**UNIVERSITY OF CAPE COAST**

# DISTRIBUTION AND ABUNDANCE OF HORNBILLS IN SOME SELECTED MATRICES/LANDSCAPES IN SOUTHERN GHANA

**SELASI DZITSE**

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**UNIVERSITY OF CAPE COAST**

# DISTRIBUTION AND ABUNDANCE OF HORNBILLS IN SOME SELECTED MATRICES/LANDSCAPES IN SOUTHERN GHANA

**BY**

**SELASI DZITSE**

**Thesis submitted to the Department of Entomology and Wildlife of the School of Biological Sciences, University of Cape Coast in partial fulfilment of the requirements for the award of Master of Philosophy degree in Wildlife Management.**

**MAY 2014**

## DECLARATION

CANDIDATE'S DECLARATION

I hereby declare that this thesis is the result of my own original work and that no part of it has been presented for another degree in this University or elsewhere.

……………………………………. ……………………….

SELASI DZITSE DATE

(CANDIDATE)

SUPERVISOR'S DECLARATION

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

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PROF. K.A. MONNEY DATE

(PRINCIPAL SUPERVISOR)

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MR. K.B. DAKWA DATE

(CO- SUPERVISOR)

## DEDICATION

This work is dedicated to my dearest mother Justine Akorkor Dugbazah and my wife Mrs. Charlotte Amonoo Dzitse

**ABSTRACT**

A study of the seasonal patterns of distribution and abundance of hornbills was carried out from October 2010 to September 2011 in six protected areas of the Upper Guinea Forest of Ghana, a sacred grove, two urban settlements and a biodiversity plot in four regions of Ghana. The study compared the effects of the rainy and dry seasons on the distribution and abundance of hornbills in different matrix types. More hornbills were recorded in the dry season than in the rainy season. Five hornbill species were recorded. They were: *Ceratogymna atrata* (Black-casqued Hornbill), *Tockus fasciatus* (African Pied Hornbill), *Tockus hartlaubi* (Black Dwarf), *Bycanistes fistulator* (Piping Hornbill) and *Tropicranus albocristatus* (White-crested Hornbill). Although the occurrence of *Bycanistes cylindricus* was expected, its absence is an indication of the high level of destruction of Ghana's forests, even protected areas. The study reveals that the populations of Ghana's hornbills may be low. The generally low abundance in some of the study areas may probably be due to effects of prolonged disturbance within their home ranges resulting from mining, logging, hunting and clearing of forests for farming. Examination of the knowledge possessed by indigenous people on aspects of hornbill ecology and possible threats faced by these species indicated that hornbills were currently overexploited. Given this current and other known threats to African forest-dwelling hornbills, this study serves as a basis on which the status of these species may be reviewed periodically.

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# CHAPTER ONE

## Introduction

The forest zones of Ghana extends over the south-western parts of the country and constitutes the eastern end of the upper Guinean forest block, an area considered to be high conservation priority because of the high species diversity and endemism. On the basis of their botanical importance and status of the vegetation, the forests Zones of Ghana have been classified into different categories of (Conditions I-VI) (Ntiamoa-Baidu, Asamoah, Owusu & Owusu-Boateng, 2000). Thus conditions I forest would be an excellent forest with few signs just about (<2%) of human disturbance or fire damage, with good canopy and virgin or late secondary forest throughout, while VI will have no forest left.

It is estimated that over 70% of the Ghana's original closed forest has been destroyed (International Institute for Environment and Development, 1992), leaving only about 11% as intact forest, the bulk of which is within protected areas. Deforestation and fragmentation of forests in Ghana is attributed mainly to clearance for agricultural purposes, logging and bush fires and its loss is estimated at a rate of 22,000 ha per annum (Hawthorne, 1990). The high rate of deforestation has resulted in a patchwork of secondary vegetation and farmlands outside protected areas. The protected areas themselves have been subjected to various degrees of disturbance and only a few of the protected areas still remain relatively unmodified.

Studies on the avifauna of the forests of Ghana include those of Dutson & Branscombe, (1990); Holbech, (1996) and Ntiamoa-Baidu et al. (2000). The study of Ntiamoa-Baidu et al. (2000) indicated that the abundance and diversity of avifauna differed significantly in the different categories of forest. Thus diversity was more in forest types Conditions I and II. No known studies have addressed the distribution of birds especially hornbills in the country's protected areas and also taking into consideration the potential effects of various matrices surrounding the various protected areas on their distribution and abundance. This approach seeks only to measure species presences and absence in these protected areas ignoring the potential of other landscapes to support other biodiversity which leaves out some important concerns such as:

i. How remnant habitat qualities influence species' responses to habitat fragmentation?
ii. How the matrix characteristics, such as matrix suitability, connectivity and heterogeneity influence species' responses to habitat fragmentation?

As a result, there is an urgent need to integrate the habitat quality and matrix characteristics in order to understand how they can shape natural communities. Although some of the matrices may provide some form of useful resources such as food for some species, others are equally hostile to other species (Strayer, Power, Fagan, Pickett & Belnap, 2003). It is therefore expected that, in forested landscapes, land uses that result in ‘‘open’’ deforested habitats, such as agricultural land or residential areas, may be considered equally hostile to forest-dwelling species. This prediction, however, remains largely untested given the paucity of studies that examine the relative impacts of different types of human-modified land cover on species patterns of distribution (Kupfer, Malanson & Franklin, 2006).

Studies from the Dja National park in Cameroon revealed that the larger hornbill *Ceratogymna atrata* reached their highest diversity in matured forests; which also correlated with fruit availability. Hence to better understand hornbill movement, forest utilization and the effect of the various matrices surrounding their respective habitats, it was important to undertake studies in all their ranges (Whitney & Smith, 1998; Raman & Mudappa, 2003).

Birds are a useful model group for examining the effects of habitat fragmentation on biodiversity conservation for three main reasons: first, they have shown to be particularly sensitive to anthropogenic habitat changes (Holt, & Miller, 2011); second, their ecology is indirectly tied to other taxonomic groups (e.g. insects and plants) (Vergara & Armesto, 2009); and finally, some of their natural history and behaviors, such as migration patterns and nest-location, are closely related to the phenology and structural characteristics of the crops. With current anthropogenic factors; logging, poaching, urbanization, agricultural activities as well heavy mining in the protected areas, this thesis investigated the relative abundance of Ghana's hornbill in different landscapes. In a study of forest fragments in Ghana, both Black-casqued and Yellow-casqued Hornbills were completely absent, and the slightly smaller Brown-cheeked and Black-and-white-casqued Hornbills were very rarely recorded (Pepper, 2007).

Bird species such as hornbills that are relatively large-bodied and frugivorous may thus be expected to suffer disproportionately as a result of modification of their natural habitats (Lambert, 1992; Thiollay, 1995; Marsden & Pilgrim, 2003). According to O'Brien, Kinnaird, Jepson, & Setiwan, (1998) Sumba Wreathed Hornbills (*Aceros everetti*) tended to occur primarily in forest patches >1,000 hectares in area and were influenced by forest structure and habitat disturbance. This therefore suggests that hornbills need large tracts of forests which provide the needed resources for their normal activities (Raman & Mudappa, 2003).

**Statement of problem**

Although some studies have been conducted on the presence and absence of hornbills in Ghana, none of these studies had taken into consideration factors affecting their distribution and abundance (Holbech, 1996). Little or no data exist on the status of hornbills in Ghana as well as the potential of well managed sacred groves to support hornbill population and also how hornbills might respond to matrix characteristics surrounding the various protected areas. The World Conservation Union currently classifies African hornbills as "Least Concern" species on the Red Data List because such species are not facing immediate threat of extinction (Kemp, 2001). This may be due to lack of current data on their distribution and abundance patterns. The implication of listing hornbills as List Concern species is that hornbills may receive little conservation attention and this will make the species susceptible to local extinction.

With current anthropogenic factors such as logging, poaching, urbanization, agricultural activities as well heavy mining in the protected areas, there is the need to document how much of Ghana's hornbill species are facing local extinction. In a study of forest fragments in Ghana, both Black-casqued and

Yellow-casqued Hornbills were completely absent, and the slightly smaller Brown-cheeked and Black-and-white-casqued Hornbills were very rarely recorded (Pepper, 2007). The wildlife Conservation Regulation Art of 1995 of Ghana places the Ground-Hornbill (*Bucorvus abyssinicus*) and Black–casqued Hornbill (*Ceratogymna atrata*) as First Schedule animals. “In this Schedule, hunting, capturing or destroying of these animals is absolutely prohibited at all times”.

**Justification**

This study therefore is aimed at filling existing gaps with respect to hornbill conservation in Ghana.

Hence the need for this study to gather information on the current trend of distribution and abundance of the species in formulating plans for long-term scientific monitoring of the species of hornbills populations in Ghana.

This research would form the basis for the formulation of effective management plans and to promote further detailed studies on other aspects of hornbill ecology in all forest remnants of Ghana. Aside the charismatic nature of the hornbills, knowledge on their distribution within the protected areas of the country would help generate revenue for the country as well as the local people through tourism. Encouraging or maintaining hornbill activity through management may be necessary to ensure that they continue to disperse seeds and foster the regeneration of diverse forests. Also, understanding and preserving hornbill movements outside protected areas is even more critical in the face of the bushmeat crisis and the enormous loss of mammal diversity and other important seed-dispersers, especially primates, throughout all protected area from hunting for commercial and subsistence use (Holbrook et al., 2002).

## Study Objectives

### Main objective

The study seeks to gather information on how the matrix activities might potentially affect the distribution and abundance of the species of hornbills within the rainy and dry seasons.

### Specific objectives

The specific objectives of the study are to:

1. identify the species of hornbills within selected study areas;
2. estimate relative abundance and distribution of hornbills within the study areas;
3. determine the factors that are potentially threaten hornbills in the study areas;
4. determine the tourism potential of hornbills using encounter rate;
5. identify the most appropriate areas for forest protection and restoration that will benefit hornbill conservation by identifying land use preference of hornbill species based on the matrix characteristics;
6. study some aspects of ecological behaviour of hornbill species that would aid their conservation;
7. find out local people's perceptions of the hornbills and their interest in conserving them;

These data were examined using One-way ANOVA and t-test at 0.05 alpha levels were used to test significant differences in the means of abundance. Pearson's correlation was used to assess any linear relationships between abundance; and tree density and elevation and Chi-Square test was used to test the significant differences between the frequencies of responses of the two towns.

Considering the paucity of information regarding the distribution and abundance and status of hornbills in Ghana, it is hoped that the findings of this research would be used in planning for hornbill conservation and management.

# CHAPTER TWO

## Literature review

The habitat of a species has been defined as an area with a combination of resources and environmental conditions that promote occupancy by individuals of a given species and allows those individuals to survive and reproduce successfully (Morrison, Marcot & Mannan, 1992). Particularly, the habitat of an animal species is usually dictated by the types of plant species growing, the climatic conditions and the general geography of the area. There are different forms of habitat which could be found on the surface of the earth and are generally classified into three, namely terrestrial, fresh water and marine habitats. Globally, it is generally observed that all these types of habitat have experienced some forms of disturbances such as fragmentation (Ewer & Didham, 2006).

Habitat fragmentation may be defined as an ecological process in which natural habitat is divided into progressively smaller patches in which the original habitat is isolated from each other by a matrix designated as non-habitat (Wilcove, McLellan & Dobson, 1986). Fahrig (2003) proposed that four effects form the basis of most quantitative measures of habitat fragmentation. They are reduction in habitat amount, increase in the number of fragments, decrease in fragment size and increase in fragment isolation (Boscolo & Metzger, 2011). Therefore, a fragmented habitat results after the original cover has been cleared leaving behind a number of smaller patches of the remnant surrounded by a matrix of new atypical habitats such as farmlands, roads, human settlements or even barren land (Hill, Gray, Khen, Benedick, Tawatao & Hamer, 2011). Habitat fragmentation affects different species in different ways. Some species decline sharply or disappear while others remain roughly stable, and even others increase in population.

Two main theories provide the basis for understanding habitat fragmentation and they are best explained by the theory of Island biogeography and Metapopulation dynamics. Island biogeography (MacArthur & Wilson, 1967) and metapopulation theories (Hanski, 1998) put together predict that the processes of extinction and colonization are influenced by island/habitat area and isolation and determine species distributions and persistence patterns. These conceptual models have frequently been applied to explain species patterns and processes in fragmented landscapes (Laurance, 2008).

**Island biogeography theory**

According to Island biogeography theory (MacArthur & Wilson, 1967), the theory has profoundly influenced the study of biogeography, ecology and even evolution (Heaney, 2000). It has also had an enormous impact on conservation biology and thus provides a useful model for understanding contemporary habitat fragmentation. According to this theory, species richness of an island increases with the size and decreases with its degree of isolation of the island (Powledge, 2003; Watling & Donnelley, 2006; Laurance, 2008). This therefore implies that, small and or more isolated habitat fragments are expected to contain fewer species than larger and or less isolated habitat fragments. Despite the fact that this theory has fueled a lot of debate in the scientific world (Debinski & Holt, 2000), nonetheless, has also shaped conservation policies and continue to be the foundation of many present day conservation policies (Powledge, 2003; Watling and Donnelley, 2006; Laurance, 2008).

**Metapopulation theory**

The term metapopulation was coined by Richard Levins in 1970 to describe a model of population dynamics of insect pests in agricultural fields, but the idea has now been most broadly applied to species in naturally or artificially fragmented habitats (Hanski, 2001). Human alteration of the landscape frequently leads to the fragmentation and isolation of once contiguous wildlife habitat. A single population that formerly was dispersed throughout the continuous forest may be isolated into several smaller patches of habitat. These smaller populations may interact if individuals disperse among the remaining habitat patches (Cronin, 2004). This group of spatially separated populations of the same species which interact at some level is what is termed as a metapopulation (van Nouhuys, 2009). The theory postulates that, each population cycle is relative independent of the other populations and eventually goes extinct as a consequence of demographic stochasticity (fluctuations in population size due to random demographic events). Thus the smaller the population, the more prone it is to extinction (van Nouhuys, 2009). However, the metapopulation as a whole is often stable because immigrants from one population are likely to recolonize habitat which has been left open by the extinction of another population. They may also emigrate to a small population and rescue that population from extinction that is rescue effect (van Nouhuys, 2009).

In light of the above, whereas the theories of Island biogeography and metapopulation only provide the bases for understanding species persistence in fragmented habitat in relation to the size of their habitat, the fragmentation of habitat has been to shown to arise from natural and anthropogenic factors (Sahney, Benton & Falcon-Lang, 2010).

**Causes of habitat fragmentation**

Natural and anthropogenic factors are known to cause fragmentation of natural habitat. Evidence of habitat destruction and fragmentation through natural processes such as volcanism, fire and climate change has been documented in fossil record (Sahney et al., 2010). For example, habitat fragmentation of tropical rainforests in Euramerica 300 million years ago led to a great loss of amphibian diversity, but simultaneously the drier climate spurred on a burst of diversity among reptiles (Sahney et al., 2010).

Nonetheless, induced fragmentation of habitat by humans has been shown to be the mechanism of extinctions of many species (Sahney et al., 2010). Habitat loss caused by humans poses the greatest threat to species. The world's forests, plains and other habitats continue to disappear as they are harvested for human consumption and cleared to make way for agriculture, housing, roads, pipelines, rural development, urbanization, creation of hydroelectric reservoirs and industrial development ( Peres & Palacios, 2007). The end result of these fragmentations is typically a mosaic of remnant fragments of habitat containing a sub-sample of the flora and fauna that occupied the formerly continuous habitat (Fahrig, 2003; Ewers & Didham, 2006).

The natural and anthropogenic factors of fragmentation may therefore determine how species are distributed and to a large scale the number of species which can inhabit a given habitat.

**Habitat fragmentation, distribution and abundance of species**

Naturally, the distribution and abundance of wildlife populations have been shown to arise from random demographic processes (Boag & Grant, 1984; DeSante & Geupel, 1987) and the ability of an individual to move within the habitat (Wheelwright, 1983). Such movements may be in response to climatic changes (Root, 1998), breeding (Sergio, Rizzolli, Marchesi & Pedrini, 2004), temporal and spatial variation in food resources (Forsman, Hjernquist, Taipale & Gustafsson, 2009) and predator-prey relationship among species (Selonen, Sulkava, Sulkava, Sulkava & Korpimäki, 2010). Vegetation structure and elevation of a given environment may also shape the availability of critical resources such as resting, or perching sites and shelter which also affect the distribution and abundance of species (Henle, Sarre & Wiegand, 2004).

In tropical forest today, the abundance and distribution of wildlife are strongly correlated with pattern of human modified habitat more than natural occurrences (Kupfer et al., 2006). Thus habitat selection by animals in a fragmented habitat may be influenced by the composition and configuration of the habitat (Stubblefield, Vierling & Ramble, 2006; Radford & Bennett, 2007). This therefore suggests that, animal movements among fragment are dependent on those elements within the habitat which influence the individual species (Hawes, Barlow, Gardner & Peres, 2008; Lee & Pere, 2008). As pressure increases on the remaining forest (Tilman, Fargione, Wolff, D'Antonio, Schlesinger, Simberloff & Swackhamer, 2001), species become more sensitive to the destruction (Stratford & Robinson, 2005) and ultimately become prone to more predation.

Morris (2003), was of the view that species distribution and abundance in part depend on how favourable the habitat is to the species which determine the habitat selection patterns of a particular species. In this direction, it realized that two groups of species may evolve with respect to the nature of the habitat. These are the generalist and specialist species. Habitat generalist species may occupy several habitat types but preferring habitats offering the most resources (Magura, Tóthmérész & Elek, 2003), and switch their habitat selection patterns over time which give them an advantage over specialist species which may require one or only few special habitat types to survive (Chen, Wang & Zhang, 2008). The generalist species are therefore able to persist even in human-disturbed landscapes (Vergara & Armesto, 2009).

**Overview of habitat fragmentation and its effect on biodiversity**

Habitat fragmentation has been shown to affect both plants and animal taxa. These effects determine the distribution and abundance, species diversity, life history strategies and mating systems of individual species (Wiegand, Revilla & Moloney, 2005; Revilla & Wiegand, 2008), interaction of plants with their animal seed dispersers (Herrera & García, 2010), mycorrhizal fungi relation (Peay, Garbelotto & Bruns, 2010), insect herbivores (Cagnolo, Valladares, Salvo, Cabido & Zak, 2009) and parasites (Valladares, Salvo & Cagnolo, 2006).

The impacts resulting from the effect of fragmentation may be classified as negative, positive or neutral on the organisms involved and as such depends on the species-specific properties and local ecological conditions (Wiegand et al., 2005). This therefore suggests that individual species' response to fragmentation depends on its degree of specialization, individual habitat requirements and dispersal abilities as well as interspecific competitive interactions and stochastic event (Uriarte, Anciaes, Da Silva, Rubim, Johnson & Bruna, 2011).

For example, Holt (1997) explained that where species richness increased after habitat fragmentation it could be attributed, in part, to an increase in early successional species, transient species, or edge effects that is community "spillover" from surrounding habitats. A similar study conducted in fragments by Laurance & Bierregaard (1996) on frogs showed an increase in diversity after fragmentation. This was attributed to immigration by generalist species that flourished in the matrix. Quinn & Robinson (1987) also found increased flowering plant and insect species richness with increasing habitat subdivision. Small mammal studies in fragmented habitats also showed an increase in species population. Foster & Gaines (1991) observed a high density of deer mice on small fragments and substantial numbers in the intervening matrix habitat of which Schweiger, Diffendorfer, Pierotti & Holt (1999) interpreted as a combination of habitat generalization and competition. The above investigations therefore revealed that habitat fragmentation may favour on some species.

Also examination of data gathered on passerine by Schmiegelow, Machtans & Hannon (1997), found no significant difference in their richness before habitat fragmentation and after two years of fragmentation. These therefore indicate that habitat fragmentation may sometimes have neutral effect on the abundance and distribution of some species.

Although the above examples may suggest positive or neutral effects of habitat fragmentation, Jackson & Hobbs (2009) have proposed that the negative effects of habitat fragmentation on biodiversity are weightier than those of the positive and neutral effects. The detrimental effects of forest fragmentation from deforestation has been shown to have wide variety of results such as increases in wildfire susceptibility and therefore tree mortality (Alencar, Solorzano & Nepstad, 2004), and changes in plant and animal species composition (Barlow, Peres, Henriques, Stouffer & Wunderle, 2006; Cushman, 2006).

Additionally, habitat fragmentation leads to edge effects. Edges are transitional zones between the patch's natural vegetation and the adjacent modified habitat matrix, which contrast in structure and floristic composition due to changes in physical and ecological processes in the fragments (Ewers, Thorpe & Didham, 2007). The creation habitat edges result in changes in the microclimate conditions that can strongly affect native species (Ewers et al., 2007). As fragmentation occurs, the amount of more edges created increase into the natural vegetation. Edge effects have been proven to create unfavorable conditions for some species in fragmented forests (Fahrig, 2003; Ewers et al., 2007; Banks-Leite, Ewers & Metzger, 2010; Laurance et al., 2011), though these same conditions may favor other species that are more likely to thrive in edge environments (Davies, Norris & Thomas, 2000).

Habitat fragmentation may also increase predation (Herrerías-Diego, Quesada, Stoner, Lobo, Hernández-Flores & Montoya, 2008) and other easier access to interior forest, leading to increased hunting and resource extraction (Peres, 2001) or conversion to agroscape (Kaimowitz & Angelsen, 1998). Hunting and habitat loss, often reinforce each other and hunting pressure tends to be higher in smaller forest patches (Holbech, 1996; DeFries, Foley & Asner, 2004).

Also roads associated with logging or other extractive activities often open up intact forests to hunters in formerly undisturbed areas by creating easy access for the hunters (Pereira Jr., Zweede, Asner & Keller, 2002; Thibault & Blaney, 2003; Walker, 2003). Species population is therefore expected to decline in forest fragments where hunting pressure is high. Subsequently, in forests affected by hunting, the regeneration of large-seeded plants, which include many of the slower-growing canopy trees, is often inhibited as a result of elimination of their dispersers by hunters (Nuñez-Iturri & Howe, 2007; Terborgh et al., 2008; Brodie, Helmy, Brockelman & Maron, 2009; Holbrook & Loiselle, 2009; Sethi & Howe, 2009). This phenomenon threatens species persistence in the habitat and in most cases forces species to move out to find new suitable habitats. The distance and quality of the matrix may represent a constraint for species movement, limiting dispersal, colonization and food availability (Prugh, Hodges, Sinclair & Brashares, 2008).

Studies have shown that habitat fragmentation may ultimately end up in species paying for a “debt” accrued over the years and eventually lead to the extinction of species. Such a debt is what is termed by some ecologists as extinction debt (Vellend et al., 2006; Kuussaari et al., 2009). Extinction debt may be defined as the number or proportion of extant specialist species of the focal habitat expected to eventually become extinct as the community reaches a new equilibrium after environmental disturbance such as habitat destruction, climate change or invasion of exotic species (Kuussaari et al., 2009). Extinction debt is caused by habitat destruction and fragmentation (Kuussaari et al., 2009). The time to "payoff" of extinction debt can be very long. Species may experience a delayed time extinction called ‘relaxation time’ even for centuries after disturbances within their ranges but will ultimately go extinct (Kuussaari et al., 2009). It has been documented that islands that lost habitat at the end of the last ice age 10,000 years ago still appear to be losing species (Diamond, 1972). The incurrence of extinction debts due to human actions has been proven to have shorter timescales. Gonzalez (2000) reported that local extinction of birds from rain forest fragmentation may occur within decades. It has also been proven that plants in grassland fragments showed extinction debts lasting 50 to 100 years (Lindborg & Eriksson, 2004) and tree species in fragmented temperate forests have debts lasting 200 years or more as a result of induced human fragmentation of habitats (Vellend et al., 2006).

**Habitat fragmentation and plant population**

Habitat fragmentation can cause changes in the movement patterns of frugivores which have consequences for seed dispersal (Grünewald, Breitbach & Böhning-Gaese, 2010; Lenz, Fiedler, Caprano, Friedrichs, Gaese, Wikelski & Böhning-Gaese, 2011; Yang, Ferrari & Shea, 2011), especially for plants with large, big-seeded fruits because their dispersal often only depends on one or a few large frugivores (Guimarães, Jordano &Thompson, 2011). Seed dispersal effectiveness of plants with smaller fruit largely depends on the range of frugivore body sizes in the network. Smaller frugivores are able to disperse seeds within their habitats, while larger frugivores disperse seeds between different patches (Spiegel & Nathan, 2007). Therefore a fragmented habitat may not only limit the dispersal of such fruiting trees but may also limit the populations of their dispersers (Schurr, Spiegel, Steinitz, Trakhtenbrot, Tsoar & Nathan, 2009). In addition to that, Lowe, Boshier, Ward, Bacles, Navarro (2005) explained that plant reproduction becomes negatively affected by habitat fragmentation and as such when fragmentation increases, it leads to small and isolated plant populations as well as a decline in the abundance of pollinators (González-Varo, Arroyo & Aparicio, 2009). For example in windpollinated species, their population densities may be drastically reduced after habitats have become fragmented. These have been shown to lead to substantial reductions in seed production (Jacquemyn & Brys, 2008; Hesse & Pannell, 2011). An experiment conducted in fragmented population of dune plant (*Centraurin erythrae),* revealed that, plants growing in pollinatorrich environment had markedly high anther-stigma separation than same species growing in the fragmented (pollinator poor) environment ( Brys & Jacquemyn, 2011).

**Habitat fragmentation and bird population**

For animal taxa such as birds, anthropogenic habitat fragmentation involves series of inter-related components that affects species community and interaction. This may greatly lead to a reduction in the area available for birds to nest, roost and forage. Experiment undertaken by Ruiz, Rosenmann, Novoa & Sabat (2002) on birds has shown that habitat loss increases movement costs to individuals and decreases breeding success (Hinsley, Rothery & Bellamy, 1999). Species of birds whose range encompasses multiple ranges may be more vulnerable compared to those with single patch. For individuals maintaining multiple patch home ranges, smaller and more isolated patches of habitat may require that they consistently travel farther for resources (Bélisle & Desrochers, 2002). Meffe and Caroll (1997) working on songbirds revealed that their composition and abundance changed as fragmentation took place in the landscapes. Ford, Winslow, Whitehead & Koukol (2001) further revealed that reproductive success of songbirds nesting in the forests near an agricultural corridor was lower than in the forest interior. That is, songbirds reproduce more successfully in large forested areas as well as in old growth forests (Brittingham & Temple, 1983). In addition, most forest birds are important in the regulation of insect herbivores populations and their associated damages on plants, wood or fruit production which greatly affect the survival of seedlings and the regeneration of forest (Simonetti, Grez, Celis-Diez & Bustamante, 2007; Philpott, Soong, Lowenstein, Pulido, Lopez, Flynn & DeCleck, 2009; Giffard, Corcket, Barbaro & Jactel, 2012) a decrease in population of insectivorous birds due to habitat fragmentation may lead to an increase of in insect outbreak (Bretagnolle & Gillis, 2010). The biological control of forest insect pests by insectivorous birds is considered a major ecosystem service provided by biodiversity (Wenny, DeVault, Johnson, Kelly, Sekercioglu, Tomback & Whelan, 2011).

**Matrices and fragmentation**

Habitats in fragmented landscape are often embedded in complex mosaics which differ from the original habitat (Ewer & Didham, 2006; Kupfer et al., 2006). It is typically characterized by the portion of the landscape which has undergone anthropogenic disturbances such as road construction, logging, hunting, slush and burn and agricultural activities (Kupfer et al., 2006). Thus the matrix may be a heterogeneous area made of several types of land cover (Lindenmayer & Franklin, 2002), with varying degrees of effects on the structure and dynamics of the fragments (Prugh et al., 2008). The response of any species ultimately depends on the total area and quality of remaining habitat (Gibson et al., 2011), species' dispersal ability and population persistence within fragments. Thus, species may respond differently in a given matrix (Ricketts, 2001).

A matrix that is favourable to an organism is one whose structure and composition provide supplementary resources in the form of food and breeding grounds (Brotons, Monkkonen & Martin, 2003; Cook, Anderson & Schweiger, 2004) and may minimize edge effects as well as harbouring some amount of the original biota (Pardini, Faria, Accacio, Laps, Mariano-Neto, Paciencia & Baumgarten, 2009) . For example matrices of agroecosystems exhibiting diverse habitat structure have been documented to compensate for forest loss and also provide additional food resources (Laube, Breitbach, Böhning-Gaese, 2008). Result from the Amazon forest indicated that, forest fragments surrounded by cattle pastures suffered consistently from greater species loss than do those regrowth forest. The regrowth forest provided species such as certain primates, obligate flocking birds and euglossine bees suitable habitat for recolonization. A hostile matrix is one whose structure and microclimate differ from the primary habitat (Sodhi, Liow & Bazzaz, 2004). Hladyz, Åbjörnsson, Giller & Woodward, 2011) studies also revealed how *Rhododendron ponticum* tree invaded an aquatic-terrestrial fragment matrix edge and subsequently collapsed the food web of the adjacent stream. The invasive plant formed dense dark monoculture that outcompeted the native riparian plant species.

Matrix type can also impact on the internal forest conditions. For example, large scale mining activities may involve removal of vegetation and topsoil and the creation of open pits of exposed earth, all of which could alter soil water retention, create dust pollution, and lead to biogeochemical and hydrologic changes (Bell & Donnelly, 2006; Kennedy, Marra, Fagan & Neel, 2010). All of these factors impact within the forest microclimate and structure and may alter the composition of fauna and flora (Simmons, Currie, Eshleman, Kuers, Monteleone, Negley, Pohlad & Thomas, 2008). It has been documented that even after post-mining restoration, ecological communities may not fully recover to their original state (Parrotta & Knowles, 2001).

Bird species are thus disproportionately affected by forest disturbance from human activities (Kennedy et al., 2010; Marzluff, Bowman & Donnelly, 2001; Rodewald & Bakermans, 2006). However, an unsuitable matrix for one species may be suitable for another (Robichaud, Villard & Machtans, 2002) hence the degree of utilization of a given matrix may depend on the species specific requirements. Species that have restricted ecological preferences (habitat specialists) are likely to be more strongly affected by habitat loss and fragmentation than species those that have broader ecological tolerances and are able to occupy a wider range of habitats (generalist species) (Devictor, Julliard, Couvet & Jiguet, 2008).

**Matrices and avifauna**

Birds may consume fruiting trees within neighbouring matrices. The passage of the these fruits through the alimentary canals aid in faster seed establishment, regeneration and restoration of the once fragmented habitat (Fisher, Stott & Law, 2010). However, for some species of birds, the surrounding matrix may mediate edge effects and influence movements (Laurance et al., 2011). Species of birds that are unable to utilize the surrounding matrix are therefore totally cut off from other fragments (Gillies & St. Clair, 2008). Species which use the matrix may prefer areas that are structurally similar to the primary forest. A project undertaken by Laurance, Lovejoy, Vasconcelos, Bruna, Didham, Stouffer & Sampaio (2002) to reestablish bird community in some parts of the Amazon forest revealed that, the success of reestablishment depended on the nature of matrix. Therefore matrices hostile to birds may lead to a collapse in their diversity.

**Habitat fragmentation in Ghana**

The most fragmented tropical forests today occur in the Philippines, peninsular Malaysia, Ghana, and Costa Rica (Beier, van Drielen & Kankam, 2002). Although protected-area systems in the tropics have been somewhat successful in reducing habitat clearance (Bruner, Gullison, Rice & da Fonseca, 2001; Brooks, Wright & Sheil, 2009), they have been much less effective at preventing more insidious types of habitat degradation (Wright, Sanchez-Azofeifa, Portillo-Quintero & Davies, 2007). In most parts of the tropics, poachers enter and leave so-called protected areas with impunity. Thus the only insurance against the loss of biodiversity is to strengthen existing protected areas which now account for 18% of the tropical rainforest (Brooks, da Fonseca & Rodrigues, 2004).

**An overview of Hornbills, Taxonomy, Phylogeny and Evolution**

Hornbills (Class Aves, Order Bucerotiformes, Suborder Bucerotes and Family Bucerotidae) are species divided into two subfamilies: the Bucorvinae which contains the two ground-hornbills in a single genus. The two ground-hornbill are the earliest surviving offshoots, with fossil evidence from the mid-Miocene in Morocco some 15 million years ago (Kemp & Woodcock, 1995) whereas the Bucerotinae contains all other genera. In the Sibley-Ahlquist taxonomy, hornbills are separated from the Coraciiformes as a separate Order Bucerotiformes, with the subfamilies elevated to family level (Johansson & Ericson, 2003). The Orders that are mostly closely related to hornbills are the Upupiformes (hoopes) and Coraciiformes (rollers, kingfishers and bee-eaters) that share several physical, behavioural, anatomical and morphological features (Kemp & Crowe, 1985).

Based on cladistic analysis, the earliest offshoots appear to be the radiation of the 14 small African *Tokus* species, which are most similar to the hoopoes and woodhoopoes in their biology (Kemp & Crowe, 1985). The three species of *Ocyceros* species of the Indian subcontinent are closely related to, and were earlier placed in the *Tokus* genus. The *Ocyceros* again shows some affinities with the Indomalayan genus *Anthracoceros*. Some of the larger *Anthracoceros* species share similarities with the very large hornbills of the Indomalayan genus *Buceros*. Within the four species of *Buceros,* the Helmeted Hornbill is aberrant in being and the only hornbill with a solid heavy casque and was earlier placed in a separate genus, *Rhinoplax*. The closest relatives in Africa seem to be the seven medium-to-large-sized hornbills (*Ceratogymna*), five of which were earlier in the *Bycanistes*. The remaining three genera, *Anorrhinus*, *Aceros*, and *Penelopides* are all Indomalayan and their relationships with other genera are not clear (Kemp & Crowe, 1985). In Africa, 13 of 23 species are savanna-dwelling, while only one out of 31 in Asia is found in the savanna. The separation of forest patches and isolation may have led to radiation and sub-speciation among forest *Tockus* and *Ceratogymna*. The distribution patterns of hornbills in the Indian subcontent may have also arisen as a result of changes in distribution of forest-savanna mosaics (Ripley& Beehler, 1990).

Evolutionary pathways of hornbills have been determined from the distribution and relationships of the host-specific parasitic feather-lice (*Mallophaga*) found on hornbills (Kemp & Woodcock, 1995), DNA analysis from different species (Sibley & Ahlquist, 1991) and finally the comparison of the number and structure of chromosomes. The DNA analysis also largely support the branching pattern suggested by cladistic and parasitic analysis though not all genera have so far been analyzed (Kemp & Crowe, 1985). Past climatic changes, vegetation distribution and landmass movements are also important in understanding species origins and radiations, and evolutionary relationships and current distribution patterns. The distribution of plant families such as *Lauraceae*, *Palmae*, *Burseraceae Meliceae* and *Moraceae*, which are important sources of hornbill food, especially in Asia have been linked to evolution of hornbills (Lenz *et al*., 2011).

Hornbills have been considered to be monophyletic group on the basis of some unique anatomical and morphological features such as the possession of a casque on top of the bill, fusion of the first two neck vertebrae that support the skull, presence of an accessory supraoccipital condyle along with the normal basioccipital condyle, bi-lobed kidney and prominent eyelashes (Kemp & Woodcock, 1995).

The plumage of hornbills is typically black, grey, white, or brown, although typically offset by bright colours on the bill. Some species exhibit sexual dichromatism; in the Abyssinian Ground-hornbill, for example, pure blue skin on the face and throat denotes an adult female, and red and blue skin denotes an adult male. Hornbills also show considerable variation in size as a family, ranging in size from the Black Dwarf (*Tockus hartlaubi*), at 30 cm, to the Southern Ground-hornbill (*Bucorvus leadbeateri*), at up to 1.2 m (Kemp, 2001)

**Behaviour**

Hornbills generally wake at dawn, preen their feathers, and then begin their search for food. Normally, hornbills move about in pairs, but some species are found in family groups of three to 20 individuals. Others gather in large flocks around clumped food resources (Anggraini, Kinnaird & O'Brien, 2000). For instance, the Sulawesi Redknobbed Hornbill which is occasionally seen in groups of more than 100 individuals at large fruiting figs. In Thailand, Wreathed Hornbills roost in flocks of over 1,000 individuals. The Plain-pouched Hornbill (*Aceros subruficollis*) has been recorded to have the largest aggregations; over 2,400 individuals were counted in Malaysia in 1998 travelling to roost (Kemp, 2001). Many hornbills range widely but none of these movements is considered migratory. Most hornbills are sedentary and many are territorial. The majority of *Tockus* and small-bodied forest hornbills are territorial throughout the year. Hornbills communicate through a wide range of spectacular calls and each species can be identified by its vocalizations. Loud calls announce territories, or in the non-territorial species, aid in maintaining contact (Kemp & Woodcock, 1995).

**Diet**

Hornbills are omnivorous feeding on a wide range of food substances. They cannot swallow food caught at the tip of the beak as their tongues are too short to manipulate it, so they toss it back to the throat with a jerk of the head. Species that specialize in feeding on fruit are generally found in forests (Kemp, 2001). Forest living species of hornbills are considered to be important seed dispersers and had been shown to disperse between 60-80% fruit trees, while feeding (Holbrook, Smith & Hardesty, 2002).

**Breeding**

Hornbills generally form monogamous pairs, although some species engage in cooperative breeding. The female lays up to six white eggs in existing holes or crevices, either in trees or rocks. The cavities are usually natural, but some species may nest in the abandoned nests of woodpeckers and barbets (Kalina, 1988). Nesting sites may be used in consecutive breeding seasons by the same pair. Before incubation, the females of all Bucerotinae sometimes assisted by the male begin to close the entrance to the nest cavity with a wall made of mud, droppings and fruit pulp. There is only one narrow aperture, big enough for the male to transfer food to the female and eventually the chicks. The function of this behaviour is apparently related to protecting the nesting site from rival hornbills (Kalina, 1988). The sealing can be done in just a few hours, at most it takes a few days. Having sealed the nest it takes a further five days for the first egg to be laid. Clutch size varies from one or two eggs in the larger species to up to eight eggs for the smaller species. During the incubation period the female undergoes a complete and simultaneous moult.

It has also been reported that, non-breeding females and males may go through a sequential moult (Moreau, 1966). When the chicks and the female are too big to fit in the nest, the mother breaks out, and then both parents feed the chicks( Kemp, 1991).

The only research on the faithfulness of hornbills failed to find evidence of extra-pair paternity in Monteiro's hornbill (*Tockus monteiri*), boosting confidence in their monogamous behaviour. Among cooperative social groups, there is generally one monogamous breeding pair and a number of offspring who become "helpers" during the nesting season, delivering morsels to their mother and siblings and defending a mutual territory. Cooperative breeding occurs more often in hornbills than any other bird family, and may characterize up to one-third of all hornbill species (Kemp & Woodcock, 1995).

**Associations with other species**

A number of hornbills have associations with other animal species. For example, hornbills in Africa have a mutualistic relationship with dwarf mongooses, in which they forage together and warn each other of nearby birds of prey and other predators (Anne & Rasa, 1983). Other relationships are commensal, for example with monkeys or other animals (Gaietti & McConkey, 1998).

**Cultural significance**

The casques of most species are very light, containing a good deal of airspace. However, the Helmeted Hornbill has a solid casque made of a material called hornbill ivory, which is greatly valued as a carving material in China and Japan. It is often used as a medium for the art of netsuke (Solanki, Cutia & Singh, 2004; Riba, 2012).

**Significance to humans**

Like many other groups of birds, hornbills are hunted for food and medicinal purposes. For example, in Africa, parts of the ground-hornbill are eaten to improve health and sagacity (Pepper, 2007). In India, oil extracted from the Great Hornbill, the Indian Pied Hornbill, and the Indian Gray Hornbill are supposedly to aid in childbirth and relieve gout and joint pains. In Indonesia, the meat of the Sumba Hornbill is roasted and eaten to relieve rheumatism and asthma. Because they are easily tamed, hornbills are captured and traded for pets or exhibitions (Kumar et al., 2011).

Hornbills also play special roles in the folklore and ceremonies of the countries where they occur. Long, elegant tail feathers are the most sought-after hornbill part, but heads and casques are also coveted. The Nishis people of Arunachal Pradesh, India, attach the upper beak of the great hornbill to rattan *bopiah* caps as traditional male headgear. Neighbouring Wanchos of eastern Arunachal use the warm, chestnut-coloured neck feathers of rufous-necked hornbills to cover caps (Kumar et al., 2011).

Hornbills are increasingly highlighted as local mascots or state birds. This is especially true in Asia. The Great Hornbill is the state bird of Arunachal Pradesh, northern India. The Rhinoceros Hornbill has been adopted as the state bird of Sarawak, Malaysia, where it appears on tourism advertisements, T-shirts, and even the state coat-of-arms. In Indonesia, the

Helmeted Hornbill, the Sulawesi Red-Knobbed Hornbill and the Sumba Hornbill proudly serve as official mascots for three provinces.

**Ecological significance**

Hornbills are good indicators of the state of the rainforests as they have highly specialized requirements such as large nesting trees and large seeded lipid-rich fruit (Kemp & Woodcock, 1995; Mudappa, 2000; Datta, 2003). They are also considered as mobile link species responsible for linking one forest type to another as a result of their dispersal abilities (Balasubramanian, Aruna, Anbarasu & Kumar, 2011). Studies undertaken by Whitney et al., (1998) indicated that three species of hornbills dispersed between 60%-96% of forest fruiting trees.

**Conservation status**

According to the IUCN, only 16% of all hornbill species are classified as being under some level of threat, ranging in increasing degree from Vulnerable to Critical and Endangered. An additional 12 species, however, are considered Near Threatened and will probably experience a decline in status within the twenty-first century. According to the IUCN (BirdLife International, 2001), Africa presently has no hornbills in danger of extinction; only two West African forest inhabitants, the Yellow-Casqued Hornbill (*Ceratogymna elata*) and the Brown-Cheeked Hornbill (*Bycanistes cylindricus*), are classified as Near Threatened (BirdLife International, 2001). However it is believed that species in danger or suffering some threat reside in Asia. This accounts for about (77%) of the Asia hornbills with majority occurring on small oceanic islands. The Sumba and Narcondam hornbills, both single-island endemics, are classified as Vulnerable, with total populations assumed to hover around 4,000 and 300, respectively; and this may be due partly to the fact that there are no rigorous population estimates for hornbill species (BirdLife International, 2001). The underlying threat to hornbill populations is habitat alteration resulting in forest loss and fragmentation. As forests become smaller and more isolated, hornbill populations decline, resulting in increased vulnerability to extinction (Kumar et al., 2011). Unsustainable hunting as food, pets, and body parts have also been identified as a major problem facing hornbill populations (Kumar et al., 2011). Traditions that require feathers or skulls take a toll on living birds. For example, female Kenyalang dancers of Malaysia carry up to 10 hornbill tail feathers in each hand, thus supplying a full complement of 20 dancers can cost up to 80 hornbills (BirdLife International, 2001).

Lepage (2007) has recorded twelve species of hornbills in Ghana. Two of the twelve species are resident in the savannas and woodlands, while the remaining ten are considered to be forest-dwelling. They include; Brown-Cheeked, Piping, African Pied, White-crested, Black-casqued, Black-and-white-casqued, Yellow-casqued and Black Dwarf Hornbills. Results of studies on hornbill distribution and abundance in some other parts of Africa gives strong indication that hornbills are affected by a variety of factors especially the types of matrix activities surrounding their habitats (Whitney & Smith, 1998).

**Brown-Cheeked Hornbill (*Bycanistes cylindricus*)**

It is a large, stout black-and-white forest hornbill measuring between 65-77 cm in length. It can be distinguished by the presence of a broad black band on a white tail. The underparts to upper belly and upper thighs are black in colour, while the lower belly and undertail-coverts of the body also appear white as depicted in Plate 1. The head-sides and upper throat areas appear brownish and in most cases adult females are smaller in size with smaller bill and casque, while juveniles look similar to adult but have bills which are smaller and lacking casque. It is a species of primary and mature secondary undisturbed forest (Thiollay, 1985; Holbech, 1996). As with other large hornbills, it is dependent on the presence of large emergent trees and dead standing trees at heights between 20-25 m for nest sites and appears to be all year round breeder (Gartshore, Taylor & Francis, 1995; del Hoyo, Elliott & Sargatal, 2001). It forages on fruit in the canopy and will also take insects (Fry, Keith & Urban, 1988). They may gather in small groups at fruiting trees, often with other species of hornbills. They have strong flight and with loud swishing wing beats interspersed by glides (Borrow & Demey, 2010).

This species is listed as Near Threatened because it is suspected to be undergoing at least a moderately rapid population decline owing to the impacts of habitat destruction and degradation and hunting pressure. If the rate of decline is found to be greater, the species may qualify for uplisting to a higher threat category (BirdLife International, 2011).

*Bycanistes cylindricus* is restricted to the Upper Guinea forests of West Africa, where it is found in southern Guinea, Sierra Leone (Okoni-Williams, Thompson, Wood, Koroma & Robertson, 2001), Liberia (Gartshore et al., 1995), South-West Ghana and Togo (Kemp & Woodcock, 1995).


**Plate 1:** Brown-cheeked Hornbill (*Bycanistes cylindricus*)

**Piping Hornbill (*Bycanistes fistulator*)**

It is a medium-sized, compact black-and-white forest hornbill measuring between 50-60 cm in length. It distinguished by the presence of black wing with white tips to the secondaries as shown in Plate 2. The adult female is usually smaller in size than the adult male. The bill of the juvenile is smaller and all dusky (Dowsett & Forbes-Watson, 1993; Sibley & Monroe, 1993; Borrow & Demey, 2010).

Piping Hornbills usually move in pairs or family trios in canopy of lowland and gallery forest and may congregate in feeding flocks during the breeding seasons. Their flight is slightly undulating with fast, shallow wing beats interspersed by glides which make rushing sound in flight (Borrow & Demey, 2010).

This species has an extremely large range, and hence does not approach the thresholds for 'vulnerable' status and has been reported to be generally common (del Hoyo et al., 2001; BirdLife International, 2011).


**Plate 2:** Piping Hornbills (*Bycanistes fistulator*)

**African Pied Hornbill (*Tockus fasciatus*)**

It is a medium-sized, slender black-and-white hornbill with cream-yellow bill with black tip as shown in Plate 3. The hornbill measures between 48-55 cm long. The African Pied Hornbill is black in colour entirely, except for the lower breast to undertail-coverts which are white (Clements, 2008; Borrow & Demey, 2010). The adult female is quite smaller in size than the adult male and has a slightly smaller bill. The female lays up to four white eggs in a tree hole, which is blocked off during incubation with cement made of mud, droppings and fruit pulp. There is only one narrow aperture, just big enough for the male to transfer food to the mother and the chicks. When the chicks and the female are too big to fit in the nest, the mother breaks out and rebuilds the wall, and then both parents feed the chicks (Clements, 2008).

African Pied Hornbill is omnivorous and eats fruits and insects and is also attracted to oil palms trees (Borrow & Demey, 2010). African Pied Hornbill is a common resident breeder in much of West Africa , Central and East Africa. The global population size has not been quantified, but the species is reported to be widespread and locally common to very common (del Hoyo et al., 2001).


**Plate 3: African Pied Hornbill (*Tockus fasciatus*)**

**White-crested Hornbill (*Tropicranus albocristatus*)**

Depicted in Plate 4, the White-crested Hornbill (*Tropicranus albocristatus*), also known as the Long-tailed Hornbill, is a species of hornbill found in humid forests. It is slender in nature with characteristic white head and crest and a blackish bill. The bird can also be identified with a distinct bare pinkish throat patch. It is monotypic within the genus *Tropicranus*, but is sometimes included in the genus *Tockus* instead. The White-crested Hornbill has a large range in Africa across Angola, Benin, Cameroon, Central African Republic, Democratic Republic of the Congo, Ivory Coast, Equatorial Guinea, Gabon, Ghana, Guinea, Guinea-Bissau, Liberia, Nigeria, Sierra Leone, Togo, and Uganda (BirdLife International, 2004).

This species has an extremely large range, and hence does not approach the thresholds for 'vulnerable' under the range size criterion (Extent of Occurrence <20,000 $km^2$ combined with a declining or fluctuating range size, habitat extent/quality, or population size and a small number of locations or severe fragmentation). For these reasons the species is evaluated as Least Concern (BirdLife International, 2011). According to del Hoyo et al. (2001), the global population size has not also been quantified, but the species is reported to be widespread and locally common but patchily distributed.


**Plate 4: White-crested Hornbill (*Tropicranus albocristatus*)**

**Black-casqued Hornbill (*Ceratogymna atrata*)**

It is a very large, black forest hornbill with black bill. It measures about 70-90 cm in length. The adult male looks all black, except for broad white tips at the outer tail feathers with a massive cylindrical casque which is blackish in colour. The eye is round with a bare skin and inflatable bare throat wattles which are light blue in colour as shown in Plate 5. The adult female is usually smaller in size, with rufous head and neck, and smaller bill and casque. The juvenile looks similar to adult female in appearance but has smaller bill, without casque and wattles.

(Dowsett & Forbes-Watson, 1993; Sibley & Monroe, 1993; Borrow & Demey, 2010). Black-casqued Hornbill moves in pairs or small family parties in canopies of mature lowland forests and sometimes several individuals may gather at fruiting trees, often with other large hornbills.

It is also found across the Central and West of Africa (BirdLife International, 2004). Although the population size has not been quantified, it is not believed to approach the thresholds for 'vulnerable' hence it is evaluated as Least Concern (del Hoyo et al., 2001).

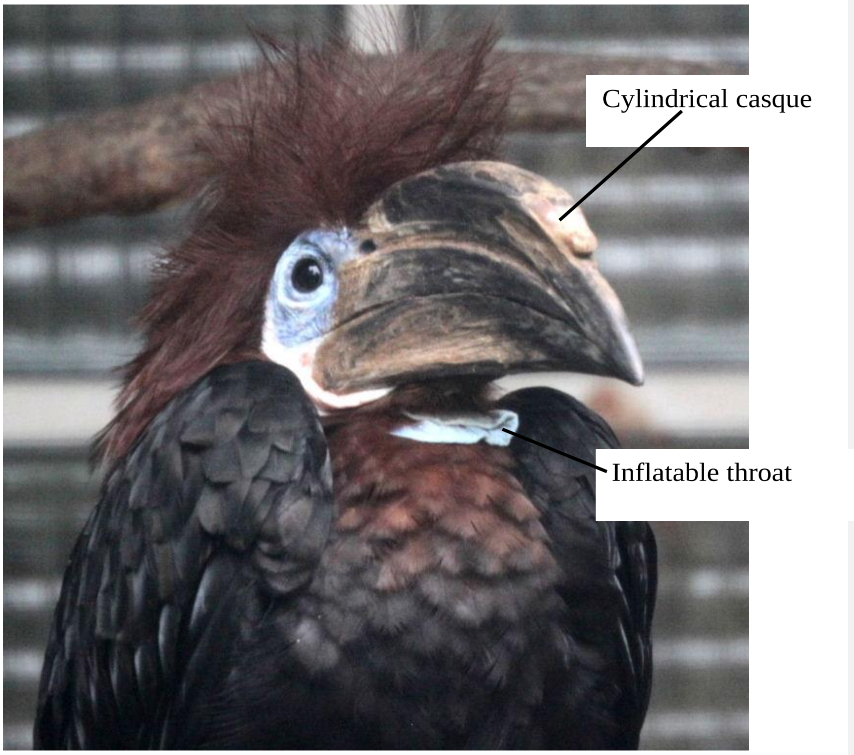


**Plate 5: Black-casqued Hornbill (*Ceratogymna atrata*)**

**Black-and-white-casqued Hornbill (*Bycanistes subcylindricus*)**

The Black-and-white-casqued Hornbill is also known as Grey-cheeked Hornbill. It is large, approximately 60-70 cm long and has an over-sized blackish bill with large casque on top. It has a characteristic black central tail feathers with while the rest of the tail is white with a broad black band on the centre tail as shown in Plate 6. The entire wings are black with the secondaries and inner primaries being white. The males are usually larger than females in size (Borrow & Demey, 2010). The Black-and-white-casqued Hornbill breeds throughout the year, but generally concentrates breeding during the local rainy season of each part of their range. It nests in naturally formed cavities measuring between 9-30 m high in large rainforest trees, and seal the cavity with mud pellets collected by the male. Inside, the female lays 2 white eggs, which she incubates alone for about forty-two days, while the male delivers food to the female through a small slit, by regurgitating numerous fruits, mammals and insects (Borrow & Demey, 2010). The Black-and-white-casqued Hornbill is most commonly found in subtropical and tropical lowland and mountain forests, being also sighted in artificial landscapes such as plantations or urban areas, heavily degraded forests and dry savannas. These birds are mostly frugivorous, with the fruits of *Ficus* trees composing more than half of their diet. Overall, they are known to eat the fruits of over 41 plant genera, which they forage by hopping from branch to branch in the rainforest canopy and reaching for fruit with the tip of the bill, which they then swallow whole. They also consume eggs, insects, bats, lizards, molluscs, other small animal prey, mosses, lichens, and fungi (Borrow & Demey, 2010).

The global population size has not been quantified, but the species is reported to be locally uncommon to common over its very large breeding range (del Hoyo et al., 2001; BirdLife International, 2004). This species is able to survive in degraded forest and open areas, which allows it to survive large scale habitat degradation occurring throughout its range. However, forest degradation in Africa means that hornbills now occur in more open areas with few large trees, which makes them more prone to hunting (Pepper, 2007). These birds are found throughout West and Central Africa (Borrow & Demey, 2010).


**Plate 6: Black-and-white-casqued Hornbill (*Bycanistes subcylindricus*)**

**Yellow-casqued Hornbill (*Ceratogymna elata*)**

It is a very large forest hornbill resembling the Black-casque Hornbill but with differently shaped and coloured casque and different tail patterns. The neck feathers have white bases and brown tips and the adult male has cream-coloured upper part on the casque distinguishing it from the adult female (Borrow & Demey, 2010).

It is a bird of lowland primary forest but also occurs in logged and secondary forest, riverine forest and oil palm plantations (Elgood, Heigham, Moore, Nason, Sharland & Skinner, 1994). It undergoes local movements in response to fruit availability and usually move in pairs or in small family parties in tree canopies. It may also been seen in gallery forest and forest patches in the savannah often gathered at fruiting tree, with other large hornbills (Borrow & Demey, 2010).

Yellow-casqued Hornbill is widespread in West Africa (Elgood et al., 1994; Jam, 2006). This species is now listed in the IUCN threat category as Near Threatened. The rate of population decline in this species is estimated at about 16% over the past ten years. Hunting and logging have been attributed as two of the most probable threats to the species in small forests throughout its range (Holbech, 1996).

**Plate 7: Yellow-casqued Hornbill (*Ceratogymna elata*)**

**Black Dwarf Hornbill (*Tockus hartlaubi*)**

It is a small scruffy-looking, black forest hornbill with broad greyish-white supercilium from bill to nape. The underparts are grey, becoming whitish on the belly. The adult male has characteristic black bill tipped dark red while in the adult female, the bills are entirely black as depicted in Plate 8. The juveniles are similar to adult females only differing in size (Borrow & Demey, 2010).

The Black Dwarf Hornbill is mostly found in lowland and gallery forests moving in singles, in pairs or small family parties. They mostly inhabit the liana-rich areas at mid-level and lower canopies of the forest and often seen perching silently for long periods and may pick insects from leaves or in mid-air (Borrow & Demey, 2010).

It can also be found in parts of West, Central and East Africa. The global population size has not been quantified, but the species is reported to be locally common (del Hoyo et al., 2001). The population is suspected to be stable in the absence of evidence for any declines or substantial threats. This species has an extremely large range, and hence does not approach the thresholds for 'vulnerable'. For this reason the species is evaluated as Least Concern (del Hoyo et al., 2001).


**Plate 8: Black Dwarf Hornbill (*Tockus hartlaubi*)**

# CHAPTER THREE

## Study areas

Survey of hornbills was carried out in four regions of Ghana namely; Ashanti, Central, Eastern and Western. The study areas comprised six protected areas, a Biodiversity plot, a sacred grove and two urban settlements as shown in Figure 1.

A protected area is a geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values (Dudley, 2008). Protected areas act as refuges for species and to maintain ecological processes that cannot survive in most intensely managed landscapes and seascapes. Protected areas thus act as benchmarks against which human interactions with the natural world is understood (Dudley, 2008).

On the other hand, Biodiversity plots are patches of remnant forest of varying sizes that are left uncleared within a plantation matrix to serve as refugia for fauna and flora in the plantation area. This is one practical way of ensuring sustainability of local biodiversity within the grossly altered plantation landscape. The patches of natural forest in the area are necessary for the maintenance of local fauna and flora as well as ecological services such as stream flow, reduction in runoff water and erosion along steep slopes in the face of the mass and extensive removal of natural vegetation.

Sacred groves are considered as “Sacred Natural Sites”. They are areas of importance to one or more faith groups. (Oviedo, Jeanrenaud, & Otegui, 2005). They are also cultural sites with protection of significant and important biodiversity (Dudley, 2008). Sacred groves occur in continents such as Asia, Africa, Europe and Americas but their present occurrence is mostly restricted in Africa and Asia (Hughes & Chandran, 1998). In Ghana sacred groves were considered the dwelling places for ancestral spirits and gods and were protected by strict traditional laws and taboos. Any forms of activity within them are totally prohibited except permission is obtained from the custodian of the grove and only after libation is offered to the gods without which one may incur the wrath of the gods. Although sacred natural sites face challenges due to changing Christian religious and cultural values and modernization, some tribal and traditional groups still adhere to the practice of maintaining sacred forest and groves. Notable examples in Ghana include those of Dumpow Sacred Grove located in Agona Abrem and Anweam Sacred Grove located in the Eastern Region.

Meanwhile, urban areas are described as areas characterized by higher population density and vast human features. Urban areas may be cities and towns . Urban areas had long been disregarded as study objects in ecological research (McDonnell & Hahs, 2008). However, areas within cities and towns which offer favourable dwelling places for animals may become colonized. They provide opportunities for populations of numerous plant and animal species, which might even be more abundant in urban areas than in other ostensibly ‘natural’ areas (Angold, Sadler, Hill, Pullin, Rushton, Austin, Small, Wood, Wadsworth, Sanderson & Thompson , 2006)

In light of the above, the following were selected for the study. Supuma Shelter Belt in the Ashanti Region, Kakum National Park and Pra-Sushien Forest Reserves in the Central Region, Atewa Forest Range in the Eastern Region and Neung North and Subri River Forest in the Western Region all of which comprised the six protected areas are. The Dumpow Sacred Grove at Eguafo Abrem of the Central Region. The two urban settlements are Jukwa and University of Cape Coast Lecturer s' Village all located in the Central Region and the Biodiversity plot belonging to Ghana Oil Palm Development Company located at Kwae in the Eastern Region.

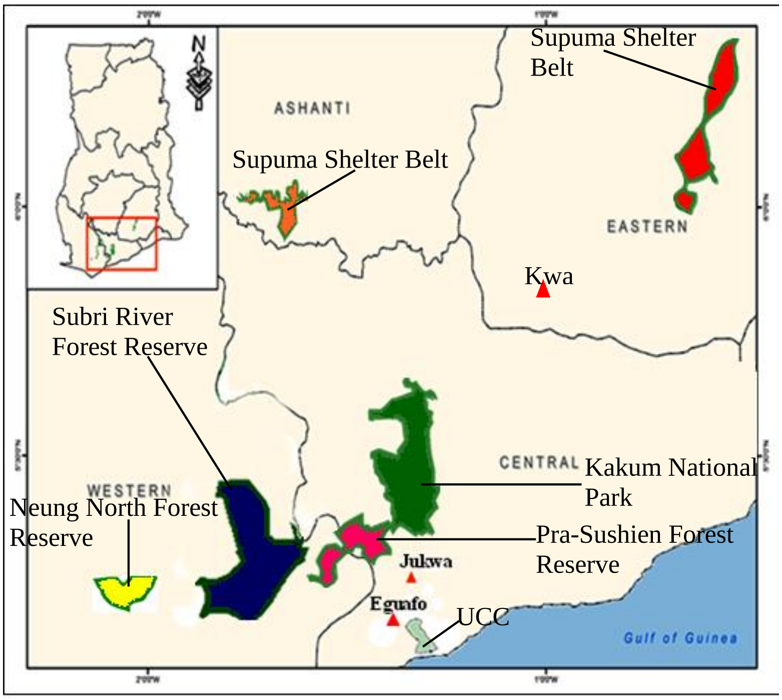


**Figure 1:** Regional distribution of the study areas.

**Atewa Forest Range**

The Atewa Forest Range is one of the couples of upland Evergreen forest and represents about 33% of the remaining closed forests in the Eastern

Region of Ghana (Hall & Swaine, 1981, Abu-Juam, Obiaw, Kwakye, Ninnoni, Owusu, & Asamoah, 2003). The Atewa Range Forest Reserve has an area of 23,663 ha. The Atewa mountain range is characterised by a series of plateaus which runs from north to south. The Forest Reserve was established as a national forest reserve in 1926 and has since been designated as a Globally Significant Biodiversity Area (GSBA) and an Important Bird Area (IBA) (Abu-Juam et al., 2003). Atewa is home to many endemic and rare species, including black star plant species and several endemic butterfly species (Hawthorne, 1998; Larsen, 2006). Seasonal marshy grasslands, swamps and thickets on the Atewa plateaus are nationally unique (Hall & Swaine, 1981). Atewa has headwaters of three river systems: the Ayensu, Densu and Birim rivers. These three rivers are the most important sources of domestic, agricultural and industrial water for local communities as well as for many of Ghana's major population centres, including Accra (Hall & Swaine, 1981).

More than 40 settlements with an estimated population of about 75,180 are located within the vicinity of the Atewa Range. The indigenes are predominantly subsistence farmers. However, the lease of the forest edges by government to SEMS Gold Exploration Group and other companies has resulted in unsustainable exploitation of the forested areas through illegal logging, illegal mining activities and illegal hunting as depicted in Plates 11, 12 and Figure 2 (SEMS Exploration, 2012). The illegal entering of hunters into the forest has resulted in the creation of many trails which are exploited for poaching activities.

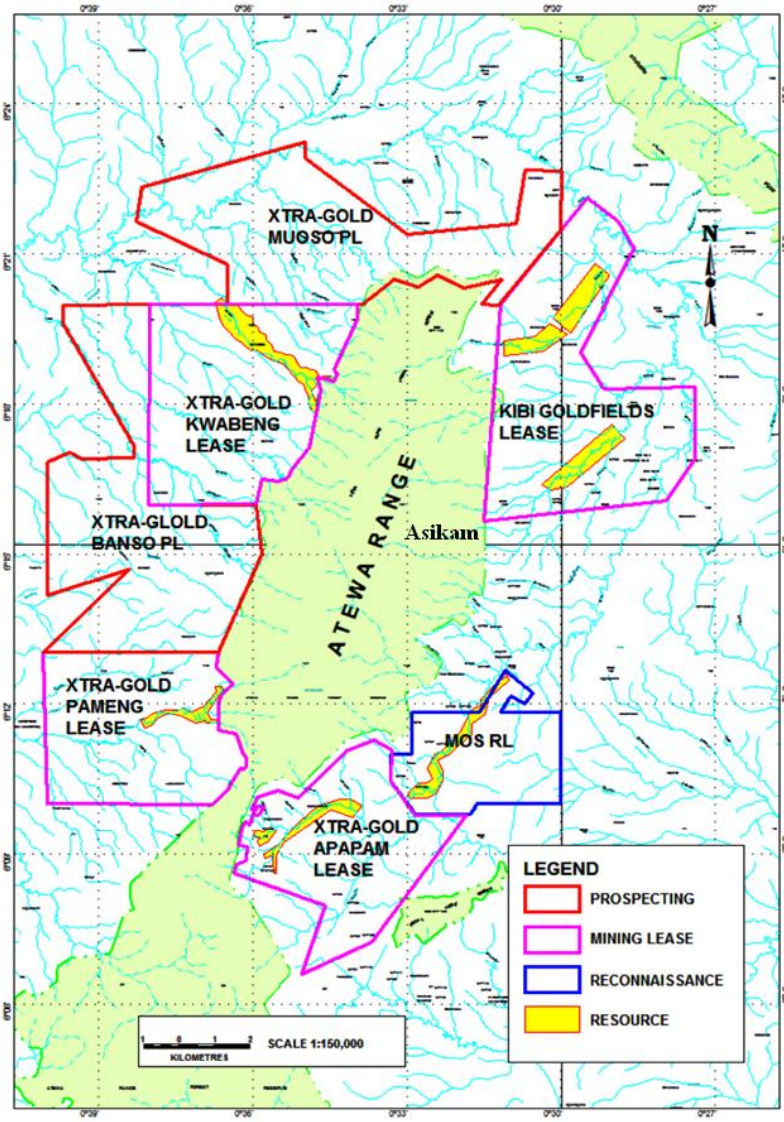


**Figure 2:** Detailed map of Atewa Forest Range showing areas earmarked for gold mining

Source: Chevyrock Engineering

**Kakum National Park (KNP)**

The KNP is a protected area but part of the irregular remnant of the fast dwindling Ghana's portion of the moist evergreen Upper Guinea Forest and dominated by *Celtis zenkeri* and *Triplochiton scleroxylon* although there are about 100 tree species. The KNP spans the Twifo Praso, Assin and Abura districts of the Central Region of Ghana (1° 30' - 1° 51' W; 5° 20'- 5° 40' N) and is sited about 165 km west of Accra, the national capital. The general climatic conditions of the country characterized by bimodal rainfall and two dry seasons (Durand & Skubich, 1982) prevail in the park. A heavy rainy season from April to July is followed by a light dry season from August to September. A light rainy season from October to early December is then followed by a heavy dry season from December to March (Kouadio, Diomande, Ouattara, Koné, Gourène, 2008). The fauna may concentrate in and around the few water spots available in the park during the dry harmattan from December to March; that is the heavy dry season. The average annual rainfall is about 1600 mm (Forestry Commission, 2007). The park protects the headwaters of permanent rivers such as Kakum, Obuo and Nemini and rivulets like Ajuesu which may dry up in the main dry season. The average relative humidity is about 80% throughout the year, while temperature ranges from 18.2 to 32.1°C. The terrain is flat to slightly undulating with an elevation of between 15 to 250 m above sea level (asl) (Forestry Commission, 2007). Most of the elevations occur in the south-western portion of the park. Light south westerly winds blow over the area almost throughout the year. About 60 fringe communities and many small settlements can be found around the Kakum National Park; six of which are designated by the Wildlife Division of Ghana as camps where park guards are stationed as shown in Figure 3. The population estimate ranges between 65,000 to 70,000. Agriculture is the major economic activity, with cocoa being the main cash crop and cultivated by most households. In parallel, the majority of households are involved in subsistence agriculture. Many households are also involved in the collection of Non-Timber Forest Products (NTFPs), such as mushrooms, snails, tortoise and fruits. On the other hand, the park itself is increasingly being developed to a holiday resort offering great potential for both tourists and holidaymakers locally, nationally and internationally (Forestry Commission, 2007).

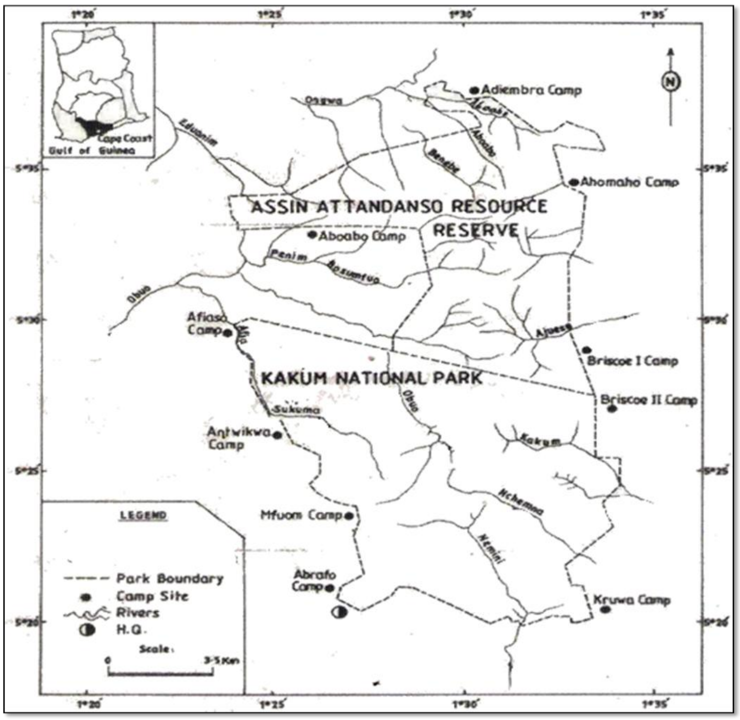


**Figure 3:** Detailed map of Kakum National Park showing some fringe communities.

Source**:** (Forestry Commission, 2007).

**Neung North Forest Reserve**

Neung North Forest Reserve located in the Wassa West District and is located immediately adjacent to the southern boundary of the Iduapriem operational area of AngloGold Ashanti in the Western Region of Ghana as shown in Figure 1. The average annual rainfall is between 1700 – 2000 mm and the soils are of highly acidic latosols. These soils also contain deposits of gold and diamond, and the forest is of the wet evergreen type. The Neung North Forest Reserve is about 44.85 $km^2$; currently undergoing large scale gold prospecting and mining by AngloGold Ashanti. Most of the inhabitants live far from the reserve and are predominantly farmers. However, due to the discovery of gold in larger quantities there are evidences of large scale illegal mining.

**Pra-Sushien Forest Reserve**

The Pra-Sushien Forest Reserve forms an irregularly-shaped block of evergreen forest stretching from south-west to north-east from the Pra river near Twifo Hemang township to Abrafo Odumase ($1^o$ 32.00' W; $5^o$ 16.00' N). It is therefore separated from Kakum Conservation Area by the Cape Coast Twifo Praso road. The terrain of the reserve is very undulating characterized by hilly slopes and narrow valleys, making accessibility even on foot hazardous. The area is drained by some tributaries of the Pra River such as Offin and Anum. The vegetation is moist evergreen forest, and dominated by primary and mature secondary forests. The inhabitants of the area are mostly subsistence farmers. However, large palm oil plantations can be seen at other areas near the reserve. Records, however, show continuous logging from 1975 to 1991. The southern parts of the reserve have been heavily disturbed, but intact forest patches persist in the areas near Kakum Conservation Area.

**Subri River Forest Reserve**

Subri River Forest Reserve is located 16 km south of the old railway line linking the Huni Valley–Twifo Praso townships. It is about 21 km from

Daboase village. The site is only some 3 km from the Pra-Sushien Reserve and is the largest Forest Reserve in the Country. The topography is generally undulating with altitudinal range of 60–125 m asl. However the northern, south-eastern and central parts have steep-sided hills that reach about 300 m high. The reserve forms part of the watershed between the Bonsa and Pra rivers and is traversed by tributaries of each, resulting in extensive areas of swampy vegetation which make accessibility difficult even in the dry season. The vegetation is moist evergreen forest, but wet evergreen forest is reported to occur in some parts. Some areas of the reserve were subjected to salvage felling between 1966 and 1976, followed by selective logging since 1978. Some 12,372 ha have been converted to cocoa plantation. Although the inhabitants are mostly farmers they have now resorted to illegal gold mining activities due to the discovery of gold at Akyempim as shown in Figure 4. The inhabitants of Essamang have also resorted to other illegal activities such as depicted (Birdlife International, 2011).

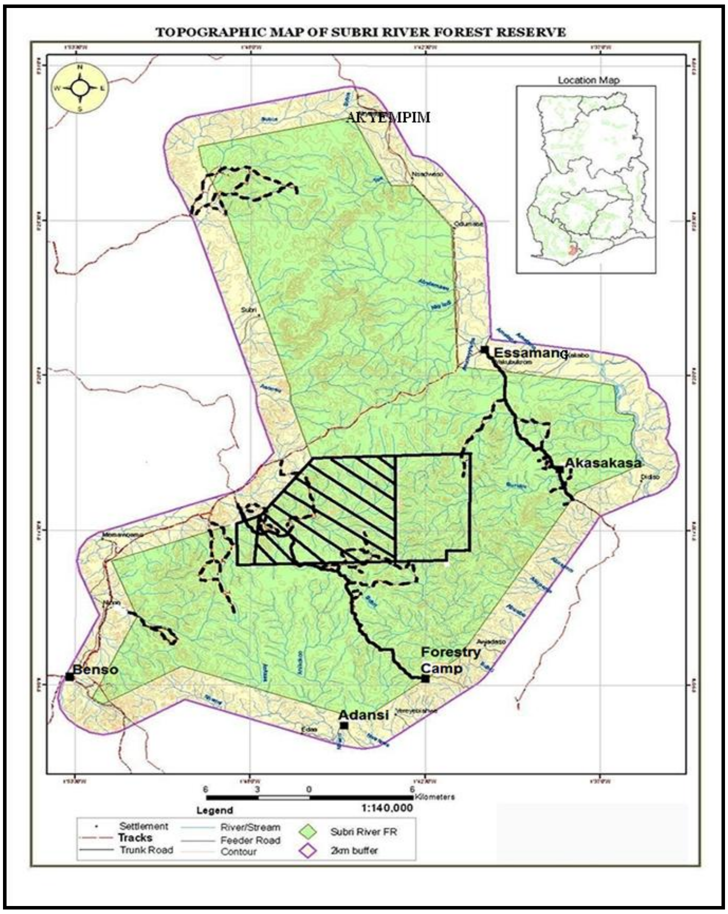


**Figure 4:** Detailed map of Subri River Forest

Source : (Malleson, R., Asaha, S., Egot, M., Obeng-Okrah, K., & Ukpe, L. 2005)

**GOPDC Biodiversity plot**

Ghana Oil Palm Development Company (GOPDC Biodiversity Plot) is located at Kwae in Kade of the Kwaebibirem District, Eastern Region. It is an integrated agro-industrial company specialized in the organic cultivation of oil palm, extraction of crude palm oil and palm kernel oil. Ghana Oil Palm Development Company produces refined specialty oils for use by the food industry in Ghana. The company was a state owned enterprise and was divested in 1995 with Siat Ghana Limited acquiring a majority stake in the new company. It has 21,000 ha of oil palm plantations at Kwae and Okumaning (GOPDC, 2008). Oil palm plantation development often involves removal of existing vegetation before planting. This often led to loss of biodiversity of the existing land. As part of maintaining biological diversity, some plots of lands have been left intact by GOPDC. The plots are positioned in upland sections of the plantation as well as along the banks of streams, where they are designed to provide a 30 m wide "buffer zone" where no clearing or erection of any structure is permitted (GOPDC, 2008).

**Plate 9:** An aerial view of Ghana Oil Palm Development Company plantation

Source : (GOPDC, 2008)

**Dumpow Sacred Grove**

Dumpow is a hill in Eguafo. The Kingdom of Eguafo is part of a mainstream ancient empire of the Akan Tribe and is the current capital of the Eguafo State and the ancient capital of what is now known as the Komenda-Edina-Eguafo-Abrem (KEEA) municipality in the Central Region, Ghana.

This is a montane sacred groove and is about 1.5 $km^2$ in area. Its pristine nature coupled with high forest trees offers an ideal habitat for the refuge of birds and other fauna. The members of the community are subsistence farmers (Chouin, 2002). This hill provides a lookout post for fishermen at Elmina and the other surrounding coastal villages. From the high point of the hill, in clear weather, one could see as far as Sekondi, forty-two miles away. This is depicted in plate 10 below.

**Plate 10:** An aerial view of Dumpow Hill

Source: (Chouin, 2002)

**Jukwa Settlement**

Jukwa, which means "So peaceful" is a town about 18 km north of Cape Coast in the Twifo Praso Lower Denkyira District in the Central Region of Ghana. Jukwa is the traditional capital of the Denkyira people of Ghana. It is located at an elevation of 75 m asl and lies within longitude 1° 20' 0" West and latitude 5° 16' 0" North. The landscape can be described as undulating having remnants of scattered forest trees. The population of the inhabitants is estimated to be 14,227 with majority of the inhabitants engaging in palm oil plantations whereas others are subsistence farmers (Christaller, 1881)

**University of Cape Coast Lecturers' Village**

The University of Cape Coast is described as one of the rare sea front universities in the world. It was established in October, 1962 as a University College and placed in a special relationship with the University of Ghana, Legon. The university, which is five kilometres west of Cape Coast, is on a hill overlooking the Atlantic Ocean. It operates on two campuses: the Southern Campus (Old Site) and the Northern Campus (New Site). The campus is endowed with serene atmosphere and beautiful landscape which gives it an ideal environment for learning and research. With a University reserve and other numerous scattered trees, the surrounding serves as a place of refuge for birds and other animals. Unlike some universities in the world, the University of Cape Coast provides lecturers with accommodation within the University premises to support over 15,000 students residing on campus with greater number of staff bungalows located at the New Site. The social life of the University is centred on the six halls of residence and the surrounding six villages.

# CHAPTER FOUR

## Methodology

### Hornbill survey methods

Survey of hornbills was carried out over a period of 12 months: from October 2010 to September 2011 to cover both the dry and wet seasons. Hornbills were surveyed twice using two line-transects in each study area. The line transects were an interior transect and an edge zone transect in the same sampling area, based on the distance sampling methods of Buckland, Anderson, Burnham, & Laake (1993). Two transects, 2 kilometre each were laid in both the Edge and Interior which were almost parallel to each other. The separation distance between the 2 transects were 1 km to avoid double counting (Bibby et al., 1998).

Edge zone was defined as distance 100 m from the forest edge (McGarigal & McComb, 1995). Line transect inside protected areas were made using existing trails and old transects. Transects and trails were marked using coloured flagging tapes. Surveys were conducted between 06.00–11.00 GMT and 14.00–18.00 GMT by the researcher. Trails were walked at a steady pace while carefully scanning the canopies for hornbills with the aid of a pair of binoculars. For each group of hornbills encountered, the species, groupsize and habitat types were recorded. Observer occasionally left the transect to confirm groupsize, but all groups were initially detected from the transect line.

**Species Identification**

A combination of direct sighting and play back vocalization were used to detect the presence of a particular species of hornbill. In situations where the observer was not sure of call of a particular species due to similarity of the calls, playback vocalizations from ipods were used to confirm the call of the species. Identification using direct sighting, were confirmed by Helm's Field Guide: Birds of Ghana by Borrow and Demey (2010).

**Relative Abundance, Distribution Encounter Rates and Aspects of Social Behaviour**

Each transect was walked simultaneously twice a day at a stead pace whiles scanning the canopies for hornbills with the aid of a pair of binoculars to avoid double counting (Bibby et al., 1998).

The number of times hornbills were sighted their calls heard were recorded and the GPS coordinates were also taken on the ground in areas where hornbills were sited (Bibby, Jones & Marsden, 1998). Flock size and activities of hornbills at the time of encounter were recorded. Aspects of social organization such as formation of feeding guilds, territoriality and location within the habitat were recorded. This is essential to hornbill conservation.

For each species, encounter rate was calculated by using the kilometric index of abundance. That is the number of birds recorded was divided by the number of kilometres spent searching.

$$Encounter\ rate = \frac{Number\ of\ hornbill\ recorded}{Distance\ covered\ in\ kilometres}$$

**Potential threats to hornbill survival**

This was done by noting human activities within the various study areas that were likely to directly or indirectly affect hornbills. Activities noted included, physical habitat destruction such as illegal logging, roads within the forest reserves and illegal mining. Hunting activities were also noted by recording the number of empty cartridges sighted on trails

**Tourism potential of hornbills**

The potential of incorporating hornbill viewing into tourism enhancing programmes were investigated by determining the probability of sighting hornbills for any kilometre walk at each study area.

**Habitat characteristics and utilization by hornbills**

Hornbill habitat utilization and association were investigated by:

measuring habitat characteristics such as number of tress with diameters of more than 60 cm. These may represent abundance of large trees for potential nesting, roosting and feeding (Mudappa & Kannan, 1997).

**Socio-economic survey**

Questionnaires were administered to members of two selected communities to ascertain the effect of fragmentation on hornbill distribution and abundance. To correlate forest fragmentation with livelihood dependency, the following tools were employed:

Opportunistic Interviews were conducted with community members such as willing hunters who were involved in forest utilization. Their socio-economic settings were captured as well as their opinions on hornbill status and conservation.

**Data analysis**

One-way ANOVA at 0.05 alpha level and t-test were used to test significant differences in the means of abundance. Pearson's correlation was used to assess any linear relationships between abundance; and tree density and elevation. Chi-Square test was used to test the significant differences between the frequencies of responses of the two towns.

## CHAPTER FIVE

## Results

### Hornbill species identification

Five species of hornbills were identified during the entire study period in all the study sites. This comprised 4 genera belonging to the Family Bucerotidae, sub-family Bucerotinae. The species of hornbills recorded were the African Pied Hornbill (*Tockus fasciatus*), Black Dwarf Hornbill (*Tockus hartlaubi*), Piping Hornbil (*Bycanistes fistulator*), White-crested Hornbill (*Tropicranus albocristatus*) and Black-casqued Hornbill (*Ceratogymna atrata*), as shown in Figure 5.

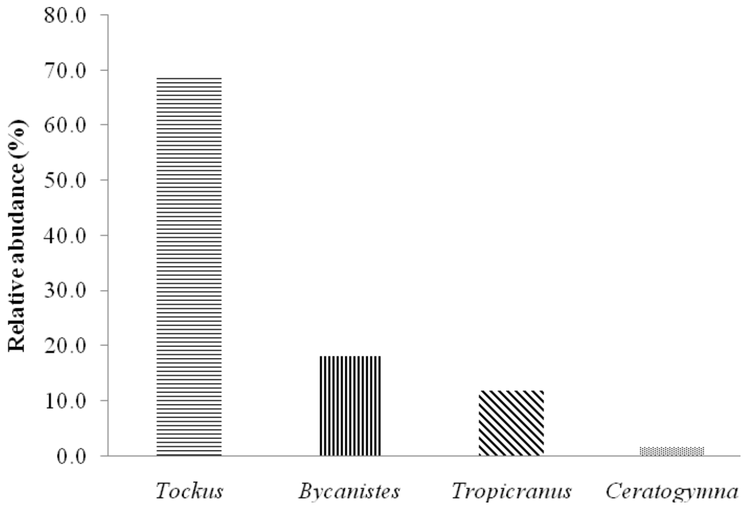


**Figure 5:** Genera of hornbills encountered

**Distribution and relative abundance**

A total of 639 individual hornbills were recorded during the study. Four hundred and forty-one (69.01%) individuals were recorded in the dry season as opposed to one hundred and ninety-eight (30.99%) individuals in the rainy season. The result of t-test conducted between the dry and rainy seasons indicated a significant difference between the two seasons ($p < 0.05$). Although the number of individuals was less in the rainy season, the numbers of different species recorded were however more as compared to those recorded in the dry season. *Tockus hartlaubi, Ceratogymna atrata, Tockus fasciatus, Bycanistes fistulator* and *Tropicranus albocristatus* were recorded in the rainy seasons. *Tockus hartlaubi* and *Ceratogymna atrata* were, however, absent in the dry season. *Tockus fasciatus* was the most occurring species in both the dry and rainy seasons. The least of hornbills recorded in both dry and rainy was *T. hartlaubi* as depicted in Figure 6 below.

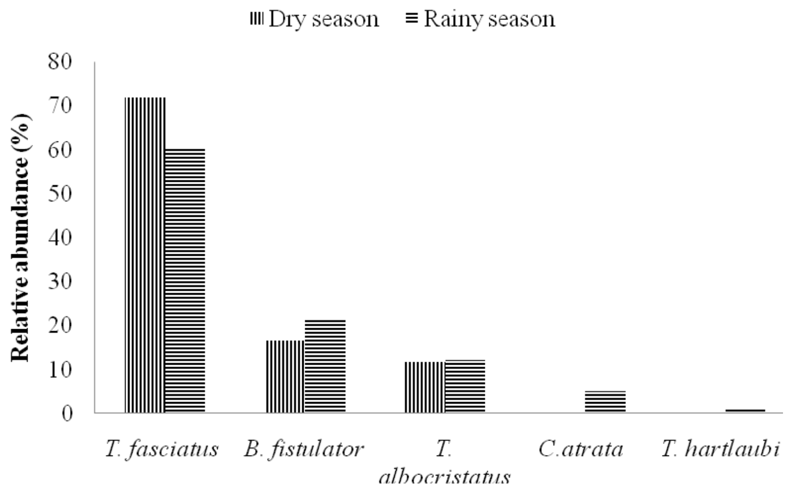


**Figure 6:** Relative abundance of hornbill species in dry and rainy seasons

*T. fasciatus* was found in all ten study areas. *B. fistulator* was recorded in only seven of the ten study areas. They were absent from Atewa Forest Range, Biodiversity plot at Kwae (GOPDC) and Dumpow Sacred Grove. *T. albocristatus* occurred in only five study areas whereas *C. atrata* and *T. hartlaubi* were recorded in only one study area each. The highest numbers of hornbills were recorded in the Subri River Forest whereas the least numbers of hornbills were recorded on the Biodiversity plot at Kwae (GOPDC). Hornbills were however fairly distributed in Pra-Sushien, Neung North, Atewa Forest Ranges and Jukwa settlements as depicted in Figure 7.

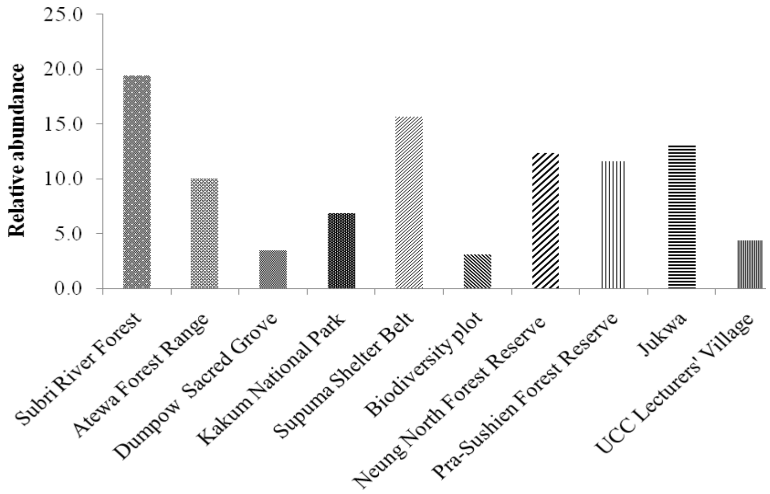


**Figure 7:** Relative abundances of hornbills in each of the study areas

**Edge and interior abundance**

Hornbill assemblage was higher at the forest edge (378 individuals) compared to 261 individuals recorded in the interior of the forest. The result of t-test, however, indicated that the difference in hornbills abundance at the edge and interior of the forest was not significant ($P > 0.05$) for both dry and rainy seasons respectively. African Pied Hornbill accounts for the greatest abundance at both the edge and interior of the forests whereas Black-casqued, Black Dwarf and White-crested Hornbills appeared to be more of interior dwellers than edge as depicted in Figure 8.

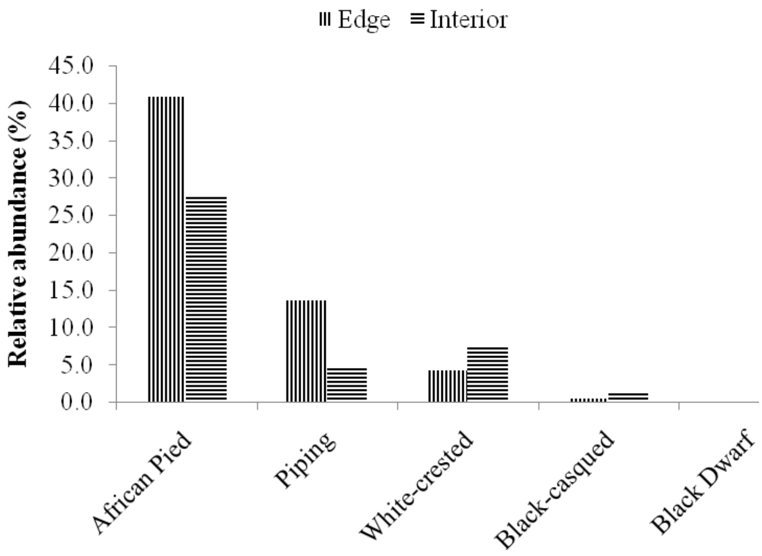


**Figure 8:** Distribution of hornbill species at both edge and interior

**Correlation of hornbill abundance and distribution with large trees**

One of the primary correlates of hornbill distribution and abundance was the presence of large trees. The average tree densities ranged from a high of 22 trees/ha at Subri River Forest to a low of 3 trees/ha at the University of Cape Coast Lecturers' Village (Figure 9). Although there was no significant difference observed in densities of trees occurring in edge and interior of the study areas ($p > 0.301$), 80% of the hornbills correlated positively with the presence of large trees except for Piping Hornbill which showed an inverse correlation to large trees (Table 1).

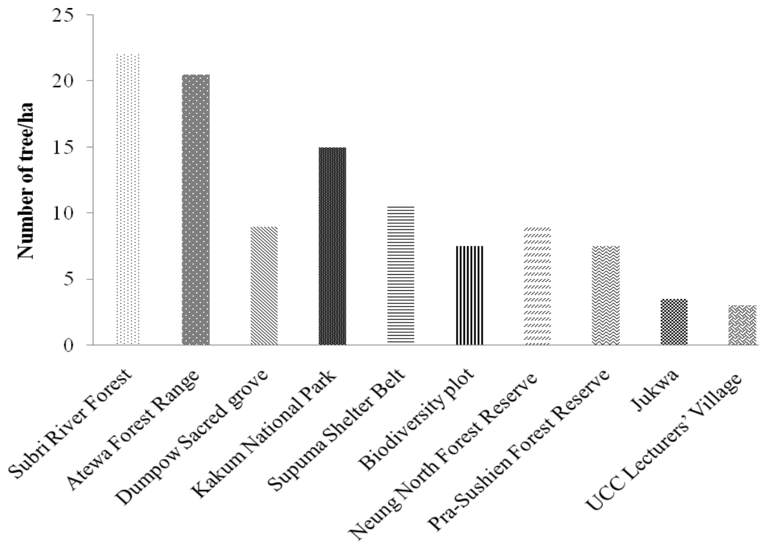


**Figure 9:** Tree densities in study areas.

**Table 1:** Correlates of hornbill distribution and abundance with large trees

| Hornbill Species | r- values | p-values |
|---|---|---|
| African Pied | 0.384 | 0.217 |
| Piping | -0.546 | 0.066 |
| White-crested | 0.015 | 0.963 |
| Black Dwarf | 0.141 | 0.662 |
| Black-casqued | 0.552 | 0.063 |

**Correlation of hornbills abundance and distribution with elevation**

The result showed a significant difference between hornbill numbers and elevation ($p < 0.05$). Majority of the hornbills correlated positively with elevation except for Black-casqued and Black Dwarf Hornbill which correlated negatively to elevation as shown in Table 2.

**Table 2:** Correlation of hornbill distribution with elevation

| Hornbill Species | r –values | p- values |
|---|---|---|
| African Pied | 0.144 | 0.655 |
| Piping | 0.002 | 0.996 |
| White-crested | 0.776 | 0.003 |
| Black-casqued | -0.038 | 0.906 |
| Black Dwarf | -0.001 | 0.997 |

**Land use preference/matrix types of hornbills**

The highest number of individual hornbills was 183 recorded in forests with matrices of mines compared to the least of 94 individuals in forests with matrices of farms. The means of hornbills' abundance were significantly different in all the matrix types ($p < 0.05$) (Figures 10). African Pied Hornbill exhibited abundance that was consistently higher in all matrix types and was predominantly found in forests with matrices of mines (123), and farm and settlements (127), except for study areas surrounded by matrix of settlement (46) only where their numbers were marginally low. Piping Hornbill, however, had the highest relative abundance in settlements (66) but was poorly distributed in matrices of farm, farm and mines, and farms and settlements. White-crested Hornbills, on the other hand, had the highest abundance in matrices of mines (27), fairly abundant in matrices of farms, and farms and mines but were poorly distributed in farms and settlement matrices (6) and were totally absent from settlements. The Black-casqued and Black Dwarf Hornbill were absent from all matrix types, except for matrices of farms and mines (2) (Figure 11).

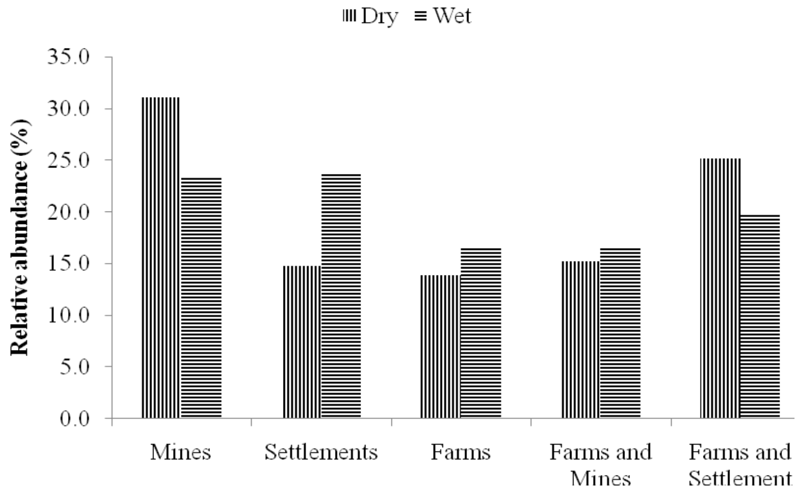


**Figure 10:** Relative abundance of hornbill species in each matrix type in both dry and rainy seasons

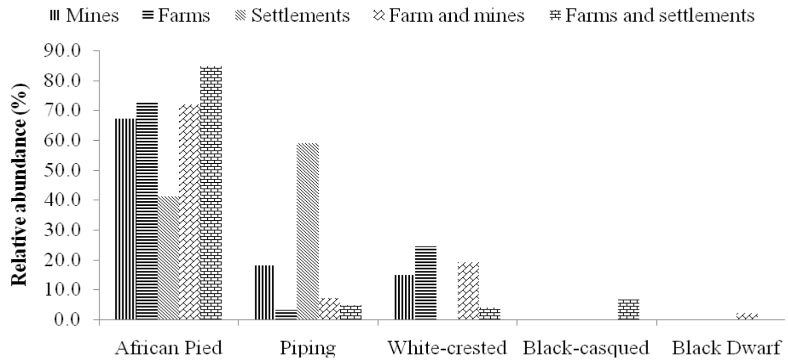


**Figure 11:** Relative abundance of individual hornbill species in the five different matrix types

**Encounter rates**

Hornbill encounter rate varied with species and from one study area type to another. The mean of Kilometric Index of Abundance differed significantly between the dry and rainy seasons ($p < 0.05$), with the mean being higher in the dry season. The probability of encountering a hornbill per a kilometer walk was far higher for Subri River Forest and Supuma Shelter Belt in both dry and rainy seasons whereas at Atewa Forest Range and Biodiversity plot at Kwae, the least encounter rates were recorded in the dry season. In the rainy season, however, the least encounter rate recorded was in University of Cape Coast Lecturers' Village (Figures 12 and 13). There was, however, no significant difference in encounter rate among the various study areas (p>0.532). Among all the species, African Pied Hornbill was the most likely species to be encountered compared any other. The encounter rate for African pied Hornbill was highest at Subri River Forest. The least encounter rate for African Pied Hornbill was recorded at UCC Lecturers' Village.

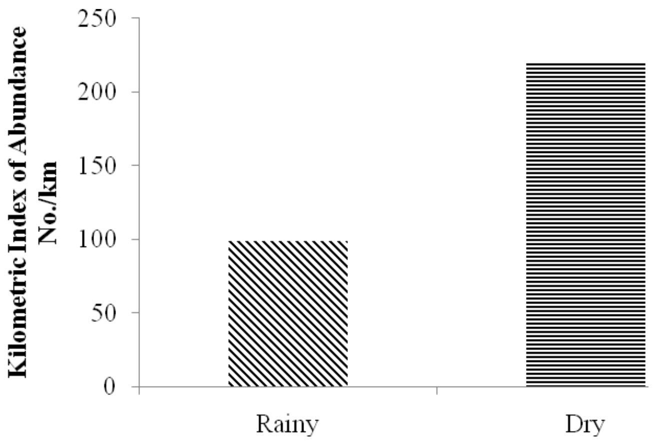


**Figure 12:** Encounter rate of hornbills in both rainy and dry seasons

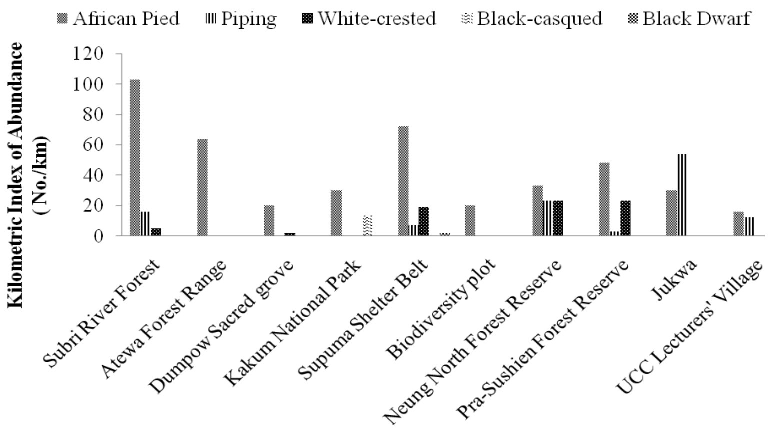


**Figure 13:** Encounter rates of each species of hornbill at the different study areas

**Human potential threats to hornbills**

Possible human activities which might be of potential threat were investigated. The major threats recorded were illegal logging, hunting and mining. Plate 11 shows the type of cartridge used by hunters. A significant difference was observed in hornbill abundance and the number of empty cartridges found in all the research areas ($p < 0.05$). Supuma Shelterbelt recorded the highest number of empty cartridges (25) followed by Subri River Forest which had (5). Kakum National Park, Dumpow Sacred Grove, and Atewa Forest Range recorded the least number of cartridges (2). No cartridges were found in Pra-Sushien, Biodiversity plot at Kwae, Neung Forest Reserve as well as Jukwa and University of Cape Coast Lecturers' Village as shown in Figure 14.

**Plate 11:** Spent/empty cartridge: an indication of hunting pressure.

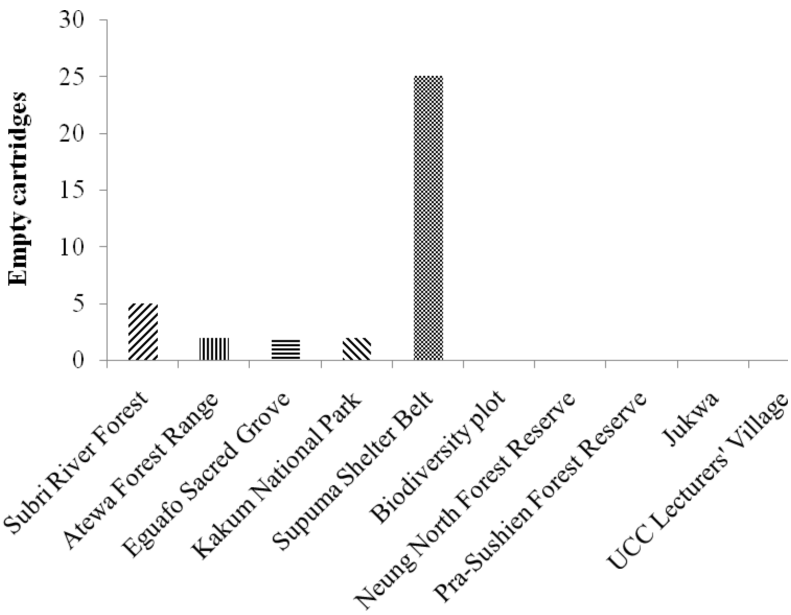


**Figure 14:** Hunting pressure depicted by spent cartridges at the study areas

Some observed activities revealed that chemicals used in extracting gold for instance, mercury, cyanide and other complex chemicals by both illegal and large scale commercial miners were not properly disposed off but were discharged on the forest floor or emptied into water bodies as shown in plate 12. Study areas suffering from pollution from both illegal and commercial mining companies include: Atewa Forest Range, Subri River Forest, Neung North Forest Reserve and Supuma Shelter Belt (plates 13-14). Further degradation of the forests by mining companies were evident in the clearings of preciously intact areas.  Explorations for gold were gradually getting deeper and deeper into the forests resulting in the loss of more forest cover as in Plates 15 and 16.

Except for Kakum National Park, all the protected areas visited were undergoing illegal logging. As a mechanism to elude park authorities and law enforcement agencies, illegally logged timbers were sawn to desired planks within the forests before they are carried out as shown in Plate 17.

No forms of illegal mining or logging were noticed at Kakum National Park. Roads, however, seemed not to be a threat to hornbills since these species fly higher than heights of all vehicles. However, the associated noise generated by the vehicles may cause disturbance to the hornbill activities.

**Plate 12:** A water body serving as Tailings dump with pollutants at Neung North Forest Reserve

**Plate 13:** Clearance of large tract of forest cover for gold "galamsey"

**Plate 14:** Diversion of a water source for gold washing by "galamsey" operators.

**Plate 15:** New clearings of forest portion for gold exploration

**Plate 16:** Section of forest reduced to bare ground.

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**Plate 17:** Sample of sawn logs.

**Aspects of Social Behaviour**

The White-crested Hornbill was observed to be niche-specific hardly moving out of its niche. The African Pied Hornbill was observed to move mostly in pairs but occasionally in large flocks of between 6 to more than 50 individuals during feeding at Subri River Forest. It was also seen in mixed flocks with Western Grey Plantain-eater (*Crinifer piscator*) and African Grey Hornbill and Piping Hornbill on University of Cape Coast Lecturers' Village. This observed mixed flocking behavior was confirmed by Candy (1984). The African Pied Hornbill utilizes any strata of the forest trees and was also attracted to palm tree and bamboo trees and landing on the ground occasionally to pick food. Piping Hornbill usually moved in groups of 1to 54 and also makes use of any strata of the forest except for the shrub layer and the forest floor but in most situations was found to occupy the canopy layer. They were also observed to form feeding guild in association with African Pied

Hornbill. The *T. hartlaubi* was observed to be secretive, moving in pairs and utilizing the under storey of the forest strata. No feeding guild or mix flocking were observed to be associated with this species. Black-casqued Hornbill moved in flocks of 10 individuals. They utilized only tall trees and were adapted to the emergent layer of the forest strata. In all situation there was no territorial defence behaviour observed in any of the species.

**Result from social survey**

**Result from respondents of local people on hornbills**

A total of 50 people were randomly interviewed. This comprised 25from forest settlements (Mfuom) and 25 from townships (Jukwa). Of the 25 people interviewed from Jukwa, 24 (96%) were males, and 1 female (4%) whereas in Mfuom, 80% of the respondent were males, while 20% were females.

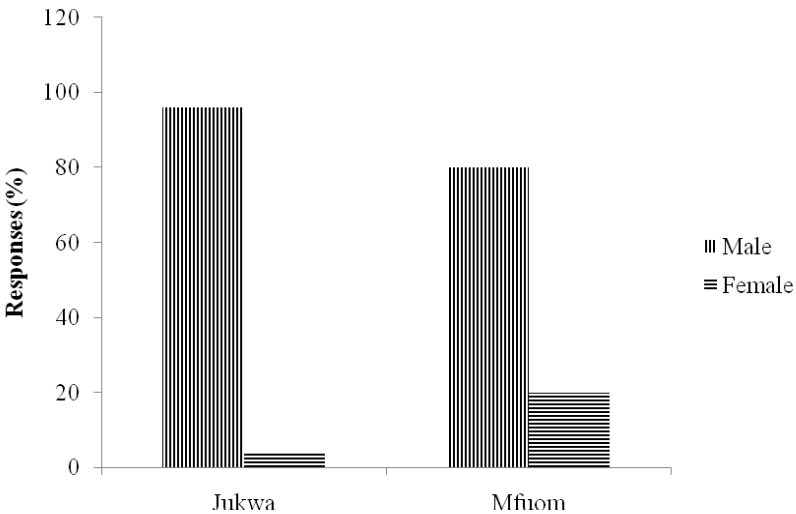


**Figure 15:** Sex ratio of respondents

In addition majority of the respondents also fell between the ages of (41-60) years for both Jukwa and Mfuom. The results of the age groups are shown in Table 3 below.

**Table 3:** Age group of Respondents

| | Jukwa | Mfuom |
|---|---|---|
| Age group | Percent | Percent |
| 16-40 | 16.0 | 16.0 |
| 41-60 | 76.0 | 52.0 |
| 61 and above | 8.0 | 32.0 |
| Total | 100.0 | 100.0 |

In both settlements, majority of the respondents (52%) had no formal education, while the remaining (48%) had only some basic education. At Mfuom, 60% of the respondent had some basic education and 8% had tertiary education. Only 32% of the respondents had no formal education as indicated in Table 4. Majority of the respondents at Jukwa (48%) had lived in their settlement between 30-40 years, twenty-eight percent had lived in the settlement for over 40 years, while 12% had lived in their settlements between 10-19 years and 20-29 years, respectively. Majority of the respondent (36%), had lived in their settlements between 10-19 years, while 24% had lived in the area between 5-9 years and 20-29, years respectively. The remaining 16% had lived in the settlement above 40 years as depicted in Table 5.

The economic activities of the respondents (Table 6) ranged from farming, hunting to chain-saw operations or a combination of these activities. Whereas majority (48%) of the respondents were solely subsistence farmers at

Jukwa, at Mfuom however, the majority (56%) were mostly farmers and hunters. Thirty-two percent were engaged in both farming and hunting, 12% were chain-saw operators and 8% were hunters.

**Table 4:** Educational background of Respondents

| | Jukwa | Mfuom |
|---|---|---|
| Educational qualification | Percentage | Percentage |
| Basic | 48.0 | 60.0 |
| Secondary | 0 | 0 |
| Tertiary | 0 | 8.0 |
| No formal education | 52.0 | 32.0 |
| Total | 100.0 | 100.0 |

**Table 5:** Number of years spent in settlements

| | Jukwa | Mfuom |
|---|---|---|
| Duration | Percentage | Percentage |
| 5-9 years | 0 | 24 |
| 10-19 years | 12 | 36 |
| 20-29 years | 12 | 24 |
| 30-40 | 48 | 0 |
| Above 40 | 28 | 16 |
| Total | 100 | 100.0 |

**Table 6:** Occupation of Respondents

| | Jukwa | Mfuom |
|---|---|---|
| Occupation | Percentage | Percentage |
| Farmer | 48.0 | 36.0 |
| Hunter | 8.0 | 8.0 |
| Hunter/farmer | 32.0 | 56.0 |
| Chain-saw operator | 12.0 | 0 |
| Total | 100.0 | 100.0 |

**Indigenous knowledge on hornbill identification**

Respondents had some knowledge on the different species of hornbills within the Jukwa and Mfuom settlements which were significantly different from each other ($p < 0.05$). At Jukwa only 4% of the respondents identified White-crested Hornbill to occur in the area, 24% identified African Pied Hornbill, Piping Hornbill and White-crested to occur in their settlement; 28% identified *T. hartlaubi* as occurring in the area and 44% identified Black-casqued Hornbill as occurring within the settlement. At Mfuom, 40% claimed the existence of Piping Hornbill, whereas 20% identified African Pied Hornbill and Black-casqued Hornbills, whereas 12% and 8% were of the view that Black Dwarf and White-crested Hornbills, respectively were present as shown in Table 7 and Table 8.

**Table 7:** Knowledge on common species encountered

| Knowledge on: | Jukwa | Mfuom |
|---|---|---|
| Hornbill species | Percentage | Percentage |
| White-crested | 4.0 | 8.0 |
| African pied | 0 | 20.0 |
| Black-casqued | 44.0 | 20.0 |
| Black Dwarf | 28.0 | 12.0 |
| African pied, Piping, White-crested | 24.0 | 40 |
| Piping | 0 | 40.0 |
| Total | 100.0 | 100.0 |

**Table 8:** Local names of hornbills from respondents

| English names | Local names |
|---|---|
| African Pied Hornbill | Akyenkyena, |
| Black Dwarf Hornbill | Kokoasebrantea, Akyenkyena |
| Black-casqued Hornbill | Kasabrekuo, owam, emmon |
| Black and white-casqued Hornbill | Owam, emmon, |
| Brown-cheeked Hornbill | Owam-homa, owam |
| Piping Hornbill | Boemframa, emmon, |
| White-crested Hornbill | Asokwa, kokoasebrantea, kokoasekodaa |
| Yellow-casqued Hornbill | Owam, emmon |

**Knowledge on seasonal abundance of hornbill**

As shown in Table 9, most of the respondents from both Jukwa and Mfuom had similar knowledge on hornbill seasonal abundance and distribution but this observation was not significant by difference in scores between the two groups ($p > 0.05$). While 52-60% respondents from both settlements claimed that there were more hornbills in the rainy season (15 and 13) than in any other season, 28-40% claimed hornbills were encountered more in the dry season and only 0- 20% were of the view that they were rather encountered throughout the year.

**Table 9:** Season with highest number of occurrence

| Season | Jukwa | Mfuom |
|---|---|---|
| | Percentage | Percentage |
| Rainy season | 60 | 52 |
| Dry season | 40 | 28 |
| Throughout the year | 0 | 20 |
| Total | 100 | 100 |

In addition, respondents from Jukwa agreed that Yellow-casqued and African Dwarf hornbills were the most abundant species (9) in their respective localities with African pied, Piping and White-crested hornbills being the least (0-4) of species inhabiting their respective localities. In contrast, 40% of the responses from Mfuom revealed that African Pied hornbill (10) was rather the most abundant of the species and that Black Dwarf, Black-and-white-casqued Hornbills and Yellow-casqued Hornbills were the least (0) of the species inhabiting their environs(Table 10).

**Table 10:** Knowledge on seasonality of hornbills

| | Jukwa | Mfuom |
|---|---|---|
| Hornbill species | Percentage | Percentage |
| White-crested | 4.0 | 28.0 |
| Black-casqued | 12.0 | 20.0 |
| African Dwarf | 36.0 | 0 |
| African Pied | 0 | 40 |
| Black-and- white-casqued | 12.0 | 0 |
| piping | 0 | 12.0 |
| Yellow-casqued | 36.0 | 0 |
| Total | 100.0 | 100.0 |

Majority of the respondents (14 and 10) agreed that the hornbills were restricted to the tree canopies for both Jukwa and Mfuom. A few of the respondents (4%) from Jukwa settlements were of the view that the hornbills were restricted to thickets contrary to 24% of those of Mfuom as shown in Table 11 below. These were however not significantly different between the two groups ($p < 0.05$)

**Table 11:** Habitat of encounter during season of highest occurrence

| | Jukwa | Mfuom |
|---|---|---|
| Habitat | Percentage | Percentage |
| Farms | 20 | 32 |
| Forest edges | 20 | 4 |
| Tree canopies | 56 | 40 |
| Thickets | 4 | 24 |

| | | |
|---|---|---|
| Total | 100 | 100 |

The views of respondents from Jukwa and Mfuom on the number of hornbills in both past years and recent years differed significantly ($p < 0.05$). As high as 92% of respondents from Jukwa lamented that hornbill numbers had reduced drastically in recent times. Only a few of the respondents (8%) were of the view that hornbill numbers had increased in recent times.

At Mfuom, the majority (52%) were also of the view that numbers of hornbills have reduced drastically in recent times. Only a minority (48%) of the respondents think otherwise that hornbill numbers have increased in recent times (Table 12).

With regards to the absences of some species in recent times (64%) of respondents from Jukwa testify that some species are totally absent from Jukwa environs in recent times. These species are Yellow-casqued Hornbill, White-crested Hornbill, Black-casqued Hornbill, African Dwarf Hornbill and Black and white-casqued Hornbill. The 36% of the remaining respondents were positive that no species have been absent. 92% of the respondents from Mfuom also confirmed that some species had been missing completely in recent times. They are Black and white-casqued Hornbill, White-crested Hornbill and Black-casqued Hornbill as shown in the Table 13.

**Table 12:** Numbers of hornbills in the past compared to recent

| | Jukwa | Mfuom |
|---|---|---|
| Response | Percent | Percent |
| Reduced | 92.0 | 52.0 |
| Increased | 8.0 | 48.0 |

| | | |
|---|---|---|
| Total | 100.0 | 100.0 |

**Table 13:** Responses on species not seen in recent times

| | Jukwa | Mfuom |
|---|---|---|
| Response | Percent | Percent |
| Yes | 64.0 | 92.0 |
| No | 36.0 | 8.0 |
| Total | 100.0 | 100.0 |

Majority of the respondent from Jukwa indicated that physical habitat destruction was the major cause of hornbill decreased numbers in recent times. At Mfuom, the respondents were of different views. They believed hunting for food was the major cause of their decline (Table 14).

**Table 14**: Reasons given for declining numbers of hornbills in recent times

| | Jukwa | Mfuom |
|---|---|---|
| Causes | Percentage | Percentage |
| Habitat destruction | 76.0 | 40.0 |
| For food | 24.0 | 60.0 |
| Total | 100.0 | 100.0 |

On the issue of increased in numbers of hornbills in recent times, respondents from Jukwa and Mfuom claimed that hornbills received constant protection from state authorities. Only respondents from Jukwa emphasized that taboos accounted for the increased numbers. Some groups of respondents from both Jukwa and Mfuom agreed having no idea on the trend of hornbill population (Table 15). The views shared by both respondents were significant ($p<0.05$)

**Table 15:** Reasons given for hornbill increased numbers

| | Jukwa | Mfuom |
|---|---|---|
| Causes | Percentage | Percentage |
| Taboos | 28.0 | 0.0 |
| Protection State from Authority | 20.0 | 32.0 |
| No idea | 52.0 | 68.0 |
| Total | 100.0 | 100.0 |

**Knowledge of local people on hornbill foods**

At Jukwa 100% of the respondent agreed to have some knowledge on hornbill foods. At Mfuom however, only 60% of the respondent had knowledge on hornbill food, while 40% had no idea at all as shown in Figure 16. Some of these food items include the fruit and flowers of: *Trichilia lanata*, *Ficus exasperata*, *Raphia hookeri*, *Theobroma cacao*, *Carica papaya*, *Viscum album* (LINN.), *Elaeis guineensis*, *Antiaris toxicaria*, and *Ehretia anacua* as well as insects. No significant difference was observed in the responses between the two settlements ($p <0.05$). In addition, 68% of the respondents from Jukwa also agreed that food is most abundant during the months of June-July whereas 32% also agreed that food was available all year round. Those of Mfuom, however, had different views about food abundance of hornbills (Figure 17).

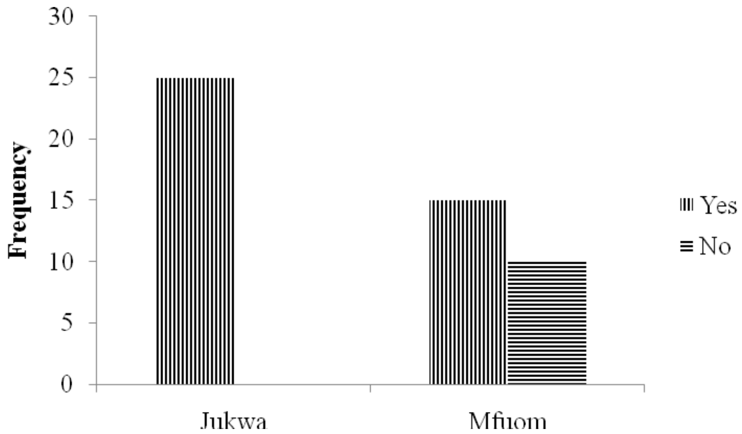


**Figure 16:** Knowledge of Respondents on hornbill food type

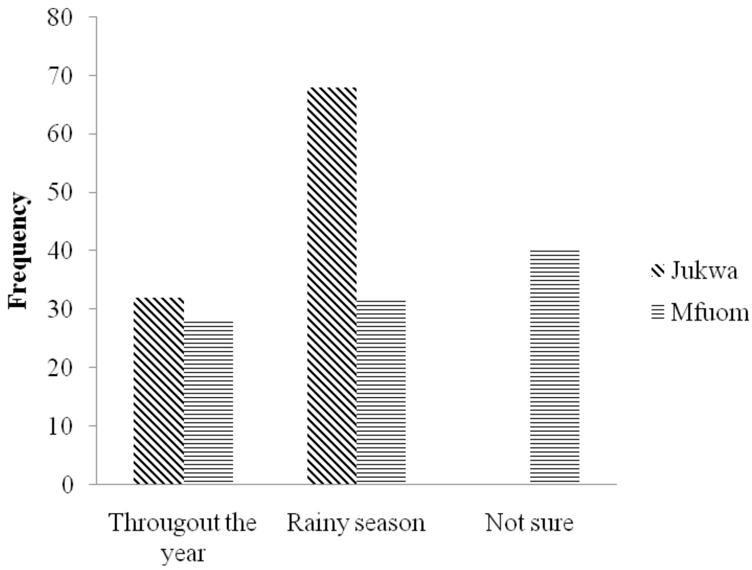


**Figure 17:** Knowledge on hornbill food availability

**Knowledge of local people on Hornbill reproduction**

Majority of the respondents (80%) from Jukwa environs had some knowledge about the reproduction of hornbills. They agreed that hornbills were cavity nesters and that this mechanism protects them from predators. The respondents further observed that hornbills lay few eggs, a maximum of two eggs at a time but hatch all their eggs. Only a few of the respondents (20%) had no knowledge about the reproduction of hornbills. On the other hand, (80%) of the respondents from Mfuom reported having no knowledge on hornbill reproduction. Only 20% reported having some knowledge on the reproduction of hornbills. They also confirmed that the hornbills were cavity nesters and laid a maximum of two eggs at a time as in Figure 18.

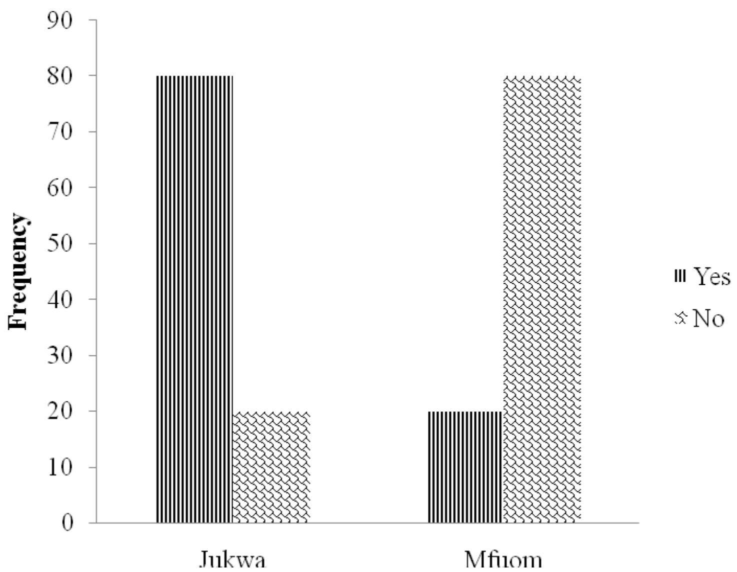


**Figure 18:** Knowledge of Respondent on hornbill reproduction in two settlements

**Knowledge on folklore, myth or legends associated with hornbill protection**

High numbers of the respondents from both communities shared a similar view that there are no such things as folklore, myths and legends associated with the hornbill species. The minority who claimed there were some folklore, myths and legends associated with the species were unable to tell which folklores, myths and legends were associated with the hornbills (Figure 19)

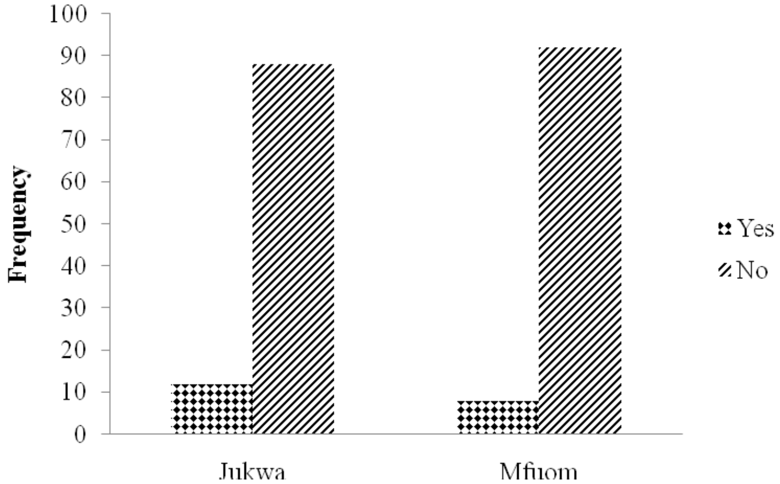


**Figure 19:** Knowledge shared by respondent on traditional conservation of hornbills in two settlements

**Importance of hornbill to the local people**

As high as 60% of the respondents from Jukwa use hornbill as a source of protein compared to 32% of those from Mfuom. 40% of the Jukwa respondents also agreed that the hornbills were beautiful to watch as compared to 4% of those from Mfuom; 64% of respondents from Mfuom further agreed that they used hornbills as a source of income for their livelihood.

Some of the respondents further agreed that the feathers of the hornbills were the reasons why they kill or capture them. Others also agreed that skull was of more importance to them but never gave reasons what it was being used for.

However, one respondent agreed to have used the casque of African Pied Hornbill for key holder. View by respondents from both Jukwa and Mfuom differed significantly ($p < 0.05$).

Those who claimed to have used hornbills in some way agreed using guns to shoot or life trapping using adhesive made of latex. The respondents further reported that they frequently use the hornbills for the above mentioned reasons (68% and 84%), respectively, from Jukwa and Mfuom). Only 28% of the respondents from Jukwa confirmed to have never used hornbills. Tables 16 and 17 show the responses on the importance of hornbills to the local people.

**Table 16:** Importance of hornbill to the local people

| | Jukwa | Mfuom |
|---|---|---|
| Importance | Percentage | Percentage |
| Protein | 60 | 32 |
| Income | 0 | 64 |
| Beauty | 40 | 4 |
| Total | 100 | 100 |

**Table 17:** Frequency of hornbill utilization

| | Jukwa | Mfuom |
|---|---|---|
| Responses | Percentage | Percentage |
| Very often | 68.0 | 84.0 |
| Rarely | 4.0 | 16.0 |
| Never | 28.0 | 0 |
| Total | 100.0 | 100.0 |

**Knowledge on hornbill trade**

Although the respondents (64%) from Mfuom earlier reported using hornbill as a source of income, they were however reluctant to provide answers on the issue of hornbill trade for the fear of being arrested. Eighty percent denied ever engaging in any form of hornbill trade. Twenty-eight percent, however, did reveal to have been engaged in some sort of hornbill trade. Although some of the respondents agreed they did not directly partake in hornbill trade, they however, agreed to be witnesses. Only 32% confessed not having anything to do with hornbill trade (Figure 20). Those who were willing to disclose information on the trade agreed that, the business was very lucrative. Hornbills were believed to sell from GH¢10.00 and above (Figure 21). This view was shared by both respondents from Jukwa and Mfuom. They also confessed that the larger species: Black-casqued, Yellow- casqued and Brown-cheeked Hornbills were the favoured targets for most hunters. It was also agreed that in times of scarcity they captured or hunted any of the other species which they may chance upon.

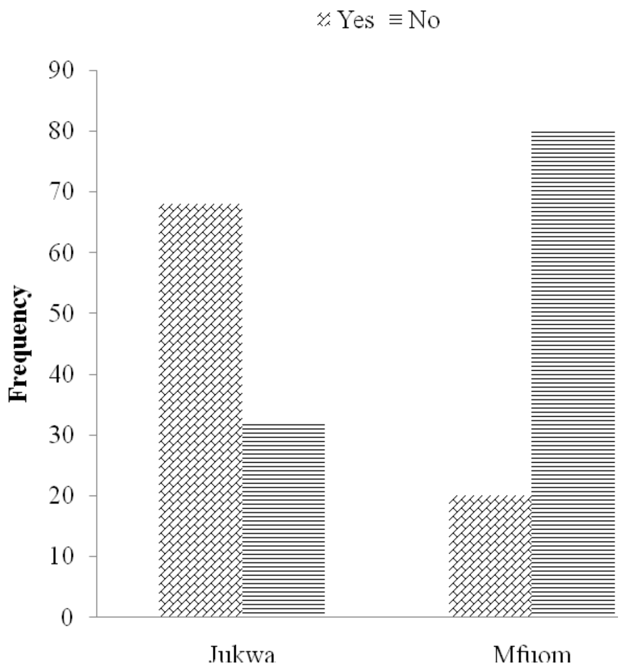


**Figure 20:** Respondents knowledge on hornbill trade in two settlements

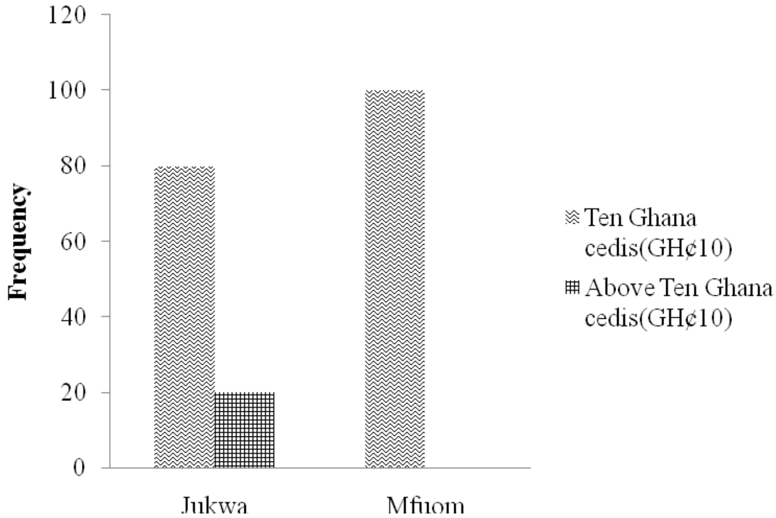


**Figure 21:** Responses on average cost of hornbill in two settlements

**Conservation of hornbill**

On the issue of hornbill conservation, 76% of the respondents were of the view that the all hornbill species should be conserved, because posterity might not see these species if they go extinct. Some were, however, not in favour of their conservation because they regarded them as crop pests and a nuisance. They also believed all the species cannot be conserved and that some should be harvested. This is shown in Figure 22.

On the question of who should be responsible for their conservation, respondents from Jukwa were of divergent views: forty percent were of the view that community groups should be organized to enforce their conservation. Thirty- two percent also believed it was the responsibility of park managers/forest guards to conserve the species, while 24% of the respondents were of the view that it was everybody's responsibility; but 4% were not sure whose responsibility it was to conserve these species.

Respondents from Mfuom had different view as to whose responsibility it was to conserve the hornbill species. As many as 52% believed it was the responsibility of everyone to ensure that hornbills were conserved; 28% also believed it was the responsibility of park managers and forest guards. Other groups were of the view that community groups should be empowered to conserve the hornbills, whereas 8% said hornbill conservation would be successful if the Chief and Elders were actively involved (Figure 23).

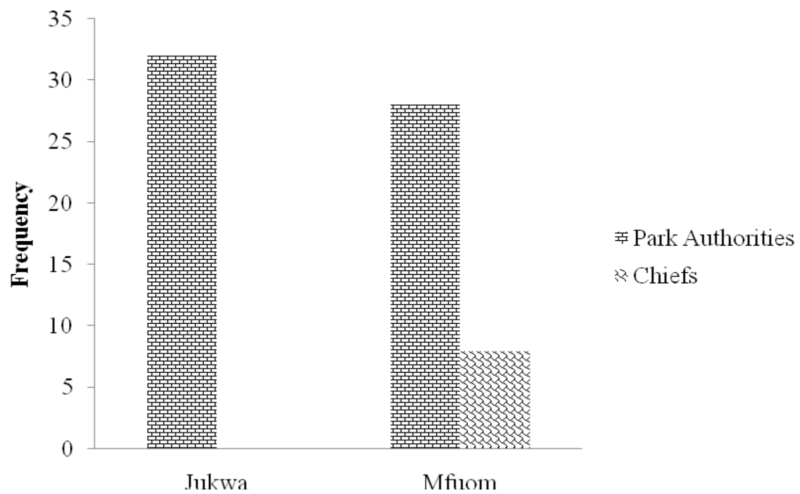


**Figure 22:** Respondents' views on hornbill conservation in two settlements

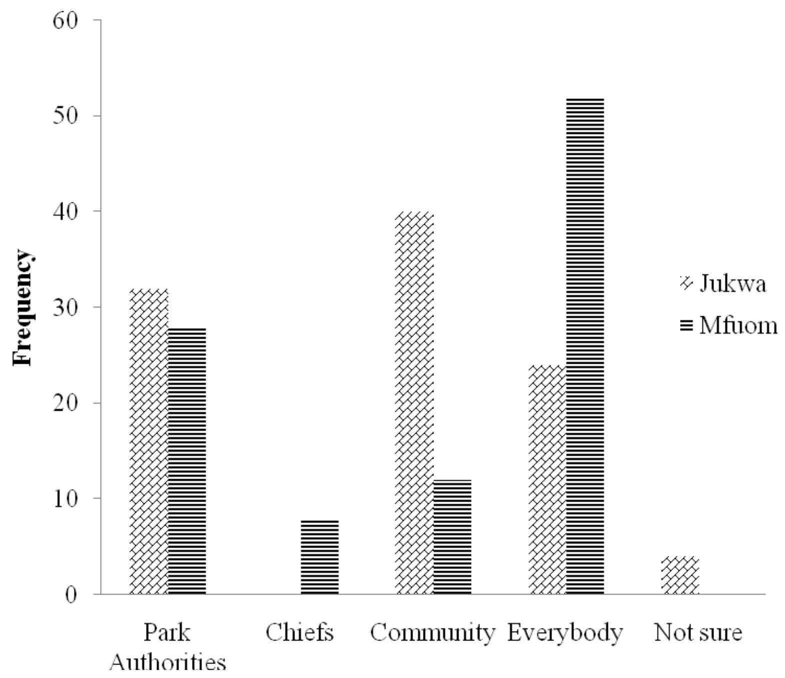


**Figure 23:** Respondents' views on whose responsibility it was to conserve hornbill species in two settlements

# CHAPTER SIX

## Discussion

**Hornbill identification, distribution and abundance.**

Except for a biological assessment of the terrestrial ecosystems in which some hornbills were identified, McCullough, Alonso, Naskrecki, Wright, & Osei-Owusu, ( 2007), no data have reported the effect matrices on hornbill distribution and abundances (Lepage, 2007). In the wake of the ever increasing habitat disturbance and transformation of forest landscape, this research was necessary and intended to gather information which would be used for conservation planning and action not only for hornbill species but other biota on which they depend and the information gathered would also fill gaps in the field of ornithology. The information gathered would be relevant to conservation organizations, institutions and individuals.

Of the ten expected forest species of hornbills that were believed to occur in the forest zones of the country (Borrow & Demey, 2010), only five species were identified throughout the entire study period. The absence of the remaining five species of hornbills are expected to be due to unfavourable factors prevailing in Ghana's forests.

Contrary to the claim of Beier et al. (2002), that Black-casqued Hornbills were completely absent from Kakum National Park, result from this research proved that there were still some population of Black-casqued Hornbills in the Kakum National Park probably at low population. Their absence from the Kakum National Park at the time of Beier's research could be due to the fact that this species might have been experiencing some form of habitat disturbance and might have possibly migrated to neighbouring forests such as the Pra-Sushien Forest Reserve.

Though there was no significant difference in hornbill abundance between edge and interior zones there was, however, a high assemblage of hornbills at the edge than interior. This could be attributed to the abundance of more resources at the edge than the interior as confirmed by Gates & Gysel (1978) whose field experiment revealed that birds are mostly attracted to forest edges with greater food abundance. The knowledge of hornbills aggregating on fruiting trees especially at forest edges is well exploited by hunters and this is likely to put hornbills at risk of poaching.

Also the relative low abundance of hornbills observed in the wet season could be attributed to the fact that hornbill abundance estimate was likely to be too small or it may have excluded part of the population especially nesting females which are mostly incarcerated in their nests during the wet/ breeding seasons as revealed by Raman and Mudappa (2003). This can be corrected if there were good data on population structures of hornbills. For instance, comparing data on adult sex ratios just prior to and during the breeding season and availability of nesting sites, one can estimate the proportion of breeding females in the population. In light of the above a better understanding of the effects of habitat disturbances would therefore require surveys of hornbills and resource availability in all seasons in fragments and surrounding areas as confirmed by Raman & Mudappa (2003).

**Seasonal encounter rate of hornbills**

Datta (1998) reported encounter rates of hornbills of 0.10 to 1.11 birds/km in north-east India. Similarly, Raman and Mudappa (2003) estimated encounter rate for Malabar Grey Hornbill to be 5.74 detections/km. The encounter rates obtained in this study fall largely within this range with the exception of Black Dwarf Hornbill and African Pied Hornbills. The encounter rate for Black Dwarf Hornbill fell below these ranges. Also the encounter rate of African Pied Hornbill was far above those obtained by Datta (1998) and Raman and Mudappa (2003).

The probability of encountering any species of hornbill for every kilometre in the dry season, however, was quite high compared to the wet season. Each study area recorded at least one species of hornbill in both dry and wet seasons. The significant difference observed in the encounter rate among the different species for both dry and wet seasons suggests that species differentially made use of the different habitat types. Some species, especially the African Pied Hornbill utilized all the habitat types and could therefore be considered as generalist (Chen et al., 2008), whereas others such as the White-crested, Black Dwarf Hornbills were habitat specific as confirmed in the findings of Borrow and Demey (2010). Though the Piping Hornbill is considered to be a forest specific species (Borrow & Demey, 2010), its presence in urban/peri-urban settlements could suggest that the Piping Hornbill population could be undergoing some sort of habitat disturbance. Their high relative numbers in urban settlement could also mean that these areas may be offering some refuge or beneficial resources which support their population. The difficulty in detecting Black Dwarf in most of the study areas could be due to its shy nature and the degree to which most of their habitats are continuously being destroyed. White-crested Hornbill was also not recorded in some of the study areas. Since White-crested Hornbill requires a stable habitat to dwell and owing to the fact that most of the study areas were experiencing some sort of habitat disturbance such as logging, hunting and mining, it is possible that these areas may not be attractive to White-crested Hornbill and thus may not support their viable population.

**Potential threats to hornbill populations**

Potential harmful activities which were capable of negatively impacting the populations of hornbills were investigated. Most of the study areas visited suffered from at least one form of habitat disturbance. Although these activities appeared to have no immediate visible effect on the species, it is, however, feared that the future repercussions of these activities could be very serious.

Walker (2003), had confirmed that logging greatly facilitate hunting to some extent and in those cases the impacts of logging on hunted species, and the resulting fragmentation of their habitats, could have far greater effects. Kumar et al. (2011) stated that large birds are often favoured target for local hunters. This was confirmed when hunters were interviewed during this research. Also a similar survey conducted on biodiversity in the Atewa Forest Ranges,

Draw River, Boi-Tano, Tano Nimiri and Krokosua Hills forest reserves of Ghana by McCullough et al., (2007) revealed that large Hornbills were favoured bird hunted by hunters. It is therefore possible that hornbills in Supuma Shelterbelt and other protected areas might have been suffering from hunting pressure. The continuous illegal logging in Ghana's protected areas is likely to disrupt vital ecosystem processes. These activities cause marked disruptions to forest understorey mainly by roads and skidder tracks (Pereira et al., 2002). Although the impact of logging on hornbills may not directly be quantified, nevertheless, similar studies by Plumptre (1996) further revealed that, the detrimental impacts of selective logging may extend many years destroying deep canopies of the forest thus intact forests may not be regained for years. The disturbances may also restrict birds from accessing foraging areas as large hornbills require continuous habitat for their food resource and tracking these resources may involve seasonal movements that cover large areas (Guindon, 1996). The activities of loggers also reduce the large trees in which hornbills select for nesting cavities and reduction of sites may lead to changes in nest competition and reproductive success as confirmed by Poonswad & Kemp (1993). A reduction in tree density may therefore concentrate species in one forest fragment and may lead to depletion of resource. Logically, when a population is isolated by fragmentation into smaller patches, its intensity is likely to be high when time progresses, leading to congestion in the population in the isolated patches (Debinski & Holt, 2000). This situation may lead to crowding effect in the isolated fragments immediately after cutting takes place in the landscape (Schmiegelow et al., 1997). It is expected that the current of habitat fragmentation and destruction if not checked would result in populations of hornbills experiencing local extinction in the nearest future as a result of extinction debt (Meffe et al., 1997; Vellend et al., 2006; Kuussaari et al., 2009) and the species of hornbills likely to suffer are those lacking wide foraging grounds and good dispersal abilities (Sodhi et al., 2004).

Comparing the distribution of the five hornbill species encountered in the current study across the study sites, it was clear that Black-casqued, White-crested and Black Dwarf Hornbills appeared to be more susceptible to habitat disturbance whereas African Pied Hornbill appeared to be more resistant to habitat disturbances across the fragmented sites. The absence of Brown-cheeked Hornbill in all the study areas during the period of the study should be worth noting. This gives a critical indication that Ghana's forests were fast declining at an alarming rate and unless pragmatic actions are taken to avert the problems, Ghana's protected areas may soon collapse. As reported by BirdLife International (2001), the Brown-cheeked Hornbill is the first of hornbill species to disappear from forests following a disturbance. Unless quick actions are taken, Ghana would lose most of its larger hornbills as in the case of Singapore and Hong Kong where habitat fragmentation resulting from logging and hunting had lead to the elimination of large frugivores including three species of hornbills (Corlett & Turner, 1997).

The activities of illegal miners ("galamsey") may have the tendency of offsetting the ecosystem balance. "Galamsey" activities were observed in almost all the study areas visited, except for those that were actively protected and the sacred grove. The diversion of water bodies in the reserves for gold washing is one that is worrying and must be looked at with keen interest as shown in Plate 12. The wastes generated from these activities were also dumped indiscriminately in the forest or into water bodies. Even in areas where licensed commercial mining was ongoing, the story is not different from those of the illegal miners. Chemicals were observed to be leaking into forest floors from pipes which convey waste chemicals to their tailings dumps.

These harmful chemicals used by the miners may affect the health of the forest if not immediately, then in the near future. It is possible that the forests of Ghana may be experiencing some form relaxation and they are likely to be prone to extinction considering the activities within and surrounding them.

**Aspects of social behaviour**

Knowledge on some aspects hornbill social behaviour will be very vital for their conservation. Black Dwarf Hornbill was observed to move in pair utilizing liana-rich areas at mid-level and lower canopies and was observed to be very silent as compared to other hornbill as confirmed by Borrow & Demey (2010). Since these species utilized lower canopies of the forest strata, any minimal change to the forest as a result of logging may have a deleterious effect on this species and so the need for conservation of every aspects of the forest and its strata.

The findings from the research on African Pied Hornbill social behaviour agreed with that of Borrow & Demey (2010). This species is conspicuous and gregarious often announced its presence with loud vocal calls. The findings also agreed with that of Candy (1984) who reported African Pied Hornbill formed feeding guilds with turaco species. It was observed that African Pied Hornbill utilized every type of habitat and appears not to be affected in anyway by human activities. They were mostly attracted to bamboo trees and palm trees. The attraction of this species to palm trees and its fruit may offer an alternate source of food for them in the absence of other food sources. Black-casqued hornbill was observed to move in small family group which confirmed studies done by Borrow and Demey (2010). Since this species utilized the emergent layers of the forest strata, it was therefore important to protect the tall trees within the reserves to ensure their survival. Studies by Borrow and Demey (2010) also agreed with findings from this research which noted that White-crested Hornbills were forest specific and foraged in dense forest. However, no association with monkeys were observed during the period of study as suggested by Borrow and Demey (2010). This could have been due to high hunting pressure been experienced in most of the study areas. Piping hornbills were mostly observed moving in trios or in large groups and often congregated in feeding flock as confirmed by Borrow and Demey (2010). This makes them target species for hunters as they congregate in large numbers. The findings also agreed with Candy (1984) referred to earlier.

**Correlate of hornbill abundance and distribution**

In the absence of food, a primary correlate of hornbill distribution and abundance was observed to be tall trees and elevation. The findings of the study agreed with those of Raman & Mudappa (2003) performed in the southern Western Ghats, India. However, Piping Hornbill distribution and abundance were inversely correlated to large trees. The significant difference in hornbill abundance and distribution with elevation suggested that hornbills utilized different altitude. Except for Piping Hornbill and White-crested Hornbills, all hornbills correlated positively with elevation.

**Hornbill distribution and abundance with respect to matrix types**

Birds in various forests may be influenced more by the extent to which the landscape matrix mediates the availability of critical resources, either via resource supplementation in matrix or differential reduction of the resource or a combination of both (Pardini et al., 2009). Studies had shown that matrix habitats may be hospitable for some native species and may provide supplemental or additional resources that allow for population maintenance or growth in fragmented systems (Brotons et al., 2003; Cook et al., 2004). This confirms the findings from this research in which mechanized palm oil plantation had supplemented the diet of African Pied Hornbills. However where subsistence farming is practised they become target species of hunters.

Bird communities, however, responded differently to the three human-modified matrix types. Patches surrounded by mine matrix maintained greater numbers of hornbills than other matrices. This probably might have been due to abundance of large trees or some other resources whereas areas surrounded by matrices of farms maintained greater diversity of hornbills.

Landscape matrix type can also impact internal forest conditions from, mining activities which involve large-scale removal of vegetation and topsoil and the creation of open pits of exposed earth, all of which could alter soil water retention, create dust pollution, and lead to biogeochemical and hydrologic changes (Bell & Donnelly, 2006; Kennedy et al., 2010). Although the degree of this phenomenon is unknown, Simmons et al. (2008) believed they may alter microclimate and structure of the forest and also alter the composition of the fauna and flora. Post-mining restoration, may not fully recover ecological communities to their original state (Parrotta & Knowles, 2001). The study strongly suggests that such land conversions would cause the loss of a large proportion of the hornbill community, even without additional forest loss or isolation in the nearest future. Another worrying phenomenon observed during the course of the study was that land which had been reclaimed was done with exotic species of plants. These plants do not support avian communities in any way and as such may further cause more collapse to the avian communities.

**Local people's perception on hornbills**

The economic activities of the respondents had allowed for more interaction with the hornbill species. Although the local people had divergent views about the names of the same species of hornbills, they were, however, able to identify the different species of hornbills correctly. This could be deemed an encouraging phenomenon as it may pave the way to involve local people in hornbill conservation. Majority of respondents who were of the view that hornbill numbers were greatest during the rainy seasons contradicted the findings from this field research. This observational difference may be due to change in the habit of the hornbill species or the local people did not take into consideration the breeding season of these species where breeding females were mostly excluded from the population. It was also possible that sample size were inadequate to bring out such differences.

There was strong affirmation that hornbills numbers had declined in recent times of which respondents cited hunting for food, physical habitat destruction due to logging, conversion of forest to agricultural land and hornbill trade as the possible cause of their decline. DeFries et al. (2004) had confirmed that there had been a global trajectory of land conversion in many regions of the world from subsistence agriculture to increasing urbanization which had been exacerbated by the development of roads at the cost of plants and animal lives. In addition, Ahmed (2004) reported that in some part of India there was a rapid decline in hornbill population as a result of the lucrative trade in hornbills for various reasons such as pet, food, sport, black magic, medicinal value, taxidermy and other derivatives.

Although minority of the local people thought hornbill population had increased, it is possible that they were exaggerating their numbers or could not have had prior knowledge on the species and their numbers. Some cited taboos and protection from authorities as the reasons for their increase although they were unable to prove the kinds of taboos used to control poaching on hornbills. Others also believed hornbills migrated during certain seasons into the environs leading to an increased number of the species.

**Importance of Hornbill to local people**

Most of, the respondents had some knowledge on hornbills' foods. This finding is encouraging because these food trees could be protected through intensive education. It was also interesting to note that the local people had a perfect idea on hornbill reproduction. They confirmed hornbills laid few eggs all of which hatched. Most respondents cited protein supplement as the reason for their importance. However, others cited source of income through hornbill trade, while others thought they were beautiful to watch. Those of the view that the species were traded confessed that it was a lucrative business. Hornbill sold on the average between GH¢10 and upwards.

Since little or no records exist on international trade on hornbills, especially in Africa for that matter Ghana, it is possible that the rate of harvest would be underestimated. Harvest of hornbills could be higher than currently known. Even in a well developed country like the United States, there is lack of data on this trade. The primary means of tracking international trade in wildlife is the CITES Trade Database, maintained by the World Conservation

Monitoring Centre which does not provide any information on African hornbills. US Fish and Wildlife Service (USFWS) Office was responsible for entering data of any wildlife that is imported into the country. From March 1999 to March 2006, 129 import declarations involving African hornbill species were processed by USFWS, involving 434 declared items. This number excluded those not declared possibly due ignorance to deliberate smuggling, which were not always detected by law enforcement (Pepper, 2007).

Hornbill imports entered the United States were from 15 African countries of which Ghana was ranked as having contributed 3% of the total importations (Pepper, 2007). This number could be an underestimate considering the fact that; there are no monitoring mechanisms on the export of hornbills from Ghana. Clean skulls of some species were for sale on Internet online auction and skeleton sale sites. Species involved included the Black-casqued Hornbill, Yellow-casqued Hornbill, Brown-cheeked Hornbill, Trumpeter Hornbill, Piping Hornbill and numerous species of *Tockus* hornbills (Pepper, 2007). There is therefore the need to intensify patrols in forest reserves of Ghana as well as establishing a well equipped monitoring task force to oversee this illegal trade.

The overwhelming affirmation given by local people on hornbill conservation was very encouraging as majority (98%) were willing to get involved in the conservation of hornbills. The minority who disagree to this gave reasons such as the species were nuisance and were identified as crop pest by some cocoa farmers. Local conservation may be achieved if only individuals were self determined and having the will power to stop the killings. Also intensive conservational education must be carried out.

## CHAPTER SEVEN

### Summary, conclusions and recommendations

### Summary

Conservation of hornbills in the tropical forests requires an understanding of the seasonal patterns of abundance and distribution as well as other factors mediating their responses. The study compared the distribution and abundance of hornbills in different landscape types as well as the effect of seasonality on species distribution and abundances. The Black-casqued Hornbill, African Pied Hornbill, Black Dwarf, Piping Hornbill and White-crested Hornbill were identified out of the 10 forest species believed to occur in Ghana forest reserves. The absence of the other types of forest species calls for concern especially the Brown-cheeked Hornbill which was believed to be the first hornbill to disappear following habitat fragmentation. All these species occurred in low numbers except for the African Pied Hornbills whose numbers seem to be quite stable. The low abundance probably effects of prolonged fragmentation. Habitat fragmentation resulting from mining, logging, clearing of forest for farming, hunting pressure and international trade of hornbills were some of the drivers of the low numbers observed. Thus hornbill conservation will be possible if the local people are involved.



### Conclusions

The current study has several implications for conservation of hornbills in the country as well as other biota. The results emphasized the importance of large forest tracts for conservation of hornbills, particularly large species such as Black-casqued, Yellow-casqued and the Brown-cheeked Hornbills.

Differences in distribution and abundance of hornbills from one study area to another suggests that there may be variations in local conditions which may result from differences in matrix characteristics. The results also indicated that some matrices especially those of farms may impact positively on some species of hornbills thus helping to maintain populations and in addition provide food. It is therefore important to take keen interest in the conservation values of these matrices by educating owners (farmers) on the importance of their matrix on conservation of hornbill species and other biota.

African Pied Hornbill seemed to be under minimal threat compared with the others. This is evident in their greater numbers than other species. It was found in all matrix types and this may be due, in part, to its resilience to habitat modification and in part due to their greater dispersal abilities as compared to the others.

Although a number of socio-economic reasons may explain the increasing pressure on Ghana wildlife populations, the impact of forest exploitation practices must also be well noted. Roads constructed by gold prospectors had increased access to previously unreachable areas and allowed hunters to install their camp sites and hunt in these areas without any control by the authorities. The activities of chain saw operators were worth noting as they seriously impact negatively on the forests by destroying tree species and valuable nesting and roosting sites for hornbills. The activities of licensed mining companies and illegal miners also may have contributed immensely to the low populations of hornbills in some study areas. The continuous damping and leakage of chemicals used for gold processing into water bodies should be well noted as these could have a deleterious effect on the food chain and may drive species to local extinction in the nearest future.

Although these birds are beautiful and fascinating to look at, the results obtained on their abundance during this research may not encourage tourism as it would be difficulty in citing them. Apart from the African Pied Hornbill, citing of any other hornbill may be by chance or when there are favourable fruiting trees. Indicators for the presence of some hornbill species such as calls and flapping of wings could be exploited by tourists. Some of the hornbills have sharp and distinct calls and the very large species produce loud sounds when in flight. Although low in number in all the study areas yet, it was, however, observed to be a niche specific species. Considering the various economic activities that are on-going in the various forests in Ghana, it is possible that there had been a reduction in hornbill numbers. However, each of the forests holds some fringe communities of the different species of hornbills at probably low numbers. It is therefore important to actively protect areas which hold smaller numbers of hornbill species.

Seasonality was observed to have effect on hornbill abundance. Lower numbers in the wet season may have been due to the fact that nesting females might have been excluded from the main populations.

Since no known database exist on the exportation of hornbills from Ghana, it is impossible to quantify the magnitude of exports resulting from international trade and it is expected that this numbers may rather be high. It must be noted, however, that hornbill trade is a booming one and if this activity is not checked, it may lead to extinction of the species. This phenomenon was revealed by both local people during the study period and the United State Fish and Wildlife Service which had some data on declared importation of African hornbills including those from Ghana. It is therefore important to increase both local and international protection for hornbill species especially the Black-casqued Hornbill, Yellow-casqued Hornbill and the Brown-cheeked Hornbill which are the most sought after species.

Findings of the study indicated that local people had good knowledge on the different species of hornbills within their localities. Respondents had no problem with their identification although they had divergent views on the same species' local names. They also had knowledge on some aspects of their ecology such as feeding behaviour and reproduction. They also believed hornbill numbers were large during the past but did also agree that their numbers had dwindled in recent times with some species completely absent from the vicinities. Reasons given to that effect include habitat destruction, international trade and local consumption as source of protein. It was reported, however, that when target species were difficult to hunt, other species may be hunted when chanced upon. Local conservation of hornbill was achievable if the local people are willing to change their attitude towards bushmeat consumption.

**Recommendations**

It is hoped that the following recommendations when followed and acted upon would help control, to a large extent, the rate at which hornbill populations are declining in Ghana's forests.

1. Monitoring and protection of hornbill nest and roost sites should be done in conjunction with local people. A more effective way would be

by identifying and integrating poachers into monitoring programme of hornbill nests. This would ensure that hornbills would be protected at specific sites since the local people are familiar with the nesting and roosting places of these birds. This would reduce the destruction of important habitats and also offer protection to the few areas left with hornbill viable population. It would also reduce the hunting pressure on the remaining species. Monitoring by local people will help in providing employment opportunities and also help in changing their attitudes to wildlife resources and protected areas as something that is beneficial for them.

2. Existing regulations on wildlife and forestry needs to be strengthened so as to offer stiffer punishment to violators.
3. Modelling an index of the hunting level in every forest reserve of the country is very crucial in finding lasting solutions to combat the hunting of hornbills. This would also help to evaluate changes in attitudes and success in the conservation efforts.
4. Due to the ever increasing high demand for hornbill and their products for the international market, it would be important to domesticate species which could be sold to meet the demands of these markets.
5. It is strongly recommended that existing population of hornbills in other areas of the country be strengthened and also making effort to creating suitable habitats which would maintain viable populations.
6. It is very important to educate local people on the importance of hornbills as a priceless heritage given to them by nature. It is therefore very prudent to develop ways in which the local people would have a

sense of belongingness in conserving these species. This may be done by training local people as nature guides. This would not only create employment for them, but also garner greater commitment to conservation from the local communities thereby strengthening their traditional knowledge.

7. Since hunting forms the source of protein and income for a large part of the rural population in the forest regions, it would be important to identify other areas of economic activities by creating alternate source of livelihood such as grass-cutter rearing, snail farming among others for the local people. This would wean communities away from hunting of hornbills and other wildlife.
8. Initiating intensive conservation education/awareness programmes throughout the country and Encouraging an interest and pride in the rich wildlife and forests of the state, especially among schoolchildren who will be crucial in changing adult attitudes and for a long-term change in the conservation scenario of the state. Talks, lectures, slide and film shows should be geared towards schoolchildren, and colleges as well as university students.
9. As suggested by Datta & Rawat (2003), It will be important to document the traditional customs, rituals, folklore and stories about hornbills and other wildlife in the country. This would help in the traditional conservation of wildlife in the country.
10. A thorough study/research into the biology of hornbills of Ghana is necessary. This knowledge may be used in captive breeding

programmes which may serve as a repository for future replacement of the wild species.

11. The activities of chain saw operators and illegal miners must be keenly watched and actions taken immediately as their activities destroy valuable habitats for hornbill species and other biota in the forest. This calls for regular patrols within the forest reserves by staffs. It is also important to regularly organize refresher courses for wildlife and forest officers to update their knowledge in the current techniques and technologies used in managing forest reserves and protected areas as well as motivating hard working staffs.
12. Licensed commercial mining companies should be monitored so that they do not go beyond their boundaries or mining concessions as this has the potential of destroying the valuable forest. Their activities could also be keenly monitored at time intervals to see if they are in compliance with environmental policies.
13. Buffer zones and boundary lines must be clearly mapped out and demarcated as these would discourage people entering into the forest reserves.

**Recommendations for further research**

Hornbill species are among one of the least species thoroughly researched partly due to the impression created that they were species of least concern. It is therefore necessary to initiate a long-term scientific monitoring of the hornbill population by having data on their reproduction, nest and roost sites in all forest reserves in the country through scientific data collection on breeding and nesting sites. This should cover counts on population during the breeding and non-breeding seasons. This can be done by creating a database and regularly updating it.

Park managers and forestry staff must be encouraged to actively take regularly inventory of the populations of hornbills and other species so as to have ideas on their trends.

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## APPENDIX I

**QUESTIONNAIRES**

**PERCEPTION OF LOCAL PEOPLE ON HORNBILL SPECIES**

**RESEARCHER: MR. SELASI DZITSE**

This questionnaire is designed to enable the researcher seek the opinion of local people on the species of hornbills.

All information given are confidential and for the purpose of the research only. Thank you.

Please respond to the following questions as far as you can.

**Personal details:**

Sex : Male ( ) Female ( )

Age: below 15( ) 16-40 ( ) 41 – 60 ( ) Above ( )

Educational qualification Basic ( ) Secondary ( ) Tertiary( )

Other (Please specify…………………………………..

1. How long have you lived in this place?

5-9 years ( ) 10-19 years ( ) 19-29 years ( ) 30-40 years ( ) above 40 years ( )

2. What is/are your occupation(s)?

Farmer ( ) Hunter ( ) Both farmer/hunter ( ) Chain saw operator ( )

Other(s)....................................................

3. Do you have any knowledge on the different types of hornbills?

Yes ( ) No ( )

4. Which of the species do you commonly see?

African pied ( ) Local names……………………………

Piping ( ) Local names…………………………

White-crested ( ) Local names……………………………

Black-casqued ( ) Local names……………………………

African Dwarf ( ) Local names……………………………

Black-and- casqued ( ) Local names………………………………

Brown-cheeked ( ) Local names……………………………

Yellow-casqued ( ) Local names……………………………

5. In what season(s) of the year do you have the highest numbers of hornbills?

During the rainy season ( ) Dry season ( ) Throughout the year ( )

6. In which area(s) are they normally found during this/these season(s)?

Farms ( ) Forest edges ( )

Tree canopies ( ) Thickets ( )

7. What can you say about their numbers in the past years?

High ( ) Low ( )

8. What can you say about their numbers now/recently?

High ( ) Low ( )

9. What might be the possible reason(s) for their increase?

Taboos ( ) Protection State Authority ( ) No idea ( )

10. What might be the possible reason(s) for their decline?

Habitat destruction ( ) Used as pets ( ) For food ( ) Sale ( )

11. Are there any species you do not see recently?

Yes ( ) No ( )

If yes which of the species is/ are unavailable?

……………………………………………………………………………….

12. What are some of the favourite foods of these animals?

.................................................................................................

13. What can you say about their food availability?

Throughout the year ( ) Rainy season ( ) Not sure ( )

14. Do you have any knowledge on hornbill reproduction?

Yes ( ) No ( )

15. What are your observation about their reproduction?

………………………………………………………………………

16. Are there any folklore, myth or legends about these birds?

Yes ( ) No ( )

If Yes, Please specify…………………………………………………

17. What is/are the importance of these birds to you?

Protein ( ) Income ( ) Beauty ( )

Others, please specify..............................................................

18. How often do you use them for these purposes

Very often ( ) Rarely ( ) Never ( ) Festivals ( )

Others, please specify ....................................................................

19. Are these birds traded or sold in anyway?

Yes ( ) No ( )

20. So how much do you think a species or their parts might cost averagely?

5 Ghana cedis ( ) Above 5 Ghana cedis ( )

21. Which parts are often important/ used often?

Skulls

Feathers

Others, please specify ………………………

22. Do think these species should be conserved for future generations?

Yes ? ( ) No ( )

If No please specify..........................................................................

Crop pests ( ) Nuisances ( ) Common ( ) Not sure ( )

Others, please specify ……………………………………

23. Whose responsibility is it to conserve them?

Park managers/Forest guards ( )

The chief and elders ( )

Community groups ( )

Everybody ( )

Not sure ( )

# APPENDIX II

## ANALYSIS

**Distribution and abundance of hornbills (Dry and Wet Seasons)**
**Two-Sample T-Test and CI: Dry, Wet**

```
Two-sample T for Dry vs Wet

      N  Mean  StDev  SE Mean
DRY  12  36.8   21.2      6.1
Wet  12  16.5   12.4      3.6


Difference = mu (DRY) - mu (Wet)
Estimate for difference:  20.2500
95% CI for difference:  (5.5442, 34.9558)
T-Test of difference = 0 (vs not =): T-Value = 2.86  P-Value = 0.009
DF = 22
Both use Pooled StDev = 17.3693
```

**Distribution and abundance of hornbills ( Edge and Interior)**
**Two-Sample T-Test and CI: Edge, Interior**

```
Two-sample T for Edge vs Interior

           N   Mean  StDev  SE Mean
Edge      21   18.0   14.8      3.2
Interior  17  15.35   9.16      2.2


Difference = mu (Edge) - mu (Interior)
Estimate for difference:  2.64706
95% CI for difference:  (-5.71812, 11.01223)
T-Test of difference = 0 (vs not =): T-Value = 0.64  P-Value = 0.525
DF = 36
Both use Pooled StDev = 12.6424
```

**Large tree density**
**One-way ANOVA: L. Edge, L. Interior**

```
Source  DF     SS    MS     F      P
Factor   1   18.4  18.4  1.12  0.301
Error   22  359.6  16.3
Total   23  378.0

S = 4.043   R-Sq = 4.86%   R-Sq(adj) = 0.54%


                                Individual 95% CIs For Mean Based on
                                Pooled StDev
Level         N    Mean  StDev  ---------+---------+---------+--------
-+
L. Edge      12   8.583  2.778  (-----------*-----------)
L. Interior  12  10.333  4.997           (-----------*-----------)
                                ---------+---------+---------+--------
-+
                                       8.0      10.0      12.0
14.0
```

```
Pooled StDev = 4.043
```

**Correlations: Total Trees, African Pied, Piping Hornb, White-creste, ...**

```
                Total Trees  African Pied  Piping Hornb  White-creste
African Pied          0.384
                      0.217

Piping Hornb         -0.546        -0.071
                      0.066         0.825

White-creste          0.015         0.398         0.049
                      0.963         0.200         0.879

Black-casque          0.552        -0.100        -0.175        -0.197
                      0.063         0.757         0.586         0.539

Black Dwarf           0.141         0.563        -0.054         0.428
                      0.662         0.056         0.868         0.165


              Black-casque
Black Dwarf         -0.091
                     0.779


Cell Contents: Pearson correlation
               P-Value
```

**One-way ANOVA: Elevation, African Pied, Piping Hornb, White-creste, ...**

```
Source  DF      SS     MS      F      P
Factor   5  200630  40126  15.91  0.000
Error   66  166413   2521
Total   71  367043

S = 50.21   R-Sq = 54.66%   R-Sq(adj) = 51.23%


                                      Individual 95% CIs For Mean
Based on
                                      Pooled StDev
Level              N    Mean   StDev  -----+---------+---------+------
---+----
Elevation         12  148.50  119.93                         (----*-
---)
African Pied Hor  12   36.33   19.94        (----*----)
Piping Hornbill   12    9.67   15.56    (----*---)
White-crested Ho  12    6.00    9.57   (----*----)
Black-casqued Ho  12    1.08    3.75  (----*----)
Black Dwarf Horn  12    0.17    0.58  (----*----)
                                      -----+---------+---------+------
---+----
                                           0        60       120
180

Pooled StDev = 50.21
```

**Correlations: Elevation, African Pied, Piping Hornb, White-creste, ...**

```
                 Elevation  African Pied  Piping Hornb  White-creste
African Pied         0.144
                     0.655

Piping Hornb         0.002        -0.071
                     0.996         0.825

White-creste         0.776         0.398         0.049
                     0.003         0.200         0.879

Black-casque        -0.038        -0.100        -0.175        -0.197
                     0.906         0.757         0.586         0.539

Black Dwarf         -0.001         0.563        -0.054         0.428
                     0.997         0.056         0.868         0.165


              Black-casque
Black Dwarf         -0.091
                     0.779


Cell Contents: Pearson correlation
               P-Value
```

## Matrix types

**One-way ANOVA: African Pied, Piping, White, Black-casqued, Black Dwarf**

```
Source  DF     SS    MS      F      P
Factor   4  25523  6381  14.78  0.000
Error   20   8637   432
Total   24  34160

S = 20.78   R-Sq = 74.72%   R-Sq(adj) = 69.66%


                                Individual 95% CIs For Mean Based on
                                Pooled StDev
Level           N   Mean  StDev -----+---------+---------+---------+--
--
African Pied   5  87.20  35.93                         (-----*----)
Piping         5  23.20  26.74       (-----*----)
White          5  15.00  11.51     (----*-----)
Black-casqued  5   2.00   4.47  (-----*----)
Black Dwarf    5   0.40   0.89  (----*-----)
                                -----+---------+---------+---------+--
--
                                     0        35        70       105

Pooled StDev = 20.78
```

**Tourism potential of hornbills using Kilometric Index of Analysis (KIA)**

**Two-Sample T-Test and CI: KIA Dry season, KIA Wet season**

```
Two-sample T for KIA Dry season vs KIA Wet season

                 N  Mean  StDev  SE Mean
KIA Dry season  12  18.4   10.6      3.1
KIA Wet season  12  8.25   6.21      1.8


Difference = mu (KIA Dry season) - mu (KIA Wet season)
Estimate for difference:  10.1250
95% CI for difference:  (2.7721, 17.4779)
T-Test of difference = 0 (vs not =): T-Value = 2.86  P-Value = 0.009
DF = 22
Both use Pooled StDev = 8.6847
```

**One-way ANOVA: Subri River , Atewa Forest, Dumpow Sacre, Kakum Nation, ...**

```
Source   DF      SS    MS     F      P
Factor    9   478.1  53.1  0.89  0.532
Error   150  8912.4  59.4
Total   159  9390.5

S = 7.708   R-Sq = 5.09%   R-Sq(adj) = 0.00%



Level                      N   Mean   StDev
Subri River Forest        16  5.250  14.173
Atewa Forest Reserve      16  4.000  10.954
Dumpow Sacred grove       16  1.375   2.527
Kakum National Park       16  2.750   4.171
Supuma Shelter Belt       16  6.250   7.987
Biodiversity plot         16  1.250   3.587
Neung North Forest Reser  16  4.938   4.509
Pra-Sushien Forest Reser  16  4.625   5.488
Jukwa                     16  5.250  10.567
UCC Lecturers Village     16  1.750   3.276

                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level                     -------+---------+---------+---------+--
Subri River Forest                   (----------*----------)
Atewa Forest Reserve              (---------*----------)
Dumpow Sacred grove       (----------*----------)
Kakum National Park           (----------*----------)
Supuma Shelter Belt                     (----------*----------)
Biodiversity plot         (----------*---------)
Neung North Forest Reser            (----------*----------)
Pra-Sushien Forest Reser           (----------*----------)
Jukwa                                (----------*----------)
UCC Lecturers Village      (----------*----------)
                          -------+---------+---------+---------+--
                               0.0       3.5       7.0      10.5

Pooled StDev = 7.708
```

**One-way ANOVA: Number, Spent Cartridge**

```
Source  DF     SS    MS      F      P
Factor   1   5611  5611  22.55  0.000
Error   18   4479   249
Total   19  10091

S = 15.77   R-Sq = 55.61%   R-Sq(adj) = 53.14%


                                   Individual 95% CIs For Mean Based
on
                                   Pooled StDev
Level             N   Mean  StDev  ----+---------+---------+---------
+-----
Number           10  37.60  21.01                        (------*-----
-)
Spent Cartridge  10   4.10   7.50  (------*------)
                                   ----+---------+---------+---------
+-----
                                       0        15        30        45

Pooled StDev = 15.77


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons

Individual confidence level = 95.00%


Number subtracted from:

                  Lower  Center   Upper
Spent Cartridge  -48.32  -33.50  -18.68

                   +---------+---------+---------+---------
Spent Cartridge    (--------*--------)
                   +---------+---------+---------+---------
                 -48       -32       -16         0
```