de rencontre de 0,12 groupes par km). Ces groupes contenaient quatre espèces de singes diurnes : la Mone de Lowe* (Cercopithecus campbelli lowei)*, le Hocheur blanc-nez* (Cercopithecus petaurista petaurista)*, le Colobe magistrat* (Colobus vellerosus) *et le Colobe vert olive* (Procolobus verus)*. Plus de la moitié de nos rencontres concernaient des groupes multi-spécifiques. La distribution des chimpanzés était agrégée et leur aire de répartition était limitée à cinq des 14 réserves analysées tandis que les singes couvraient entre neuf et onze des 14 réserves analysées. Nous avons trouvé des indices d'activité de chasse dans l'ensemble du BGFB avec une majorité de collets.*

Mots clé: *chimpanzés, singes menacés, réserves de forêt, transects linéaires, Ghana*

INTRODUCTION

The Bia-Goaso Forest Block (BGFB) in southwestern Ghana is one of the priority sites in West Africa for the conservation of chimpanzees (Kormos *et al*., 2003) (Figure 1). The importance of the site was further enhanced when it was identified as one of the five priority regions, or hotspots, for biodiversity conservation at Conservation International's West Africa Priority Setting workshop in December 1999. The area also has been proposed as a trans-frontier corridor for elephants moving between forest reserves in Ivory Coast and Ghana (Parren *et al.*, 2002).

Chimpanzees were thought by some to be extinct or nearly extinct in Ghana (Caldecott & Miles, 2005), however, during a recent elephant survey of western Ghana (Danquah *et al*., 2009), rangers reported having seen chimpanzees in the BGFB. Corroborating evidence of the presence of chimpanzees in the over-arching forest complex (including the Ayum, Subim, Bonsam-Bepo forest reserves) was gathered by field teams from the Nature Conservation Research Centre in 2008. Based on this information, we decided to undertake a new survey

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to determine the status of chimpanzee populations within the area and then to secure their long-term survival. In the current paper, we present the preliminary results of our wet season survey of chimpanzees and threatened monkeys in the BGFB.

STUDY AREA

The study area comprises an extensive network of three shelterbelts (Bia, Goa, and Abonyere), nine Forest Reserves (Asukesi, Bia Tano, Mpameso, Bonkoni, Ayum, Subin, Bonsam Bepo, Krokosua Hills, and Bia North) and two Wildlife Reserves [Bia Resource Reserve (BRR) and Bia National Park (BNP)], together referred to as the Bia Conservation Area. The shelterbelts are linear strips of forest (1.5 km wide) that connect two reserves and act as wildlife corridors. The focus of management of forest reserves is for timber production, while that for wildlife reserves is for wildlife protection. The study area, which covers approximately 5000 km^2, lies to the south of Sunyani and to the west of the Tano River on the Ghana-Ivory Coast border (Figure 1).

The primary vegetation-type in these reserves is semi-deciduous tropical forest, although further to the south, the vegetation-type of the BRR changes to moist evergreen tropical forest (Hall & Swaine, 1981). Mean monthly rainfall for the study period indicates a bimodal distribution occurring in March-July and September-November, peaking in June and October. The average annual rainfall ranges from 1,500 to 1,800 mm and the mean monthly temperature is typical of tropical lowland forest, ranging from of 24ºC to 28ºC (PADP, 2001).

METHODS

Preliminary Survey

We undertook a three-week preliminary survey of the study area in July 2009. We initially interviewed staff of the Forestry Commission (especially the Goaso Bio-Monitoring Unit) and select communities living on the edges of the reserves to gather presence and absence data on chimpanzees. We then spent one day walking recces in each reserve, following paths and trails on predetermined compass

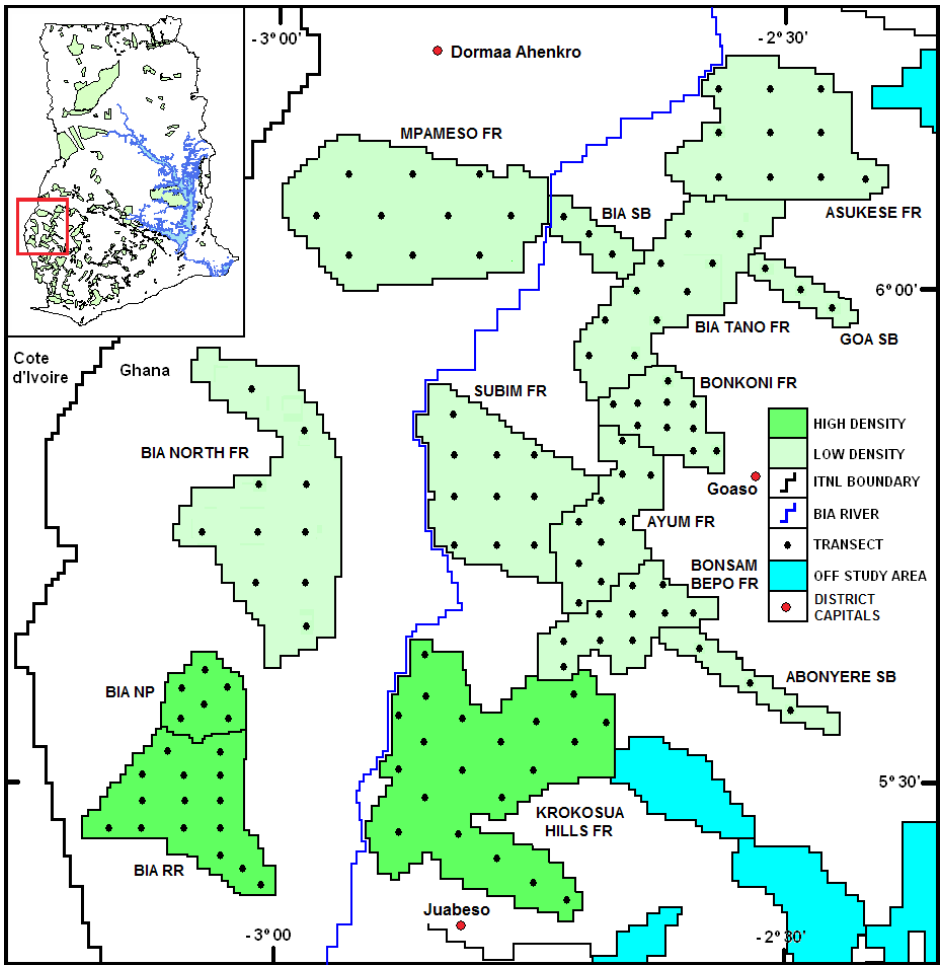

Figure 1. Study area showing distribution of transects in the high density (areas of chimpanzee presence) and low density (areas of chimpanzee absence) strata. The inset map shows the location of the study area in southwestern Ghana.

bearings and recording signs of chimpanzee presence (such as nests, droppings, footprints, feeding signs and vocalizations). The intention was to obtain an estimate of the relative density of chimpanzees to serve as the basis for stratifying the study area for more systematic transects. We calculated the distance walked with a Global Positioning System (GPS).

Stratification

We stratified the study area into two zones, namely 'areas of chimpanzee presence' and 'areas of apparent chimpanzee absence' (Figure 1), based on chimpanzee signs recorded in the preliminary survey. We assigned areas with the presence of chimpanzees (the Bia Conservation Area and the Krokosua Hills Forest Reserve) as a high-density stratum, whilst we classified all other areas which lacked evidence of chimpanzees (covering the rest of the forest reserve) as a low-density stratum.

Main Primate Survey

In the main primate survey, we adopted the line transect methodology as described in Burnham *et al.* (1980), and methodology to sample chimpanzee and monkey signs in accordance with Buckland *et al.* (2001).

Distribution of transects

Based on an average chimpanzee sign encounter rate of 2.35 signs per km calculated in our preliminary survey, we estimated an optimum sample size (OSS) of 129 transects (each 1 km in length) across the study area (Hedges & Lawson, 2006). This gave us 40 transects in the high-density stratum, and 89 transects in the low-density stratum (Figure 1).

We randomly placed a grid of cells, each 1.84 km in length or width over a map of the study area using ArcInfo GIS 8.3 (ESRI, 1993). The intersections of the gridlines formed the starting point for each transect. We randomly placed the first transect of each stratum, then distributed the subsequent ones systematically through the various strata based on the initial primate encounters made during the recce survey (Norton-Griffiths, 1978; Buckland *et al.,* 2001). The orientation of our transects was east–west and they were constructed perpendicular to the main drainage channel of the area (the north-south running Bia River).

Transect procedures

We conducted the line transect survey during the minor wet season and part of the dry season, from August 2009 to February 2010, with three survey teams of three persons each. We navigated using a compass and a geographical positioning system (GPS) to reach the starting point of each transect. Once at the beginning of the transect we walked along in a straight line, scrutinising the vegetation on both sides looking for chimpanzee nests. We made the following notes for each chimpanzee nest observed: the distance along the transect measured by a topofil, and the perpendicular distance of each nest from the transect centre-line, measured with a tape measure.

We made other observations along the transect, particularly of monkey groups and other chimpanzee and monkey signs (droppings, footprints, feeding and vocalizations) in order to document their distribution in the area. We recorded feeding directly by observation, or indirectly by associated feeding signs such as footprints or droppings (mostly for chimpanzees). We plotted chimpanzee and monkey distribution using their co-ordinates from a GPS.

DATA ANALYSIS

Chimpanzee Population Estimate

There were two components to our data analysis. First, we obtained chimpanzee nest density estimates based on the program DISTANCE 4.0 (Thomas *et al.*, 2002). Five models available in DISTANCE 4.0 software were fitted to the perpendicular distances of nests from the transect. Model fitting used the automatic selection of model adjustment terms with sequential selection method to estimate nest density (Thomas *et al.,* 2002). These models were Half-normal + cosine, Half-normal + polynomial, Hazard rate + cosine, Hazard rate + hermite, and Uniform + cosine. Selection of the model that best fitted the data used the lowest value of the "Akaike Information Criterion"- AIC (Buckland *et al.*, 2001; Thomas *et al.*, 2002).

Secondly, we estimated chimpanzee numbers in the region using density of nests detected along transects, correcting for variables such as rates of nest production and decay (White & Edwards, 2000). We took the mean nest decay rate from Marchesi *et al.* (1995; 73 days) and the nest construction rate from Plumptre and Reynolds (1996; 1.09 nests per individual per day), as shown below (White and Edwards, 2000):

$$C = \frac{Y}{s \times D} \qquad (1)$$

Where:

C is the chimpanzee density,

Y is the estimate of nest density per sq km,

s is the estimated mean duration of nests, and

D is the rate of construction of nests.

We used a spreadsheet that employed the delta method (Seber, 1982; Buckland *et al.*, 2001) to calculate the standard error of *C*. The population size estimate for chimpanzees was calculated by multiplying chimpanzee density by the total habitat size.

Primate Sign Encounter Rates

In addition to calculating the population size of chimpanzees, we also estimated nest ecounter rates of chimpanzees and group ecounter rates of monkeys using an indirect technique called an index count, which produces relative numbers based on encounter rates of chimpanzee nests or monkey groups on transects. Index counts relate animal numbers to an index of animal signs detected along line transects (Barnes *et al.*, 1997; Buckland *et al.*, 2001).

Sign encounter rate = [number of primate signs / total distance walked]---------(1)

RESULTS

Chimpanzee Population Estimate

For our estimate of chimpanzee individual and nest densities per km² in the region, the Half-normal + cosine model gave the best fit, based on the size of the Akaike's Information Criterion (AIC). The Half-normal + cosine model without truncation gave an estimate of 20.99 nests per sq km (confidence interval from 12.38 to 35.58) and a CV = 26.98%. We estimated a density of 0.26 chimpanzees per sq km (SE = 0.25, CV = 111.7%) in the five reserves (i.e., chimpanzee range of 1,016 sq km) and obtained an estimate of 264 ±579 weaned chimpanzees for the area.

Chimpanzee Nest Encounter Rates

We had no direct encounters with chimpanzees during the survey period. We did observe their signs, however, in the Bia CA and the Krokosua Hills, Bonsam Bepo, Ayum and Subim Forest Reserves. The signs consisted of nests (69%) and feed remnants (31%), the latter being the remains of cocoa (*Theobroma cacao*) pods and kroma (*Klainedoxa gabonensis*) fruits.

We recorded eighteen chimpanzee nests (Table 1) on 129 km length of line transects in the five reserves which constituted the chimpanzee range; three at Bia RR (encounter rate = 0.27 nests per km); four at Krokosua Hills FR (0.20 nests per km); six at Bonsam Bepo FR (0.60 nests per km); two at Ayum FR (0.20 nests per km) and two at Subim FR (0.20 nests per km).

Table 1 - Mode of confirmation and encounter rates of primate species on line transects.

Reserve / Common Name	Scientific Name	Mode (number) of Confirmations					
		Sight	Call	Feed	Nest	Total Signs	Encounter Rate (km^{-1})
Bia NP							
Lowe's monkey	*Cercopithecus campbelli lowei*	1	1	-	-	2	0.04
Spot-nosed monkey	*Cercopithecus petaurista petaurista*	-	-	-	-	0	0.00
Bia RR							
Chimpanzee	*Pan troglodytes verus*	-	-	3	4	7	0.47
Lowe's monkey	*Cercopithecus campbelli lowei*	2	2	-	-	4	0.27
Spot-nosed monkey	*Cercopithecus petaurista petaurista*	2	1	-	-	3	0.20
Black & white colobus	*Colobus vellerosus*	-	-	-	-	0	0.00
Olive colobus	*Procolobus verus*	1	-	-	-	1	0.07
Krokosua Hills FR							
Chimpanzee	*Pan troglodytes verus*	-	-	2	4	6	0.30
Lowe's monkey	*Cercopithecus campbelli lowei*	3	2	-	-	5	0.25
Spot-nosed monkey	*Cercopithecus petaurista petaurista*	2	1	-	-	3	0.15
Black & white colobus	*Colobus vellerosus*	-	-	-	-	0	0.00
Olive colobus	*Procolobus verus*	1	-	-	-	1	0.05

Table 1 - Continued, next page...

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Reserve / Common Name	Scientific Name	Mode (number) of Confirmations					
		Sight	Call	Feed	Nest	Total Signs	Encounter Rate (km^{-1})
Bonsam Bepo FR							
Chimpanzee	*Pan troglodytes verus*	-	-	1	6	7	0.70
Lowe's monkey	*Cercopithecus campbelli lowei*	-	-	-	-	0	0.00
Spot-nosed monkey	*Cercopithecus petaurista petaurista*	-	3	-	-	3	0.30
Black & white colobus	*Colobus vellerosus*	-	1	-	-	1	0.10
Olive colobus	*Procolobus verus*	-	-	-	-	0	0.00
Ayum FR							
Chimpanzee	*Pan troglodytes verus*	-	-	-	2	2	0.20
Lowe's monkey	*Cercopithecus campbelli lowei*	1	-	-	-	1	0.10
Spot-nosed monkey	*Cercopithecus petaurista petaurista*	-	-	-	-	0	0.00
Black & white colobus	*Colobus vellerosus*	-	2	-	-	2	0.20
Olive colobus	*Procolobus verus*	-	1	-	-	1	0.10
Subim FR							
Chimpanzee	*Pan troglodytes verus*	-	-	2	2	4	0.40
Lowe's monkey	*Cercopithecus campbelli lowei*	2	2	-	-	4	0.40
Spot-nosed monkey	*Cercopithecus petaurista petaurista*	-	1	-	-	1	0.10
Black & white colobus	*Colobus vellerosus*	-	1	-	-	1	0.10
Olive colobus	*Procolobus verus*	-	-	-	-	0	0.00
Bia North FR							
Lowe's monkey	*Cercopithecus campbelli lowei*	-	2	-	-	2	0.20
Spot-nosed monkey	*Cercopithecus petaurista petaurista*	-	1	-	-	1	0.10
Black & white colobus	*Colobus vellerosus*	-	1	-	-	1	0.10
Olive colobus	*Procolobus verus*	-	-	-	-	0	0.00
Mpameso FR							
Lowe's monkey	*Cercopithecus campbelli lowei*	-	2	-	-	2	0.20
Spot-nosed monkey	*Cercopithecus petaurista petaurista*	-	2	-	-	2	0.20
Black & white colobus	*Colobus vellerosus*	-	1	-	-	1	0.10
Olive colobus	*Procolobus verus*	-	-	-	-	0	0.00
Asukese FR							
Lowe's monkey	*Cercopithecus campbelli lowei*	-	-	-	-	0	0.00
Bia Tano FR							
Lowe's monkey	*Cercopithecus campbelli lowei*	-	2	-	-	2	0.20
Spot-nosed monkey	*Cercopithecus petaurista petaurista*	-	1	-	-	1	0.10
Olive colobus	*Procolobus verus*	-	-	-	-	0	0.00
Bonkoni FR							
Lowe's monkey	*Cercopithecus campbelli lowei*	-	-	-	-	0	0.00
Spot-nosed monkey	*Cercopithecus petaurista petaurista*	1	1	-	-	2	0.20
Black & white colobus	*Colobus vellerosus*	-	1	-	-	1	0.10
Olive colobus	*Procolobus verus*	-	-	-	-	0	0.00
Bia, Goa and Abonyere SBs		-	-	-	-	0	0.00

Monkey Group Encounter Rates

We directly encountered 16 monkey groups (Table 1), resulting in an overall encounter rate of 0.12 groups per km. Individual group encounters were made with Lowe's monkey (0.08 groups per km); lesser spot-nosed monkey (0.03 groups per km); black and white colobus (0.00 groups per km) and olive colobus (0.02 groups per km). Fifty-nine percent of group encounters were with polyspecific (mixed group) associations of Lowe's, spot-nosed and olive colobus, with the majority (82%) being mixed groups of Lowe's and spot-nosed monkeys.

Distribution of Chimpanzee Signs

Chimpanzee occurrence was patchy and restricted to only five of the 14 reserves (Figure 2). Generally, we encountered chimpanzee signs only in southern Bia RR, northern Krokosua Hills FR and mid portions of Bonsam Bepo, Ayum and Subim FRs.

Our interviews with villagers in southern Bia RR revealed the occurrence of low-intensity and sporadic raids on cocoa crops by small groups of chimpanzees in the area, which took place most frequently during the periods when the cocoa pods were ripe. These raiding attacks/expeditions often took place during late afternoons (between 1 - 3pm) when the farms were quiet. Consequently, some farmers have placed scarecrows on their farms to scare off chimpanzees.

We recorded chimpanzee signs in Krokosua HIlls and Bonsam Bepo FRs in areas with very high altitudes and difficult terrain. We also found signs of chimpanzee activity in a sacred grove in northern Krokosua Hills FR, a region avoided by members of the local community, including hunters, due to fear of a curse.

Distribution of Monkey Signs

Monkeys were relatively widespread, occurring in nine to eleven of the reserves, depending on species (Figure 3).

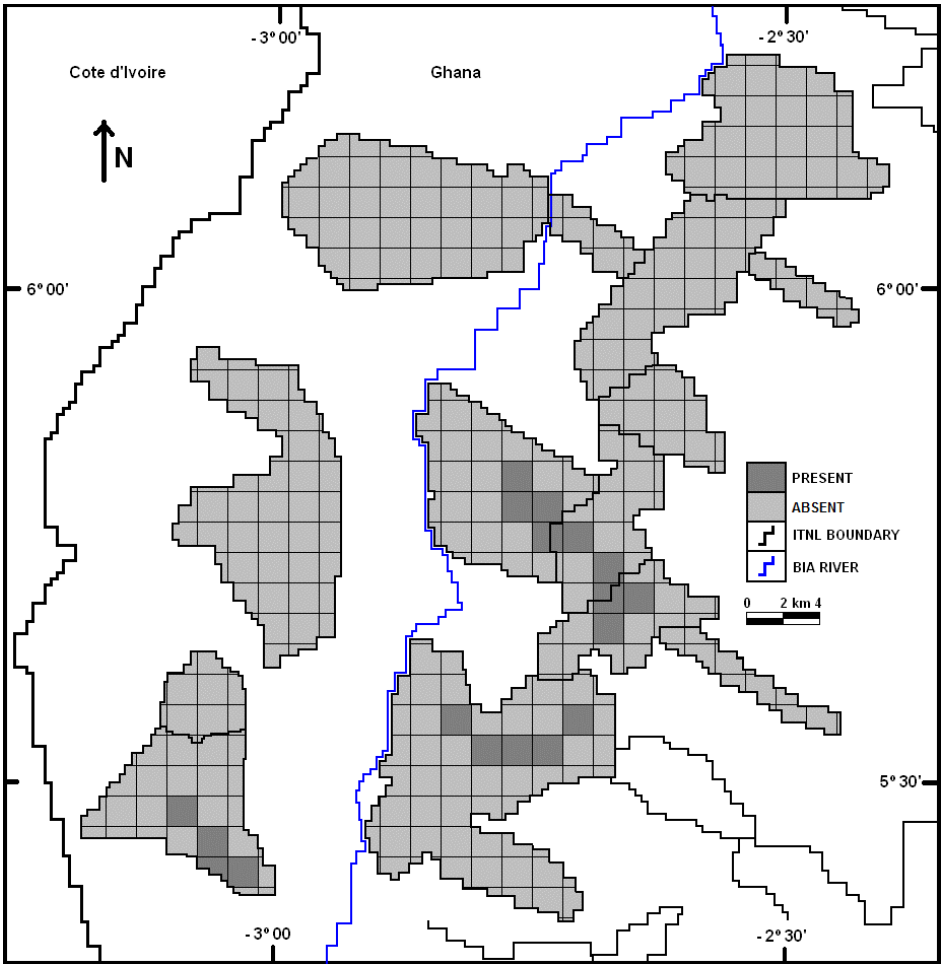

Figure 2. Map showing the distribution of chimpanzee signs across the survey areas.

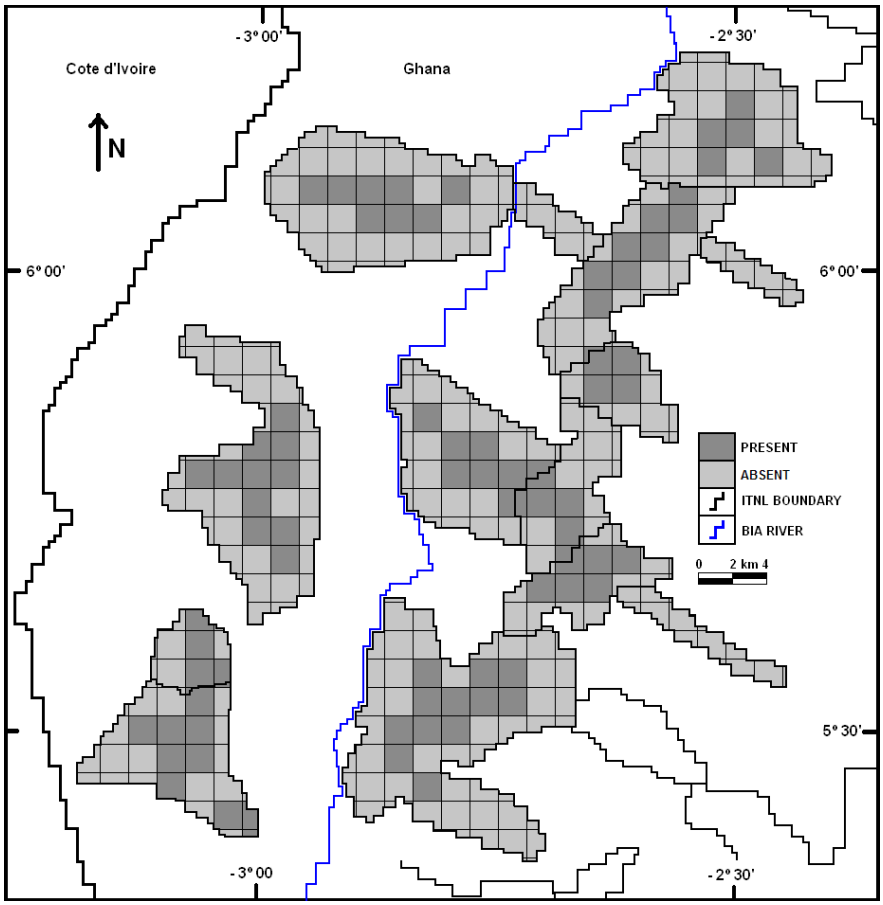

Figure 3. Map showing the distribution of monkey signs across the survey areas.

Lowe's monkey was the most widespread primate species, occurring in 11 reserves, whilst the black and white monkey occurred in nine reserves. Although we did not record any monkey signs in Asukese FR and the three shelterbelts on our line transects, we directly sighted one group and heard three calls of Lowe's monkeys outside line transects in Asukese FR during the survey. We have presented sign encounter rates of primate species observed outside line transects in the various reserves in Appendix 1.

Aside from the Miss Waldron's red colobus (*Procolobus badius waldroni*), a species which fomerly occurred in the area but is now considered extinct (Oates *et al.*, 2000), the park staff hinted at the possible presence of the white-naped mangabey (*Cercocebus atys lunulatus*), and the Diana roloway monkey (*Cercopithecus diana roloway*), although these were not recorded during the survey.

Hunting Activities

We found signs of human presence and hunting activity throughout the study area. The majority (47%) of these hunting signs were wire snares (Table 2). We found the highest index of hunting activity per km walked inside the forest reserves, encountering 13 snares in the Asukese FR alone. On the other hand, we recorded very low encounter rates of hunting activity in the wildlife reserves, with the lowest rates occurring in the Bia NP. Other indices of hunting activity recorded in the study area were spent cartridges (18%), gunshots (16%), poacher paths (11%), poacher camps (5%) and rat hunting (3%).

DISCUSSION

Density and Distribution of Chimpanzees

There have been no new estimates of chimpanzee numbers in Ghana since Teleki's (1989) estimate of between 300–500 chimpanzees. Other sources have claimed that chimpanzees have gone extinct, or nearly so, in Ghana (Caldecott & Miles, 2005). Nevertheless, our population estimate of 264 chimpanzees in the BGFB is close to the lower range estimate of 300 chimpanzees (Butynski, 2001) reported for the forests in western Ghana (Kormos *et al.*, 2003). Our estimate also is similar to the lower-end estimates of 200 chimpanzees each reported for Nigeria (Oates *et al.,* 2000) and Senegal (Teleki, 1991). In Liberia and Sierra Leone, relatively high lower-end estimates of, respectively, 1000 (Nisbett *et al.,* 2003) and 1500 (Butynski, 2001) chimpanzees also were reported for single protected areas. The chimpanzee population of Ghana is tiny compared to those in Guinea and Ivory Coast, which have

Table 2 - Mode of confirmation and encounter rates of hunting activities on line transects.

Reserve	Snares	Empty Cartridge	Gun Shots	Poacher Paths	Poacher Camps	Rat Hunting	Total Signs	Encounter Rate (km^{-1})
Bia NP	2	-	-	-	-	-	2	0.40
Bia RR	3	2	-	2	-	-	7	0.47
Krokosua Hills FR	6	8	3	3	-	-	20	1.00
Bonsam Bepo FR	8	-	6	2	2	-	18	1.80
Ayum FR	6	4	4	2	1	1	18	1.80
Subim FR	9	-	-	4	3	-	16	1.60
Bia North FR	4	6	4	2	1	1	18	1.80
Mpameso FR	9	3	-	1	-	-	13	1.30
Asukese FR	13	4	6	-	2	1	26	2.60
Bia Tano FR	7	4	2	1	-	-	14	1.40
Bonkoni FR	9	2	3	3	1	-	18	1.80
Bia SB	6	2	2	1	-	1	12	4.00
Goa SB	9	1	-	-	-	2	12	4.00
Abonyere SB	3	-	2	1	-	-	6	2.00
Total	94	36	32	22	10	6	200	
Percentage (%)	47	18	16	11	5	3		

exceptionally high lower-end estimates of, respectively, 8100 (Kormos *et al.*, 2003) and 8000 (Herbinger *et al.*, 2003) chimpanzees (and where the apes occurred in four and 10 protected areas, respectively).

Our chimpanzee estimate was imprecise. The relatively wide confidence limits suggest large margins of error, frequently a problem when dealing with small populations (Taylor & Gerrodette, 1993; Barnes, 2002). The margin of error is further magnified by the clumped distribution of chimpanzees; chimpanzee signs were seen on only a few transects, while there were many transects without chimpanzee signs.

Although we are encouraged by the continued existence of small populations of chimpanzees in a few of the southern forest reserves in the Bia-Goaso study area, increasing human migration into the region continues to exert great pressure on the forests (Sam, 2000). The immediate threats to the BGFB are unregulated timber extraction, agriculture and hunting activity (Wildlife Department, 1998). The growing pet trade also is believed to have a significant adverse effect on wild chimpanzee survival in Ghana (Mittermeier, 1987).

Encounter Rates and Distribution of Monkeys

It is difficult to make realistic comparisons of monkey densities or encounter rates with other studies in the area because very little previous data exist. Ideally, our encounter rates of 0.08 groups per km for Lowe's monkey, 0.03 for spot-nosed monkey, 0.00 for black and white colobus, and 0.02 for olive colobus should be compared with estimates derived based on similar methods, and in our case this is not possible. We are, however, encouraged by the similarity between our estimates and those based on direct observations reported by rangers on field patrols in the area for Lowe's monkey (0.10 groups per km), spot-nosed monkey (0.05), black and white colobus (0.00), and olive colobus (0.05). In contrast to our line transect methodology, rangers used a variety of reconnaissance-style surveys to increase ground coverage, following paths of least resistance along game trails and natural features (e.g., watercourses and ridges), and cutting vegetation sparingly to maintain their compass bearings (Walsh & White, 1999; White & Edwards, 2000).

Encounter rates of monkeys in the two chimpanzee strata were not significantly different from one another (Mann-Whitney U test: $U=257.5$, $p>0.05$), indicating a regular monkey distribution throughout the study area. Obviously, in terms of wildlife protection potential, the Bia population seems a more viable population than the Goaso one. In the long term, however, the Goaso population might have a better chance of survival as their range is bigger.

Hunting Activities

We found signs of human presence and hunting activity throughout the study area, with the greatest proportion occuring in the forest reserves. We recorded the highest

encounter rates of hunting activity in the Asukese FR, whilst the lowest encounter rates were found in the Bia NP. We did not have any direct encounters with hunters; however, on 18 different occasions over the course of the surveys, we heard 32 gunshots, ranging from one to four shots per occasion. Wire snares formed the highest proportion (47 percent) of all hunting signs. For most arboreal species like primates, the use of snares (placed on the forest floor) may pose less of a danger compared to the use of guns (indicated by the number of spent cartridges and gunshots encountered), which constituted 34% of hunting signs.

Implications for conservation

Primates in the BGFB are threatened as a result of habitat loss (Danquah *et al.,* 2009) due to unregulated timber extraction and agriculture (Wildlife Department, 1998). In recent years, accelerated migration from other regions into western Ghana (Sam, 2000) has exacerbated the problem and contributed to severe encroachment of humans into primate habitat. The general absence of primates, especially chimpanzees, from the northern reserves of the BGFB may be due to the historically greater accessibility of this area to humans prior to the creation of the reserves (Danquah *et al.,* 2009). Hunting activity and the pet trade also are believed to have a significant adverse effect on chimpanzees in Ghana (Mittermeier, 1987). Thus, primate conservation in western Ghana should receive special priority.

A number of factors may have favoured the persistence of chimpanzees in some reserves in the BGFB over the past few decades. One is the status of protection of the reserve. The Bia Conservation Area is fully protected; wildlife protection there is enforced by the Ghana Wildlife Division. Another contributing factor is the difficult topography of some regions. The Krokosua Hills and Bonsam Bepo FRs are generally characterized by very hilly and difficult terrains, and they are not easily navigable in certain locations, preventing access by hunters and poachers into the forest's interior.

The BGFB has high potential as an important tourist and research attraction. Researchers and tourists can appreciate a large number of wildlife species, including chimpanzees and monkeys. The charismatic appeal of primates, and in particular chimpanzees, enhances the intrinsic value of the BGFB in the public eye. These primates aid in raising awareness among the public regarding the importance of preserving the forests and fauna of the BGFB.

The data we have presented here provide important information on the consistency and variability in the demographic parameters documented in the study region. Coupled with these and future survey/monitoring efforts, educational programs aimed at improving local and tourist knowledge of the natural history of the area's primates will be a major benefit in raising conservation awareness (Muñóz *et al.,* 2008). The conservation of a relict population of threatened chimpanzees in the BGFB will provide a good example of the interplay between national and local policies in Ghana with the potential to encourage the protection of unique natural resources. The linking of healthy eco-systems to economic alternatives (e.g., ecotourism) also can provide benefits to local inhabitants (Muñóz *et al.,* 2008).

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Adult female olive colobus (Procolobus verus), with large sexual swelling, from the Ivory Coast's Tai National Park. Photo courtesy of W. Scott McGraw.

APPENDIX 1
Sign Encounter Rates of Primate Species Observed Outside Line Transects

Reserve / Common Name	Scientific Name	Mode (number) of Confirmations					
		Sight	Call	Feed	Nest	Total Signs	Encounter Rate (km^{-1})
Bia NP							
Lowe's monkey	*Cercopithecus campbelli lowei*	2	-	-	-	2	0.23
Spot-nosed monkey	*Cercopithecus petaurista petaurista*	-	1	-	-	1	0.12
Bia RR							
Chimpanzee	*Pan troglodytes verus*	-	-	4	0	4	0.15
Lowe's monkey	*Cercopithecus campbelli lowei*	7	5	-	-	12	0.46
Spot-nosed monkey	*Cercopithecus petaurista petaurista*	6	3	-	-	9	0.35
Black & white colobus	*Colobus vellerosus*	-	4	-	-	4	0.16
Olive colobus	*Procolobus verus*	6	-	-	-	6	0.23
Krokosua Hills FR							
Chimpanzee	*Pan troglodytes verus*	-	-	2	2	4	0.26
Lowe's monkey	*Cercopithecus campbelli lowei*	6	4	-	-	10	0.66
Spot-nosed monkey	*Cercopithecus petaurista petaurista*	6	1	-	-	7	0.46
Black & white colobus	*Colobus vellerosus*	-	1	-	-	1	0.07
Olive colobus	*Procolobus verus*	2	-	-	-	2	0.13
Bonsam Bepo FR							
Chimpanzee	*Pan troglodytes verus*	-	-	1	2	3	0.09
Lowe's monkey	*Cercopithecus campbelli lowei*	5	7	-	-	12	0.34
Spot-nosed monkey	*Cercopithecus petaurista petaurista*	-	8	-	-	8	0.23
Black & white colobus	*Colobus vellerosus*	-	1	-	-	1	0.03
Olive colobus	*Procolobus verus*	-	2	-	-	2	0.06
Ayum FR							
Chimpanzee	*Pan troglodytes verus*	-	-	-	-	0	0.00
Lowe's monkey	*Cercopithecus campbelli lowei*	3	2	-	-	5	0.14
Spot-nosed monkey	*Cercopithecus petaurista petaurista*	2	2	-	-	4	0.11
Black & white colobus	*Colobus vellerosus*	-	1	-	-	1	0.03
Olive colobus	*Procolobus verus*	-	1	-	-	1	0.03
Subim FR							
Chimpanzee	*Pan troglodytes verus*	-	-	1	1	2	0.05
Lowe's monkey	*Cercopithecus campbelli lowei*	6	2	-	-	8	0.22
Spot-nosed monkey	*Cercopithecus petaurista petaurista*	-	3	-	-	3	0.08
Black & white colobus	*Colobus vellerosus*	-	1	-	-	1	0.03
Olive colobus	*Procolobus verus*	1	3	-	-	4	0.11
Bia North FR							
Lowe's monkey	*Cercopithecus campbelli lowei*	2	4	-	-	6	0.19
Spot-nosed monkey	*Cercopithecus petaurista petaurista*	-	2	-	-	2	0.06
Black & white colobus	*Colobus vellerosus*	1	1	-	-	2	0.06
Olive colobus	*Procolobus verus*	-	1	-	-	1	0.03
Mpameso FR							
Lowe's monkey	*Cercopithecus campbelli lowei*	1	4	-	-	5	0.14
Spot-nosed monkey	*Cercopithecus petaurista petaurista*	-	2	-	-	2	0.06
Black & white colobus	*Colobus vellerosus*	-	1	-	-	1	0.03
Olive colobus	*Procolobus verus*	-	1	-	-	1	0.03
Asukese FR							
Lowe's monkey	*Cercopithecus campbelli lowei*	1	3	-	-	4	0.16
Bia Tano FR							
Lowe's monkey	*Cercopithecus campbelli lowei*	-	2	-	-	2	0.06
Spot-nosed monkey	*Cercopithecus petaurista petaurista*	-	2	-	-	2	0.06
Olive colobus	*Procolobus verus*	-	1	-	-	1	0.03
Bonkoni FR							
Lowe's monkey	*Cercopithecus campbelli lowei*	-	5	-	-	5	0.20
Spot-nosed monkey	*Cercopithecus petaurista petaurista*	1	2	-	-	3	0.12
Black & white colobus	*Colobus vellerosus*	-	1	-	-	1	0.04
Olive colobus	*Procolobus verus*	-	1	-	-	1	0.04
Bia, Goa and Abonyere SBs	-	-	-	-	-	0	0.00
TOTALS		58	85	8	5	156	