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Research Article

Summer Season Waterfowl Species Diversity at Katavi National Park in Tanzania

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ABSTRACT

This study on Waterfowl species diversity, richness and evenness was conducted at Katavi National park in Tanzania in summer season of 2011.The study focused at surveying on how water availability, primary productivity and vegetation cover affect the diversity of Waterfowl in Lake Chada and Katavi. Point count technique was used to count Waterfowl from seven stations established around the perimeter of each Lake. Data revealed that the correlation coefficients (r) for water availability were 0.4019 and 0.3122; a value for primary productivity was 0.3437 and 0.7537 and for the vegetation cover were 0.3437 and 0.04968 for the respective Chada and Katavi Lakes. Species richness accounted for 2.6634 and 4.7079 for Lake Chada and Katavi respectively. For the case of Species evenness (e) the value for Lake Chada was 0.5770 while Lake Katavi had 0.6260. The study found also that, there was a difference in waterfowl species diversity, richness and evenness between the two surveyed Lakes.It implies that both biotic and abiotic factors affect species diversity differently at different spatial heterogeneity. Lake Katavi has higher species richness and evenness compared to Lake Chada. The study concludes that variation in ecological factors affects the distribution and abundance of Waterfowl species during summer season at the park.

KEY WORDS
Biotic factors, Species diversity, Species richness, Waterfowl and Wetlands

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INTRODUCTION

The term Waterfowl has been used to describe certain wild fowls of the order Anseriformes, especially members of the family Anatidae, which include ducks, geese and swans (Mullen, 1998). Generally, fowls refer to birds used by humans, although there are definitions of the term "waterfowl" that include salt water shore birds or waders, gulls, pelicans and herons, as well as seabirds such as the albatrois and penguin (Mullen, 1998). Traditionally they have been a good source of meat and thus continue to be hunted as game, or raised as poultry for meat and eggs. This study investigated how biotic and abiotic

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factors during summer season affected waterfowl species diversity at Katavi National Park. Understanding waterfowl species diversity during summer seasons could aid in improving targeted and purposive tourism to avoid waste of resources by the national park tourists during summer season.

Waterfowl birds are characterized by having webbed feet; this is the common characteristic of swimming birds. The web stretches between the three front toes as in the gulls, ducks, and geese but sometimes include the hind-toe as in cormorants (Dorst, 1974). Most wetland birds have long legs together with long feet. Having longer legs and feet helps them to walk efficiently and effectively in wetland areas during search of food as well as escaping predators. For example African Jacana has long legs and feet, which prevents them from sinking when walking in wet areas (Welty & Baptista, 1988). The bodies of diving birds are more cylindrical and longer than those birds that mainly fly. Their feet are often placed far back on their bodies, where they are more effective for propulsion and easy maneuvering as seen in divers (Dorst, 1974).

The bill of birds is normally hard and thick, especially at the tip. Wetland birds have evolved a great variety of beaks adapted for their varied food habits. For example, in ducks the beak is hard only at its tip and its sides are relatively soft and blunt (Welty and Baptista, 1988). The sides of the beak are supplied with nerve endings that aid the bird in detecting seeds and insects in muddy water (Welty & Baptista 1988). Waterfowl are equipped with a defined foraging strategy that allow individuals to capture and process large quantities of prey in a single mouthful, allowing them to acquire energy at high rates when small prey are aggregated (*ibid*). Small food particles are filtered from the surrounding water. This food intake is aided by a siphon mechanism whereby a stream of water carrying particles of food is drawn into the mouth like a pipe tube. Mucus traps food particles. The rhythmic movement of cilia transports the water current with food particles towards the mouth-feeding current.

Habitat

Waterfowl, as their name implies, are most often found near water. They can, however, fly long distances to and from favorite feeding grounds, which may include agricultural or upland sites (Cleary, 1994). Most Waterfowl occupy wetland habitats. Wetland can be defined as areas of marsh, fern, peat land or water, whether natural or artificial, permanent or temporary with water that is static or flowing fresh or salty including areas of marine water, the depth of which does not exceed six meters (RAMASAR, 1975). A wetland could also be defined as an area of land consisting of soil that is saturated with moisture, such as a swamp, marsh or bog (Mullen, 1998). As defined in terms of physical geography, a wetland is an environment at the interface between truly terrestrial ecosystems and aquatic systems.

Wetlands are a significant factor in the health and existence of other natural resources of the environment. It is a habitat that provides breeding, nesting and feeding grounds and cover to many forms of wildlife, waterfowl, including migratory waterfowl and rare, threatened or endangered wildlife species (Akbar *et al.,* 2009). Wetland birds such as Greater flamingo (*Phoenicopterus rubber)*, Lesser flamingo (*Phoeniconaias minor*), African jacana (*Actophilornis africanus*), African fish eagle (*Haliaeetus vocifer*), African darter (*Anhinga rufa*), African skimmer (*Rynchops flavirostris*), African spoonbill (*Platalea alba*), Yellow-billed stork (*Mycteria ibis*), Hammerkop (*Scopus umbretta*), Little egret (*Egretta garzetta*), Cattle egret (*Bubulcus ibis*), Hadada ibis (*Bostrychia hagadash*), Glossy ibis *(Plegadis falcinellus*), Sacred ibis *(Threskiornis aethiopicus),* Black-headed heron *(Ardea melanocephala*), Great white pelican (*Pelecanus onocrotalus*) and Egyptian goose (*Alopochen aegyptiacus*) provide us with some of nature's most wonderful sights, from vast flocks wheeling overhead to newly hatched chicks drying in the sun (Weller, 1999).

Past Study on waterfowl

Past studies on waterfowl species diversity have been made through various methods at different time and places. For example, Faanes (1982) conducted a study on avian by investigating different habitats in the

Sheyenne Lake region of Central North Dakota. The study found an unusual diversity of birds for the relatively small size of the area. From this study it is concluded that population means for most species were greater than statewide/country means because of environmental heterogeneity. Geer (1982) conducted another study on urban population of ducks in Puyallup Washington, USA. Population means for most species were greater than the state wide means. Redwinged black bird (*Angelaious phoeniceus*), Yellow- headed black bird (*Xanthocephelus xanthocephelus)* Morning dove (*Zenoida macroura*) and Blue- winged teal *(Anas discors)* were the most numerous species and made up 32.9% of the total population.

Studies show that there is variation of bird densities in various sites or study points, e.g Craig & Barclay 1992 in USA, 2002) reported highest densities of breeding birds that occurred in shelter belts, semi permanent wetland and prairie thickets. Lowest densities occurred in upland native prairie and crop land. In Tanzania, specifically at Katavi National Park little is known about summer season waterfowl diversity. This study aimed at investigating the distribution and abundance of waterfowl diversity to contribute to minimize the missing information. These findings are useful in designing purposive tourism plants at Katavi National Park

Factors Affecting Waterfowl's Diversity

Both abiotic and biotic factors affect Waterfowl species diversity in any given area. These factors determine the quality and of a habitat, which in turn impacts the numerous species living within and depending on this habitat (Gopal, *et al*., 2001).Factors which affects diversity in wetlands include seasonality, quality of habitat, water availability, primary productivity, temperature and rainfall.

Seasonality

Diversity varies over the course of a year because species prefer different months for feeding and breeding (Rosenzweig, 1995). Attuning to species' seasonal behavior is essential for effective tourism in order for park managers to leverage the peak season for viewing and observation. Failing to do so could result in tourists having the experience of visiting during a season of that birds have migrated out of the park. This has several negative consequences. One consequence may be the negative experience for tourists, which may damage the reputation of the park and decrease revenue, and result in inadequate funding to support the health and maintenance of the park. In addition, the waste of time and resources could reflect poorly on park management as well as the park personnel's lack of professional knowledge of the inhabiting species. Therefore, a critical component of sustaining a healthy and vibrant park ecosystem primed for purposive tourism as data gathered in this study will function as base for sustainable tourism business in the park.

Quality of habitat

The number of bird species in a wetland is correlated to nature of vegetation types. The diversity of physical structure has both a vertical and horizontal components. In respect to vertical component, birds' diversity often increases with the complexity of plant structure (Arthur 1961 & Huston 1964 in Keddy, 2000). In general, this means that forested wetlands will have higher bird diversity than herbaceous wetlands. The horizontal component of structural diversity refers to the patchiness of habitat. Wetlands with patches of vegetation interspersed with patches of open water are considered most desirable for waterfowl (Keddy, 2000), Lake Katavi and Chada are characterized by having interspersed vegetations and this affects the distribution of birds differently this study it was also possible to quantify these

Water availability

The dynamics of water over time, whether seasonal, annual or longer term, dictates the chemical and physical character of wetland water, resulting vegetation, and use of wetlands by birds and other aquatic or semi aquatic life (Frederick *et al*., 2006). Water is the major factor influencing the variability of wetland habitat, which often changes from season to season or even from year to year. Rapid changes in water levels have direct impact on nesting birds. For example, rising water levels may flood out nests while receding water levels may dry protective water moats so that nests are exposed to predation (*ibid*). Species seems always to be searching for sites with higher food density and with assured safety from predators in a given habitat (Weller, 1999). Changes in water regimes are very likely to dramatically alter the quantity and quality of aquatic and riparian habitat, leading to local changes in the distribution of birds and mammals, and at larger scales, are likely to affect overall habitat availability, carrying capacity, and reproductive success (Frederick *et al*., 2006). In order to breed and nest successfully, aquatic mammals and waterfowl depend on the availability and quality of aquatic habitats. (*ibid*)

Primary productivity

Food needs for Waterfowl differ greatly with stages of life cycle, making generalization difficult. Their diets may differ by season and according to their stage of life. Except for those birds specialized as herbivores, most omnivores need higher animal protein during egg development, growth of young, and molting. These birds move, seek, and vary in food choices to meet these needs. Getting food of the correct type at the right time is one issue, but some birds are not effective until they have proper feeding conditions that are right foods and stage of life in a complex setup Mullen, 1998).

Temperature

Waterfowl are birds capable to regulate body temperature to respond to changes on habitats' temperature regimes as brought by stress and wind. As a matter of adaptation, their high body temperature and thermo regulation may seem of less importance to birds than to other animals. There is strong evidence that in addition to migrate to warmer regions during cold periods, they select micro habitats to reduce chilling winds or other stressful situation (Burger *et al.,* 1984 in Weller, 1999). Based on this behavioral response this study was conducted to find out how waterfowl responds to temperature changes at Katavi national Park.

Rainfall

Hydrology also has a major impact upon birds. Water levels naturally rise and fall in coastal salt marshes exposed to tidal influences. It is possible to both raise water level and reduce salinity, with water control structure such as stop ditches and impoundments (Burger *et al.,* 1982 as cited by Keddy, 2000). The dynamics of water overtime, whether seasonal, annual, or longer term, dictates the chemical and physical character of wetland water which in turn affect wetland vegetation, the nature of birds distribution and other aquatic or semi aquatic life (Weller, 1999).

Biotic Factors and Waterfowl Diversity

Competition, predation, human activities and vegetations are the primary biotic factors affecting the distribution and abundance of Waterfowl at the Katavi National Park.

Competition

Competition occurs when a number of organisms of the same or different species utilize common resources that are in short supply (exploitative competition); if the resources are not in short supply, competition occur when the organisms seeking that the resources harm one another in the process, this is interference competition (Sinclair, *et al.,*2006). The former, is the most common among higher vertebrates including Waterfowl. This kind of competition limits a competitor's access to a resource or requirement for survival, such as territory and nesting in the case of birds (*ibid*).

Predation

Predation can be defined as occurring when individuals eat all or part of other live individuals (Sinclair *et al*., 2006).It is a process by which one population benefits at the expense of the other. Natural selection acting on the predator population tends to increase the predator's efficiency at finding, capturing and eating its prey, meanwhile members of the prey population that are better at escaping predators will normally be at a selective advantage within the prey population. It has been argued that without the presence of predators a prey population would increase up to the carrying capacity of the area (Krebs & Davies, 1987). Predation is a natural component of waterfowl population biology. Ecosystem or environmental alterations have changed the magnitude and importance of predation on waterfowl especially in breeding areas (Sovada, 2001)

Human activities

As human populations increase there is more demand of land for settlement, agriculture and grazing. In addition, there is a high demand of forest products and other services. Efforts taken towards social and economical development also greatly impact the conservation of species diversity. Agricultural development, logging, mining, pollutions, illegal hunting, illegal fishing, construction of roads and construction of high electric power lines in protected areas are among the activities that lead to habitat loss and fragmentation, eventually causing species diversity loss. Studies of several species of waterfowl identified human disturbances as the cause of desertions or abandonments of nests, especially during early incubation. In one study conducted in Iowa, Korschagen & Dahlgren (1992) states that observers caused a 10% nest abandonment rate by mallards. This study also found that frequent visitations to goose nests by biologists caused nest desertion rates as high as 40%. In addition to research on how human interactions that are linked to scientific study impact waterfowl, these scholars investigated the significant impact of human presence for leisure activities on Canadian geese. Canada geese nesting in southeastern Missouri were very sensitive to persons fishing in their nesting areas. Establishing areas close to fishing during the nesting period decreased nest desertions in the Missouri (Korschagen & Dahlgren, 1992). These impacts of human disturbance are probably found in Katavi National Park hence contributing to disturbing waterfowl.

Vegetation

It has been shown that the bird diversity increases as the vertical complexity of vegetation increases from grassland to forest. This vertical structure, or stratification, seems to be more important to bird's diversity. These data are in line with those of reported by Lameed, 2011 that habitats are created by plant communities and there is a significant relationship between vegetation densities and bird species diversity. As tree density increases, diversity of bird species decreases (*ibid).* This study aimed at identifying waterfowl species diversity, it has no detailed coverage on the diversity of plants in relationships with waterfowl diversity.

METHODOLOGY

Study area description

Katavi National Park (Figure 1) lies at the core of a sprawling complex of protected and semi protected areas in Western Tanzania, including Mahale National Park in the West and Ruaha National Park in the South-East. The park shares boundary and ecosystem with the Rukwa Game Reserve. It is situated about 40km South-East of Mpanda town. It covers an area of 4471 km². Katavi National Park is located between 6˚ 40’ and 7˚05' latitudes South and between 30˚50' and 31˚ 30’ longitudes East.

Climatic condition

Rainfall in the areas follows a bimodal yearly pattern with peaks in November/December and again in March. Rainfall varies over the Rukwa Region with the Rukwa Rift Valley floor receiving between 800 and 900mm per annum. Rainfall on the higher ground increases with much of the Par and game reserve receiving between 900 and 1,000mm per annum. Analysis of long-term rainfall data from a variety of sources indicates that the area is currently undergoing a dry period. (Katavi, GMP 2001). There are two lakes in the Park, Lake Katavi and Lake Chada. Lake Katavi is in north – west of the park with an area of 105km² while Lake Chada covers an an area of 85km² it is located south – east of the park.

Vegetation

The main vegetation in these lakes is short grasses and Acacia trees, which is interspersed with fringed palm trees that cover the plain a result of an earth quake in 1923 which caused a shift in sand (Lyandi Sandi ridge).

Nature of soil

The area surrounding Lake Katavi is dominated by red sand soils, which are geologically low in nutrients content and low water holding capacity. This lake is fed and drained by the Katuma River. Lake Chada is dominated by black cotton soils and it is fed by Katuma and Msaginiya Rivers, and drained by Kavuu River southward into Lake Rukwa.

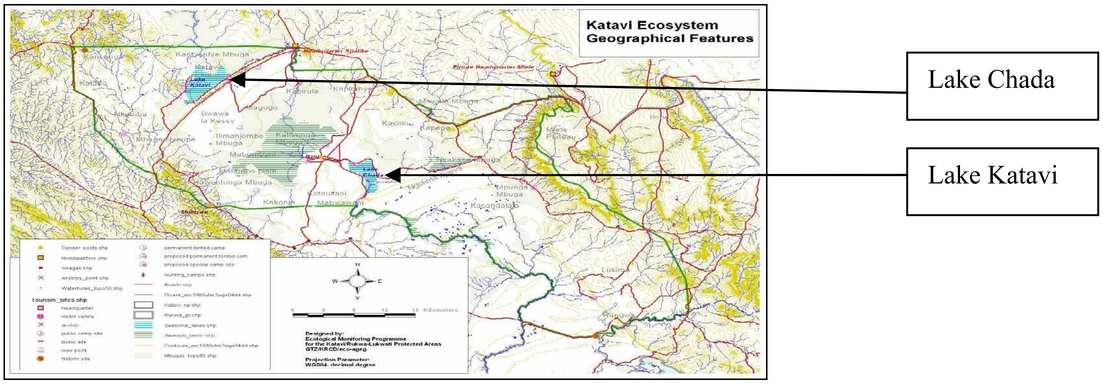

Figure 1: *A map of Katavi National Park*
Source: Adapted from Katavi National Park 2011

Data Collection and Analysis

Data collection was carried out during the summer season (June to October) in 2011. Point count technique was adopted and used to collect data directly from the two lakes. This methodology was adopted from Urfi, *et al.,* (2005) who pointed out that most bird-count methods fall into the categories of total count or sampling. The stations were systematically laid out within the study area by using maps of the respective lakes. Point count was undertaken from a fixed location for 30 min. By standing at one place it was possible to count all birds seen at a given point.

Distance from one point to another was established, this were 300m to allow distance sampling within a radius of 70m. Seven count stations were located around the lake peripheral and the location of each station was marked by using geographical positing system. Each lake was surveyed for 30 days and census was made from 7.00 am to 10.00 am and from 2.00 pm to 5.00 pm daily. A five minute rest preceded each count station to allow for the equilibration of bird activity after arriving at each station after the initial count period. There was an addition of 5 minutes to maximize the detection of secretive species. This technique was adapted from Sutherland, 1996 and was appropriate for this study. Binocular was used to view birds from a distance. A bird field guide book by Stevenson & Fanshawe (2002) was used as a reference in the identification process. In each of the sampling site, environmental variables were recorded.

The processed data were analyzed and computed to measure variables by using statistical tests. Waterfowl species diversity was calculated using Shannon's index of diversity which is given by the formula Shannon's index of diversity, $H' = \sum Pilnpi$; Where Pi = the proportion of the *ith* species expressed as a proportion of the total number of individuals of all species in the area or community (Magurran, 2004). Diversity indices provide important information about rarity and commonness of species in a community. The ability to quantify diversity in this way is an important tool for biologists to understand community structure. The Shannon- Weaver index was adopted and used in data analysis because it combines two quantifiable measures that is species richness S, (the number of species in community) and abundance N, (the total number of individuals in the sample).

The diversity index H' was separately calculated for each lake. In addition to the calculation of species diversity also species richness and species evenness for each of the lake was determined using the formula. d= S-1/lnN (Odum, 1971) where d= Species richness, S= Total number of species, N= Total importance value of all the species. Species evenness, e, for each lake was calculated using the formula: e=H'/lnS where H'= the index of species diversity and S = the total number of species. The Shannon-Wiever index was considered as a measure of diversity within a given community, or alpha diversity.

The difference in species diversity between the lakes is beta diversity, and it was calculated by such techniques as the coefficient of community similarity. In this study, Sǿrensen's coefficient of community similarity was adopted and expressed using the formula coefficient of community similarity, S= 2C/A+B. Where A= the number of species in area or community A; B= the number of species in an area or community B and C= number of species occurring in both communities A and B. This technique was adopted to find the presence and absence of certain species in a given community as pointed out by Smith (1986). Finally, relationship between population and environmental variables was determined using spearman rank of correlation as adopted from McDonald (2009).

RESULTS AND DISCUSSION

Waterfowls Species Diversity at Lake Chada and Katavi

The species diversity refers to the number of species in a given area. This study determined the species diversity of the two lakes by using Shannon's-Weaver index (H^1). This index has a minimum value of zero for a community that is a mono culture of one species and a maximum of lns for a community of species which are equally abundant. The higher the value of H^1, the greater the diversity. The study showed that there is a noticeable difference in waterfowl species diversity during dry season between Lake Chada and Katavi. The calculated Shannon's - Weaver index for Lake Katavi was 2.3251 higher than the Shannon-Weaver (H^1) – index for Lake Chada which was 1.72861.This results are in line with the findings of Lameed (2011), Craig & Barclay 1992 as cited in U.S. E PA. (2002 whereby they noted significant difference of species abundance between different studied sites

Species Richness

The two Shannon's – Weaver index were used to determine the species richness in the two lakes. Calculated species richness; d for Lake Chada was 2.6338 and that of lake Katavi was 4.7079 indicating that lake Katavi has higher species richness than lake Chada. Lake Katavi has 41 species that were counted during this study season. Dominated species included African open-billed stork (*Anastomus lamelligerus*) presented by 26.3%, Sacred ibis (*Threskiormis ethiopians*) 11.07%, Black smith plover (*Vanellus armatus*) 6.43%, Yellow billed stork (*Mycteria ibis*) 6.21%; Fulvous whistling duck (*Dendrocygna bicola,r*) 5.7% Collared pratincole (*Glareola pratincola*) 5.6% and the other 34 species occupied 15.52% in general.

Lake Chada observed to harbor 20 species during this period Yellow- billed stork (*Mycteria ibis*) dominated the findings by 50.5% followed by Grey – heron stork (A*rdea cinerea*) 10.6%, White pelican (*Pelecanus rufescens*) 9.49%, African open billed s*tork (Anastomus lamellingarus) 8.54%;* Black smith plover *(Vanellus armatus*) and Marabou stork (*Leptoptilos crumeniferus*) each presenting 6.04%, the remaining 14 different species were presented by 7.49%. Jacana, plovers and egrets were found along the shore of the lake around short grasses. This area was favorable to them as it provides foods, resting sites and escape cover. The results also indicate that some species appear to occur in a small population. For example, only five individuals were recorded in each species of the Saddle – billed stork (*Ephippiorhynchius senegalensis)* and Grey crowned crane *(Balearica regulorum*) followed by Goliath heron (*Ardea goliath)* and Hammerkop *(Scopus umbretta*) each recorded a count of two individual birds while White stork (*Ciconia ciconia*) and Common sand piper (*Actitis hypoleucos*) each gave a count of one individual bird. This variation in species richness was also observed by research findings in the studies of Nudds & Cole (1991), Korschgen & Dahlgren (1992), Houdkova (2003), Phillips (2008) and Akbar (2009)

At Lake Katavi Waterfowl with least population size were Africa Darts (*Anahinga rufa)*, Water dikkop (*Burhinus vemiculutus)* represented by one individual bird, followed by three – banded plover (*Charadrius tricollais*) and pied – king fisher *(Ceryle rudis*). Goliath heron (*A.goliath*), and Hammerkop *(S.umbretta)* with a count of three individual birds while African fish eagle (*Haliaeetus vocifer)* and Malachite king fisher (*Alcedo cristata)* were presented by 5 individuals recorded species. Unequal percentage distribution of birds in the habitats was also reported by findings of Phillips (2008) and Akbar (2009). The species difference in richness is due to variation in micro habitats and food types within the area. Yellow-billed storks, *Sacred ibis* and little egrets were found at the shore on muddy water with short grasses around Lake Chada. Egrets dominated due to availability of insects (food). This area had herds of buffaloes, so egrets were found on the bodies of buffaloes feeding on ticks and other external parasites. The duck families were found on water and muddy areas feeding on small invertebrates while others were busy swimming in open water. Similar findings were also reported by Arthur (1961) & Huston (1964) in Keddy (2000) and Lameed (2011), that both biotic and abiotic factor affects population density of waterfowl.

Species Evenness

Species evenness or species dominance is one among the three variations in the number of specie. Species evenness is a measure of biodiversity which quantifies how equal the communities are numerically (You *et al*., 2009).This parameter was determined between the two lakes. At Lake Chada the species evenness e was 0.5770 while at Lake Katavi the evenness index, e was 0.626. From the research findings, Waterfowl were distributed unevenly at Lake Katavi and Lake Chada. Some places had higher number of individual birds and species while other places had few and others none. At Lake Katavi at the exit of Katuma River (point 1) there were 1977 individuals birds from 24 different species. Caption

Near Lake Katavi campsite (points 3) there were 1339 individual birds from 15 different species, Wamweru site (point 7) had 659 individuals from 4 different species. At the exit of Kavuu River in Lake Chada (point 1) there were 137 individual birds with 10 different species whereas point 2 had 48 individuals with 7 different species, point 4 with 125 individuals with 9 different species. Point 7 just near Normad tented camp, 431 birds were observed representing 7 different species. This differing species evenness between points was due to differences in food availability. This observation is in line with the findings reported by Lameed, (2011), Bibi & Ali (2013).

Coefficient of Community Similarity

The coefficient of community similarity between the two lakes was determined to be S=0.557. Community "A" represented by lake Chada was observed to harbor 20 species (Table 1) and community "B" represented by lake Katavi was observed to harbor 41 species (Table 2). Seventeen (17) different species were observed to occur in both Lake Chada and Katavi. These results are similar to the Nawrot *et al*., (2003) findings that Waterfowl abundance differed between two different points. The reason for such variation could be due to common resource supply such as food, vegetation cover, water availability, constant temperature and relative humidity. Distribution of food and type of food determines to a large extent Waterfowl distribution at these lakes. Places with enough food of different varieties had more number and species diversity. Around each lake, there is grassland vegetation and woodlands which harbors waterfowl such as marabou stork, (*Leptoptilos crumeniferus)*, African fish eagle (*Haliaeetus vocifer*) and Hammer kop (*Scopus unbretta*). These are among the waterfowl observed to occur in the two lakes.

Table 1: *Waterfowl observed at Lake Chada*

S/n	**Species**	**Scientific name**	**Population size (ni)**	**Pi=ni /N**	**lnPi**	**Pi ln Pi**	**S/ n**	**Species**	**Scientific name**	**Population size (ni)**	**Pi=ni/N**	**lnPi**	**Pi ln Pi**
1	Egyptian goose	*Alopochen aegyptiaca*	10	0.0074	-4.9063	-0.0363	11	African Fish Eagle	*Haliaeetus vocifer*	6	0.0044	-5.4261	-0.0239
2	Grey heron	*Ardea Cinerea*	144	0.1060	-2.2443	-0.2378	12	Collared Pranticole	*Glareola pratincola*	34	0.0250	-3.6889	-0.0922
3	White Stork	*Ciconia ciconia*	1	0.00074	-7.2089	-0.0053	13	Goliath heron	*Ardea goliath*	2	0.0022	-6.1193	-0.0135
4	Yellow - billed stork	*Mycteria ibis*	686	0.5052	-0.6828	-0.3449	14	Hammerkop	*Scopus umbretta*	2	0.0022	-6.1193	-0.0135
5	Blacksmith Plover	*Vanellus armatus*	82	0.0604	-2.8068	-0.1695	15	Common Sandpiper	*Actitis hypoleucos*	1	0.00074	-7.2089	-0.0053
6	White Pelican	*Pelecanus rufescens*	129	0.0949	-2.3645	-0.2244	16	Knob - billed Duck	*Sarkidiornis melanotos*	18	0.0133	-4.3199	-0.0575
7	Malabour Stork	*Leptoptilos crumeniferus*	82	0.0604	-2.8068	-0.1695	17	Hottentol Teal	*Anas hottentota*	14	0.0103	-4.5756	0.00471
8	Saddle billed stork	*Ephippiorhynchus senegalensis*	5	0.0037	-5.5994	-0.0207	18	Grey - Crowned Crane	*Balearica regulorum*	5	0.0037	-5.5994	-0.0207
9	African open billed stork	*Anastomus lamelligerus*	116	0.0854	-2.4604	-0.2101	19	Wattled Plover	*Vanellus senegallus*	13	0.0096	-4.646	-0.0446
10	Spur winged goose	*Plectropterus gambensis*	3	0.0022	-6.1193	-0.0135	20	Squacco heron	*Ardea ralloides*	5	0.0037	-5.5994	-0.0207
									Σ	1358			-1.7286
										S = 20			
										N = 1358			
										H' = - Σpilnpi = -1 x -1.72861 = 1.72861			

Source: Survey data *2011*

Table 2: *Waterfowl observed at Lake Katavi*

S/n	**Species**	**Scientific name**	**Population size (ni)**	**Pi=ni/N**	**lnPi**	**Pi ln Pi**	**S/n**	**Species**	**Scientific name**	**Population size (ni)**	**Pi=ni/N**	**lnPi**	**Pi ln Pi**
1	Egyptian goose	*Alopochen aegyptiaca*	89	0.0182	-4.0063	-0.0729	11	Collared Pranticole	*Glareola pratincola*	274	0.0554	-2.8842	-0.1612
2	Grey heron	*Ardea Cinerea*	148	0.0302	-3.4999	-0.1057	12	Goliath heron	*Ardea goliath*	3	0.0006	-7.4186	0.0045
3	Yellow - billed stork	*Mycteria ibis*	304	0.0621	-2.7790	-0.1726	13	Hammer Kop	*Scopus umbretta*	3	0.0006	-7.4186	0.0045
4	Blacksmith Plover	*Vanellus armatus*	315	0.0643	-2.7442	-0.1765	14	Common Sandpiper	*Actitis hypoleucos*	31	0.0063	-5.0672	-0.0319
5	White Pelican	*Pelecanus rufescens*	52	0.0106	-4.5469	-0.0482	15	Sacred ibis	*Threskiornis aethiopius*	542	0.1107	-2.2009	-0.2436
6	Malabour Stork	*Leptoptilos crumeniferus*	88	0.0179	-4.0229	-0.0720	16	Little egret	*Egretta garzetta*	1134	0.2316	-1.4627	-0.3388
7	Saddle billed stork	*Ephippiorhynchus senegalensis*	9	0.0018	-6.3199	-0.0114	17	Fulvous whistling duck	*Dendrocygna bicolar*	279	0.0569	-2.8665	-0.1631
8	African open billed stork	*Anastomus lamelligerus*	1289	0.2633	-1.3345	-0.3514	18	Pied king fisher	*Ceryle rudis*	2	0.0004	-7.8240	-0.0031
9	Spur winged goose	*Plectropterus gambensis*	37	0.0076	-4.8796	-0.0371	19	Great egret	*Egretta alba*	11	0.0022	-6.1193	-0.0135
10	African Fish Eagle	*Haliaeetus vocifer*	5	0.001	-6.9078	-0.0069	20	African Darts	*Anhinga rufa*	1	0.0002	-8.5172	-0.0017

S/n	Species	Scientific name	Population size (ni)	Pi=ni/N	lnPi	Pi ln Pi	S/n	Species	Scientific name	Population size (ni)	Pi=ni/N	lnPi	Pi ln Pi
21	Water dikkop	*Burhinus vemiculatus*	1	0.0002	-8.5172	-0.0017	31	Black headed heron	*Ardea melonocephala*	9	0.0018	-6.3199	-0.0114
22	African jacana	*Actophilorois africanus*	31	0.0063	-5.0672	-0.0319	32	Glossy ibis	*Plegadis falcinellus*	6	0.0012	-6.7254	-0.0081
23	Red billed teal	*Anas erythrorhyncha*	12	0.0025	-5.9915	-0.0149	33	Knob -billed duck	*Sarkidiornis melanotos*	27	0.0055	-5.2030	-0.0286
24	Three banded plaver	*Charadrius tricollais*	2	0.0004	-7.8240	-0.0031	34	Southern Pochard	*Netta erythrophthalma*	7	0.0014	-6.5713	-0.0092
25	Black winged stilt	*Himantopus himantopus*	17	0.0035	-5.6549	-0.0198	35	Malachite kingfisher	*Alcedo Cristata*	5	0.001	-6.9078	-0.0069
26	Ringed plover	*Charandrius hiaticula*	9	0.0018	-6.3199	-0.0114	36	Little Stints	*Calidris minuta*	7	0.0014	-6.5713	-0.0092
27	Wattled plover	*vanellus senegallus*	9	0.0018	-6.3199	-0.0114	37	Common Green Shank	*Tringa ochropus*	8	0.0016	-6.4378	-0.0103
28	Hadada Ibis	*Bostrychia hagedash*	12	0.0025	-5.9915	-0.0149	38	Marsh sandpiper	*Tringa Stagnatilis*	32	0.0065	-5.0359	-0.0327
29	Little Grebe	*Podiceps ruficollis*	27	0.0055	-5.2030	-0.0286	39	Greater Snipe	*Gallinago media*	9	0.0018	-6.3199	-0.0114
30	Squaco heron	*Ardeola ralloides*	12	0.0025	-5.9915	-0.0149	40	Long-toed Lapwing	*Vannellus crassirostris*	11	0.0022	-6.1193	-0.0135
							41	Lesser Moorhen	*Gallinula angulata*	27	0.0055	-5.2030	-0.0286
									Σ	4896			-2.3251
									S	41			
									N	4896			
										H' = -Σpilnpi = -1 x -2.3251 = 2.3251			

Waterfowl Distribution and Environmental Variables

Environmental variables (primary productivity, water level and vegetation cover) were estimated qualitatively on a 0-5 point scale as follows: 0 =No productivity, water; vegetation cover. 1= Small/ Little productivity, water, vegetation cover. 2= Moderate/medium productivity, water vegetation cover. 3= High/more productivity, water, vegetation cover. 4=Very high productivity, water, vegetation cover. 5=Extreme very high productivity, water and vegetation cover. By using spearman rank of correlation the relationship between population distribution and environmental variables were determined.

By determining correlation coefficient (r), it was observed that there was a positive relationship between environmental factors and distribution of waterfowl species at Lake Chada and Katavi respectively. At Lake Chada, the most correlated environmental variable has been water level and Waterfowl population r = 0.4019 followed by vegetation cover and primary productivity r =0.3437 and 0.3437 respectively. On the other hand there was not any relationship between waterfowl population and temperature and humidity, due to constancy in measurements of the respective data variables obtained from the park authority. At Lake Katavi, the most correlated environmental variable has been primary productivity and Waterfowl population r= 0.7537 followed by water level r = 0.3122 and vegetation cover, r = 0.04968 as shown in Table 3

Table 3: *Relationship between population distribution and environmental variables*

AREA	WATER LEVEL	PRODUCTIVITY	VEGETATION COVER	TEMPERATURE	RELATIVE HUMIDITY
L. Chada	r = 0.4143	r =0.3437	r = 0.3437	r = 0	r = 0
L. Katavi	r = 0.3122	r = 0.7537	r = 0.04968	r = 0	r = 0

Source: Survey Data 2013

Water level of the Lake Chada has important implications for the Waterfowl populations in the area. When the lake is low alkaline grasslands form extensive flood plains at the northern edge of the lake and these can support large numbers of birds. High lake levels remove this food source, causing the fluctuations in population size that were noted for the major waterfowl's species at Lake Katavi. The water in Lake Chada is saline due to high inflows of salts, high evaporation rates and the fact that the lake has one out flow. An area of further research would be to investigate the extent of the salinity. It is important to note that it appears that lakes Katavi and Chada are receding and there is data to indicate that the area has gone through a dry period which may be a partial cause of this. A positive relationship between productivity and the waterfowl population was detected highly at Lake Katavi than at Lake Chada. These results support the view that the productivity of plots within the lake is related more predictably to the relative composition of species (reflected by evenness) than to the number of species present.

CONCLUSION

This baseline study found that Waterfowl species diversity and richness is generally high in Lake Katavi than Chada during summer season. The study identified a variation of waterfowl species diversity and richness between the two lakes. It is evident that Waterfowl population is affected by environmental variables such as primary productivity, water levels and vegetation cover in both two lakes. For effective and purposive tourism both lake should be visited with the main focus that more birds are available at Lake Katavi than Chada during summer season given that environmental factors are maintained as they are at both lakes. Both lakes need to be conserved to improve the abundance and distribution of birds in these lakes as both non-biotic and biotic factors affect waterfowl population. This study provided a baseline survey; it opens the room to study diversity of living organisms in different microclimate within any habitat. Proper management of these lakes in a park will sustain waterfowl and other animals such as

Topi (*Damaliscus korrigum*), buffaloes (*Syncerus caffer*) and elands (*Taurotragus oryx)* as they are provided with shelter, food and water especially during summer season.

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