

UNIVERSITY OF GHANA

COLLEGE OF BASIC AND APPLIED SCIENCES

ASPECTS OF THE COMMUNITY ECOLOGY OF WATERBIRDS IN MOLE

NATIONAL PARK

BY

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## DECLARATION

I, Timothy Khan Aikins, hereby declare that this thesis titled “ASPECTS OF THE COMMUNITY ECOLOGY OF WATERBIRDS IN MOLE NATIONAL PARK” is my own work and that no previous submission for a degree has been done here or elsewhere. Works by others, which served as source of information, have been duly acknowledged by reference to the authors.

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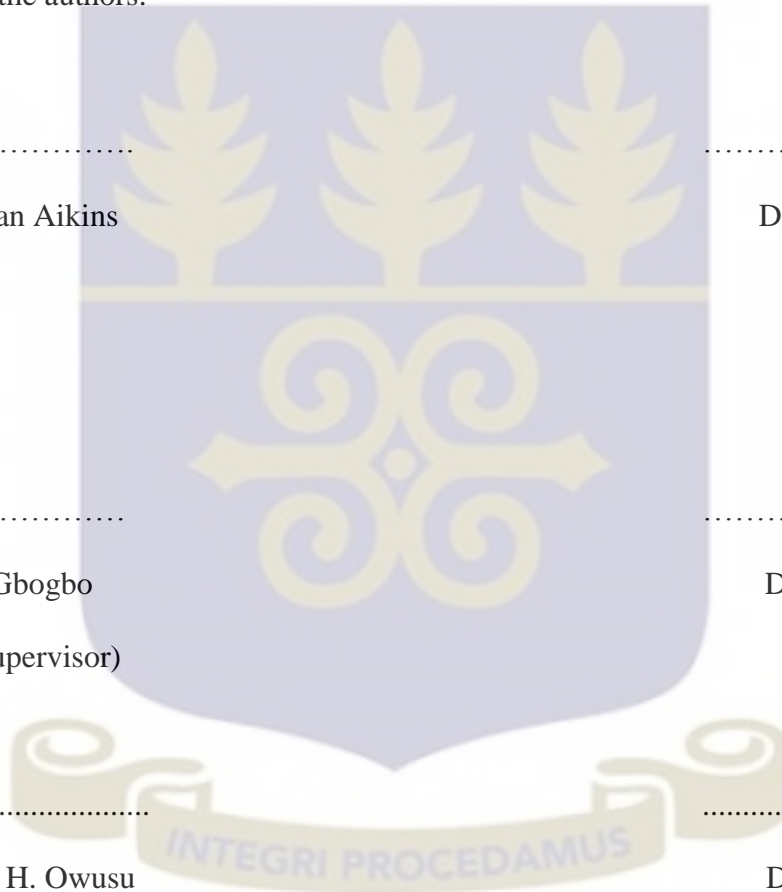
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## ABSTRACT

Mole National Park is the largest and oldest national park in Ghana. With a large number of species of birds, mammals and reptiles, the number of tourists in Mole National Park keeps increasing and therefore creating room for human disturbance in diverse ways. Using the total area count method, this study established the species of waterbirds at Mole National Park and determined the seasonal variations in their diversity and abundance in four permanent wetlands from August 2015 to February 2016. It also assessed the nature and levels of disturbance to waterbirds and determined the alert and flight initiation distances of selected species of waterbirds through daily monitoring of waterbird flushes and the conduction of flushing experiments. A total of 29 species belonging to 6 orders and 12 families were recorded of which Lana Pool had the highest proportion of the birds' abundance (58.08 %) while Asibey Pool recording the least (6.20 %). With White-faced Whistling Duck (*Dendrocygna viduata*) being the most abundant species in the study area, the highest number of species (26) occurred in Haraba Pool and the least (18) at Asibey Pool. Species richness and abundance of waterbirds in Mole National Park varied between the wet and dry seasons with the dry season generally recording higher number of waterbird species richness and abundance. Waterbird at Mole National Park on the average spend 84.95 seconds per hour due to flushing. Majority of the flushes were caused by indeterminate factors (70.5 %). Average time spent in flight by a waterbird as a result of human flushing was 17.55 seconds per hour which constitute only 20.66 % of a waterbird's average time in flight due to flushing. Grey Heron (*Ardea cinerea*) had the longest mean AD and FID whilst Green-backed Heron (*Butorides striata*) and Cattle Egret (*Bubulcus ibis*) respectively recorded the shortest AD and FID. Grass height, grass cover, shrub height,

group size and the number of heterospecifics in a group had a significant multiple regression weight with the AD of some waterbirds. It was recommended that bird watchers should schedule their visit to the park during the dry season so as to encounter more species. When considering set-back distances in the design of path ways in Mole National Park, it should consider the alert distance of the largest species as this will help reduce disturbances of smaller ones.



## DEDICATION

I dedicate this work to my dear wife Mrs. Angela Achiaa Aikins and my son Annor Fiifi Aikins.



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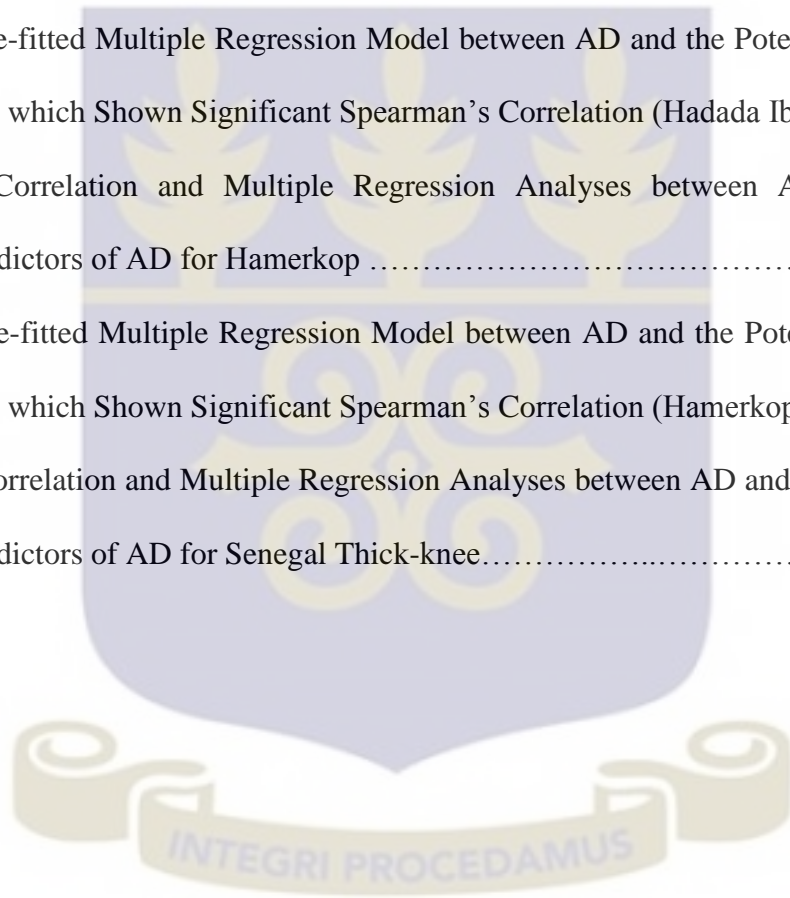
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## LIST OF ABBREVIATIONS

|          |   |  |
|----------|---|--|
| AD       | - | Alert Distance                                     |
| $C_{MH}$ | - | Morisita-Horn index                                |
| FAO      | - | Food and Agriculture Organization                  |
| FID      | - | Flight Initiation Distance                         |
| IUCN     | - | International Union for the Conservation of Nature |
| MAD      | - | Minimum Approaching Distance                       |
| SD       | - | Standard Deviation                                 |



## CHAPTER ONE

### INTRODUCTION

#### 1.1 Background

Waterbirds are “species of birds which are ecologically dependent on wetlands” (Ramsar Convention, 1999). Ecologically, waterbirds can be grouped into five (5) categories as; aerial foragers, divers, swimmers, small waders (shorebirds) and large waders (Udhayakumar *et al.*, 2011; Vachanth, 2013). Divers are medium to large sized waterbirds having stream-lined bodies with legs set far back. They dive by either wing or foot propulsion and are well adapted to catch aquatic preys (such as grebes, cormorants, coots, loons, diving ducks). Swimming birds are associated with surface water columns and use webbed feet for propulsion (for instance ducks, swans and geese). Small waders are small birds associated with shallow open expanses of water and include jacanas, sandpipers, plovers and other members of the order Charadriiformes. Large waders are large, long legged birds that wade into the shallow water in search of prey (for example ardeids, ciconids, ibises and flamingos, but also large charadriiform birds such as stilts and Whimbrel). Aerial foragers are birds that search for prey by flying over the water surface and diving from air to capture individual prey items (for example terns, gulls and skimmers) (Udhayakumar *et al.*, 2011; Vachanth, 2013).

Wetlands serve as important habitats for many species of waterbirds and are among the most productive and biologically diverse ecosystems in the world (Gibbs, 1993). As vulnerable ecosystems as they are, wetlands and waterbirds are indivisible elements and hence form a rich collection of waterbird communities (Grimmett and Inskipp, 2007). Some

waterbirds can therefore serve as good indicators of wetland environment (Wicker & Endres, 1995; Green *et al.*, 2002; Amat and Green, 2010) while the behaviour of others can serve as a bioindicator in the wetland ecosystem (Nummi *et al.*, 2000; Pöysä *et al.*, 2001). It is estimated that about 150 species of migratory waterbirds, with total population of two billion uses the wetlands around the Mediterranean (EURONATUR, 2007; RAMSAR, 2007).

Despite the importance of waterbirds and the significant roles of wetlands in waterbird support, the populations of many species of waterbirds have been decreasing in the recent past (Millennium Ecosystem Assessment, 2005). The status of globally threatened waterbirds has declined faster since 1988 than the status of terrestrial birds. About 41% of the total of 1,138 waterbirds whose biogeographic population trends are known are declining rapidly (Millennium Ecosystem Assessment, 2005). According to the Millennium Ecosystem Assessment (2005), of the 964 bird species that are principally wetland-dependent, 21% (203) are globally threatened or extinct.

With regards to waterbird population in Africa, Zwarts *et al.*, (1998) recorded a decline in the populations of 11 of the 15 species of wader between 1980 and 1997 at Banc d'Arguin, Mauritania (the most significant site for coastal waders in West Africa). Furthermore, Zwarts *et al.* (1998) also matched their findings with those of Salvig *et al.* (1994), at the mudflats and mangroves in the Bijagos Archipelago, Guinea Bissau (the second most significant site for coastal waders in West Africa). There was an overall declining for at least six waders, (of which five of them are Arctic-breeders) in these key international West

African wintering areas. Also, other authors (Underhill *et al.*, 2000; Venter *et al.*, 2002) have noted a drop in the Arctic-breeding Turnstone (*Arenaria interpres*) and the Curlew Sandpiper (*Calidris ferruginea*) populations over the last two decades in South Africa. These studies have elaborated on the population status of some waterbirds in the World and Africa and therefore conducting similar study in Ghana and specifically Mole National park will help us to keep track of the populations of these birds so as to enable us take proper conservation decisions.

Mole National Park is the oldest and largest national park in Ghana. Mole National Park is home to over 93 mammal species (Riley and Riley 2005) and 33 reptiles (Briggs, 2007; Riley and Riley 2005). The Park has about 344 species of birds (Dowsett-Lemaire and Dowsett, 2005). Despite the high diversity of bird species in the Mole National Park, the park's waterbird species has generally not been studied.

## **1.2 Justification**

Though several studies on waterbird foraging ecology has been conducted in coastal Ghana and West Africa as a result of the region's importance as wintering habitat for Palearctic migrant waterbirds (Ntiamo-Baidu *et al.*, 1998; 2000; Gbogbo and Attuquayefio, 2010; Gbogbo *et al.*, 2013; Gbogbo *et al.*, 2014), scientific studies on the ecology, diversity and abundance of waterbirds in the Northern ecological zone of Ghana are uncommon. Unlike the Northern ecological zone of Ghana, research on birds in the Southern forest belt (Arcilla *et al.*, 2015; Holbech 2005; 2009; Owusu, 2007; 2008; Demey and Hester, 2008) and coastal wetlands (Ntiamo-Baidu *et al.*, 2000; Gbogbo and Attuquayefio, 2010; Suapim *et*

*al.*, 2007) has been significantly extensive. The only notable works previously conducted in some wetlands in Northern ecological zone were to establish a baseline data of the types of birds found on the wetland (Dowsett-Lemaire and Dowsett, 2005; Obodai and Nsor, 2009) and to assess the environmental determinants influencing the seasonal diversity and abundance of birds (Nsor and Obodai, 2014). However, none of these studies focused solely on waterbirds.

Also Mole National Park being the largest National Park in Ghana attracts large numbers of tourists. Yearly data between 1998 and 2012 indicated an average of 2,959 domestic and 4,276 foreign tourist visited the park each year whilst yearly maximum number of domestic and foreign visitors to the park was 8,048 and 8,759 respectively (Lawer *et al.*, 2013). The number of visitors to the park has generally been projected to increase (Lawer *et al.*, 2013) and therefore precipitating the need for research into human-wildlife interactions and conflicts in the park. The presence of tourist may disturb birds in different forms such as flushing of the birds to flight or cause them to avoid quality foraging patches. According to Ruddock and Whitfield (2007), animals usually move away from an approaching disturbance (human) and this reaction can have adverse effects on their feeding success and behaviour.

The absence of a scientific investigation on the ecology of waterbirds in the northern ecological zone makes it impossible to determine the current state of the waterbirds in this zone. Also, because of the conservation and ecotourism role of Mole National Park, the

inadequate information on waterbirds use of wetlands in Mole National Park may seriously hamper informed conservation decisions.

The result of this study will serve as the baseline data to enable the monitoring of waterbird populations in Mole National Park. In addition, the outcome of this study would aid in equipping the park managers and other researchers with the requisite knowledge needed in taking conservation decisions with regards to wetlands and waterbird management in the northern ecological zone of Ghana.

### **1.3 Research Objectives**

#### **General Objective:**

1. To evaluate some aspects of the ecology of waterbirds in Mole National Park

#### **Specific Objectives:**

1. To determine the seasonal variations in waterbird assemblages in Mole National Park.
2. To assess the nature and levels of disturbance to waterbirds in Mole National Park.
3. To determine the Alert Distance (AD) and Flight Initiation Distance (FID) of selected waterbirds species and evaluate the effect of surrounding vegetation on AD.

## CHAPTER TWO

### LITERATURE REVIEW

#### 2.1 Waterbirds of Mole National Park

Dowsett-Lemaire and Dowsett (2005) reported that the number of waterbirds permanently visible around the Mole dams were not high but include approximately 24 individuals of Hadada Ibises *Bostrychia hagedash*, a few Green-backed Herons *Butorides striata*, African Jacanas *Actophilornis africanus*, and Black Crake *Amaurornis flavirostra*. According to Dowsett-Lemaire and Dowsett (2005), several waterbirds including Saddle-billed Stork *Ephippiorhynchus senegalensis*, Woolly-necked Storks *Ciconia episcopus* and White-faced Whistling Ducks *Dendrocygna viduata* were very visible in the rainy season but not in March (dry season).

According to Dowsett-Lemaire and Dowsett (2005), Allen's Gallinule *Porphyrola alleni*, a rainy season visitor, has become scarcer than in the past however the herons and waders are now common and no more occasional or rare visitors. The authors stated that more waterbirds have been reported in the dry season (December to March), but numbers of herons and egrets seen at Asibey's pools in March were very low. The high number of waterbirds reported in the dry season as compared to the rainy season could be attributed to the fact that in the rainy season water is everywhere and waterbirds are much dispersed (Dowsett-Lemaire and Dowsett, 2005).

Several authors (Harvey & Harrison, 1970; Greig-Smith, 1976; Wink, 1976; Grimes, 1987; Dowsett-Lemaire and Dowsett, 2005) have listed the species of birds in Mole National Park

but did not report waterbirds separately from the other birds. Appendix 1 shows an extract of waterbirds from literature on birds of Mole National Park. In all, 59 species of waterbirds have been reported to occur in Mole National Park of which 32 were recorded by Dowsett-Lemaire and Dowsett (2005) between August - September 2004 and March 2005.

However, Dowsett-Lemaire and Dowsett (2005) rejected some records of birds in Mole National Park by some authors with the reason of being misidentified or confused with other species. Other species were rejected because they do not occur within the savanna zone or do not even occur in Ghana or West Africa. In all 48 species of birds were rejected by Dowsett-Lemaire and Dowsett (2005) of which six (5) were waterbirds including; Yellow-billed Stork *Mycteria ibis*, Fulvous Whistling (Tree) Duck *Dendrocygna bicolor*, Egyptian Goose *Alopochen aegyptiaca*, Grey Plover *Pluvialis squatarola*, and Common Redshank *Tringa tetanus*.

## **2.2 Wetlands and waterbirds population decline trends**

Ramsar Convention (Article 1.1), defines wetlands as areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salty, including areas of marine water the depth of which at low tide does not exceed six metres (Matthews, 1993). The common feature of all wetlands is that the substrate is at least occasionally covered with water and that water is derived from the sea, rain and rivers. It is an international resource which must be conserved and kept free from pollution by international agreement (Matthews, 1993). Article 1.2 of the Ramsar

Convention defines waterbirds as “birds ecologically dependent on wetlands” and Wetlands International (2006) identified 34 families of waterbirds.

According to Millennium Ecosystem Assessment (2005), many waterbird species are globally threatened, and their status continues to worsen faster compared to bird species in other habitats. Of the 964 bird species (not including albatrosses and petrels) that are largely wetland-dependent, 21% (203) are globally threatened or extinct (Millennium Ecosystem Assessment (2005). Species that depend on coastal systems are now at higher risks globally compared to those that dependent only on inland wetlands.

The State of the World’s waterbirds report by Wetlands International (2010) indicates that, in the mid-1970s, the status of waterbirds in the Americas was relatively good, even though 39% of the populations were decreasing and only 17% increasing. Also the status of long distance and short distance migrants and residents has improved significantly since 1970s. However, in 2005, only 12.5% of North American resident birds and short-distance migrants were decreasing and 29% were increasing. In contrast, the status of resident and short-distant migrant waterbirds in South America has declined since the mid-1990s leading to an index below the global average (Wetlands International, 2010).

The status of waterbirds in the Asia-Pacific region is worse compared to other places: In 1990s through to 2000s, their populations have been in very poor state. Asian residents and short-distance migrants have the worst status with 71% of populations declining and only 9% increasing. The status of Asia-Pacific long-distance migrants and Oceania residents and

short-distance migrants remains at or below the global average, but shows some progress since the 1970s (Wetlands International, 2010). Furthermore, Wetlands International (2010) reported that even though East Atlantic Flyway waterbirds status have worsened significantly, their populations are better than the global average. In contrast, European resident and short-distance migrant waterbird populations have improved in status in 1996–2005.

The State of the World's waterbirds report further indicates that in Sub-Saharan African, the status of resident and short-distance migrant populations is not deteriorating but poor. However, since the 1970s there has been major decline in the status of long-distance migrant populations (Wetlands International, 2010).

Zöckler *et al.* (2003), reported on the population trend of waders in relation to their migratory behaviours. Their findings show that 51%, 47% and 35% of the population of short distance and intracontinental migrants, intercontinental migrants and sedentary waders respectively are decreasing. From this finding, it can be deduced that migratory wader populations are at high risk of decreasing as compared to sedentary species that are not known to migrate at all. However, high percentage (27%) of the short distance and intracontinental migrant populations are increasing as compared to 14% for the sedentary species and 8% for the intercontinental migrants (Zöckler *et al.*, 2003).

With respect to waterbirds populations in Ghana, several studies have been conducted on the coastal wetlands of Ghana with population estimates of waterbirds in Keta and Muni Ramsar sites (Lamprey and Ofori-Danson, 2014), Mukwe Lagoon, Sakumo Lagoon, Laiwi Lagoon and Densu Delta (Gbogbo, 2007; Gbogbo and Attuquayefio, 2010), Muni Lagoon (Ntiamo-Baidu *et al.*, 2000).

Ntiamo-Baidu *et al.* (2000) recorded a total of 48 species of waterbirds at Muni Lagoon. This comprises of waders (29 species), terns (8 species), herons and egrets (7 species), gulls (2 species), duck and cormorant (one species each). Lamprey and Ofori-Danson (2014), recorded a total of 25 species of waterbirds at both the Keta Lagoon and Muni Lagoon. A total of 24 species was recorded only at Keta Lagoon and its surrounding floodplains, whilst Muni Lagoon recorded a lower number of species of 12 species. In all, 20,217 individuals were counted with 19,757 (97.7% of the total counts) recorded in Keta Lagoon whilst 460 (2.3% of the total count) was recorded at Muni Lagoon.

The authors compared their abundance figures at Keta Lagoon with a similar work done at Keta Lagoon in 1983 to 1985 (Save the Seashore Birds Project-Ghana) and found a decline of about 63.1%. Also, comparing the number of species recorded at Muni Lagoon by Lamprey and Ofori-Danson (2014) with that of Ntiamo-Baidu *et al.*, (2000), it shows a drastic decrease in the number of species at the site (48 species in 2000 to 12 species in 2014). Lamprey and Ofori-Danson (2014) attributed the decline in the number of species at Muni Lagoon to the highly unstable limnological environment; which was mostly dried up during their study period except for rainy seasons and siltation was severe at major part of

the lagoon meaning fish could barely survive in it. These conditions imply that waterbirds could hardly find food and could possibly compel the movement of waterbirds to neighboring lagoons, streams and estuaries or to the sea to feed (Piersma and Ntiamoa-Baidu, 1995; Ntiamoa-Baidu *et al.*, 2001).

Gbogbo (2007) recorded a total of 55 waterbird species at Mukwe Lagoon, Sakumo Lagoon, Laiwi Lagoon and Densu Delta. Densu Delta and Sakumo Lagoon (managed wetlands) together recorded a total of 51 waterbird species and Laiwi Lagoon and Mukwe Lagoon (unmanaged wetlands) together recorded a total of 44 species. However Gbogbo and Attuquayefio (2010) recorded a total of 48 species of waterbirds at these same sites. Densu Delta and Sakumo Lagoon (managed wetlands) together recorded 47 species and Laiwi Lagoon and Mukwe Lagoon (unmanaged wetlands) together recorded 43 species. This shows a decrease of seven (7) species within a period of four (4) years.

### **2.3 Role of waterbirds in aquatic ecosystem**

Millennium Ecosystem Assessment (2005) defined Ecosystem services as “the benefits people obtain from ecosystems. These include provision of services such as food and water; regulating services such as flood control, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious, and other non-material benefits.” Based on the definition, these services are provided by the organisms which form the ecosystem. Birds and more specifically waterbirds are not exception to the provision of these services.

### *Waterbirds and ecosystem services*

The presence and activities of waterbirds can have significant positive effects on aquatic fauna and flora. For instance they help in the spreading of plant propagules to isolated wetlands to maintain the biodiversity of these areas (Green and Elmberg, 2014). According to Hidding *et al.* (2010), foraging by waterbirds can help to improve the diversity of submerged macrophytes. Also the regulation of interspecific competition by geese can help in maintaining high diversity in grasslands (Jasmin *et al.*, 2008). The movement and aggregate formation by waterbirds automatically influence nutrient fluxes thereby playing the ecosystem role of nutrient and biogeochemical cycling (Green and Elmberg, 2014). Guantrophication by waterbirds can have positive influence on plant diversity and productivity especially in natural landscapes where nutrients are inadequate (Van Geest *et al.*, 2007; Michelutti *et al.*, 2009). Also Mosepele *et al.* (2009), reported that wetland and fish productivity are expected to be improved by the contribution of nutrients by colonial waterbirds. Furthermore, trampling by ducks on rice residues through their foraging activities in rice fields can increase decomposition significantly (Bird *et al.*, 2000; van Groenigen *et al.*, 2003).

### *Waterbirds as bioindicators*

The diversity and abundance of waterbirds can be a cheaper and easier way of monitoring general ecological status of aquatic ecosystems as they serve as bioindicators (Green and Elmberg, 2014). According to Amat and Green (2010) some waterbirds can be used as good indicators of wetland biodiversity. For instance the presence of the crested coot *Fulica*

*cristata* can be a good indicator of high aquatic plants species richness (Green *et al.*, 2002). Also the variations in the numbers of ducks and coot can precisely show changes in the abundance of submerged macrophytes (Wicker and Endres, 1995). Furthermore the feathers and tissues of waterbirds can be used as a useful bio-monitor of heavy metals and other contaminants in wetlands ecosystem (Taggart *et al.*, 2006; Burger and Eichhorst, 2007). There is a correlation between the total phosphorus in water and the degree of pair formation by adult ducks in early breeding season (Nummi *et al.*, 2000; Pöysä *et al.*, 2001).

#### *Pest control*

Waterbirds can also control pests in the ecosystem. For example, storks, herons and ibises are known to prey on crayfish (Negro *et al.*, 2000; Tablado *et al.*, 2010) which are known to cause substantial damage to rice seeds and seedlings (Anastacio *et al.*, 2005). Equally, herons prey on tadpole shrimps *Triops spp.* which is also known to be major pest of rice (Hafner and Britton, 1983). In addition, the diet of ducklings and terns comprise largely of mosquito larvae (Miles *et al.*, 2002; Fonteneau *et al.*, 2009).

#### *Seed dispersal role*

Waterbirds also play an important role in the dispersal of seeds and other organism in the ecosystem. Invertebrates are dispersed by waterbirds either through the digestive system or sticking to feet, feathers and bills (Sánchez *et al.*, 2012). Through their role as vectors of passive dispersal, waterbirds maintain species and genetic diversity by connecting among communities in secluded aquatic systems (Amezaga *et al.*, 2002). The information on the

role of waterbirds in the ecosystem justifies the significance of monitoring and protecting diversity of waterbirds and their abundance at any given wetland.

#### **2.4 Factors that influence the species diversity and abundance of waterbirds**

Waterbird assemblages are influenced by several factors including food availability and abiotic changes in the wetlands (Paracuellos, 2006; Lagos *et al.*, 2008). Therefore, the ecosystem integrity of wetlands is affected by the changes in the hydrosphere's physical and chemical parameters. These abiotic factors in turn, affect the wetland dependent communities and also the ecosystem attributes like species richness, its density and distribution (Burkert *et al.*, 2004).

Annual rainfall has been documented to be positively related to abundance of waterbirds (Dean and Milton, 2001; Moreau, 2008; Wen *et al.*, 2011). Wen *et al.*, (2011) associated this with the improved wetland productivity; as rainfall increases it results in abundant foraging habitat and food supply. Contrary to this, Gbogbo *et al.*, (2009) reported that different waterbird guilds responded differently to changing water levels in the coastal wetlands of Ghana. The authors reported that the population densities of certain waterbird species significantly increased linearly with decreasing water levels whilst the population density of others responded significantly to moderate water levels.

According to Wen *et al.* (2011), high maximum summer temperature may be symbolic of dry prevailing conditions, poor wetland health and reduced habitat quality and can negatively affect the abundance of some group of waterbirds. Water resource development

activities such as damming for irrigation and hydroelectric power have also been reported to affect the species diversity and abundance of waterbirds (Kingsford and Thomas, 2004). The number of waterbird species around the Murrumbidgee River in Southeastern Australia reduced significantly by 21% after damming of the river to provide water, irrigation and electricity to the people (Kingsford & Thomas, 2004). The damming of the Murrumbidgee River resulted in the decline in populations of different waterbird functional groups (Kingsford and Thomas, 2004). This could imply that the waders and other waterbirds which require shallow waters to feed effectively no longer get this condition hence they move to different wetlands where they can get enough food.

High levels of anthropogenic disturbances such as fishing activities tend to have negative impact on waterbird densities (Khan, 2010; Rajashekara and Venkatesha, 2014) and waterbird community composition (Rajashekara and Venkatesha, 2014). Rajashekara and Venkatesha (2014) found a significant negative correlation with the lake area and positive correlation with the number of islands in an urban lakes system with the population density of waterbird communities. Understanding the factors that affect species diversity and abundance of waterbirds will be relevant in explaining the differences in diversity and abundance of waterbirds between sites and seasons in this current study in Mole National park.

## **2.5 Effect of seasons on the diversity and abundance of waterbirds**

Huntley *et al.* (1997a, 1997b) identified seasonal weather change as a factor that influences the ecology of species. Species either respond to variations in weather conditions by

changing their geographical locations or adapt. Seasonal weather changes can change water quality parameters in an area which in turn will change habitat variables, such as the vegetation. Changes in vegetation characteristics will affect the availability of important food resources such as seeds, seedlings, roots, tubers, fruits and nuts for species of herbivorous waterbirds. Similarly, changes in aquatic parameters resulting from season variations in weather conditions can influence availability of insects, worms, crabs, frogs and snakes for carnivorous guilds of water birds (Naugle *et al.*, 2001; Riffell *et al.*, 2001).

Aynalem and Bekele (2008) recorded more species of birds in the dry season as compared to the wet season at the southern tip of Lake Tana, Ethiopia. However in situations where the water dries up completely, species diversity and abundance was reported to be lower compared to wet periods (Behrouzi-Rad, 2009). This occurs as a result of the presence of undisturbed secure food resources and safe refuges in the wet seasons (Behrouzi-Rad, 2009). Some waterbird species can migrate in response to seasonal changes. For example Rajashekara and Venkatesha (2014), recorded higher number of waterbird species in winter as compared to other seasons because of the arrival of migratory waterbirds.

Mundava *et al.*, (2012), however reported that the highest numbers of waterbirds in the dry season when water levels are low could be attributed to the complex interplay of bird movements occurring at local, regional and international scales. Also the gathering of waterbirds at larger permanent water bodies when the small water bodies dry out could explain the high numbers of waterbirds in the dry season. However, the lower numbers of

waterbirds in the wet season could be attributed to the dispersal of waterbirds (Mundava *et al.*, 2012).

## **2.6 Flushing of waterbirds by humans**

Waterbirds are usually disturbed by human in their natural habitats through human approach or activities such as recreation (Ruddock and Whitfield, 2007). Also waterbirds are gradually affected by urbanization processes that change different aspects of their biology (Wearing and Neil, 1999; Marzluff *et al.*, 2001). Gbogbo *et al.* (2013) found that the disturbance of waterbirds in coastal wetlands of Ghana is caused by anthropogenic, indeterminate and natural factors. Flushing of waterbirds driven by anthropogenic and natural causes was reported to have constituted majority of the total flushes in coastal wetlands of Ghana (Gbogbo *et al.*, 2013).

Human-induced disturbances like walking and boating was found to alter the behaviour of birds and diverted their time and energy away from feeding (Borgmann, 2011). Similarly, Carney and Sydeman (1999) identified human disturbances to waterbirds to include the scientific investigators who often do close monitoring of waterbirds, eco-tourists and recreators. According to Christ *et al.* (2003), the disturbance of animals through human activities is expected to get worse because the rate of tourism activities at the world's biodiversity hotspots is anticipated to double by 2020.

These disturbances have been reported to adversely affect birds' feeding success (Fernández-Juricic and Tellería, 2000, Moore, 2014), range use (Andersen *et al.*, 1990),

reproduction (Giese 1996; Miller *et al.*, 1998), survival (Wauters *et al.*, 1997, West *et al.*, 2002) and abundance (Miller *et al.*, 1998; Fernández-Juricic, 2000, 2002; Ntongani and Andrew, 2013). In terms of the effect of disturbance on species diversity and abundance, Ntongani and Andrew (2013), recorded significantly higher species richness on low than on high disturbed grasslands but on the contrary, the birds were more abundant at the high disturbed habitat.

With respect to the effect of disturbance on foraging behaviour and feeding success, Moore (2014) found that Green Heron (*Butorides virescens*) foraging behaviour is not significantly affected by human recreational disturbance but influenced more by differences in habitat at San Marcos, Texas. However, the authors continued to explain that it is likely that the birds have become habituated to disturbance and tolerant of humans and hence may adjust their foraging skill to maximize their foraging efficiency.

Furthermore, the effect of disturbance has been reported to affect reproduction and according to Carney and Sydeman (1999), the disturbances of birds during the breeding season may result in nest neglect or increased danger of nest predation thereby decreasing reproductive success. Also Ruhlen *et al.* (2003) reported of greater loss of Western Snowy Plover chick on weekends than weekdays when higher number of people visit their breeding sites at the beach.

## 2.7 Setback Distances as a Tool for Birds Conservation

Conservationists are increasingly concerned about human disturbance in conservation areas. As human populations continue to grow, ecotourism increases and wildlife in shrinking areas of shelter are exposed to anthropogenic activities (Wight, 2002; Christ *et al.*, 2003). Wildlife managers and policy makers construct buffer zones or set-back distances around possibly sensitive centres of wildlife activity. This is to control human activities near areas such as nest sites of rare or species of conservation concern and/ or breeding colonies. Establishing set-back distances could minimize disturbance and ensure the co-existence of wildlife and human (Rodgers and Smith, 1997; Richardson and Miller, 1997).

Two approaches have been used in prescribing buffer zones. One approach is to estimate the minimum approaching distance (MAD); that is the distance at which humans should be separated from wildlife. By this, areas within wildlife where humans should not intrude to prevent disturbing wildlife can be prescribed (Richardson and Miller 1997; Fernández-Juricic *et al.*, 2005).

According to Ruddock and Whitfield (2007), the commonest method used to estimate MAD is to observe the responses of focus animals to the approach of a single disturbance source. During which one or two measurements are taken; (i) “alert distance (AD), the distance between the disturbance source and the animal at the point where the animal changes its behaviour in response to the approaching disturbance source” and (ii) “flight initiation distance (FID), the distance at which the animal move away from the approaching disturbance source or flushes” (Fernández-Juricic and Schroeder, 2003).

The understanding of the principles of the setback distance and its application will help in making an informed decision in setting minimum approaching distance (MAD) for waterbirds in this current study.

### ***2.7.1 Factors that influence alert distance (AD) and flight initiation distance (FID)***

The nature of the disturbance may also influence the reaction of animals; for example the reaction of animals to grouped disturbance sources like group of tourist may be at greater distances as compared to individual tourist (Beale and Monaghan, 2004a; Geist *et al.*, 2005). Furthermore, Fernández-Juricic *et al.* (2001) found that the alert distance of birds is also influence by the location of human activity that is alert distance increase in closeness of pathways.

Birds which are less capable of enduring the effects of disturbances like those with poor body conditions or stressed by food availability will have less reaction distance (Gill *et al.*, 2001, Beale and Monaghan, 2004b). For example, Beale and Monaghan (2004b) enhanced the conditions of Turnstones, *Arenaria interpres* through the provision of additional food and found greater response to standardized human disturbances by those whose conditions were enhance and thus they fly away at a greater distance from the observer when flushed.

Furthermore the FID and AD may be influenced by availability of alternative habitat around where the birds are disturbed (Gill *et al.*, 2001, West *et al.*, 2002). Fernández-Juricic, *et al.* (2001) found that habitat structure influences the alert distances of birds with increasing bird tolerance with greater availability of escape cover.

The direction of approach by the disturbance source could also affect the FID and AD as animals approached directly will elicit greater FID than those approached on the tangential (Burger & Gochfeld 1981).

Animal group size is also known to affect the AD and FID (Burger and Gochfeld, 1991). For example depending on the response of the most alert individual, sensitivity or risk averse constituent of the flock (Cooke 1980; Hilton *et al.* 1999; Fernández-Juricic *et al.*, 2002), FID may sometimes be longer with larger group sizes. On the contrary, the lower the predation risk to flocks or an increase in competition among members of foraging flocks may lead to reduction in individual attentiveness in foraging flocks (Beauchamp, 2001; Randler, 2005).

Habituation and or prior exposure to disturbance can also influence the response of birds to disturbance (Burger and Gochfeld, 1983; Ruggles 1994). According to Blumstein *et al.* (2005), habituation effects are related to the regularity with which different species interacted with humans. Resident species tend to have shorter flight initiation distance than migratory species that have greater flight initiation distances. Similarly, experience with human disturbance or hunting could also influence the response to disturbance (Galeotti *et al.*, 2000).

According to Gutzwiller and Marcum (1997) observers' clothing colour has an influence on the FID and also AD. Blumstein *et al* (2003) reported that FID may be a species specific

trait and that body mass and FID are positively correlated in birds. Thus larger species have greater alert distance than smaller species (Blumstein *et al.*, 2005). Similarly, several authors (Fernández-Juricic *et al.*, 2001; Weston *et al.*, 2012) found that AD differs among species, with large species being less tolerant of human disturbance as compared to small species. Fernández-Juricic *et al.* (2002) attributed this to the fact that larger bodied species are less aerodynamic than smaller species and hence they may need more time or space to flee. Furthermore, Blumstein (2006) explained that smaller-bodied species may react later to disturbance in an attempt to maximize foraging time to fulfill their higher energy requirement.



## CHAPTER THREE

### MATERIALS AND METHODS

#### 3.1 Study Area

The study was conducted in Mole National Park in the Northern Region of Ghana (Figure. 1). The park was established in 1958 as a game reserve and in 1971, it was upgraded to a National Park (Ntiamoah-Baidu *et al.*, 2001). Mole National Park lies between latitude  $9^{\circ}12'$ – $10^{\circ}06'$  North and longitude  $1^{\circ}25'$ – $2^{\circ}17'$  West and covers an area of 4,840 km<sup>2</sup>. The elevation ranges from 120 to 490 m with terrain that is largely undulating with low scarps. The vegetation is mainly open Guinea Savanna woodland with trees growing to an average height of 11 m although others can grow up to 22 m tall. *Terminalia avicenniodes*, *Burkea africana*, *Butyrospermum paradoxum*, *Combretum spp.* and *Isobertia doka* are some of the common tree species in the park (Ntiamoah-Baidu *et al.*, 2001). Water courses are lined with species-rich riparian forest, with closed canopy and dense undergrowth. Grassland and swamps are also common around water holes and flood-plain of rivers (Ntiamoah-Baidu *et al.*, 2001). The rainy season (May to October) and the dry season (November to April) are the two seasons that the park experience (Kuuder, 2012).

The major rivers that drain through the park include Mole, Samole, Lovi, Zuo, Polzen and Kulpawm rivers. These rivers are important watering points for animals, especially during the dry season. Nevertheless, only the Mole, Kulpawm and Polzen rivers flow permanently. The other rivers usually dry up or are reduced to stagnant pools in the dry season (Kuuder, 2012).

A total of 344 bird species have reliably been reported to occur in Mole and this is the largest number of species reported for any conservation site in Ghana (Ntiamoah-Baidu *et al.*, 2001; Dowsett-Lemaire and Dowsett 2005).

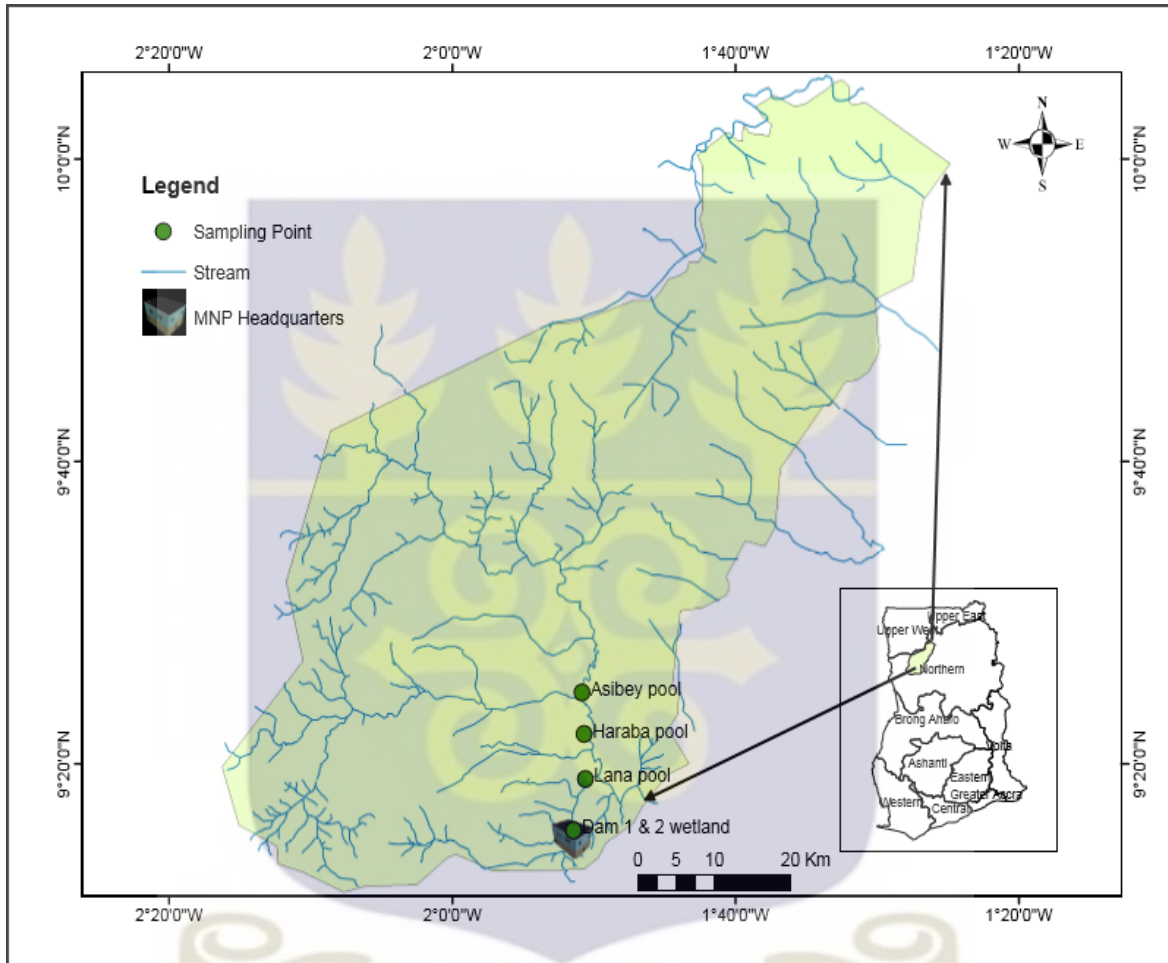


Figure 1: Map of Ghana showing Mole National Park and the study sites.

### 3.2. Selection and description of study locale

A total of four (4) permanent wetlands which were easily accessible in both wet and dry seasons were selected for the study. These include (i) Dam 1 & 2 Wetland, (ii) Lana Pool, (iii) Haraba Pool and (iv) Asibey Pool

### **3.2.1 Dam 1&2 Wetland**

Dam 1 & 2 Wetland (N 09<sup>0</sup> 15.576', W 001<sup>0</sup> 51.423') was created in the 1960s by the damming of the Samole River just below the Mole escarpment (Dowsett-Lemaire and Dowsett 2005). It is about 500 m from the park headquarters. These have no floating vegetation but are bordered by trees on one side and grassland on the other (Dowsett-Lemaire and Dowsett 2005). This site serves as nesting grounds for birds like the Hamerkop *Scopus umbretta*, African Jacana *Actophilornis africanus*, Red-throated bee-eater *Merops bullocki* and several passerine birds. The dams serve as a source of drinking water for large mammals including elephants *Loxodonta africana*, waterbucks *Kobus ellipsiprymnus*, Kobs *Kobus kob*, Bushbuck *Tragelaphus scriptus* Patas monkeys *Erythrocebus patas*, green monkeys *Cercopithecus aethiops* and many bird species. During the dry season, elephants use these dams as bathing ponds and therefore the water is always turbid.

### **3.2.2 Lana Pool**

Lana Pool (N 09<sup>0</sup> 19.858', W 001<sup>0</sup> 50.383') is located about 9 km from the park headquarters and is about 3 km from the main access road. It is the largest of the pools and it has floating vegetation mainly on the water with trees at the banks. Buffalos *Syncerus caffer*, Elephants *Loxodonta africana*, Kobs *Kobus kob*, Waterbucks *Kobus ellipsiprymnus* and Warthogs *Phacochoerus africanus* use this pool frequently especially in the dry season. This pool served as the gathering point for the White-face Whistling Duck prior to their migratory departure during the dry season.

### **3.2.3 Haraba Pool**

Haraba Pool (N 09<sup>0</sup> 21.268', W 001<sup>0</sup> 50.981') is located about 12 km from the park headquarters and is about 200 m from the main access road. It is a large circular pool with vast grassland interspersed with shrubs and trees including, *Combretum fragrans*, *Daniellia oliveri*, *Anogeissus leiocarpus* and *Piliostigma thonningii*. The pool also has floating aquatic weeds such as the tropical white water lilies at certain portions of the water. This pool serves as the bathing pool for Elephants *Loxodonta africana* and also drinking source for several mammals including Hartebeest *Alcelaphus buselaphus*, Kobs *Kobus kob*, Waterbucks *Kobus ellipsiprymnus* and Gambian Mongoose *Mungos gambianus*

### **3.2.4 Asibey Pool**

Asibey Pool (N 09<sup>0</sup> 22.431', W 001<sup>0</sup> 50.574') is located about 17 km from the park headquarters and is about 100 m from the main access road. It is an open wetland with water that forms a permanent pool throughout the year. It has trees and shrubs such as *Diospyros mespiliformis*, *Kigelia africana*, *Anogeissus leiocarpus*, *Morelia senegalensis* and *Ochna schweinfurthiana* that form thickets at one side of the pool and grassland at the other side of the pool. The pool serves as a source of drinking water for Elephants *Loxodonta africana*, Buffalos *Syncerus caffer*, Waterbucks, Kob *Kobus kob*, Patas monkeys *Erythrocebus patas*, Green monkeys *Cercopithecus aethiops* and many bird species.

## **3.2 Methods**

### ***3.2.1 Total Area Count of waterbirds***

All waterbirds sighted were counted on each wetland from the southern part of the site to the northern part. This gave an unbiased estimate of abundance of the various species without statistical inferences or underlying assumptions (FAO, 2007).

Three (3) days of counts per month were undertaken on each of the 4 wetlands between August and October 2015 (Wet season) and December 2015 to February 2016 (Dry season). However, due to inaccessibility of two of the sites (Lana and Haraba pool) in the month of October when the rainfall was at its peak, total number of days spent counting was 66 instead of 72.

On each of the days, all waterbirds sighted were counted hourly between 6:00 am and 9:00 am, and 3:00 pm to 6:00 pm. An 8 x 40 Nikon pair of binoculars was used to view the birds from a distance. Also a digital camera (Canon SX50 with 50x optical zoom and 200x digital zoom) was used to take pictures of unfamiliar birds to aid identification. Birds were identified using Borrow and Demey (2010) field guide.

### ***3.2.2 Studies on Waterbird Disturbance in the Form of Bird Flushes***

Data on waterbirds disturbance was collected as described by Gbogbo *et al.* (2013), with minor modifications. Between 9:30 am to 3:00 pm on each wetland, a flock of waterbirds was randomly selected for observation and monitored until the flock dispersed and then a new flock chosen immediately for observation. For each flock that was observed, the number of times birds were flushed into flight, the perceived causal factor of the flush, and

the time interval between flush initiation and resettlement were recorded. The resettlement time of flocks that split into two or more during flushing was treated as the average time taken by all the split flock to settle. Observations were carried out from a distance using 8 × 42 binoculars to avoid interference with the birds' responses as described by (Gbogbo *et al.*, 2013).

Each of the four selected wetlands was monitored two days each from August 2015 to February 2016. Data was not collected in the month of October for Lana and Haraba pool due to inaccessibility of these sites. In all, a total of 44 days of monitoring and 242 hours of observation were carried out for the entire study period.

### ***3.2.3 Monitoring of users of the wetlands***

Monitoring of the users of the wetlands was carried out as per Gbogbo *et al.* (2013) with minor modifications. Monitoring of the users of the wetlands was carried out at the same time with the monitoring of waterbirds. On every hour between 9:30am and 2:30pm, the entire wetland was visually and quickly skimmed through using binoculars and the number of users both human and animals recorded. Because the study is only interested in the number of users of the wetland at every hour, the count did not take into account whether users have been counted previously or not. This is to help know the intensity of use of these wetlands.

### ***3.2.4 Waterbirds flushing experiment***

On each wetland, a flock of waterbird was randomly selected at a time between 7:00 am to 10:00 am and 3:00 pm to 6:00 pm. The researcher then walked directly from a distance

towards the selected flock until the bird changes behaviour in reaction to the approaching researcher. The average of this distance was estimated (measured with surveyors tape) and considered AD. The process it was continued until the bird flushes away when the researcher approaches (FID) (Ruddock and Whitfield, 2007; Fernández-Juricic and Tellería, 2000).

In the process of approaching the flock, an individual bird was focused on for the measurement of the AD and FID as described by Fernández-Juricic *et al.* (2001). According to Fernández-Juricic *et al.* (2001), (i) there should be no other person within 30 m of the focal individual bird other than the researcher, (ii) the bird should not be feeding, and (iii) it should not display any type of alert behaviour before the approach. Thus in choosing the individual bird within the flock for the measurement of AD and FID, these guidelines were complied with.

Before the approach, the group size and the number of heterospecifics around the focal bird in a 15-m radius circular plot was recorded. The focal individual was then approached by the researcher at a steady speed of 1 step/sec). When the focal individual flies away, the researcher continued to the bird's original position, where the following microhabitat variables were measured within a 25-m radius circular plot; grass cover (%), grass height (cm) and shrub height (m). Distance estimations were done with a surveyors tape.

For each species and wetland, flushing was carried out from different positions in order to avoid disturbing the same individual more than once. Also only one observer was involved

in all the flushes. In order to avoid the influence of different clothing colours on the alert and flight initiation distances, the observer used the same clothing for the flushing throughout the entire study period. In situations where a different user of the wetland flushes the focal waterbird, that particular flushing record was cancelled and repeated after the birds have settled. Data was collected from August 2015 to February 2016 except in October during which the sites were flooded and flushing was not possible.

### 3.3 Data Analysis

The list of waterbirds at Mole National Park was generated by pulling together all the species recorded for all the study sites. Species accumulation curve showing the number of species against the sample effort (days) was plotted using Microsoft excel.

The relative abundance (R) of waterbirds was calculated using the expression;

$$R = \frac{N_i \times 100}{T_n} \dots\dots\dots(1)$$

where

$N_i$  = total number of individuals of the  $i$ th species and  $T_n$  = total number of individual of all species.

Species similarities between the four sites were estimated using the quantitative Morisita Horn index ( $C_{MH}$ ). The quantitative Morisita Horn index ( $C_{MH}$ ) is little biased by differences in species richness and sample size (Magurran, 1988). The quantitative Morisita Horn index is derived by the expression:

$$C_{MH} = 2 \cdot \sum (a_i \cdot b_i) / (d_a + d_b) \cdot a_N \cdot b_N \dots\dots\dots(2)$$

Where

$a_N, b_N$  = total number of individuals in sites A&B,  $a_i, b_i$  = number of individuals in the  $i$ th species in site A&B,  $d_a = \sum a_i^2 / a_N^2$ ,  $d_b = \sum b_i^2 / b_N^2$ .

The value for the similarity indices ranges between 0 and 1. When the value is 0 it implies no species overlap, 1 = complete overlap,  $<0.25$  = similarity is very low,  $0.25-0.50$  = similarity is moderate,  $0.50-0.75$  = similarity is high and  $>0.75$  = similarity is very high. A high similarity between two sites corresponds to a low complementarity between these sites.

The waterbird abundance data was subjected to Shapiro-Wilk tests of normality. As the data were not normally distributed, a non-parametric test; Mann-Whitney U test was used to test for the existence of significant difference in the abundance of waterbirds at the various study sites between the wet and the dry seasons. Mann-Whitney U test was used because few constraints apply to this test (Nachar, 2008) and is one of the most powerful non-parametric test (Landers, 1981); as it is at less risk to give a wrongly significant result when there is presence of one or two extreme values in the sample under study (Siegel and Castellan, 1988). Also, Kruskal-Wallis test was used to test for the existence of any significant difference in the abundance of waterbirds among the four study sites. This test was used because it provides a good balance between robustness and power (Acar and Sun, 2013). Where significant difference was established, a post hoc analysis; Dunn-Bonferroni pairwise comparisons were conducted to evaluate the differences among the four sites.

These analyses were conducted using SPSS 20.0

Kruskal-Wallis test was also used to test for significant difference in the flush induced airborne time among the five cause of flush with a post hoc analysis; Dunn-Bonferroni pairwise comparisons. Rate of waterbird flushing (number of flushes per hour) for Mole National Park in general and each of the wetlands was calculated using the expression below:

$$\text{Rate of Flushing (No./hr)} = \frac{\text{Total Number of flushes}}{\text{Total Observation hours}} \dots\dots\dots(3)$$

To obtain a fair estimate of the average time spent by waterbirds as a result of flushing at Mole National Park, the mean flush induced airborne time was multiplied by the rate of flushing. Thus:

$$\text{Average time spent by waterbirds due to flushing} = \text{Mean Flush induced airborne time} \times \text{Rate of Flushing} \dots\dots\dots(4)$$

Correlation analysis (Spearman’s correlation) in SPSS 20.0 was conducted to examine the relationship between the AD of some selected waterbirds and the bird’s surrounding conditions (Group size, number of heterospecifics, grass height, grass cover and shrub height). Where a significant relationship was established, multiple linear regression analysis (Enter method) was then conducted to determine which of the variables contributes significantly to the model hence in predicting the AD of a particular waterbird. Where none of the predictor variables show significant regression relationship, variables which did not produce a significant Spearman’s correlation were removed from the regression model and the model refitted with only variables that produced significant correlation.

## CHAPTER FOUR

### RESULTS

#### 4.1 General abundance and species composition of waterbirds in Mole National Park

##### 4.1.1 Species richness observed

A total of 29 species of waterbirds belonging to 6 orders and 12 families were identified in this study (Table 2). Twenty-six (26) of the species occurred in Haraba Pool compare with twenty-three (23) in Lana Pool, twenty-one (21) in Dam1&2 Wetland and Eighteen (18) in Asibey Pool. The most common bird order recorded was Pelecaniformes (herons, egrets, ibis and hamerkop) with 12 species occurring in the study area. White-faced Whistling Duck *Dendrocygna viduata* was the most abundant species accounting for 53% of the total abundance of waterbirds in the study area followed by the Senegal Thick-knee *Burhinus senegalensis* which accounted for 7% of the total abundance of waterbirds in the study area.

The species accumulation curve showing how the species were discovered throughout the entire study period of 66 days is shown in Figure 2. At the end of the wet season (30 sample days) 18 species of waterbirds were recorded. The last species (29<sup>th</sup> species) was recorded on the 55<sup>th</sup> day of sampling. Although sampling continued till the 66<sup>th</sup> day, no more species was encountered. From the logarithmic regression equation,  $R^2 = 0.8078$ , which implies that the sampling effort is 80% accurate and therefore increasing the sampling effort will not lead to any significant increase in the number of species encountered.

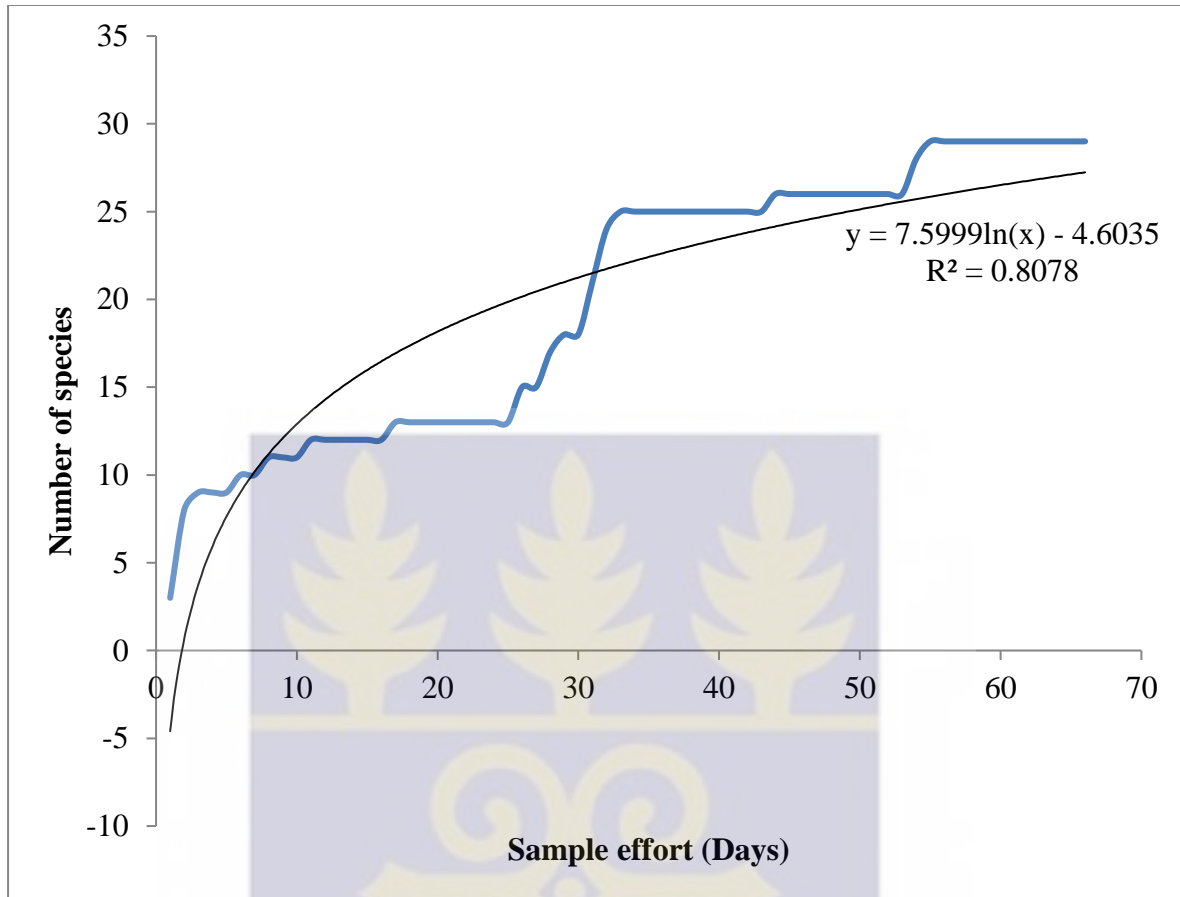


Figure 2: Species accumulation curve with a logarithmic regression equation for waterbirds in the Mole National Park

#### 4.1.2 Species Similarity and Complementarity

Of the total number of waterbirds species encountered, 16 out of the total of 29 were shared species among all the four study sites. Lana Pool and Haraba Pool recorded the highest number of shared species of 20 contrary to that between Dam 1&2 wetland and Asibey Pool which recorded the lowest of 14 shared species.

From the quantitative Morisita-Horn similarity index ( $C_{MH}$ ), species similarity was highest between Haraba Pool and Asibey Pool ( $C_{MH} = 0.651$ ) and lowest between Lana Pool and Haraba Pool ( $C_{MH} = 0.209$ ) (Table 1). The similarity between Haraba Pool and Asibey Pool indicates a high similarity and low complementarity. Also the species similarity between Lana Pool and Haraba Pool indicates a very low similarity and a very high complementarity.

Table 1: Species Similarity among the Four Study Sites in Mole National Park, as Shown by the Quantitative Morisita-Horn Index ( $C_{MH}$ ).

| Sites       | Lana Pool | Haraba Pool | Asibey Pool |
|-------------|-----------|-------------|-------------|
| Dam 1&2     | 0.299     | 0.523       | 0.564       |
| Lana Pool   | -         | 0.209       | 0.494       |
| Haraba Pool | -         | -           | 0.651       |

$$C_{MH} = 2 \cdot \frac{\sum (a_{ni} \cdot b_{ni})}{(d_a + d_b) \cdot a_N \cdot b_N}, \text{ where } d_a = \sum a_{ni}^2 / a_N^2 \text{ and } d_b = \sum b_{ni}^2 / b_N^2$$

#### 4.1.3 Species Abundance

Lana Pool recorded 58% (18,215) of the total number of birds counted followed by 23% (7,336) in Dam 1&2 Wetland, 12% (3,867) in Haraba Pool with Asibey Pool recording the least numbers of 1,943 birds (6%) (Table 2). Statistically, there was a significant difference among the mean number of waterbirds in the four study sites (Kruskal-Wallis H test,  $\chi^2 (3, N=66) = 23.785, p < 0.05$ ). The proportion of variability in the ranked dependent variable (eta square) accounted for by the sites was 0.366, indicating a weak relationship between site and the abundance of waterbirds in the combined dry and wet seasons at Mole National

Park. The result of the post hoc analysis (Table 3) shows a significant difference in the abundance of waterbirds between Asibey Pool ( $120 \pm 104.317$ ) and Dam1&2 Wetland ( $446.17 \pm 203.167$ ) and also between Asibey Pool ( $120 \pm 104.317$ ) and Lana Pool ( $1245.33 \pm 1900.825$ ). Dam1&2 Wetland recorded a significant higher numbers of waterbirds than Asibey Pool. Also Lana Pool recorded a significant higher numbers of waterbirds than Asibey Pool.

At Dam 1&2 Wetland, Senegal Thick-knee was the most abundant species, constituting 29% of its waterbird abundance while Spur-winged Goose *Plectropterus gambensis* was the least occurring with 0.01% of the abundance. In contrast, White-faced Whistling Duck was the most abundant species at Lana and Asibey Pools whilst Lana Pool had Marabou Stork *Leptoptilos crumeniferus* as the least occurring species compared to Green Sandpiper *Tringa ochropus* and Wood Sandpiper *Tringa glareola* in Asibey pool. At Haraba Pool, Hamerkop *Scopus umbretta* was the most abundant species and the least being White-backed Night-heron *Gorsachius leuconotus*.

#### **4.1.4 Species of conservation significance**

In relation to conservation significance, only one (1) of the species recorded (Woolly-necked Stork *Ciconia episcopus*) has been classified as vulnerable according to the IUCN Red List (2015-4). Three (3) of the species recorded (White-faced Whistling Ducks, Marabou Stork, and Saddle-billed Stork *Ephippiorhynchus senegalensis*) have not been assessed by the IUCN Red List. The remaining 25 species recorded in the study area have been classified by the IUCN Red List (2015-4) to be of Least Concern.

Table 2: Species Composition and General Abundance of Waterbirds at Mole National Park

| Order           | Common Name                 | Scientific Name                | Number recorded per site |       |        |        | Total number encountered | Percentage Composition (%) |
|-----------------|-----------------------------|--------------------------------|--------------------------|-------|--------|--------|--------------------------|----------------------------|
|                 |                             |                                | Dam 1&2                  | Lana  | Haraba | Asibey |                          |                            |
| Anseriformes    | Spur-winged Goose           | <i>Plectropterus gambensis</i> | 1                        | 233   | 0      | 0      | <b>234</b>               | <b>0.75</b>                |
|                 | White-faced Whistling Ducks | <i>Dendrocygna viduata</i>     | 994                      | 14916 | 315    | 426    | <b>16651</b>             | <b>53.09</b>               |
| Charadriiformes | African Jacana              | <i>Actophilornis africanus</i> | 547                      | 795   | 107    | 371    | <b>1820</b>              | <b>5.80</b>                |
|                 | African Wattled Lapwing     | <i>Vanellus senegallus</i>     | 631                      | 85    | 69     | 57     | <b>842</b>               | <b>2.68</b>                |
|                 | Common Sandpiper            | <i>Actitis hypoleucos</i>      | 59                       | 41    | 20     | 12     | <b>132</b>               | <b>0.42</b>                |
|                 | Forbes' Plover              | <i>Charadrius forbesi</i>      | 0                        | 2     | 46     | 0      | <b>48</b>                | <b>0.15</b>                |
|                 | Greater Painted Snipe       | <i>Rostratula benghalensis</i> | 0                        | 0     | 18     | 0      | <b>18</b>                | <b>0.06</b>                |

Table 2 continued.

| Order           | Common Name         | Scientific Name                      | Number recorded per site |      |        |        | Total number encountered | Percentage Composition (%) |
|-----------------|---------------------|--------------------------------------|--------------------------|------|--------|--------|--------------------------|----------------------------|
|                 |                     |                                      | Dam1&2                   | Lana | Haraba | Asibey |                          |                            |
| Charadriiformes | Green Sandpiper     | <i>Tringa ochropus</i>               | 4                        | 9    | 39     | 8      | <b>60</b>                | <b>0.19</b>                |
|                 | Senegal Thick-knee  | <i>Burhinus senegalensis</i>         | 2123                     | 0    | 138    | 0      | <b>2261</b>              | <b>7.21</b>                |
|                 | Spur winged lapwing | <i>Vanellus spinosus:</i>            | 30                       | 59   | 0      | 0      | <b>89</b>                | <b>0.28</b>                |
|                 | Wood Sandpiper      | <i>Tringa glareola</i>               | 0                        | 8    | 47     | 8      | <b>63</b>                | <b>0.20</b>                |
| Ciconiiformes   | Abdim's Stork       | <i>Ciconia abdimii</i>               | 0                        | 34   | 296    | 53     | <b>383</b>               | <b>1.22</b>                |
|                 | Marabou Stork       | <i>Leptoptilos crumeniferus</i>      | 0                        | 1    | 28     | 16     | <b>45</b>                | <b>0.14</b>                |
|                 | Saddle-billed Stork | <i>Ephippiorhynchus senegalensis</i> | 15                       | 17   | 3      | 0      | <b>35</b>                | <b>0.11</b>                |
|                 | Woolly-necked Stork | <i>Ciconia episcopus</i>             | 68                       | 154  | 289    | 99     | <b>610</b>               | <b>1.95</b>                |
| Gruiformes      | Black Crake         | <i>Amaurornis flavirostra</i>        | 243                      | 90   | 356    | 0      | <b>689</b>               | <b>2.20</b>                |

Table 2 continued.

| Order          | Common Name               | Scientific Name              | Number recorded per site |      |        |        | Total number encountered | Percentage Composition (%) |
|----------------|---------------------------|------------------------------|--------------------------|------|--------|--------|--------------------------|----------------------------|
|                |                           |                              | Dam1&2                   | Lana | Haraba | Asibey |                          |                            |
| Pelecaniformes | Black-crowned Night Heron | <i>Nycticorax nycticorax</i> | 143                      | 0    | 154    | 0      | <b>297</b>               | <b>0.95</b>                |
|                | Black-headed Heron        | <i>Ardea melanocephala</i>   | 25                       | 0    | 35     | 59     | <b>119</b>               | <b>0.38</b>                |
|                | Cattle Egret              | <i>Bubulcus ibis</i>         | 546                      | 760  | 374    | 265    | <b>1945</b>              | <b>6.20</b>                |
|                | Green-backed Heron        | <i>Butorides striata</i>     | 274                      | 59   | 117    | 59     | <b>509</b>               | <b>1.62</b>                |
|                | Grey Heron                | <i>Ardea cinerea</i>         | 229                      | 99   | 238    | 109    | <b>675</b>               | <b>2.15</b>                |
|                | Hadada Ibis               | <i>Bostrychia hagedash</i>   | 788                      | 543  | 361    | 235    | <b>1927</b>              | <b>6.14</b>                |
|                | Hamerkop                  | <i>Scopus umbretta</i>       | 282                      | 197  | 401    | 93     | <b>973</b>               | <b>3.10</b>                |
|                | Intermediate Egret        | <i>Egretta intermedia</i>    | 0                        | 24   | 206    | 14     | <b>244</b>               | <b>0.78</b>                |
|                | Little Egret              | <i>Egretta garzetta</i>      | 3                        |      | 113    |        | <b>116</b>               | <b>0.37</b>                |
|                | Purple Heron              | <i>Ardea purpurea</i>        | 9                        | 33   | 46     | 14     | <b>102</b>               | <b>0.33</b>                |

Table 2 continued

| Order  | Common Name              | Scientific Name                | Number recorded per site |              |             |             | Total number encountered | Percentage Composition (%) |
|--|--------------------------|--------------------------------|--------------------------|--------------|-------------|-------------|--------------------------|----------------------------|
|  |                          |                                | Dam1&2                   | Lana         | Haraba      | Asibey      |                          |                            |
| Pelecaniformes                                 | Squacco Heron            | <i>Ardeola ralloides</i>       | 322                      | 48           | 49          | 45          | <b>464</b>               | <b>1.48</b>                |
|  | White-backed Night-heron | <i>Gorsachius leuconotus</i>   | 0                        | 0            | 2           | 0           | <b>2</b>                 | <b>0.01</b>                |
| Suliformes                                     | Long-tailed Cormorant    | <i>Phalacrocorax africanus</i> | 0                        | 8            | 0           | 0           | <b>8</b>                 | <b>0.03</b>                |
| <b>Total Number of Individuals encountered</b> |                          |                                | <b>7336</b>              | <b>18215</b> | <b>3867</b> | <b>1943</b> | <b>31361</b>             | <b>100.00</b>              |
| <b>Total Number of Species</b>                 |                          |                                | <b>21</b>                | <b>23</b>    | <b>26</b>   | <b>18</b>   | <b>29</b>                |                            |



Table 3: Pair-wise comparison of study sites for abundance of waterbirds (combined wet and dry seasons) using Bonferroni Adjustment after significant Kruskal Wallis test.

| Sites          | Test<br>Statistic | Std. Error | Std. Test<br>Statistic | Adj. Sig. |
|----------------|-------------------|------------|------------------------|-----------|
| Asibey-Haraba  | -14.778           | 6.710      | -2.202                 | 0.166     |
| Asibey-Lana*   | -25.544           | 6.710      | -3.807                 | 0.001     |
| Asibey-Dam1&2* | 28.528            | 6.398      | 4.459                  | 0.000     |
| Haraba-Lana    | -10.767           | 7.009      | -1.536                 | 0.747     |
| Haraba-Dam1&2  | 13.750            | 6.710      | 2.049                  | 0.243     |
| Lana-Dam1&2    | 2.983             | 6.710      | 0.445                  | 1.000     |

\*Significant difference, Kruskal-Wallis  $H$  test  $\chi^2 (3, N = 66) = 23.785, p = 0.000$ .

*Eta square ( $\eta^2$ )=0.366 (implies a weak relationship between site and the abundance of waterbirds)*

#### 4.2 Seasonal variation in the species richness and abundance of waterbirds in Mole National Park

A total of 18 species of waterbirds were recorded in the wet season (Table 4) compared to 29 species in the dry season (Table 5). During the wet season, the highest number of species (17) was recorded at the Dam1&2 Wetland and the least number of species (5) was recorded at Asibey Pool with Lana and Haraba Pools recording equal numbers of species (7 each). In contrast, Habana Pool recorded the highest number of species (25) in the dry season followed by Lana Pool (21) with Dam1&2 Wetland and Asibey Pool recording the

lowest of 17 species each. The total number of waterbirds species recorded at Haraba Pool (25), Lana Pool (21) and Asibey Pool (17) during the dry season constituted more than 100% increase in the number of species they recorded in the wet season. On the contrary, Dam1&2 Wetland recorded the same number of species in both seasons.

On the basis of the use of the individual wetlands by the waterbird species, the White-faced Whistling Duck was the most abundant species at three of the study sites namely Dam1&2 Wetland, Lana and Haraba Pools during the wet season, whilst Asibey Pool was dominated by the African Jacana *Actophilornis africanus*. In the dry season however, White-faced Whistling Duck again dominated Lana and Asibey Pools while Senegal Thick-knee and Hamerkop respectively dominated Dam1&2 Wetland and Haraba Pool. All the White-faced Whistling Ducks gathered at Lana pool towards the end of December 2015 and migrated out of the park in early January 2016.

In terms of waterbird abundance, a total of 4,317 waterbirds were encountered during the wet season compared to 27,044 in the dry season. Out of the 4,317 waterbirds encountered in the wet season, Dam 1&2 Wetland recorded 59% (2,532) followed by 21% (900) in Lana Pool, 12% (509) in Haraba Pool with Asibey Pool recording the least 9% (376). On the contrast, out of the total of 27,044 waterbirds encountered in the dry season, Lana Pool recorded 64% (17,315) followed by 18% (4,804) in Dam 1&2 Wetland, 12% (3,358) in Haraba Pool with Asibey Pool recording the least of 6% (1,567).

Table 4: Species Diversity and Relative Abundance (R.A.) of Waterbirds in the Wet Season at Mole National Park

| Scientific Name                      | Wet Season     |            |             |            |             |            |             |            | Total number encountered | Percentage Composition |
|--------------------------------------|----------------|------------|-------------|------------|-------------|------------|-------------|------------|--------------------------|------------------------|
|                                      | Dam1&2 Wetland |            | Lana Pool   |            | Haraba Pool |            | Asibey Pool |            |                          |                        |
|                                      | Total count    | Rel. Abun. | Total count | Rel. Abun. | Total count | Rel. Abun. | Total count | Rel. Abun. |                          |                        |
| <i>Plectropterus gambensis</i>       | 1              | 0.04       | 0           | 0          | 0           | 0          | 0           | 0          | <b>1</b>                 | <b>0.02</b>            |
| <i>Dendrocygna viduata</i>           | 994            | 39.26      | 351         | 39.00      | 315         | 61.89      | 0           | 0          | <b>1660</b>              | <b>38.45</b>           |
| <i>Actophilornis africanus</i>       | 220            | 8.69       | 335         | 37.22      | 4           | 0.79       | 202         | 53.72      | <b>761</b>               | <b>17.63</b>           |
| <i>Vanellus senegallus</i>           | 278            | 10.98      | 0           | 0          | 0           | 0          | 0           | 0          | <b>278</b>               | <b>6.44</b>            |
| <i>Actitis hypoleucos</i>            | 0              | 0          | 0           | 0          | 0           | 0          | 0           | 0          | <b>0</b>                 | <b>0.00</b>            |
| <i>Charadrius forbesi</i>            | 0              | 0          | 0           | 0          | 0           | 0          | 0           | 0          | <b>0</b>                 | <b>0.00</b>            |
| <i>Rostratula benghalensis</i>       | 0              | 0          | 0           | 0          | 0           | 0          | 0           | 0          | <b>0</b>                 | <b>0.00</b>            |
| <i>Tringa ochropus</i>               | 4              | 0.16       | 0           | 0          | 0           | 0          | 0           | 0          | <b>4</b>                 | <b>0.09</b>            |
| <i>Burhinus senegalensis</i>         | 377            | 14.89      | 0           | 0          | 0           | 0          | 0           | 0          | <b>377</b>               | <b>8.73</b>            |
| <i>Vanellus spinosus:</i>            | 7              | 0.28       | 0           | 0          | 0           | 0          | 0           | 0          | <b>7</b>                 | <b>0.16</b>            |
| <i>Tringa glareola</i>               | 0              | 0          | 0           | 0          | 0           | 0          | 0           | 0          | <b>0</b>                 | <b>0.00</b>            |
| <i>Ciconia abdimii</i>               | 0              | 0          | 0           | 0          | 0           | 0          | 0           | 0          | <b>0</b>                 | <b>0.00</b>            |
| <i>Leptoptilos crumeniferus</i>      | 0              | 0          | 0           | 0          | 0           | 0          | 0           | 0          | <b>0</b>                 | <b>0.00</b>            |
| <i>Ephippiorhynchus senegalensis</i> | 13             | 0.51       | 0           | 0          | 0           | 0          | 0           | 0          | <b>13</b>                | <b>0.30</b>            |
| <i>Ciconia episcopus</i>             | 40             | 1.58       | 0           | 0          | 0           | 0          | 0           | 0          | <b>40</b>                | <b>0.93</b>            |

Table 4 continued.

| Scientific Name                | Wet Season     |            |             |            |             |            |             |            | Total number encountered | Percentage Composition |
|--------------------------------|----------------|------------|-------------|------------|-------------|------------|-------------|------------|--------------------------|------------------------|
|                                | Dam1&2 Wetland |            | Lana Pool   |            | Haraba Pool |            | Asibey Pool |            |                          |                        |
|                                | Total count    | Rel. Abun. | Total count | Rel. Abun. | Total count | Rel. Abun. | Total count | Rel. Abun. |                          |                        |
| <i>Amaurornis flavirostra</i>  | 75             | 2.96       | 90          | 10.00      | 65          | 12.77      | 0           | 0          | <b>230</b>               | <b>5.33</b>            |
| <i>Nycticorax nycticorax</i>   | 0              | 0          | 0           | 0          | 0           | 0          | 0           | 0          | <b>0</b>                 | <b>0.00</b>            |
| <i>Ardea melanocephala</i>     | 5              | 0.20       | 0           | 0          | 0           | 0          | 0           | 0          | <b>5</b>                 | <b>0.12</b>            |
| <i>Bubulcus ibis</i>           | 0              | 0          | 0           | 0          | 0           | 0          | 0           | 0          | <b>0</b>                 | <b>0.00</b>            |
| <i>Butorides striata</i>       | 155            | 6.12       | 59          | 6.56       | 21          | 4.13       | 59          | 15.69      | <b>294</b>               | <b>6.81</b>            |
| <i>Ardea cinerea</i>           | 65             | 2.57       | 22          | 2.44       | 8           | 1.57       | 4           | 1.06       | <b>99</b>                | <b>2.29</b>            |
| <i>Bostrychia hagedash</i>     | 183            | 7.23       | 39          | 4.33       | 93          | 18.24      | 107         | 28.46      | <b>422</b>               | <b>9.78</b>            |
| <i>Scopus umbretta</i>         | 109            | 4.30       | 0           | 0          | 3           | 0.59       | 4           | 1.06       | <b>116</b>               | <b>2.69</b>            |
| <i>Egretta intermedia</i>      | 0              | 0          | 0           | 0          | 0           | 0          | 0           | 0          | <b>0</b>                 | <b>0.00</b>            |
| <i>Egretta garzetta</i>        | 3              | 0.12       | 0           | 0          | 0           | 0          | 0           | 0          | <b>3</b>                 | <b>0.07</b>            |
| <i>Ardea purpurea</i>          | 0              | 0          | 4           | 0.44       | 0           | 0          | 0           | 0          | <b>4</b>                 | <b>0.09</b>            |
| <i>Ardeola ralloides</i>       | 3              | 0.12       | 0           | 0          | 0           | 0          | 0           | 0          | <b>3</b>                 | <b>0.07</b>            |
| <i>Gorsachius leuconotus</i>   | 0              | 0          | 0           | 0          | 0           | 0          | 0           | 0          | <b>0</b>                 | <b>0.00</b>            |
| <i>Phalacrocorax africanus</i> | 0              | 0          | 0           | 0          | 0           | 0          | 0           | 0          | <b>0</b>                 | <b>0.00</b>            |
| Total No. encountered          | <b>2532</b>    | <b>100</b> | <b>900</b>  | <b>100</b> | <b>509</b>  | <b>100</b> | <b>376</b>  | <b>100</b> | <b>4317</b>              | <b>100</b>             |
| Total No. of species           | <b>17</b>      |            | <b>7</b>    |            | <b>7</b>    |            | <b>5</b>    |            | <b>18</b>                |                        |

Table 5: Species Diversity and Relative Abundance of Waterbirds in the Dry Season at Mole National Park

| Scientific Name                      | Dry Season     |            |             |            |             |            |             |            | Total number encountered | Percentage Composition (%) |
|--------------------------------------|----------------|------------|-------------|------------|-------------|------------|-------------|------------|--------------------------|----------------------------|
|                                      | Dam1&2 Wetland |            | Lana Pool   |            | Haraba Pool |            | Asibey Pool |            |                          |                            |
|                                      | Total Count    | Rel. Abun. | Total Count | Rel. Abun. | Total Count | Rel. Abun. | Total Count | Rel. Abun. |                          |                            |
| <i>Plectropterus gambensis</i>       | 0              | 0          | 233         | 1.35       | 0           | 0          | 0           | 0          | <b>233</b>               | <b>0.86</b>                |
| <i>Dendrocygna viduata</i>           | 0              | 0          | 14565       | 84.12      | 0           | 0          | 426         | 27.19      | <b>14991</b>             | <b>55.43</b>               |
| <i>Actophilornis africanus</i>       | 327            | 6.81       | 460         | 2.66       | 103         | 3.07       | 169         | 10.78      | <b>1059</b>              | <b>3.92</b>                |
| <i>Vanellus senegallus</i>           | 353            | 7.35       | 85          | 0.49       | 69          | 2.05       | 57          | 3.64       | <b>564</b>               | <b>2.09</b>                |
| <i>Actitis hypoleucos</i>            | 59             | 1.23       | 41          | 0.24       | 20          | 0.60       | 12          | 0.77       | <b>132</b>               | <b>0.49</b>                |
| <i>Charadrius forbesi</i>            | 0              | 0          | 2           | 0.01       | 46          | 1.37       | 0           | 0          | <b>48</b>                | <b>0.18</b>                |
| <i>Rostratula benghalensis</i>       | 0              | 0          | 0           | 0          | 18          | 0.54       | 0           | 0          | <b>18</b>                | <b>0.07</b>                |
| <i>Tringa ochropus</i>               | 0              | 0          | 9           | 0.05       | 39          | 1.16       | 8           | 0.51       | <b>56</b>                | <b>0.21</b>                |
| <i>Burhinus senegalensis</i>         | 1746           | 36.34      | 0           | 0          | 138         | 4.11       | 0           | 0          | <b>1884</b>              | <b>6.97</b>                |
| <i>Vanellus spinosus:</i>            | 23             | 0.48       | 59          | 0.34       | 0           | 0          | 0           | 0          | <b>82</b>                | <b>0.30</b>                |
| <i>Tringa glareola</i>               | 0              | 0          | 8           | 0.05       | 47          | 1.40       | 8           | 0.51       | <b>63</b>                | <b>0.23</b>                |
| <i>Ciconia abdimii</i>               | 0              | 0          | 34          | 0.20       | 296         | 8.81       | 53          | 3.38       | <b>383</b>               | <b>1.42</b>                |
| <i>Leptoptilos crumeniferus</i>      | 0              | 0          | 1           | 0.01       | 28          | 0.83       | 16          | 1.02       | <b>45</b>                | <b>0.17</b>                |
| <i>Ephippiorhynchus senegalensis</i> | 2              | 0.04       | 17          | 0.10       | 3           | 0.09       | 0           | 0          | <b>22</b>                | <b>0.08</b>                |
| <i>Ciconia episcopus</i>             | 28             | 0.58       | 154         | 0.89       | 289         | 8.61       | 99          | 6.32       | <b>570</b>               | <b>2.11</b>                |

Table 5 continued

| Scientific Name                | Dry Season     |            |              |            |             |            |             |            | Total number encountered | Percentage Composition (%) |
|--------------------------------|----------------|------------|--------------|------------|-------------|------------|-------------|------------|--------------------------|----------------------------|
|                                | Dam1&2 Wetland |            | Lana Pool    |            | Haraba Pool |            | Asibey Pool |            |                          |                            |
|                                | Total Count    | Rel. Abun. | Total Count  | Rel. Abun. | Total Count | Rel. Abun. | Total Count | Rel. Abun. |                          |                            |
| <i>Amaurornis flavirostra</i>  | 168            | 3.50       | 0            | 0          | 291         | 8.67       | 0           | 0          | <b>459</b>               | <b>1.70</b>                |
| <i>Nycticorax nycticorax</i>   | 143            | 2.98       | 0            | 0          | 154         | 4.59       | 0           | 0          | <b>297</b>               | <b>1.10</b>                |
| <i>Ardea melanocephala</i>     | 20             | 0.42       | 0            | 0          | 35          | 1.04       | 59          | 3.77       | <b>114</b>               | <b>0.42</b>                |
| <i>Bubulcus ibis</i>           | 546            | 11.37      | 760          | 4.39       | 374         | 11.14      | 265         | 16.91      | <b>1945</b>              | <b>7.19</b>                |
| <i>Butorides striata</i>       | 119            | 2.48       | 0            | 0          | 96          | 2.86       | 0           | 0          | <b>215</b>               | <b>0.80</b>                |
| <i>Ardea cinerea</i>           | 164            | 3.41       | 77           | 0.44       | 230         | 6.85       | 105         | 6.70       | <b>576</b>               | <b>2.13</b>                |
| <i>Bostrychia hagedash</i>     | 605            | 12.59      | 504          | 2.91       | 268         | 7.98       | 128         | 8.17       | <b>1505</b>              | <b>5.57</b>                |
| <i>Scopus umbretta</i>         | 173            | 3.60       | 197          | 1.14       | 398         | 11.85      | 89          | 5.68       | <b>857</b>               | <b>3.17</b>                |
| <i>Egretta intermedia</i>      | 0              | 0          | 24           | 0.14       | 206         | 6.13       | 14          | 0.89       | <b>244</b>               | <b>0.90</b>                |
| <i>Egretta garzetta</i>        | 0              | 0          | 0            | 0          | 113         | 3.37       | 0           | 0          | <b>113</b>               | <b>0.42</b>                |
| <i>Ardea purpurea</i>          | 9              | 0.19       | 29           | 0.17       | 46          | 1.37       | 14          | 0.89       | <b>98</b>                | <b>0.36</b>                |
| <i>Ardeola ralloides</i>       | 319            | 6.64       | 48           | 0.28       | 49          | 1.46       | 45          | 2.87       | <b>461</b>               | <b>1.70</b>                |
| <i>Gorsachius leuconotus</i>   | 0              | 0          | 0            | 0          | 2           | 0.06       | 0           | 0          | <b>2</b>                 | <b>0.01</b>                |
| <i>Phalacrocorax africanus</i> | 0              | 0          | 8            | 0.05       | 0           | 0          | 0           | 0          | <b>8</b>                 | <b>0.03</b>                |
| <b>Total No. encountered</b>   | <b>4804</b>    | <b>100</b> | <b>17315</b> | <b>100</b> | <b>3358</b> | <b>100</b> | <b>1567</b> | <b>100</b> | <b>27044</b>             | <b>100</b>                 |
| <b>Total No. of species</b>    | <b>17</b>      |            | <b>21</b>    |            | <b>25</b>   |            | <b>17</b>   |            | <b>29</b>                |                            |

Pair-wise comparison of the mean waterbird abundance in the wet season with that of the dry season indicated a statistically higher abundance of waterbirds in the dry season than the wet season on each of the four wetlands (Mann-Whitney U;  $p < 0.01$ ). In general (All sites combined), there was significant difference in the abundance of waterbirds between the dry and wet season with the dry season recording a significant higher numbers of waterbirds than the wet season (Table 6).

Table 6: Mann-Whitney U Test of Significance Difference in Seasonal Abundance of Waterbirds at the Four Study Sites.

| Sites       | Wet Season   |    | Dry Season   |    | Mann-U | P <sub>value</sub> |
|-------------|--------------|----|--------------|----|--------|--------------------|
|             | Mean±SD      | N  | Mean±SD      | N  |        |                    |
| Dam 1&2     | 281.1±108.6a | 9  | 611±121.6b   | 9  | 2.0    | <0.001             |
| Lana Pool   | 150±59.69a   | 6  | 1976±2196b   | 9  | 0.0    | <0.001             |
| Haraba Pool | 84.83±20.86a | 6  | 471.6±335.1b | 9  | 2.0    | <0.002             |
| Asibey Pool | 41.78±10.54a | 9  | 198.8±95.64b | 9  | 0.0    | <0.001             |
| All Sites   | 143.9±117.5a | 30 | 814.2±1272b  | 36 | 131.5  | <0.001             |

*Mean with similar letters in rows are significantly different.*

Statistically, there was a significant difference among the mean number of waterbirds in the four study sites in the wet season (Kruskal-Wallis H test,  $\chi^2 (3, N = 30) = 25.172$ ,  $p = 0.000$ ). Significant differences existed between Asibey Pool and Lana Pool (Adj. Sig.  $P=0.015$ ). Also significant differences existed between Asibey Pool and Dam 1&2 Wetland (Adj. Sig.  $P=0.000$ ) (Kruskal-Wallis H test with post hoc Dunn-Bonferroni pair-wise comparison) (Table 7). Both Lana Pool and Dam 1&2 Wetland recorded a significant higher numbers of waterbirds than Asibey Pool.

Similarly in the dry season, there was significant difference among the mean number of waterbirds in the four study sites (Kruskal-Wallis H test  $\chi^2 (3, N = 36) = 15.829, p = 0.001$ ). Significant differences existed between Asibey Pool and Dam1&2 Wetland (Adj. Sig.  $P=0.006$ ). Also significant difference existed between Asibey Pool and Lana Pool (Adj. Sig.  $P=0.002$ ) (Table 8). Dam1&2 Wetland recorded a significant higher numbers of waterbirds than Asibey Pool. Likewise Lana Pool recorded a significant higher number of waterbirds than Asibey Pool.

Table 7: Pair-wise comparison of study sites for abundance of waterbirds in the wet season using Bonferroni Adjustment after significant Kruskal Wallis test.

| Sites          | Test<br>Statistic | Std. Error | Std. Test<br>Statistic | Adj. Sig. |
|----------------|-------------------|------------|------------------------|-----------|
| Asibey-Haraba  | -8.167            | 4.638      | -1.761                 | 0.470     |
| Asibey-Lana*   | -14.000           | 4.638      | -3.019                 | 0.015     |
| Asibey-Dam1&2* | 20.222            | 4.148      | 4.875                  | 0.000     |
| Haraba-Lana    | -5.833            | 5.080      | -1.148                 | 1.000     |
| Haraba-Dam1&2  | 12.056            | 4.638      | 2.599                  | 0.056     |
| Lana-Dam1&2    | 6.222             | 4.638      | 1.342                  | 1.000     |

\* = Significant difference, Kruskal-Wallis H test,  $\chi^2 (3, N = 30) = 25.172, p = 0.000$ , Eta square ( $\eta^2$ ) = 0.868 (implies a strong relationship between site and the abundance of waterbirds in wet season).

Table 8: Pair-wise Comparison of Study Sites for Abundance of Waterbirds in the Dry Season using Bonferroni Adjustment after Significant Kruskal Wallis Test.

| Sites           | Test<br>Statistic | Std. Error | Std. Test<br>Statistic | Adj. Sig. |
|-----------------|-------------------|------------|------------------------|-----------|
| Asibey-Haraba   | -10.556           | 4.966      | -2.126                 | 0.201     |
| Asibey-Dam 1&2* | 16.444            | 4.966      | 3.311                  | 0.006     |
| Asibey-Lana*    | -17.667           | 4.966      | -3.558                 | 0.002     |
| Haraba-Dam 1&2  | 5.889             | 4.966      | 1.186                  | 1.000     |
| Haraba-Lana     | -7.111            | 4.966      | -1.432                 | 0.913     |
| Dam 1&2-Lana    | -1.222            | 4.966      | -0.246                 | 1.000     |

\* = Significant difference, *Kruskal-Wallis test*  $\chi^2 (3, N = 36) = 15.829, p = 0.001$ ,  
*Eta square* ( $\eta^2$ ) = 0.452 (implies a weak relationship between site and the abundance of waterbirds in the dry season)

### 4.3 Nature and Levels of Disturbance to Waterbirds in Mole National Park

#### 4.3.1 Level and Causes of Waterbirds Flushes at the Various Sites at Mole National Park

A total of 610 bird flushes were recorded over the 242 hours of observations giving a rate of 2.5 bird flushes per hour. The rate of flushing at Lana Pool, Dam 1&2 Wetland, Haraba Pool and Asibey Pool were 3.0, 2.9, 2.1 and 2.1 per hour respectively. Dam1&2 Wetland recorded the highest number of flushes (30.95%) while the lowest number of flushes was recorded at Haraba Pool constituting 19.02% of the total flushes (Table 9).

Majority of the flushes were caused by indeterminate factors (70.5%) while flushes caused by moving vehicle were the least; 0.7% (Table 9). In relation to individual wetlands, indeterminate cause was the most important factor in all the sites constituting 83.62%, 83.33%, 71.26% and 52.38% respectively of the flushes at Haraba Pool, Asibey Pool, Lana Pool and Dam1&2 Wetland. Bird flushes caused by the presence of tourists and Game wardens (staff) was recorded only at Dam1&2 Wetland and Haraba Pool where it constituted 39.15% and 0.86% respectively of their flushes. Bird flushes caused by moving vehicle was only observed at Asibey Pool (2.90%).

Table 9: Causes of Waterbirds Flushes at the various Sites

| Site        | Indeterminate cause | Birds of Prey | Non-predatory birds/Animals | Tourist /staff | Moving Vehicles | Total    |
|-------------|---------------------|---------------|-----------------------------|----------------|-----------------|----------|
| Dam1&2      | 99(52.38%)          | 14(7.41%)     | 2(1.06%)                    | 74(39.15%)     | 0(0%)           | 189(100) |
| Lana pool   | 119 (71.26%)        | 46(27.54%)    | 2(1.20%)                    | 0(0%)          | 0(0%)           | 167(100) |
| Haraba pool | 97(83.62%)          | 15(12.93%)    | 3(2.59%)                    | 1(0.86%)       | 0(0%)           | 116(100) |
| Asibey pool | 115(83.33%)         | 18(13.04%)    | 1(0.72%)                    | 0(0%)          | 4(2.90%)        | 138(100) |
| Total       | 430(70.5%)          | 93(15.2%)     | 8(1.3%)                     | 75(12.3%)      | 4(0.7%)         | 610(100) |

#### ***4.3.2 Relationship between Cause of Flush and Flush Induced Airborne Time***

The aggregate flush induced airborne time (Total time spent in flight as a result of flushing) for birds in all the study sites was 20,695 seconds which is 2.38% of the total observation time of 871,200 seconds (242 hrs). On the basis of the individual study sites, total flush induced airborne time was highest at Dam1&2 Wetland (7002 sec) followed in decreasing order by Lana Pool (6254), Haraba Pool (4281) and Asibey Pool (3158 sec). The mean flush induced airborne in the various study sites are presented in Table 10. There was significant difference in the mean flush induced airborne time among the various study sites using Kruskal-Wallis test ( $\chi^2 (3, N =610) = 52.000, p = 0.000$ ). Asibey Pool recorded a significant lower mean flush induced airborne time compared to all the remaining three sites (Table 10).

A total of 610 flushes and with aggregate flush induced airborne time of 20,695 seconds in air all together gave an average flush induce airborne time of 33.93 seconds. Since the rate of flushing in general was 2.5 an hour at Mole National Park , it follows that waterbird in Mole National Park on the average spends 84.95 seconds per hour ( $33.93 \times 2.5$ ) as a result of flushing. Focusing on individual study sites, a waterbird in Lana Pool spends 113.01 sec/hr due to flushing followed in decreasing order of 107.45 sec/hr in Dam 1&2 Wetland, 77.51 sec/hr in Haraba Pool and 48.05 sec/hr in Asibey Pool

Table 11 shows the findings on flushing due to the various causes of the bird flushes. There was significant difference in the mean flush induced airborne time among the five causes of flush using Kruskal-Wallis test ( $\chi^2 (4, N =610) = 174.706, p = 0.000$ ). Flushes by

Tourist/Staff resulted in the highest mean flush induced airborne time followed in a decreasing order by birds of prey, moving vehicles, non-predatory birds/animals and indeterminate cause. Statistically, mean flush induced airborne times of Tourist/Staff and Birds of prey were significantly higher than Indeterminate Cause (Table 11).

However, indeterminate cause of flush resulted in the birds spending the longest time in air (46.49 sec/hr) as a result of flushing whilst the lowest was observed among birds flushed by moving vehicles (0.76 sec/hr) (Table 11).

Table 10: Flush Induced Airborne Time at the various Sites

| Sites          | Total Observation hours | Range (seconds) | Total Flush induced airborne time (sec) | Mean $\pm$ SD                     | Rate of flushing (no./hr) | Average time spent by bird due to flushing (sec/ hour ) |
|----------------|-------------------------|-----------------|---|-----------------------------------|---------------------------|---|
| Dam1&2         | 66                      | 4-138           | 7002                                    | 37.05 $\pm$ 23.90 <sup>a</sup>    | 2.9                       | 107.45  |
| Lana pool      | 55                      | 5-131           | 6254                                    | 37.67 $\pm$ 24.58 <sup>a</sup>    | 3.0                       | 113.01  |
| Haraba pool    | 55                      | 8-107           | 4281                                    | 36.91 $\pm$ 19.45 <sup>a</sup>    | 2.1                       | 77.51   |
| Asibey pool    | 66                      | 3-91            | 3158                                    | 22.88 $\pm$ 16.35 <sup>b</sup>    | 2.1                       | 48.05   |
| <b>Overall</b> | <b>242</b>              | <b>3-138</b>    | <b>20695</b>                            | <b>33.98<math>\pm</math>22.55</b> | <b>2.5</b>                | <b>84.95</b>  |

*Mean  $\pm$  standard deviation with the same letter in columns are not significantly different*

*( $P > 0.05$ ) according to Kruskal-Wallis test.*

Table 11: Effect of Cause of Flush on Flush Induced Airborne Time

| Cause of Flush              | Rate of flushing due to the causal factors (no./hr) | Flush induced airborne time (sec) |                                | Average time spent by bird due to flushing (sec/hr) |
|-----------------------------|---|-----------------------------------|--------------------------------|---|
|                             |   | Range                             | Mean $\pm$ standard deviation  |   |
| Indeterminate cause         | 1.78  | 3-105                             | 26.12 $\pm$ 16.17 <sup>a</sup> | 46.49   |
| Non-predatory birds/Animals | 0.03  | 4-95                              | 36 $\pm$ 32.16 <sup>ab</sup>   | 1.08  |
| Moving Vehicles             | 0.02  | 4-72                              | 38 $\pm$ 28.94 <sup>ab</sup>   | 0.76  |
| Birds of Prey               | 0.38  | 10-131                            | 51.66 $\pm$ 24.51 <sup>b</sup> | 19.63   |
| Tourist /staff              | 0.31  | 10-138                            | 56.61 $\pm$ 22.69 <sup>b</sup> | 17.55   |

*Mean  $\pm$  standard deviation with the same letter in columns are not significantly different ( $P>0.05$ ) according to Kruskal-Wallis test.*

#### 4.3.3 Users of the wetlands at Mole National Park

Of 765 number of wetland users other than birds recorded, 71% consisted of mammals and reptiles while the remaining 29% were humans. Tourists/Staff were the highest users of Asibey Pool constituting 64% of its users compared to Dam1&2 Wetland, Lana Pool and Haraba Pool where tourists and staff accounted for only 30%, 0% and 33% respectively of their users (Table 12). Thus animal activity accounted for majority of the users at Dam1&2 Wetland, Lana Pool and Haraba Pool contrary to that of humans at Asibey Pool.

Table 12: Number of Wetland Users at the various Study Sites

| Sites          | Number of users                      |                |           |
|----------------|--------------------------------------|----------------|-----------|
|                | Other Animals (Mammals and Reptiles) | Tourists/Staff | Total     |
| Dam1&2 Wetland | 474 (69.60%)                         | 207 (30.40%)   | 681(100%) |
| Lana Pool      | 50 (100%)                            | 0(0%)          | 50 (100%) |
| Haraba Pool    | 8 (66.67%)                           | 4 (33.33%)     | 12 (100%) |
| Asibey Pool    | 8 (36.36%)                           | 14 (63.64%)    | 22 (100%) |
| Total          | 540 (70.59%)                         | 225 (29.41%)   | 765(100%) |

#### 4.4 Alert and Flight Initiation Distances of some common species of waterbirds

##### 4.4.1 Alert (AD) and Flight Initiation (FID) Distances of some waterbirds at Mole National park

The result of the single observer walk approach in determining the AD and FID are shown in table 13 for some selected waterbirds. Grey Heron had the longest mean AD ( $120.80 \pm 31.91$ ) followed by Hadada Ibis ( $79.12 \pm 49.26$ ) with Green-backed Heron recording the shortest mean AD ( $41.00 \pm 8.73$ ). Similarly, Grey Heron had the longest FID ( $113.53 \pm 31.92$ ) followed by Hadada Ibis ( $65.20 \pm 54.25$ ) with Cattle Egret recording the shortest mean FID ( $32.71 \pm 23.77$ ).

Table 13: Alert Distance (AD) and Flight Initiation Distance (FID) of selected waterbirds species at Mole National Park

| Species                    | Number of observations | AD (m)             |        | FID (m)            |        |
|----------------------------|------------------------|--------------------|--------|--------------------|--------|
|                            |                        | Mean $\pm$ SD      | Range  | Mean $\pm$ SD      | Range  |
| Grey Heron                 | 15                     | 120.80 $\pm$ 31.91 | 77-218 | 113.53 $\pm$ 31.92 | 64-208 |
| Hadada Ibis                | 25                     | 79.12 $\pm$ 49.26  | 39-208 | 65.20 $\pm$ 54.25  | 16-205 |
| Cattle Egret               | 55                     | 77.91 $\pm$ 21.62  | 12-127 | 32.71 $\pm$ 23.77  | 1-76   |
| Squacco Heron              | 16                     | 73.06 $\pm$ 15.23  | 47-89  | 40.94 $\pm$ 20.77  | 4-82   |
| Senegal Thick-knee         | 18                     | 66.94 $\pm$ 16.58  | 39-90  | 45.39 $\pm$ 15.95  | 10-64  |
| African Jacana             | 13                     | 59.00 $\pm$ 14.75  | 36-83  | 43.62 $\pm$ 21.08  | 6-75   |
| Hamerkop                   | 15                     | 54.47 $\pm$ 13.22  | 37-68  | 49.73 $\pm$ 12.99  | 32-65  |
| White-faced Whistling Duck | 14                     | 54.07 $\pm$ 6.96   | 35-63  | 48.07 $\pm$ 8.00   | 30-60  |
| Green-backed Heron         | 13                     | 41.00 $\pm$ 8.73   | 25-48  | 34.15 $\pm$ 8.81   | 17-41  |

#### ***4.4.2 Factors that Influence the Alert Distance of Waterbirds at Mole National Park***

Nine (9) species of waterbirds were successfully flushed throughout the entire study period. These include African Jacana, Cattle Egret, Green-backed Heron, Grey Heron and Hadada Ibis. The rest are Hamerkop, Senegal Thick-knee, Squacco Heron and White-faced Whistling Duck. The correlation and multiple linear regression analysis between alert distance and the predictor variables did not show any significant relationships for African Jacana, Green-backed Heron, Grey Heron, Squacco Heron and White-faced Whistling Duck for all predictor variables. However, there were significant relationships between the AD

and some of the predictor variables for Cattle Egrets, Hadada Ibis, Hamerkop and Senegal Thick-knee as presented in the following sub-sections.

#### ***4.4.2.1 Relationship between the AD of Cattle Egret and its surrounding conditions***

The correlation and multiple linear regression analysis as summarized in table 14 indicate that grass height and grass cover are negatively and significantly correlated with the AD of Cattle Egret. However, there was no significant relationship between the AD of Cattle Egret and group size, number of heterospecifics and shrub height. The multiple linear regression model with all five predictors produced  $R^2_{adj.} = 0.406$ ,  $F(5, 49) = 8.379$  and  $P=0.000$ . As shown in Table 14, group size and grass height had significant negative regression weights, implying that group size and grass height are significant predictors of AD of Cattle Egret. This therefore indicates that, increase in group size and grass height decreases the AD of Cattle Egrets. However, the numbers of heterospecifics, grass cover and shrub height did not significantly contribute to the multiple linear regression model, hence they are not significant predictors of AD of Cattle Egret.



Table 14: Correlation and multiple linear regression analyses between AD and potential predictors of AD for Cattle Egret

| Variable                  | Mean± SD    | Correlation with Alert Distance (AD) | Multiple regression weights |       |
|---------------------------|-------------|--------------------------------------|-----------------------------|-------|
|                           |             |                                      | b                           | Sig.  |
| Constant                  |             |                                      | 139.556                     | 0.000 |
| Group size                | 6.27±2.60   | -0.086 <sup>ns</sup>                 | -3.648**                    | 0.001 |
| Number of heterospecifics | 6.18±3.19   | 0.146 <sup>ns</sup>                  | 0.561 <sup>ns</sup>         | 0.529 |
| Grass height              | 23.35±8.72  | -0.571**                             | -1.264**                    | 0.003 |
| Grass cover               | 35.36±20.77 | -0.546**                             | -0.264 <sup>ns</sup>        | 0.064 |
| Shrub height              | 3.41±0.94   | 0.206 <sup>ns</sup>                  | -0.989 <sup>ns</sup>        | 0.735 |

$R^2_{Adj.}=0.406$  ns = Not significant, \* =  $p<0.05$ , \*\* =  $p<0.01$ , b=Unstandardized coefficients

#### 4.4.2.2 Relationship between the AD of Hadada Ibis and its surrounding conditions

The correlation and multiple linear regression analysis as summarized in table 15 indicate that grass height is negatively and significantly correlated with the AD. Also the number of heterospecifics was positively correlated with AD. However, there was no significant relationship between the AD of Hadada Ibis and the grass cover, group size and shrub height. Although the multiple regression model with all five predictors was significant ( $R^2_{Adj.}=0.319$ ,  $F(5, 19)=3.249$ ,  $P=0.027$ ), none of these five predictor variables had a significant regression weight (Table 15). Therefore the variables which did not produce a significant Spearman's correlation were removed from the regression model and the model refitted with only grass height and number of heterospecifics (Table 16). The refitted model with the two predictors produced  $R^2_{Adj.}=0.310$ ,  $F(2, 22)=6.394$ ,  $P=0.006$ . As shown in

table 16, only grass height had a significant negative regression weight, indicating that grass height is a significant predictor of AD in Hadada Ibis. This implies that increase in grass height decreases the AD of Hadada Ibis. However, the number of heterospecifics although had a significant positive correlation, it is not a significant predictor of AD in Hadada Ibis.

Table 15: Correlation and multiple regression analyses between AD and potential predictors of AD for Hadada Ibis

| Variable                  | Mean± SD    | Correlation with Alert Distance (AD) | Multiple regression weights |       |
|---------------------------|-------------|--------------------------------------|-----------------------------|-------|
|                           |             |                                      | b                           | Sig.  |
| Constant                  |             |                                      | 104.260                     | 0.069 |
| Group size                | 1.12±1.05   | 0.140 <sup>ns</sup>                  | 7.862 <sup>ns</sup>         | 0.364 |
| Number of heterospecifics | 9.12±4.23   | 0.487*                               | 4.085 <sup>ns</sup>         | 0.127 |
| Grass height              | 24.68±8.57  | -0.475*                              | -1.903 <sup>ns</sup>        | 0.156 |
| Grass cover               | 42.20±23.85 | -0.233 <sup>ns</sup>                 | -0.803 <sup>ns</sup>        | 0.093 |
| Shrub height              | 3.96±2.54   | 0.032 <sup>ns</sup>                  | 2.444 <sup>ns</sup>         | 0.586 |

$R^2_{Adj.} = 0.319$ , *ns* = Not significant, \* =  $p < 0.05$ , \*\* =  $p < 0.01$ , *b* = Unstandardized coefficients



Table 16: Re-fitted multiple regression model between AD and the potential predictors of AD which shown significant Spearman's correlation (Hadada Ibis)

| Variable                     | Mean±SD    | Correlation with<br>Alert Distance (AD) | Multiple regression weights |       |
|------------------------------|------------|---|-----------------------------|-------|
|                              |            |   | b                           | Sig.  |
| Constatnt                    |            |   | 136.701                     | 0.000 |
| Grass height                 | 24.68±8.57 | -0.475*                                 | -3.159**                    | 0.004 |
| Number of<br>heterospecifics | 9.12±4.43  | 0.487*                                  | 2.235 <sup>ns</sup>         | 0.252 |

$R^2_{Adj.} = 0.310$ , *ns* = Not significant, \* =  $p < 0.05$ , \*\* =  $p < 0.01$ , *b* = Unstandardized coefficients

#### 4.4.2.3 Relationship between the AD of Hamerkop and its surrounding conditions

The correlation and multiple linear regression analysis as summarized in table 17 indicate that grass cover had a negative and significant correlation with the AD. However, group size, the number of heterospecifics, grass height and shrub height did not show any significantly correlation with the AD. Although the multiple regression model with all five predictors was significant ( $R^2_{Adj.} = 0.652$ ,  $F(5, 8) = 5.875$ ,  $P = 0.014$ ), none of these five predictor variables had a significant regression weight (Table 17). The refitted model with grass cover produced  $R^2_{Adj.} = 0.692$ ,  $F(1, 13) = 32.414$ ,  $P = 0.000$ . As shown in table 18, only grass cover had a significant negative regression weight, indicating that grass cover is the only significant predictor of AD of Hamerkop among the five predictor variables. Hence increase in grass cover decreases the AD for Hamerkop.

Table 17: Correlation and multiple regression analyses between AD and potential predictors of AD for Hamerkop

| Variable                  | Mean±SD     | Correlation with Alert Distance (AD) | Multiple regression weights |       |
|---------------------------|-------------|--------------------------------------|-----------------------------|-------|
|                           |             |                                      | b                           | Sig.  |
| Constant                  |             |                                      | 78.038                      | 0.002 |
| Group size                | 0.07±0.27   | -0.313 <sup>ns</sup>                 | 9.019 <sup>ns</sup>         | 0.384 |
| Number of heterospecifics | 11.80±7.61  | 0.486 <sup>ns</sup>                  | 0.186 <sup>ns</sup>         | 0.564 |
| Grass height              | 17.07±9.09  | -0.443 <sup>ns</sup>                 | -0.280 <sup>ns</sup>        | 0.592 |
| Grass cover               | 23.00±24.99 | -0.856 <sup>**</sup>                 | -0.309 <sup>ns</sup>        | 0.140 |
| Shrub height              | 3.63±1.33   | -0.314 <sup>ns</sup>                 | -3.886 <sup>ns</sup>        | 0.247 |

$R^2_{Adj.} = 0.652$ , *ns* = Not significant, \* =  $p < 0.05$ , \*\* =  $p < 0.01$ , *b* = Unstandardized coefficients

Table 18: Re-fitted multiple regression model between AD and the potential predictor of AD which shown significant Spearman's correlation (Hamerkop)

| Variable    | Mean        | Correlation with Alert Distance (AD) | Multiple regression weights |       |
|-------------|-------------|--------------------------------------|-----------------------------|-------|
|             |             |                                      | b                           | Sig.  |
| Constant    |             |                                      | 64.746                      | 0.000 |
| Grass cover | 23.00±24.99 | -0.856 <sup>**</sup>                 | -0.447 <sup>**</sup>        | 0.000 |

$R^2_{Adj.} = 0.692$ , *ns* = Not significant, \* =  $p < 0.05$ , \*\* =  $p < 0.01$ , *b* = Unstandardized coefficients

#### ***4.4.2.4 Relationship between the AD of Senegal Thick-knee and its surrounding conditions***

The correlation and multiple linear regression analysis as summarized in table 19 indicate that grass height and shrub height are negatively and significantly correlated with the AD of Senegal Thick-knee. However there was no significant relationship between AD and group size, number of heterospecifics and grass cover. The multiple linear regression model with all five predictors was significant and produced  $R^2_{Adj.} = 0.896$ ,  $F(5, 12) = 30.417$ ,  $P = 0.000$ . As shown in Table 19, the number of heterospecifics, grass cover and shrub height all had a significant negative regression weights whilst grass height had a significant positive regression weight. This implies that increase in the number of heterospecifics, grass cover and shrub height decreases the AD of Senegal Thick-knee whilst increase in grass height increases AD of Senegal Thick-knee. These variables are therefore significant predictors of AD of Senegal Thick-knee whilst Group size is not a significant predictor of AD of Senegal Thick-knee.

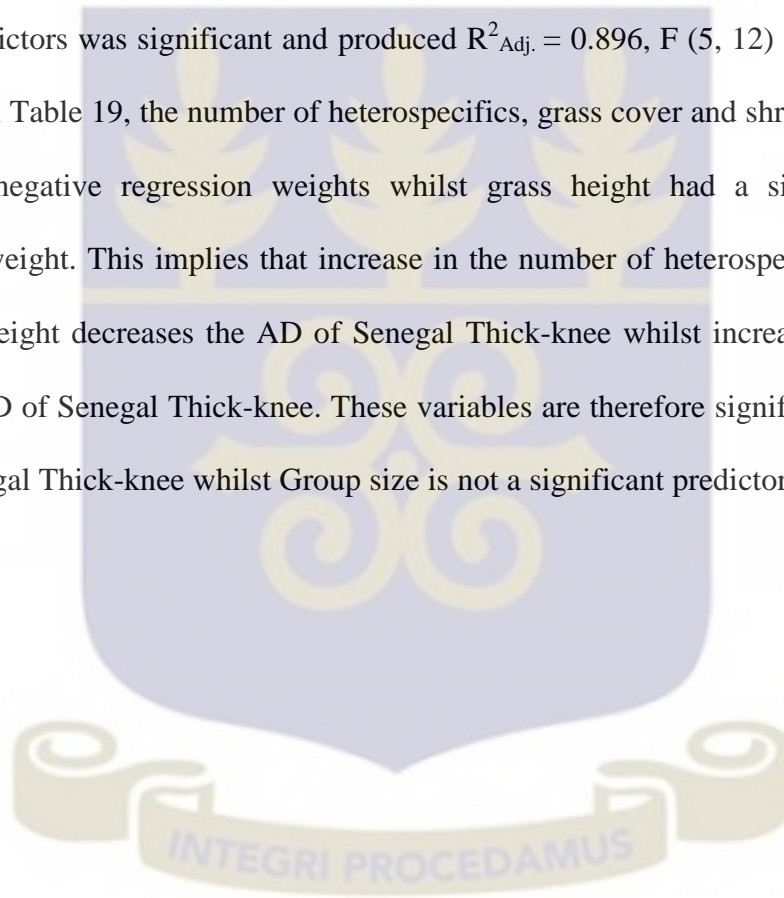


Table 19: Correlation and multiple linear regression analyses between AD and various potential predictors of AD for Senegal Thick-knee

| Variable                     | Mean±SD     | Correlation with<br>Alert Distance<br>(AD) | Multiple regression<br>weights |       |
|------------------------------|-------------|--|--------------------------------|-------|
|                              |             |  | b                              | Sig.  |
| Constant                     |             |  | 118.517                        | 0.000 |
| Group size                   | 15.17±9.36  | -0.222 <sup>ns</sup>                       | 0.279 <sup>ns</sup>            | 0.352 |
| Number of<br>heterospecifics | 1.11±2.32   | -0.448 <sup>ns</sup>                       | -2.793**                       | 0.001 |
| Grass height                 | 33.39±9.35  | -0.626**                                   | 0.753**                        | 0.009 |
| Grass cover                  | 34.44±13.82 | 0.358 <sup>ns</sup>                        | -0.784**                       | 0.000 |
| Shrub height                 | 6.87±3.72   | -0.511*                                    | -7.398**                       | 0.000 |

$R^2_{Adj.} = 0.896$ , *ns* = Not significant, \* =  $p < 0.05$ , \*\* =  $p < 0.01$ , *b* = Unstandardized coefficients



## CHAPTER FIVE

### DISCUSSIONS

#### 5.1 Species of waterbirds at Mole National Park

Of the 59 species of waterbirds reported by Dowsett-Lemaire and Dowsett (2005), only 32 were actually observed by the authors during their field work and the remaining 27 species were added based on studies conducted by other researchers. The current study identified 29 species of waterbirds in Mole National Park which is similar to the total number of waterbird species recorded by Dowsett-Lemaire and Dowsett (2005).

A comparison of this species list with that of Dowsett-Lemaire and Dowsett, (2005) indicated that eight out of the 32 species observed by Dowsett-Lemaire and Dowsett (2005), were not recorded in this current study. These include the Spotted Thick-knee, Lesser Black-winged Lapwing, Great Egret, Four-banded Sandgrouse, Common Moorhen, Black Stork, Allen's Gallinule and African Finfoot. These species were recorded to inhabit the very sites at which this study was carried out therefore the inability to record them could be an indication that the current habitat conditions in these sites may no longer be conducive for their habitation. For example Asibey pool is now shallow and dries faster during the dry season. Also Sabory pool had no water at the beginning of this current study but has been reported to be a good site to find the Common Moorhen.

In addition, four (4) species which were not observed by Dowsett-Lemaire and Dowsett (2005) but reported by other authors to be present in Mole National Park were confirmed by this current study. These include the Abdim's Stork, Spur-winged Lapwing, White-backed

Night Heron and Greater Painted-Snipe. Since this present study did not cover the whole year, some species were most likely not to be encountered. Therefore conducting a research to cover the other wetlands could help identify some of the species which were missed.

## **5.2 Seasonal Variation in the Species Richness and Abundance of Waterbirds in Mole National Park**

Huntley *et al.* (1997a, 1997b) identified seasonal weather change as a factor that influences the ecology of species hence species may either exhibit a spatial response by changing their geographical distribution or may exhibit adaptation through natural selection. This current study at Mole National Park recorded higher number of species of waterbirds in the dry season (29) as compared to the wet season (18 species). Also at all the study sites, the number of species recorded in the dry season was higher than the numbers recorded in the wet season.

The higher number of waterbird species recorded in the dry season could probably be due to the gathering of waterbirds at larger permanent water bodies when the small water bodies dry out (Mundava *et al.*, 2012). During this period also, the piscivorous waterbirds can easily find fish/prey. The relatively low number of waterbird species observed during the wet season could be attributed to the dispersal of waterbirds throughout the park to take advantage of the abundance of water all over the park during the wet season as previously observed by Dowsett-Lemaire & Dowsett, (2005) and Mundava *et al.* (2012). Similar observations have been made across Africa including Aynalem and Bekele (2008) who

recorded more species of birds in the dry season as compared to the wet season at the southern tip of Lake Tana, Ethiopia.

Contrary to the general trend of most habitats recording higher species richness in the dry season, the number of species recorded in Dam 1&2 Wetland was higher in the wet season. It appears that habitat conditions are better in the wet season as compared to dry seasons at Dam 1&2 Wetland. This trend could also be attributed to the higher tourist activities at this study site during the dry season due to its easy accessibility. High levels of human disturbances have been reported to have negative impact on waterbirds community composition (Ntongani and Andrew, 2013; Rajashekara and Venkatesha, 2014).

In this study, measures of similarity ( $C_{MH}$ ) indicate that Haraba Pool waterbirds were closely related to that of Asibey Pool compared to the other study sites. This could be attributed to the closeness of these two sites (approximately 4km apart) hence they may have similar vegetation and habitat conditions. However, the lowest similarity ( $C_{MH}$ ) between Lana Pool and Haraba Pool could also be attributed to the differences in the vegetation structure and habitat conditions between these two sites.

The changes in the physical and chemical factors of the hydrosphere are known to affect the ecosystem integrity of wetlands. These abiotic factors in turn, affect communities that are dependent on wetlands and also the ecosystem attributes like species richness, density and distribution (Burkert *et al.*, 2004). In this study, a significantly higher numbers of waterbirds were counted in the dry season as compared to the wet season. As indicated

earlier, the significant higher numbers of waterbirds observed in the dry season could be attributed to the congregation of waterbirds at larger permanent water bodies when the small water bodies dry out in the dry season (Mundava *et al.*, 2012). However, the lower numbers of waterbirds observed during the wet season could be attributed to the dispersal of waterbirds to different part of the park since water is everywhere (Mundava *et al.*, 2012, Dowsett-Lemaire & Dowsett, 2005). According to Dowsett-Lemaire & Dowsett (2005) more numbers of waterbirds have been reported in the dry season at Mole National Park.

For example, as 58% of the waterbird abundance in the wet season was observed at Dam 1&2 wetland, it appears that wetland conditions at this sites in the wet season favours the assemblages of higher numbers of waterbirds (Paracuellos, 2006; Lagos *et al.*, 2008). On the contrary, the highest number of waterbirds recorded at Lana Pool in the dry season is an indicative of the congregation of waterbirds at larger permanent wetlands (Dowsett-Lemaire & Dowsett, 2005).

Although higher numbers of waterbirds were recorded at Dam 1&2 wetland in the dry season as compared to the wet season, it did not record the overall highest abundance in terms of the study sites as it did in the wet season. This may be suggestive that the habitat conditions in this wetland are not suitable for high assemblage of waterbirds in the dry season. It could also be attributed to the high anthropogenic activities at this wetland especially during the dry season as this site is the closest to the park's headquarters (Khan, 2010).

### **5.3 Nature of disturbance to waterbirds in Mole National Park**

#### ***5.3.1 Causes of waterbird flushes at the various sites***

This study has demonstrated that each waterbird in Mole National Park spends 84.95 seconds per hour in flight as a result of flushing and this appears to be an insignificant fraction of an hour. Besides, the average time spent in flight by a waterbird as a result of human flushing amounted to 17.55 seconds per hour which constitute only 20.66% of a bird's average time in flight due to flushing. It can therefore be concluded from these that, waterbirds in Mole National Park spend an insignificant amount of their time in flight due to flushing. Borgmann (2011) indicated that human-induced disturbances like boating and walking alter the behaviour of birds and diverts their time and energy away from feeding.

The rate of flushing per hour as observed in this study was higher than the rate of flushing in coastal wetland of Ghana as observed by Gbogbo *et al.* (2013). This could be attributed to the higher waterbird numbers and activities at Lana Pool and Dam 1&2 Wetland which resulted in higher indeterminate causes of flushes.

According to Ruddock and Whitfield (2007), animals are usually disturbed by human in their natural habitats through human approach or activities such as recreation. At the coastal wetlands of Ghana, Gbogbo *et al.* (2013) observed similar causes of flush as observed in this study. Majority of all the flushes at Mole National Park were caused by indeterminate factors. These factors include the bird's quest to relocate in search for food and other behavioural activities of the birds that require them to fly but not coerced by external

factors. Therefore, the majority of the flushes of waterbirds in Mole National park may not constitute disturbance.

Contrary to this study, Gbogbo *et al.* (2013) found that disturbance (flushing) of waterbirds driven by anthropogenic and birds of prey constituted majority of the total flushes at the coastal wetlands of Ghana. The lower number of flushes caused by anthropogenic factors in Mole National Park could be attributed to the fact that Mole National Park is a restricted use area for only tourism and educational activities whilst the coastal wetlands of Ghana area mostly open to all kind of use; mostly fishing. Also movement into these wetlands is not restricted.

Waterbirds flushes caused by human were generally low in all the study sites except for Dam 1&2 Wetland. The high level of flushes by human at Dam1&2 Wetland could therefore be attributed to the proximity of this wetland (approximately 500 m) to the park's headquarters. This makes the use of this wetland more frequent. Although the number of flushes caused by humans are low, it could increase with increasing tourist visit to the park as the rate of tourism activities at the world's biodiversity hotspots is anticipated to double by the year 2020 (Christ *et al.*, 2003), Furthermore, the lower number of human flushes recorded at Lana, Haraba and Asibey Pools could be attributed to the infrequent use of these wetlands by tourist because of their locations from the park's headquarters (approximately 9 km, 12 km and 17 km respectively) .

Majority of the users of the wetlands in the study area were animals (reptiles and mammals) and the least being tourist/staff. The proximity of Dam 1&2 Wetland to the park's headquarters and the easy access to this wetland contributed to its high tourist/staff use. The dams in this wetland serve as the bathing pool for elephants. This therefore attracts a lot of tourists to this site thereby increasing its tourist use. On the contrary, Lana, Haraba and Asibey Pools are very far from the park's headquarters and the access to these sites especially Lana Pool is very difficult. For instance there is no proper access route to Lana Pool and also in the wet season, Lana Pool can only be accessed by crossing small pools of water.

### ***5.3.2 Relationship between cause of flush and flush induced airborne time***

Ruddock and Whitfield (2007) reported that, animals normally move away from an approaching human and this reaction can have adverse effects on their feeding success as they spend more time flying. Similarly in this study, waterbirds flush caused by Tourist/staff resulted in the longest mean flush induced airborne time. This is because the birds may want to stay longer in air so that the disturbance is dispersed. On the contrary, indeterminate cause of waterbird flush resulted in the shortest mean flush induced airborne time. This may probably be due to the fact that this cause of flush does not constitute much disturbance to the birds.

The flush induced airborne time of tourist/staff was similar to that of birds of prey and these two are higher than the others. Mathot *et al.* (2009) observed that flushed induced airborne time turns to be longer with increased predation risk. Thus it appears birds perceive

tourist/staff and birds of prey to be of the same risk whilst the others are considered to be of lower risk. This therefore implies that bird flushes caused by tourist/staff and birds of prey constitute more of disturbances and has negative influence on birds than indeterminate cause of bird flush.

#### **5.4 Alert and Flight Initiation Distances of some common species of waterbirds**

##### ***5.4.1 Alert (AD) and Flight Initiation (FID) Distance of some Waterbirds at Mole National Park.***

All the waterbirds flushed responded differently to the disturbance source in terms of AD and FID and therefore indicating AD and FID are species specific trait (Blumstein *et al.*, 2003). According to Blumstein *et al.* (2005), body mass and AD/FID are positively correlated in birds. Larger bird species are known to have greater alert distance than smaller species (Blumstein *et al.*, 2005). Several authors (Fernández-Juricic *et al.*, 2001; Weston *et al.*, 2012) have reported that AD differs among species, with large species being less tolerant of human disturbance as compared to small ones.

In this study, Grey Heron had the longest mean AD as well as FID and was also the largest among the species selected for the disturbance studies. Furthermore, the smallest among the selected birds; Green-backed heron had the shortest mean AD. According to Fernández-Juricic *et al.* (2002) bird species that are heavy are less aerodynamic compared to smaller species and therefore they need more time to flee. Furthermore, Blumstein (2006) explained that smaller-bodied species may respond later to disturbance in an attempt to

maximize foraging time to fulfill their higher energy requirement. These explanations are indeed consistent with the results of this study.

It was also observed that cattle egrets had the shortest FID ( $32.71 \pm 23.77$ ). This could probably be attributed to habituation and or prior exposure of cattle egrets to disturbance (Burger & Gochfeld 1983, Ruggles 1994). According to Blumstein *et al.* (2005), habituation effects are related to the regularity with which different species interacted with humans and hence resident species tend to have shorter flight initiation distance than migratory species that have greater flight initiation distances.

#### ***5.4.2 Factors that influence the Alert Distance of waterbirds at Mole National Park***

Fernández-Juricic, *et al.* (2001) found that habitat structure influences the alert distances of birds, hence greater availability of escape cover increases birds tolerance to disturbance. In this study, group size, numbers of heterospecifics, grass height, grass cover, and shrub height correlated with AD of some selected species.

Grass height had a significant negative regression weight on AD of Cattle Egret and Hadada Ibis whilst in Senegal Thick-knee the regression was positive. This therefore implies that grass height is a significant predictor of AD of these species. Hence increase in grass height decreases the AD for Cattle Egret and Hadada Ibis whilst it increases the AD of Senegal Thick-knee. This could be attributed to the possibility of the tall grasses giving the bird a sense of security making it feel hidden. Also, some species of birds are known to remain motionless in grass and take advantage of it to startle predators. Mathot *et al.* (2009)

observed that increase in the level of threat to birds increases the proportion of time spent to be vigilant, hence the proportion of time spent feeding also decreases.

In addition, the significant negative regression observed between the grass cover and AD of Hamerkop and Senegal Thick-Knee, implies that grass cover is a significant predictor of AD in Hamerkop and Senegal Thick-knee. Hence increase in grass cover decreases the AD of Hamerkop and Senegal Thick-Knee. This could be attributed the fact that grass cover hampers the bird's ability to locate food and therefore compelling the bird to concentrate on the search for food at the expense of vigilance.

Furthermore, group size had a significant negative regression with AD of Cattle Egret whilst the number of heterospecifics in groups had a significant negative regression with AD of Senegal Thick-Knee. This implies that group size and number of heterospecifics are significant predictors of AD of Cattle Egret and Senegal Thick-knee respectively. Hence increase in the group size and the number of heterospecifics decrease the AD of Cattle Egret and Senegal Thick-knee respectively. Burger & Gochfeld (1991) found animal group size to affect the AD of birds. Thus increase in group size renders the group more visible for attacks and therefore individual birds are more vigilant to an approaching object when in larger groups than in small groups. On the contrary, other authors have reported that increase in competition among members of foraging flocks usually leads to decrease in individual vigilance in foraging flocks with an increase in group size (Beauchamp, 2001; Randler, 2005).

The last habitat structure to show a significant relationship was shrub height and this had a negative regression weight with the AD of Senegal Thick-knee. AD and FID are reported to be influenced by availability of alternative habitat when birds are disturbed (Gill *et al.*, 2001, West *et al.*, 2002). Thus birds get a good escape cover (perch) when the surrounding shrubs are taller and therefore might be prepared to tolerate disturbance with tall shrubs than short ones which is consistent with the finding of Fernández-Juricic, *et al.* (2001) that habitat structure influences the alert distances of birds with increasing bird tolerance with better accessibility to escape cover.



## CHAPTER SIX

### 6.0 CONCLUSION AND RECOMMENDATIONS

#### 6.1 Conclusion

Based on the results and discussions, it is evident that;

At least 29 species of waterbirds belonging to 6 orders and 12 families currently occur at Mole National Park with White-faced Whistling Duck being the most abundant species. The highest number of species occurred in Haraba Pool.

Species richness and abundance of waterbirds in Mole National Park varied according to the wet and dry seasons with both the number of species and abundance higher in the dry season than the wet season.

Based on the flush rate and mean flight time, birds at Mole National Park do not spend a significant fraction of their time in air as a result of human disturbance. The most important cause of bird flush was indeterminate factors which are not considered as disturbance.

AD and FID varied among the different species of waterbirds. It can be concluded from the findings that, AD and FID increases with the size of the animal with larger size species having longer AD and FID compared to small size species.

Grass height is a significant predictor of AD of Cattle Egret, Hadada Ibis and Senegal Thick-knee. Also, grass cover is a significant predictor of AD of Hamerkop and Senegal

Thick-knee whilst the number of heterospecifics and group size are significant predictors of AD of Senegal Thick-knee and Cattle Egret respectively.

## **6.2 Recommendations**

Some species of waterbirds previously recorded in Mole National Park were not seen in this study. Longer period of monitoring should be done to establish the current status of such species.

More species and numbers of waterbirds were counted in the dry season compared to the wet season. It is therefore recommended that tourists who are interested in waterbirds should particularly visit the park in the dry season as their chances of encountering more species and numbers of waterbirds is higher in the dry season compared to the wet season.

When considering set-back distances in the design of trails in Mole National Park, it should consider the alert distance of the largest species as this will help reduce disturbances to smaller ones.

Habitat complexity was observed in this study to increase tolerance levels of waterbirds by increasing the availability of escape cover. Management practices intended to increase vegetation structure, specifically grass and shrub cover could be a moderately easy means to minimize human disturbance to waterbirds in Mole National Park.

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## APPENDIX

## Appendix I: Species of Waterbirds Reported by Different Researchers in Mole National Park

| S.N | Common Name               | Scientific Name                | References (Recorded in Mole by these authors)                             |
|-----|---------------------------|--------------------------------|--|
| 1   | Abdim's Stork             | <i>Ciconia abdimii</i>         | Maze (1971), Wilson (1993) as cited in Dowsett-Lemaire and Dowsett (2005). |
| 2   | African Finfoot           | <i>Podica senegalensis</i>     | Dowsett-Lemaire and Dowsett (2005)   |
| 3   | African Jacana            | <i>Actophilornis africanus</i> | Dowsett-Lemaire and Dowsett (2005)   |
| 4   | African Open-bill Stork   | <i>Anastomus lamelligerus</i>  | Greig-Smith (1976), Wilson (1993)  |
| 5   | African Pygmy Goose       | <i>Nettapus auritus</i>        | Greig-Smith (1976), Wilson (1993), Harvey & Harrison (1970)                |
| 6   | African Wattled Lapwing   | <i>Vanellus senegallus</i>     | Dowsett-Lemaire and Dowsett (2005)   |
| 7   | Allen's Gallinule         | <i>Porphyryla alleni</i>       | Dowsett-Lemaire and Dowsett (2005)   |
| 8   | Black Crake               | <i>Amaurornis flavirostra</i>  | Dowsett-Lemaire and Dowsett (2005)   |
| 9   | Black Crowned Crane       | <i>Balearica pavonina</i>      | Payne in Greig-Smith (1976)  |
| 10  | Black Stork               | <i>Ciconia nigra</i>           | Riley (2004) as cited in Dowsett-Lemaire and Dowsett (2005)                |
| 11  | Black-crowned Night Heron | <i>Nycticorax nycticorax</i>   | Dowsett-Lemaire and Dowsett (2005)   |
| 12  | Black-headed Heron        | <i>Ardea melanocephala</i>     | Dowsett-Lemaire and Dowsett (2005)   |
| 13  | Black-winged Stilt        | <i>Himantopus himantopus</i>   | Wilson (1993)  |
| 14  | Bronze-winged             | <i>Rhinoptilus</i>             | Grimes (1987), Sutton (1965)   |

|    |                        |                                |   |
|----|------------------------|--------------------------------|---|
|    | Courser                | <i>chalcopterus</i>            |   |
| 15 | Cattle Egret           | <i>Bubulcus ibis</i>           | Dowsett-Lemaire and Dowsett (2005)  |
| 16 | Common Greenshank      | <i>Tringa nebularia</i>        | Greig-Smith (1977)  |
| 17 | Common Moorhen         | <i>Gallinula chloropus</i>     | Dowsett-Lemaire and Dowsett (2005)  |
| 18 | Common Sandpiper       | <i>Actitis hypoleucos</i>      | Greig-Smith (1977), Dowsett-Lemaire and Dowsett (2005)                      |
| 19 | Common Snipe           | <i>Gallinago gallinago</i>     | Dowsett-Lemaire and Dowsett (2005)  |
| 20 | Dwarf Bittern          | <i>Ixobrychus sturmii</i>      | Greig-Smith (1976),   |
| 21 | Egyptian Plover        | <i>Pluvianus aegyptius</i>     | Wilson (1993), Grimes (1987)  |
| 22 | Forbes's Plover        | <i>Charadrius forbesi</i>      | Dowsett-Lemaire and Dowsett (2005)  |
| 23 | Four-banded Sandgrouse | <i>Pterocles quadricinctus</i> | Greig-Smith (1976, 1977), Sutton (1970), Dowsett-Lemaire and Dowsett (2005) |
| 24 | Goliath Heron          | <i>Ardea goliath</i>           | Harvey & Harrison (1970), Wilson (1993), Grimes (1987).                     |
| 25 | Great Bittern          | <i>Botaurus stellaris</i>      | (Grimes 1987)   |
| 26 | Great Egret            | <i>Egretta alba</i>            | Dowsett-Lemaire and Dowsett (2005)  |
| 27 | Great Snipe            | <i>Gallinago media</i>         | Greig-Smith (1977), Greig-Smith in Grimes (1987)                            |
| 28 | Greater Painted-Snipe  | <i>Rostratula benghalensis</i> | Taylor & Macdonald (1978)   |
| 29 | Green Sandpiper        | <i>Tringa ochropus</i>         | Sutton (1970), Dowsett-Lemaire and Dowsett (2005)                           |
| 30 | Green-backed Heron     | <i>Butorides striata</i>       | Dowsett-Lemaire and Dowsett (2005)  |
| 31 | Grey Heron             | <i>Ardea cinerea</i>           | Dowsett-Lemaire and Dowsett (2005)  |
| 32 | Hadada Ibis            | <i>Bostrychia hagedash</i>     | Dowsett-Lemaire and Dowsett (2005)  |
| 33 | Hamerkop               | <i>Scopus umbretta</i>         | Dowsett-Lemaire and Dowsett (2005)  |
| 34 | Intermediate Egret     | <i>Egretta intermedia</i>      | Dowsett-Lemaire and Dowsett (2005)  |

|    |                             |                                      |   |
|----|-----------------------------|--------------------------------------|---|
| 35 | Kittlitz's Plover           | <i>Charadrius pecuarius</i>          | Greig-Smith (1976), Grimes (1987).                                      |
| 36 | Knob-billed Duck            | <i>Sarkidiornis melanotos</i>        | Maze (1971)   |
| 37 | Lesser Black-winged Lapwing | <i>Vanellus lugubris</i>             | Riley as cited by Dowsett-Lemaire and Dowsett (2005)                    |
| 38 | Little Bittern              | <i>Ixobrychus minutus</i>            | Harvey & Harrison (1970), Wink (1976), Greig-Smith 1976), Wilson (1993) |
| 39 | Little Egret                | <i>Egretta garzetta</i>              | Dowsett-Lemaire and Dowsett (2005)                                      |
| 40 | Long-tailed Cormorant       | <i>Phalacrocorax africanus</i>       | Dowsett-Lemaire and Dowsett (2005)                                      |
| 41 | Marabou Stork               | <i>Leptoptilos crumeniferus</i>      | Dowsett-Lemaire and Dowsett (2005)                                      |
| 42 | Marsh Sandpiper             | <i>Tringa stagnatilis:</i>           | Greig-Smith (1977)  |
| 43 | Purple Heron                | <i>Ardea purpurea</i>                | Dowsett-Lemaire and Dowsett (2005)                                      |
| 44 | Ruff                        | <i>Philomachus pugnax</i>            | Greig-Smith (1977)  |
| 45 | Sacred Ibis                 | <i>Threskiornis aethiopicus</i>      | Wilson (1993) Harvey & Harrison (1970)                                  |
| 46 | Saddle-billed Stork         | <i>Ephippiorhynchus senegalensis</i> | Dowsett-Lemaire and Dowsett (2005)                                      |
| 47 | Senegal Thick-knee          | <i>Burhinus senegalensis</i>         | Dowsett-Lemaire and Dowsett (2005)                                      |
| 48 | Spotted Thick-knee          | <i>Burhinus capensis</i>             | Greig-Smith (1976), Dowsett-Lemaire and Dowsett (2005)                  |
| 49 | Spur-winged Goose           | <i>Plectropterus gambensis</i>       | Dowsett-Lemaire and Dowsett (2005)                                      |
| 50 | Spur-winged Lapwing         | <i>Vanellus spinosus</i>             | Riley as cited by Dowsett-Lemaire and Dowsett (2005)                    |
| 51 | Squacco Heron               | <i>Ardeola ralloides</i>             | Dowsett-Lemaire and Dowsett (2005)                                      |

|    |                               |                              |   |
|----|-------------------------------|------------------------------|---|
| 52 | Temminck's<br>Courser         | <i>Cursorius temminckii</i>  | Wilson (1993)   |
| 53 | Whimbrel                      | <i>Numenius phaeopus</i>     | Harvey & Harrison (1970)  |
| 54 | White Stork                   | <i>Ciconia ciconia</i>       | Greig-Smith (1976); Grimes (1987)   |
| 55 | White-backed<br>Night Heron   | <i>Gorsachius leuconotus</i> | Zakaria Wareh (personal communication) as cited by Dowsett-Lemaire and Dowsett (2005) |
| 56 | White-faced<br>Whistling Duck | <i>Dendrocygna viduata</i>   | Dowsett-Lemaire and Dowsett (2005)  |
| 57 | White-headed<br>Lapwing       | <i>Vanellus albiceps</i>     | Sutton (1970)   |
| 58 | Wood Sandpiper                | <i>Tringa glareola</i>       | Harvey & Harrison (1970), Dowsett-Lemaire and Dowsett (2005)                          |
| 59 | Woolly-necked<br>Stork        | <i>Ciconia episcopus</i>     | Dowsett-Lemaire and Dowsett (2005)  |

