CHECKLIST, ABUDNANCE AND DIVERSITY OF BEETLES IN BENIN MOAT

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CERTIFICATION

We certify that this work was carried out by **Theresa Osariemen IHUEGHIAN** in the Department of Animal and Environmental Biology, Faculty of Life Sciences, University of Benin City, Nigeria.

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DEDICATION

This thesis is dedicated to God Almighty, who has been my source, sustainer and strength to go through to the end of this program of study.

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I render my profound gratitude to God Almighty for guarding my steps, for his mercies, wisdom, favor and strength thus far.

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ABSTRACT

The world and human ecosystem has increasingly evolved with time; despite anthropogenic activities in tropical regions of the world leading to loss of plant and animal species. The impact of such activity poses a level of threat on the ecosystem. In the midst of these activities, fauna and flora are also kept intact through the structure of the Benin moat. Despite the encroachment of urban activities in Benin City into the moat, it is still a home for wide distribution of plants and animals. To preserve and keep proper record of ant species in that environment: sampling exercise was carried out within the moat using vials charged with ethyl acetate before taken to the laboratory for identification to provide a checklist. Diversity and abundance was computed using PAST software which revealed *Componotus perrisinigeriensis* (Formicinae) as the most abundant individual ant species and *Tetramorium sericeiventre* (Myrmicinae) as the least abundant ant species. This study revealed thirteen species of ants distributed among thirteen genera and four subfamilies (Formicinae, Myrmicinae, Dolichoderinae, and Ponerinae). According to the non-parametric estimates, Chao2 and Jackknife2 were between 98.9% and 100% of the ants species foraging within the moat were captured in this survey. This suggest that beating stick and tray method is an efficient technique to sample and monitor ant species occurrence within plants. In sum, the complete inventory observed here would allow subsequent studies to monitor the absence previous or presence of new ones within the moat for conservation purposes.

CHAPTER ONE INTRODUCTION

For several centuries until 1897, Benin Kingdom relied on a massive dig, commonly known as moat or 'Iya' by the people of Benin, sometimes written as 'Bini'(ref). Bini was coined from the word 'ubini' (ref). The moat's primary purpose was defence against intruders and invaders. Benin moat is one of the great historical and cultural heritage of the Benin people and is an earthwork made up of banks and ditches otherwise known as *'walls'* of Benin City(ref). The surrounding areas were described as "the world's largest earthworks carried out prior to the mechanical era" by the Guinness book of Records(ref), which predates the use of modern earth-moving equipment or technology. The moat encircles the old perimeter precincts of the city and was constructed as a defensive barrier in times of war (Connah, 1997, Ogundiran, 2005). Oba Oguola (about 1280-1295) dug the first and second moats to fortify the city from invaders, including the imperial European invaders, who at the time hunted Africans for slave labours. Similar moats were built around other villages on account of Oba Oguola's decree; which culminated in 20 moats around Benin and its environs. The other moats were dug by Oba Ewuare the Great (1440-1473 CE).

Benin City is located is in the Lowland Forest region of Nigeria which is a part of the Lower Guinean forest of West Africa. Due to the lack of in-depth research in the region, there is a gap of knowledge regarding the diversity and quantity of insect Fuana, especially beetles, in the Benin Moat. This Checklist of the abundance and diversity of Beetles in the moat is to make available, no matter how little, knowledge of the insects (Beetles) found in Benin Moat.

Coleoptera commonly known as beetles is the largest and most diverse order of insects on our planet (Rainio and Niemelä, 2003). Nearly 350,000 species of beetles have been described around the world (Gullan and Cranston 2010) and have a high diversity, representing about 30%

of all insects (Fahri *et al.,* 2015). Beetles can be found almost in all available habitats in Benin City. Beetles living in terrestrial environments are usually found in soil, leaf litters and humus; in dung, carrion and the fruiting bodies of various types of fungi (Nyundo and Yarro, 2007).

They are also found beneath the bark of living and dead trees or in decomposing wood as well as under stones and logs. Certain species of beetles live exclusively in caves whereas others live in the nests of vertebrates and or social insects such as termites or in man-made environments such as grain store (Lak, 2015). They have ability to inhabit various habitat types and are easily sampled.

Beetles differ in shapes and colors, but are characterized by the forewings having evolved into hardened wing-cases (elytra) and the possession of mouth-parts adapted to chewing and crushing their food. They are holometabolous, with a larval stage that may be predatory, detritus-feeding or herbivorous, and pupate for a period of days or longer before enclosing as adults to reproduce. Many species are known to be herbivores, scavengers or predator as adults; however, certain adult beetles do not feed at all. Some beetle species are predatory when in the larval stage and plant-feeders when adults (Zanetti *et al.,* 2015). They are important in ecological functioning of most ecosystems, due to their wide range of feeding mechanisms and being very abundant. In addition to the roles (herbivore, predator and detritivores) played by beetles in ecosystem food web, they are pollinators, also used as food for amphibians, birds, mammals and reptiles. Like other insects, beetles also play roles in decomposition and nutrient cycling in forest ecosystems.

Furthermore, beetles are used as biological indicator species of environmental change and forest health and management (Ashraf *et al.,* 2016). Species diversity of beetles, especially Carabidae (ground beetles), is frequently used as a proxy for overall ecosystem health, and thus as a rapid metric for assessment of land management effectiveness. The diversity of beetles in an area can be measured by comparing data from inventory studies. The inventories can be carried out by different methods suitable for sampling groups of beetles occurring in a study area.

Additionally, insects are highly sensitive to changes in climatic factors such as rainfall, temperatures, wind, humidity and altitudes (Khaliq *et al.,* 2014; and Alarape *et al.,* 2015), as these affect their population dynamics, distribution, abundance, intensity and feeding behavior (Ayres et al., 2009). Insect play a vital role in our environment such as aiding in the production of fruits, seeds, vegetables, and flowers, improve physical condition of soil and promote fertility by burrowing, devouring bodies of dead animals and plants and also act as bio-indicator of fresh water bodies, some of the insects also provide us with honey, silk and other commercial value products; they serve as food for bird and fish (Chima *et al.,* 2013). However, they are also disease vectors to many other organisms, including humans (Schowalter *et al.,* 2011).

It is critical to understand the factors shaping the abundance and diversity of insects, which provide a range of supporting ecosystem functions in urban ecosystems (Thompson and McLachlan, 2007), support other, insectivorous taxa, such as birds and bats (Scanlon and Petit, 2008), and constitute sensitive indicators of changes in management practices and habitat characteristics impacting overall biodiversity (Clarke *et al.,* 2008).

Habitat loss poses the greatest threat to the long term survival of species on earth. Saunders et al. (1991) reported that, decreases in species richness, in density and in species abundance and alteration of interspecific interactions are some possible biotic effect of habitat loss and fragmentation recognized as the major causes of the current biodiversity crisis. However, changes in land use like intensification of agriculture, habitat fragmentation and invasion of alien species have led to the decline of species such as butterflies (Dover *et al.,* 1990; Thomson, 2001), bees (Calabuig, 2000; Cane and Tepedino, 2001), and bumblebees (Kwak and Bergman, 1996).

Anthropogenic activities on a moat could have an adverse effect on the insect fauna hence, the need to identify and explore the effect of spatial differences on insect species diversity and abundance in the area.

1.2. JUSTIFICATION OF STUDY

The growing awareness on the need to understand and conserve bio-diversity has triggered the interest in evaluating insect richness and diversity in various habitats and ecosystems. Therefore, this study is designed to give a preliminary inventory on the composition and abundance of beetles in and around Benin Moat Area, Benin City, Nigeria, which will provide a base-line data/partial checklist for more extensive studies in the study area and also give an overview of the beetle's species found in Benin City.

1.3. AIMS AND OBJECTIVES

The specific aims and objectives of this study is to;

- Evaluate the diversity of beetle's species in Benin Moat.
- Assess the composition and Relative abundance of Beetles in Benin Moat.

CHAPTER TWO LITERATURE REVIEW

Biodiversity has emerged at the center of one of the most contentious global debates of this century. The debate often focuses on tropical rainforests, which are extremely diverse. Insects are one of the most important and dominant inhabitants of the rainforest. Approximately three quarters of all species worldwide are insects, and more than half are found in tropical rainforests.

To date, a substantial amount of research has been carried out to investigate insect diversity in the tropics (e.g. Stork 1991; Davis *et al*. 1997; Chung 1999). However, the current level of understanding of the diversity of many insect groups is still deficient. The importance of good local species-richness data for a wide range of questions posed by evolutionary biology in general and ecology in particular, is evident (Hammond 1990). To assess habitats for their relevance for conservation, ecological and diversity inventories provide an essential tool for environmental management, and insects are a major component in every terrestrial habitat.

Beetles belong to the insect order Coleoptera, which is characterized by a pair of sheath wings known as elytra. This is believed to be the most important factor that has contributed to the evolutionary success of the beetles (Evans 1977). The body and the elytra (forewings) are usually heavily sclerotized, giving the beetle an armoured appearance, which also protect it from dehydration and ultraviolet radiation. The cuticle (outer skin and skeleton) consists of chitin and protein, which is tough and protects the soft, inner organs. Another typical characteristic feature of this group is the biting mouthparts, giving them great adaptability. The word 'beetle' actually comes from the Middle English word 'bityl' or 'betyll' and the Old English 'bitula' meaning 'little biter' (Lawrence & Britton 1994). Beetles are an endopterygote group, that is they exhibit complete metamorphosis (holometabolous development), with distinct larval and pupal stages. Other detailed characteristic features of beetles are explained in standard taxonomical and ecological references of this group, for example, Evans (1977), Lawrence and Britton (1994) and Crowson (1981).

Beetles are probably related to soft-bodied, weakly flying insects such as alder flies (Megaloptera) and lacewings (Neuroptera) (Evans 1977; Lawrence & Newton 1982). The ancestors of beetles probably evolved about 300 million years ago during the Upper Carboniferous or Lower Permian periods (Evans 1977). There are fossils showing that the primitive Coleoptera had megalopteran-like venation on the elytra. Some other fossils have been found in the Ural mountains, Russia and in Czechoslovakia, showing marked similarities to the recent archostematan Ommadidae (a primitive Coleoptera family). The evolutionary history and phylogeny of beetles are discussed in Crowson (1981), and Lawrence and Newton (1982).

With an estimated 400,000 species, beetles form the most diverse insect order, outnumbering the Lepidoptera and Hymenoptera (Hammond 1992; 1995). They encompass two-fifths of all insect species. In comparison, there are about 45,000 species of vertebrates and 250,000 species of plants. Beetles are not only diverse in species but also in structure and size: the largest of them (the cerambycids Titanus giganteus from South America and Xixuthrus heros from Fiji) attain a length of 200 mm, almost 800 times greater than that of the smallest ones (Nanosella and related genera in the family Ptiliidae), which fall well within the size range of larger protozoans, such as Paramecium (Lawrence & Britton 1994).

There are a few beetle classifications used worldwide (e.g. Crowson 1981; Lawrence 1982; 1991; Paulian 1988) since the first appearance of Crowson's major work in 1955. One of the latest and widely used was compiled by Lawrence and Newton (1995), in accordance to the International Code of Zoological Nomenclature (ICZN 1985). This classification listed 166 families, 453 subfamilies and approximately 3,300 genera placed within four suborders.

The largest suborder of Coleoptera is Polyphaga, which is divided into five series and 16 superfamilies, covering more than 90% of all beetle species. Within the Polyphaga, the superfamilies Chrysomeloidea, Curculionoidea and Staphylinoidea are the most successful groups (Lawrence & Newton 1982). The Chrysomeloidea (Chrysomelidae-BruchidaeCerambycidae) and Curculionoidea (Anthribidae-Attelabidae-Brentidae-ApionidaeCurculionidae-Scolytidae-Platypodidae) are predominantly herbivorous with 70,000 and 60,000 described species, respectively. The superfamily Staphylinoidea (c. 40,000 described species) contains the predominantly predacious and saprophagous Staphylinidae (c. 30,000 described species), Pselaphidae, Scydmaenidae, Leodidae and Ptiliidae.

Because of their high diversity, beetles are suitable insects to use as indicators of environmental change. They are found in numbers in most vegetation types and can be easily sampled using various techniques (Chung et al. 2000b). Beetles are widely used in studies on diversity and ecology (Davis et al. 1997; Chung 2004). Documentation of diverse and ecologically important insect groups, such as assemblages of beetles, can provide qualitative and quantitative measures of biodiversity that provide a basis for decision making in relation to conservation (Harper & Hawksworth 1995).

CHAPTER THREE

MATERIAL AND METHODS

3.1. Study Area

This study was conducted at Benin Moat, Edo State, Nigeria. The study area is situated in the Lowland Forest region of Nigeria which is a part of the Lower Guinean forest of West Africa. The Geo-coordinates of the collection area is 06.33148°N 5.65034°E

The Benin Moat (Iya in the local language) is one of the most historically significant artefact in the city and it consist of a series of earthworks made up of banks and ditches (Patrick, 2015). It was built as a defensive fortification around Benin City in the great Kingdom during the time it was at its height and when the kingdom engaged in many wars. Oba Oguola dug/built the first and second moat around 1280-1295 to fortify the city from invaders. Due to its effectiveness, Oba Oguola made a decree that other towns and villages surrounding the city should build similar moats. An extension of the moat was constructed during the reign of Oba Ewuare the Great (1440-1473) who also ordered a moat to be dug around the heart of the city to enabled them have control of the access to the capital. The Moat which is otherwisely known as *'walls'* of Benin City and surrounding areas were described as "the world's largest earthworks carried out prior to the mechanical era" by the Guinness book of Records. Edo state lies at elevations between 500 feet (150 m) in the south and more than 1,800 feet (550 m) in the north.

Climate of the area is humid. Annual rainfall averages 1,360 mm (53.5 in), characterized by two rainy and two dry seasons. The principal rainy season is from April to late July, with a shorter less intense rainy period from late September to November. The main dry season is from December to April, with a short cooler dry season from late July to early September. Temperatures and humidity are high along the tropical coast. In the moat, the average maximum temperature is 31 °C (87.8 °F); the minimum is 24 °C (75.2 °F).

3.2. Sample collection and identification of beetles

Samples were collected in January 2022 to February 2022 within the moat using, beating stick and tray. Beetles larger than the aspirator were hand-picked. All insects were eutharised in a glass jar charged with ethyl acetate. Afterwards the collections were sorted accordingly and preserved in insect box for further identification.

Beetle specimens collected were dry mounted and sorted to morphospecies based on external characters and general appearance. All insects were identified to order and family after Scholtz and Holm, 2012. Wherever possible, sorted specimens were further identified to genus and/or species using available insect reference collections. A beating sheet is basically just a piece of heavy duty cloth stretched across two diagonal pieces of wood joined at the center. Collections of beetles were done by shaking or hitting the tree or its branch while holding the beating sheet. Aspirator was used to collect insects that were too small to be collected using hand. Killing jar was used to kill and hold the insects collected.

The insect species collected from each sampling site/block were pooled and their relative abundance and frequency of occurrence computed. Insect species with relative abundance (RA) ≥ 1 % and frequency of occurrence (FO) ≥ 25 % were categorized as dominant species (Dajoz, 2000, Zaime and Gautier, 1989 cited in Adja et al., 2016, Kekeunou et al., 2017).

Beetle species that did not meet the aforementioned criteria were categorized as rare species. The dominant species were then categorized based on their feeding guilds as outlined by Wardhaugh et al. (2012) and Neves *et al.* (2014). Diversity indices (Shannon's diversity index, Margalef species richness index and, Buzas and Gibson's Evenness index) were computed using the Paleontological Statistics Tool – Past3 (Hammer *et al.,* 2001).

CHAPTER FOUR RESULTS

A total of 19 samples were collected within the Benin moats. From these samples a total of 99 individual beetles were collected within Benin moat. Six beetle species were identified; they are *Monolepta bioculata, Korynetes caeruleus, Paederus fuscipes, Chaetocnema concinna, Harmonia axyridis* and *Araecerus fasciculatus* with eleven morphospecies. The most abundant beetle species found within Benin moat was *Monolepta bioculata* which was thirty two in number followed by *Korynetes caeruleus* and morphospecies A which were fourteen in number. The least abundant beetle species appeared in six species which are *Chaetocnema concinna, Araecerus fasciculatus,* morphospecies D, K, M and O, (Table 2).

In the samples (N=19), the individual species were in percentages from the highest to the least in occurrence. *Monolepta bioculata* was the highest (47.4%), *Korynetes caeruleus* (52.6%)*, Paederus fuscipe*(15.8%) *, Chaetocnema concinna* (5.3%)*, Harmonia axyridis* (21.1%) and *Araecerus fasciculatus* (5.3%), morphospecies A (31.6%) , morphospecies B (21.1%), morphospecies D (5.3%), morphospecies F (26.3%), morphospecies H (10.5%), morphospecies L (10.5%), morphospecies M (5.3%), morphospecies N (5.3%), morphospecies O (5.3%), morphospecies R (10.5%).

Table 1: Species composition per sample of beetles within Benin moat.

	Samples																		
Morphospecies	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
MSP **A**	3	0	0	2	0	3	0	4	0	0	0	0	0	1	0	1	0	0	0
MSP **B**	2	0	0	0	0	1	0	0	0	0	0	0	2	0	1	0	0	0	0
Monolepta	15	3	0	5	2	0	0	2	0	1	0	1	2	0	0	1	0	0	0
MSP **D**	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MSP **F**	0	1	0	1	0	0	0	0	2	1	0	0	0	3	0	0	0	0	0
Korynetes caeruleus	0	1	2	1	0	1	1	2	0	0	0	0	0	0	1	3	0	1	1
MSP **H**	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Paederus	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
Chaetocnema	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MSP **K**	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
MSP **L**	0	0	0	0	0	0	0	0	1	0	0	0	0	3	0	0	0	0	0
MSP **M**	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
MSP **N**	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
MSP **O**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Harmonia axyridis	0	0	2	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0
Anthribidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
MSP **R**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1

Table 2: Total taxonomic composition of Beetles within Benin moat.

Beetles (Identified and morphospecies)	**Occurrence (%of total samples, n=19)**	**Abundance of individual Beetle species**	**Total (%Relative abundance)**
MSP **A**	6(31.6)	14	14.1
MSP **B**	4(21.1)	6	6.1
Monolepta bioculata	9(47.4)	32	32.3
MSP **D**	1(5.3)	1	1
MSP **F**	5(26.3)	8	8.1
Korynetes caeruleus	10(52.6)	14	14.1
MSP **H**	2(10.5)	2	2
Paederus fuscipes	3(15.8)	4	4
Chaetocnema concinna	1(5.3)	1	1
MSP **K**	1(5.3)	1	1
MSP **L**	2(10.5)	4	4
MSP **M**	1(5.3)	1	1
MSP **N**	1(5.3)	2	2
MSP **O**	1(5.3)	1	1
Harmonia axyridis	4(21.1)	5	5.1
Araecerus fasciculatus	1(5.3)	1	1
MSP **R**	2(10.5)	2	2

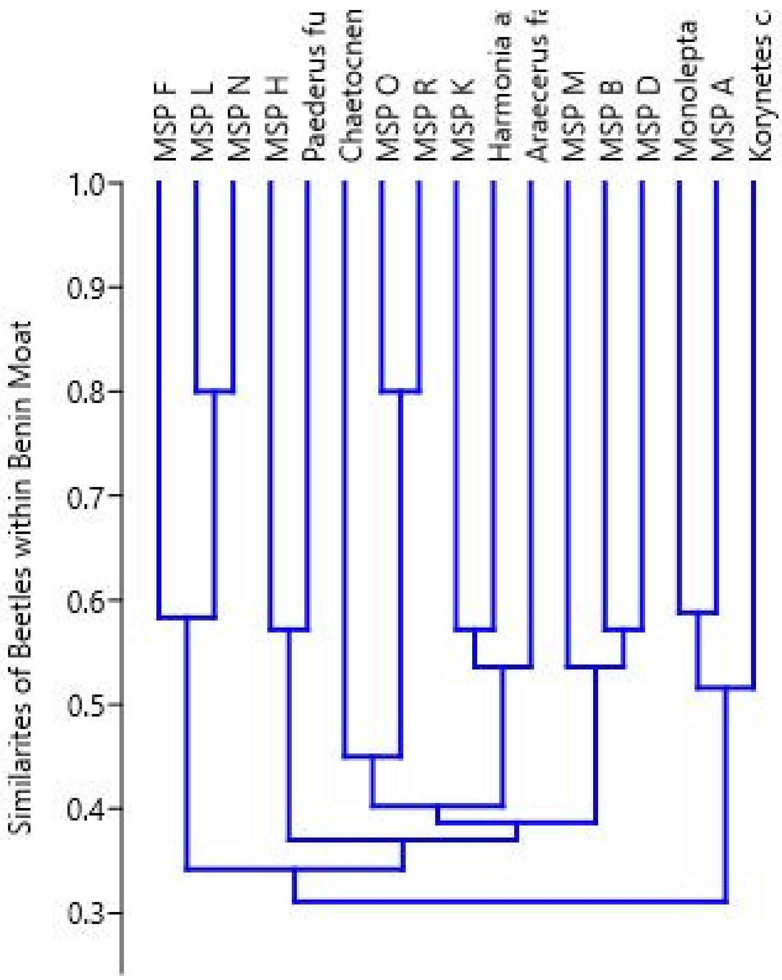

Figure 1: Dendrogram of similarities of Beetles resident within Benin moat

CHAPTER FIVE DISCUSSION

This study examined checklist, diversity and abundance of beetles within Benin.