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Diversity and Abundance of Bird Species in Mole National Park, Damongo, Ghana

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Abstract
A survey of birds in Mole National Park in the Northern Region of Ghana between February and May 2016 to identify and determine the diversity and abundance of bird species. Using Point Count Method, all birds were observed at fixed locations using an Opticron Polarex 8×40 field binocular and identification of birds' species were confirmed by Birds of Ghana and recorded vocal replay of birds. The Gamin GPS device was used to take the coordinate and location of all stations. 366 of individual birds consisting of 59 species were recorded, 45 were identified by sighting and 14 by vocalization, all belonging to 29 families. Species abundance indicated that Helmeted Guineafowl (Numida meleagris) (Relative Abundance (RA)= 4.90%), followed by Red-throated Bee-eater (Merops hirundineus) (RA =4.63%), Red-billed firefinch (Lagonosticta Senegala) (RA =4.36%), Little Weaver (Ploceus lucteolus) (RA =4.09%), Senegal Parrot (Piocephals senegalus) (RA =3.81%), Bar-breasted firefinch (Lagonosticta rufopicta) (RA =3.54%), White faced Whistling Duck (Dendrocygna viduata) (RA =3.27%) and Laughing Dove (Sterptopelia senegalensis) (RA =3.00%), whereas, the Bateleur Eagle (Terathopius ecaudatus) (0.54), African Dwarf Kingfisher (Ceyx lecontei) (0.27) and Klaas's Cuckoo (Chrysococcyx caprius) (0.27) had low relative species abundance. Estrildidae and Alcedinidae families were highest in abundance, (8.5%) of the total respectively, followed by Columbidae and Malaconotidae with the same relative abundance (6.8%), Ploceidae (5.1%). The practice of bird watching aimed at avifauna conservation can be encouraged in the fringe communities such as; Morgnori, Larabanga and Murugu, to document and protect bird species to improve community livelihood. Further investigations are required to compare avifauna within the off reserve and the protected areas (on reserve).
Keywords: Avifauna, Opticron, Polarex, Diversity, Abundance

1. Introduction

Biodiversity is formally defined by the Convention on Biological Diversity (CBD) as: "the variability among living organisms from all sources including, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (UN 1992 Article 2).

Birds represent an important component of global biodiversity. Thanks to the interest, they stimulate with their behaviors, colors and songs, birds are the best known group of animals at the global level with the most extended time series of data available. The world's biodiversity is diminishing rapidly (Balmford *et al.*, 2003; Jenkins *et al.*, 2003), therefore at the 2002 World Summit on Sustainable Development, the nations of the world agreed to pursue more effective implementation of the objectives of the Convention on Biological Diversity (CBD) in order to achieve a significant reduction in the current rate of loss of biological diversity by 2010 (Secretariat of the Convention on Biological Diversity, 2003).

The study of avifaunal diversity is an essential ecological tool, which acts as an important indicator to evaluate different habitats both qualitatively and quantitatively. It also fulfills many ecological functions, which include disease regulation, biomass recycling, seed dispersal of fleshy fruits, and pollination (Helm, 2002).

Migratory birds also represent a component of biodiversity whose conservation is particularly challenging, given the need for an international approach to the relevant legislation for their protection. (Fernando, 2012).

Land-use change is another key driver of current and future biodiversity change in the tropics, and conversion of native forests to pastures, croplands, botanical gardens and other human dominated habitats are other primary causes of biodiversity loss (Luck and Daily,2008; Sala *et al.*, 2000). According to Şekercioğlu *et al.* (2004, 2006) even though only 1.3% of bird species have gone extinct since 1500 AD, the global number of individual birds is estimated to have experienced a 20–25% reduction during the same period, indicating that avian populations and dependent ecosystem services are declining faster than species extinctions would indicate.

Although patterns of biodiversity loss have been explored extensively, their ecological implications have been extended to cover botanical gardens, (Wiafe and Faalong, 2012) and National Parks. The issue of resource conservation has grown along with human population growth and as such, numerous attempts and measures have been put in place to conserve the world's biodiversity. These measures include laws and policies and the creation of conducive environment to support the regeneration of species of conservation interest. This may take the form of establishment of Game, Resource and Strict Nature reserves, National Parks, Wildlife

Sanctuaries, Zoos (Cowlishaw and Dunbar, 2000)

People, worldwide, are rapidly degrading ecosystems, especially in the tropics, leading to a massive reduction in biodiversity (Laurance and Bierregaard, 1997; Vitousek *et al.,* 1997; Pimmand R, 2000 and Dirzoand R, 2003) indicate the effects of their change on biodiversity.

There are over 2,300 bird species in the African Region, a high proportion of which are endemic to the continent. Although birds present huge opportunities for nature tourism, it is also one of the reliable indicators of terrestrial biological richness (Bibby, 2000)

As West African forests are rapidly disappearing, the survivals of the birds of the Upper Guinea forests are becoming increasingly dependent on fewer areas. Despite a number of field studies conducted in the region in recent years, Demey *et al.,* 2004, 2005; Rainey *et al.,* 2005, De Laat, 2010 and Manu, 2011, the avifauna of the majority of these forest remain inadequately known. In West Africa, the decline has been on a large scale for the last 300-400 years especially for mammalian fauna (Decher *et al*., 2000). Several reasons have been proposed for this decline. Prominent among them is the decline in original habitat, which has been observed at the global level to be the most common cause of population decline and species extinction (Stewart *et al.,* 1996; Mace et *al*., 2000). It has been estimated that 36% of animal extinctions, where the cause is known, were due to habitat destruction Jenkins, 1992. Another estimate suggests that habitat destruction is responsible for the extinction of over 100 species daily Ehrlich *et al*., 1991. The other major cause of extinctions is hunting pressure, which continues with increasing human populations in local communities around forests. Thus, there is now widespread agreement that many threats to species are anthropogenic in origin Stewart and Hutchings, 1996; Ghimire and Pimbert, 1997.

Ghana's forest and savanna lands still support a diverse array of plant and animal species, although much of the resource is severely depleted. Data on status of individual plant species are not readily available, but it is estimated that over 70% of the original 8.22 million hectares of closed forest in Ghana has been destroyed (IIED, 1992) and only about 10.9% to 11.8% (representing 15,800 to 17,200 square kilometers of forest cover) remains as intact forests. Deforestation rate in the country is estimated at 22,000 square kilometers per annum (Hawthorne and Mussah, 1993). At this rate, without adequate intervention there will be no intact forest left in the country within the next 100 years. The country's productive systems as well as the livelihood and very survival of Ghanaians are threatened by the severe environmental degradation associated with deforestation (e.g. soil erosion, local climate changes, instability of hydrological regimes and loss of biological diversity). Currently there are eight threatened bird species and 14 near-threatened species in Ghana i.e. species at risk and requiring monitoring (Collar and Stuart, 1985; Collar and Andrew, 1988). Four of the threatened species are restricted range species endemic to the Upper Guinea forest block, while two are Palearctic migrants, the Damara tern *Sterna balaerum* and the Roseate Tern *Sterna dougallii*. The Damara tern is recorded only rarely on the Ghana coast while the Roseate occurs in appreciable numbers.

In Ghana, there are about 760 species of birds Brown and Borrow, 2010). This contributes to the biodiversity of birds and populations of birds in the country. In Mole National Park there are about 350 species of birds Dosset and Dosset, 2008 that constitute about 40% of the overall Ghanaians bird population. Due to the large number of birds' species and a series of ornithological survey and studies conducted in the Park, the park is one of the Important Birds Areas in Ghana Bird Life International, 2005.

In the past decade a series of scientific research has been conducted in the park, including a few birds' surveys. The latter were conducted mainly by students from overseas in the summer rains of 1968 Harvey and Harrison 1970, and in July–August 1974 and 1975, and from October to December 1975 by Greig-Smith 1976, who drew up a first checklist of birds in tabulated form, taking into account earlier records, published or unpublished. Other accounts from that period include Genelly 1969, who identified some 90 species, July–October 1966, Maze 1971, 101 species in January, April and August 1967 and 1968, Sutton 1965, 1970, who visited in late March 1964 and December–January 1968–9, Taylor and Macdonald 1978, a brief April 1976 visit, Wink 1976 and Macdonald 1978a, b who added a few records of migrants.

Payne 1985, 2004 studied fire finches and indigo birds in October 1975, and his other records are included in Greig-Smith 1976, 1977a. Nevertheless, there has been no update on the diversity of birds in Mole National Park since 2008 by L. Dosset and R. Dosset.

Though bird species are often important mobile links Lundberg *et al.,* 2003, top consumers, and keystone species in some habitats Raffaelli, 2004; their value in the ecosystems cannot be over emphasized. In the face of structural developments in Mole National Park recently, it is important that bird watchers become keen to document the surviving species and know the distribution of existing bird species to add on to check on their status.

This study will provide information about bird species abundance, distribution and availability within the Mole Loop Game viewing road. The research will also add to the existing information on the previous checklist of birds of Mole National Park and to stimulate interest in bird watching, which will help Wildlife Division, Mole National Park, and researchers.

1.1 Biophysical setting

Mole National Park as well as its fringe communities works within several major vegetation types as in typical Guinea Savanna zone. The dominant vegetation is open woodlands, riverine forest and floodplain grasslands and swamps. The major occupations of the inhabitants are subsistence farming and hunting (Mole National Park Management Plan, 2005).

The average annual rainfall ranges from 1000mm to 1100 mm. More than 90% of the rainfalls in the rainy season start from April to October, with its peaks from July to September. The dry season lasts from November to March with a mean annual temperature of 28°C, varying from 26°C in December to 31°C in March. The average range from day to night is 13°C. It can be unpleasantly hot in March and April, with temperatures sometimes in the 40°C. (Mole National Park Management Plan, 2005)

1.2 Objectives

The objective of this project is to do a snap checklist of birds in Mole National Park by a quick survey to establish the diversity and abundance of bird species.

The specific objectives are:

1. To identify bird species along the Mole loop game viewing road in Mole National Park.
2. To estimate the density of birds in Mole loop game viewing loop road in Mole National Park.
3. To determine the abundance of bird's species along the Mole loop game viewing road in Mole National Park.

1.3 Methodology

1.3.1 Study Area

Mole National Park is one of six National Parks in Ghana and one of three established in the northern savanna zone. It is the largest protected area in Ghana and considered to be the most prestigious. In Ghana, Mole National Park is one of the prime sites for biodiversity conservation.

The Park is the largest national and most developed protected area for eco-tourism and nature conservation. Mole National Park is situated in the Northern Ghana between 09˚12' – 10˚ 06' N and 01˚ 25' – 02˚ 17' W and covers an area of 'Four thousand, Seven hundred and Fifty-five (4755) km2.The elevation ranges from 120 to 490m above sea level (Mole National Park Management Plan, 2005) Figure 1. The park is about One hundred and Forty-six (146) km from Tamale the Regional capital and Twenty-six (26) km from Damongo the district capital. The Park shares boundary with four districts namely the West Gonja district, West Mamprusi district, Sawla-Tuna-Kalba district, and the Wa East district. There are thirty-three fringe communities around the park.

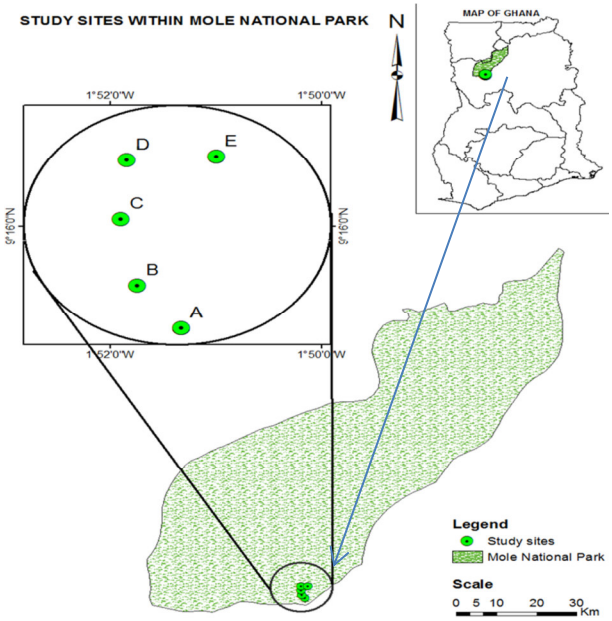

Figure 1: Map of Study Area

1.4 Experimental Procedure

The research was conducted in Mole National Park in the Northern Region of Ghana between February and May, 2016 using Point count method (Hamel *et al*., 1996; Ralph *et al.,* 1993, 1995a, 1995b) along Mole loop game viewing road behind the park Headquarters of Mole National Park (MNP). Using Point-count method to monitor

bird populations, all birds observed at a fixed location were tallied at repeated observation periods. Information on the relative abundance of all bird species over time was recorded. The field work was carried out in the morning between 6:00 am to 9:00 am, for five (5) stations at regular interval of thirty (30) minutes each and five (5) minutes rest to a different station for a total distance of 9 km along the Mole loop game viewing road in Mole National Park.

An Opticron Polarex 8×40 field binocular was used to assist in the observation and identification of the bird species. The Gamin GPS device was used to take the coordinate and location of the stations. Nomenclature of birds was referenced in field book of birds; 'Birds of Ghana' by Borrow *et al.*, (2010) and vocal replay of birds were used.

1.5 Analysis of Data

All records were in a tabular form in the excel data sheet and the data were analyzed.
Given that;

1. Abundance: $= \frac{ni}{N}$;
   Where ni = the number of individuals in the ith species,
   N = total number of individuals of species recorded during the study period.
2. Population density: = number of individuals/total area (km).

Bird diversity for each study site was calculated using Shannon Wiener diversity index (H) and Simpson indices (D) Shannon and Weaver, 1963, while the similarities in the five study sites were using Jaccard index (Cj) given that;

1. $H= -\sum [ni/N * \ln(ni/N)]$
2. $D=(\sum[ni*(ni-1)])/N(N-1)$
3. $Cj= (|X \cap Y|)/(|X \cup Y|)$

Where; ni= number of individuals in the i^{th}species, N = total number of individuals of species recorded during the study period, $X \cap Y$ = number of species in both site and $X \cup Y$ = total number of species in either site Kangah-Kesse *et al.,* 2005.

One – way analysis of variance (ANOVA) was used to test for differences between sites in species richness and diversity values Simon and Okoth, 2016.

1.6 Result

A total of 366 of bird individuals consisting of 59 species, 29 families were recorded during this study. Using the point count method 59 species was recorded, out of which 45 species were recorded by sighting and 14 species were recorded by vocalization Figure 2.

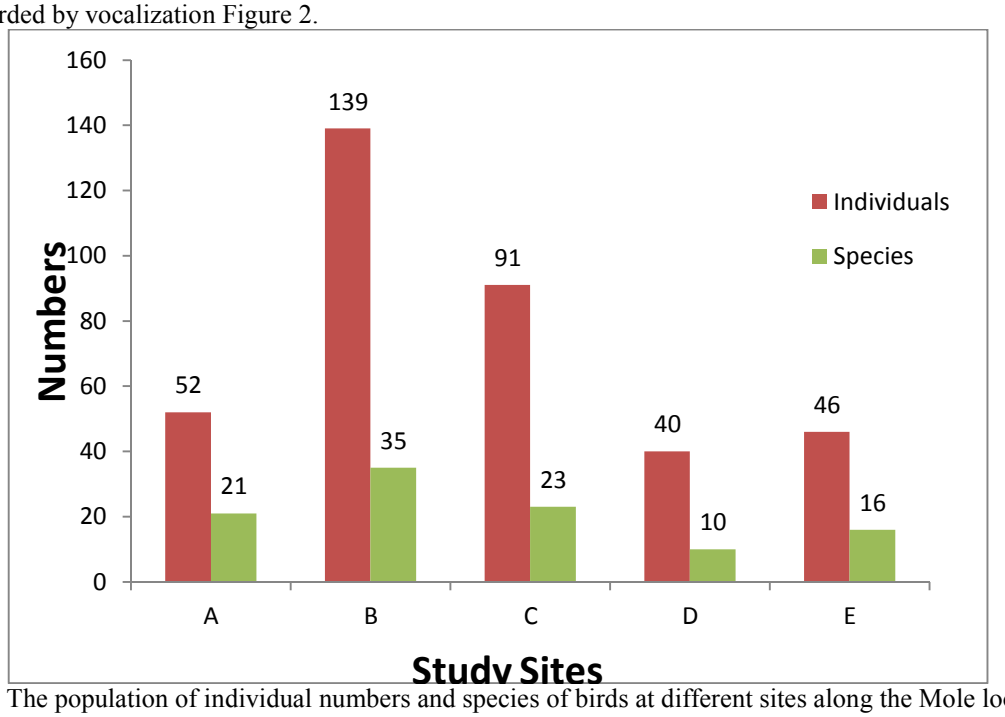

Figure 2: The population of individual numbers and species of birds at different sites along the Mole loop game viewing road in the Mole National Park.

Analysis of variance was conducted to evaluate the hypothesis that, the diversity, abundance and distribution of bird species does not depend on different vegetation type. At alpha level of 0.05, the differences

of means of all populations at, were significant at $p < 0.05$ ($F= 1.39$, DoF= 4, $P = 0.02$) (Table 1).

Table 1: Analysis of Variance (ANOVA) between sites

	Sum of Squares	DoF	Mean Square	F value	*P value*
Between groups	47.30	4	11.82	1.39	0.024
Within groups	844.55	99	8.53		
Total	891.85	103			

Table 2: Species composition of birds along the Mole loop game viewing road in the Mole National Park

Study Site	GPS Coordinates	Number of Individuals	Number of Species
A	Lat. 9.2462 Lon. -1.8555	52	21
B	Lat. 9.2548 Lon. -1.8624	139	35
C	Lat. 9.2681 Lon. -1.8650	91	22
D	Lat. 9.2800 Lon. -1.8641	40	10
E	Lat. 9.2807 Lon. -1.8500	46	16

Species composition was recorded according to the GPS locations along the game viewing loop as in Table 2. The relative abundance of birds' species was presented in a histogram in figure 3 below.

The most abundant species in the park was Helmeted Guineafowl (*Numida meleagris*) (Relative Dominance (RD)= 4.90%), followed by Red-throated Bee-eater (*Merops hirundineus*) (RD =4.63%), Red-billed fire finch (*Lagonosticta Senegala*) (RD =4.36%), Little Weaver (*Ploceus lucteolus*) (RD =4.09%), Senegal Parrot (*Piocephals senegalus*) (RD =3.81%), Bar-breasted fire finch (*Lagonosticta rufopicta*) (RD =3.54%), White faced Whistling Duck (*Dendrocygna viduata*) (RD =3.27%) and Laughing Dove (*Sterptopelia senegalensis*) (RD =3.00%). These species had relatively high abundant whereas, the Bateleur Eagle (*Terathopius ecaudatus*) (0.54), African Dwarf Kingfisher (*Ceyx lecontei*) (0.27) and Klaas's Cuckoo (*Chrysococcyx caprius*) (0.27) also had the lowest abundance.

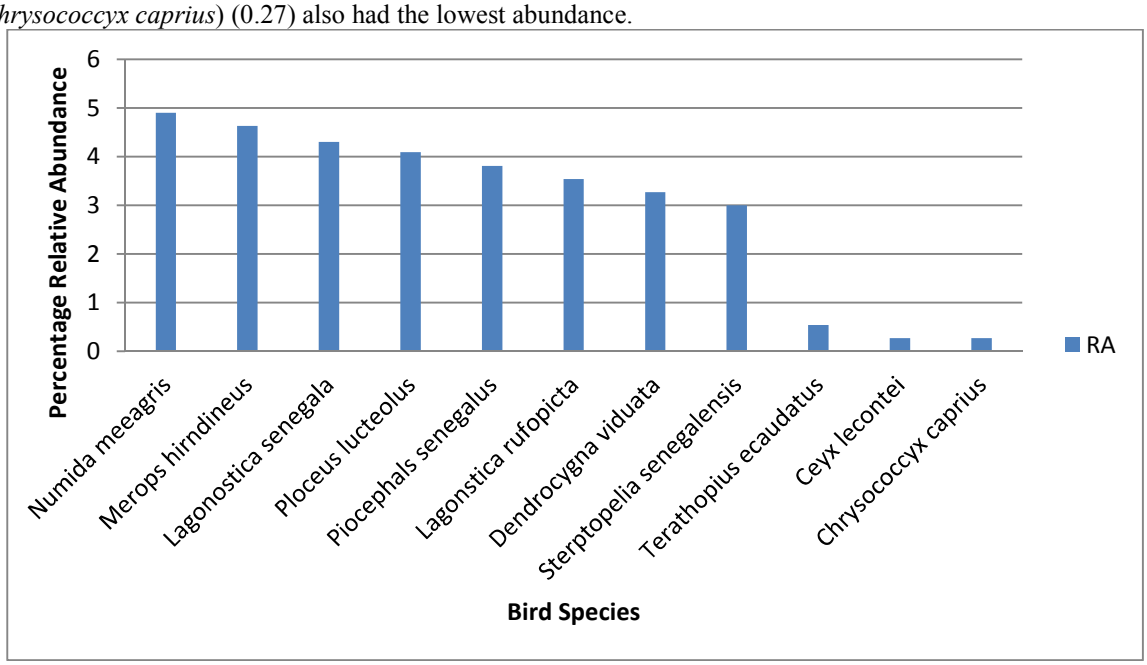

Figure 3: Percentage Relative abundance of birds

The Shannon diversity index of bird species survey in the study site A was 2.82 and evenness of 0.93 (3.26, 1.69 at 95% Confidence Limit (CL)); in the study site B the diversity was 3.39 and evenness of 0.95 (4.99, 2.95 at 95% CL); in the study site C the diversity was 2.79 and evenness of 0.90 (5.67, 2.60 at 95% CL); in the study site D the diversity was 1.89 and evenness of 0.82 (6.17, 1.83 at 95% CL) and in the study site E the diversity was 2.57 and evenness of 0.93 (3.87, 1.88 at 95% CL) (Figure 3). The reverse Simpson index (i.e. 1-D)

yielded values of 0.95, 0.96, 0.93, 0.85 and 0.93 for the study site; 'A', 'B', 'C', 'D' and 'E' respectively, suggesting that the study site 'B' had the highest bird species diversity and the study site 'C' and 'E' had the same species diversity Table 3.

Table 3: Diversity and evenness of bird species at 95% Confident Level

Study Site	H	D	1 - D	E_H	CL	UL	LL
A	2.82	0.05	0.95	0.93	0.78	3.26	1.69
B	3.39	0.04	0.96	0.95	1.02	4.99	2.95
C	2.79	0.07	0.93	0.90	1.53	5.67	2.60
D	1.89	0.15	0.85	0.82	2.17	6.17	1.83
E	2.57	0.07	0.93	0.93	0.99	3.87	1.88

Legend

H – Shannon Wiener Biodiversity Index, D – Simpson Biodiversity Index, 1-D – Reverse Simpson Biodiversity Index, E_H – Shannon Species Evenness, CL – Confidence limit, UL – Upper Limit and LL – Lower Limit.

Jaccard index of similarity of bird species was calculated to support the hypotheses that there was similarity between the study sites, similarity between sites A, B was 0.27, similarity between site B, and C yielded a value of 0.19. Site D and E had a similarity of 0.15, the results show that the similarities between the study site was relatively low ('1' complete similarity; '0' complete dissimilarity).

Both Estrildidae and Alcedinidae family had the highest species abundance, comprising 8.5% of the total species respectively, followed in order by Columbidae and Malaconotidae with the same family composition of 6.8%, Ploceidae (5.1%).

1.7 Discussion

A total of 366 of bird individuals consisting of 59 species in 29 families were recorded during this study. This indicates that the Mole loop game viewing road attracts diverse numbers of bird species for conservation. According to Bibby *et al*., 2000 bird's conspicuousness can vary with observer, weather, and time of the day.

In the Mole loop game viewing road, 93.22% of the species encountered were identified as savanna generals Kangah-Kesse, 2006, within the savanna general; 62.71% constitute pure savanna inhabitants and 30.51 encountered were savanna woodland inhabitants, whilst 6.77% of species encountered identified as forest inhabitants Grimes 1987. Most of the species encountered were residence and common within the study site, according to Dowsett-Lemaire & Dowsett, 2008, the near-lack of data for the season and the short duration of most visits mean that the status of many migrants and the duration of their stay remain incompletely documented.

The avifauna is typically Sudanian, and 36 of the 37 species considered endemic to the Sudanian (Sudan-Guinea) biome that occur generally in Ghana Fishpool and Evans, 2001 are represented in Mole National Park. It was observed that during the latter part of the dry season in March Dowsett-Lemaire and Dowsett 2008, shrub land and the riverine forest with the study site 'B' had the highest density of birds. This could be associated with greater openness in the habitat which supports shrubs that provides food and cover for different bird species Askin *et al.,* 2012; Shochast *et al.,* 2010.

The present study of bird diversity in the 'Samole loop game viewing road' indicates that the bird species by varieties are very high as compared to other Game Viewing Loop in the park in numbers, since birds are highly diverse and conspicuous species of the ecosystem and birds as sentinel to environmental stresses Newton, 1995; Navarro and Benítez, 1995; Blair, 1999; Hobson and Rempel, 2001; Turner, 2002.

Dowsett-Lemaire & Dowsett, 2008, explained in his discussion that the presence of some species within the study site was subjected to habitat changes. As poaching has been increasing over the years, large mammals were forced to concentrate in the better-protected area in the vicinity of the motel and park headquarters. Over-grazing was noticeable in the rains of 2004, both in the marsh and surrounding woodland, up to only 1 km north of the motel.

The species diversity index and evenness of habitats during the entire period revealed that the study site 'B' had the highest diversity and abundance of bird species as a result of the inaccessibility of people and large mammals, as compared to other study sites. Factors that promoted the high diversity include a wide variety of resources, high productivity and moderate levels of predation Miller, 2002.

The study site 'C' had a species richness of 91 individuals, Shannon's diversity index (H) of 2.79 and evenness of 0.90 (5.67, 2.60 at 95% CL), whilst the study site 'E' had a species richness of 46 individuals, Shannon's diversity index of 2.57 and evenness of 0.93 (3.87, 1.88 at 95% CL) means they different species richness and different diversity indices according to Shannon's.

Further analysis made by using reverse Simpson's index (1-D) proved statistically, that both site 'C' and 'E' had the same bird species diversity of 0.93 the findings were further supported by Tramer, 1967 that in a given community, bird diversity can be adequately described by merely counting the number of species present; i.e., their relative abundances can be disregarded. Therefore, we can conclude that the factors that regulate bird

species diversity do so by determining the number of species that can coexist in a given habitat. The result is that in most avian communities, the available species partition the breeding space in a characteristic way, and a series of samples from the same or from different localities will yield similar distributions of species diversity.

The distribution and abundance of many bird species are determined by the composition of the vegetation that forms a major element of their habitats. Bird species abundance depended significantly on vegetation characteristics, indicating that areas with high plant resources supported more birds. Thus, the relatively low abundance of birds in the highly disturbed sites to the other sites may be due to fewer resources provided by this vegetation type in within the sites. As vegetation changes along complex geographical and environmental gradients, a particular bird species may appear, increase or decrease in number and disappear as the habitat changes Lee and Rotenberry, 2005.

The most abundant species in the park was Helmeted Guineafowl, *Numida meleagris*, (Relative Abundance (RA)= 4.90%), followed by Red-throated Bee-eater, *Merops hirundineus*, (RA =4.63%), Red-billed fire finch, *Lagonosticta senegala*, (RA =4.36%), Little Weaver (*Ploceus lucteolus*) (RA =4.09%),Senegal Parrot, *Piocephals senegalus*, (RA =3.81%), Bar-breasted fire finch, *Lagonosticta rufopicta*, (RA=3.54%), White faced Whistling Duck, *Dendrocygna viduata*, (RA =3.27%) and Laughing Dove, *Sterptopelia senegalensis*, (RA =3.00%). These species had relatively high abundant whereas, the Bateleur Eagle, *Terathopius ecaudatus*, (RA=0.54), African Dwarf Kingfisher, *Ceyx lecontei*, (RA=0.27).

The result indicates that most of the species from the family Estrildidae consisting of '*Lagonosticta rufopicta* Bar-breasted fire finch; *Uraeginthus bengalus* Red-check Cordon-bleu; *Estrilda melpoda* Orange-checked Waxbill; *Estrilda troglodytes* Black-rumped Waxbill and the family Ploceidae consisting of '*Ploceus lucteolus, Ploceus cucullastus and Plocepasser superciliosus,* were mostly dominant around study site 'C' with which the mole marsh is located. Dowsett-Lemaire and Dowsett (2008), also be attributed to the appearance of these species to the

presence of shorter grasses at the site and further explained that poaching has been increasing over the years, large mammals were forced to concentrate in the better-protected area in the vicinity of the motel and park Headquarters where over-grazing was highly notice both in the and the woodland causing habitat changes in area.

There were three (Hooded Vulture, Bateleur Eagle and African Dwarf Kingfisher) globally threatening birds recorded during the survey (Birdlife International, 2017). *Ceyx lecontei* African Dwarf Kingfisher, Cruse, (2002) recorded this rain forest species in Mole National Park and was later withdrawn by Cruse 2003 (Dowsett-Lemaire and Dowsett, 2008). During the survey the African Dwarf Kingfisher were encountered at study site 'E' which possess some riparian forest and small waterholes. These findings are consistent with the previous work of Kangah-Kesse *et al.,* 2005 who stated that, since the habitat choice of birds is highly specific and driven by plant communities, the presence of savanna species in the forest area suggest the trans-formation of forest vegetation into savanna.

1.8 Conclusion and Recommendations

The study established that the Mole loop game viewing road harbors a sizable number of bird species from forest and other vegetation zones such as thickets and savanna as primarily vegetation. Birds are well known indicator taxon due to their sensitivity to environmental perturbations, relevant to ecosystem functioning (e.g. pollination and seed dispersal) and relative ease in sampling. Consequently, bird diversity and abundance differed significantly among the vegetation types, and depended significantly on plant community diversity and structure of the vegetation.

The result indicates that the site with less human disturbance and other large mammal's interference had high species richness, diversity, composition, abundance and distribution and support many rare bird species, as compared to other sites, which are exposed to more Human-induced disturbance, deforestation and over-grazing by large mammals.

There was a positive relationship between the number of birds and the habitat types and the available within that habitat, i.e. as habitat type approaches the nature of forest, the bird numbers also increase. Therefore, disturbance from human and large mammals have negative effects on the diversity and distribution of avifauna.

Since avifauna species are organism without boundary, it is recommended that the practice of bird watching as a source of avifauna conservation should be encouraged in the fringe communities such as; Morgnori, Larabanga and Murugu, which would protect these bird species and improve community livelihood.

Further studies should be done within the fringe communities to compare avifauna survey, within off reserve and protected areas (on reserve)

To reduce the level of disturbance by tourist along the 'Samole Game Viewing' Loop the management of Mole National Park can build a game viewing post for tourists (bird watchers) along the loop.

Further studies can be done by comparing the population of Bird species both in the dry season and the raining season, to identify the appropriate season for bird watching and bird watchers.

Acknowledgement
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Appendix 1: Species composition, abundance and density of birds along the Mole loop game viewing road in the Mole National Park.

Family	Common Name	Species	Number of Individual (ni)	Dominance	Density
Numididae	Helmeted Guineafowl	*Numida meleagris*	18	4.90	2.00
Meropidae	Red-throated Bee-eater	*Merops hirundineus*	17	4.63	1.89
Estrildidae	Red-billed firefinch	*Lagonosticta senegala*	16	4.36	1.78
Ploceidae	Little Weaver	*Ploceus lucteolus*	15	4.09	1.67
Psittacidae	Senegal Parrot	*Piocephals senegalus*	14	3.81	1.56
Estrildidae	Bare-breasted firefinch	*Lagonosticta rufopicta*	13	3.54	1.44
Anatidae	White faced Whistling Duck	*Dendrocygna viduata*	12	3.27	1.33
Ploceidae	Village Weaver	*Ploceus cucullastus*	11	3.00	1.22
Columbidae	Laughing Dove	*Sterptopelia senegalensis*	11	3.00	1.22
Estrildidae	Red-check Cordon-bleu	*Uraeginthus bengalus*	10	2.72	1.11
Columbidae	Vinaceous Dove	*Streptopelia vinacea*	9	2.45	1.00
Ardeidae	Cattle Egret	*Bubulcus ibis*	9	2.45	1.00
Phasianidae	Double-spurred Francolin	*Francolinus bicalcaratus*	8	2.18	0.89
Nectariniidae	Scarley-chested sunbird	*Chalcomitra senegalensis*	8	2.18	0.89
Hirundinidae	Wire-tailed Swallow	*Hirundo smithii*	8	2.18	0.89
Columbidae	Black-bill Wood Dove	*Turtur abyssinicus*	8	2.18	0.89
Passeridae	Grey headed Sparrow	*Passer griseus*	8	2.18	0.89
Bucerotidae	African Grey Hornbill	*Tockus nasutus*	7	1.91	0.78
Alcedinidae	Blue-breasted Kingfisher	*Halcyon malimbica*	7	1.91	0.78
Accipitridae	Hooded Vulture	*Necrosytres monachus*	7	1.91	0.78
Ploceidae	Chestnut-crown Sparrow Weaver	*Plocepasser superciliosus*	7	1.91	0.78
Malaconotidae	Northern Puffback	*Dryoscopus gambensis*	7	1.91	0.78
Alcedinidae	Grey Headed kingfisher	*Halcyon leucocephala*	7	1.91	0.78
Nectariniidae	Beautiful Sunbird	*Cinnyris pulchellus*	7	1.91	0.78
Timaliidae	Brown babbler	*Turdoides plebejus*	7	1.91	0.78
Estrildidae	Black-rumped Waxbill	*Estrilda troglodytes*	7	1.91	0.78
Sylviidae	Senegal Eremomela	*Eremomela pusilla*	6	1.63	0.67
Pycnonotidae	Common Garden Bulbul	*Pycnonotus barbatus*	6	1.63	0.67
Coraciidae	Broad-billed Roller	*Eurystomus glgucurus*	6	1.63	0.67
Estrildidae	Orange-checked Waxbill	*Estrilda melpoda*	6	1.63	0.67
Threskiornithidae	Hadada Ibis	*Bostrychia hagedash*	5	1.36	0.56
Muscicapidae	Northern Black flycatcher	*Melaenornis annamarulae*	5	1.36	0.56
Fringillidae	Yellow fronted canary	*Serinus mozambicus*	5	1.36	0.56
Charadriidae	African Wattle Lapwing	*Vanellus senegalus*	5	1.36	0.56
Musophagidae	Western Grey Plantain-eater	*Crinifer piscator*	4	1.09	0.44
Turdidae	African Thrush	*Turdus pelios*	4	1.09	0.44
Coraciidae	Blue-billed Roller	*Coracias abyssinicus*	4	1.09	0.44
Phasianidae	Stone Patridge	*Ptilopachus petrosus*	4	1.09	0.44

Family	Common Name	Species	Number of Individual (ni)	Dominance	Density
Malaconotidae	Yellow Crown Gonolek	*Laniarius barbarous*	4	1.09	0.44
Columbidae	Bruce's Green Pigeon	*Treron waalia*	4	1.09	0.44
Alcedinidae	African Pygmy kingfisher		3	0.82	0.33
Monarchidae	Africa Paradise flycatcher	*Terpsiphone viridis*	3	0.82	0.33
Platysteiridae	Senegal Batis	*Batis senegalensis*	3	0.82	0.33
Scopidae	Hamerkop	*Scopus umbretta*	3	0.82	0.33
Muscicapidae	Snowy-crowned Robin Chat	*Cossypha albicapilla*	3	0.82	0.33
Bucerotidae	Northern Red-billed Hornbill	*Tockus erythrorhynchus*	3	0.82	0.33
Ardeidae	Grey Heron	*Ardea cinerea*	2	0.54	0.22
Passeridae	Bush Petronia	*Petronia dentate*	2	0.54	0.22
Indicatoridae	Greater Honey Guide	*Indicator*	2	0.54	0.22
Malaconotidae	Black-crown Tchagra	*Tchagra senegalus*	2	0.54	0.22
Phoeniculidae	Green wood hoopoe	*Phoemicuslus purpureus*	2	0.54	0.22
Alcedinidae	Malackite Kingfisher	*Alcedo cristata*	2	0.54	0.22
Cisticolidae	Oriole Warbler	*Hypergerus atriceps*	2	0.54	0.22
Accipitridae	Bateleur Eagle	*Terathopius ecaudatus*	2	0.54	0.22
Cuculidae	Senegal Coucal	*Centropus senegalensis*	2	0.54	0.22
Sylviidae	Tawny-flanked Prinia	*Prinia subflava*	2	0.54	0.22
Alcedinidae	African Dwarf Kingfisher	*Ceyx lecontei*	1	0.27	0.11
Malaconotidae	Grey-headed bush shrike	*Malaconotus blanchoti*	1	0.27	0.11
Cuculidae	Klaas's Cuckoo	*Chrysococcyx caprius*	1	0.27	0.11
	Total Count		59		
	Total		367		

Appendix 2: Checklist of bird species with their status and habitat at the Mole loop game viewing road in Mole National Park

Family/ Species	Common Name	Site	Habitat	Status
		A B C D E		
Estrildidae				
Lagonosticta rufopicta	Bar-breasted firefinch	- 7 6 - -	S	c
Lagonosticta senegala	Red-billed firefinch	- 16 - - -	S	c
Uraeginthus bengalus	Red-check Cordon-bleu	- 10 - - -	S	c
Estrilda melpoda	Orange-checked Waxbill	- - 6 - -	S	c
Estrilda troglodytes	Black-rumped Waxbill	- - 7 - -	S	u
Total species =5 (8.5%)				
Alcedinidae				
Ceyx pictus	African Pygmy kingfisher	1 2 - - -	FC	f
Halcyon malimbica	Blue-breasted Kingfisher	1 3 - - 3	S	c
Halcyon leucocephala	Grey headed kingfisher	- - 3 2 2	S	c
Ceyx lecontei	African Dwarf Kingfisher	- - - - 1	F	r/s
Alcedo cristata	Malachite Kingfisher	- 2 - - -	S	c
Total species =5 (8.5%)				
Malaconotidae				
Laniarius barbarous	Yellow-crowned Gonolek	1 1 1 - 1	S	c
Tchagra senegalus	Black-crown Tchagra	- - - - 1	S	c
Dryoscopus gambensis	Northern Puffback	2 3 - 2 -	S	c
Malaconotus blanchoti	Grey-headed Bush Shrike	- - - - 1	SW	c
Total species =4 (6.8%)				
Columbidae				
Turtur abyssinicus	Black-bill Wood Dove	3 5 - - -	SW	c
Streptopelia vinacea	Vinaceous Dove	- 6 3 - -	S	c
Treron waalia	Bruce's Green Pigeon	- 2 2 - -	SW	c
Sterptopelia senegalensis	Laughing Dove	2 3 2 2 2	SW	c
Total species =4 (6.8%)				
Ploceidae				
Ploceus lucteolus	Little Weaver	- - 15 - -	SW	f/c
Ploceus cucullastus	Village Weaver	- - 11 - -	S	c

Plocepasser superciliosus	Chestnut Crown	-	7	-	-	-	S	u/f				
Total species =3 (5.1%)	Sparrow Weaver											
Sylviidae												
Prinia subflava	Tawny-flanked Prinia	-	-	-	2	-	S	c				
Eremomela pusilla	Senegal Eremomela	2	2	2	-	-	S	c				
Total species =2 (3.4%)												
Cuculidae												
Centropus senegalensis	Senegal coucal	-	2	-	-	-	S	c				
Chrysococcyx caprius	Klaas's Cuckoo	1	-	-	-	-	F	f				
Total species =2 (3.4%)												
Nectariniidae												
Cinnyris pulchellus	Beautiful sunbird	-	-	-	-	7	SW	c				
Chalcomitra senegalensis	Scarley-chested	2	4	2	-	-	S	c				
Total species =2 (3.4%)	Sunbird											
Accipitridae												
Necrosytres monachus	Hooded Vulture	-	4	3	-	-	S/F	c				
Terathopius ecaudatus	Bateleur Eagle	-	2	-	-	-	S	u/f				
Total species =2 (3.4%)												
Phasianidae												
Francolinus bicalcaratus	Double-spurred Francolin	3	5	-	-	-	SW	c				
Ptilopachus petrosus	Stone Patridge	4	-	-	-	-	S	f				
Coraciidae												
Coracias abyssinicus	Blue-billed Roller	-	2	2	-	-	SW	u/f				
Eurystomus glgucurus	Broad-billed Roller	-	1	1	2	2	S	c				
Ardeidae												
Ardea cinerea	Grey Heron	-	2	-	-	-	S	f/c				
Bubulcus ibis	Cattle Egret	-	-	-	9	-	S	c				
Muscicapidae												
Melaenornis annamarulae	Northern Black Flycatcher	-	3	-	2	-	S	f				
Cossypha albicapilla	Snowy-crowned Robin Chat	1	2	-	-	-	S	f/c				
Passeridae												
Petronia dentate	Bush Petronia	-	-	2	-	-	S	f/c				
Passer griseus	Grey Headed Sparrow	-	8	-	-	-	S	c				
Bucerotidae												
Tockus nasutus	African Grey Hornbill	2	1	2	1	1	SW	c				
Tockus erythrorhynchus	Northern Red-billed Hornbill	1	-	2	-	-	SW	u/f				
Musophagidae												
Crinifer piscator	Western Grey Plantain-eater	-	4	-	-	-	SW	c				
Total species =1 (1.7%)												
Pycnonotidae												
Pycnonotus barbatus	Common Garden bulbul	6	-	-	-	-	S	c				
Hirundinidae												
Hirundo smithii	Wire-tailed swallow	4	4	-	-	-	S	u/f				
Indicatoridae												
Indicator indicator	Greater Honey Guide	-	-	2	-	-	SW	u/f				
Numididae												
Numida meleagris	Helmeted Guineafowl	8	-	-	10	-	S	c				
Phoeniculidae												
Phoemicuslus purpureus	Green Wood Hoopoe	-	1	2	-	-	SW	c				
Fringillidae												
Serinus mozambicus	Yellow-fronted Canary	1	4	-	-	-	SW	c				
Timaliidae												
Turdoides plebejus	Brown Babblers	-	-	-	-	7	SW	f				
Charadriidae												

Vanellus senegalus	African Wattle Lapwing				1	4	- - -	S	f
Threskiornithidae									
Bostrychia hagedash	Hadda Ibis				3	-	2 - -	S	f
Scopidae									
Scopus umbretta	Hamerkop				-	-	- - 3	S	f
Platysteiridae									
Batis senegalensis	Senegal Batis				-	-	- - 3	S	f
Turdidae									
Turdus pelios	African Thrush		-	4	- - -			SW	c/f
Anatidae									
Dendrocygna viduata	White faced Whistling Duck	-	-	4	8	-		S	f
Cisticolidae									
Hypergerus atriceps	Oriole Warbler	-	2	-	-	-		SW	u
Meropidae									
Merops hirundineus	Red-throated Bee-eater	-	11	6	-	-		S	c
Monarchidae									
Terpsiphone viridis	Africa Paradise flycatcher	-	3	-	-	-		SW	c
Psittacidae									
Piocephals senegalus	Senegal Parrot	3	7	4	-	-		SW	c
Total		52	139	91	40	46			

Legend: Habitat: S – Savanna, SW – Savanna Woodland, F – Forest, FC – Forest Clearings and CS – Coastal Savanna
Status: c – common, f – fairly common, u – uncommon, s – scarce and r – rare.