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THE METEOROLOGICAL ROLE ON THE SURVIVAL OF BIRDS IN LIMBE BOTANIC GARDEN, SOUTHWEST REGION, CAMEROON

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ABSTRACT

The association of atmosphere and wildlife population is prominent in ecological management strategies. Meteorological changes do not only determine the behavioral activity of wildlife, rather also play a major role in surviving them in their habitats. Many bird species survive climatic conditions, such as extreme temperature situations through migratory movements to other areas with conducive climate. The coastal region of Cameroon is rich in bird population and species, but very little studies have been carried out on their inventory, social organization, and ecological impact on their behavior. Hence, the aim of this study was to assess the impact of meteorological conditions on the behavioral activity of birds in Limbe Botanic Garden. Research data was collected each day from 8:00 am – 5:00 pm, for three months. Both behavioral activity and atmospheric environmental factors were collected simultaneously. In the study meteorological conditions showed a significant association, $X^2 = 23.352$ df=6 P=0.001, $X^2 = 5.751$ df=6 P<0.05, and $X^2 = 43.227$ df=45 P<0.05 on automobile traffic noise, food type, and bird type respectively. More so, meteorological conditions recorded 59% on sunshine, 24% on rainfall, 11% on cloud, and 6% on wind respectively. The most observed birde were African thrush (*Turdus pelios*) 18%, common bulbul (*Pycnonotus barbatus*) 13%, and grey-backed camaroptera (*Camaroptera brevicaudata*) 11%, while the least observed were grey-crowned negrofinch (*Nigrita canicapillus*) 2%, black-and-white mannikin (*Lonchura bicolor*) 2%, and african palm swift (*Cypsiurus parvus*) 2% respectively. Also, bird type showed a positive significance $X^2 = 19.682$ df=15 P<0.05 on landscape. Furthermore, landscape revealed a positive correlation significance r = 0.102 P<0.05, and r = 0,308 P=0.023 on meteorological conditions and food type respectively. The study examined three key birds' activity, feeding 39%, movement 37%, and roosting 24% respectively. However, the rich floral vegetation with many bird species is a key attraction to research and tourism in the garden. Most of the bird species in this garden are sea birds, since the garden is adjacent to the sea. Finally, the study recommends an inventory on the population of birds in the garden in order to enhance their conservation. Understanding the number of bird species, their population and ecology is important to wildlife conservation management plan.

Keywords: Atmosphere, wildlife, birds, Garden, Activity, Inventory, Population.

INTRODUCTION

Birds are both visually and acoustically conspicuous organisms of most ecosystems. Because they are comparatively easy to identify, birds have received considerable attention of humans (McLay, 1974; Whelan et al., 2008). Although they occupy most of the earth's surface, most species are found only in particular regions and habitats, whereas others are cosmopolitan (Van Tyne and Berger, 1959). Patterns of abundance and distribution of birds are strongly related to environmental factors, which determine their presence and activity. The power of flight allows them to move easily through the air and yet they are perfectly adapted to every environment that fits their requirements for successful reproduction and survival (Welty 1975; Estrella, 2007). In cities, vegetation provides critical shelter, nesting, and foraging habitat for bird species (Antikainen 1992; Narango, Tallamy, and Marra 2017). Vegetation composition and structure are long-recognized predictors of species presence and diversity (Betts et al. 2013; Paker et al. 2014). Human actions, including development and landscaping choices, determine vegetation community composition and structure in cities (Dyson 2019; Fuentes 2020). Development actions are disturbances and include removing native vegetation and topsoil and compacting soil with heavy equipment. Landscaping actions partly replace succession processes and include choosing and planting tree and shrub species in specified proportions and locations (Niinemets and Peñuelas 2008; Grimm et al. 2017). The resulting vegetation communities may differ in the proportion of native species and ornamental non-native species as well as tree canopy cover in historically forested areas (Dyson 2019; Fuentes 2020).

Birds have been particularly useful as indicators to evaluate effects of habitat change because they are easy to watch, and the populations of many decrease or increase when the landscape is modified by such activities. They are well-known indicator taxa due to their sensitivity to environmental perturbations, relevance to ecosystem functioning and relative ease in sampling (Posa and Sodhi, 2006). They are indicators and useful models for studying variety of environmental changes Urfil et al. 2005; Estrella, 2007). Many of them have adapted with the changes that humans have inflicted on the ecosystem. Birds are important for the ecosystem as they play various roles as bio-indicators of different kind of environmental changes like urbanization (Padmavathy et al., 2010). Urban environments provide birds with considerable quantities of food and roosting sites especially in gardens and parks (Dorst, 1974). Some species could be attracted to such areas since it introduces new exploitable resources such as water, ornamental plants and grasses (Posa and Sodhi, 2006). Vegetation structure and rainfall played important roles in determining the species diversity and richness of birds Elizabeth (Yohannes, 1996). Avian studies are important to determine the importance of the site, habitat requirements of the species, size of a population species, and to understand the population dynamics (Gibbons et al., 1996).

Urban areas hold large populations of many bird species (Bland et al. 2004; Cannon et al. 2005), and for some species suburbia provides a refuge for declining populations (Gregory & Baillie 1998). While there is evidence of an increasing disconnection between people and nature (Miller 2005), garden bird feeding is perhaps the most important way for people to engage with wildlife in many parts of the world (Cox & Gaston 2016). Some 48% of households in Britain (Davies et al. 2009) and 53 million households in the USA feed wild birds (US Fish and Wildlife Service 2014), providing an enormous and highly localized additional food resource. In suburban Reading, UK, over 55% of householders provide supplementary food for wild birds, enough to support a minimum of 131750 individual birds, based on the average energy requirements of the UK's 10 commonest bird species utilising bird feeders in gardens (Orros & Fellowes 2015b). While species such as hummingbirds (Hill et al. 1998; Courter et al. 2013) and Red Kites *Milvus milvus* (Orros & Fellowes 2014; Orros & Fellowes 2015a) may have specialist food provided for them, suburban feeding stations typically provide supplementary food for seed-eating and omnivorous passerines (Cannon et al. 2005; Chamberlain et al. 2005).

Diversity and extent of natural habitats will continue to decline as human populations increase and alter landscape for development (Petit et al., 1999). Such activities transformed natural areas by establishing towns, building houses, gardens and public parks, which create entirely artificial environments. Factors determining which species can coexist with human settlements include the presence and patch size of native vegetation as well as competition with exotic species and non-native predators. The structure and floristic attributes of planted vegetation as well as supplementary feeding by humans affect the level of such coexistence (Chace and Walsh, 2006). The effective management of human activities in wildlife areas is an important conservation issue, as the footprint of human influence continues to expand and incidental impacts of human activities spread into more areas. Such expanding anthropogenic activity is widely perceived to lead to negative consequences for the wildlife beyond habitat loss

alone. Understanding how animals respond to anthropogenic activities is fundamental to resolving potential conflicts between humans and animals. Distribution, abundance, reproductive success and behavior of animal species are often sensitive to habitat change caused by human activities (Chace and Walsh, 2006).
The ecological importance of birds is well known, and their role in environment as indicators has attracted research globally. Additionally, their beautiful plumage and other body structures are useful to human tradition. However, poaching and habitat loss to agricultural cultivation are major setback to their population increase. Hence, the conservation of birds in the tropics where most bird species are endemic would increase their population. The coastal region of Cameroon is rich in bird population and species, but very little study has been carried out them. The atmospheric impact on the behavioral activity of birds in Limbe botanic garden was given a consideration by this study. Limbe botanic garden is situated at the sea-shore of Limbe city, it has both a floral and bird species diversity. The richness in flora and birds has been the major source of tourism and research attraction.

MATERIALS AND METHODS

Description of the study area

Limbe Botanic Garden (LBG) is the first botanical garden in Cameroon and the oldest in Africa. It was created in 1892, during the German colonial era, in Victoria (former name of Limbé), between the ocean and Mount Cameroon at 4°0'49.46″N and 9°12'3.13″E (fig. 1). Initially intended for agricultural purposes, it has become one of the main curiosities of South West Cameroon Region. The Garden has also served as a training center for Cameroonians in the fields of agriculture, horticulture and forestry. It is also an international center for biodiversity research (Tchinmegni and Djeukam 2023)
Today, the garden, which originally covered 250 hectares, has only 48 hectares, the rest (202 hectares) is the rainforest. The garden has about 1,500 taxa (1,000 herbaceous and 500 woody plants). There are rare or endangered plants: 150 endemics, 100 from the south-west, including *Calamus sp*, *Prunus africana*, *Gnetum spp*. Some plants are the object of particular attention, notably the African palms, the endemic plants of Mount Cameroon, the *Musa spp*. Others are cultivated for conservation purposes: *Irvingia gabonensis, Garcinia kola, Afrostyrax kamerunensis, Cola spp, Prunus africana, Gnetum spp, Pterocarpus soyauxii, Diospyros, Rauvolfia vomitoria, Nauclea diderrichii, Terminalia spp, Enantia chlorantha, Eremomastax speciosa, Bryophyllum spp* and *Physostigma venenosum*. The botanical garden also houses a herbarium, which in 2001 had about 21,000 specimens and more recently 30,000. Its acronym in the Index Herbariorum is SCA (Tchinmegni and Djeukam 2023).

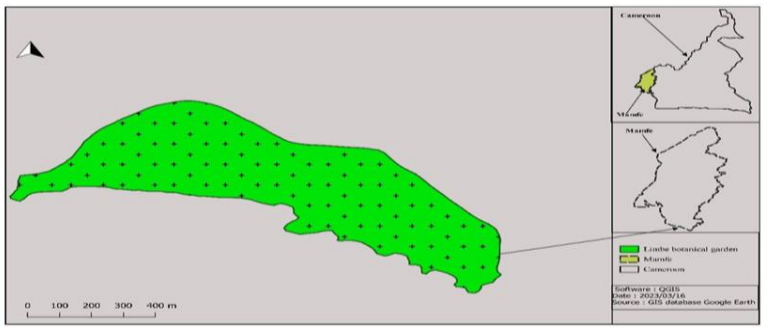

Figure 1. Limbe Botanic Garden (Tchinmegni and Djeukam 2023).

Method of Data Collection

Data collection program involved the use of standardized search method, which allows for comparison of heterogeneous study sites, retains the parcel as the unit of analysis instead of changing it to the point count circle, and is compatible with the geometry of parcels (Watson 2003; Dyson 2019). With the standardized search methodology, the entire site is sampled, and a results-based stopping rule is used to provide equivalently accurate estimates of species richness between sites (Watson 2003). The method encourages observer movement, which allowed for detection of bird species, observation of bird behavior and foraging activity, and repositioning to mitigate the impacts of urban noise. Pilot data collected using both point count and standardized search methodology

confirmed that the standardized search methodology was multiple times more effective in detecting birds than point counts. Data collection was done for a period of three months, each day from 8:00 am – 5:00 pm. However, the research data collection method was tested to have a feasibility confirmation on the variable to be used during the process. A letter of authorization was written by the Department of Forestry and Wildlife to the authorities of Limbe Botanic Garden for research approval before the data collection was launched. The Garden has a longstanding reputation on the conservation of many endangered species of plants, and rainforest area where this study was carried out. The rainforest vegetation area has many species of wild birds.

Data Analysis

The research data was analyzed by using SPSS version 25, with the help of statistical models, such as chi-square and spearman correlation. Analysis started with exploratory statistics, and later the variable were subjected to a further test of inferential statistics. The atmospheric condition was tested against other variables like landscape, automobile traffic, food type, and bird type. Hence, the results of analyzed data was displayed on bar-charts, pie-charts, and graphs.

RESULTS

The atmospheric ecological components play a vital role on the sustainability of life on the earth planet. The components of the atmosphere are rain, sun, cloud, wind and other related useful components contributive to the welfare of living organisms. However, there are still very harmful materials in the atmosphere due to anthropogenic activity disorder causing global warming problems that affects humans and other living organisms negatively. Anthropogenic activities, such as rainforest incineration for cultivation, automobile operations, aircraft systems, and industries manufacturing goods have released toxic gases into the atmosphere, posing enormous threat to human welfare on the planet. Hence, the atmospheric conditions, considered for this study revealed a positive significance $X^2 = 23.352$ df=6 P=0.001, $X^2 = 5.751$ df=6 P<0.05, and $X^2 = 43.227$ df=45 P<0.05 on automobile traffic activity (fig.2), food type (fig. 3), and bird type (fig. 4) respectively. Atmospheric conditions recorded 59% for sun, 24% for rain, 11% cloud, and 6% for wind (fig. 5) respectively. The sunny atmosphere witnessed the highest rating because much of the data collection covered the month of March and April, relatively dry compared to the month of May that had more rain. Studies carried out in other places showed that wildlife behavioral activity budget is relatively favored by a sunny atmosphere. Also, road traffic activity was observed highest during the sunny atmosphere reducing other bird activities.

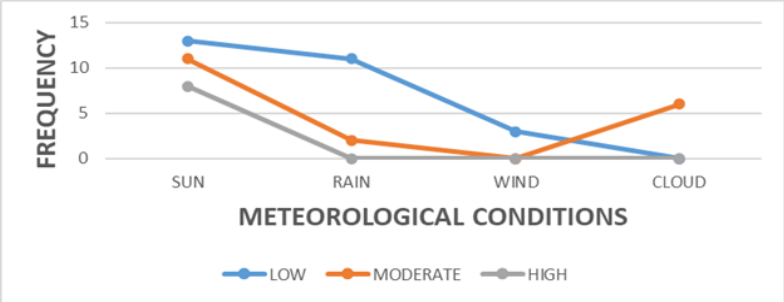

Figure 2. Meteorological conditions and automobile activity.

Noise intensity from road traffic is known to interfere with acoustic sounds, obstructing audio communication system of wild birds, especially those depending on roadside habitat for survival. Contact calls, songs, whistles, screams, etc used by birds to assemble themselves for social activities become obstructed by the road-traffic noise pollution. In many situations, the population of birds in very noisy areas shift their activities to other locations far off the roadside habitats. Some studies have shown that noise pollution can cause hearing, and blood pressure disorders in humans and some animal species, hence, should be avoided. Though, wild birds sometimes invade these noisy habitats for food exploitation, they might be handicap in audio communication.

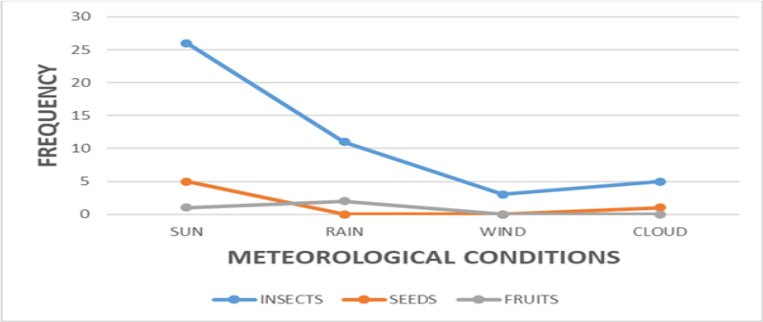

Figure 3. Meteorological conditions and food type.

The atmosphere does not only protect life on planet earth through the ozone layer, but provides warmness, moisture, air etc to support our healthy living. Life on planet earth is a delicate balance between fundamental elements, such as rain, sunshine, wind etc. However, if any of these components becomes dominant or lacking, the entire life support system is affected. Eventually, prolonged dry season would slow down wildlife activities, causing their populations to cluster more on watersides for atmospheric moisture to facilitate body-heat reduction. On the other hand, extreme low temperature or snowfall that covers the surface would prevent wild animal feeding activity on vegetation, insects, seeds, roots, etc. Hence, extreme low temperature forces some wild animals to borrow deep into the earth, or seek shelter in caves for protection. It's also known that some wildlife species hibernate, preventing movement during extreme winter conditions. Because, the colder it gets, the more energy is needed by the body metabolism to maintain its activities.

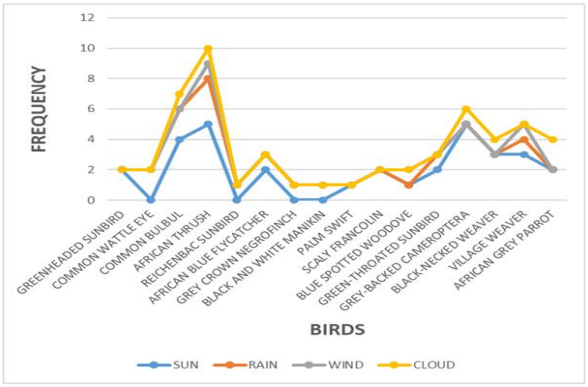

Figure 4. Meteorological conditions and bird types.

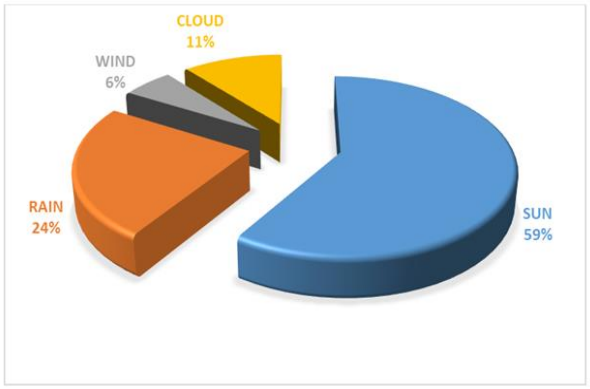

Figure 5. Atmospheric conditions.

The most observed birds were African thrush (*Turdus pelios*) 18%, common bulbul (*Pycnonotus barbatus*) 13%, and grey-backed camaroptera (*Camaroptera brevicaudata*) 11%, while the least observed were grey-crowned negrofinch (*Nigrita canicapillus*) 2%, black-and-white mannikin (*Lonchura bicolor*) 2%, and african palm swift (*Cypsiurus parvus*) 2% respectively (fig. 6). Limbe botanic garden is rich in floral and bird species, potentials that have gained the area a research and tourism global recognition. Nevertheless, weaver-bird species recorded a relative low observation because of the absence of agricultural cereal crops like maize (*Zea mays*) that they scramble for in other areas of Limbe municipality. Majority of birds observed in the garden were endemic rainforest species. The presence of rainforest vegetation in the garden seems to have an created to wild birds for frequent exploitation.

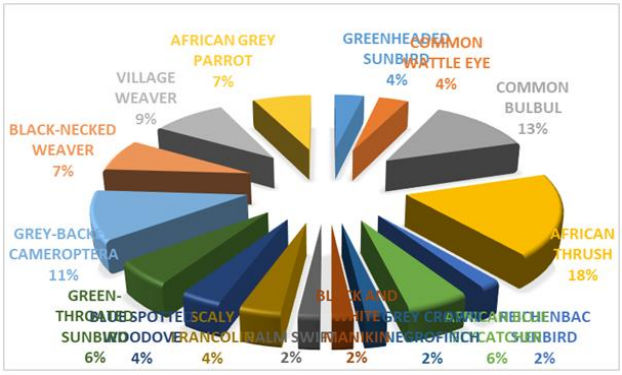

Figure 6. Birds in the garden.

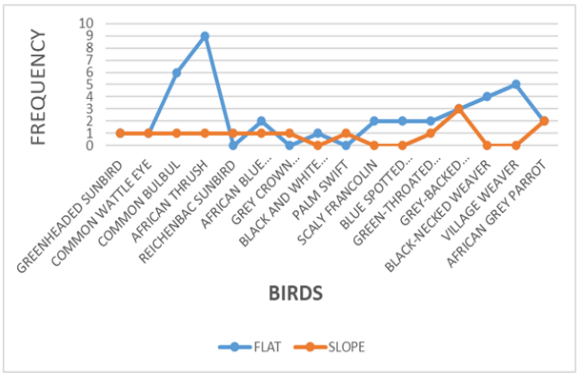

Figure 7. Bird type and landscape.

Bird type showed a positive significance $X^2 = 19.682$ df=15 P<0.05 on landscape (fig 7). The association between birds and landscape is extremely important to feeding, nesting, and other related activities connected to the survival of bird species. Wild birds are known to nest and duel on difficult landscapes, such as cliff and escarpment, areas with little or no access to bird-predators. Fortunately, their ability to duel in these type of areas have gained population increase to various species of birds. Secondly, their continental flight migration capacity to avoid extreme climatic conditions like winter and drought is a population stabilization strategy. Ornithological studies have proven that migration movements, ranging thousands of kilometers are done by some bird species during winter period from North America continent to African. This survival strategy is known to outsmart other terrestrial wildlife species, and it's very important in protecting these species.

Landscape revealed a positive correlation significance r = 0.102 P<0.05, and r = 0,308 P=0.023 on meteorological conditions (fig. 8) and food type (fig. 9) respectively. Food is important and it's the source body energy in living organisms, reason why most wildlife species including humans only live in areas where there is easy access to food resource. Food is the main source of energy needed to run body metabolism activities, hence, animal's body, needs food-intake whenever energy shortage is experienced in order to severe health crisis that could lead to death. But having the food, needs kinetic energy, to cover distances searching for food. Location of healthy feeding sights is challenging and competitive within same group, other groups, and species. The landscape of the garden is rich in birds' food resources, a key attraction to the huge population of birds in the area.

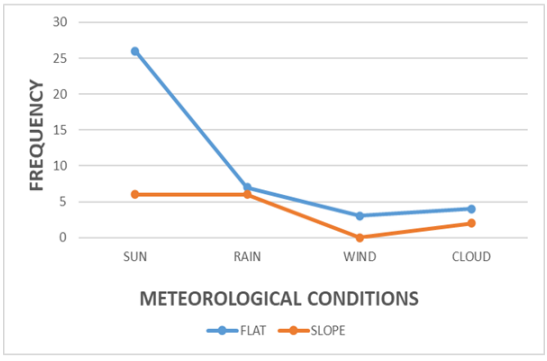

Figure 8. Landscape and meteorological conditions.

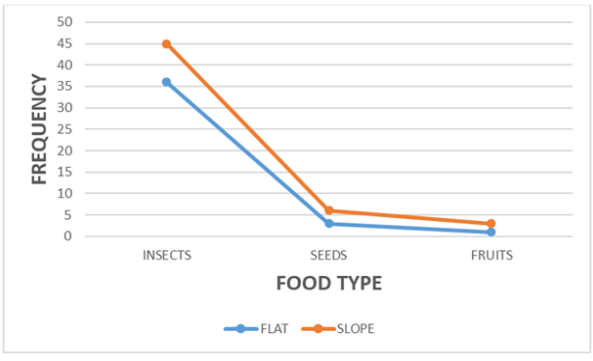

Figure 9. Landscape and food type.

The study examined three key birds' activities; feeding 39%, movement 37%, and roosting 24% respectively (fig. 10). The sunshine atmosphere witnessed a lot of birds' activity, especially feeding, though, sometimes slowed down by rain and automobile traffic noise intensity, a steady increase occurred immediately after these periods. Birds' roosting, in this study included groom and play, witnessed during bright atmosphere, was an indication of a healthy breeding ground for the garden birds.

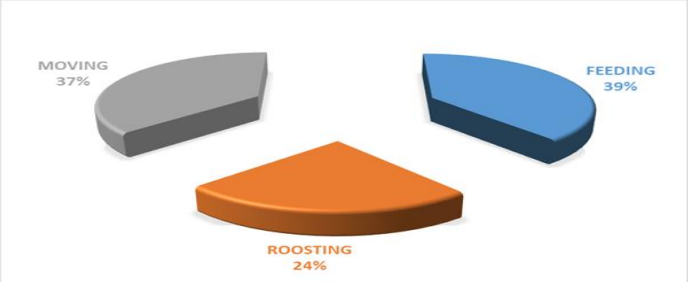

Figure 10. Birds' activity.

Discussion. Most human habitations, apart from those of highly urbanized populations, have some kind of surrounding land under the private or shared control of their occupants which can be characterized as a yard or garden. The typical configuration and exploitation of such land varies between cultures but the total amount of land and the resources applied can be quite significant. For example over 10 million hectares are devoted to lawn grass in the United States, consuming more synthetic fertilizer than India uses for all of her crops (Uhl 1998). In such affluent societies, leisure gardens have traditionally been ornaments, status symbols, hobbies, even art forms or expressions of spirituality but as general conservation awareness increases, a growing number of these plots are being managed to some extent as wildlife havens by gardeners hungry for information and practical support. Private gardens are already of significant value as wild bird habitat and can be productively exploited for the benefit of bird conservation both locally and generally. Garden ornithology can really work, inspiring professionals, engaging amateurs and providing unique data for conservation. British gardens already support species of serious conservation concern and their relative value as productive habitat is increasing as the wildlife gardening movement nudges them towards ecological integrity and sustainability and as other types of habitat deteriorate. They become more significant culturally, educationally and ornithologically as monitoring surveys and other simple, hands-on conservation-orientated garden projects become established, produce results and propagate. And furthermore they enable real people to participate in increasingly real conservation and to experience a genuine sense of the wild on their doorsteps.

Habitat available for birds in cities is driven by human choices (Müller et al. 2013; Avolio et al. 2018). Bird habitat use is determined by species' habitat selection process and adaptability, the spatial layout of habitat in the landscape, habitat availability and quality and the local species pool (Müller et al. 2013). Sites with more native vegetation community composition are more likely to be used by native bird species, as many native birds prefer to feed in native trees and shrubs (Paker et al. 2014), though some are more adaptable and will readily use non-native ornamental vegetation (Daniels and Kirkpatrick 2006; Belaire, Whelan, and Minor 2014). Heterogeneous plant layers are positively correlated with high bird diversity and native forest birds (Paker et al. 2014; Smith et al. 2015). Where vegetation structure is simplified, bird abundance is reduced, particularly for leaf-gleaning insectivores (Ellis, Kroll, and Betts 2012; Betts et al. 2013). Large lawns and monoculture woods without underbrush are favorable for alien bird species and urban exploiters (Paker et al. 2014; Smith et al. 2015). One potential contributing factor to this pattern is that ground cover and increased vegetation structural complexity are frequently associated with increased abundance and diversity of arthropods, an important food source (Frampton, Van Den Brink, and Gould 2000). Habitat loss and degradation are primary drivers of extinction in anthropogenic habitat (Alberti 2005; Polasky et al. 2005). Successful conservation requires the urban habitat matrix to provide enough resources and connectivity for local species, in addition to habitat preservation (Fischer, Lindenmayer, and Manning 2006; Shoffner et al. 2018). Thus, acting to alter urban vegetation communities can positively impact bird species richness and assemblages (Threlfall et al. 2016).

The seasonal distribution of birds is affected by their migration patterns. Migration is long-distance movement of individuals, often seasonally, for a variety of reasons. Sometimes many individuals of a single species migrate together in groups. There are also a few common paths that multiple species use to migrate to similar places. Temperature change is the most common reason to migrate. If a bird's habitat gets too cold in the winter or too warm in the summer it will fly south or north, respectively for the season. Food availability, often determined by seasonal temperature variation, is another incentive to leave one's habitat temporarily. Some birds change diets as they migrate, picking places to rest along the way based on where they found good food the years before. Migration is a voluntary activity, but is one of necessity caused by climatic conditions such as the food supply and the length

of the daylight (Lincoln, 1998). In Eastern Africa, the following three types of migration can be recognized. Complete, trans-equatorial and local. Complete migration includes those species visiting Eastern Africa during the non-breeding season from Europe or Asia. Trans-equatorial migration includes those species that move either to a more humid or to a drier area for breeding, and in so doing cross the equator. Local migration includes those species, which breed in Southern Africa and move Northward in the non-breeding season (Mackworth-praed and Grant, 1956). Birds are one of the most important components of biodiversity. This is reflected by the ecological, economical and esthetic values. It is often asserted that birds are convenient indicators of biodiversity, and they are useful for monitoring environmental changes. One reason is that birds have long been popular with naturalists, amateurs and professionals and consequently their systematics and distributions are better known than any other comparable groups of animals, with the possible exception of larger mammals (Furness and Green wood, 1993). Birds are extremely efficient and cost-effective insect pest controllers (Pschorn-Walker, 1977). As a group, insectivorous birds display a wide variety of feeding specializations, from hunting in the air (swifts and swallows) to excavating deeply in wood (woodpeckers). Roughly 60% of the approximately 8600 species recognized by Mayr and Amadon (1951) are partly or largely insectivorous. Insect pest outbreaks can annually destroy hundreds of millions of dollars of agricultural and forest products. Birds can alter their diets to feed almost exclusively on an insect pest during an outbreak if it becomes profitable for them to do so. Birds can act as bio-indicators of environmental conditions (Gregory et al., 2003). Birds are often used as a biological model because they are good ecological indicators and they are easily observable (Clergeau et al., 2001). Some of the birds are sensitive and have capability of early warning for changes like heavy metal pollution (Marchant et al., 1990) and (Baillie et al., 1997) showed that birds in agricultural land declined as chemicals and other inputs are applied for agricultural intensification to increase productivity, which at the same time leads to the collapse of many invertebrates and microorganisms.

CONCLUSION

The atmosphere consists of many environmental factors, such as ozone layer, moisture, sunlight, gases and other related environmental components needed for life sustainability. Many elements, including rain is cycled by the atmosphere, hence, life would not be possible without it. In many parts of the world, extreme temperature condition is witnessed, resulting to drought, flood, and heavy snowfall. This study revealed that meteorological condition, such as the rain, sunshine wind, and cloud play a significant role in the activity of birds in Limbe botanic garden. The activities of garden-wild birds showed a significance on all the atmospheric conditions. A moderate sunshine weather condition was observed with highest birds' activity budget, while roosting recorded the least. More so, automobile traffic noise intensity showed a negative impact on birds' activity on roadside habitats. However, the rich floral vegetation with many bird species is probably the key factor attracting researchers and tourists to the garden. However, the location of the garden, adjacent to the sea and mount Cameroon national park is a key contribution to its huge bird population. This study recommends an inventory be carried out on the bird population in the garden, to enhance the conservation of birds.

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