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CURRENT STATUS, DISTRIBUTION AND ABUNDANCE OF THE WESTERN CHIMPANZEE (*Pan troglodytes verus*) AND OTHER DIURNAL PRIMATES IN THE BIA-GOASO FOREST AREA, GHANA

BY

EMMANUEL AKOM

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By

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(BSC NATURAL RESOURCES MANAGEMENT)

A Thesis submitted to the School of Graduate Studies, Kwame Nkrumah University of Science and Technology, Kumasi, in partial fulfillment of the requirements for the degree of

Master of Philosophy in Wildlife and Range Management

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DECLARATION

I hereby declare that this submission is my own work towards the M.Phil. Wildlife and Range Management and, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

Emmanuel Akom	…………………	…………………..…
(PG3213509)	Signature	Date

CERTIFIED BY:

Prof. William Oduro	…………………	…………………..…
(SUPERVISOR)	Signature	Date

CERTIFIED BY:

Dr. Emmanuel Danquah	…………………	…………………..…
(HEAD OF DEPARTMENT)	Signature	Date

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ABSTRACT

Field investigations were undertaken from August 2009 to October 2010 to determine the status and conservation of the chimpanzee (*Pan troglodytes verus*) and other endangered diurnal primates in south-western Ghana. As part of field assessments, two primate surveys targeted at chimpanzees and the other endangered primates were conducted in the wet and dry seasons in the Bia-Goaso forest area. The surveys also aimed to prioritize major risk factors and establish the conservation value of individual forest management units within the cluster of forest reserves investigate the possibility of establishing corridors between reserves in the forest area. A combination of line transects sampling, satellite imagery analysis and interviews in communities were employed. Besides the chimpanzee; and two prosimian primates; *Galagoides demidovii* and *Perodicticus potto*, we confirmed the presence of four diurnal primates; *Cercopithecus campbelli lowei*, *Cercopithecus petaurista petaurista*, *Colobus vellerosus*, and *Procolobus verus*. The presence of three highly endangered primates; *Cercocebus atys lunulatus*, *Cercopithecus diana roloway* and *Procolobus badius waldroni* were however not detected during any of the surveys. The highest encounter of one hundred and two (102) primates was recorded in the Bia Resource Reserve (i.e. 50 in the wet season and 52 in the dry season), followed by Krokosua Hills Forest Reserve (77), Bonsam Bepo Forest Reserve (75), Subim Forest Reserve (50) and then Ayum Forest Reserve (44). Comparatively, very few primate species were recorded at Bia Tano Forest Reserve (18) and Asukese Forest Reserve (16) whilst no record of primates was made at the Bia, Goa and Abonyere Shelterbelts. Overall, Bia Resource Reserve was found to be richest and most diverse in terms of primate species. We estimated 249 chimpanzees (SE = 196.68, CV = 79.02%) for five reserves which constitute the current chimpanzee range in the

study area. Chimpanzee numbers could not be estimated for nine reserves that formed the rest of the study area because of inadequate number of nests recorded on transects. There was an average encounter rate of 0.48 monkey signs per km and 0.23 monkey groups per km of which more than 50% were polyspecific (mixed group) associations of Lowe‘s, Spot-nosed and Olive colobus. The majority (85%) of these associations were between the Lowe‘s and Spot-nosed monkeys. In all cases, there were significant differences in the distribution and density of primates between the medium and low-density strata but not between seasons. Lowe‘s monkey was the most widespread recorded primate whilst chimpanzees were the most restricted primates, found in only five of the fourteen reserves. General primate activity indicated a wider distribution in the wet season compared to the dry season. A logistic regression analysis of primate signs indicated that water availability, poaching activity and altitude accounted for a large proportion of this variation in the study area. However, water availability and poaching levels do not apply year-round and may change significantly between seasons. Poaching activity in the Goaso block of forest reserves was significantly higher than in the Bia Conservation Area (BCA). The Bia Conservation Area is the priority site for long-term conservation of the species based on the relatively larger chimpanzee community, the level of protection and the relatively low human disturbance. The Subim forest reserve offers the best possibility for conservation of chimpanzees among the Goaso complex of reserves. This is followed by Ayum, Krokosua Hills and Bonsam-Bepo forest reserves in descending order of importance. The high incidence of habitat destruction and hunting across the forest reserves need to be addressed as a matter of urgency through uncompromising law enforcement. In the face of limited resources, conservation efforts should concentrate on protecting the identified priority sites. Over the long term the development of corridors through the Community Resource Management Area approach is proposed to link the individual reserve units and incorporate them into a wider network of conservation area.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

The Guinean forest hotspot is known for its high diversity of primates. Despite their paramount conservation and ecological significance, surprisingly little reliable information exists on chimpanzee populations in much of their range in West Africa. Within the region, the endangered western chimpanzee (*Pan troglodytes verus*) (IUCN, 2007) is known to have once occurred in 12 countries, but is currently patchily distributed in nine or ten countries from south-east Senegal to the Dahomey Gap (Lee *et al.*, 1988; Teleki, 1989). The combined effects of deforestation, hunting and capture for the pet trade have been attributed to this dramatic decline. According to Bailey (2003) concerns such as management of small populations, and estimates of population viability, are generally not being addressed. With the current alarming declines in population (Amman *et al.*, 2000) within the project area and elsewhere in the sub-region, there are fears that the chimpanzees might face extinction within the next 10 to 20 years if appropriate measures are not taken to safeguard their survival. The study is therefore important in contributing to the survival of dwindling populations of primates in the Bia/Goaso block of forests, and is coherent with the objectives of the Action Plan for the conservation of chimpanzees in West Africa (Kormos *et al*., 2003) and the Primate Conservation Strategy of Ghana (Oates, 2006).

1.2 Problem Statement and Justification

The Bia Goaso Forest Block (BGFB) in south-western Ghana has been delineated among a number of priority sites for the conservation of chimpanzees in West

Africa (Kormos *et al*., 2003) (Figure 1). The importance of this site is further highlighted by the fact that it is one of five priority regions or hotspots for biodiversity conservation identified by participants during the West Africa Priority Setting workshop held by Conservation International in December 1999. The area has also been proposed as a transfrontier corridor for elephants moving between forest reserves on the Cote d'Ivoire side of the border and those in the study area (Parren *et al*., 2002). Chimpanzees and elephants are therefore two of the flagship species within this hotspot.

This notwithstanding, little research and monitoring has been done on the chimpanzees and other primates (Whitesides and Oates, 1995; Abedi-Lartey, 1999; Oates *et al*., 2000; Magnuson *et al*., 2003) in this area and in the other chimpanzee ranges in Ghana. Mostly importantly however, current chimpanzee population size and distribution remains unknown. No wide-ranging estimate of chimpanzee numbers exists in Ghana since Teleki's estimate of between 300–500 in the late 1980's (Teleki, 1989). With the possible exception of the Bia Conservation Area (Bia National Park and Resource Reserve), where Martin (1991) conducted some preliminary surveys, little or no extensive research has been done in the complex of reserves. A lot remains unknown about the status of chimpanzees and other primate populations within the Bia-Goaso forest block and elsewhere in Ghana. Likewise, there have been little meaningful attempts to assess the conservation status of the other endangered primate species including the Roloway Diana monkey (*Cercopithecus diana roloway*) and the White-naped mangabey (*Cercocebus atys lunulatus*) in the country. There is therefore a dearth of knowledge on the distribution and abundance of primate species in the country and especially concerning the project area despite the reported presence of several restricted-ranges of highly endangered primates. The Primate Conservation

Strategy of Ghana (Oates, 2006) recommends that as a matter of urgency, more wide-ranging surveys of chimpanzees, roloway monkeys and white-naped mangabeys should be undertaken to adequately identify the best sites for their conservation in Ghana. According to Descher and Kpelle (2005), given their tenuous conservation situation, any area hosting threatened primate populations deserves attention and in particular those areas representing ecosystems or remnant habitats benefiting from protected status. Also given the low estimates of the total number of chimpanzees in Ghana (Teleki, 1989; Magnuson *et al.*, 2003), the protection of every confirmed chimpanzee population should be crucial to the survival of this endemic species across its range in Ghana and West Africa. Improved information of the distribution and density of chimpanzee populations is needed in the region for management planning that includes monitoring protocols. This study is therefore essential in providing critical information on the locations, connectivity and potential viability of Ghana's existing chimpanzees and other diurnal primate populations in the project area. Understanding the factors that influence population distribution and abundance can greatly enhance attempts to protect suitable chimpanzee habitat and stop the decline in their population size. The study is therefore important in informing conservation planning and action and to the development of management alternatives by Park managers. It will lay the groundwork for more elaborate and extensive education and awareness creation campaign amongst all levels of the Ghanaian society and especially in communities fringing chimpanzee habitats. Finally, it will contribute to local training and capacity building for primate research and monitoring in Ghana. The primary goal of this study therefore is;

1.3 Goal and Objectives

To contribute to the conservation and long-term survival of chimpanzees and other primate populations in the Upper Guinea forest zone.

The specific objectives are to;

- Determine the distribution and abundance of chimpanzees and other diurnal primates in the Bia-Goaso forest area.
- Investigate the relationship between primates (chimpanzees and other diurnal primates) abundance and human activity/ecological variables.
- Identify potential forest reserves that could be added to the established network of permanent chimpanzee conservation sites in Ghana.

Hypotheses

For the study the following hypotheses are proposed;

- H_0: Chimpanzee and other primates are randomly distributed in the study area.
- H_0: The patterns of chimpanzee and other primate distribution are similar for both seasons of the year.
- H_0: Chimpanzee abundance is not associated with human disturbance or ecological/geographical variables.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 General Patterns in Species Abundance and Distributions

It is generally known that species are distributed in space - but within limits (Lawton *et al.*, 1994, Brown and Lomolino, 1998). Understanding the factors shaping species' ranges (distribution limits) is a central question in both ecology and evolutionary biology (e.g. interpreting faunal responses to large-scale environmental fluctuations, Graham *et al.*, 1996). Comparative studies from the center to the margin of species' ranges allow us to explore species' demographic responses along gradients of increasing environmental stress (Holt, 2005). Also, the abundance of different species can provide insight into how a community functions (Verberk, 2012). Data on species abundances are relatively easy to obtain, and may give insight into less visible aspects of a community, such as competition, predation and mutualism (Verberk, 2012). Species that are restricted in their geographic distribution tend to be scarce whereas widespread species are likely to occur at high densities (Brown, 1984). This positive interspecific distribution-abundance relationship is intimately related to the patterns in species abundance. This relationship may seem self-evident. Yet although a larger area is more likely to be able to sustain a higher total number of individuals of a species, it is not clear why the density (number of individuals in a given area) should also increase (Verberk, 2012). It is vital to understand how the processes linking the local abundance of a species and its regional distribution because this has some far reaching consequences. For example, suppose that restricted ranges inevitably lead to low densities then efforts to conserve a particular species by protecting a small part of high quality habitat will not be effective. This goes to show that there is a positive feedback between population size and distribution (Bock and Riclefs, 1983; Falster *et* *al.*, 2001). Species will either be widespread and abundant (so called core species) or they will be restricted and scarce (so called satellite species) (Hanski, 1982). Being widespread will ensure the continuous arrival of individuals to all places and thus a species will be less likely to disappear from a particular locality. Understanding these patterns has important implications for practical issues like reserve selection and predicting extinction risk (Verberk, 2012). The factors influencing population distribution patterns in time and space are therefore a central theme in population ecology and for the chimpanzees in the Bia-Goaso area this is what the present study seeks to investigate.

2.2 Current Distribution and Abundance of chimpanzees in Africa

The historical chimpanzee range was in at least 25 countries throughout Equatorial Africa. Today, chimpanzees occur in 22 countries from 13^{o}N to 7^{o}S latitude (Lee *et al.*, 1988; Teleki 1989, Butynski 2003). The present range covers an area of approximately 2,342,000 km sq (Butynski, 2003), but distribution and numbers are poorly known in most areas (Butynski, 2003; Lee *et al.*, 1988). There is a vast difference in the geographic and known ranges of the four sub species of chimpanzees. While data relating to the distribution and approximate number of chimpanzees in some countries exist, many populations have not been surveyed or have only had isolated surveys in some forest blocks which are of interest to particular conservation organizations (Butynski, 2003). While there has been an effort made in the past five years to carry out surveys in many countries, there have been very few countrywide censuses where forests have been extensively surveyed.

The West African sub species (*P. t. verus)* occurs in 10 countries in West Africa. The current known populations are fragmented and declining in numbers. Historically, *P.*

t. verus were believed to have occurred in 12 countries. The geographical range was 631,000 km sq with an estimated population range of 21,000 to 55,000 (Butynski, 2003).

The recent identification of a new subspecies, *P. t. vellerosus*, includes the population of chimpanzees straddling the northern border of Cameroon and the Southern border of Nigeria between the Niger River and Sanaga Rivers. They have a relatively limited range of 142,000 km sq. The estimated number for this subspecies is between 5,000 and 8,000 individuals (Butynski, 2003).

The range of central African subspecies (*P .t. troglodytes)* extends across seven countries from Cameroon in the north to the Congo River in Peoples Republic of Congo (PRC). The largest population of this subspecies is found in Cameroon and Gabon, while substantial populations exist in PRC. Smaller populations are present in Equatorial Guinea, The Central African Republic (CAR), northern Angola and the extreme west of Democratic Republic of Congo (DRC). The known geographic range is approximately 695,000 km sq. The central African chimpanzee population is estimated to be between 70,000-116,000 individuals (Butynski, 2003). This subspecies is found in some of the most undisturbed habitat remaining. The eastern chimpanzee (*P. t. schweinfurthi)* occurs in seven countries with a geographic range of 87,400 km sq and it is estimated to be about 76,400-119,600 (Butynski, 2003).

2.3 Distribution and Abundance of chimpanzees in West Africa

Today, in West Africa, 75% of chimpanzees have disappeared in the last 30 years (Kormos *et al.,* 2003). Of the two subspecies occurring in this region, the western chimpanzee (*Pan troglodytes verus)* has already been completely extirpated in three countries. Populations in Ghana and two other countries—Senegal and Guinea-Bissau are extremely threatened, numbering only in the hundreds. Within the upper guinea forests where it can be found, centuries of human activities have led to a loss of nearly 70% of the original forest area which has resulted in the contraction of its range. The continuous erosion and fragmentation of its habitat has meant that currently wherever they occur, populations are small, scattered and isolated within relict patches of rainforest habitat. It is largely as a result of the combined effects of habitat destruction, hunting and capture for the pet trade that populations have declined. While this decline by itself is alarming, it merits additional concern because, more than any other species, chimpanzees closely resemble humans genetically, behaviorally and physically, and thus provide an important link to our evolutionary history.

According to Gonder *et al.*, (1997) the widely accepted view of chimpanzee distribution patterns suggests that *Pan troglodytes verus* occurs from Senegal to western Nigeria. The Dahomey Gap, a dry-forest zone covering present-day eastern Ghana, Togo, and Benin, divides *Pan troglodytes verus* into two populations. The lower Niger River, in Nigeria, separates *Pan troglodytes verus* and *P. t. troglodytes*. They further suggest that the two populations in West Africa historically have been more isolated from each other than chimpanzees in western equatorial African forests have been from those in eastern Africa. However scientists are still unable to say where the main geographic divide occurs between the two groups of West African chimpanzees. According to Gonder *et al.*, (1997) chimpanzees are rare in western Nigeria, and the sample of chimpanzees from that area is small. Scientists have not sampled chimpanzees in western Ghana. They further stated that more data are needed before we can state more confidently whether a phylogeographic division exists between West African chimpanzees at the Niger

River, or at the Dahomey Gap in the vicinity of Togo, or whether chimpanzees in western Nigeria form a distinct genetic population. Increased sampling coverage in western Ghana and western Nigeria, analyses of additional genetic loci, and further morphological analysis are necessary to understand the phylogeographic history of chimpanzees more fully.

2.4 Distribution and status of chimpanzees in Ghana

In the forest zone of Ghana three different surviving chimpanzee populations are living completely isolated from each other (Magnuson *et al.*, 2003). These populations are confined mainly to the high forest zone of south-western Ghana which comprises the Western, Ashanti, Central and Brong-Ahafo regions. Within Ghana, three important forest areas (all in south-western Ghana) have been identified as priority sites for chimpanzees: Bia-Goaso, Ankasa-Tano, and Fure River (Magnuson *et al.,* 2003). All three populations occcur mainly along the Ghana, Côte d'Ivoire border (Teleki, 1989). As of 1995 chimpanzees were confirmed to still be present in the Bia-Goaso, Ankasa-Tano and Fure River forest regions of western Ghana. A preliminary study of the ecology of chimpanzees was carried out by Martin (1991) in the Bia and Ankasa Conservation Areas. Magnuson (2002) conducted primate surveys in nine forest areas throughout south-western Ghana. Field surveys detected chimpanzees in the Ankasa Resource Reserve, which followed three reports of chimpanzee observations in this park. Abedi-Lartey and Amponsah (1999) and White and Berry (1999) were also able to confirm chimpanzee presence in the Krokosua Hills Forest Reserve during their primate surveys in the study area. Chimpanzee presence was also detected in a recent primate study implemented by West African

Primate Conservation Action (WAPCA) in the Krokosua forest reserve and Ankasa and Bia CAs (WAPCA, 2010).

2.4.1 Ankasa-Tano chimpanzee range

The Ankasa-Tano chimpanzee range is about 1463 km^2 and comprises Dadieso, Jema Asemkrom, Boin River, Boin Tano, Yoyo and Draw River forest reserves and Ankasa-Nini Sushien National Parks all in south-western Ghana (Magnuson *et al.*, 2003). Within most of these reserves in the area chimpanzee had been reported to occur in reasonable numbers. Their reported presence has been recorded in reserves like Dadieso, Boin Tano, Yoyo and Draw although under heavy hunting pressure (IRNR, 2005). For the Ankasa-Nini Sushien National Parks, all 10 forest primates recorded in Ghana, including *Cercocebus atys* (LR/nt), *Cercopithecus diana roloway* (CR), *Procolobus verus* (LR/nt), *Colobus vellerosus* (VU) and *Pan troglodytes* (EN), have been reported in the past (WAPCA, 2010). The recent 2004 Globally Significant Biodiversity Area (GSBA) faunal surveys also confirmed the occurrence of chimpanzees in the Jema Asemkrom forest reserve (IRNR, 2005). The site together with the other forest reserves in the block certainly merit protection, being some of the few significant relatively undisturbed blocks of forest remaining in the country. A more detailed study is required to establish the faunal importance of the sites.

2.4.2 Fure chimpanzee range

Of the three ranges, the Fure chimpanzee range is the smallest and it is about 373 km^2. The range comprises Fure River, Fure Headwaters forest reserve and the Mamiri forest reserve, which lies to the north of the Fure River. The three sites form an almost continuous crescent-shaped block of forest. The terrain of most of the reserves is hilly, with the hills strongly dissected by steep-sided deep valleys (IRNR, 2005). These valleys become flooded during the rainy season, creating swampy habitats. During the 2000 Ghana national wildlife surveys under the multi-resource inventory project, the only site where chimpanzees were recorded was Fure Headwaters (RMSC, 2002). Beside the chimpanzee, other important primate species believed to be resident in the range include the Diana monkey *Cercopithecus diana roloway*.

2.4.3 Bia-Goaso chimpanzee range

The Goaso and Bia complex of the forest reserves may harbour more forest chimpanzees than any other place in South-western Ghana. The Goaso and Bia complex is the largest block of chimapanzee habitat in Ghana and is about 2,600 km^2 (Magnuson *et al.*, 2003). The area comprises important forest reserves like, Bia National Park, Krokosua, Subim, Ayum, Bonsam-bepo, Bia North, Mpameso, and Asukese forest reserves, with chimpanzees known to be resident in Bia Conservation area and Krokosua forest reserve.

2.5 Major determinants of wildlife distribution and abundance

There are several factors that can influence the distribution and relative abundance of animal species within a given area (Elmouttie, 2009). On the large scale distribution patterns of species are shaped by environmental and historical constraints (Lehman and Fleagle, 2006; Kamilar, 2009; Harcourt and Wood, 2012). On the small scale behavioural characteristics including territoriality, location of nesting sites, predation, and competition for food or mates determine where a species is found (Nkurunungi and Stanford, 2006). The distribution of animals, including chimpanzees therefore varies across landscapes. Many landscape-scale models of herbivore distributions focus primarily on the role of biotic factors such as forage quality and quantity (Redfern *et al.,* 2003). However, Bailey *et al.* (1996) suggested that abiotic factors, such as slope and distance to water, are equally as important and can act as the primary determinants of large scale distribution patterns. Other interacting factors, which influence this distribution, include shelter, salt licks, soil fertility (nutrients for plants) and elevation (Blom *et. al.*, 2005; Wall *et al.*, 2006). Additionally, human disturbance, quantifiable by population density, socio-economic and cultural factors, and the extent of roads and highways (Fa *et al*., 2002; Yackulic *et.al*. 2011; Vanthomme *et al.*, 2013) is one of the major determinants of wildlife distributions (Paudel and Kindlmann, 2012) including chimpanzees (Torres *et al.*, 2012; Junker *et. al.*, 2012). Corfield (1973) and Williamson *et al.* (1988) further suggest that where the land is shared by humans and their livestock, human activities may interfere with animal distributions and preempt access by wildlife to critical habitats. According to Andrewartha and Birch (1954) an understanding of the biological and environmental factors that limit the distribution and abundance of organisms is fundamental to ecology, and is central to our understanding of the niche concept (Hutchinson, 1978). It is on this basis that this study has sought to determine how human related anthropogenic factor together with ecological factors influence the distribution and abundance of chimpanzees in the study area.

2.6 Factors that influence the distribution and abundance of chimpanzees

2.6.1 Ecological factors

According to Balcomb *et. al*., 2000, habitat composition and structure of a forest are the primary determinants of the abundance of chimpanzees. These most often relate to availability of food and nesting materials. Seasonal changes in food abundance influence ranging patterns of chimpanzees in the landscapes (Kano, 1971a; Baldwin *et. al.*, 1982; Plumptre and Reynolds, 1994). In forested habitats, chimpanzees have smaller nomadic ranges (about 20 km^2) than in savanna woodland where they have a wider range of about 70-200 km^2 (Suzuki, 1969; Kano, 1971a; Baldwin *et. al.*, 1982).

Again, feeding behaviour in chimpanzees varies seasonally and is greatly influenced by food availability and habitat type. During Hernandez-Aguilar's (2009) study on chimpanzee nesting patterns in Issa, Ugalla, western Tanzania, he realized that chimpanzees ranged more widely during the dry season, when food abundance was lowest, food was available mainly in open vegetation types, and when drinking water was restricted to a few sources.

2.6.2 Anthropogenic disturbances

Many studies have analyzed primate distributions with respect to different levels of human disturbance (Oates, 1996; Tutin & Fernandez, 1984; Hall *et al.*, 1998; Pusey *et. al*., 2008) and the impact of human activities on specifically, chimpanzee populations has been evaluated over large areas (Junker *et al.*, 2012; Stokes *et al.*, 2010). According to Chapman *et al.* (2006), Morgan *et al.* (2006) and Oates (2006), in several places in Africa, chimpanzees are hunted for food and where human hunting pressures are high it is possible that chimpanzees have decreased in density. Hunting of adult chimpanzees for bushmeat therefore has a disproportionate impact on populations because of the species' slow reproductive rate. The live animal trade, including capture of infants for the pet trade and entertainment industry, and the international biomedical trade, are additional pressures. Beside, human population increases and hunting, commercial logging, the conversion of forest habitat to agricultural land for cash crops and subsistence farming, mineral prospecting, mining, and forest fires, are yet another set of problems to chimpanzee populations. Even if humans do not kill chimpanzees directly, their effect through indirect destruction of vegetation is great. Marchesi *et al.*, (1995) and Oates (2006), highlighted the fact that chimpanzees in Africa face many problems such as habitat decline because of forest resource utilizations, and forest clearing for timber and agriculture. Habitat fragmentation has isolated majority of chimpanzee populations leading to reduced survival (Goodall, 1986). Progressive habitat loss often leaves small and unconnected patches in which chimpanzee populations are isolated and at risk from chance demographic factors.

2.7 Prioritizing conservation areas for wildlife including chimpanzees

Across the natural forests of West Africa, many underlying factors are contributing to wild chimpanzee vulnerability. It is largely as a result of the combined effects of habitat destruction, hunting and capture for the pet trade that populations have declined (Kormos *et al.*, 2003). Chimpanzees are particularly vulnerable to hunting and other human induced pressures, given their generally low population densities and slow rate of reproduction. The nature and magnitude of threats to wildlife change over time (Mwambo, 2010) and require constant re-evaluation by conservationists. Even where threats seem to have remained unchanged, external anthropogenic factors from diverse sources and forms have in many cases accelerated and aggravated the threats to biodiversity and nature as a whole.

According to Rao and Bynum (2007) conservation strategies designed and implemented by practitioners to protect species, landscapes, and ecosystems are largely in response to threats to biodiversity. In general, the role of threat assessment for site conservation planning is to identify and rank threats to conservation targets in order to select appropriate conservation strategies. A number of different systematic approaches to selecting sites that account for representation have been developed (e.g., Margules and Pressey 2000, Groves *et al.*, 2002). Some researchers have suggested that the effectiveness of conservation planning could be improved by prioritizing areas based both on representation and the vulnerability of sites to potential threats (Margules and Pressey 2000, Pressey and Taffs 2001). Including measures of vulnerability in the selection process allows planners to practice a form of triage (Myers, 1979).

This study therefore aims to apply a similar technique to prioritise sites in the Bia-Goaso forest block in south-western Ghana. Despite the paramount importance of this forest block, over the years, the combined effect of (illegal) logging and encroachment by farmers in the forest reserve, together with high levels of hunting, has left the chimpanzee and other wildlife populations in many of the individual forest management units, rare, patchy and in some cases extirpated. For this reason there is an urgent need to carry out an assessment of the conservation threats and opportunities in the landscape to determine the areas with the highest conservation value given the fact that investment in habitat protection and restoration remains insufficient to meet the conservation challenge. Prioritization of sites within the network of 14 reserves is therefore of major concern for management in the light of issues related to cost benefit, the need for simple protection and possibilities of further degradation of habitats.

A key objective of this study is to contribute to the effective long-term conservation of chimpanzees in the Bia-Goaso forest area through the prioritization of forest habitat areas where conservation efforts could be focused. Such sites could provide the best chance of survival of the species when conservation activities and resources are targeted to address the anthropogenic disturbances that the sites are subjected to.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of Study Area

The study area comprises an extensive network of three Shelter Belts (Bia, Goa and Abonyere SBs), nine Forest Reserves (Asukese, Bia Tano, Mpameso, Bonkoni, Ayum, Subim, Bonsam Bepo, Krokosua Hills and Bia North FRs) and two wildlife reserves [Bia Resource Reserve (Bia RR) and Bia National Park (Bia NP)], together referred to as Bia Conservation Area, south of Sunyani and to the west of the Tano River towards the Ghana-Cote d'Ivoire border (Figure 1).

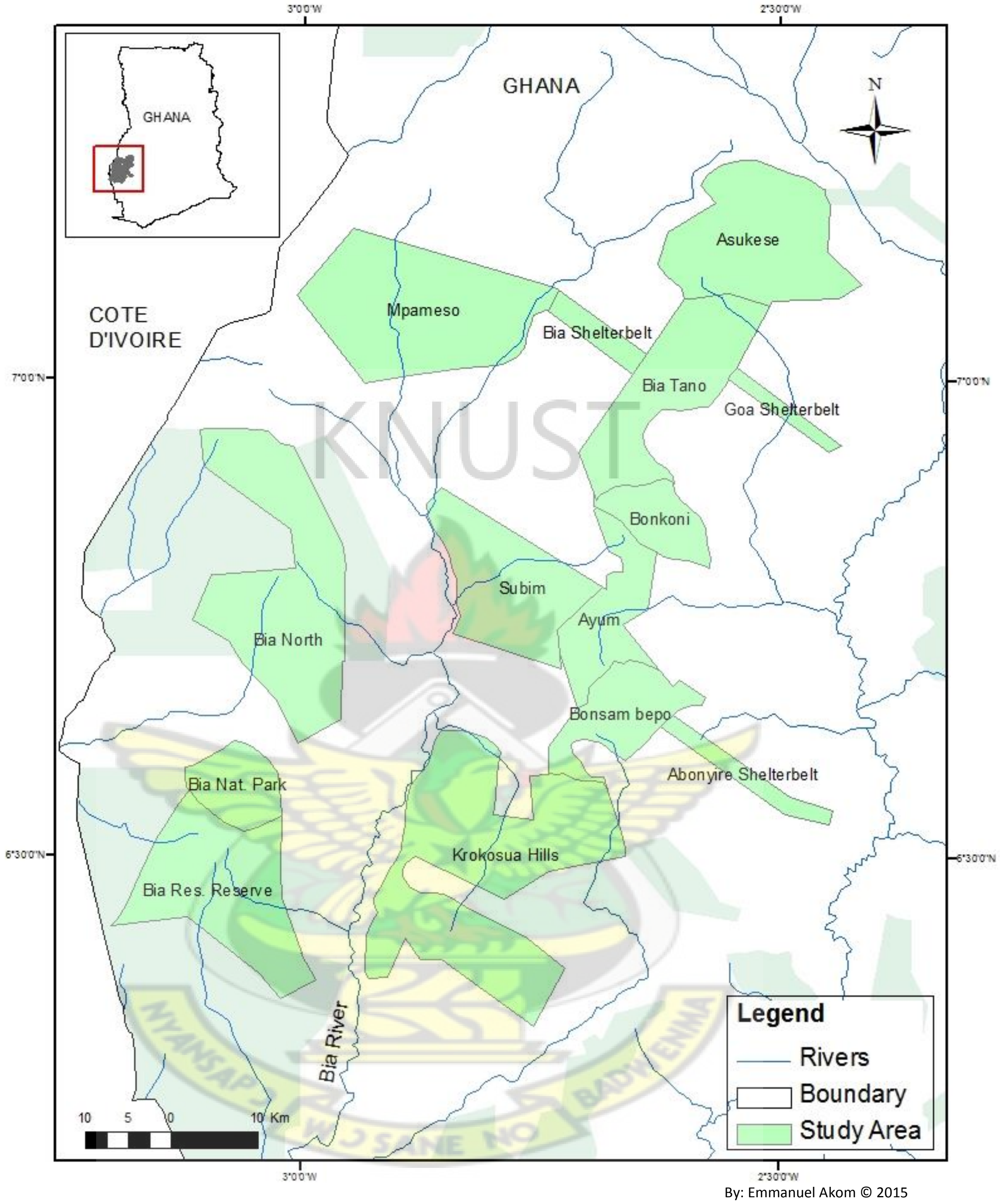


Figure 1: The study area showing constituent reserves. The inset map shows the location of the study area in relation to Ghana.

The study area is about 5000 sq. km and the reserves belong to the moist semi-deciduous, north-west vegetation zone (de Leede, 1994). However, more south-west wards, the vegetation of the Bia RR, changes into the moist evergreen vegetation type

(Hall and Swaine, 1981). Mean monthly rainfall for the study area indicates a bimodal distribution occurring in March-July and September-November, peaking in June and October respectively (Ghana Wildlife Division, 1996).

3.2 Pilot Survey

A three-week preliminary survey was undertaken within the study area. It was conducted by interviewing Staff of the Forest Services Division (FSD), and Wildlife Division (WD) (especially the Goaso Bio-Monitoring Unit), employees of timber companies and local inhabitants surrounding the forests to gather preliminary information on the presence and absence of chimpanzees and other primates and establish field effort priorities. This was combined with reconnaissance transect walks into the forests. Distance was calculated with a *Global Positioning System* (GPS). Notes on illegal activities were also recorded.

3.3 Stratification

Based on the preliminary survey, and in order to reduce the sampling error because of the variability of chimpanzee populations across the range, the study area was stratified into two zones namely; medium and low primate density strata (Figure 2). The medium density stratum comprised the Bia Conservation Area and the Krokosua Hills Forest Reserve, whilst the low-density stratum covered the rest of the forest reserves in the study area (mainly the Goaso Reserves) where no chimpanzee activities were initially found.

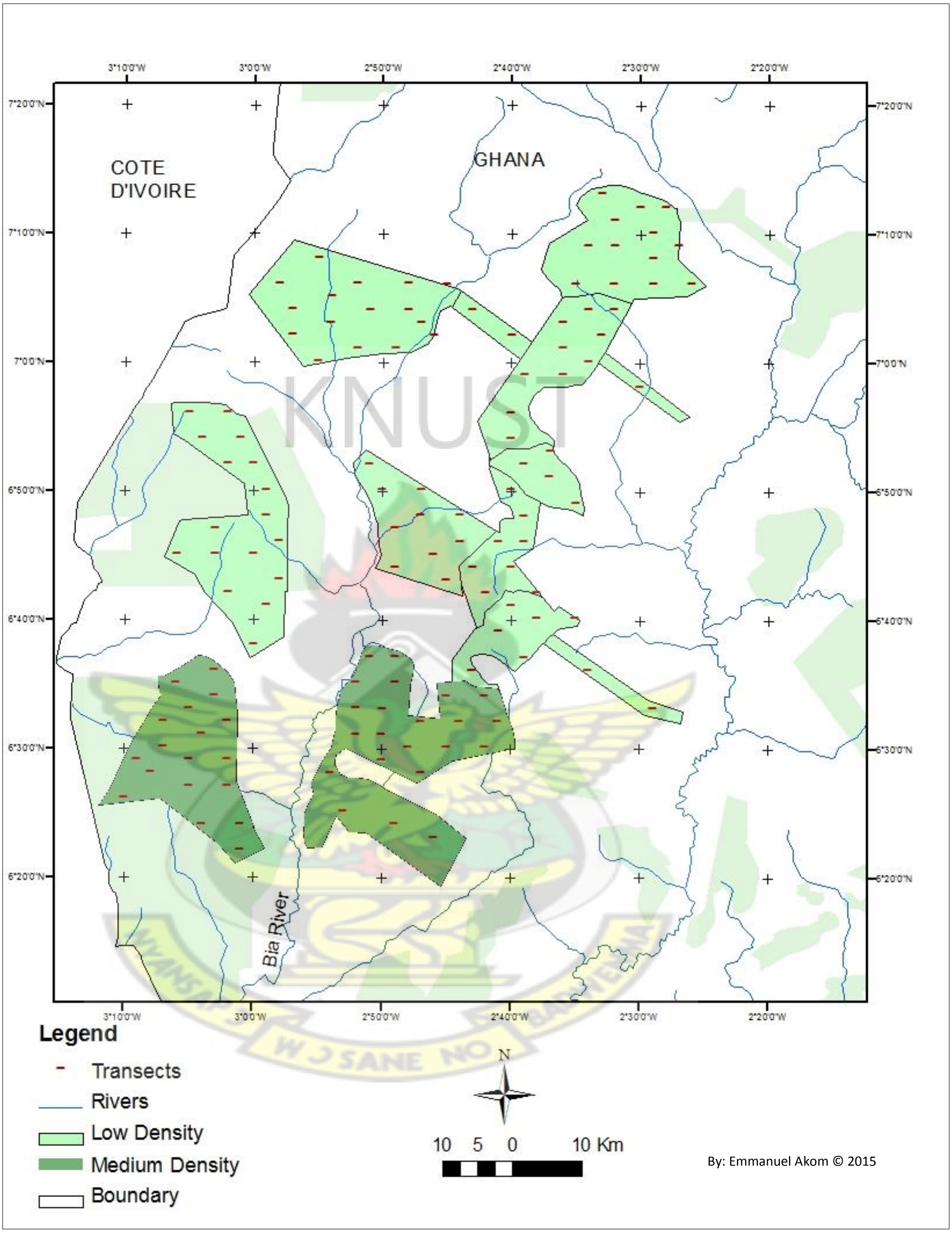


Figure 2: Study area showing distribution of transects in the medium and low density strata

3.4 Line Transects and Reconnaissance (Recce) transects

As a rule, direct counts of animals such as primates require the use of well-maintained permanent trails in order to move stealthily and count; whilst counting signs such as nests require line transects where considerable amount of noise could be made in cutting the transects (White and Edwards, 2000). We adopted both methods, undertaking repeat counts trails easily accessible from base camps and between line transects, in addition to a series of line transects in more remote areas.

3.4.1 Line transects

3.4.1.1 Distribution of line transects

Based on an average sign density of 2.35 primate cues per km calculated in our preliminary survey, an optimum sample size (OSS) of 129 transects (each 1 km in length) was estimated for the study area (Hedges and Lawson, 2006). This gave 40 transects in the medium-density and 89 transects in the low density strata (Figure 2).

Using the ArcGIS software package, a grid consisting of cells, each one-minute of latitude or longitude was placed at random over a map of the study area. The intersections of the lines then formed the midpoint for each transect. The first transect of each stratum was randomly placed while subsequent ones were distributed systematically in the various strata based on the initial primate encounters on the recce survey (Norton-Griffiths, 1978; Buckland *et al*., 2001). Transect orientation was perpendicular to the main drainage lines of the area (i.e the Bia River and its tributaries).

The design conformed to the *systematic segmented line transect* design. Transect orientation was perpendicular to the main drainage lines of the area. Since the main River Bia flows from north to south, the transect run from east to west.

3.4.1.2 Transect methods

Nest count surveys were conducted in the wet (September - November, 2009) and dry seasons (December 2009 – February, 2010), using the line transect method (Burnham *et al.*, 1980; Buckland *et al.*, 1993, 2001).

Three survey teams of three persons each and led by a compass man (team leader) were maintained in each survey to ensure consistency in data collection procedures. Straight transects were maintained throughout both surveys.

We navigated with a compass and a GPS to reach the starting point of each transect. Once on the transect, only those nests seen from the transect centre-line were recorded. Team members marched in line along transects. They included a compass man who also sighted on a stake held by a line cutter. Once the stake was correctly aligned, all marched in a straight line towards the line cutter, scrutinizing the undergrowth on either side for primate activities including chimpanzee nests.

3.4.2 Reconnaissance (Recce) transects

The aim of recce transects is to increase ground coverage and assess more data between line transects. The basic principle was to take paths of least resistance to move between line transects and from base camps, by intentionally walking through forest types and along animal or human trails. Data collection is similar to that for line transects, but this method allowed teams to cover ground more rapidly and stealthily; teams are not restricted to movement in a straight line, and more direct observations are taken.

The total distance walked between line transects for a particular field day represented one recce transect. Such an index was also vital to describe the general density and distribution of primate activity in the study area.

3.5 Factors Affecting Chimpanzee Abundance and Distribution

The following notes were made each time a primate cue including chimpanzee nest was recorded: the distance along the transect, measured by the GPS and the perpendicular distance from the cue to the transect centre-line, measured with a tape-measure. The stages of nest decay were classified based on White and Edwards (2000). Other notes were made along the transect, particularly of ecological and human factors that might explain the distribution of primates: dominant foot tree species, altitude, water sources (ponds, rivers, streams), signs of poaching activity (wire snares, empty cartridge cases, cane and wood cuttings), etc. Using GIS, we measured the distance between each transect and the nearest WD camp and park boundary line. Table 1 shows the variables recorded for each transect walked in the wet and dry seasons.

Table 1: List of the variables recorded for each transect for both wet and dry seasons

Variable	Description of variable
X1	Date that the transect was walked
X2	Number and types of primate cues seen on the transect
X3	Number of signs of poaching activities seen on the transect
X4	Number of water sources seen on the transect
X5	Distance to the nearest WD/FD guard post (km)
X6	Distance to the nearest forest edge (km)
X7	Dominant tree species in area
X8	Altitude

3.6 Identification and Establishment of Chimpanzee Conservation Sites

The identification of prospective forest reserves to establish a network of permanent chimpanzee (primate) conservation sites in Ghana was determined using data on chimpanzee occurrence data (from transect surveys and by which means diversity index for the various reserves was calculated). This data was used in combination with information on poaching and non-hunting illegal activities (which were used as proxies of human disturbance), and conservation management status (which was used as an index of management effectiveness). An evaluation scheme to judge conservation value was done after combining the various criteria via a numerical index (Wright, 1977). This numerical index was used to rank the relative importance of different forest reserves within the study area for the conservation of forest primates. Satellite images of the study area were also examined and this served to provide the locations and physical conditions of the vegetation between the reserves and human influence. Data obtained include: distance and width of potential corridors, human influence (human pressure), land use practices, presence of rivers and streams, as well as remaining forest cover. Secondary data on community perception and local support for wildlife corridors exist for the area (ARG, 2009) and this was also consulted.

3.7 Data Analysis

3.7.1 Density of chimpanzees and other primates

Nest counts relate chimpanzee numbers to a count of nests detected along transects, corrected for variables such as the rate of construction of nests and rate of nest decay (White and Edwards, 2000). A software package (DISTANCE 5.0) was used for the analysis of density estimates. Conversion of nest densities to chimpanzee densities and calculation of standard errors was done using the delta method (Seber, 1982; Buckland *et al*., 2001).

An indirect technique such as an index count, which produces relative numbers based on other sign encounter rates, was used to estimate densities of the various primate species.

Primate sign density = [number of signs / total distance walked]--------------(1)

Index counts relate animal numbers to an index of animal signs detected along line transects (Buckland *et al*., 2001; Barnes *et al*., 1997).

A Z-Test was used to test whether density estimates from different strata and seasons are significantly different (White and Edwards, 2000; Buckland *et al.*, 1993):

$Z = D_2 - D_1 / \sqrt{[se(D_2)^2 + se(D_1)^2}$---eqn 1

where Dn = density estimate of population n or the same population at time n; and se(Dn) = standard error of this estimate.

Differences in primate frequency and distribution between the different strata and seasons were tested with Wilcoxon two-sample test in SAS (1990).

3.7.2 Resolution of density estimation

The resolution of a density estimate is defined here as the percentage change that is detectable between two independent surveys. The resolution depends on the standard errors of the two density estimates. If we make an assumption that the standard error of a density estimate is equal to the standard error of a second density estimate, which is changed by a factor R, i.e. $D_2=D_1+D_1*R$, where D_1 = density estimate and R = proportional change or resolution ($100R$=% change), then we can derive a simple equation from the Z-Test equation above to calculate the resolution (R). Substituting $D_2=D_1+D_1*R$ in the equation above (Plumptre, 2000):

$Z = D_1 - D_1 + D_1 * R / \sqrt{[\text{se}(D_2)^2 + \text{se}(D_1)^2]}$--------------------------------------- eqn 2

Therefore, for P=0.05, 2-tailed test:

$R = Z * \sqrt{[\text{se}(D_2)^2 + \text{se}(D_1)^2]} / D_1$ ---eqn 3

This test provides a measure of the percentage change in a population.

3.7.3 Distribution of Chimpanzees and other Primates

All areas utilized by chimpanzees were noted and their coordinates marked using GPS receivers. The areas were later geo-referenced into a Geographic Information System (GIS) (ArcGIS version 9.3; ESRI). A Point-pattern analysis was done to show the spatial distribution of chimpanzees, and this also provided the basis for the distribution maps which were prepared.

A logistic regression analysis was used to assess the factors that influence chimpanzee and other primate distribution in the study area. In this case the statistical package StatView 5.0.1 was used. The goal was to build mathematical models that described the distribution of primates.

As the response variable, the number of nests recorded on transects are typical count data: they are not normally distributed and they consist of integers, positive numbers and sometimes there were many zeroes. Therefore, variables were statistically normalised before analyzing.

3.7.4 Ranking of Priority Reserves

Using an objective ranking system of all the data that was gathered including; animal abundance and index of hunting pressure (from field surveys), human density and settlements (from the 2000 National Population Census Report), degree of illegal logging and forest degradation, length of road, rivers and forest reserve boundary (from satellite imagery), were scored and averaged for each site to get a cumulative index.

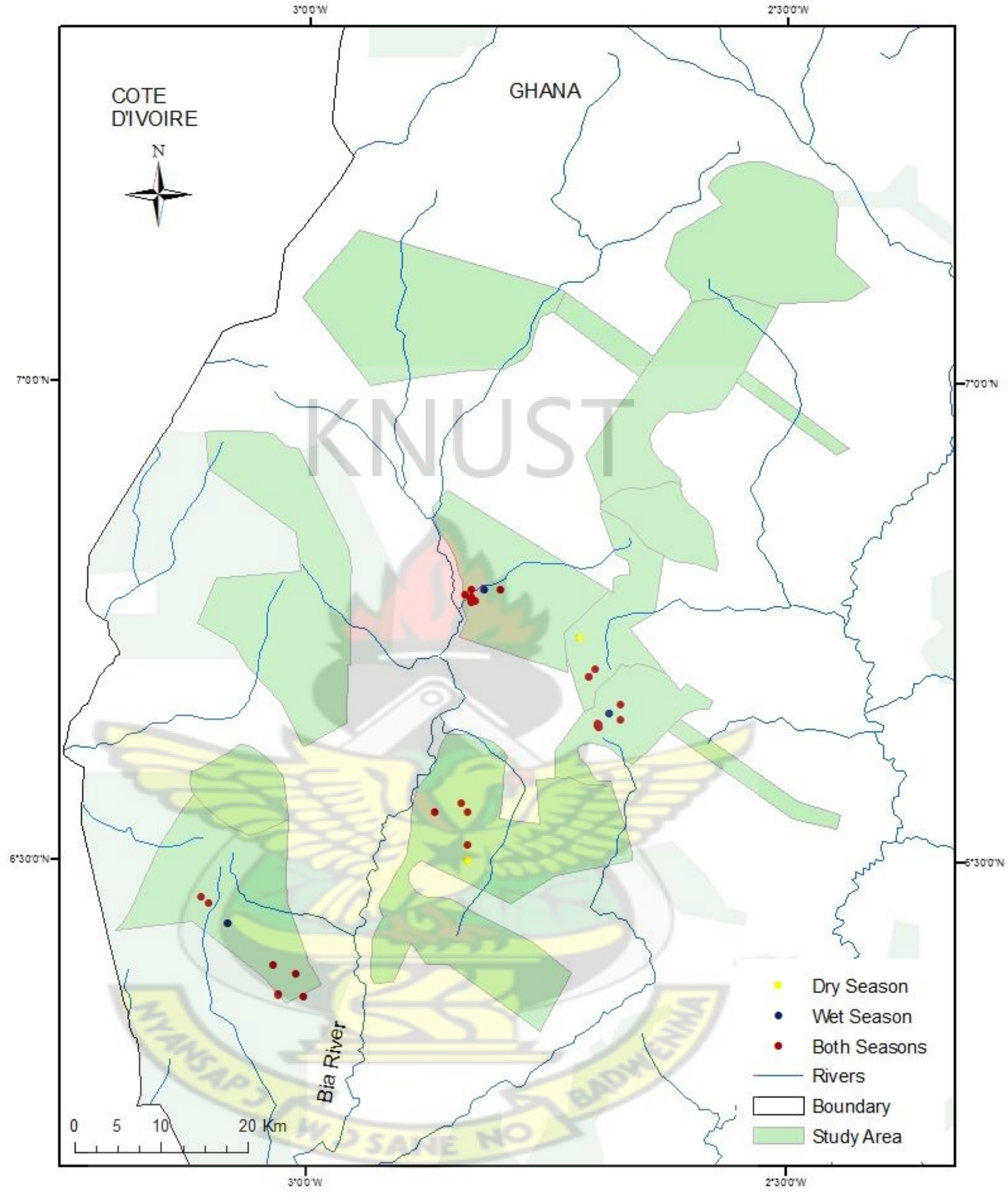
CHAPTER FOUR

4.0 RESULTS

4.1 Primate Distribution and Abundance

4.1.1 Chimpanzee occurrence, range and distribution

Chimpanzees were very restricted in their extent and clumped with regards to their distribution. Signs of their presence throughout the study area were also rare. For both survey periods, their activities were recorded in only five southern reserves, namely Bia RR, Krokosua Hills FR, Bonsam Bepo FR, Ayum FR and Subim FR (Figure 3). They were never directly observed throughout the entire survey period, although right after the survey period the survey team came across a party of three (a male and two females) in the Camp 5 area of the Bia RR. All results presented in this chapter are therefore based on indirect signs of their presence (i.e. nests and feeding signs, knuckle prints and tracks). Relatively high concentrations of their activities were recorded in the Bia RR as well as the ridge top in the Agyemandiem Area of the Krokosua Hills GSBA, compared to the remaining reserves. Based on the spread of activities dating back to the wet season, a more clumped chimpanzee distribution most likely occurs in the dry season compared to the wet season, especially in Bia CA. From the spread of these activities also it is believed that the small resident population of chimpanzees found in the Bia CA is made up of at most 3 groups residing in southern Bia area between Anum Camp (Camp 4) and Manso Camp (Camp 7) and in the locality of the Bongo Sub-Range Camp and Camp 8. Although there were no direct encounters, the survey team on two occasions heard what might have been distant chimpanzee calls around the Anum Camp (Camp 4) area. On two occasions, we came across very recent feeding remains of cocoa pods that chimpanzees had scattered along the boundary after raiding some cocoa farms bordering the southern-western portion of the reserve, close to Camp 7 (See Plates in Appendix). Interviews with park staff and local communities in the area confirmed sporadic cocoa raiding by a small party of chimpanzees especially during periods when the pods are ripe (*Personal comm*. Phillip Mensah – Ranger, Bia NP). These raiding forays often take place during periods in the late afternoons when the farms are fairly quiet. Fresh tracks and knuckle prints of chimpanzees and feeding remains on *Marantochloa leucantha* (Sibrie) stems were also observed along some riverbeds in the Camp 5 area, within the swampland dominated by *Raphia spp.*, *Marantochloa leucantha*, *Thaumatococcus daniellie* (Anwonomoo), and *Thaumatococcus* spp. (Aworampan). Freshly gathered and cracked seed kernels of *Klainedoxa gabonensis* (Kroma) (a large fruit with fibrous flesh) were observed along the trail leading to the Camp 8 junction, from the Bongo Sub-Range Camp and around the Camp 4 area. Most chimpanzee nests were also recorded in these areas (See Plates in Appendix 4).



By: Emmanuel Akom © 2015

Figure 3: Species distribution map of chimpanzee activities in wet and dry seasons. The colours represent point-occurrences within the study area

In the Goaso block of forest reserves, chimpanzee activity was encountered in the Krokosua Hills FR and adjacent areas including the Bonsam Bepo, Ayum and Subim

FRs. Interviews with local hunters indicate their presence in the Bia North Forest Reserve although field surveys failed to establish these claims. For Krokosua, all chimpanzee signs including nests were recorded in the GSBA portion of the reserve in very high altitudes and steep terrain along the ridge tops. At Subim FR, most of the chimpanzee activities were found in the swampland around the Subim River. Some hunters and local people in the Sebebia community reported often hearing chimpanzee vocalizations in the forest reserve. This claim proved to be positive when we came across many nests, knuckle prints and tracks on transects within that locality of the forest. Most chimpanzee activities were however, common along the base of the Bonsam-bepo peak. In this area, there was a stream and during the dry season the nearly dried-up river-bed with small pools of water seemed to serve as an important watering ground for the chimpanzees and many other animals especially during the dry season, considering the frequent activities of their presence in the area.

4.1.2 Wet season abundance

All chimpanzee signs were recorded in the medium density stratum. A total of 39 chimpanzee signs were encountered with the most frequently encountered signs being that of feeding. No direct sightings or vocalizations of chimpanzees were made during this period.

Table 2: Summary of chimpanzee signs distribution from transect surveys and nest searches during the wet season in the Bia-Goaso forest area

Reserves	Mode (number) of confirmation					Encounter rate	
	Sight	Call	Feed	Nest	Total	(km^{-1})	(hr^{-1})
Bia RR	-	-	7	4	11	0.20	0.13
Krokosua Hills FR	-	-	4	6	10	0.28	0.13
Bonsam Bepo FR	-	-	2	8	10	0.22	0.19
Ayum FR	-	-	-	2	2	0.04	0.04
Subim FR	-	-	3	3	6	0.13	0.11

4.1.2.1 Density of chimpanzee nests

Twenty-three chimpanzee nests were recorded on 228 km of transects (line and recce transects) in the five reserves (i.e. chimpanzee range; 1,175 sq km): four at Bia CA, six at Krokosua Hills FR, eight at Bonsam Bepo FR, two at Ayum FR and three at Subim FR (encounter rate = 0.10 nests per km). The number of nests ranged from zero to two nests per transect.

The perpendicular distances are shown in Figure 4. This shows a typical visibility curve for sample counts in the forest. Few chimpanzee nest was seen beyond 4.0 metres from the centre-line.

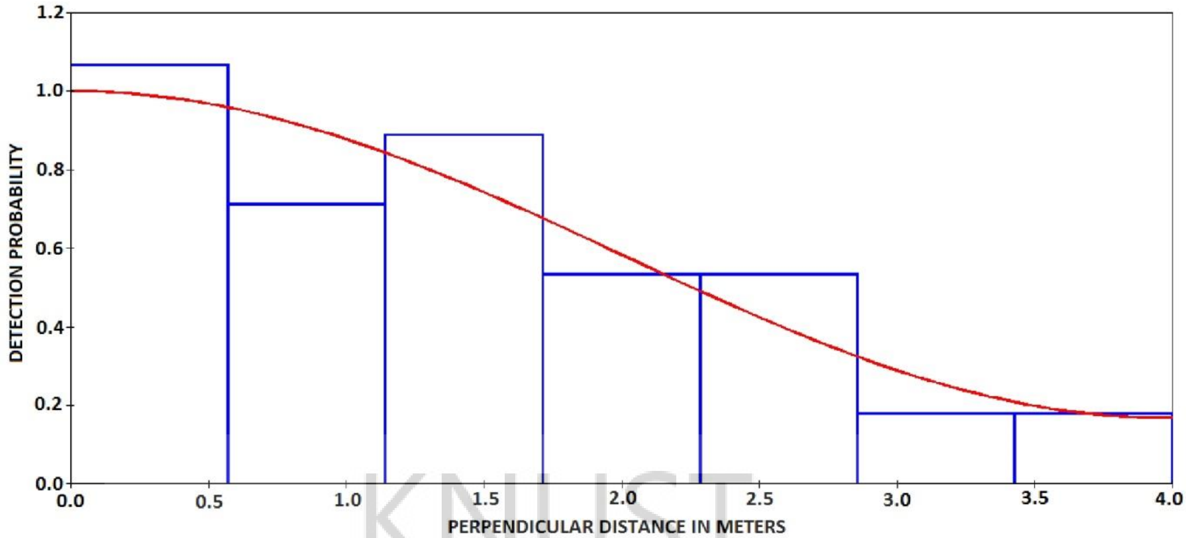


Figure 4: Histogram produced by DISTANCE showing the perpendicular distances and the fitted visibility curve (uniform + cosine)

Using DISTANCE 5.0, we applied the six models recommended by Buckland *et al.* (2001). The results are shown in Table 3. The most useful criterion is Akaike‘s Information Criterion (AIC): the smaller this value the better the fit of the model. Table 5 shows that the uniform + cosine gave the best fit. Hence, all further analyses were conducted with the uniform + cosine model. Usually truncation improves the fit of the model (Buckland *et al*., 2001), but here it made little difference and rather increased the coefficient of variation (CV), hence, we decided not to truncate in further analyses. The uniform + cosine model without truncation gave an estimate of 21.70 nests per sq km (confidence interval from 13.44 to 35.03) and a CV = 24.46%.

Table 3: The parameters estimated by each of the six models fitted to the line transect data

Parameter	Uniform + cosine	Uniform + simple polynomial	Half-Normal + cosine	Half-normal + hermite polynomial	Hazard rate + cosine	Hazard rate + simple polynomial
f(0)	0.4283	0.3438	0.4143	0.4143	0.3675	0.3675
Density (km^{-2})	21.70	17.419	20.989	20.989	18.62	18.62
CV (%)	24.46	22.35	26.98	26.98	27.13	27.13
Upper CL	35.03	27.01	35.58	35.58	31.66	31.66
Lower CL	13.44	11.23	12.38	12.38	10.95	10.95
X^2	0.7949	1.6117	0.8128	0.8128	0.9036	0.9036
P(X^2)	0.9774	0.8998	0.9762	0.9762	0.9240	0.9240
AIC	59.70	61.30	60.14	60.14	61.85	61.85

F(0) is the value of estimated probability density function (pdf) at zero for line transects. Density is the number of nest groups per sq km; Percent (%) CV measures the precision of the estimate and the upper and lower confidence limits (CL) describe the precision of the estimate. Chi-square (X^2) compares the fit of the visibility curve to the histogram of the perpendicular distance data and P(X^2) is the probability of X^2. AIC is the Akaike Information Criterion (Buckland *et al*, 2001).

4.1.2.2 Estimation of chimpanzee abundance

Having estimated the density of nests on the area (21.70 nest per sq km), if one takes an estimate of the mean survival time of nests and rate of construction from elsewhere then one can proceed to calculate the number of chimpanzees (White and Edwards, 2000). The mean duration of nests was obtained from White and Edwards (2000) i. e. 106 days, and the rate of construction of nests from Plumptre and Reynolds (1997), i.e. 0.88 nests per individual per day.

The three variables were combined in the equation below (White and Edwards, 2000):

$$C = \frac{Y}{s \times D}$$

where C was the chimpanzee density, Y was the estimate of nest density per sq km, s was the estimated mean duration of nests and D was the rate of construction of nests.

This calculation was conducted with a spreadsheet that used the delta method (Seber, 1982; Buckland *et al*., 2001) to calculate the standard error of *E*. This gave an estimate of 0.23 chimpanzees per sq km (SE = 0.26, CV = 111.1%). Taking the total chimpanzee range into consideration, an estimate of 273±595 chimpanzees was obtained for the wet season (Table 4).

Table 4: Summary of Chimpanzee estimates in the wet season

Chimpanzee	Low density stratum	Medium density stratum	Total chimpanzee range
Number of nests	13	10	23
Nest density (km^{-2})	14.61	14.21	21.70
CV (%)	28.97	29.57	24.46
Chimpanzee density (km^{-2})	0.16	0.15	0.23
Population estimate	71	110	273
Confidence interval	± 156	± 242	± 595
CV (%)	112.22	112.39	111.15
Standard Error	79.73	123.61	303.81
Detectable Difference between Strata			
Resolution			0.549
Z test			0.265
Wilcoxon sign rank test			-3.113
P-value			P<0.05

There was an average of 55 percent detectable change in chimpanzee density between the low and medium strata. Similarly, there was a significant difference in the distribution and density of chimpanzees between the two strata.

4.1.3 Dry season abundance

A total of 33 chimpanzee signs were recorded during the dry season. As observed during the wet season, the majority of these signs were that of feeding signs. Table 5 gives the distribution of these signs for the various reserves in the study area.

Table 5: Summary of chimpanzee signs distribution from transect surveys and nest searches during the dry season in the Bia-Goaso forest area

Reserve	Mode (number) of confirmation					Encounter rate	
	Sight	Call	Feed	Nest	Total	(km^{-1})	(hr^{-1})
Bia RR	-	-	7	3	10	0.18	0.12
Krokosua Hills FR	-	-	5	5	10	0.28	0.13
Bonsam Bepo FR	-	-	2	5	7	0.16	0.13
Ayum FR	-	-	-	3	3	0.02	0.02
Subim FR	-	-	3	3	3	0.06	0.06

4.1.3.1 Density of chimpanzee nests

Nineteen chimpanzee nests were recorded on 228 km of transects (line and recce transects) in five reserves (i.e. chimpanzee range; 1,175 sq km): three at Bia CA, five at Krokosua Hills FR, five at Bonsam Bepo FR, three at Ayum FR and three at Subim FR (encounter rate = 0.08 nests per km). The number of nests ranged from zero to two nests per transect. The perpendicular distances are shown in Figure 5. This shows a typical visibility curve or sample counts in the forest. Few chimpanzee nests was seen beyond 4.0 metres from the center-line.

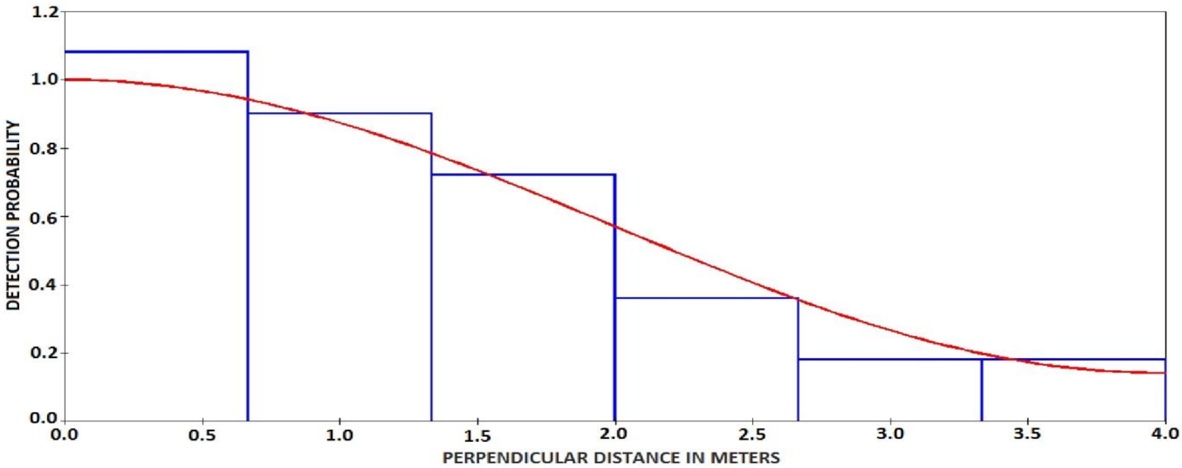


Figure 5: Histogram produced by DISTANCE showing the perpendicular distances and the fitted visibility curve (uniform + cosine)

Using DISTANCE 5.0, we applied the six models recommended by Buckland *et al.* (2001). The results are shown in Table 6. The most useful criterion is Akaike‘s Information Criterion (AIC): the smaller this value the better the fit of the model. Table 6 shows that the uniform + cosine gave the best fit. The uniform + cosine model without truncation gave an estimate of 18.34 nests per sq km (confidence interval from 11.10 to 30.29) and a CV = 25.67%.

Table 6: The parameters estimated by each of the six models fitted to the line transect data

Parameter	Uniform + cosine	Uniform + simple polynomial	Half-normal + cosine	Half-normal + hermite polynomial	Hazard rate + cosine	Hazard rate + simple polynomial
f(0)	0.4381	0.4462	0.4519	0.4519	0.4677	0.4677
Density (km^{-2})	18.335	18.675	18.914	18.914	19.574	19.574
CV (%)	25.67	29.55	27.86	27.86	36.07	36.07
Upper CL	30.29	33.27	32.59	32.59	39.63	39.63
Lower CL	11.10	10.48	10.98	10.98	9.67	9.67
X^2	0.3781	0.3122	0.3837	0.3837	0.2035	0.2035
P(X^2)	0.9842	0.9577	0.9838	0.9838	0.9770	0.9770
AIC	47.61	49.18	48.15	48.15	49.358	49.358

4.1.3.2 Estimation of chimpanzee numbers

Having estimated the density of nests on the area (18.34 nest per sq km), we applied the mean survival time of nests as 106 days (White and Edwards, 2000) and the rate of construction of nests as 0.88 nests per individual per day (Plumptre and Reynolds, 1996) and combined the three variables in the equation below (White and Edwards, 2000):

$$C = \frac{Y}{s \times D}$$

where C was the chimpanzee density, Y was the estimate of nest density per sq km, s was the estimated mean duration of nests and D was the rate of construction of nests.

This gave an estimate of 0.20 chimpanzees per sq km (SE = 0.22, CV = 111.4%), with the total chimpanzee estimate for the entire range being 231±504 chimpanzees during the dry season (Table 7).

Table 7: Summary of Chimpanzee estimates in the dry season

Chimpanzee	Low density stratum	Medium density stratum	Total chimpanzee range
Number of nests	11	8	19
Nest density (km^{-2})	20.732	11.364	18.34
CV (%)	39.19	34.24	25.67
Chimpanzee density (km^{-2})	0.22	0.12	0.20
Population estimate	101	88	231
Confidence interval	± 225	± 196	± 504
CV (%)	114.00	113.71	111.43
Standard Error	114.77	100.01	257.35
Detectable Difference between Strata			
Resolution			0.403
Z test			0.204
Wilcoxon sign rank test			-1.036
P-value			P<0.05

There was an average of about 40 percent detectable change in chimpanzee density between the low and medium density strata in the dry season. Similarly, there were significant differences in the distribution or density of chimpanzees between the two strata.

The wet and dry season chimpanzee estimates were merged (Norton-Griffiths, 1978) to produce an estimate of 249±385 (SE = 196.68, CV = 79.02%) chimpanzees for the study area.

4.2.0 Diversity of other diurnal primates

Of the eight species of anthropoid primates known to occur in the forests of Ghana, the presence of four were confirmed beside the chimpanzee, during surveys in the Bia-Goaso forest area. These were *Cercopithecus campbelli lowei* (Lowe's monkey), *Cercopithecus petaurista petaurista* (Lesser spot-nosed monkey), *Colobus vellerosus* (Geoffroy's black and white colobus) and *Procolobus verus* (Olive colobus). The presence of two nocturnal prosimians (*Perodicticus potto* and *Galagoides demidovii*) were also observed however, they were not included in the analysis as the focus was on diurnal primates. During the entire study period, no direct observations, vocalisations or signs were recorded for the Miss waldron's red colobus (*Procolobus badius waldroni*), a species now considered extinct by Oates *et al*. (2000), the White-naped mangabey (*Cercocebus atys lunulatus*), and the Diana Roloway monkey (*Cercopithecus diana roloway*), although interviews with Park staff and local communities indicate the possible presence of the White-naped mangabey, and the Diana Roloway monkey in the Bia CA and Krokosua Hills FR. Given the unhabituated and cryptic nature of most monkeys in the reserves, probably due to the hunting pressure they have been subjected to over the years, it was difficult to frequently observe the primates directly and most encounters were that of auditory cues.

Bia RR, Ayum and Subim FRs were found to be richest and most diverse in terms of primate species when various richness and diversity indices were applied to the data (Table 3). These indices were comparatively higher in the reserves that constitute the medium density stratum than in the low-density stratum.

Table 8: Primate species richness and diversity indices generated by EstimateSWin800 for the various reserves

RESERVES / STRATUM	RICHNESS INDEX BOOTSTRAP MEAN	DIVERSITY INDEX SHANNON MEAN[1]
MEDIUM DENSITY STRATUM		
BIA RR	5	1.51
KROKOSUA HILLS	5	1.35
BONSAM BEPO	5	1.39
AYUM	5	1.48
SUBIM	5	1.43
LOW DENSITY STRATUM		
BIA NORTH	4	1.15
MPAMESO	4	1.17
BONKONI	4	1.22
BIA TANO	3	0.97
BIA NP	2	0.31
ASUKESE	1	0.00
BIA SB	0	0.00
GOA SB	0	0.00
ABONYERE SB	0	0.00

The generally higher species diversity in the medium density stratum in comparison to low-density stratum may result from the presence of a disproportionately higher number of uncommon primates like the Black & white colobus.

Asymptotes of species accumulation curves for the wet season and dry seasons were exceeded (Figure 6). This suggests that most of the primate species had been confirmed in the study area.

[1] The Shannon index is a more information statistic index, which means it assumes all species are represented in a sample and that they are randomly sampled.

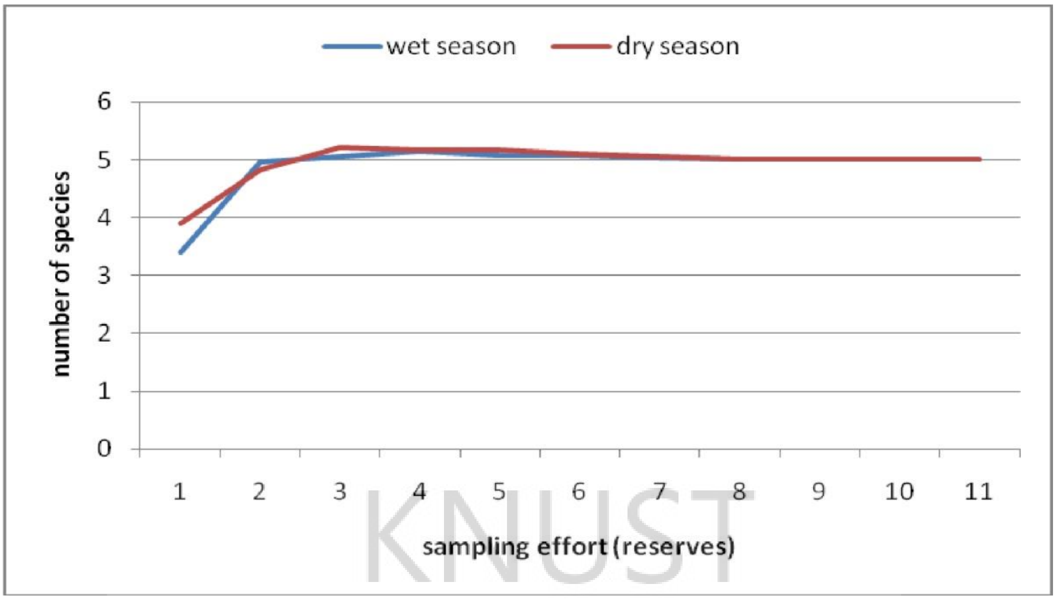


Figure 6: Primate species (both chimpanzees and other diurnal primates) accumulation curve generated by EstimateSWin800 for the study area

The species accumulation curves were not significantly different (Wilcoxon Signed Rank Test: Z = -1.838, P>0.05) for the two surveys.

4.2.1 Distribution and abundance of other diurnal primates

4.2.1.1 Lowe's monkey

Lowe's monkeys were recorded at all the sites surveyed and they occurred in comparatively much higher densities than the other monkeys. This monkey formed about 65% percent of the total observed primate encounters. We visually confirmed the presence of the Lowe's monkey on nine occasions.

Their current distribution in the reserves which make up the medium-density stratum is not quite different from what occurs in the low-density stratum where activities are more or less spread out. The monkey's range in the wet season expanded compared to the dry season.

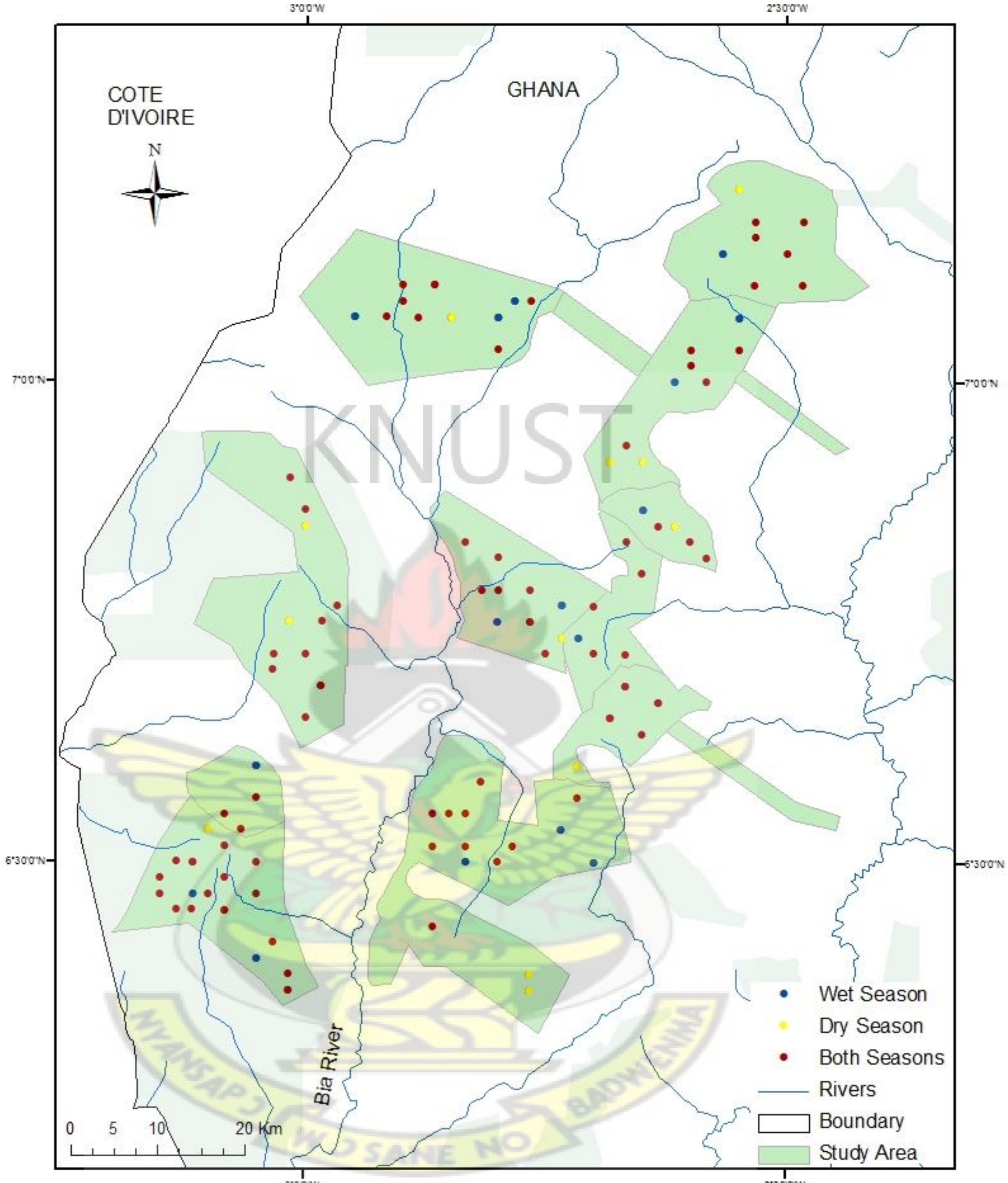


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Figure 7: Study area showing distribution of Lowe's monkey activities in the wet and dry seasons

4.2.1.2 Spot-nosed monkey

Next to the Lowe's monkey the spot-nosed monkeys was the most frequently encountered species and their distribution was just as widespread (Figure 7). There were fewer encounters with spot-nosed monkeys in the reserves in the northern part of the study area compared to the ones south. The current distribution of spot-nosed monkeys in the dry season is also quite different from what was observed previously in the wet season. Spot-nosed monkeys seemed much more dispersed in the dry season than in the wet season.

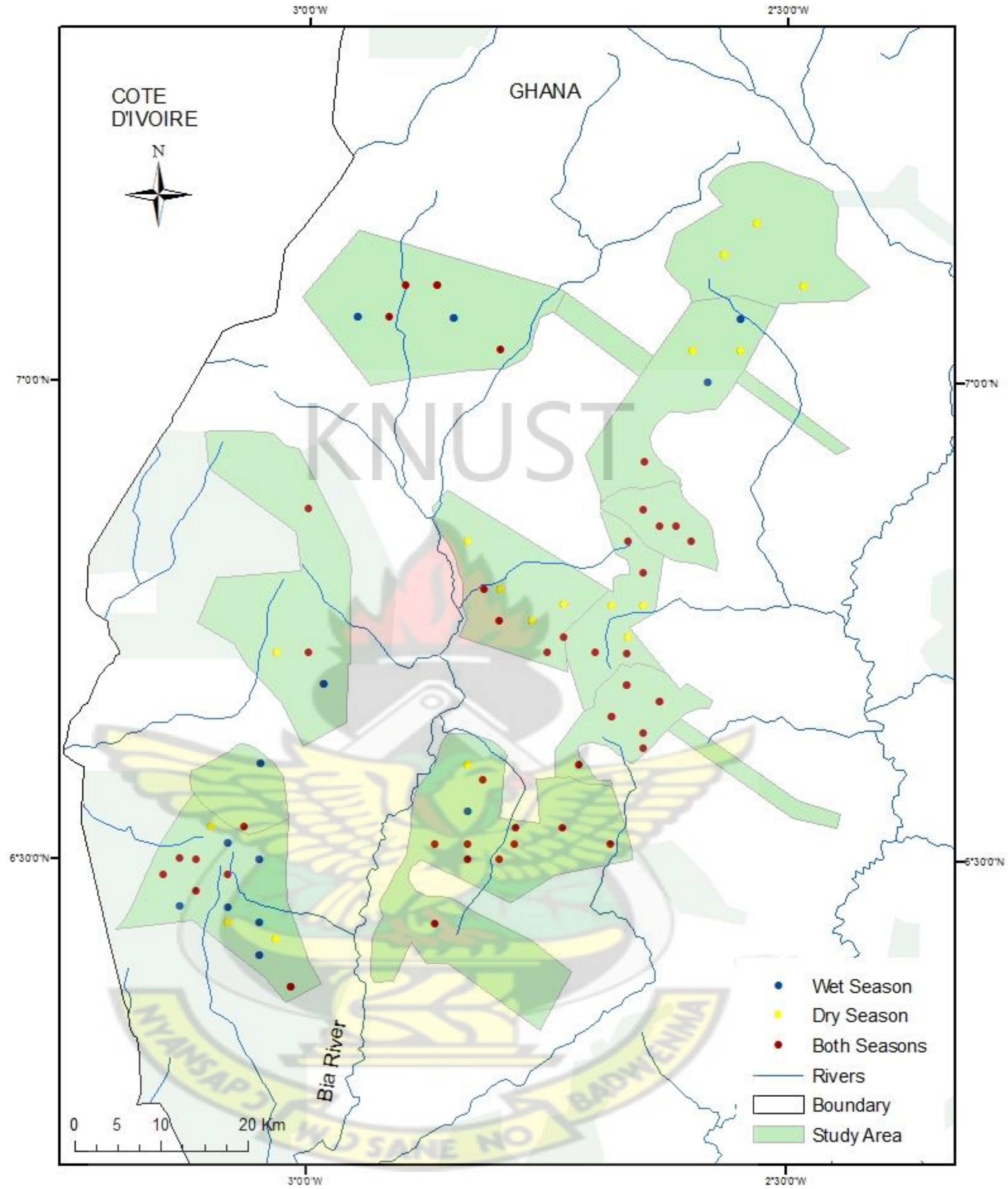

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Figure 8: Study area showing distribution of spot-nosed monkey activities in the wet and dry seasons

4.2.1.3 Olive colobus

Encounters with olive colobus were few and their observations were patchily distributed (Figure 7) nevertheless, these observations indicated a clear difference in distribution for the wet and dry seasons. In the wet season, the range of olive colobus was within the central parts of the reserves, whilst the dry season witnessed a more peripheral distribution. We visually confirmed the presence of the Olive colobus on only eleven occasions.

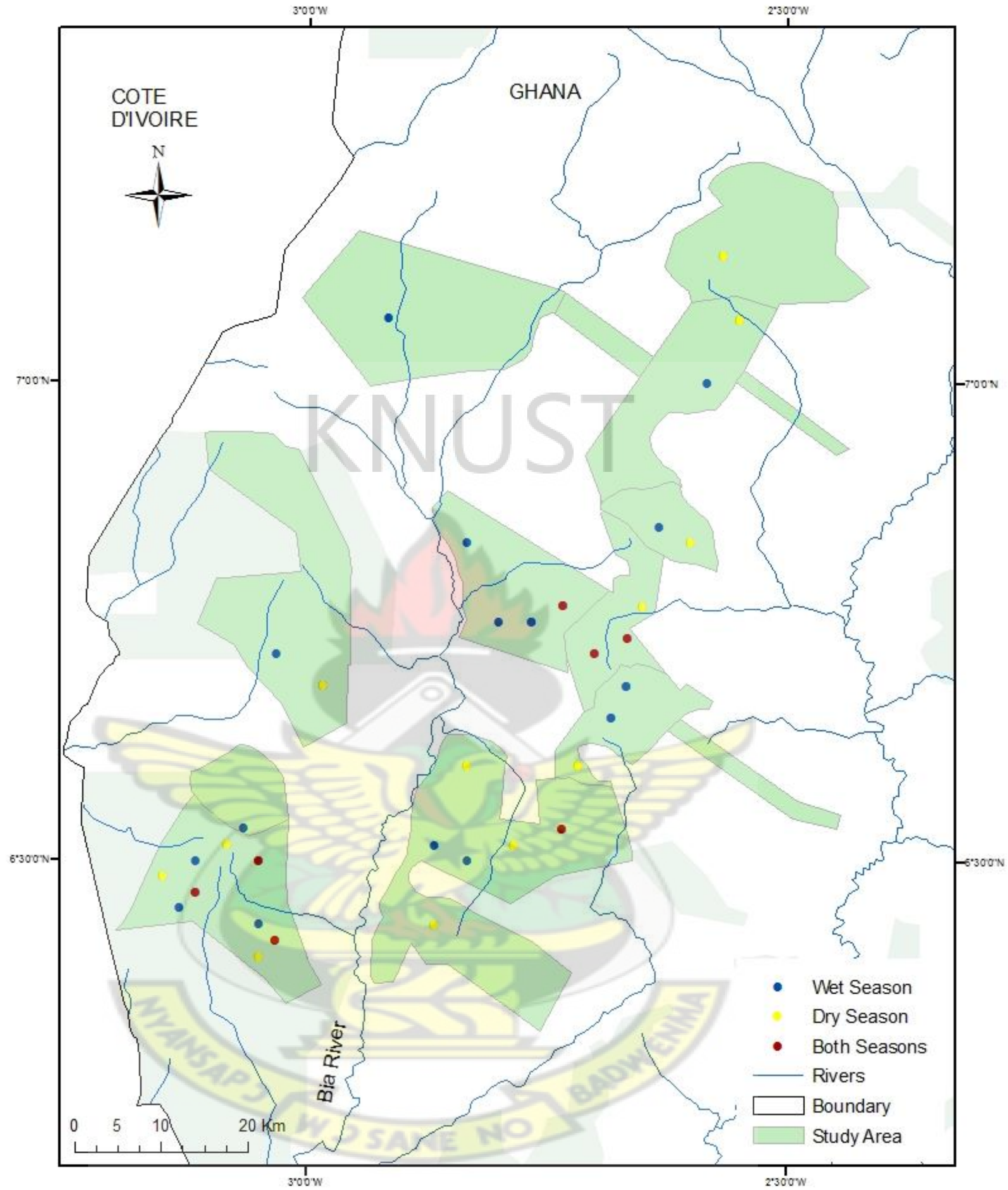

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Figure 9: Study

area showing distribution of Olive colobus activities in the wet and dry seasons

4.2.1.4 Distribution of Black & White colobus signs

Black & white colobus were by far the rarest monkeys and they occurred in very low numbers, so their distribution was especially difficult to describe accurately in both survey periods. However, compared to their much clumped distribution in the dry season, these monkeys also seem more dispersed in the wet season (Figure 9). Very few records of their presence were made in the northern reserves of the study area.

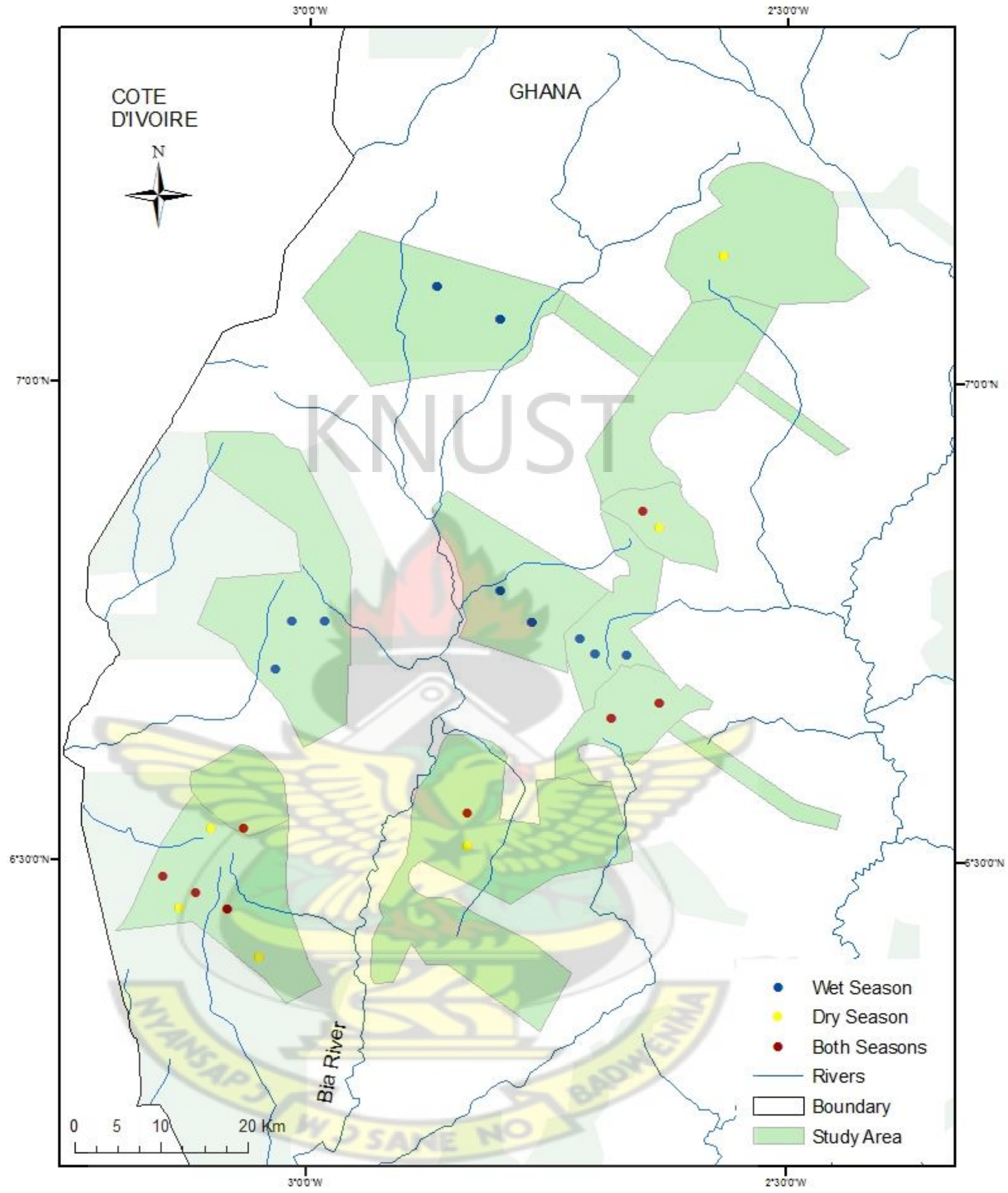

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Figure 9: Study area showing distribution of Black and White colobus activities in the study area

4.2.2 Wet season Relative Abundance

One hundred and ninety-one encounters with monkeys were made on 428 km of transects (line and recce transects) laid in the whole study area (i.e. Bia Goaso Forest Block; 2,600 sq km). Forty-four encounters with monkeys were made in the Bia CA, 29 at Krokosua Hills FR, 27 at Bonsam Bepo FR, 16 at Ayum FR, 21 at Subim FR, 15 at Bia North FR, 14 at Mpameso FR, four at Asukese FR, eight at Bia Tano FR and 13 at Bonkoni FR. No primate groups were encountered in the Bia, Goa and Abonyere SBs. Specific encounter rates of primates for the various reserves are listed in Table 9.

With an encounter rate of 0.45 per km (ie. both sightings and vocalizations), the number of encounters per transect ranged from zero to five. Overall, there were 94 individual visual primate group encounters, which gave an encounter rate 0.22 groups per km of census. Of this total, 59% were polyspecific (mixed group) associations of Lowe‘s, Spot-nosed and Olive colobus, with the majority (82%) between the Lowe‘s and Spot-nosed monkeys.

We visually confirmed the presence of Lowe‘s monkey on fifty-four occasions, spot-nosed monkey on twenty-eight occasions, olive colobus on eleven occasions and black-and-white colobus on only one occasion (Table 9.). No primate activity was seen in any of the shelterbelt reserves (i.e. Bia, Goa and Abonyere SBs).

Table 9: Summary of Primate signs distribution and encounters from line and recce transect surveys during the wet season in the Bia-Goaso forest area

Reserve	Species confirmed	Mode (number) of confirmation					Encounter rate	
		Sight	Call	Feed	Nest	Total	(km^{-1})	(hr^{-1})
Bia NP	Lowe's monkey	2	2	-	-	4	0.14	0.11
	Spot-nosed monkey	1	-	-	-	1	0.04	0.03
Bia RR								
	Lowe's monkey	12	4	-	-	16	0.29	0.19
	Spot-nosed monkey	8	4	-	-	12	0.22	0.14
	Black& white colobus	-	4	-	-	4	0.07	0.05
	Olive colobus	7	-	-	-	7	0.13	0.09
Krokosua Hills FR								
	Lowe's monkey	9	6	-	-	15	0.43	0.20
	Spot-nosed monkey	8	2	-	-	10	0.28	0.13
	Black& white colobus	-	1	-	-	1	0.03	0.01
	Olive colobus	3	-	-	-	3	0.09	0.04
Bonsam Bepo FR								
	Lowe's monkey	5	7	-	-	12	0.27	0.22
	Spot-nosed monkey	9	3	-	-	11	0.25	0.21
	Black& white colobus	-	2	-	-	2	0.04	0.04
	Olive colobus	-	2	-	-	2	0.04	0.04
Ayum FR								
	Lowe's monkey	4	2	-	-	6	0.13	0.13
	Spot-nosed monkey	2	2	-	-	4	0.09	0.08
	Black& white colobus	-	3	-	-	3	0.06	0.06
	Olive colobus	-	2	-	-	2	0.04	0.04
Subim FR								
	Lowe's monkey	8	4	-	-	12	0.26	0.23
	Spot-nosed monkey	-	4	-	-	4	0.09	0.08
	Black& white colobus	-	2	-	-	2	0.04	0.04
	Olive colobus	1	3	-	-	4	0.09	0.08
Bia North FR	Lowe's monkey	4	4	-	-	8	0.19	0.12
	Spot-nosed monkey	-	3	-	-	3	0.07	0.04
	Black& white colobus	1	2	-	-	3	0.07	0.04
	Olive colobus	-	1	-	-	1	0.02	0.01
Mpameso FR	Lowe's monkey	2	4	-	-	7	0.18	0.12
	Spot-nosed monkey	1	3	-	-	4	0.09	0.07
	Black& white colobus	-	2	-	-	2	0.05	0.03
	Olive colobus	-	1	-	-	1	0.02	0.02
Asukese FR	Lowe's monkey	1	3	-	-	4	0.11	0.07
Bia Tano FR	Lowe's monkey	2	2	-	-	4	0.09	0.07
	Spot-nosed monkey	-	3	-	-	3	0.07	0.05
	Olive colobus	-	1	-	-	1	0.02	0.02
Bonkoni FR	Lowe's monkey	2	3	-	-	5	0.14	0.10
	Spot-nosed monkey	2	3	-	-	5	0.14	0.10
	Black& white colobus	-	2	-	-	2	0.06	0.04
	Olive colobus	-	1	-	-	1	0.03	0.02
Bia, Goa and	-	-	-	-	-	-	-	-
Abonyere SBs	-	-	-	-	-	-	-	-

There was not enough data to provide realistic indications of abundance for most of the smaller-bodied monkey species, hence data on these species have been pooled together and the general term monkeys used to describe species recorded in this category. Table 10 shows a summary of density estimates for monkeys derived from visual and auditory encounters for low and high-density stratum respectively in the wet season.

Table 10: Summary of estimates for monkey species in wet season based on auditory and visual encounters

Monkey	Low density stratum	Medium density stratum	Total monkeys range
Number of signs	68	123	191
Encounter rate (km^{-1})	0.30	0.54	0.42
Sign density (km^{-2})	59.64	107.61	83.66
CV (%)	29.94	11.85	18.30
Standard Error	17.86	12.76	15.31
Detectable Difference between Strata			
Resolution			0.804
Z test			2.185
Wilcoxon sign rank test			-2.642
P-value			P<0.05

Monkeys had an average of 80 percent detectable change in densities between the two strata and there was a significant difference in the numbers and distribution of monkeys within the low and medium density strata.

4.2.3 Dry season Relative Abundance

Two hundred and twelve (212) monkey encounters were recorded on 428 km of transects (encounter rate of 0.50 per km) in the dry season. Forty-six primate encounters were recorded in the Bia CA, 28 at Krokosua Hills FR, 31 at Bonsam

Bepo FR, 23 at Ayum FR, 20 at Subim FR, 12 at Bia North FR, 12 at Mpameso FR, 12 at Asukese FR, 10 at Bia Tano FR and 18 at Bonkoni FR. Again, no primate signs were encountered in the Bia, Goa and Abonyere SBs. Specific encounter rates of the primates for the various reserves are listed in Table 11.

There were 99 individual visual primate group encounters, which gave an encounter rate 0.23groups per km of census. Of this total, 46% were polyspecific (mixed group) associations of Lowe‘s, Spot-nosed and Olive colobus, with the majority (87%) between the Lowe‘s and Spot-nosed monkeys.

We visually confirmed the presence of Lowe‘s monkey on 59 occasions, spot-nosed monkey on 33 occasions, olive colobus on five occasions and black-and-white colobus on two occasions (Table 2.). No primate activity was seen in any of the shelterbelt reserves (i.e. Bia, Goa and Abonyere SBs).

Table 11: Summary of relative abundance and distribution of monkey encounters from line and recce transect surveys during the dry season in the Bia-Goaso forest area

Reserve	Species confirmed	Mode (number) of confirmation					Encounter rate	
		Sight	Call	Feed	Nest	Total	(km^{-1})	(hr^{-1})
Bia NP	Lowe's monkey	3	1	-	-	4	0.14	0.11
Bia RR								
	Lowe's monkey	10	6	-	-	16	0.29	0.19
	Spot-nosed monkey	9	4	-	-	13	0.24	0.15
	Black& white colobus	-	7	-	-	7	0.13	0.08
	Olive colobus	2	4	-	-	6	0.11	0.07
Krokosua Hills FR								
	Lowe's monkey	7	4	-	-	11	0.31	0.15
	Spot-nosed monkey	6	4	-	-	10	0.28	0.13
	Black& white colobus	-	2	-	-	2	0.06	0.03
	Olive colobus	2	3	-	-	5	0.14	0.07
Bonsam Bepo FR								
	Lowe's monkey	5	8	-	-	13	0.29	0.24
	Spot-nosed monkey	6	9	-	-	15	0.33	0.28
	Black& white colobus	-	2	-	-	2	0.04	0.04
	Olive colobus	-	1	-	-	1	0.02	0.02
Ayum FR								
	Lowe's monkey	5	7	-	-	12	0.26	0.25
	Spot-nosed monkey	3	5	-	-	8	0.17	0.17
	Olive colobus	1	2	-	-	3	0.06	0.06
Subim FR								
	Lowe's monkey	8	3	-	-	11	0.23	0.21
	Spot-nosed monkey	4	4	-	-	8	0.17	0.15
	Olive colobus	1	-	-	-	1	0.02	0.02
Bia North FR	Lowe's monkey	3	6	-	-	9	0.21	0.13
	Spot-nosed monkey	-	2	-	-	2	0.05	0.03
	Olive colobus	-	1	-	-	1	0.02	0.01
Mpameso FR	Lowe's monkey	4	5	-	-	9	0.20	0.15
	Spot-nosed monkey	-	3	-	-	3	0.07	0.05
Asukese FR	Lowe's monkey	2	5	-	-	7	0.20	0.13
	Spot-nosed monkey	-	3	-	-	3	0.08	0.06
	Black& white colobus	1	-	-	-	1	0.03	0.02
	Olive colobus	-	1	-	-	1	0.03	0.02
Bia Tano FR	Lowe's monkey	4	2	-	-	6	0.14	0.11
	Spot-nosed monkey	2	1	-	-	3	0.07	0.05
	Olive colobus	-	1	-	-	1	0.02	0.02
Bonkoni FR	Lowe's monkey	5	4	-	-	9	0.25	0.18
	Spot-nosed monkey	5	2	-	-	7	0.20	0.14
	Black& white colobus	1	-	-	-	1	0.03	0.02
	Olive colobus	-	1	-	-	1	0.03	0.02
Bia, Goa and	-	-	-	-	-	-	-	-
Abonyere SBs	-	-	-	-	-	-	-	-

Table 12 shows a summary of density estimates for monkeys derived from encounters of calls and actual sightings for low and medium density stratum respectively in the dry season.

Table 12: Summary of estimates for monkey species in dry season

Monkey	Low density stratum	Medium density stratum	Total monkeys range
Number of signs	70	142	212
Encounter rate (km^{-1})	0.31	0.62	0.46
Sign density (km^{-2})	61.40	124.23	92.86
CV (%)	24.93	8.21	13.74
Standard Error	15.31	10.20	12.76
Detectable Difference between Strata			
Resolution			1.023
Z test			3.415
Wilcoxon sign rank test			-3.942
P-value			P<0.05

Monkeys had a relatively high detectable change in density of about 102 percent between the low and medium density strata and there were significant differences in the numbers and distribution of monkeys within the two strata.

4.3.0 Factors Affecting Chimpanzee and other Primates Distribution and Abundance

4.3.1 Types and Distribution of Poaching signs

We found signs of human presence and poaching activity distributed throughout the study area. The majority (49%) of these poaching signs were that of wire snares (Table 13). The greater proportion of snaring incidence was concentrated in the Goaso reserves, where on one transect alone the team removed 11 snares.

For mostly arboreal species like primates, what poses the most danger is the use of guns as it is the main means by which they are hunted. Although there were no direct encounters with hunters, field teams heard gunshots in three reserves on eight different occasions.

Table 13: Encounter rates (signs/km) of anthropogenic disturbances (hunting activities and habitat degradation activities) in the Bia Conservation Area and Goaso complex of forest reserves. For each activity, the encounter rate (with the total number of signs in parenthesis) is given

	Encounter Rate (Hunting Activities)								(Non-hunting Activities)			
Reserve	WS	SC	PP	TRAP	SHOT	HRAT	CAMP	HUNT	FARM	LOG	PSTL	Total illegal activities
Bia CA	0.37(50)	0.21(28)	0.09(13)		0.11(15)	0.02(3)	0.04(5)				0.09 (12)	0.93 (126)
Mpameso	4.66(317)	1.155(79)	1.15(78)		0.04(3)	0.07(5)	0.06(4)	0.06(4)	0.13(9)	0.12(8)	0.16(11)	7.65(518)
Asukese	3.83(260)	0.95(65)	0.95(64)		0.045(3)	0.045(3)	0.045(3)	0.045(3)			0.02(1)	5.92(402)
Ayum	1.7(116)	1.11(75)	1.3(89)	0.22(15)		0.18(12)	0.22(15)	0.23(16)			0.3(20)	5.27(357)
Bia North	2.5(170)	1.14(77)	0.05 (4)	1.36(92)	0.02(1)	0.04(3)	0.05(4)	0.04(3)	0.26 (18)	0.18 (12)	0.12(8)	5.75(390)
Bia Tano	1.7(116)	0.73(49)	0.63(43)				0.09(6)				0.16 (11)	3.31(225)
Subim	2.09(146)	0.89(62)	0.78(54)						0.18(12)			3.92(274)
Bonkoni	1.25(85)	0.57(38)		0.225 (15)		0.45(32)		0.45 (31)		0.18 (12)	0.1(7)	3.22(219)
Bonsam Bepo	2.52(171)	0.82(55)	0.41(28)	0.36(24)			0.295(20)	0.43(29)	0.09(6)		0.05(3)	4.96(336)
Krokosua Hills	0.94(124)	1.02(135)	0.04(6)	1.35 (178)	0.05(7)	0.04(6)	0.06(8)	0.07(9)	0.14 (18)	0.54 (71)	0.06(8)	4.29(567)

For each type or human activity, WS- Wire snare, SC-Spent catridges, PP-Poachers path, TRAP- Animal trap other than wire-snare, SHOT-Gunshot (heard), HRAT-Signs of Rat hunting (dug holes), CAMP- Signs of overnight camping, HUNT-Hunters seen inside forest, FARM-Farms inside reserve, LOG-Signs of logging, PSTL- Sings of pestle and other NTFP harvesting.

It seems that hunting with guns is the least favoured means of hunting in the Bia area compared to the Goaso area. Poachers are more likely to encounter wildlife guards in the Bia area and it is likely that the few remaining poachers are aware that gunshots could easily reveal their positions to nearby patrolling WD teams for their activities to be quickly dealt with. High incidence of wire snares compared to hunting with guns suggest that most of the poaching activities are those of small game poachers.

Most poaching activities were recorded in the Goaso block of forest reserves, especially in the low-density stratum (Figure 11). There are very few wildlife guard posts in the study area. The only two are the southern situated Bia CA wildlife guard post and the centrally located Goaso wildlife monitoring post. The area is too big to be monitored only by these two wildlife field stations.

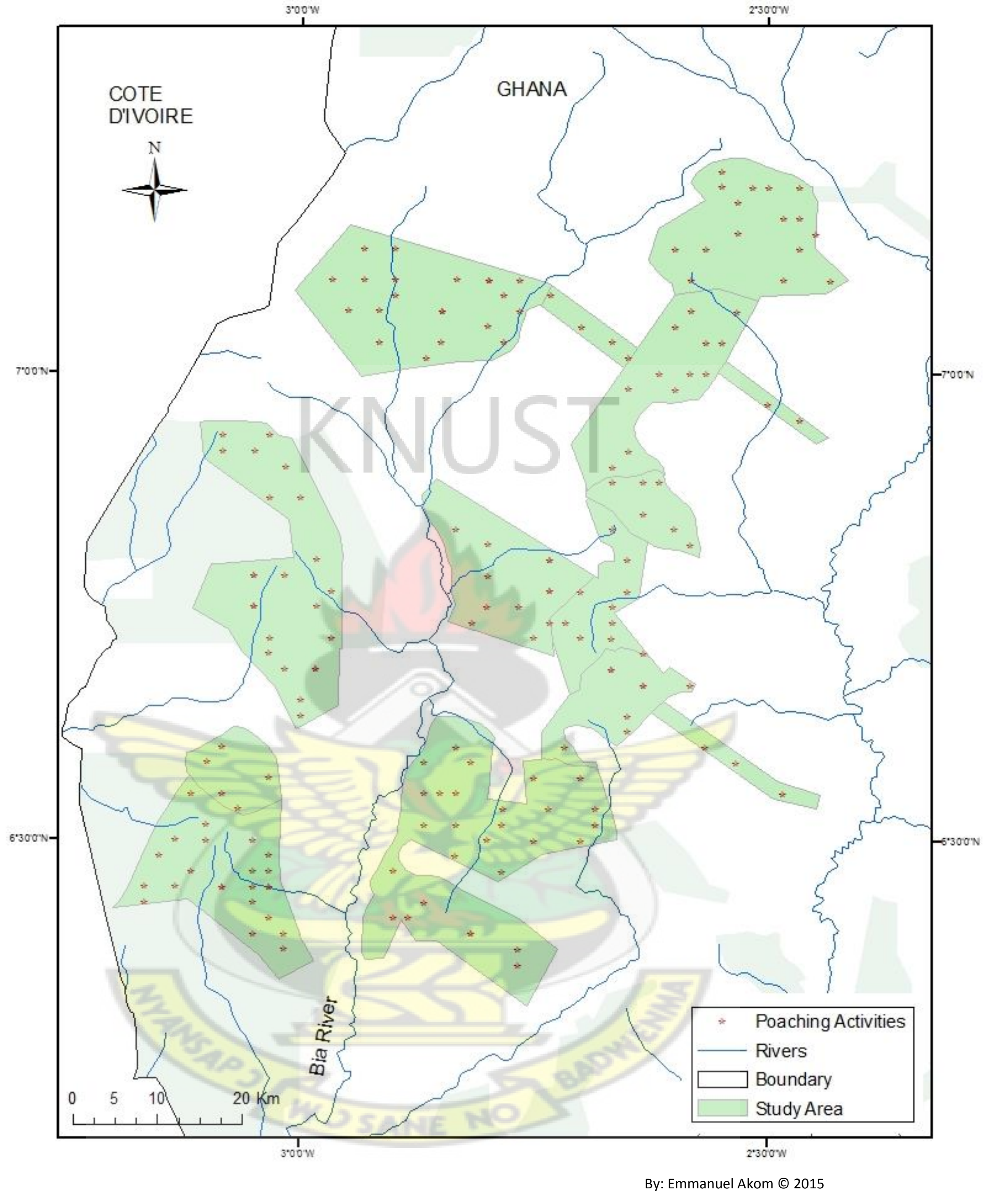

Figure 11: Study area showing distribution of poaching activities in the wet and dry seasons

4.3.2 Relationship between Primate Sign Densities and Recorded Variables

In a first step, an initial assessment of relationships between primate sign densities and the variables recorded on transects revealed that altitude, water availability and poaching activities strongly affected the distribution of primates in the study area (Table 14).

Table 14: Spearman rank correlation coefficients (rs) between an index of primate signs per km and a suite of human and ecological variables recorded on transects

Description of variable	Wet Season		Dry Season		Pooled Data	
	r_s	P	r_s	P	r_s	P
Elevation	0.665	< 0.01	0.643	< 0.01	0.657	< 0.01
Number of water sources seen on the transect	0.666	< 0.01	0.717	< 0.01	0.693	< 0.01
Index of poaching activities seen on the transect	- 0.683	< 0.01	- 0.676	< 0.01	- 0.681	< 0.01
Distance to the nearest forest edge (km)	0.208	> 0.05	0.208	> 0.05	0.208	> 0.05
Distance to the nearest WD/FD guard post (km)	0.311	> 0.05	0.311	> 0.05	0.311	> 0.05

In a second step, each of the potential predictive variables (Table 1) was regressed with sign densities of the various primate species. Initially, there were no significant relationships between the individual primate sign densities and any of the variables. Hence, the data was further analysed at another level by regression. The pooled sign densities for individual transects were examined, in other words at the primate level. For this level of analysis, the sign data for all primates on a common transect was combined and related to each of the potential predictive variables.

The variable that greatly explained (r^2=0.611, P<0.01) primate distribution was the availability of water (i.e. the number of water sources in an area) when expressed as a polynomial (Figure 12).

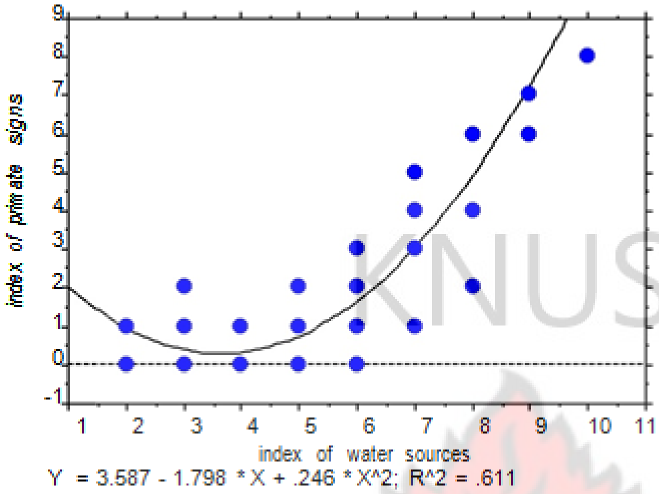

Figure 12: Relationship between primate distribution and the number of water sources in an area

The intensity of poaching activity (i.e. number of poaching activities in an area) emerged as the second most important variable (r^2=-0.582, P<0.01) that influenced primate distribution (Figure 13).

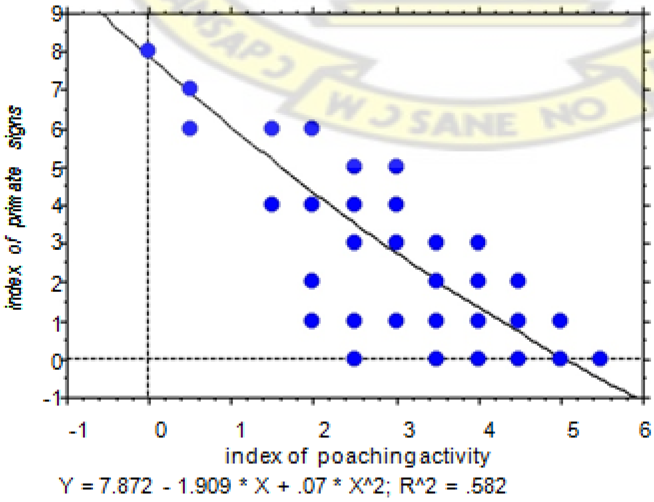

Figure 13: Relationship between primate distribution and poaching activity

The third most important variable that also strongly influenced (r^2=-0.529, P<0.01) primate distribution was altitude (i.e. elevation) (Figure 14).

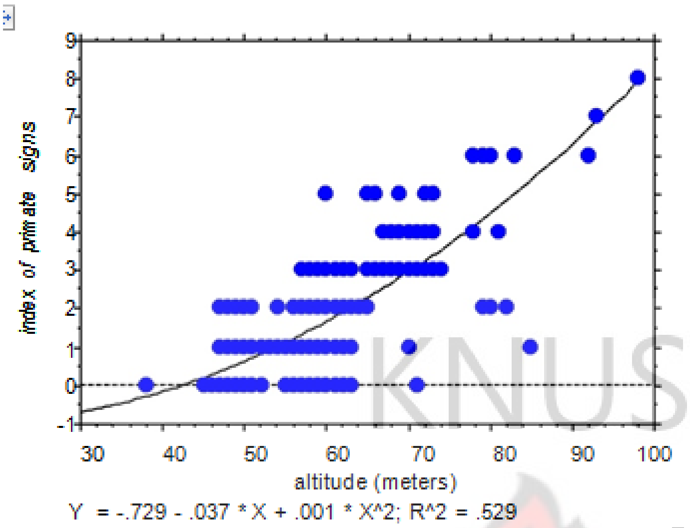

Figure 14: Relationship between primate distribution and altitude

These models allow us to calculate the number of primate signs expected in an area given altitude, water availability and the level of poaching activities present.

4.4.0 Chimpanzee Conservation Sites Prioritization

Based on chimpanzee presence, condition of forest, local people's attitude and distances, the most suitable chimpanzee conservation sites are ranked below in Table 16.

Table 15: Indices of chimpanzee presence and human pressure in the study area

Reserves	Chimpanzee Density	Chimpanzee Sightings	Crop Damage	Human Pressure
Bia Area				
Bia CA	++	Few	Few	++
Bia North FR	(?)	None	None	+++
Goaso Area				
Krokosua Hills FR	++	Few	None	+++
Bonsam Bepo FR	+	None	None	+++
Ayum FR	+	None	None	+++
Subim FR	+	None	None	+++
Mpameso FR	(?)	None	None	+++
Asukese FR	(?)	None	None	+++
Bia Tano FR	(?)	None	None	+++
Bonkoni FR	(?)	None	None	+++
Bia SB	-	None	None	+++
Goa SB	-	None	None	+++
Abonyere SB	-	None	None	+++

Chimpanzee sightings and crop damage (none, few, frequent), chimpanzee density and human pressure (- = none, (?) =suspected, + = low, ++ = medium, +++ = high), FR = Forest Reserve, CA = Conservation Area, SB = Shelterbelt Forest Reserve

Table 16: Priority ranking for the establishment of proposed permanent chimpanzee conservation sites[2]

Reserve	Chimpanzee & other diurnal primate diversity	Rel. ranking	Degree of Perceived threat		Total	Rel. ranking	Conservation Management Status	Total Re. rank = sum of rel. rankings	Assigned Priority/Relative Importance
			Habitat disturbance	Hunting Pressure					
Bia CA	1.51	1	0.09	0.84	0.93	1	1	3	1
Mpameso	1.17	7	0.41	7.2	7.61	10	2	19	9
Asukese	0.00	10	0.02	5.9	5.92	9	2	21	10
Ayum	1.48	2	0.03	4.97	5	7	2	11	4
Bia North	1.15	8	0.56	5.19	5.75	8	2	18	8
Bia Tano	0.97	9	0.16	3.15	3.31	3	2	14	7
Subim	1.43	3	0.18	3.75	3.93	4	2	9	2
Bonkoni	1.22	6	0.28	2.93	3.21	2	2	10	3
Bonsam-bepo	1.39	4	0.14	4.82	4.96	6	2	12	5
Krokosua Hills	1.35	5	0.73	3.56	4.29	5	2	12	5

[2] In assigning a priority ranking to each reserve unit, two desirable properties are combined, and these are degree of Biological Importance and Vulnerability. Chimpanzee and other diurnal primate diversity (Shannon-wiener mean) were used as a proxy for biological importance. The index of habitat disturbance/degradation and hunting activities recorded on transects were used as proxies for threats. These combine to give degree of perceived threat (risk of further clearing or land degradation and threat to chimpanzees). Another criteria is Conservation management status (and this has to do with the degree of law enforcement and protection afforded the reserve); Good=2 (Protected Area), Poor=1 (Forest Reserve). Higher Overall values mean lower conservation importance or priority.

A. Bia CA area: The largest chimpanzee population in the region is confined to the forests of the Bia area. From our field data and contacts with farmers and staff of the Wildlife Division, we conclude the Bia CA showed relatively high chimpanzee presence, with the highest concentration of chimpanzees in the southern located Bia RR. We observed chimpanzee feeding activities and droppings over the southeastern length of the Bia RR, confirming local reports and observation of low intensity sporadic cocoa raiding activity and chimpanzee presence in the area. Consequently, a few farmers have placed scarecrows on their farms to scare chimpanzees off.

B. Subim FR: The Bia River borders the western external boundary of the reserve and together with the Subim River the two constitute the main drainage system of the area. These major rivers and the generally gentle relief of the reserve tend to make a large section of the area water-logged during the wet season. Although the existing forests are heavily impacted due to illegal farming and illegal logging, Subim presents a tremendous opportunity for species conservation due to its naturally difficult terrain.

C. Ayum FR: The predominant threat to the wildlife population in this reserve is hunting by guns and snaring. Another major threat is the ubiquitous harvesting of pestles (*Celtis* spp.). During pestle harvesting, operators not only destroy (or alter) the wildlife habitat, but they also hunt with shotguns, traps or digging of burrows. In the event of more effective and tighter controls on poaching there is hope for its relic chimpanzee population.

D. Krokosua Hills FR: The reserve offers good possibility for conservation of chimpanzees among the Goaso complex of reserves. A small population of chimpanzees, most likely limited to a few troops, lives in the northern part of the reserve and our field data and observations from hunters corroborate these findings. Both commercial logging and other forms of forest clearance may threaten presently unknown sites for the species. Forest clearance for agriculture has left the south-eastern part of the reserve completely degraded. Most of these illegal farms in the reserve are used for both cocoa and food crop production.

E. Bonsam-Bepo FR: The forest reserve is managed by the FSD for timber, but some compartments are exempted from exploitation for the preservation of watershed and regeneration of threatened timber species. There is a hill sanctuary which consists of 32 protective forest compartments on a steep terrain reaching 1900 feet above sea level in some areas. The hills form a ridge stretching from the southwest to the northwest of the Bonsambepo reserve and covers about 18% of the 135.9 km sq. Only 6 of the 32 compartments within the hill sanctuary were recorded as ever been legally logged in the 1980s and early 1990s (FSD Harvest Schedule Records, Goaso). However, much of the hill vegetation has been affected by wildfire. The most recent incidence of wildfire outbreak was in March 2007. Other threats include farm encroachment and prevalence of poaching. Despite these threats the hilly terrain of the Bonsambepo ridge predisposes it as one of the good remaining habitats of the chimpanzee and other endangered wildlife species of mammals including the Black and white colobus and its potential for conservation of the species is significant.

F. Bia North FR: The forest reserve has become completely isolated from surrounding forest fragments. Bushfires, poaching and encroachment of land are threatening the existence of the reserve. The high exploitation of timber for logs and lumber by both registered timber companies and illegal chainsaw operators has contributed significantly to deforestation in the reserve. The development of settlements within the forest such as Adabokrom, and unchecked farming practices and encroachment in the forest reserves has also compounded the situation. During interviews there were unconfirmed reports of the presence of chimpanzees in the forest and this claim needs to be investigated further.

G: The reserves of Bia Tano, Mpameso and Asukese: These forests are the ones with the highest human disturbance and various forms of forest clearance and the forests are disappearing rapidly. These are all reserves where the species was not detected during the present study but they are sites where they have formerly been known based on available records. During interviews, however some key informants revealed that they are still present in these reserves. Though these reserves seem to offer the least prospects for chimpanzee conservation as they stand, a more intensive field survey would be needed to conclusively determine the status of the species. Any follow-up surveys to establish their presence would have to be of the uttermost urgency before any further fragmentation, rapid decline and eventual extinction of any remaining populations occurs.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Chimpanzee Distribution and Abundance

The results showed the presence of relatively small populations of chimpanzees inhabiting five of the reserves in the southern sections of the study area. Interviews with local hunters indicate their possible presence in the Bia North Forest Reserve, Mpameso and most of the other forest reserves although field surveys failed to establish this and many hunters had not seen chimpanzees in over five years. This indicates that they may be more widespread than previously thought, although their distribution is patchy and clumped. Previous surveys in the study area by Martin (1991), Abedi-Lartey and Amponsah (1999), Oates *et al.*, (2000) and WAPCA (2010) recorded the presence of chimpanzees in Bia CA and Krokosua forest reserve, however they provided no estimates of their abundance. For many years there had been virtually no estimate of chimpanzee numbers in Ghana since Teleki‘s (1989) (guess) estimate of between 300–500 chimpanzees. The estimate of 249 chimpanzees for the BGFB is therefore the first for any site in Ghana and is close to the lower range estimate of 300 chimpanzees suggested by Butynski, (2001) for the Bia Goaso Corridor Area in Ghana. Across other sites in the sub-region, particularly Liberia and Sierra Leone, relatively high lower range estimates of 1000 (Nisbett *et al*., 2003) and 1500 (Butynski, 2001) chimpanzees respectively have been reported for single protected areas. However, in the light of the widespread alarming declines in Cote d'Ivoire (which was thought to be one of the final strongholds of the endangered West African chimpanzee) estimated to support between 8,000 and 12,000 individuals, it puts populations in the sub-region in a tenuous situation. Given the lack of evidence for their continued presence in many recent surveys and their relatively low numbers for a total of five protected areas in our current study, it is possible that chimpanzees are also on the decline in Ghana. This highlights the importance of urgent conservation actions to prevent them from going along the same extirpation path of some guenons in the country.

5.2 Chimpanzee Density and Limitations to Estimates

The abundance estimates of chimpanzees for the wet and dry season surveys were significantly imprecise. The relatively wide confidence limits suggest some sources of bias. The most problematic was relying on nest decay and construction rate data from other sites, usually many kilometers away. Decay rates can be highly variable between sites with different environmental variables. The next potential bias can arise when dealing with small numbers of chimpanzees, as this result in a large margin of error (Taylor and Gerrodette, 1993; Barnes, 2002). The margin of error is further widened by the clumped distribution of chimpanzees, where groups of chimpanzee nests are seen on a few transects, with many other transects where no chimpanzees are seen. A merged estimate of 249±385 chimpanzees however had narrower confidence limits (Norton-Griffiths, 1978).

The Bia chimpanzee range has not been as heavily impacted by logging disturbance like the Goaso range (PADP 2000, 2001), and most parts are structurally pristine, possibly due to its status as a wildlife protected area. Hence, the Goaso range harbours lower densities of most primates including chimpanzees compared to Bia (Danquah *et al*., 2001). This pattern was also evident in the current study. Bia is generally among the most biodiverse forest areas in Ghana (Kormos *et al*., 2003; Hawthorne and Musah, 1993). Poaching has especially reduced the chimpanzee populations of these areas in comparison to past levels of abundance.

Primate sign densities for the two strata were significantly different, confirming the generally high percent resolution between strata. Obviously, the Bia population in terms of its size, seems a more viable population compared with the Goaso population. Nevertheless, some small populations that would be listed as vulnerable or in danger of extinction based on small size or restricted distribution may in fact be very stable. Hence, in the long term the Goaso population might have a better chance of survival, as the range is bigger and especially when wildlife protection is stepped up and sustained.

The results of this study emphasize the importance of improving forest habitat for chimpanzees and other primates in the study area. However, the rapidly increasing human population in the area has placed significant pressure on such forests, which are being replaced with subsistence farming (Sam, 2000). The immediate threats to the Bia Goaso Forest Block are unregulated timber extraction, agriculture and hunting activity (Wildlife Department, 1998). The increasing pet trade is also believed to have a significant adverse effect on wild chimpanzees in Ghana (Mittermeier, 1987).

5.3 Other Primate Distribution and Abundance

We confirmed the presence of two anthropoid monkey species, the Lowe's and spot-nosed monkeys for all sites. The two primate species together with the olive colobus monkeys are reportedly the most common of the eight diurnal forest primate species found in Ghana (Kingdon, 1997). Magnuson (2002), White and Berry (2000), Oates (2006) and WAPCA (2010) also confirmed this when they reported the two species as widespread in the Ghanaian forest zone and elsewhere in West Africa. They have a wide dietary breadth and to a large degree are forest habitat generalists capable of subsisting in extensive areas of disturbed primary forest and second growth. Their ability to adapt to a wide variety of habitats makes them quite common in many parts of their range and this is an important factor in the long-term persistence of the species especially in the non- protected areas of their range.

With the exception of the Lowe's and spot-nosed monkeys, the primate populations in the forest reserves in the forest area are very low. This is similar to the findings of WAPCA (2010), Oates (2006) and other previous surveys (Oates *et al.*, 1996-97; Oates *et al.*, 2000; Struhsaker and Oates, 1995; Struhsaker, 1993; Whitesides and Oates, 1995; Magnuson, 2002; Abedi-Lartey, 1999; 1998).

Recent studies have shown that a species' extinction risk may be determined by two types of factors: intrinsic biological traits and exposure to external anthropogenic threats. The range of most primate species, reliant on closed canopy conditions, has considerably contracted, due to heavy logging especially in the Goaso area. This is especially true for the Black and white colobus, as only a few isolated populations were detected in often mature undisturbed forest patches in the range. These highly arboreal species depend on immature leaves, seeds, and unripe fruit (Davies 1994), and may therefore be at high risk of extinction from deforestation and other extractive activities (Davies, 1994; Marsh *et al.*, 1987). Olive colobus, the other colobine monkey is more widespread in its occurrence and has not experienced as much declines as the Black and White colobus. The persistence of this colobus species in the forest sites may be related to a dietary preference for secondary growth (Onderdonk and Chapman, 2000).

Roloway Diana monkey and White-naped mangabey, appear to be extirpated as their presence could not be confirmed across the forest reserves including Krokosua forest reserve although locals, indicated small populations of white-naped mangabey may remain in some areas, particularly the Krokosua Hills forest reserve and the Bia CA. According to Oates *et al.*, 1997, and Oates *et al.*, 2000 prior research had found the Krokosua FR and the Ankasa conservation area to harbor the largest remaining populations of Roloway guenons in Ghana. Magnuson (2002) confirmed the species could still be found in four of the nine forest areas visited including Krokosua Hills FR, although they were found to be among the rarest of Ghana's primates and were facing a high risk of extinction. By 2006, the presence of the species together with the white-naped mangabey could not be established across the study area (WAPCA, 2010). This study also recorded the same outcome indicating that even if they exist at all, the status of the three endemic subspecies (*P. b. waldroni*, *C. d. roloway*, and *C. a. lunulatus*) have worsened over the intervening years.

5.4 Factors Influencing Distribution and Abundance

5.4.1 Forest loss, modification and fragmentation

The underlying cause of virtually all recent and ongoing declines of primate species in the BGFB is the growth of human populations and associated impacts such as habitat loss and hunting. Current satellite images combined with ground investigations indicate few forests remain outside the reserves as much of the original land has been converted to agriculture and settlements. The study area became important from the 1970s for cocoa production, coffee and oil palm plantation development. Acceleration of the movement of migrants from other regions into the Western Region since then (Sam, 2000), has resulted in severe encroachment on the forest reserves resulting in a hard edge between the reserves and the surrounding farmlands. Reserves in the area which have been completely lost to cocoa farms and human settlements as a result include Bia Tawya (679 km^2), Manzan (305 km^2) and Sukusuku (148 km^2). As a result the two forest areas of Bia CA and Bia North FR are completely isolated from surrounding forest fragments. The net effect of these activities has been a reduction in the vegetation cover. Bosu *et. al.*, (2008), estimates that for the Goaso complex, between 1990 and 2000, the forest cover within the forest blocks had decreased by 4.53%. Increase in open areas in the reserve was attributed to small scale (illegal) logging and encroachment by farmers in the forest reserve. They observed that within a 5 km radius from the edge of the forest reserves, there was an 82.96% increase in non-forest vegetation cover, as a result of large scale cocoa and coffee plantations mainly in the southern parts of the Goaso forest area.

The absence of chimpanzees and most primates in general in the northern reserves of the Goaso area may be the result of historically greater anthropogenic activity in the area, before the reserves were created. Better access roads due to a major highway linking the major district capitals of Goaso to the west and Dormaa Ahenkro to the north and neighboring towns transformed the landscapes in the northern section of the Goaso forest complex and may have resulted in greater pressures upon the primate fauna compared to the very bad road networks that exist in the southern sections around Bia CA. It is possible that before the Goaso-Dorma Ahenkro highway was built, primates occurred in relatively high densities in both sections of the BGFB. The expansion of the urban areas of Goaso and Dormaa Ahenkro at the western and northern ends of the Goaso forest area was probably an added factor. However, better wildlife protection at Bia CA and the difficult terrain at Krokosua Hills and Bonsam Bepo FRs have somewhat diminished such pressures from the southern-placed district capital of Juabeso and its surrounding towns.

5.4.2 Hunting and bushmeat exploitation

There is enough reliable data on hunting for the study area to suggest an upward trend over the years. This study confirms the opportunistic foraging habits of hunters in the study area. It clearly shows that hunters will hunt and eat virtually whatever species of primate and other wildlife is available locally. Active hunting has caused a behavioural change in terms of vigilance of species. Primate groups in the study area showed much fear in response to humans. They no longer called and tended to freeze on contact with humans, making them very difficult to spot, and other species were also less conspicuous.

For chimpanzees, the numbers killed are most likely low relative to numbers of other wildlife (monkeys, duikers, cane rats, etc.), however they have a low reproductive rate and extended infant dependence making them vulnerable to even low levels of mortality (WWF, 2003). Outside protected areas, primates and other wildlife fair even worse. The logging concessions are often associated with an increase in poaching due to the demand for meat by the workers and the increased access provided by logging roads and vehicles.

The vulnerability of Roloway diana monkey, and white-naped mangabey to hunting seems clear given the fact they have very nearly been extirpated from all available sites in the study area. Being slow and large-bodied, Black and white colobus are susceptible to hunting and are an early indicator of overhunting. It is only in the case of olive colobus that hunters often report that it is not their favorite meat species because it usually smells bad, but when other species become rarer due to hunting pressure, they are also heavily hunted as is evidenced by their generally low numbers. In the case of the Miss Waldron’s Red colobus it has already been declared extinct many years ago when Oates *et al.*, (2000) were unable to find any surviving populations of species during surveys in 1993-1999 and for which he attributed hunting by humans to be the ultimate cause of the species demise. For many endangered species therefore it is not the lack of suitable habitat that has imperiled them, but hunting, and various studies conducted in the study area over the years have sought to highlight this fact (Oates *et al.*, 2000; 2006; Magnuson, 2002; WAPCA, 2010). A case in point is Holbech's (1998) PADP bushmeat survey, during which time he extrapolated about 5,000 hunters (of which c. 3,240 are gun-hunters) within a 7 km radius of the Bia CA. Similarly, he estimated that about 75% of all families living around the park had at least one person who hunts in one way or another. Increasing direct disturbance by humans, as a result of poaching activity have therefore had a negative effect on the abundance and distribution of primates in the study area.

In the face of increased hunting disturbance, two primary factors may have favored the persistence of the primate populations in several reserves in the BGFB over the past few decades. First, is the protective status of a reserve and secondly, how difficult a reserve's topography is. The Bia Conservation Area is a fully protected area; hence a considerable level of protection is accorded the wildlife by staff of the Ghana Wildlife Division who go on patrols and carry out regular monitoring. The Krokosua Hills and Bonsam Bepo FRs generally have very hilly and difficult terrain and Subim FR also has impassable terrain during certain times of the year as such they are not easily navigable in certain locations, militating against access by hunters and poachers to the interior of the forest.

5.5 Establishment of Prospective Priority Chimpanzee Conservation Sites

The priority areas for chimpanzee conservation in the study area in order of importance are; the Bia Conservation Area, the Globally Significant Biodiversity Area of Krokosua Hills, the Bonsam Bepo, Subim and Ayum forest reserves. Magnsuon *et al*., (2003) proposes Bia North, Bia Tano, Mpameso and Bonkoni in addition to these reserves. The Bia CA has long been viewed as a prime area for chimpanzee research and conservation based on the level of protection that exists. However, the area has been heavily hunted in the recent past, making observation of large mammals difficult. Many local communities have not encountered chimpanzees in over ten years. If better protected, it is likely that any remaining population of chimpanzees would rebound in time. The topography of Krokosua Hills, Bonsam Bepo and parts of Ayum and Subim FRs is very challenging and it seems poaching activities do not extend far beyond the well-known trails already in existence (especially in Krokosua Hills). Assuming an effective law enforcement and monitoring programme could be placed permanently in these areas to reduce hunting pressure, these large contiguous forest reserves may provide the best chance of supporting a large chimpanzee population in Ghana.

5.5.1 Creation of corridors as means of linking priority conservation sites

Low conservation status areas with existing high impacts may be worthless and the costs of reversing degradation trends may be too high to be of any significant value. However given the fact that chimpanzees, monkeys and other wildlife (e.g. elephants) are long-ranging animals, the survival of these species in the long term lie in their ability to move free within the landscape and interbreed. Several calls have therefore been made for the establishment of a series of boundary habitat-corridor continuum

(Puth and Wilson, 2001) linking the individual reserve units and for them to be incorporated into a wider network of conservation areas. Similar to the case of elephants (Parren and Sam, 2003), human pressure, the presence of food plants, availability of water, and the size and structure of the reserves and connecting corridors are important aspects taken into consideration in proposing areas of suitable corridors.

5.5.2 Characteristics of successful corridors

In establishing these corridors, conservation sites (network of forest reserves) should be designed to attract chimpanzees into them. Such a network of chimpanzee conservation sites would require a number of actions and guidelines to improve the possibility of effectiveness. Chimpanzees feed on certain fleshy fruits when these are available and rely upon less nutritious foods during periods of fruit scarcity. In Ghana, the period of fruit scarcity for favorite forest tree species is from May to October, i.e. during the rainy season. In that period, chimpanzees leave the forest and raid cultivated crops, like cocoa as it is the case along the western boundary of the Bia RR. Reforesting degraded areas of corridors and enriching forests close to reserves with native species including *Klainedoxa gabonensis*, *Sacoglottis gabonensis*, *Parinari excels*, *Panda oleosa* as well as other preferred fruit trees could attract chimpanzees and increase the chance of them permanently using these reserves. Almost the whole length of the Bia riverbanks is deforested and used as agricultural fields. Further downstream along the Bia River towards the border with Côte d'Ivoire the same pattern is found. In villages along the Bia River, the population is aware of the environmental degradation taking place along the river and affecting their livelihoods and water availability especially during the dry seasons. Farmers associate the present water situation with the deforestation along the riverbanks and for that reason, they support afforestation, hoping that the forests bring back good quality and higher water levels and hence fish. The fact that farmers are eager to plant trees along riverbanks is an important aspect when considering the creation of corridors. The Bia River could therefore serve as an important connecting corridor between the two isolated chimpanzee ranges (i.e the BCA and the Goaso reserve). In this regard, portions of land within the Asempaneye CREMA (bordering the Krokosua Hills FR) and Elluokrom Community Resource Management Area (CREMA) (bordering the Bia CA) could be reforested with preferred native species with one of its prime objective being as a wildlife corridor to foster migration of chimpanzees between the two chimpanzee ranges. The same suggestion has been made for elephants as well, where elephants and other wildlife have been reported to use the Bia SB to move between the Mpameso and Bia Tano FRs (ARG, 2009).

5.5.3 Prospective Corridor locations

The development of corridors (such as the Bia River or the Asempaneye – Elluokrom CREMA) to link the above-mentioned priority chimpanzee conservation areas and other potential reserves (areas) is vital for managing chimpanzees and other endangered species in the long-term. Currently, the Bia River has an almost intact 200 m width forest along some portions of its banks. These would have to be widened to a zone of at least 500 m wide, while at the same time conserving all remaining forest patches within 1.5 km from the riversides (Parren and Sam, 2003).

The Bia river corridor: To connect the Bia chimpanzee population with the Goaso population, the corridor could be created by following the Bia river southwards. The southern edge of Krokosua Hills FR is located at the point where the Bia River crosses over a short distance of about 6 km to southern Bia RR near the border with Côte d'Ivoire (Figure 15). A forest corridor along the Bia River would link the Bia population with that of the reserves of southern Goaso through the Krokosua Hills FR. At the same time, it serves as a potential for linking the southern reserves of the Goaso area to the northern reserves, thereby increasing the potential chimpanzee range. The Krokosua Hills FR touching almost the Bia riverbanks forms a natural access route which can easily be crossed by chimpanzees between Bia RR and Krokosua Hills FR. The other adjoining forest reserves where chimpanzees were not recorded could be managed properly to provide suitable habitat for their range expansion.

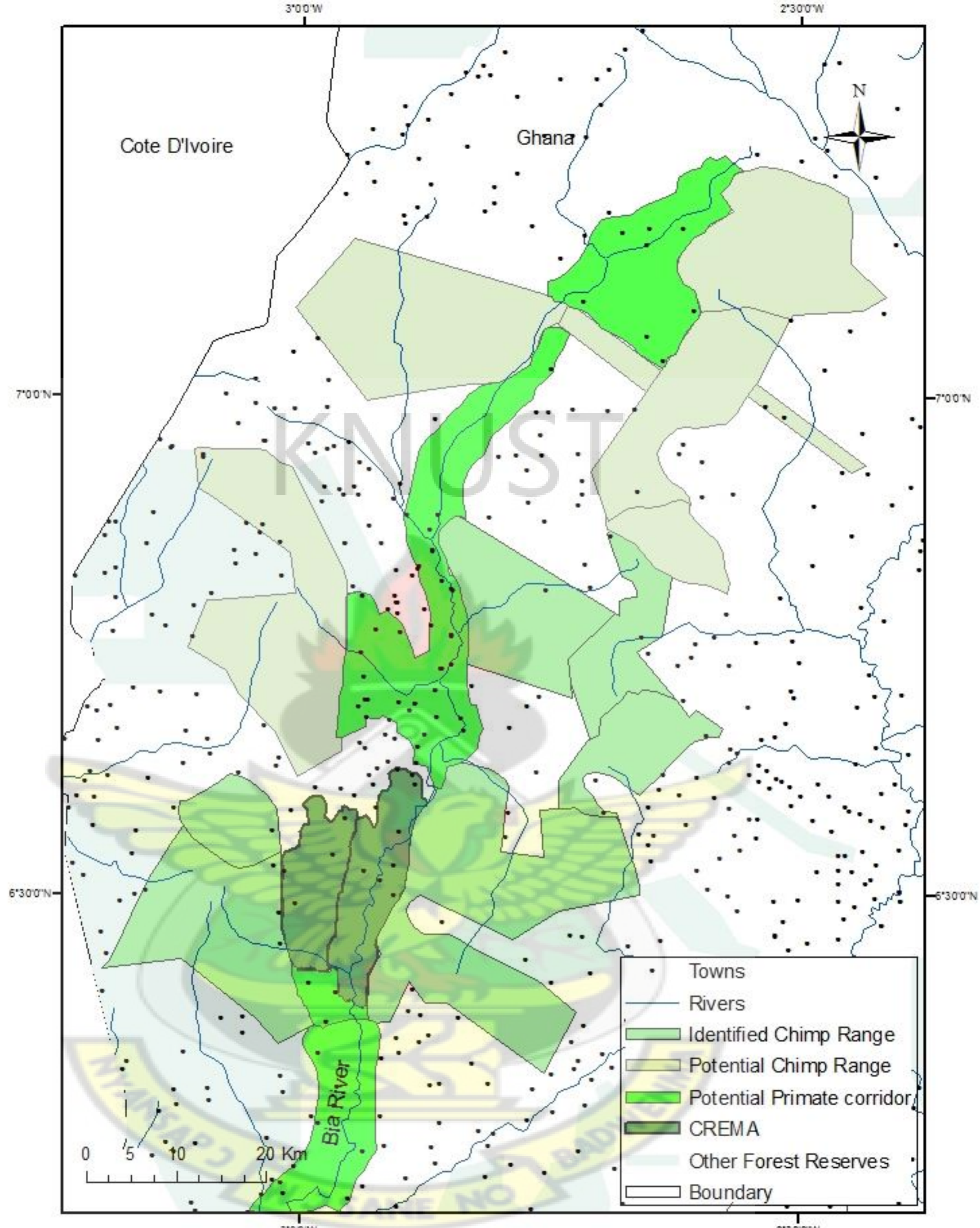

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Figure 15: Map of the Bia-Goaso chimpanzee range, showing how chimpanzee habitat could extend from the Goaso Reserves, southwards to Bia Conservation Area

The Asempaneye-Elluokrom CREMA corridor: Forest restoration within the Asempaneye-Elluokrom CREMAs, a vast area almost touching the most western side of the Krokosua Hills FR and the eastern part of the Bia CA (Figure 15), offers new opportunities for corridor establishment between the Bia and Goaso chimpanzee populations. Although the distance (width) is long (about 6 - 10 km) the CREMA corridor is an interesting option. Firstly, more than half this distance covers small forest fragments and there is the potential for increasing the forest area. Secondly, the potential corridor could follow sacred grooves, streams and inundated areas where the local human population is sparse. An additional advantage is that the Forestry Commission through its divisions (FSD and WD) has a good relationship with the local population at the site of the potential corridor.

5.6 Implications for Conservation

With such small populations, the probability of extinction in the near future might be unacceptably high for chimpanzees and other primate species as well as for most large and medium-sized mammals. Catastrophes, such as fires, or the action of hunters can easily annihilate entire communities of chimpanzees in a very short time. Even though the costs of creating corridors would be high, corridors can provide more services than just conservation of biodiversity. As farmers along the Bia river suggested, corridors can be beneficial for improving the quality and quantity of water available to rural communities as well as for the production of useful timber and non-timber forest products. Community involvement by offering them the chance to improve their livelihoods through better agricultural practices and sustainable use of the forest resources would be the needed offset and improved livelihoods of local communities should guarantee their long-lasting functioning as a way of passage for chimpanzees and other wildlife. The latter could form the key motivation to local participation in forest restoration, wildlife management and monitoring such as developed through the CREMA programme. To ensure that chimpanzees and other endangered animals including elephants will make use of these corridors as a way of passage it has to be ensured that human intervention in the corridor zone is well regulated with restrictions in time and space for harvesting.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Decreased frequency of primate signs, especially chimpanzees in the study area is evidence of a diminishing population. There is high incidence of habitat destruction and hunting especially across all the forest reserves. The combination of these pressures need to be addressed with extreme urgency through uncompromising law enforcement. Considering the wide-ranging habits of chimpanzees and other wildlife including elephants, the ideal would be for the establishment of wildlife migratory or dispersal corridors to link the network of forest reserves. In the face of limited resources however, conservation efforts should concentrate on protecting priority sites especially BCA, Ayum, Krokosua Hills, Subim and Bonsam-bepo Forest Reserves. In that event species recovery plans should be developed and operationalised for chimpanzees in the target reserves to support their conservation in the long term.

6.2 Recommendations

To advance the conservation of primates in the study area, the following specific recommendations are proposed.

1. It is evident that more surveys of the primate population of the BGFB need to be carried out. Further research, on the general ecology, specific habitat requirements and behaviour of endangered primate species should be encouraged especially in the Goaso area. This should encompass one or more annual cycles and especially in the Asukese, Mpameso and Bia Tano sections of the part of the study area where the presence of chimpanzees were reported but not evidenced. This will confirm the estimates regarding the size of the

population existing in the area and will provide important data on distribution, seasonal and inter-annual fluctuations in presence, size, and demographic structure of the population. Similarly, studies are needed to document how the primates sustain themselves throughout the year.

2. Many studies in the area have confirmed that apart from the Bia CA, hunting activities is on the increase in the study area. Analyses of the situation indicate that improved law enforcement can have a positive measurable effect on most mammals including primates in terms of abundance and distribution. If protection is stepped up and there is a built up of primate populations, tourists can view many wildlife such as chimpanzee and monkeys. The charismatic appeal of these primates will enhance the intrinsic value of the BGFB in the public eye, making the visit more attractive. This would raise awareness among the public regarding the importance of preserving the forests and the primates that exist in the BGFB.

3. It must be emphasized that basic knowledge on mammal abundance and distribution in and around Bia is very adequate for many species, and this fact has certainly paved the way for their effective protection. Almost every medium to large mammal group in the Bia CA has received considerable research and monitoring inputs, from Wildlife Division and consultants. In contrast, monitoring or research effort in the Goaso area is currently irregular and not carried out on planned basis. It is believed that the development of a monitoring and research facility for the Goaso part of the study area will help support this situation. In line with this, it is crucial that more efforts be geared towards basic Wildlife Division-based low-cost monitoring and research

systems to ensure long-term viability and continuity to achieve long-term conservation objectives. Forest guards operating in the Goaso area should be better trained and equipped with basic knowledge on monitoring and research techniques.

4. Lastly, with these efforts, conservation education should also be promoted and integrated into elementary education for schools in the study area. This can be done by forming and supporting more environmental clubs in schools which could be spearheaded by both WD and NGO's like A Rocha Ghana and Care working in the area.

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APPENDICES

Appendix 1: Data form for Primate Transect surveys

Surveyor(s):	**Forest Reserve/PA**	**Start Time:**	**End Time:**	
Vegetation Type:			**Date:**	
Weather condition:	**Transect No:**	**GPS start pt:**	**GPS end pt:**	**Length:**

			Distances								
Obser. No.	**Species**	**Mode of detection**	**Distance on Transect**	**Observer-Animal (m)**	**Perpendicular Distance**	**GPS Coord.**	**Bearing**	**Time**	**Estimated & sighted no.**	**Activity**	**Notes**

Notes: Mode of detection (Visual, Auditory, knuckle prints, faeces, feeding sign etc); Activity (eating, sleeping, playing etc), Observation (Also recorded as illegal activities – poaching sign - wire snare, gunshot, poachers camp; farms etc).

Appendix 2: Data form for chimpanzee nest counts

Surveyor(s):		**Start Time:**	**End Time:**
Vegetation Type:	**Forest Reserve/PA**		**Date**
Weather condition:	**Transect No:**	**GPS start Pt:**	**GPS end Pt:**

	Nests				**Distances**			**Nesting Tree**				
Nest No.	**Height of Nest**	**Age/Percentage openness**	**Dimensions**	**Min. Dist. btn Nests**	**Dist. on Transect**	**Perpendicular distance**	**GPS Coordinate**	**Species**	**Height**	**DBH**	**Min. Dist btn trees**	**Notes**

Notes: Nests (In tree or on ground, construction material –woody or herbaceous etc ,species , Number of nests per tree, Anthropogenic activities); Dimensions (Widest & narrowest diameter); Age /Percentage openness (1. New = Green leaves within the cup of the nest and the nest intact, 2. Old = leaves brown but the nest still pretty much intact, 3. Very Old = gaps in the cup of the nest that the observer can look through due to loss of leaves)/ Percentage openness- the percentage of open gaps in the nest cup in relation to the total area of nest

Appendix 3: Data form for Questionnaire survey

Survey of attitudes of members of fringe communities to trends in distribution and abundance of chimpanzees and other primates and future conservation prospects

Personal Information

1. Community……………………………… Age………. Sex Male [ ] Female [ ]
2. Occupation [ ] Farmer [ ] Hunter [ ] WD/FSD Staff [ ] other (state)……………………………….
3. Are you a native of the community or area? [ ] YES [ ] NO
4. If NO, for how long have you lived or worked in the area? ....

Land Use Practices

5. What are the various land uses you have here? [ ] farming [ ] charcoal burning [ ] fishing [ ] others…………….
6. Which Forest reserve is closest to your community..
7. What have you observed about the forests? [ ] increased [ ] reduced [ ] no idea [ ]
8. If reduced, what is the cause? [ ] bush burning [ ] farming activities [ ] others [ ]…………………………………..
9. Can something be done to improve the situation? [ ] YES [ ] NO
10. What do you think can be done to improve the situation? [ ] Afforestation [ ] Regulate logging
[ ] Stop bush burning [ ] others ……………………………………………………………………..

Current and Historical distribution and Abundance of Chimpanzees

11. Have you seen a chimpanzee or its activities (*feeding sign, knuckle prints, droppings, nest*) before? [ ] YES [ ] NO
12. If Yes, when was it (give date)………………… month(s) /season(s)…………………………………………….
Place (s) [ ] Forest [ ] farm [ ] Village [ ] other (state) …………………………………
Direction of movement…………….............................
13. If seen in the forest, in which locality did you see it?
……………………………………………………………..
14a. How many did you see?……………………….. 14b. Were Young ones in the group? Yes or No
15. What is your observation about chimpanzees in last 10-20 years? [ ] increased [ ] reduced [ ] no idea [ ]
16. What is the reason for your observation?..
17. If No, did your fathers talk about chimpanzee presence in times past? [ ] YES [ ] NO
18a. Do you think chimpanzees and other primates are of any benefit? [ ] YES [ ] NO
18b. Why?..

19a. Do you have any traditional beliefs or taboos against the hunting of chimpanzees or any other primate?
[ ] YES [ ] NO
19b. If Yes explain…………………………………………………………………………………………………..

20. Status of other Primates

Primate	Last seen/ Heard	Locality in the forest	Abundance	Trends
Efoo (Black-&-White Colobus)				
Kraku (White-naped Mangabey)				
Awinhemaa (Spot-nosed monkey)				
Kwakuo (Lowe's monkey)				
Asibey (Olive Colobus)				
Biopia (Roloway monkey)				
Ebene (Red Colobus)				
Aposo (Potto)				
Aprenkesema (Galago)				

Abundance rating: A - Abundant, C- common, U- Uncommon, R - Rare, E – Locally Extinct
Trend in population: (I) increasing, (S) stable, (D) decreasing, (?) unknown

Status of wildlife in General
21. Have you observed any changes in trend of wildlife numbers over the years? [ ] Decreased [ ] Increased
22. What could be the reason for your observation in the trend? ……………………………………..
23. Do you think wild animals should are important and should be protected? [ ] YES [ ] NO
24. If Yes, why? [ ] bush meat [ ] heritage/future generations [ ] tourism [ ] ecosystem function [ ]
Other (state) [ ] ………

Potential for corridor Establishment

25. Do you know about corridors? [ ] YES [ ] NO
26. Would you sacrifice part of your land to create chimpanzee/primate or elephant corridors? [ ] YES [ ] NO
27. Why?……………………………………………………………………………………........
28. Would you be willing to relocate if the need arrives and compensation given?………………………………...
29. Have you been engaged in tree planting exercise before? [ ] YES [ ] NO
30. If Yes, would you like to do it again? [ ] YES [ ] NO

Why?..

Appendix 4: Plates with Signs of Chimpanzee Presence

Plate 1: A chimpanzee nest up a *Heretiera utilis* (Nyankom) tree in the Krokosua Hills Forest Reserve

Plate 2: Feeding remains of cocoa pods scattered along the Park boundary (Camp 4 area of Bia Conservation Area)

Plate 3: Feeding remains on fruits of *Klainedoxa gabonensis* along trails in Camp 8 - Bia Conservation Area (BCA)

Plate 4: *Klainedoxa gabonensis* fruits cracked open and seed kernels eaten by chimpanzees (Camp 4 Area of BCA)