PROTOCOL

The Vice Chancellor,
The Deputy Vice Chancellor (Development Services),
The Deputy Vice Chancellor (Management Services),
The Deputy Vice Chancellor (Academics and Research),
The Registrar,
The Bursar,
The University Librarian,
The Provost, College of Medicine,
Dean, Faculty of Science,
Deans of Other Faculties,
Members of the University Senate,
Heads of Departments,
Distinguished Academic and Professional Colleagues,
Distinguished Non-Teaching Colleagues, (Administrative and Technical),
Your Lordships (Spiritual and Temporal),
Dear Students,
Gentlemen of the Press,
Distinguished Guests, Ladies and Gentlemen.

PREAMBLE

I am grateful to Almighty God who made it possible for me to present my Inaugural Lecture at the "University of First Choice and the Nation's Pride". The University of Lagos is known for excellence in training both in academics and in morals from which I have greatly benefited by being in a network of colleagues, mentors and students. They have greatly inspired me to attain this height; making my career journey smooth despite the enormous challenges along the way.

I welcome you all to the 24th Inaugural Lecture for the Academic Session 2021/2022, the 52nd from the Faculty of Science, the 16th in the Biological Sciences and the 6th in the Department of Zoology. The topic, 'The Amazing World of Insects' emanates from the astonishing numerous characteristics, contributions and impacts of insects to life. This topic was suggested by my students from numerous topics. The word "world" in the topic means the overall life of insects that distinguishes them from other species, taking everything into account, including interaction with other life forms. Because of their uniqueness (diversity in size, form and behaviour), they are in a world of their own, and their world interacts with our world. Many of us have tasted honey; we have eaten termites and we have eaten weevils (knowingly or unknowingly) in cowpeas (beans). We can recount experiences with the ubiquitous cockroaches, not to mention the annoying bite of mosquitos and the resultant fever from the malaria disease they transmit. We have observed colourful butterflies and may have used their beautiful patterns in fashion. We may have also heard the chirping of crickets at night. We definitely have spent money buying insecticides.

The world of insects is all around us. They epitomize the phrase 'small but powerful'. They impact several decisions that we make. For example, no one wants to buy grains infested with beetles or weevils, or vegetables that have been perforated by insects. Neither would you want to live in a house infested with ants or cockroaches or bedbugs. Insects have the capacity to make or destroy an economy. An infestation of insects on a farm is capable of destroying hundreds of hectares of crops. Conversely, the greater the number of bees a honey farmer has, the better the chances of business growth.

Insects are prolific and impact all areas of our lives from the food that we eat to the disposal and or breakdown of our wastes. They are so integral to humans that they have been woven into the very fabric of our society, for example, our languages, manifesting in aphorisms and lessons about life. They serve as a testament to the interconnectivity of all things and the significance of fostering sustainable living, exemplifying the importance of preserving biodiversity. *'If you think that you're too small to make a difference, you haven't spent the night with a mosquito.'* (African Proverb).

Indeed it may be said that we live in the world of insects and not them in ours. They have whole communities and colonies, some have queens, with well-defined organisational structures and systems that have operated effectively for millennia. They are so amazing that the Bible in Proverbs 6:6-8 encourages us to learn from the ants. *‘Go to the ant, you sluggard; consider its ways and be wise! It has no commander, no overseer or ruler, yet it stores its provisions in summer and gathers its food at harvest.* Today, we will take a peep into this “**Amazing World of Insects”.**

INTRODUCTION

What is Entomology?

Entomology, derived from the Greek word "ἒντομος" (meaning "entomon"), is the scientific study of insects, including their relationship with humans, the environment, and other organisms. The term "insect" comes from the Latin word *insectum*, which means "cut up or divided into segments". It refers to the insect's body being divided into three segments: head (caput), thorax, and abdomen. The thorax contains three pairs of legs and, in most groups, two pairs of wings, although some insects are wingless. Insects possess a chitinous exoskeleton, jointed appendages (legs), and they are ectothermic (cold-blooded) animals. These characteristics are shared with other related arthropods, such as Myriapoda (centipedes and millipedes), Arachnida (spiders, harvestmen, scorpions, ticks, and mites), and Crustacea (barnacles, crabs, lobsters, crayfish, and shrimps). Together, these groups form the phylum Arthropoda (Budd and Telford, 2009; Lilholt, 2015).

A World Without Insects

Have you ever paused to contemplate the extent of our dependence on insects and envision a world without them? Let us embark on a thought-provoking journey by posing the question: What would happen if every insect were to vanish? In response, remember the Chinese proverb.

The absence of insects would lead to a collapse of all food chains within ecosystems. Producers, such as plants, capture solar energy through photosynthesis to produce food. However, it is the insects that play a crucial role in consuming plants and transferring this energy to the next trophic level. Animals that rely on insects as a food source, known as insectivores, would depend on this energy to sustain their survival. Therefore, the presence of insects is vital for supporting and maintaining the integrity of the food chains.

Can you imagine how dull life would become without having butterflies or lightning beetles to add interest and beauty to a landscape? People benefit in so many ways by sharing their world with insects. Unfortunately, most people are more aware of the few insects that cause problems than they are of the many beneficial insects. It is common to think that all insects are bad, because of the harm some of them cause on agricultural produce or the diseases some of them carry as vectors and hence in need of control. Yet this does not have to be the case. In fact, most major insect pests in agriculture are non-native species that have been introduced into a new ecosystem, usually without their biological control agents (natural enemies).

Ecosystem Service Providers

Insects are bold, shy, beautiful, ugly, good and some are bad. The good done by many insects far outweighs any bad caused by a few pest species (1% to 3%). They create the biological foundation for all terrestrial and most aquatic ecosystems. They cycle nutrients, disperse seeds, maintain soil structure and fertility, control the population of other organisms, and provide a major food source for other taxa including humans (Schowalter, 2013). Insects form the largest biomass and are prime pillars of our ecosystem. There are about 10 quintillion insects alive on our planet right now. A quintillion contains 18 zeros after one (1,000,000,000,000,000,000)! There are more than 100 million insects for every human being on earth.

Insects as Keystone Species

Some insect species are very important in the ecosystem and can be said to be keystone species because their loss (extinction) can upset the entire ecosystem function leading to its collapse. They are important as primary or secondary decomposers. Without insects to help break down and decompose organic wastes, dead animals and plants would accumulate in the environment, and this would be chaotic indeed. Burrowing insects, such as ants and beetles, dig tunnels that provide channels for water percolation, which is beneficial to plants. They also help to fertilize the soil with the nutrients from their droppings. Termites, for example, breakdown cellulose in tropical soils, suggesting that they are keystones in tropical soil structuring (Gullan and Cranston, 2005; Kemabonta and Balogun, 2014).

Pollination and Products from Insects

Insects help in the production of food that we enjoy and rely on. Ants, bees, flies, butterflies, and wasps pollinate flowers that produce fruits. About 75% of crops that produce food are pollinated by insects (Plates 1a-f). As of 2003, the total value of pollination services rendered by all insects globally was estimated to be more than $100 billion annually (Gullan and Cranston, 2005). The bees also produce honey, beeswax and other useful products.

a. Ant

b. Beetle

c. Bee

d. Butterfly

e. Fly

f. Wasp

Plates 1 (a-f): Insects as pollinators

Feeding by Insects

Insects feed on an endless array of foods. Many are omnivorous, meaning that they can eat a variety of foods including plants, fungi, dead animals, decaying organic matter and nearly anything they encounter in their environment. Still, others are specialists in their diet, which means that they may rely only on one particular plant or even one specific part of a particular plant or animal to survive. Many insects are predatory or parasitic/parasitoid, either on plants or on other animals, including humans. Such insects are important in nature to help keep pest population (insects or weeds) to a tolerable level.

Insects as rich source of Protein

Insects are often underappreciated for their role in the food web. They are the sole food source for many amphibians, reptiles, birds, and mammals. Insects themselves are harvested and eaten by people in some cultures. They are a very rich source of protein, vitamins, and minerals, and are prized as delicacies in many parts of the world (Dossey *et al.,* 2016). Among the most popular are cicadas, locusts, mantids, caterpillars, crickets, ants, black soldier flies, termites, and wasps) (Plates 2).

Plates 2: Insects consumed by humans

Raw Materials for Industries

Insects produce raw materials for industries. Silk from the cocoons of silkworm moths, *Bombyx mori* and related species have been used for fabrics for centuries. The red dye cochineal is obtained commercially from scale insects of *Dactylopius coccus* cultured on *Opuntia cacti*. Another scale insect, the lac insect *Kerria lacca*, is a source of a commercial varnish called shellac (Ude *et al.,* 2014).

Insects in Medicine

Insects have also been used in medicine. In the past. Fly larvae (maggots) were used to treat wounds to prevent or stop gangrene. Gangrene is caused by infection of dead flesh. Maggots only eat dead flesh, so when they are placed on the dead flesh of humans, they actually clean the wound and can prevent infection. Some hospitals still use this type of maggot therapy treatment (Nigam and Morgan, 2016; Mumcuoglu *et al*., 1999; Mohd *et al*., 2020).

.

Insects in DNA Studies and Others

Entomologists combine knowledge in other disciplines such as genetics to carry-out applied research. For example, taking advantage of the short generation time of the vinegar fly, *Drosophila melanogaster*, it is manipulated to understand genetic traits. Furthermore, insect groups such as Odonata (made up of damselflies and dragonflies) possess a strong fossil record for studies (Sánchez-Herrera and Ware, 2012). Odonata nymphs are beneficial to humans because they can be used by fishermen as bait for fishing and to assist in the control of aquatic insect pests (such as mosquitoes in domestic water tanks). Dragonflies, therefore, have potential health and economic values which are yet to be fully exploited (Kemabonta *et al*., 2016).

Wisdom from Insects

Insects are fascinating creatures indeed. Social insects exhibit an organised hierarchical community structure, where they cooperate and share resources among themselves without conflicts. If humans could emulate the positive aspects of these insects, which comprise approximately 98% of known insect species worldwide, I believe we could achieve a more peaceful world. Insects make our world much more interesting. Naturalists derive a great deal of satisfaction in watching ants work, bees pollinate or dragonflies patrol their environment. Do you now agree with me that without insects life will be impossible? **Amazing world of Insects.**

Some idiomatic expressions related to insects include: "The Bee's Knees," "A Social Butterfly," and "Ants in Your Pants." Additionally, there are some expressions like "The only cockroach in my cupboard that I cannot kill (love letters)" and "The only mosquito that will suck my blood and I will not kill (love letters)." Furthermore, when referring to impudence or extreme annoyance, one might say "Of all the maggots in the toilet..."

Carriers of Diseases

There are indeed numerous diseases of which insects serve as vectors. They can carry pathogens and transmit them to humans and other animals through various means. For example, mosquitoes are responsible for the transmission of malaria and dengue fever, while house flies can spread diseases such as typhoid, cholera, dysentery, and anthrax. These diseases can be highly dangerous and potentially fatal (Kalluri *et al.,* 2007).

CAREERS IN ENTOMOLOGY

Careers in entomology encompass a wide range of fields, including medical and veterinary, industrial, forest, forensic and public health. Others include beekeeping, curatorship and teaching. Within these careers, individuals can choose to specialise in any of the various areas such as vespalogy (the study of wasps), myrmecology (the study of ants), entomophagy (insect as food) and apiology (the study of bees).

In addition to these traditional areas of specialisation, emerging fields in entomology have recently gained prominence. Paleo-entomology focuses on studying insects and their interactions with pollen. Entomo-aerodynamics explores the use of insects as drones and investigates their flight mechanics. Molecular entomology combines DNA studies and bioinformatics to gain insights into the genetic makeup and characteristics of insects.

The dynamic nature of entomology as a field allows for continuous growth and exploration, with new sub-disciplines and research areas continually emerging. By embracing these diverse avenues, entomologists contribute to our understanding of insects, their ecological roles and their interactions with the world around us. **Amazing world of insects**!

MY CONTRIBUTIONS TO KNOWLEDGE

Madam Vice Chancellor, throughout the years, I have utilised insects as invaluable tools for conducting applied research in various areas of environmental sustainability. My focus has encompassed pest management, particularly in the realms of storage and public health, as well as ecology, conservation and taxonomy.

During a significant period of my career, spanning from 1990 to 2010, I dedicated 19 prime years to the Nigerian Stored Products Research Institute in Lagos. In this role, I actively promoted research on storage insects and other pests that pose risks to public health. I explored the intricate relationships between these pests, humans, the environment, and other organisms, seeking to understand their impact and develop effective management strategies.

In 2010, I embarked on a new chapter in my professional journey by joining the University of Lagos as a Lecturer I in the Department of Zoology. With gratitude to the divine, I was honoured with an appointment as a Professor of Entomology and Pest Management on October 1st 2020.

My tenure at the University of Lagos has allowed me to contribute to the field of Entomology, sharing knowledge and insights with aspiring students. As a professor, I continue to explore the fascinating world of insects, their roles in ecosystems and the development of sustainable pest management practices.

Throughout my career, I have been driven by a passion for research, the desire to advance knowledge in entomology and a commitment to environmental sustainability. I am grateful for the opportunities I have had to make meaningful contributions in the field and I look forward to continuing my journey in the pursuit of knowledge and its application for the betterment of our environment and society.

I have absolutely no regrets about pursuing my studies and teaching in the field of entomology. In fact, it brings me immense joy to engage in research, impart knowledge through teaching and mentor students. One aspect that particularly excites me is embarking on field trips to forests and parks, where I conduct insect sampling and surveys, with a focus on ants, Odonata (dragonflies and damselflies), and Lepidoptera (butterflies).

Fieldwork presents its own set of challenges, especially when working in remote areas. Inadequate telephone network coverage, poor road conditions, contaminated water and encounters with wild animals are not uncommon. However, amidst these challenges, I find solace in the serene and peaceful environment, free from air pollution and phone calls! Over time, I learned to adapt quickly to such situations and I genuinely relish my time spent with colleagues and students (as a family) in these locations.

During field expeditions with colleagues and students, we often find ourselves immersed in dense forests for several days, working alongside rangers and sampling insects. It is during these moments that unexpected discoveries occur. For instance, while conducting research in the Okomu National Park in Edo State, our team had the extraordinary opportunity to encounter an elephant that a Ph.D. student at the Department of Zoology, University of Lagos had been seeking. The elephant, rather than attacking us, expressed its annoyance by warning us repeatedly before eventually turning around to leave the area (Plate 3). This incident served as a remarkable reminder of the unpredictable nature of fieldwork.

Following this extraordinary encounter, we departed for Lagos the following day, reflecting on the memorable experiences and lessons learned during our time in the field.

I consider myself fortunate to have embarked on this entomological journey, where I have embraced both the joys and challenges of research, teaching and fieldwork. It is through these experiences that I continue to grow both personally and professionally, cherishing the moments shared with colleagues and students, as well as the remarkable encounters with nature.

Plate 3: Photos from field work, including Forest Elephant (*Loxodonta cyclotis*) sighted for the first time in Okomu National Park

Madam Vice Chancellor, permit me to mention some of my contributions to knowledge in different areas of Applied Entomology, Pest Management and Ecotoxicology (Environmental Sustainability).

1. BIOLOGICAL CONTROL USING INSECTS

Ladybird Beetle (*Cheilomenes lunata*) and Cowpea Aphid (*Aphis craccivora*)

Early in my career, during my first degree, I conducted a study on the life cycle of the ladybird beetle, *Cheilomenes lunata* (Fab), with a focus on its potential as a biocontrol agent for the cowpea aphid, *Aphis craccivora* (Koch) (Plates 4a-b) (Odebiyi and Kemabonta, 2006).

All stages of the ladybird beetle exhibited predatory behaviour, effectively reducing the population of the prey species. The predator had a longer lifespan compared to the prey and continued to lay eggs, ensuring a sustainable food supply for the newly hatched larvae of the predator.

Furthermore, we observed that except for the pupal stage, all life stages of the ladybird beetle actively engaged in predation, leading to a further decrease in the population of the prey species. Based on these findings, we concluded that practical steps should be taken to educate and raise awareness among local farmers about the significance of preserving and appreciating the presence of ladybird beetle as a predator on their farms, especially during insecticide applications.

We recommended that during periods of pest outbreaks, mass rearing and releasing of the ladybird beetle could prove to be a profitable strategy. This approach would help augment the natural population of the predator and contribute to pest control efforts. Additionally, the ladybird beetle can serve as a valuable component of Integrated Pest Management (IPM) strategies for aphid-infested farms.

a. Ladybird beetle (*Cheilomenes lunata*), Fab

b. Cowpea aphid (*Aphis craccivora*), Koch

Plates 4 (a-b): Ladybird beetle (*Cheilomenes lunata*) and Cowpea Aphid (*Aphis craccivora*)

Mango Mealybug (*Rastrococcus invadens*) and *Gyranusoidea tebyg*i

The mango mealybug, *Rastrococcus invadens*, originally originated from the oriental region (Williams 1986). However, it was unintentionally introduced into West Africa between 1981 and 1982, where it quickly established itself as a significant pest on various fruit trees, including the mango *Mangifera indica* (Anacardiaceae). The spread of this mealybug was rapid, reaching Ghana and Togo in 1986. It further expanded to Côte d'Ivoire, Nigeria, and Zaire (currently the Democratic Republic of Congo) in 1989 (Moore, 2004).

The mango mealybug was considered the most potentially dangerous pest and the second significant new threat to horticulture in Nigeria. Despite efforts to control *R. invadens* using cultural, mechanical and chemical methods, these approaches proved ineffective due to the pest's ability to feed on a wide range of host plants and its rapid re-infestation of trees. Additionally, the fact that it predominantly infests the adaxial side of the leaf makes chemical control methods challenging.

In response to this pest outbreak, *Gyranusoidea tebygi* (Noyes), an exotic parasitoid of *R. invadens*, was released from its country of origin. Little was known about the host, *R. invadens*, and its newly introduced parasitoid, *G. tebygi* at that time. Consequently, a survey was designed to investigate its distribution and its biological control agent, *G. tebygi*, at the University of Ibadan campus in Oyo State, Nigeria. This research aimed to gather valuable information about the presence and interactions of these organisms in order to develop effective management strategies for the mealybug (Kemabonta and Odebiyi, 2001; Kemabonta and Odebiyi, 2002; Kemabonta and Odebiyi, 2003). Our goals were:

- determine the abundance and distribution of *R. invadens*
- examine the development, survival and fecundity of *R. invadens* on four of its major host plants: *Mangifera indica* (mango), *Plumeria sp*. (Frangipani), *Citrus sp.* (Citrus plant) and *Ficus sp.* (Ficus) in Nigeria.
- study the life table of the parasitoid, *G. tebygi*, and its host, *R. invadens*, at five constant temperatures.
- compare the life table parameters of the host, *R. invadens*, and that of the parasitoid, *G. tebygi*, so as to assess the effectiveness of the latter as a parasitoid on the former.
- determine the relationship between *G. tebygi* and its host *R. invadens* so as to provide baseline data to assess its suitability as a biological control agent.

Initially, plant infestations by mealybugs at the University of Ibadan campus were limited to eight sites. However, within two years, the infestation had spread to more than 32 sites. This rapid spread was likely facilitated by the movement of horticultural plants within the campus by groundsmen responsible for maintaining the University's lawns and residential areas throughout the year.

G. tebygi, the parasitoid released for biological control was recovered from sites far away from the initial release location within just two months. As the survey progressed, there was a noticeable decrease in the degree of mealybug infestation during the second year. This decline could be attributed to the activities of *G. tebygi*, which proved to be an effective natural enemy of the mealybug, *R. invadens*.

Within one year of its release, *G. tebygi* successfully established itself at the University of Ibadan campus and spread throughout the areas infested by *R. invadens*. Despite facing attacks from two hyperparasitoids, *G. tebygi* displayed strong control over the mealybug population.

The research findings indicated that *G. tebygi* was a primary, solitary, arrhenotokous and monoembryonic endoparasite which exhibited a higher intrinsic rate of increase and a faster developmental rate compared to *R. invadens* across all temperatures studied. Moreover, after two years, *G. tebygi* not only persisted and increased in number relative to its host but also effectively controlled *R. invadens*. The consistent presence of the parasitoid and the synchronized population fluctuations between *G. tebygi* and its mealybug host indicated a stable relationship between them.

Moreover, the reduction in the level and intensity of pest outbreaks provided clear evidence of the effectiveness of *G. tebygi* in controlling the mealybug population. Based on these findings, *G. tebygi* proved to be a highly effective biological control agent against *R. invadens*.

2. FOOD SECURITY: PROTECTING AND PREVENTING INSECT PESTS FROM STORED FOODS

It has been estimated that insects cause huge losses of grains (20 to 50%) especially in developing countries because of their feeding and reproductive activity (Eesiah *et al.*, 2022). These losses can be classified into quality, weight, germinability, nutritional and commercial losses (Boxall, 2001; Kumar and Kalita, 2017). Plate 5 shows the pictures of insect pests on stored products my team have worked on (Kemabonta and Okogbue, 2002; Kemabonta and Okoye, 2004; Kemabonta and Odebiyi, 2005; Kemabonta *et al*., 2009; Makanjuola *et al.,* 2009; Anikwe *et al*., 2009; Kemabonta, and Anikwe, 2010; Kemabonta *et al*., 2010; Sadiku *et al.,* 2016; Kemabonta *et al*., 2017; Sadiku *et al.,* 2017; Babarinde *et al*., 2018; Sadiku *et al.,* 2019).

Rice weevil, *Sitophilus oryzae* (Linnaeus)

Maize weevil, *Sitophilus zeamais* (Motschulsky)

Kola Nut weevil, *Balanogastris kolae* (Desbrochers)

Cowpea Beetle, *Callosobruchus maculatus* (Fabricius)

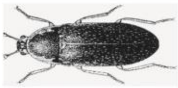
Grain Beetle, *Ahazerus advena* (Walti)

Flat Grain Beetle, *Cryptolestes ferrugineus* (Stephens)

Sawtoothed Grain Beetle, *Oryzaephilus surinamensis* (Linnaeus)

Merchant Grain Beetle, *Oryzaephilus mercator* (Fauvel)

Cigarette Beetle, *Lasioderma serricorne* (Fabricius)



Hide Beetle, *Dermestes maculatus* (De Geer)

Red Flour Beetle, *Tribolium castaneum* (Herbst)

Confused Flour Beetle, *Tribolium confusum* (Herbst)

The Larger Grain Borer, *Prostephanus truncatus* (Horn)

The Lesser Grain Borer, *Rhyzopertha dominica* (Fabricius)

Psocid, *Liposcelis bostrychophila* (Enderlein)

Psocid, *Liposcelis entomophila* (Enderlein)

Indianmeal Moth, *Plodia interpunctella* (Hubner)

Angoumois Grain Moth, *Sitotroga cerealella* (Olivier)

Grain Mite *Cheyletus malaccensis* (Ouds)

Plates 5: The stored Products insect pests I worked on (Mag x200) (CABI, 2021)

2.1 Molecular Identification, Genetic Diversity and Population Structure of Insect Pests and Mites Associated with Rice in Nigeria (Ezeobiora *et al*., 2021; Ezeobiora *et al*., 2023a; 2023b).

Rice holds a position of immense importance as the world's most vital staple food crop being consumed by more than half of the global population (Awika, 2021; Singh *et al*., 2021). However, the infestation of rice products by insect pests can result in significant quantitative and qualitative damage. Therefore, the accurate identification of insect pests associated with stored rice is crucial for effective management strategies. In Nigeria, there is a lack of molecular characterisation data for many stored product insect pests. To address this gap, my research team conducted an evaluation of molecular identification, genetic diversity, and population structure of insect pests and mites associated with rice in Nigeria.

For the study, we randomly selected fourteen (14) towns in Nigeria. From each town, we collected 1kg of both imported and local rice grains from three (3) different vendors in the local markets, totalling three markets per town. Insects were collected from the rice samples, and nucleic acids were extracted from these specimens. We amplified the partial mitochondrial cytochrome oxidase subunit 1 (mtCOI) gene using specific primers. We subsequently purified and sequenced the obtained DNA following standard procedures.

In total, we obtained 5,601 insects and mites belonging to four (4) insect orders, nine (9) families, and twelve (12) species from both local and imported stored rice samples across Nigeria (Figures 1a-d). Notably, *Cheyletus malaccensis, Liposcelis bostrychophila, Liposcelis entomophila* and *Liposcelididae spp.* were recorded for the first time on stored rice in Nigeria while *Sitophilus oryzae* exhibited the highest relative abundance. The rice samples from Lagos and Ife showed the highest species diversity, whereas those from Makurdi and Birnin-Kebbi had the lowest insect diversity while only psocids were recorded in Benin-Kebbi and Sokoto.

Through DNA analysis, we identified nine (9) species from three (3) orders, with the sequenced fragments ranging from 392 to 683 base pairs. The obtained sequences were assigned GenBank accession numbers **MW727984 to MW728049 and MZ293795 to MZ293796,** with three (3) species being newly identified in Nigeria. Our findings revealed low genetic diversity within the insect pests associated with stored rice in Nigeria, irrespective of species or orders, although higher genetic variability was observed in populations of *Cheyletus malaccensis* and *Ahasverus advena*.

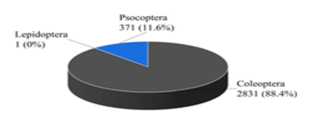
Furthermore, we observed higher mutation rates in *A. advena* and *L. bostrychophila* when compared to other insect populations. Most of the insect pests of stored rice formed monophyletic groups with isolates from other parts of the world. However, populations of *Rhyzopertha dominica* and *Oryzaephilus mercator* clustered into two (2) distinct groups, while *A. advena* populations displayed three (3) separate clusters, indicating diverse evolutionary relationships (Figures 2a-b). There was low-frequency polymorphism across all insect populations except in *A. advena*. Populations of *L. bostrychophila* had the highest haplotypes while haplotypes from *C. malaccensis* and *A. advena* were evenly distributed across the populations (Figures 3a-d). Putative origins of most of the insect populations were India and China while others were from Germany, USA and France (Table 1).

In their work, Lale and Yusuf (2000) hypothesized the presence of *Liposcelis bostrychophila* in stored millet from Northeastern Nigeria but this study represents the first definitive identification, molecular description and characterisation of the species in Nigeria. Furthermore, this study also reveals the first identification of *Liposcelis entomophila* and an unclassified Liposcelididae species in stored rice grains in Nigeria. Additional investigations are needed to determine the taxonomy of the unclassified psocid species.

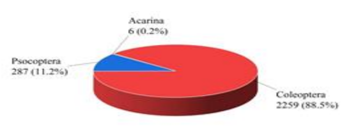
To the best of our knowledge, this is the first molecular description of *Ahasverus advena* in Africa and the sequences obtained from this study are the first publicly available from the continent. This information is crucial for the effective management of the insect. As Nigeria is Africa's most populous country, it is imperative to mitigate the impact of *A. advena* through accurate identity and knowledge of its diversity. The study reveals a high genetic diversity within insect pests of stored rice in Nigeria, regardless of species or orders. *A. advena* demonstrated particularly high genetic diversity within its populations, suggesting the possibility of cryptic species within the Nigerian *advena* population. Further investigation and evaluation of larger putative populations of *A. advena* are required to confirm this hypothesis. The study focused on analysing the partial mtCOI gene of the three psocid species found in stored rice grains, adding to the genetic information available for insect pest species associated with stored grains.

Table 1: Putative origins of insect and mite pests associated with rice in Nigeria

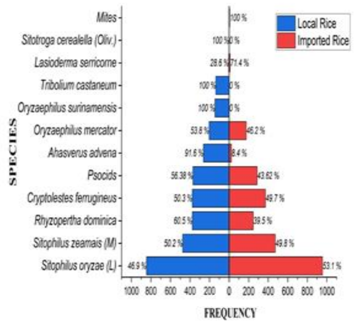
Scientific name	**Country of origin**
Rhyzopertha dominica	India
Liposcelis bostrychophila	India, China
Liposcelis entomophila	China
Liposcelididae sp.	India
Oryzaephilus mercator	USA, India
Oryzaephilus surinamensis	India, France
Cheyletus malaccensis	China
Lasioderma serricorne	USA, India
Ahasverus advena	Germany



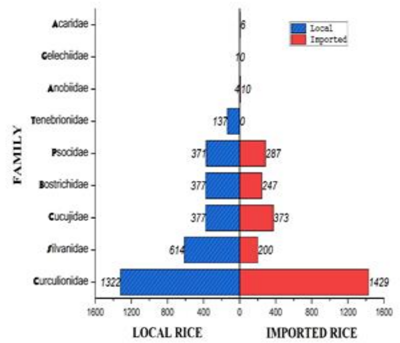
a. Insect orders collected in local rice across different sampling locations



b. Insect orders collected in imported rice across different sampling locations

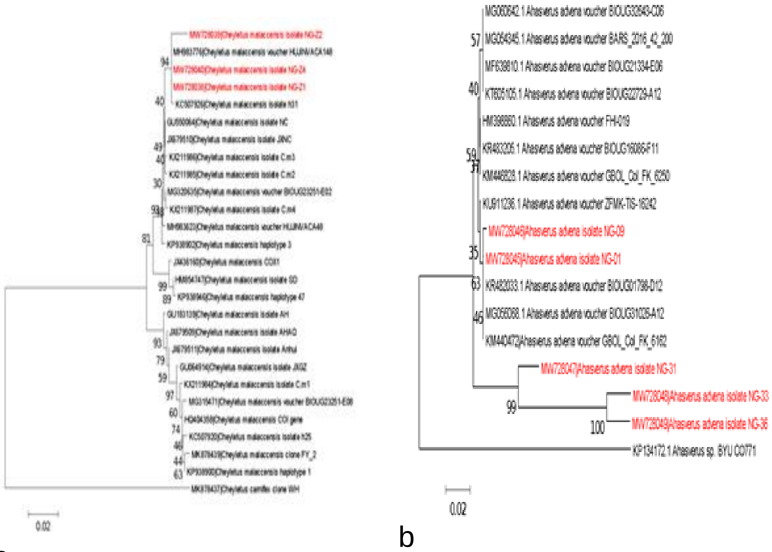


c. Distribution of insect pests in local and imported rice grains



d. Distribution of insect families in local and imported rice grains

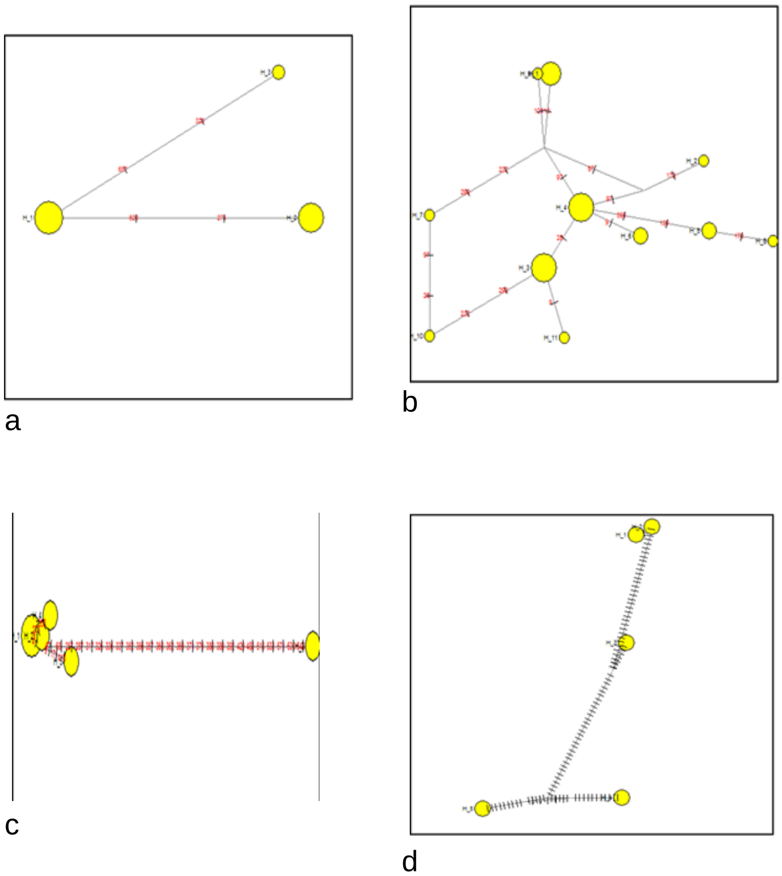
Figures 1 (a-d): *Insects species from both local and imported stored rice samples across Nigeria*



a b

Figures 2 (a-b): *Phylogenetic tree showing evolutionary relationships of the three Cheyletus malaccensis (A) and five Ahasverus advena (B) populations from rice grains in Nigeria (in red) with other worldwide isolates based on the partial cytochrome oxidase subunit 1 (CO1) gene*

The tree was inferred using the neighbour-joining algorithms on MEGA v6.06. Numbers at tree nodes represent bootstrap percentages based on 1,000 replicates. The scale bar shows the number of nucleotide substitutions per site.



Figures 3 (a-d): *Median-joining network of Rhyzopertha dominica (a), Liposcelis bostrychophila (b), Oryzaephilus mercator (c), and Ahasverus advena populations based on the haplotypes of the single gene from the partial mitochondrial cytochrome oxidase subunit 1(d)*

2.2 Control of Stored Product Insect Pest Using Biorational Pesticides

Synthetic insecticides used for controlling stored product pests have raised significant concerns in public health and agriculture. Their effective yet excessive use has led to pest resistance, environmental degradation, harm to non-target organisms, pesticide residues in food, pest resurgence, genetic variation in plants, and negative impacts on biodiversity (Stejskal *et al.,* 2021). In response, the use of "biorational" pesticides is advocated. These pest control materials are relatively non-toxic to humans, have minimal environmental side effects, and align well with Integrated Pest Management (IPM) strategies. By prioritising early pest detection and selective product usage, biorational pesticides preserve ecological health, minimise harm to beneficial insects and provide guidance for decision-making. Biorational pesticides that have been used by our team include:

a. Diatomaceous Earth (Mineral-Based Pesticides)

Diatomaceous earth is composed of fossilized remains of single-celled algae called diatoms and is an inert dust. It is highly effective as a natural insecticide, particularly against insects with setaceous and rough surfaces. When diatomaceous earth comes into contact with insects, it damages the protective wax coating on the cuticle through adsorption or, to a lesser extent, abrasion. As a result, the insects experience desiccation, leading to death due to the loss of moisture from their bodies (Korunic, 1998; Korunic *et al.,* 2016). Table 2 provides a summary of the research study conducted on the use of diatomaceous earth (Kemabonta and Anikwe, 2010; Nwanade *et al.,* 2020).

Table 2: Use of diatomaceous earth (DE) to control stored insect pests

Name of Insect	**Pesticide Used**	**Results**	**References**
Callosobruchus maculatus (Fab) Coleoptera: Chrysomelidae	Diatomaceous earth (DE) (ProtectIt®)	Diatomaceous Earth (DE) is ovicidal, reduces oviposition, or prevents the development of the eggs to the adult stage and reduces the longevity of emerged adults. It can be recommended for control of *C. maculatus* in storage devices in Nigeria at 1.5g/ kg.	Kemabonta and Anikwe (2010)
Sitophilus zeamais (Motsh) Coleoptera: Curculionidae	Diatomaceous earth, Spinosad and K Obiol powders	Spinosad showed some insecticidal efficacy against *S. zeamais* on storage than Diatomaceous Earth and K Obiol powders.	Nwanade *et al.,* 2020

b. Spinosad (Microbial Pesticides of Bacteria Origin)
Spinosad is a naturally derived insecticide that is obtained through the fermentation process of a soil bacterium called *Saccharopolyspora spinosa,* specifically an actinomycete. It acts as a neurotoxin by targeting postsynaptic nicotinic acetylcholine and GABA receptors, leading to symptoms such as tremors, paralysis and ultimately, death in insects. Table 3 provides a summary of the research study conducted on spinosad and its effects on insects (Anikwe *et al.,* 2009; Babarinde *et al.,* 2018; Kemabonta *et al.,* 2009; Kemabonta *et al.,* 2013)

Table 3: Effect of spinosad on some storage insect pests

Name of Insect	Pesticide Used	Results	References
Balanogastris kolae (Desbr) Coleoptera: Curculionidae	Spintor dust (0.125% spinosad), Phostoxin, Gammalin 20, and 'Alum	Spintor dust applied at three different concentrations did not taint kola nuts. No off – flavor taste was felt on treated nuts as the insecticide was found to be odorless and tasteless. It also compared well in its efficacy and residuality to Gammalin – 20. Farmers could exploit the insecticidal properties of Spintor dust for improved kolanut production coupled with the fact that the insecticide has low acute toxicity even on rats.	Anikwe *et al.,* 2009, Kemabonta *et al.,* 2009
Dermestes maculatus (De geer) Coleoptera: Dermestidae	SpinTor™ dust	SpinTor dust was effective in rotecting dried *Tilapia iloticus* from *D. maculatus* ıfestation at the 0.5% eatment while the 0.25 and .125% treatments were not s effective as 0.5% in reventing infestation of *D. ıaculatus* on dried *T. iloticus*. SpinTor™ dust did ot affect the emergence of ıe larvae since over 90% of ıe introduced larvae in the eated fish successfully merged into F1 adults.	Kemabonta *et al.,* 2013a

Tribolium castaneum (Herbst) Coleoptera: Tenebrionidae	Spinosad with three Nigerian spices	The combination of spinosad with *P. guineense* powder or *E. aromatica* powder performed better than the combination with *A. melegueta* powder and is therefore recommended as a biorational approach for the control of *T. castaneum.*	Babarinde *et al.,* 2018

c. Plant Products (Botanicals and Essential Oils) Botanical pesticides are chemical derivatives naturally occurring in plants that possess various properties such as repellency, attraction, antifeedant, and growth inhibition. When these compounds are extracted using suitable solvents and mixed with necessary pesticide adjuvants, they transform into botanical pesticides. These pesticides have been extensively used for the prevention and control of insect pests in stored products and those of health significance. Notably, botanical pesticides offer advantages such as wide availability, affordability, accessibility, rapid degradation, and low toxicity to beneficial organisms. Table 4 provides a summary of some of the research studies conducted on plant-based extracts and their effects on storage insects (Kemabonta and Okogbue, 2002; Kemabonta and Okoye, 2004; Kemabonta and Falodu, 2013; Babarinde *et al.,* 2021).

Table 4: Plant-based extracts and their effects on storage insect pests

Name of Insect	Pesticide Used	Results	References
Callosobruchus maculatus (Fab) Coleoptera: Chrysomelidae	*Chenopodium ambrosioides* (Chenopodiaceae)	Extracts of *C. ambrosioides* were ovicidal to treated eggs and positively toxic on *C. maculatus* adult	Kemabonta and Okogbue (2002)
*Rhyzopertha dominica (*Fab) Coleoptera: Bostrichidae and *Sitophilus zeamais* (Motsh) Coleoptera: Curculionidae	*Syzygium aromaticum* and *Xylopia aethiopica*	Powder of *S. aromaticum* is significantly more effective than *X ethiopica* in controlling two major stored product pests *Rhyzopertha dominica (*Fab) and *Sitophilus zeamais* (Motsh) in maize grains	Kemabonta and Okoye (2004)
Sitophilus oryzae Coleoptera: Curculionidae	*Azadirachta indica, Anacardium occidentale* and *Moringa oleifera* seeds	Powders and oils of *A. indica, A. occidentale* and *M. oleifera* seeds were toxic and suppressed the development of *S. oryzae* in all treated stored wheat grains.	Kemabonta and Falodu, 2013

Tribolium castaneum Coleoptera: Tenebrionidae	Rough lemon (*Citrus jambhiri* Lush.)	*C. jambhiri* fruit rind essential oil (EO) was an effective toxicant against *T. castaneum*. With 51 identified chemical compounds in the EO, the tendency of *T. castaneum* to develop resistance against the EO is low. Since *C. jambhiri* rind is often thrown away after peeling, the results of this research have established the potential of waste product of *C. jambhiri* in the pest control segment.	Babarinde *et al.,* 2021

d. Diflubenzuron (Insect Growth Regulators)

Insect Growth Regulators (IGRs) disrupt the regular growth and development of insects, ultimately leading to their mortality prior to reaching the adult stage. IGRs belong to the Benzoyl urea family and act by inhibiting the synthesis of chitin, which is a key component of the insect's exoskeleton. Table 5 provides a summary of some of the research studies conducted on insect growth regulators (IGRs) and their effects on stored product insects (Kemabonta and Odebiyi, 2005; Kemabonta *et al.,* 2010).

Table 5: Insect Growth Regulators (IGRs) on stored insect pests

Name of Insect	**Pesticide Used**	**Results**	**References**
Callosobruchus maculatus (Fab) Coleoptera: Chrysomelidae	Diflubenzuron	Diflubenzuron was found to be ovicidal, larvicidal, reduced oviposition and longevity of adult *C. maculatus*	Kemabonta and Odebiyi (2005)
Callosobruchus maculatus (Fab) Coleoptera: Chrysomelidae	Diflubenzuron	Diflubenzuron suppressed the build-up of *C. maculatus* population by 97 percent and reduced seed damage by 95 percent with a single application of diflubenzuron for at least 3 months. The subtle increase in population that became noticeable after the 4th month in treated seeds indicates that more than one application may be necessary to keep cowpea from reinfestation for a longer period.	Kemabonta *et al.,* 2010

e. Cigarette Beetle, *Lasioderma serricorne* (Fabricius, 1792) An Invasive Insect Pest of Stored Products

The cigarette beetle, *Lasioderma serricorne* (Fabricius, 1792) is a member of the Anobiidae family. It is a small, about 2 to 3 mm and reddish-brown beetle that looks like the drugstore beetle but it is lighter in color and lacks pitted lines on its wing cover. It is widely distributed throughout the world because of its ability to adapt to a wide range of food commodities. (Cabrera, 2002). The cigarette beetle is considered a pest of economic importance in most regions, including tropical and subtropical areas. It is an important insect pest of tobacco, food processing and distribution facilities. In addition, it is an insect pest of flour and other food products stored in kitchen cabinets and other areas in the house. It can also infest non-food products, including drugs, pills, dried plants, and herbarium specimens (Cabrera, 2002). Table 6 shows some of the research work carried out on Cigarette beetle, *Lasioderma serricorne* (Kemabonta *et al.,* 2017a; 2017b; Kemabonta *et al.,* 2020a).

Table 6: Cigarette beetle (*Lasioderma serricorne)* as an invasive insect of stored product

WHAT WAS DONE	FOOD TYPE	SUMMARY OF RESULTS	REFERENCES
Infestation and development of *Lasioderma serricone*	Rice, Millet, cowpea, guinea corn	The insect developed on all grains. Millet was the most susceptible among the other grains and had the least developmental period, and highest Fi adult emergence when compared to other grains studied	Kemabonta *et al.,* 2017
Control of *L serricorne* using five different spices.	Ginger, Turmeric, Cinnamon, Garlic and Pepper.	*P. nigrum, Cinnamon cassia* completely prevented the development and emergence of F1 adults. Ginger gave the highest number of emerged adults and therefore has little or no effect on *L serricorne.*	Kemabonta *et al.,* 2017
Food preference of the Cigarette beetle (*Lasioderma serricone)*	Plantain chips, yam chips, yam flour, cassava flour and baked cassava flakes (Yoruba Garri).	Cassava flakes (Yoruba garri) did not support the growth and development of *Lasioderma serricorne*, while plantain chips significantly promoted the growth and development of its growth.	Kemabonta *et al.,* 2020

2.3 Control of Insects Pest of Health Importance

Public health insects, also known as insect vectors, are insects that play a significant role in the transmission of diseases to humans. These insects act as carriers or vectors for various pathogens, including bacteria, viruses, and parasites, which can cause diseases such as malaria, dengue fever, Zika virus, and Lyme disease. Controlling and managing these insects is crucial for protecting public health.

Table 7 (a-b) gives a summary of some of the research studies carried out using biorational pesticides (7a) and conventional pesticides (7b) in the control of public health insects (Anikwe *et al.,* 2014; Kemabonta and Akinhanmi, 2013; Kemabonta and Nwankwo, 2013; Kemabonta *et al.,* 2013; Kemabonta *et al.,* 2014; Kemabonta and Amadi, 2014; Kemabonta and Ajiboye, 2018; Kemabonta *et al.,* 2018a).

Table 7 (a-b): Public health insects' control using biorational pesticides and conventional pesticides

7a. Biorational pesticides

Anopheles gambiae (Giles) and *Aedes aegypti* (Linnaeus) Diptera: Culicidae	Spinosad and Temephos	Temephos granules and a suspension concentrate formulation of spinosad were both highly effective larvicides when used singly and not jointly against *Aedes aegypti and Anopheles gambiae.* Spinosad and Temephos should therefore be used singly rather than jointly.	Kemabonta and Nwankwo (2013)
	Skeetar Abate and Spintor Dust	Skeetar Abate and Spintor Dust were both effective when used jointly against *Aedes aegypti and Anopheles gambiae.*	Kemabonta *et al.,* 2013b

Anopheles gambiae (Giles) Diptera: Culicidae	*Lantana camara*	The crude extracts from *L. camara* leaf powder showed effective larvicidal, adulticidal and repellency activity in the control of the larvae of *An. Gambiae*	Kemabonta *et al.,* 2014a
Anopheles gambiae (Giles) Diptera: Culicidae	*Piper nigrum* and *Curcuma longa*	Extracts of *P. nigrum* and *C. longa* showed strong toxicity and repellent activities against *An. gambiae* larvae and adults at varied concentrations.	Kemabonta *et al.,* 2018a

7b. Conventional pesticides

Adult albino mice, *Mus musculus* (Rodent)	Chlorpyrifos, Dichlorvos, and Alpha Cypermetrin	The pesticides caused depletion in sperm motility and an increase in the number of abnormal sperm cells in the exposed mice, which is an indication of infertility. The health implications of these abnormalities can be threatening and can affect the well-being of humans exposed to inhalation of pesticides for a long time.	Kemabonta and Akinhanmi (2013)
Periplaneta americana and *Blattella germanica*	Indoxacarb Gel Bait	Advion 0.6% indoxacarb gel bait was toxic and highly effective in the control of common domiciliary cockroaches (*P. americana and B. germanica*) in Nigeria.	Anikwe *et al.,* 2014
Blattella germanica (German Cockroach)	Deltamethrin and Chlorpyrifos	The study showed that Chlorpyrifos was more effective than Deltamethrin at the concentrations used in the control of the German cockroach.	Kemabonta *et al.,* 2014b

Blattella germanica (German cockroach) Blattodea (Blattellidae)	Sniper and Alpha Cypermethrin	Sniper and Alpha Cypermethrin were found to be effective in the control of *B. germanica*. Sniper, however, was more effective than Alpha Cypermethrin	Kemabonta and Amadi (2014)

Due to their positive impacts on environmental preservation, low toxicity to mammals, and low risk of developing resistance in target pests, biorational pesticides can be used as valuable tools for Integrated Pest and Vector Management (IPM and IVM). They can serve as alternative approaches to pest control

3. ODONATA AS BIOINDICATORS AND BIOMONITORS OF ECOLOGICAL HEALTH

Dragonflies and damselflies (Odonata) are found in freshwater ecosystems worldwide and their nymphs play a crucial role in energy flow and nutrient cycling across trophic levels. Adults are aerial predators, while nymphs (naiads) are aquatic predators. Nymphs contribute to controlling mosquito populations in open water tanks and domestic water containers. These species are sensitive to pollution and habitat disturbance, making them valuable bioindicator species for assessing the impact of climate change on wetlands, rivers, streams, riparian forests and lake shores globally. Furthermore, as bioaccumulators, they can assist in detecting toxins in ecosystems, even when present in low concentrations (Kemabonta *et al*., 2020a).

In Nigeria, the knowledge of Odonata fauna is relatively limited compared to other countries such as South Africa. Therefore, conducting a biodiversity survey of the country was essential and my research team aimed to address this gap. Nigeria, as a whole, has not been systematically surveyed and may serve as a habitat for threatened and relict Odonata species. The country's forests and their biodiversity face threats of extermination from agriculture and rapid urbanisation. Despite some species earlier listed for the country, no comprehensive survey of the country has been conducted.

Our group planned to establish a collection of Dragonfly specimens that would support further research on the entire Nigerian Odonata fauna (Figure 4). Additionally, we aimed to describe new species, develop identification keys and create a database for future studies on the ecology, taxonomy, and conservation of dragonflies in Nigeria. Categorising species according to IUCN Red Listing was another important aspect of our research.

The areas surveyed by our team, along with collaborators from the Netherlands, Germany, and South Africa, included Okomu, Omo National Forests, Cross River Forests, Parks and Estates in Lagos, Natural History Museums in Nigeria, as well as streams and rivers in various higher institutions across Lagos, Oyo, Osun, and Ondo States (Adu *et al.,* 2015; Adu *et al.,* 2016a; 2016b; 2016c; Kemabonta *et al.,* 2016; Zakka *et al.,* 2017; Kemabonta *et al.,* 2018; Omoloye and Kemabonta, 2019; Kemabonta and Adu, 2019; Essien and Kemabonta, 2019; Kemabonta and Ogbogu, 2019; Kemabonta *et al.,* 2019a; 2019b; Alafia and Kemabonta, 2019; Ekpah *et al*., 2020a; 2020b; Kemabonta *et al.,* 2020a; 2020b; Ekpah *et al*., 2021).

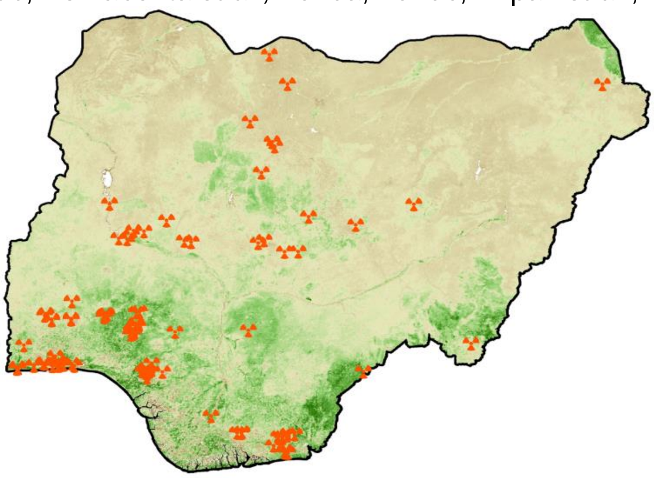


Figure 4: *Odonate Surveyed Areas in Nigeria by the Team (Including Museum samples)*

Madam Vice Chancellor**,** our research efforts have led to the identification of over 350 species from 104 genera and 16

Families. (Table 8, Figures 5a-b). Remarkable discoveries have been made during our fieldwork, including the use of Odonata as indicators of ecological health in locations such as the Lekki Conservation Centre, LUFASI, and Omu Resort in Lagos. It was observed that disturbed areas exhibited a low abundance of stenotopic Odonata species. In the case of the University of Ibadan, Oyo State, it was found that the water bodies had become increasingly polluted, leading to the disappearance of many stenotopic species associated with clean waters over a period of 40 years (Figure 6).

During our sampling, we found exceptionally clean waters in Cross Rivers, showcasing a specific range of species, while Lagos State displayed a higher abundance of dirty, organic, and polluted waters compared to other freshwater sources surveyed. Interestingly, our international colleagues who joined us during the survey of Cross River forests water directly from the rivers/streams, despite the need to boil or purchase bottled water, as they discovered members of the family Lestidae, Perilestidae, Megapodagrionidae and Amphipterygidae naiads and adult dragonflies in the Oron river (Plates 6a-i).

Although Lagos State with a total of 279 (26.1%) Odonate species had the most studied sites (10), Ondo State with 295 (27.6%) species from 7 sites had the highest Odonata species diversity. Study in Lagos was for one year while that of Ondo State was more than 3years. Ondo State may therefore be considered an Important Odonata Area (IOA). An area of conservation priority was Cross River State 180 (16.9%) where Oban Hills, Afi Mountains and Obudu were sampled for less than one month. Although the Odonata Diversity was less compared to Lagos and Ondo States, Ekpah *et al.,* (2020) reported rare species of Odonata from the area (Fig. 6). The members of the Libellulidae family were more abundant during the study (Fig. 5a). Orthetrum species, for example, were found in all sites (Figure 7).

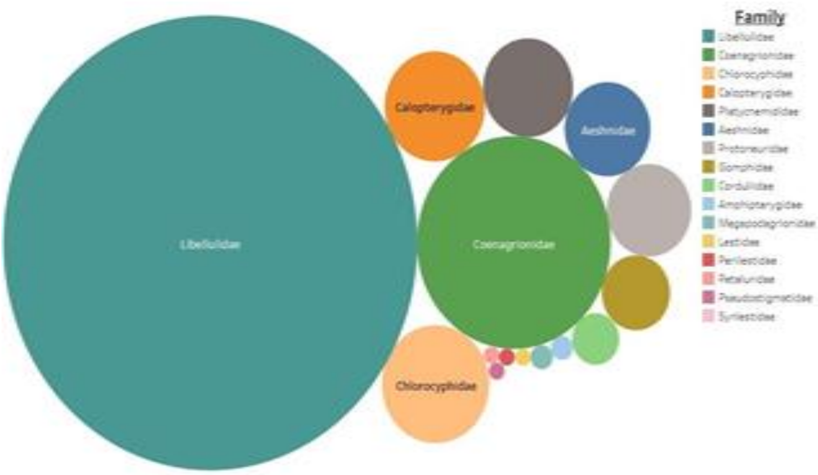
A significant accomplishment was the rediscovery of the endangered *Ceriagrion citrinum* Campion, 48 years after, in Igele Sunmoge village, Nigeria. The ecological characteristics of this species were described, highlighting the importance of Igele Sunmoge village as a Dragonfly hotspot and a conservation priority due to the presence of the endangered *C. citrinum* (Ekpah *et al.,* 2021) (Fig 6a).

Our research outputs included an Odonata checklist encompassing all reliably recorded species in Nigeria, as well as the establishment of a Citizen Science platform for nature enthusiasts and a network of local and international experts focused on Odonata. This forum facilitates the exchange of information, ideas, and mentorship support. We have also digitized nearly 7,000 individuals of Odonate species in the GBIF database. Molecular characterisation of unidentified species is currently underway and it is hoped that new species may be discovered through this process. According to the IUCN Red list categories for Nigeria, 2, 3 and 8 species are Critically Endangered (CR), Endangered (EN), Near Threatened (NT) and Vulnerable (VU) respectively (Table 9). Some unidentified individuals have been sent for molecular characterisation. The urgency of this study lies in the fact that once a baseline is established, it becomes perpetually valuable but creating retrospective baseline data is impossible. Our research serves as a biomonitoring and bioindicator tool, providing crucial baseline information for future studies on the ecology, taxonomy, and conservation of dragonflies in Nigeria. Additionally, it aids the government in monitoring and understanding the quality of freshwater resources in the country.

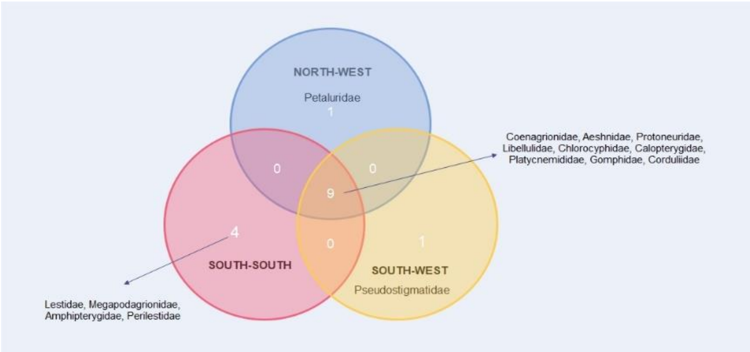
Table 8: Families of the Odonata group

Family	**Total Value**
Synlestidae	0%
Pseudostigmatidae	0.09%
Petaluridae	0.09%
Perilestidae	0.09%

Lestidae	0.09%
Megapodagrionidae	0.19%
Amphipterygidae	0.19%
Corduliidae	0.84%
Gomphidae	1.78%
Protoneuridae	2.72%
Aeshnidae	2.81%
Platycnemididae	3.09%
Calopterygidae	3.84%
Chlorocyphidae	4.40%
Coenagrionidae	14.33%
Libellulidae	65.45%



a



b

Figures 5 (a-b): *Odonata Families in sampled areas*

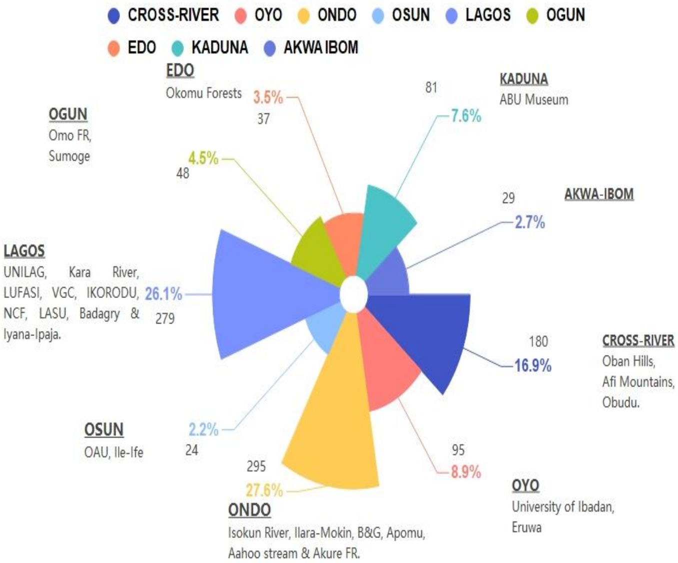


Figure 6: *Odonata Species (%) in surveyed states*

a. Male and Female *C. citrinum* in tandem in Igele Sunmoge village

b. *Nubiolestes diotima* (Schmidt, 1943)

c. *Umma purpurea* (Pinhey, 1961)

d. *Africocypha centripunctata* (Gambles, 1975)

e. *Africocypha lacuselephantum* (Karsch, 1899)

f. *Pentaphlebia stahli* (Förster, 1909)

g. *Phyllomacromia lieftincki* (Fraser, 1954)

h. *Allocnemis nigripes* (Selys, 1886)

i. *Elattoneura acuta* (Kimmins, 1938)

Plates 6 (a-i): *C. citrinum* from Sumoge Village in Ogun State (6a) and Some Odonate Species from Cross River State

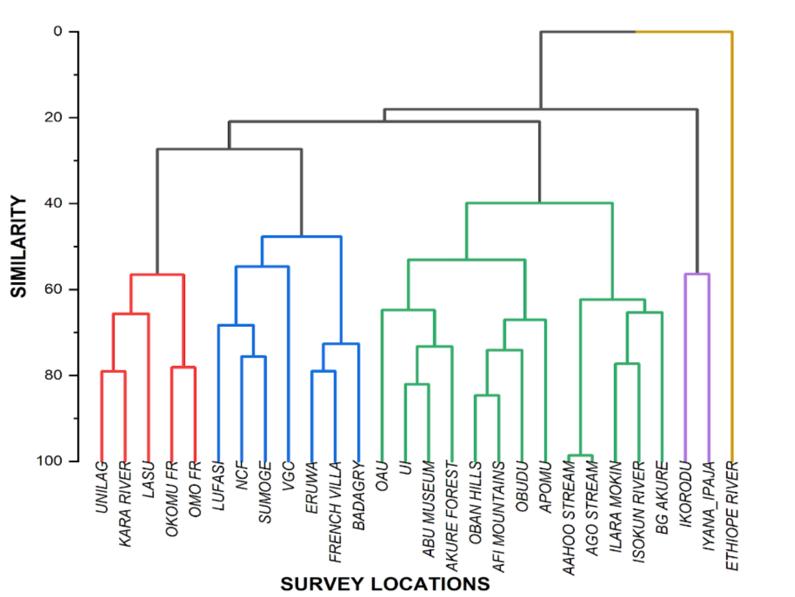


Figure 7: *Similarities in species of Odonates in surveyed areas*

Table 9: Odonata species according to IUCN Red Listing

Name	**IUCN Categories**
Chlorocypha aurora	CR
Micromacromia miraculosa	CR
Ceriagrion citrinum	EN
Oreocnemis phoenix	EN
Platycypha auripes	EN
Teinobasis alluaudi	EN
Chlorocypha molindica	NT
Umma mesumbei	NT

Urothemis luciana	NT
Atoconeura luxata	VU
Chlorocypha centripunctata	VU
Chlorocypha flammea	VU
Elattoneura pasquinii	VU
Gynacantha bispina	VU
Platycnemis rufipes	VU
Pseudagrion bicoerulans	VU
Umma declivium	VU

Source: IUCN (Year)

4. INSECTS AS POLLINATORS AND ECOTOURISM INSTRUMENTS

Butterflies are vital components of ecosystems due to their significant role in the food chain and their role as pollinators, alongside bees. By feeding on nectar from flowers and coming into contact with pollen, butterflies inadvertently carry pollen on their bodies and legs, enabling its transfer over long distances. This genetic material can then be transferred to the female parts of other plants they visit, facilitating reproduction. Consequently, butterflies play a crucial role in the production of one out of every three vegetables and fruits consumed by humans. Their contributions to the global food economy are estimated to exceed $200 billion. Moreover, butterflies also foster genetic variation and resistance to diseases by facilitating the process of pollination (Ghazanfar *et al.,* 2016).

4.1 Remediate Air Pollution

Butterfly species have been reported to help in air pollution remediation, especially in the removal of carbon dioxide. High levels of atmospheric carbon dioxide contribute to global warming. Ghazanfar *et al.* (2016) reported that monarch butterflies and caterpillars are capable of absorbing carbon dioxide and reducing the amount of air pollution. Butterflies can also be used for conservation monitoring because some are particularly sensitive to environmental pollution and changes in habitat structure through their close adaptation to the environment and because they also embody the majority of the links in the community food chain (Nally *et al.,* 2004).

4.2 Indications of a Healthier Ecosystem

Many butterflies specialise in a specific plant species for oviposition or feeding (Oostermeijier and Van-Swaay, 1998). If butterflies are threatened in a particular habitat, then other plants, insects and invertebrates tend to also be at risk. Therefore, endangered butterflies serve as a barometer of natural conditions in that habitat (Tekulsky, 2015). Butterflies react quickly to minor changes such as light disturbance in the environment, providing an alarming signal for other reductions in wildlife and making them good indicators of biodiversity. In 2012, Dobson reported a 72% decline in Butterfly and moth species for the last ten years. Therefore, butterflies are the best monitoring group of insects in the world and show whether the ecosystem is stable or not.

4.3 Source of food for other Organisms

Many animals in the ecosystem such as birds, ants, bats, scorpions, mice, reptiles, amphibians and other insectivores benefit from butterflies, as they are one of the sources of their food. Eggs of some flies and wasps live as parasites inside caterpillars' bodies and feed on them. Consequently, the decline in their population in the ecosystem will also result in a subsequent decrease in the population of birds, mice and other animals that rely on them as primary sources of food.

4.4 Promote Tourism

Butterflies have been admired for hundreds of years with specimens displayed in museums. In the last five years, butterfly tourism has increased in popularity as people from around the world enjoy the beauty of these insects. This intrigue is not just for scientific purposes but to also experience the joy of butterflies in their natural habitat. In Texas, USA and Daegu in South Korea, there is an annual Butterfly (Insect) festival where over 10000 species of insects (including butterflies) can be seen in a display. This contributes to the local economy, with sales of tickets costing thousands of dollars.

4.5 Medicinal Properties

Butterfly species have been found to possess medicinal properties that have the potential for therapeutic applications. The wings of the butterfly, *Precis coenia* have been found to contain compounds that have anti inflammatory and analgesic effects (Ramos-Elorduy *et al.*, 2005).

Understanding their population, diversity and associated plants of butterflies will promote conservation planning, management, aesthetics, and tourism. Our team, under the TETFund Centre of Excellence in Biodiversity Conservation and Ecosystem Management (TCEBCEM), established a Butterfly garden and surveyed butterflies, the host plants (for the larval stages) and their pollinators in Lagos State. The research was sponsored by Lagos State Research and Innovation Council (LASRIC). Monthly survey of butterflies of Cross Rivers forest is ongoing (Since, 2021).

5. BUTTERFLY GARDEN

The primary aim of the research was to bring back butterflies (Butterfly Garden) for enhanced food security: thus providing the necessary information needed to prepare a strategy for the conservation of butterflies. The team of researchers included experts from Universities and Government organisations in the field of Entomology, Botany, Cell Biology and Genetics and Architecture. There are three locations at the University of Lagos Butterflies had their host flowers and plants, alone, shared with ants, wasps, bees or all of the above. Flowering plants associated with butterflies in Lagos State included Common Lantana, Local Hibiscus, Firebush, Golden Trumpet, Lance-leaved Coreopsis, Yellow Alder, Christmas Senna, Mexican Marigold, Wing-pod Portulaca, Tridax (weed), Parrot Beak, Elegant Zinnia, Jungle Flame and Madagascar Periwinkle (Plates 7). The biodiversity indices revealed that the distribution, abundance and diversity of butterflies were affected and determined by disturbance within their habitat. In addition, the different stages and morphometrics of the African Monarch Butterfly, *Danaus chrysippus;* the Sweet Potato Butterfly, *Acraea acerata* and the African Giant Skipper, *Pyrrhochalcia iphis* were reared on artificial and natural diets.

Entomopalynologically, *Delonix regia*, *Albizia zygia*, *Tridax procumbens* and Euphorbiaceae were the most popular plants extracted from the butterflies' abdomen. While maintaining the garden (which is very expensive and can be exposed to poaching/stealing of the equipment used in the Garden) it is very important to have perennial weeds- eg. *Tridax spp* in the gardens. They are necessities-hosts plants and pollen for many Butterfly larvae and adults respectively.

While on this research, we found the Yellow Cosmos (*Cosmos sulphureus*), Alexandrian Senna (*Senna alexandrina*) and Candelabra Bush (*Senna alata*) flowers to be major host plants for bees in Lagos State (Plates 8). BEEKEEPERS TAKE NOTE !!!


Graphium policenes on Common Lantana


Belenois calypso on Common Lantana


Coliades forestan on Common Lantana


Juunonia oenone on Common Lantana


Catopsilia florella on Firebush


Hypolycaena antifausnus on Firebush


Junonia sophia on Parrot Beak


Danaus chrysippus on Tridax (weed)


Belenois calypso on Jungle Flame

Plates 7: Some flowers in the garden that attract butterflies

Yellow cosmos (*Cosmos sulphureus*)

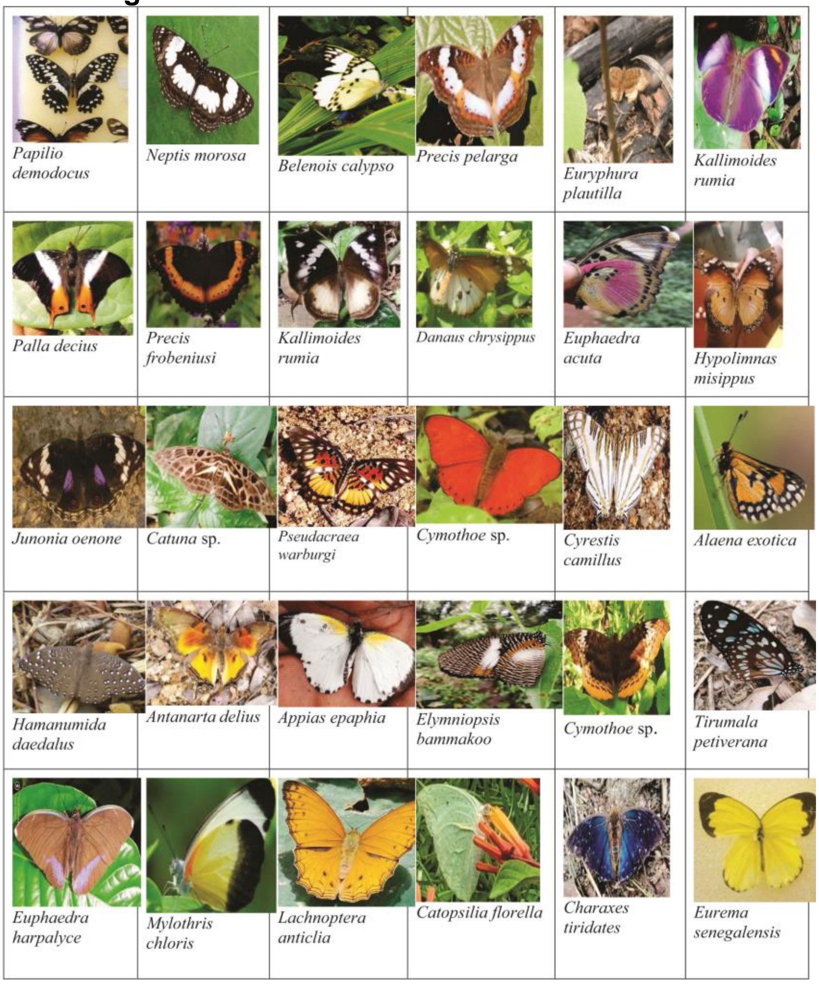
Alexandrian Senna (*Senna alexandrina*)

Candelabra Bush (*Senna alata*)

Plates 8: Some flowers that attract bees in Lagos

5.1 Butterflies in some Parks in Nigeria

Much study has been carried out on Butterfly diversity in Okomu National Park in Edo State Nigeria, Cross Rivers Forest, LUFASI Parks, OMU Resort and NCF Lagos and of course at the University of Lagos. The team has over 300 species of Butterflies with over 3000 pictures from these parks. Plate 9 shows some of the Butterfly species we have in Nigeria (Kemabonta *et. al*., 2015; Kemabonta *et al.,* 2023). It is an ongoing project.



Plates 9: Some Butterfly species in Nigeria

6. INSECTS AS FOOD

6.1 Black Soldier Fly (BSF) *Hermetia illucens* (Linnaeus)

The practice of eating insects as food is known as entomophagy and many animals such as spiders, lizards and birds are entomophagous, feeding on insects as their primary source of sustenance. Insects offer a promising solution to address food security, environmental sustainability, and nutritional challenges. In many cultures, insects have been a part of traditional diets for centuries providing a valuable protein source, vitamins, minerals and healthy fats (Evans *et al.,* 2015). One insect species that has garnered significant attention in the field of entomophagy is the black soldier fly. Black soldier fly larvae are voracious eaters and can efficiently convert organic wastes into biomass. This attribute has led to their use in waste management systems, particularly for converting food waste and agricultural by-products into protein-rich insect larvae. The larvae of black soldier flies are highly nutritious, containing substantial amounts of protein, essential amino acids, and beneficial fats. They can be processed into various forms, such as whole larvae, protein powder, or oil, for incorporation into food products or animal feed. Black soldier flies and their larvae have shown promise in the circular economy and sustainable agriculture.

Black soldier fly larvae grown on organic wastes such as chicken manure harbour lactic acid bacteria (LAB) which have the potential as probiotics for ruminants. In general, BSF larvae have potential as an ingredient for milk replacers, creep feed, fattening ration, and sources of LAB for probiotics (Astuti and Wiryawan, 2022).

Benefit of BSF

- Waste biomass is converted into larvae
- the residue which is used for fuel production
- **±40% protein, high in calcium and many amino acids**
- Larvae fed on organic wastes has shown to **inactivate disease-transmitting bacteria**
- Waste reduction of up to 80% on wet weight basis has been demonstrated
- Fertilizer and soil additive with natural pest-repellent properties.
- A high waste-to-biomass conversion rate of up to 25%

Our team carried out the study with the overall aim to investigate the benefits as well as possible dangers of BSF larvae for use as alternative protein sources. We investigated the development and biomass conversion of the BSF larvae; determined the proximate composition of the larvae reared on the four substrates, measuring the dry matter (DM), crude protein (CP), ether extracts (EE), ash, fibre and mineral composition; and determine potential bioaccumulation of heavy metals including copper (Cu), zinc (Zn), cadmium (Cr), lead (Pb), and chromium (Cr). (Adebayo *et al.,* 2021; Elechi *et al.,* 2021).

Larvae reared on Crude Fiber (CF) demonstrated superior growth and development with the highest prepupal weight, length and fastest development time compared to other substrates. Chicken mash and Brewers mash resulted in the highest rate of waste reduction, while Fruit waste had the lowest rate. Food waste showed the lowest substrate reduction rate, whereas larvae reared on fruit waste had the highest substrate reduction rate. Larvae fed on food waste had the highest nitrogen and potassium content, while those reared on fruit waste had the highest potassium content (Table 10).

Prepupae fed on Crude Fiber (CF) and Brewers mash (BW) had the highest crude protein (CP) content at 48.93% and 44.52% respectively. The ether extract (EE) and ash contents of the prepupae varied significantly among substrates, with CF-reared prepupae having low EE and high ash content compared to prepupae reared on Fruit waste (FW), BW, and FR. Larvae fed on different substrates exhibited distinct accumulation patterns of minerals, with FW resulting in the highest turnover of minerals, specifically Potassium at 46.94g/kg (Table 11).

The concentrations of heavy metal levels found were Lead, Cadmium, Chromium, Zinc and Copper. Larvae reared on brewery waste were more likely to exhibit bioaccumulation compared to other substrates. Bioaccumulation factors greater than one were reported for three heavy metals (Cu, Pb, and Cr). Importantly, all heavy metal concentrations in the study were below the safe limits for use in animal feeds (Table 12).

BSF is a highly nutritious food source for animals and Humans. This result provides a basis for further consumption and industrialisation of this edible and medicinal insect

Table 10: Development time, mean length, and mean weight of *Hermetia illucens* prepupae reared on four different substrates

Substrate	**Development Time (days)**	**Mean Length (cm)**	**Mean Weight (g)**
Chicken Mash	21c	2.18 ± 0.09^{a}	0.30 ± 0.02^{b}
Brewers Mash	23c	2.16 ± 0.08^{a}	$0.28 \pm 0.001^{a,b}$
Food Waste	28b	1.96 ± 0.07^{a}	0.24 ± 0.003^{a}
Fruit Waste	38a	1.52 ± 0.09^{b}	0.12 ± 0.02^{c}

Values are mean ± standard deviation within a column
Values followed by different letters in a column are significantly different

Table 11: Proximate composition of the BSF prepupae reared on different substrates

Parameter	Chicken Feed	Brewery Waste	Food remains	Fruit Waste
Dry Matter %	76.60 ± 0.24[a]	76.57 ± 0.18[b]	82.82 ± 0.18[a]	72.26 ± 0.33[a]
Moisture %	23.40 ± 0.24[a]	23.43 ± 0.19[c]	17.18 ± 0.18[b]	27.74 ± 0.32[b]
Crude protein %	48.93 ± 0.61[a]	44.52 ± 0.25[a]	32.97 ± 0.50[a]	38.27 ± 0.21[a]
Ether extract %	31.30 ± 0.16[a]	33.21 ± 0.17[c]	34.26 ± 0.12[b]	34.05 ± 0.13[a]
Crude ash %	4.12 ± 0.33[a]	11.23 ± 0.05[a]	9.52 ± 0.22[b]	13.90 ± 0.06[a]
Crude Fiber %	9.24 ± 0.02[a]	10.29 ± 0.13[a]	5.24 ± 0.46[a]	5.24 ± 0.30[a]
Soluble fibre %	5.86 ± 0.29[a]	2.78 ± 0.09[a]	3.61 ± 0.22[a]	1.67 ± 0.36[a]
Insoluble fibre %	2.00 ± 0.06[a]	1.72 ± 0.02[a]	2.29 ± 0.03[a]	1.33 ± 0.07[a]
Total dietary fibre %	3.73 ± 0.15[a]	3.62 ± 3.62[c]	5.84 ± 0.18[a]	3.29 ± 0.14[b]
Phytate mg/100g	22.92 ± 0.35[a]	23.65 ± 0.58[c]	12.66 ± 0.68[a]	15.53 ± 0.76[b]
Carbohydrate %	56.94 ± 0.83[a]	51.75 ± 0.68[a]	43.99 ±1.17[a]	46.97 ± 0.62[a]

Values are mean ± standard deviation within a row followed by different letters that vary significantly.

Table 12: Mean heavy metal concentrations for *Hermetia illucens* prepupae

Sample	Mean (mg/kg)				
	Cu	Zn	Pb	Cd	Cr
CMP	0.24 ± 0.01[b]	16.10 ± 1.11[a]	0.36 ± 0.01[a]	0.03 ± 0.04	0.15 ± 0.15[a]
FDWP	0.10 ± 0.05[c]	3.69 ± 0.24[c]	0.12 ± 0.08[c]	0.16 ± 0.12	0.21 ± 0.10[a]
BWP	0.25 ± 0.09[a]	8.08 ± 2.31[b]	0.15 ± 0.12[b]	0.05	0.08 ± 0.03[a]
FTWP	0.12 ± 0.02[b]	5.67 ± 2.04[b]	0.25 ± 0.04[b]	0.13 ± 0.04	0.23 ± 0.03[a]

CMP=chicken mash prepupae, FDWP=food waste prepupae, BWP=brewery waste prepupae, FTWP=fruit waste prepupae
Values are mean ± standard deviation within a column

7. INSECTS AS NUTRIENT RECYCLERS AND WOOD DEGRADERS

Ants (Hymenoptera: Formicidae), the most diverse group of organisms, are eusocial (true social) insects with colonies characterised by one or several reproductive queens, some reproductive males and sterile female workers, while some species of ants have a special caste of workers that are adapted for defence known as a soldier caste.

They are known as environmental, ecological and biodiversity indicators. They are well noted for nutrient recycling, upturn of soil and seed dispersal (Tschinkel, 2003). They engage in mutualistic associations with other organisms, serving as predators and scavengers in the ecosystem. Being predators, they are involved in pest regulation and management (Guenard, 2013). Interestingly, ants are considered to be ecosystem 'engineers' (Kovar *et al*., 2013) and they directly or indirectly affect resource availability for other organisms through nest building and waste management (Nemec, 2014).

However, ants can be pests, as some species may destroy agricultural produce, household furniture and some may even sting humans if threatened (Wetterer, 2009; Wetterer, 2015). Notable species of ants are invasive and/or pests of crops which pose global threats and food insecurity, gravely disrupting the local ecosystem, causing economic loss and health risks in extreme cases. While the number of ant species including the invasive ones are known in many countries, Nigeria does not know the number of species she has and is not sure if there are invasive species of ants or not.

Our team investigated the diversity of ant species across three different ecosystems (nature reserves, agroecosystems and residential areas) in selected locations in Lagos State, Nigeria. This was to add to the baseline data of ants in Nigeria, bring up a Myrmecologist and ascertain the presence of tramp (exotic) ant species in Nigeria.

Description of the Study Area

The study was carried out in Lagos State, Nigeria (Figure 8)

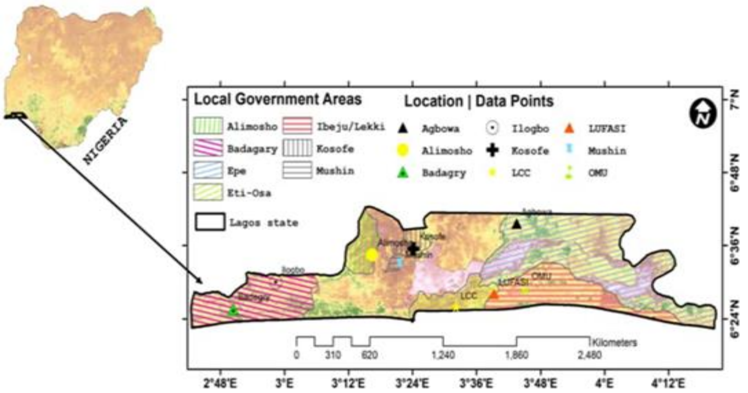


Figure 8: *Study Areas in Lagos State*

Our study recorded a total of One hundred and one (101) ant species from 30 genera and 6 Subfamilies. The 6 subfamilies are Pseudomyrminae (1%), Dolichoderinae (4%), Dorylinae (5%), Ponerinae (7%), Formicinae (18%) and Myrmicinae (65%) (Figure 9).

Pitfall trap was the most effective means of sampling ants (30 species) followed by hand collection (12). Twenty-one (21) species were common to all the sampling techniques, this species could be tagged generalist (Figure 10). Each season had species assemblage peculiarities, the dry season recorded 23 species that were exclusively present during the season, the wet season had 6 species and both seasons shared 72 species (Figure 11) (Jimoh *et al.,* 2023; Kemabonta and Balogun, 2014). There were significant variations in diversity and richness between Nature reserves (LUFASI, NCF and Omu). There were also differences in Agroecosystems and residential ecosystem types ($P<0.05$, Tukey Test) (Figures 12a-c). Comparing all the land use types, Badagry with a different colour separation was more diverse than all other locations. Species diversities of ants in Agbowa, Ilogbo NCF, LUFASI and Omu were similar while Agbowa and Ilogbo were closest. Kosofe, Alimosho and Mushin were similar in ant diversity but Alimosho and Mushin were closest (Figure 13). LUFASI and NCF shared a very close species composition and abundance, followed by Alimosho and Omu, all these four locations have connections and the tree further extends to Kosofe and Mushin (Figure 14). This shows that nature reserves and residential land-use types share much more species composition than the agroecosystems. The locations of the agroecosystem land-use types were distinctively in connection together before the tree extends to other land-use types. Nature reserves and agroecosystems were not significantly different from one another but both were significantly different from residential land-use types.

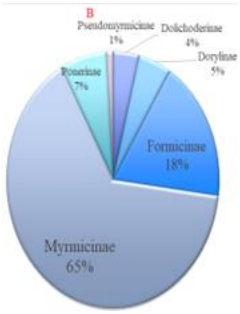


Figure 9: *Ants Species Collected (%)*

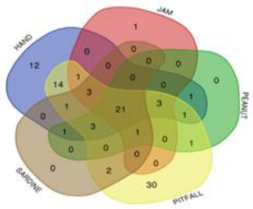


Figure 10: *Ant assemblage (species) in all the sampling methods*

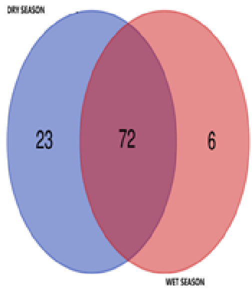
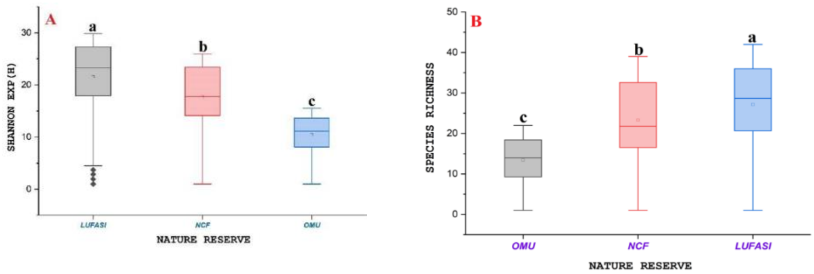
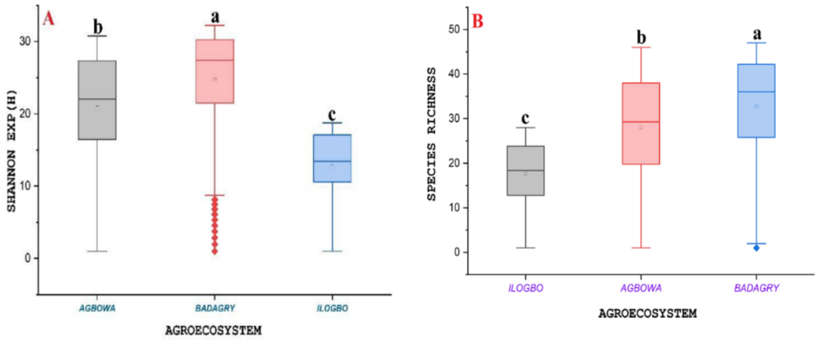


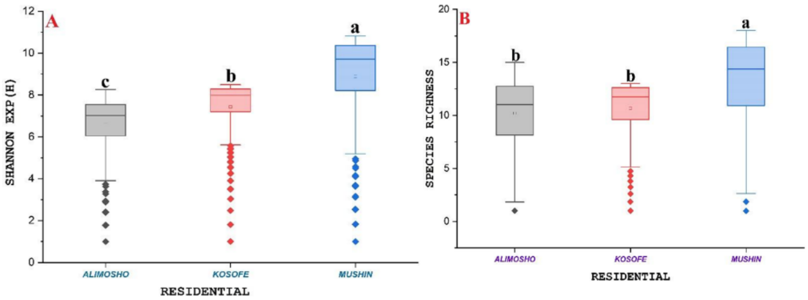
Figure 11: *Seasonal interaction and variations in the species richness across all land-use types*



a. Mean species diversity and richness across locations surveyed under the Nature reserve land use class. (P<0.05, Tukey test



b. Mean species diversity and richness across locations surveyed under Agroecosystem (Cassava farm) land-use class (P<0.05, Tukey test)



c. Mean species diversity and richness across locations surveyed under the Residential land-use type.

Figures 12 (a-c): *Species Richness across Locations surveyed (Nature reserve, Agroecosystem and Residential Areas)*

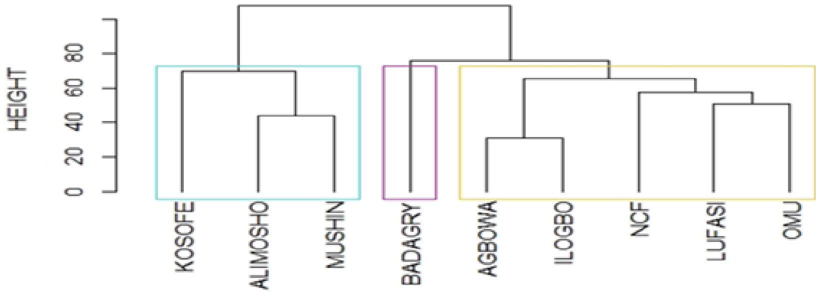


Figure 13: *Diversity relationship between all the nine locations (Similarity in diversity exist between location within same colour)*

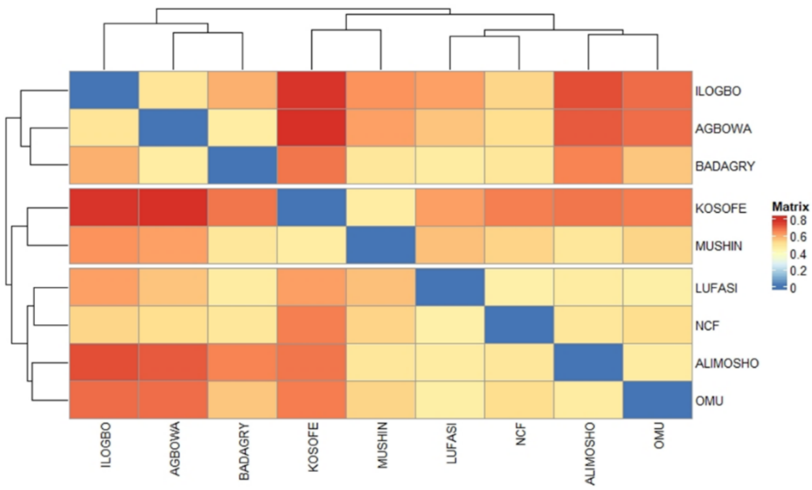


Figure 14: *Cluster analysis of locations with similar species composition and abundance. (From the far left, the location with correspondence colour shade has resemblance in species composition and abundance)*

Ten (10) species of ant that were non-native (exotic) to Nigeria were recorded out of which six (6) were recorded for the first. The first records are *Nylanderia bourbonica, Solenopsis globularia, Tetramorium bicarinatum, Tetramorium lanuginosum, Trichomyrmex destructor* and *Trichomyrmex* *mayri* (Jimoh *et al*., 2021). Three of these species, known to be natives of Africa but are tramp species (because they have spread all over the world through human commerce) are invasive species. They include; *Cardiocondyla emeryi, Pheidole megacephala and Tetramorium simillimum* (Jimoh *et al*., 2023). The percentage composition of exotic, tramp and native ant species was 15.78%, 13.3% and 70.92% respectively (Figure 15). Exotic species were more concentrated at the residential land-use types (Kosofe, Mushin and Alimosho), followed by the nature reserves (LUFASI, NCF/ LCC and OMU) (Figure 16). *Paratrechina longicornis* and *Solenopsis globularia* (Plates 10a-b) are the most frequent and abundant exotic species in the study areas (Jimoh *et al*., 2023). Most invasive ant species were found in urbanised environments, which may facilitate the spread of propagules of invasive species into natural environments (Van Ham *et al*., 2013).

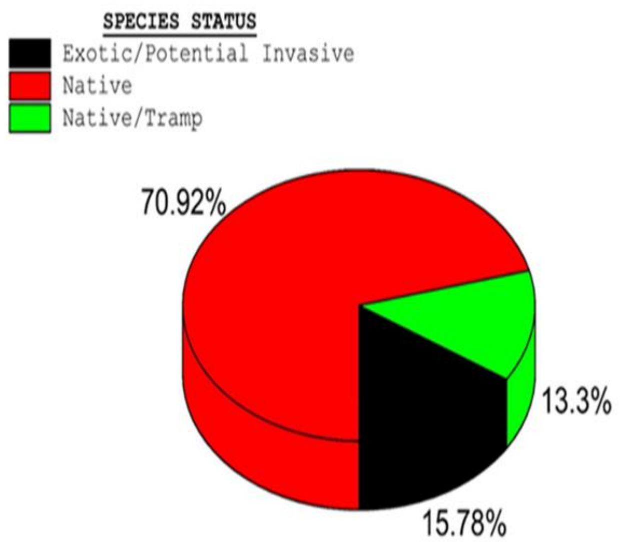


Figure 15: *Composition (%) of exotic ant species present in all three ecosystems in Lagos State*

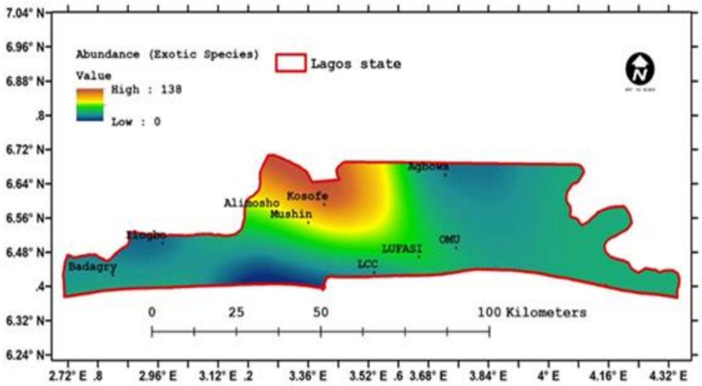
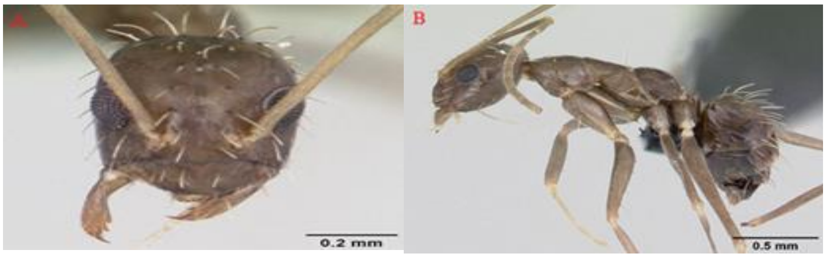


Figure 16: *Exotic (potentially invasive) ant species occurrence between all the nine areas*



a. *Paratrechina longicornis* (Latreille, 1802) (a) head in full-face view (b) body in profile (April Nobel, CASENT055961, Antweb.org)

b. *Solenopsis globularia* (Smith, 1858) (a) head in full-face view. (b) body in profile (April Nobel, CASENT0104814, Antweb.org)

Plates 10 (a-b): Abundant and frequent exotic ant species in Lagos State, Nigeria

8. ENTOMOPALYNOLOGY

Palynology is the study of pollen grains produced by seed plants (angiosperms and gymnosperms) and spores (pteridophytes, bryophytes, algae and fungi) (Jones and Jones, 2001). The study of the pollens collected from insects is entomopalynology. It can be applied in many areas such as pollination biology, forensic biology and the investigation of migration routes.

The team examined the palynomorph content of three randomly selected *Macrotermes* sp. mounds (termitaria) and two *Vespula vulgaris* nests collected at the University of Lagos campus were examined. Palynological analysis showed the presence of 298 well-preserved palynomorphs showing characteristic morphological features. The recovered palynomorphs included pollen, pteridophyte spores and fungal spores, along with insect parts (106), diatoms (7) and a protest (1). The pollen assemblage of termite mounds comprised 78 pollen and pteridophyte spores, with Poaceae and Arecaceae pollen as dominants. In the wasp nest, the pollen assemblage comprised 28 pollen and spore taxa, with Poaceae and Arecaceae pollen also dominant. Both mounds and nests had, besides diatoms, six pollen and spore taxa: Poaceae, Amaranthaceae, Pteridophyte spores, Arecaceae, Raffia spp. and Rhizophora spp. Vegetational grouping of the recovered pollen and spores indicated five phytoecological groups: secondary forest, mangrove swamp forest, freshwater, open vegetation and Poaceae.

In statistical analyses, termite mounds had a higher species richness value (2.08 as compared to 1.99 from the wasp nests), while the wasp nests had a higher species diversity value (0.997 as compared to 0.845 from the termite mounds). Pollen analyses of the termite mounds and wasp nests suggest that both could be useful tools in environmental studies. This is the first attempt to evaluate the potential of termite mounds and wasp nests as natural pollen accumulators in Nigeria. The team also recovered insect parts from the atmosphere (in pollen) and ascertained their possible implication in allergies (Adebayo *et al.,* 2017; Kemabonta *et al.,* 2018).

9.ECOTOXICOLOGY

Ecotoxicology delves into the complex web of interactions between organisms and their surrounding environment, specifically focusing on the effects of toxic substances. Its goal is to unravel the intricate mechanisms by which pollutants can shape and disrupt ecosystems, enabling us to mitigate the harmful consequences and work towards a sustainable future.
By studying the effects of pollutants, we gain invaluable insights into the potential risks posed to human health. Through rigorous research and toxicological evaluations, we can identify the substances that may have adverse effects on our well-being, and in turn, take proactive measures to minimise exposure and protect ourselves.

Pollution, whether it be from industrial discharges, agricultural runoff, or improper waste disposal, can lead to a range of detrimental effects. These include increased susceptibility to diseases, disruption of reproductive cycles, biodiversity loss, and ecological imbalances. Here are some research works carried out on ecotoxicology with my team (Aribisala *et al.,* 2022; Kemabonta and Aderemi, 2014; Kemabonta and Ezebiora, 2014; Kemabonta *et al.,* 2020b; Kemabonta *et al.,* 2020c; Osuala *et al.,* 2017a; 2017b; 2017c).

10. CONSULTANCY (Pest Management)

I was in charge of the pest control section at the Nigerian Stored Products Research Institute Lagos- for the Internally Generated Revenue (IGR) of Lagos Station for 19 years. During this period, my team generated some good millions for the Institute. I am a member of the Pest Control Association of Nigeria (PECAN) and the Environmental Health Officers Association of Nigeria.

Pests generally cause substantial damage to our homes, crops, and natural ecosystems. They jeopardize our food security, disrupt our living spaces, and pose health risks to humans and animals alike. The complexities of pest behaviour, their rapid reproductive cycles, and evolving resistance to conventional control methods necessitate a comprehensive and strategic approach to pest management.

This is where the invaluable role of consultancy in pest management comes into play. Consultants specialising in this field possess a wealth of knowledge, experience, and insights into the biology, behaviour, and control methods of various insect pests. They employ scientific principles, advanced techniques, and integrated pest management strategies to address pest problems efficiently and sustainably.

The primary objective of a pest management consultant is to provide tailored solutions that meet the specific needs and challenges of each unique situation. By conducting thorough assessments, they identify the pest species, assess the extent of infestation, and analyse the potential risks associated with the presence of pests. Armed with this information, consultants can devise targeted and environmentally friendly management plans.

Consultants play a pivotal role in educating and raising awareness among individuals, communities and organisations. They empower us to make informed decisions and adopt preventive measures to minimise the risks posed by insects and other pests. By sharing their expertise through training programs, workshops, and seminars, consultants enable us to develop the skills and knowledge needed to address pest-related challenges effectively.

Pest management consultancy also extends beyond mere problem-solving. Consultants collaborate with stakeholders, including farmers, businesses, and environmental agencies, to develop sustainable pest management strategies. They advocate for the adoption of Integrated Pest Management practices that prioritise all other control methods and the judicious use of chemical controls as a last resort. Such an approach ensures the long-term health of our ecosystems while minimising the reliance on potentially harmful chemicals.

Occupational health should be of utmost importance and this can be achieved by ensuring the provision of effective protective equipment for individuals involved in pest control activities. Additionally, it is advisable to minimise the domestic use of pesticides and instead rely on professional pest control services for homes, offices and other locations.

By engaging trained pest control experts and environmental health officers that have the knowledge, experience, and access to specialised equipment, the risks associated with pesticide handling and application can be effectively managed, ensuring the safety of both the environment and individuals (Kemabonta *et al.,* 2014).

11. MENTORING /COMMUNITY SERVICE

Apart from teaching, I have face-to-face interactions with my students where I offer advice, set expectations and facilitate their joining professional networks. I came to understand that students face a lot of challenges and often lack someone to talk to. I, therefore, look beyond academics to the socio-economic wellbeing of my students.

For example, I have been the Secretary and Coordinator of Wilson Badejo Foundation (now Wilson and Yinka Badejo Foundation) since its inception. The Foundation gives scholarships to indigent but brilliant students. Over 500 undergraduates from public higher institutions have benefited from the scheme. We also organise critical programmes and services that help give young boyz (miscreants in the society) a chance for a brighter future, inspire better lifestyle choices for them so as to build responsible young men and ladies, vibrant and peaceful communities. Many boyz (and girlz) (over 1000) from Jibowu, Fadeyi, Mushin, Ajegunle and Ikorodu have benefitted from the Foundation and some have been equipped with some skills.

I was in charge of the Annual Lecture series of the Faculty of Science. This is an avenue to give Career Counseling to make students (Science students) understand that Medicine, Engineering and Pharmacy are not ‘all-in-all’. That they can still make it as scientists. We invited men and ladies who studied science at the undergraduate level and are now prominent in the Nation. We started with about a hundred students at the Faculty of Science boardroom and rose to over 2,500 students attending a lecture. I was the local Church and District Teens Coordinator of Foursquare Gospel Church Festac/Agboju and Victoria Garden City (VGC) for 26 and about 7 years respectively. If there is anything I enjoy doing, it is in building and moulding the lives of teenagers and youths. No regret. I am excited to do it and will continue to do it.

I am also the Chairperson and Coordinator of Prof. Ogundipe Innovation Challenge (over 3,000 students in attendance) where we empower students all over the Nation who showcase their scientific innovations. I was Fagunwa Hall Warden and later Mistress for over 10 years. What I enjoyed most was bringing 'hope' to hopeless students. I am a member of the Senate and Ceremonies Committee. For several years, I served as the Hall Warden and Hall Mistress of Fagunwa Hall. It was an amazing time working with the Hall Facility Managers, staff, student leaders and students. I belong to several professional associations where I served in different capacities. I am a Fellow of the Entomological Society of Nigeria. I coordinated different outreach programmes of the Organisation of Women in Science for the Developing World, (OWSD) Lagos, now UNILAG Chapter. In 2022, I served as the Chair of the International Conference of the Zoological Society of Nigeria.

Madam Vice Chancellor, I always look out for students who are 'square pegs in square holes' and try as much as possible to either let them adjust or go back to their appropriate holes. Some of the students I mentored have pitched their tents on the international scene with their works being recognised locally and globally. My door is ever opened to **ALL** students.

CONCLUDING REMARKS

There is a global increasing interest in the use of insects to understand and solve human challenges including climate change, diseases and food security. In Nigeria, beneficial insect species are fast disappearing while harmful insects such as mosquitoes are acquiring features making them more adaptable to the environment. There is therefore not only the need to carry out more research but to also apply the research by translating it into simple languages understandable by the common Nigeria.

These common Nigerians are mostly affected by the harmful insects by virtue of their living in and/or near forest areas or other biodiversity host spots. However, since insects affect us in diverse ways, we should learn to modify our socioeconomic lives in response to insect activities irrespective of where we live. Learning how to modify our lives, controlling and taking full advantage of insects while conserving their habitats involves going into '**The Amazing World of Insects'.**

RECOMMENDATIONS/ADVICE

Insects are not given priority when conservation decisions are taken because of their small size, abundance and short life cycle. Although they are small in size, no life is small. An insect has the same life as an elephant, hence, must be treated equally. The bias towards insects could be due to the fact that some are pests. Fortunately, insect pests are just about two percent of all insects. Increasing globalisation and changing climates are constantly reshaping the abundance, diversity and distribution of insect communities. It is imperative that we understand the forces underlying where and how insects live, so we can maintain healthy and productive ecosystems that support beneficial insects and eradicate or minimise the impact of pest insects.

Butterfly Garden

It is necessary to identify the rare Butterfly species and plant their favourite host plants. This will help to improve the conservation management of these plants, establish sustainable butterfly gardens and buffer zones. Further, the ability to develop the recipe for farming/rearing butterfly species will help in solving the growing challenges of the declining population of butterflies. Please, do not remove all weeds from your gardens. They are host plants and pollen for the developmental stages and adult of butterflies respectively. To ensure food security, we must protect our voiceless pollinators. The government should censor the use of herbicides and other pesticides that destroy our insects.

Entomophagy

There is a mine of wealth the nation is yet to tap into; growing insects for economic and nutritional purposes. Our study showed that the rearing of Black Soldier Fly (BSF) larvae can be used to convert organic waste streams to valuable biomass, by turning waste materials into alternative protein sources. This concept can be considered safe for consumption in regard to heavy metal bioaccumulation, which we found to be below safe limits for use in animals. Edible insects should be reared for their high nutritional qualities and sold to the populace since these insects provide high quality proteins and supplements (antibiotics, minerals and vitamins) even when dried. Awareness about the benefits of edible insects, especially for BSF, should be strongly propagated. Government should encourage small and medium scale insect farmers with low interest loans.

Stored Grains

Our studies highlighted the low genetic diversity observed within the psocid population on stored rice grains in Nigeria, which is crucial for their management. A relatively high genetic variability was, however, observed in *A. advena* and *Cheyletus malaccensis* compared to the other species studied. A higher mutation rate was also observed in *A. advena* and *Liposcelis bostrychophila* compared to other insect populations.

Most of the insect pests associated with stored rice products form monophyletic groups with worldwide isolates. *Rhyzopertha dominica* and *Oryzaephilus mercator* populations cluster into two distinct groups, indicating diverse evolutionary relationships, while *A. advena* populations form three separate clusters. The putative origins of most insect populations are traced back to India and China. It is important to note that multiple sources of origin for insect pests often pose significant challenges in their identification and management. The insect pests of rice grains used in this study were sampled from various geographical locations across Nigeria and showed very similar molecular and phylogenetic characteristics. Therefore, it is crucial to monitor rice imports and stored grains meticulously to control the distribution and maintain the low genetic diversity of these insects.

Standard regulations involving the input from all stakeholders (Local Insect Farmers collectors, community heads, food companies, NAFDAC and SON) should be formulated and implemented. Moreover, with collaboration with appropriate stakeholders, the plant products can be made into capsules or tablets that can be applied to grains to prevent stored product insect infestations.

Odonata

Our research serves as a biomonitoring and bioindicator tool, providing crucial baseline information for future studies on the ecology, taxonomy, and conservation of Dragonflies in Nigeria. Furthermore, to help in environmental monitoring using insects, more volunteers (especially retirees and young ones) are required to join Citizen Science Projects. It also helps the government to monitor and understand the quality of freshwater resources in the country.

Entomo Palynology

Our work on Entomo Palynology suggests new possibilities for the use of the pollen records preserved in Termite mounds and Wasp nests for environmental research. They should prove useful in the study of pollen rain, the character of vegetation, climatic phases and possibly the paleoecology of an area. Insect parts in the air could possibly be the cause of Asthma disease.

Pest Control Operations

I urge you all to recognise and appreciate the indispensable role of consultancy in Pest Management. Since insects have both positive and negative effects on human life and livelihood, it is recommended that appropriate and holistic control measures are used. By seeking professional guidance, we can address pest-related challenges in a holistic, sustainable and environmentally conscious manner. Let us embrace the expertise and knowledge of consultants to protect our homes, prevent resistance of insects against pesticides, safeguard our crops, and preserve the delicate balance of our ecosystems.

Parents
For us to achieve a sustainable environment, parents should please, stop enforcing their career will on their children.

University of Lagos
I wish to acknowledge the role this Citadel of Learning has been playing not only in academics but also in the welfare of both the students and the lecturers with special emphasis on accommodation for staff and students. The ever-increasing population of our country and by implication, the student and staff population has taken a great toll on the efforts of the university in this regard. The hydra-headed traffic situation in Lagos is pointing at the need for more efforts in the construction of more hostels for students and accommodations for staff and lecturers. This is necessary in order to ensure the physical wellbeing and wellness of staff and students of the University for Optimal Productivity.

I, therefore, wish to recommend that massive and more proactive steps could be employed in the realisation of this humble suggestion in the following ways viz:

* Going into partnership with developers;
* Attracting the goodwill of people who have the means and immortalizing their names; and/or
* Calling on the goodwill of political leaders of the environment or the State to assist.

Lecturers
Discover your niche and work there. Fingers are not equal but all are very important. Let all fingers be used to archive the optimum heights.

Students
To my students (Faculty of Science), it takes just a little more to become extraordinary. Add an 'extra' to your ordinary and you will become extraordinary and outstanding. Never give up on your dreams.

Finally, by integrating scientific research, public awareness, and collaborative efforts in our daily lives, we can pave the way for a cleaner, safer, and more harmonious coexistence with ourselves and our environment, especially our insects.

There is indeed an amazing world of Insects!

Thank you

APPRECIATIONS

This lecture would have never been a success without your presence here. I sincerely appreciate you all for coming online and on-site. To all my teachers, friends, siblings and schoolmates and all who have travelled long distances to attend this inuagural lecture, a big thank you to you all. Thank you. Thank you. Thank you. Ese, Dalu, Na gode, Merci beaucoup, 谢谢.

My profound appreciation goes to the University of Lagos under the leadership of Prof. Folasade Ogunsola and her DVCs, Prof. Ayodele Atesenuwa, Prof. L. O. Chukwu and Prof. Bola Oboh for providing the occasion and an enabling environment for this landmark event of my life. If I should name all the institutions and individuals to whom I am indebted in my long journey to the professorial chair that I now hold, we would not leave here today. However, permit me to mention only a few from my fallible memory: All the past and current Deans and HODs of the Faculty of Science, Deans of Students Affairs, "The house Keepers" under the able leadership of Prof. Joy Okpuzor, Welfare, Annual Lecture, Prof. Ogundipe Innovative Challenge, Seminar teams during my time there, thank you so much. My success stories are all hinged on the cooperation I received from you all. Thank you.

I can see mates from the Class of 1979, Federal Government College, Jos; Class of 1987, Faculty of Agriculture, University of Ibadan; senior friends of the 1980s from Ibadan Varsity Christian Union (IVCU). It is a humbling experience and very gratifying. Thank you. Thank you. Thank you. Friends and mates from High School, Undergraduate and graduate school days. Thanks to WhatsApp. We are regrouping and reviving vital support systems. My mates from Graduate School, prominent among them my personal friend Professor E. Osai and stupendous friends Professor A. Omoloye, Professor Femi Pitan and Prof. Osupitan, fellow proteges and students of Professor Odebiyi - virtuous mafiosos of the Odebiyi Brought Ups.

I say a big thank you to all members (past and present) of the Department of Zoology for the right hand of fellowship they gave me. The "Three Musketeers": Prof. W. A. Makanjuola, who brought me to the Department of Zoology, University of Lagos from Nigeria Stored Products Research Institute, Prof. O. A. Otubanjo, and Prof. R. I. Egonmwan, thank you so much. To my current HOD, Prof. E. T. Idowu, Prof. J. K. Saliu, Prof. A. A. Otitoloju, Prof. B. Akinsanya, Dr. A. B. Onadeko and his ever-available wife, Dr. N. H. Amaeze, Drs. K. A. Bawa-Allah, I. A. Aneyo, C. L. Oforka, T. Adubi, S. B. Iwajomo, and all the non-teaching staff headed by Mr. Aina, Mrs. Amoko and our Mama, Mrs. Ojelabi (Technical and Administrative), I say thank you to you all.

I appreciate the Foursquare Gospel Church in Nigeria where I belong, under the leadership of Rev. Sam Aboyeji and his amiable wife, for the spiritual preparation that has physically manifested in what we are celebrating today. The following ministries, arms and branches of the Foursquare Gospel Church in Nigeria: Foursquare Gospel Church, Victoria Garden City (VGC) especially the Diaconate and the Teens Church; FGC, Festac and Agboju. National Foursquare Women International (FWI), National Foursquare Teens Ministry and National Protocol Team where I served at one time or the other. My Spiritual Parents and Spiritual Lords who guided me to value the celestial chair more than the professorial chair that brought us together today: The Reverend Dr. Wilson Badejo, now by the sovereign will of God, of blessed memory - whose memory brings tears to my eyes as I write and his amiable consort, Reverend Yinka Badejo, Rev. Oluwagbohun, Rev. Richard Oloidi, Rev. Felix Meduoye, Rev. I. K. Utah, and Rev. Peter Ameadaji. a big thank you for their care, love and prayers.

How could I forget Rev. Dr. Ben Oruma, who joined my husband and I in holy wedlock? Or my prayer Apostle, Rev. Dr Moses Arinsiola? What about Dr. D. K. Olukoya, both spiritual and temporal Lord who ministered to me both spiritually and materially? Thank you very much. The Provost of LIFE Theological Seminary, Prof. Orgu and all my teachers and schoolmates. I say a big thank you to you all.

My Lord Temporal, Big brothers who minister to my material needs by sponsoring my programmes and always there for me, the Reverend Dr. Babajide Olowodola, Rev. Tijani, Dcn John Obaro, Dcn, Olumide Bajomo, Elder Amusan, Bishop Ben Enwuchola and Elder Segun Olusanya, I appreciate you all. Special mention must be made today of the past and the present Deans of the Faculty of Science of this University- Prof. Familoni *FAS*., Prof M. Ilori *FAS*, Prof A. Adekunle and Prof. E. Oyeyemi, I acknowledge with gratitude your contributions in bringing out the potential in me at various stages which culminated in my journey to this point. Thank you very much. My gratitude also goes to Prof. R. Bello, Prof Oni and Prof. B. Alo, FAS. Our former VC, Prof. O. T. Ogundipe and his DVC, Prof. O. B. Familoni.

Nigeria Stored Products Research Institute (NSPRI), where it all started - my research career - and so is rightly in a class of its own. Friends and former colleagues from NSPRI, among them Dr. Olagbaju, Mrs. Bukky Echendu, Mrs. Oladokun, Dr. Tope Falade, Mr. Seyi Fatokunbo and Late Mr Godwin Egesi, who stood by me like the Rock of Gibraltar through thick and thin. Thanks to all who made my stay memorable. I sincerely thank the landlord and residents of Good Homes Estate, Ajah, Lagos.

The following professional associations/groups to which I belong: Entomological Society of Nigeria, Zoological Society of Nigeria, Dragonfly Society of America, Environmental Health Officers of Nigeria (EHCON), Pest Control Association of Nigeria, and Black Odonatologist group- thank you. Special gratitude to the current Registrar of EHCON, Dr Y. M. Baba of and his able men and ladies especially, Mr Isah Adamu. I sincerely appreciate the current President of Pest Control Association of Nigeria, PCO Mr Kunle Williams, the former Presidents PCO K. Odubogun, PCO A. Ogunyadeka, PCO. Mama PECAN, K. Adegboye, Late Dr Coker and the members. I sincerely appreciate San Dr S. A Akingbehin for being always there for me. Special appreciation to Pastor San. M. A. Somoye, and San T Awonuga. To all PECAN members, my own people I love you all. I appreciate all my Professional colleagues amongst who are - Prof Adedire, Prof A A Oyerinde, Prof NES Lale, Prof A. Denloye, Prof Dan Enobakare, Prof K. Ademolu, Prof. Sam Nwogbo, Prof. H. Bandiya, Prof. T A Ande, Prof. F. A. Ajayi, Prof. Idowu, Prof. Ewuim and Prof. M O. Ashamo. Others include Prof. G. Nansat, Prof. A Adesiyun, Late Prof. E O Ogunwolu, Dr O Ajayi.

Wilson and Yinka Badejo Foundation (WBF), named for my spiritual parents, now sadly of blessed memory, where I cut my teeth in giving back to Society. All WBF Board members and Partners. co-labourers, especially Rev. Dr. Osar Emokpae, Rev. Akin Akeju, Rev. Dr. Ben Taiwo, Rev. Bola Adams, Rev. Mrs. Olaiya, Mrs. Doyin Akinade, Prof. Bayo Oladipo, Dr. D. Kwakpovwe, Elder Segun Olusanya, Engr. Okunoren, Tobak, Chief Olusegun Abraham, Prof. Grace Esiobu, and the Badejos, I say a very big thank you to you all.

My Veteran Mentors double also as my outstanding university teachers, among them Professor J. A. Odebiyi and Professor I. Fawole. They gave me the confidence and strength to be what I am today. My proximate Mentors, among them Emeritus VC, Prof. O. T. Ogundipe, FAS and Prof. M. O. Ilori, were a huge source of encouragement and guidance to me. They steered me away from stored products entomology into ecology and biodiversity, my second specialty now. Thank you, Sirs.

My PhD graduates, Dr. Sadiku Bukola, Dr. Bunmi Jimoh, and Dr. Ifeoma Ezeobiora, thank you so much. A big thank you to my PhD and other graduate students, obviously too numerous and too invidious to mention - fully or partially. I have gained as much knowledge as I have imparted in teaching you. My Undergraduate project and seminar Students, mentoring experience has enhanced my personal growth in ways that I did not imagine. All my adopted students, those I mentored out of choice rather than the requirement of duty, are part of my extended family of teens and mentees - a family too big to fail, too big to mention seriatim here, I acknowledge you all.

All my Church teenagers, too numerous to mention, many of them now full-fledged adults, whom I see as an extension of my family - what a big family! They have impacted my life as much as I have theirs. You have heard me sing the praise of "my teens", whom I regard as an extension of my extended family. Here are some of those who made it happen, my dedicated, tireless Teens Church Coordinators especially: Rev. B. Aliu, Sis. Odera Okonkwo, Sis. Kike Lawal, Sis. Chika Sanni, Bro. and Sis. Kenny and Bolanle Oludare. Others include Sis Lolade Ososanmi, Sis. Layide Adesanya, Sis. Ronke Adebayo, Sis. Ronke Adeleye, Sis. Dupe Ubeku, Bro. Bayo Omole, Sis. Labake Egbeyemi, Bro. Tope Awofeko, Bro. Kunle Anjorin, Bro. Tam Kemabonta, and Bro. Osas Ekator.

I appreciate the care and love from Rev. Mrs. Ruth Ayeni and Mommy Onuzo, veteran FWI presidents. God bless and increase you. Amen.

The sponsors of all my major programmes: IBTC, ably headed by Dr. Demola Sogunle; SystemSpecs, by the group MD, Dcn John Obaro; MD, Sunnet Systems, Rev. Paul Olagunju; Vitafoam, by the Group MD Mr. Taiwo Adeniyi; Zenith Bank, Wema Bank by Mr. Adebise and Mr. Segun Oloketuyi, Mountain of Fire Ministries, etc, Thank you so much for sponsoring our major programmes. Saro Agrosciences ably headed by the group MD, Mr. Rasheed Sarumi, and his right hand man, Mr. Leo Anyawu. I am indebted to all the current and past student presidents of the Faculty of Science (faculty and departments) and their executives who gave their all to see to the success of the programs in the faculty. Thanks to you all. I love and appreciate you all. I am also grateful to all the Units of the University, the Deans of students' affairs (past and present) Prof. O. Amund, Prof. A. Adeleke and Prof. Obalola, with all staff of student affairs. Past and present chief security officers of the University, Unilag works director, health centre, and UNILAG power. Thank you for ensuring we heard great outings.

I am very grateful to all my national collaborators, over 75 of them; colleagues, students and other stakeholders (See References) who made my research work worth it. Notably are Prof. W. A. Makanjuola, Prof. Bolanle Oboh, Prof. Oluwatoyin Ogundipe, *FAS*, Prof. S. S. Ogbogu, Prof. A. Omoloye *FESN*, Dr. J. C. Anikwe, Dr. B. W. Adu, Dr. T. O. Onuminya, Dr. F. I. Osuala, Prof. L. A. Ogunkanmi, Prof. S. A. Babarinde, Prof.

M. N. Igwo-Ezikpe, Prof. K. O.Adekoya, Dr. P. A. Adeonipekun, Dr. F. A. Adetoro and Dr. K. O. Ajelara. Others include Dr. O. Pereira-Sheteolu Dr. Amaka Dueke-Eze, Dr. Azeezat Alafia, Dr. R. E. Essien, Dr. E. O. Akeredolu, Dr. Fatsuma Olaleru, Dr. N. Uduma- Ologu, Dr. I. C Orabueze, Mr Steven Aina, and Dr. Temitope Sogbanmu. I am especially grateful to the following international collaborators: Kiko Gomez, Prof. Zhihong Li, Dr. Jessica Ware, Dr. Opit, Dr. Palesa Natasha, Dr. Ethel Phiri, and Judicaël Fomekong Lontchi.

A very big thank you to my research assistants, especially Dr. Nwanade, C. F., Mr. Balogun, S. A., Mr. Ekpah, O., Mr. Uche-Dike, R., Mr. Adeniran, J., Mr. Femi Igbekoyi, Mr. Adelowo, O., Ms. Elechi, M.C., Mr. Adesina, O., Mr. Ugbodaga, E., Lt Ohadiwe, A. C, Mrs. M. Abanise, M., and Late Ms. Isong, I.U. A special thank you to my special younger friends, Mr. and Mrs. Charles and Toyin Gbagi, Dcn. Emmanuel Eguwrube, Dr. and Mrs. Tope and Lade Falade, Mr. Sogo Kolawole and his amiable wife.

My bosom friends, sisters and brothers from another mother: Dcns. Margaret Udoh, Mrs. Chidi Ejim, Dr. Bola Bolaji, Rev. Victor Odunjo, Dr. Nonye Enyidah, QS. Chudi Ikedionwu, Yemisi Folivi, Prof. Amana Onekutu, Dr. Noma Owens-Ibie, Dcns Iyabo Ogunsola, Dr. Samuel Adeogun, Mr. Femi Omolaiye, Mr. Akin Fatoye, Pastor Doyin Jibodu, and Pastor David Akintola. Thank you very much for your unfeigned friendship.

My domestic and personal staff, my kitchen cabinet, who keep me organised and well provisioned at home so I can deliver the goods in the classroom, field and laboratory, the non-descript pillars that hold the magnificent edifice: Mr. Benard Gbemudia, Mr. Samuel Ekpo, Mr. Chinedu Heziala, Mr. Solomon Ayidun. Mr. Solomon Igba, Mr. Femi Akingbulu, Mr. Precious Onyema, Ms. Naomi, Ms. Comfort, Mr. Edet, Ms. Shola, all my daughter's former care takers and all my past drivers, I am forever grateful to you all. A very big thank you to all my clients and supporters-Zenith, Wema, Cornerstone … too numerous to mention, thank you so much

My maiden nuclear family: My late brothers, Olu, Odu, and late sister, Wuraola; my brother-in-law, late Engineer J. Imoukhede; may their souls rest in peace. My sister, who also stands as my mentor and friend, Pharm. Felicia Sobowale and her husband, Dr. Yemi Sobowale, I am forever grateful to you. My sister Dr. (Mrs.) Carol and her husband Dr. Osarenkhwoe; my Brother, Pastor Kehinde and his wife Bimpe Martins; and my youngest brother, my Bodi for life, Williams and Bunmi Martins, his wife, a very big thank you for always being there for me. All my nieces, nephews, grand nieces and nephews, a big thank you to you all. All the Martins, my extended family, especially Hajia Martins and Olu mi "Maiyaki", I say a big thank you for always being there for me. Thanks to all my inlaws especially my father and mother-in-law, Late Chief and Mrs Abonta, my sweet sisters and friend, Ayebatonye Ben-Basuo and late Numo and her husband, Alhaji M. Aliu, Chiwuchi Akparanta and Buchi Ihezie. Forever grateful to you all for accepting me as your wife. My aunt-in-laws, Mrs. Caterine Wachukwu and Ms. Edith Akparantha, Thanks to you all Mas. Gratitude to all my in laws, I appreciate you all. Many thanks to Prof. Eyinna Chuta and his beautiful and elegant wife, Dr Chuta for always being there for me.

Last but not the least, my immediate nuclear family: Tam Alex (Engr.) Kemabonta, Dr. Abike Kemabonta, and James Kemabonta. Thank you for the support, thank you for bearing with me and thank you for accepting me as your mother.

Finally, to the one who said, "Go! Finish this PhD and come back"... My husband (Olowo ori mi), my one and only Atonye Kemabonta. Thank you for loving me and accepting me for who I am.

Finally finally, to God be all the Glory!

REFERENCES

Adebayo, M. B., Adeonipekun, P. A., Adeleye, M. A. and **Kemabonta, K. A.** (2017). Comparative palynology of *Macrotermes sp.* mounds and *Vespula vulgaris* nests on the University of Lagos campus, Akoka. *Acta Palaeobotanica*, **57**(2): 397-406.

Adebayo, H. A., **Kemabonta, K. A**., Ogbogu, S. S., Elechi, M. C. and Obe, M. T. (2021). Comparative assessment of developmental parameters and proximate compositions of black soldier fly (*Hermetia illucens*) prepupae reared on organic waste substrates. *International Journal Tropical Insect Sci*ence, **41**: 1953-1959.

Adu, B. W., **Kemabonta, K. A**. and Giwa, O. E. (2016a). Study of water quality characteristics and benthic macroinvertebrate assemblages of Aahoo stream, Akure, South Western Nigeria. *Nigerian Journal of Scientific Research*, **15**(3): 499-504.

Adu, B. W., **Kemabonta, K. A.** and Ogbogu, S. S. (2016b). Composition and abundance of Odonates at Alatori Stream, South-West Nigeria. *Unilag Journal of Medicine, Science and Technology*, **4**(1): 96-110.

Adu, B. W., **Kemabonta, K. A.** and Ogbogu, S. S. (2016c). Monitoring of environmental disturbance using abundance and distribution of red-vein and dark-vein species of genus Trithemis (Odonata: Libellulidae). *The Zoologist*, **14**: 31-36.

Adu, B. W., Ogbogu, S. S., **Kemabonta, K. A**. (2015). Dragonflies and damselflies (Insecta: Odonata) as tools for habitat quality assessment and monitoring. *FUTA Journal of Research in Sciences*, **11**(1): 36-45.

Alafia, A. and **Kemabonta, K. A.** (2019). Odonates of Lagos State University. Version 1.6. Lagos State University. Occurrence dataset http://ipt-nigeria.gbif.fr/resource?r=odonates_of_lagos_state_university

Anikwe, J. C., **Kemabonta, K. A.**, Okelana, F. A. and Omoloye, A. A. (2009). The efficacy of spintor dust in controlling the kola weevil, *Balanogast*ris *kolae* (Desbrochers) infesting kolanuts in storage. *African Journal of General Agriculture,* **5**(1): 33-37.

Anikwe, J. C., Adetoro, F. A., Anogwih, J. A., Makanjuola, W. A., **Kemabonta, K. A.** and Akinwande, K. L. (2014). Laboratory and field evaluation of an indoxacarb gel against two cockroach species (Dictyoptera: Blattellidae) in Lagos, Nigeria. *Journal of Economic Entomology*, **107**(4): 1639-1642.

Aribisala, O. A., Sogbanmu, T. O. and **Kemabonta, K. A.** (2022). Genotoxic, biochemical and histological biomarkers of subacute concentrations of paraquat and glyphosate in Nile Tilapia. *Environmental Analysis Health and Toxicology*, **37**(2): e2022012.

Astuti, D. A. and Wiryawan, K. G. (2022). Black soldiers fly as feed ingredients for ruminants. *Animal Bioscience*, **35**(2): 356-363. https://doi.org/10.5713/ab.21.0460

Babarinde, S. A., **Kemabonta, K. A.,** Aderanti, I. A., Kolawole, F. C. and Adeleye, A. D. (2018). Synergistic effect of spinosad with selected botanical powders as biorational insecticides against adults of Tribolium castaneum, Herbst, 1797 (Coleoptera: Tenebrionidae). *Journal of Agricultural Sciences*, **63**(1): 39-51.

Babarinde, S. A., **Kemabonta, K. A.,** Olatunde, O. Z., Ojutiku, E. O. and Adeniyi, A. K. (2021). Composition and toxicity of rough lemon (*Citrus jambhiri*, Lush) rind essential oil against *Tribolium castaneum*, Red flour beetle. *Acta Ecologica Sinica*, **41**(4): 325-331.

Boxall, A. (2001). Post-harvest losses to insects, a world overview. *International Biodeterioration and Biodegradation,* **48**(1-4): 137-152. https://doi.org/10.1016/ S0964-8305(01)00076-2

Budd, G. and Telford, M. (2009). The origin and evolution of arthropods. *Nature*, **457**: 812-817.

Cabrera, B. J. (2002). Cigarette beetle, Lasioderma serricorne, Fab (Insecta: Coleoptera: Anobiidae). EENY-227/IN384, 7/2001. *EDIS*.

Dobson, F. (2012). Butterflies act as wildlife indicators, warning us of ecosystem changes. *Environmental News Network*, *25*.

Dossey, A. T., Tatum, J. T. and McGill, W. L. (2016). Insects as sustainable food ingredients. 113-152. https://doi.org/10.1016/B978-0-12-802856-8.00005-3

Eesiah Sawo, Jianmei Yu, Beatrice Dingha, Barbara Amoah, and Nona Mikiashvili. (2022). Preliminary assessment of repellency and toxicity of essential oils against *Sitophilus zeamais*, Motschulsky (Coleoptera: Curculionidae) on stored organic corn grains. *Foods*, **11**(18): 2907. https://doi.org/10.3390/foods11182907

Ekpah, O., Adu, B. W. and **Kemabonta, K. A. (**2020a). An inventory of Odonata in relation to water quality in Lekki Conservation Centre, Nigeria. *British Journal of Entomology and Natural History,* **33**(2905): 1-15.

Ekpah Ojonugwa, **Kemabonta, K. A.,** Ogbogu, S. S. and Fomekong-Lontchi, J. (2020b). Records of lost and associated species of Odonata in Cross River National Park, Nigeria. *Odonatological*, **49**(3-4): 245-258.

Ekpah, O., **Kemabonta, K. A.,** Klaas-Douwe, D., Sylvester, S. O., Fomekong-Lontchi, J. and Clifford, O. (2021). Odonata from two western Nigeria rainforests, with a record of the rare Ceriagrion citrinum, Campion, 1914. *International Dragonfly Fund Report,* 1435-3393: 1-17.

Elechi, M. C**., Kemabonta, K. A.,** Adebayo, H. A., Obe, M. T., Orabueze, I. C., Ogbogu, S. S. and Adetoro, F. A. (2021). Bioaccumulation of heavy metals in prepupae of black soldier fly, *Hermetia illucens,* Linnaeus (Diptera: Stratiomyidae) reared on organic wastes and chicken feed substrates. *International Journal of Tropical Insect Science,* **41**: 2125-2131.

Essien, R. and **Kemabonta, K. A. (**2019). Odonata of Akwa Ibom State University, Nigeria. Version 1.5. Akwa Ibom State University. Occurrence dataset http://ipt-nigeria.gbif.fr/resource?r=odoantes_from_akwa_ibom_state_university

Evans, J., Alemu, M. H., Flore, R., Frost, M. B., Halloran, A., Jensen, A. B., Maciel-Vergara, G., Meyer-Rochow, V. B., Münke-Svendsen, C., Olsen, S. B., Payne, C., Roos, N., Rozin, P., Tan, H. S., Van-Huis, G. A., Vantomme, P. and Eilenberg, J. (2015). Entomophagy, an evolving terminology in need of review. *Journal of Insects as Food and Feed*, **1**(4): 3-293.

Ezeobiora, I. B., **Kemabonta, K. A.** and Makanjuola, W. A. (2021). Survey of insects and mites associated with stored rice in Nigeria. *Nigerian Annals of Pure and Applied Sciences,* **4**: 194-201.

Ezeobiora, I. B., **Kemabonta, K. A.,** Makanjuola, W. A., Zhihong, L. E. and Opit, G. (2023a). Morphological and molecular characterization of insect pests associated with stored products in Nigeria based on PCR-RFLP and Co1 DNA barcoding. *In Press.*

Ezeobiora, I. B., **Kemabonta, K. A.,** Makanjuola, W. A., Opit, G. and Zhihong L. E. (2023b). First Nigerian record of Psocid (Pscocoptera: Liposcelidae) species infesting stored rice in Nigeria. *In Press*.

Folgarait, P. (1998). Ant biodiversity and its relationship to ecosystem functioning: a review. *Biodiversity and Conservation,* **7**(9): 1221–1244.

Ghazanfar, M., Malik, M.F., Hussain, M., Iqbal, R. and Younas, M. (2016). Butterflies and their contribution to ecosystem. *Journal of Entomology and Zoology Studies*, **4**(2): 115-118.

Guénard, B. (2013). An overview of species and ecological diversity of ants. *Encyclopedia of Life Sciences*. John Wiley and Sons Ltd, Chichester.

Gullan, P. J. and Cranston, P. S. (2005). *The Insects: An Outline of Entomology*. Blackwell Publishing Ltd, (3rd edition).

Jimoh, B. O., Gomez, K., **Kemabonta, K. A.** and Makanjuola, W. A. (2021). New records of non-native ants (Hymenoptera: Formicidae) in four African countries. *Belgian Journal of Entomology*, **119**: 1-14.

Jimoh, B. O., Gomez, K., **Kemabonta, K. A.**, Makanjuola, W. A., Phiri, E.E. and Mothapo, P.N (2023). A Checklist of Nigeria ants (Hymenoptera, Formicidae): A review, new records and exotic species. *In Press*

Jones, G. D. and Jones, S. D. (2001). The uses of pollen and its implication for entomology. *Neotropical Entomology,* **30**(3). https://doi.org/10.1590/S1519-566X2001000300001

Kalluri, S., Gilruth, P., Rogers, D. and Szczur, M. (2007). Surveillance of arthropod vector-borne infectious diseases using remote sensing techniques. *PLoS Pathogens,* **3**(10): e116. https://doi.org/10.1371/journal.ppat.0030116

Kemabonta, K. A. and Odebiyi, J. A. (2001). Development, survival and fecundity of R*astrococcus invadens,* Williams (Hemiptera: Pseudococcidae) on four host plants. *Journal of Fruit and Ornamental Plant Research,* **10**(-4): 51-61.

Kemabonta, K. A. and Odebiyi J. A. (2002). Comparative studies on the effect of temperature on life tables of *Rastrococcus invadens,* Williams (Hemiptera; Pseudococcidae) and *Gyanusoidea tebygi*, Noyes (Hymenoptera: Encyrtidae). *Ghana Journal of Agricultural Science,* **35:** 23-31.

Kemabonta, K. A. and Okogbue, F. (2002). *Chenopodium ambroisoides* (Chenopodiaceae) is a grain protectant for the control of the cowpea beetle, *Callosobruchus maculatus*, Fab (Coleoptera: Bruchidae). J*ournal of Fruit and Ornamental Plant Research*, **10**: 165-171.

Kemabonta, K. A. and Odebiyi, J. A. (2003). Development and reproductive biology of *Gyranusoidea tebygi* (Hymenoptera: Encytidae). *ASSET*, **3**(2): 99-108.

Kemabonta, K. A. and Okoye, A. (2004). Comparative biological activity of *Synzygium aromaticum* and *Xylopia ethiopica* on *Rhyzopertha dominica,* Fab and *Sitophilus zeamais,* Motch in maize grains*. Journal of Asia Pacific Entomology*, **7**(3): 339-342.

Kemabonta, K. A. and Odebiyi, J. A. (2005). Susceptibility of the life stages of *Callosobruchus maculatus*, Fab (Coleoptera: Bruchidae) to diflubenzuron in cowpea seeds. *Journal of Plant Disease and Protection*, **112**(3): 193-199.

Kemabonta, K. A., Makanjuola, W. A. and Sadiku, B. T. (2009). Effectiveness of four protectants against the weevil, *Balanogastris kolae,* Desbr (Coleoptera: Curculionidae) on kolanuts, *Cola nitida* in storage. *Nigerian Journal of Science*, **43:** 63-71.

Kemabonta, K. A. and Anikwe, J. C. (2010). Insecticidal activity of Diatomaceous Earth (ProtectIt®) on the life stages of *Callosobruchus maculatus,* Fab (Coleoptera: Bruchidae). *Bioscience Research Communications,* **22:** 101-107.

Kemabonta, K. A., Odebiyi, J. A. and Olagbaju (2010). An assessment of diflubenzuron, as a protectant of cowpea grains against *Callosobruchus maculatus,* Fab

(Coleoptera: Bruchidae). *Nigerian Journal of Science,* **44:** 49-55.

Kemabonta, K. A. and Akinhanmi, F. O. (2013). Toxicological effects of chlorpyrifos, dichlorvos and alpha cypermethrin on adult albino mice, *Mus musculus. Production Agriculture and Technology*, **9**(2): 1-17.

Kemabonta, K. A. and Falodu, B. B. (2013). Bioefficacy of three plant products as post-harvest grain protectants against *Sitophilus oryzae*, Linnaeus (Coleoptera: Curculionidae) on stored wheat (*Triticum aestivum*). *International Journal of Science and Nature*, **4**(2): 259-264.

Kemabonta, K. A. and Nwankwo, A. E. (2013). Larvicidal effectiveness of Spinosad and Temephos on *Anopheles gambiae* and *Aedes aegypti*. *International Journal of Science and Nature*, **4**(2): 214-222.

Kemabonta, K. A., Anikwe, J. C. and Adaezeobiora, I. B. (2013). Bioefficacy of skeeter abates and spintor on *Anopheles gambiae* and *Aedes aegypti* mosquitoes from insecticide resistance areas in Lagos and Oyo States, Nigeria. *Journal of Biology, Agriculture and Healthcare,* **3**(3): 122-135.

Kemabonta, K. A., Makanjuola, W. A. and Omogunloye, O. A. (2013). Evaluation of spintor™ dust in the protection of dried *Tilapia niloticus* against *Dermestes maculatus,* De Geer (Coleoptera: Dermestidae). *Journal of Natural Sciences Research*, **3:** 51-59.

Kemabonta, K. A., Aninye, A., Ajelara, K. O. and Adu, B. W. (2014). Toxicity and repellency action of *Lantana camara* on *Anopheles gambiae,* Giles. *Production Agriculture and Technology*, **10**(2): 54-64.

Kemabonta, K. A. and Aderemi, A. O. (2014). Post environmental impact assessment and toxicological evaluation of major emissions on selected fauna of the AP filling station, University of Lagos, Lagos. Nigeria. *Production Agriculture and Technology*, **10**(1): 1-16.

Kemabonta, K. A. and Amadi, G. (2014). The comparative and residual efficacy of Sniper and Alpha cypermethrin in the control of *Blattella germanica*, Linnaeus (Dictyoptera: Blattellidae). *African Journal of Environmental Science and Technology,* **8**(5): 274-282.

Kemabonta, K. A. and Balogun (2014). Species richness, diversity and relative abundance of termite in the University of Lagos, Nigeria. *FUTA Journal of Research in Sciences*, **10**(2): 188-197.

Kemabonta, K. A. and Ezeobiora, I. B. (2014). Knowledge and compliance with pesticide safety precautions among stakeholders in Lagos State, southwestern Nigeria. *Nigerian Journal of Ecology*, **13**: 85-96.

Kemabonta, K. A., Ohadiwe, A. and Adetoro, F. A (2014). Toxicological and residual effects of (deltamethrin) and (chlorpyrifos) against the German cockroach, *Blatella germanica,* Linnaeus (Insecta: Blattodea: Blattellidae). *Journal of Entomology and Nematology,* **6**(7): 90- 97.

Kemabonta, K. A., Ebiyon, A. S. and Olaleru, F. (2015). The Butterfly fauna of three habits in South Western Nigeria. *FUTA Journal of Research in Sciences*, **11**(1): 1-6.

Kemabonta, K. A., Adu, B. W. and Ohadiwe, A. C. (2016). Impact of human disturbance on the abundance, diversity and distribution of Odonata in the University of Lagos, Akoka, Lagos. Nigeria. *Applied Tropical Agriculture*, **21**(3): 143-150.

Kemabonta, K. A., Ohadiwe, A. C., Akinniyi, S. Y. and Nwanade, C. (2017a). Infestation and development of the cigarette beetle, *Lasioderma serricorne*, Fab (Coleoptera: Anobiidae) on four local Nigerian grains. *Nigerian Journal of Pure and Applied Sciences*, **9**(1): 94-99.

Kemabonta, K. A., Onuoha, C. B. and Nwanade, C. F. (2017b). Mortality and development of the cigarette beetle, *Lasioderma serricorne,* Fab (Coleopter: Anobiidae) on five Nigerian spices. *Nigerian Journal of Postharvest Research,* **1:** 13-21

Kemabonta, K. A. and Ajiboye, M. O. (2018). Morphology, Protein profile and the level of infestation of bedbugs (Hemiptera: Cimicidae) in halls of residence of a higher Institution in Lagos. *Nigerian Annals of Pure and Applied Sciences* 1, 96-105.

Kemabonta, K. A., Adediran, O. I. and Ajelara, K. O. (2018a). The insecticidal efficacy of the extracts of *Piper nigrum* (black pepper) and *Curcuma longa* (turmeric) in the control of *Anopheles gambiae*, Giles (Diptera: Culicidae). *Jordan Journal of Biological Sciences*, **11**(2): 195-200.

Kemabonta, K. A., Adeonipekun, P. A., Adebayo, M. B., Anumudu, P. and Adeniyi., T. A. (2018b). Aerobiology of insect parts in Ayetoro, Ota, South West Nigeria. *Annals of West University of Timisoara, ser, Biology*, **21**(1): 57-66.

Kemabonta, K. A., Adu, B. W., Akanni, N., Olajide, J. P. and Uche-Dike, R. (2018c). Studies on the influence of human activities on the species diversity of Odonata in parts of Lagos metropolis. *Nigerian Annals of Pure and Applied Sciences*, **1:** 96-105.

Kemabonta, K. A. and Adu, B. W. (2019). Odonata of the Federal University of Technology Akure Nigeria. Version 1.4. The Federal University of Technology, Akure. Occurrence dataset http://ipt-nigeria.gbif.fr/resource?r=odonates_of_federal_university_of_technology_akure_nigeria

Kemabonta, K. A. and Ogbogu, S. S. (2019). Odonata of Obafemi Awolowo University Ile Ife Nigeria. Version 1.2. Obafemi Awolowo University. Occurrence dataset http://ipt-nigeria.gbif.fr/resource?r=odonates_of_obafemi_awolowo_university_ile_ife_nigeria

Kemabonta, K. A., Adu, B. W., Nwabueze, O. F., Ogbogu, S. S. and Ohadiwe, A. (2019a). The diversity and distribution of dragonflies and damselflies (Odonata) in University of Lagos, Akoka, Lagos, south-west Nigeria. *The Zoologist*, **17:** 1-5.

Kemabonta, K. A., Essien, R., Adu, B, W., Ogbogu, S. S., Iysa, A. and Uche-Dike, R. (2019b). Abundance and distribution of Odonates (dragonflies and damselflies) in Akwa Ibom State Nigeria. *Pan African Journal of Life Sciences,* **2:** 33-38.

Kemabonta, K. A., Babarinde, S. A., Nwanade, C. F. and Oyekunle, O. D. (2020a). Suitability and susceptibility of selected carbohydrate-based foods to Cigarette beetle, *Lasioderma serricorne*, Fab (Coleoptera: Anobiidae). *Annals of the West University Ser. Biology,* **23**(1): 47-54.

Kemabonta, K. A., Fadare, A. A., Jokanola, B. A, Ogbogu, S. S. and Adu, B. W. (2020b). Odonata fauna as bioindicators of water quality and bioaccumulation of heavy metals in

Kara and Opa streams, south-western Nigeria. *Journal of Science Research and Development.* **19**(1): 1-11.**Kemabonta, K. A.,** Ikerodah, A. and Anumudu, P. C. (2020c). Toxicological effects of petrol, xylene and tinner on *Mus musculus* (albino mice). *Pan African Journal of Life Sciences*, **4**(2): 98-103.

Kemabonta, K. A., Uche-Dike, R., Adu, B. W. and Ogbogu, S. S. (2020). Water quality of lakes in Lufasi park and Omu resort, Lagos, Nigeria as indicators of Odonata diversity, distribution and abundance. *Journal of Science Research and Development*, **19**(1): 152-165.

Kemabonta, K. A., Ukperhine, O. R., Osuala, F. and Aderolu (2020). A comparative assessment of the macro-benthic fauna diversity and heavy metals bioaccumulation in canal, Ogbe Creek and Abule -Agege Creek in Akoka, Lagos. Nigeria. *Annals of West University of Timişoara, ser. Biology*, **23**(2): 265-282.

Kemabonta, K., Oluwatobi, O., Femi, A., Emmanuel, U., Ojonugwa, E., Joseph, A. and Alafia, A. (2023). Diversity and abundance of butterflies in protected and unprotected habitation in Lagos, Nigeria. https://doi.org/10.21203/rs.3.rs-2929078/v1

Korunić, Z., Rozman, V., Liška, A. and Lucić, P. (2016). A review of natural insecticides based on diatomaceous earth. *Poljoprivreda,* **22**(1): 10-18. https://doi.org/10.18047/poljo.22.1.2

Korunic, Z. and Stefan, C. (1998). Grain bulk density as affected by diatomaceous earth and application method. *Postharvest Biology and Technology*, **13**(1): 81-89. https://doi.org/10.1016/S0925-5214(97)00076-8

Kovar, P., Vojtíšek, P. and Zentsová, I. (2013). Ants as ecosystem engineers in natural restoration of human-made habitats. *Journal of Landscape Ecology*, **6**(1):18-31.

Kumar, D. and Prasanta, K. (2017). Reducing postharvest losses during storage of grain crops to strengthen food security in developing countries. *Foods* **6**(1): 8. https://doi.org/10.3390/foods6010008

Larsen, T. B. (2005). *Butterflies of West Africa*. Apollo Books.

Lilholt, A. (2015). Entomological gastronomy: a gastronomical approach to entomophagy.

Makanjuola, W. A., Isong, I. U., Omoloye, A. A., **Kemabonta, K. A.** and Ogunyadeka, A. O. (2009). Inherent susceptibility of elite rice varieties to post harvest damage by *Sitophilus zeamais*, Mostch (Coleoptera: Curculionidae). *Nigerian Journal of Ecology*, **10:** 11-15.

Mohd, Z., Holloway, S. and Mohd, N. (2020). Maggot therapy in wound healing: a systematic review. *International Journal of Environmental Research and Public Health*, **17**(17): 6103.

Moore, D. (2004). Biological control of *Rastrococcus invadens*. *Biocontrol News and Information*, **25**(1): 17-27.

Mumcuoglu, K. Y., Ingber, A., Gilead, L., Stessman, J., Friedmann, R., Schulman, H. and Bichucher, H. (1999). Maggot therapy for the treatment of intractable wounds. *International Journal of Dermatology*, **38**(8): 623-627.

Nally, R., Fleishman, E., Bulluck, L. P. and Betrus, C. J. (2004). Comparative influence of spatial scale on beta diversity within regional assemblages of birds and butterflies. *Journal of Biogeography,* **31**(6): 917-929. https://doi.org/10.1111/j.1365-2699.2004.01089.x

Nemec, K. T. (2014). Tallgrass prairie ants: their species composition, ecological roles, and response to management. *Journal of Insect Conservation*, **18**(4): 509-521.

Nigam, Y. and Morgan, C. (2016). Does maggot therapy promote wound healing? The clinical and cellular evidence. *Journal of the European Academy of Dermatology and Venereology*, **30**(5): 776-782.

Nwanade, C., **Kemabonta, K. A.** and Odediya, O. T. (2020). Persistence and effectiveness of diatomaceous earth, spinosad and k'obiol powders against S*itophilus zeamais*, Linnaeus (Coleoptera: Curculionidae) on stored rice. *Nigerian Journal of Entomology,* **36:** 113-117.

Odebiyi, J. A. and **Kemabonta, K. A**. (2006). Life cycle of the ladybird beetle *Cheilomenes lunata,* Fab (Coleoptera: Coccinelidae), a potential biocontrol agent of the cowpea aphid, *Aphis craccivoara,* Koch (Homoptera: Aphididae). *Nigerian Journal of Entomology,* **23:** 18-21.

Omoloye, A. and **Kemabonta, K**. (2019). Odonata of University of Ibadan, Nigeria. Version 1.10. University of Ibadan.

Occurrence dataset http://ipt-nigeria.gbif.fr/resource?r=odonates_of_university_of_ibadan
Onuminya, T., Ogundipe, O., Igbari, A. and **Kemabonta, K. (2022)**. A Checklist of African Sapindaceae. v1.4. University of Lagos. Dataset/Checklist. http://ipt-nigeria.gbif.fr/resource?r=checklist_of_sapindaceae_in_the_lagos_herbarium&v=1.4
Onuminya, T., Ogundipe, O., Igbari, A., **Kemabonta, K.** and Suberu, A. (2022). Trees of Lagos Metropolitan City, Lagos, Nigeria. Version 1.1. University of Lagos. Occurrence dataset https://doi.org/10.15468/wd8cb4 accessed via GBIF.org on 2023-08-02.
Osuala, F. I., Abiodun, O. A., Igwo-Ezikpe, M. N., **Kemabonta, K. A.** and Otitoloju, A. A. (2017a). Relative toxicity of cigarette butts leachate and usefulness of antioxidant biomarker activity in Nile Tilapia *Oreochromis niloticus* (Trewavas). *Ethiopian Journal of Environmental Studies and Management* **10**(1): 75-88.
Osuala, F. I., Abiodun, O. A., Igwo-Ezikpe, M. N. and **Kemabonta, K. A.** (2017b) Toxicological assessment of four common household surfactants on *Clarias gariepinus* (Burchell, 1822) and *Oreochromis niloticu*s (Linnaeus, 1758). *Journal of Aquatic Sciences*, **32**(1): 13-23.
Osuala, F. I., Samuel, O. B., Abiodun, O. A., Igwo-Ezikpe, M. N., **Kemabonta, K. A.** and Otitoloju, A. A. (2017c). Single and joint action evaluation of insecticide and laundry detergent against *Poecilia reticulata. Ethiopia Journal of Environmental Studies and Management,* **10**(4): 530-542.
Oostermeijer, J. G. and Van-Swaay, C. A. (1998). The relationship between butterflies and environmental indicator values: a tool for conservation in a changing landscape. *Biological Conservation*, **86**(3): 271-280. https://doi.org/10.1016/S0006-3207(98)00040-8
Sadiku, B. T., **Kemabonta, K. A**. and Makanjuola, W. A. (2017). Effect of interspecific competition between the larger grain borer, *Prostephanus truncatus*, Horn (Coleoptera: Bostrychidae) and the maize weevil, *Sitophilus zeamais*, Motschulsky (Coleoptera: Curculionidae) on grain damage

and progeny production in stored maize, *Zea mays*, Linnaeus. *Nigerian Journal of Entomology*, **33:** 37-45.
Sadiku, B. T., **Kemabonta, K. A.** and Makanjuola, W. A. (2019). Reproductive performance of the larger grain borer, *Prostephanus truncatus*, Horn (Coleoptera: Bostrichidae) on three different food hosts. *Nigerian Journal of Entomology,* **35**: 19-30.
Sánchez-Herrera, M. and Ware, J. L. (2012). Biogeography of dragonflies and damselflies: highly mobile predators, global advances in biogeography, Dr. Lawrence Stevens (Ed.), ISBN: 978-953-51-0454-4, InTechOpen, Available from: http://www.intechopen.com/books/global-advances-in-biogeography/biogeography-ofdragonflies-and-damselflies-the-highly-mobile-predators
Schowalter, T. D. (2013). *Insects and Sustainability of Ecosystem Services* (1st ed.). CRC Press. https://doi.org/10.1201/b14911
Stejska, V., Tomas, V., Radek, A. and Christos, A. (2021). Synthetic and natural insecticides: Gas, liquid, gel and solid formulations for stored-product and food-industry pest control. *Insects*, **12**(7): 590. https://doi.org/10.3390/insects12070590
Tekulsy, M. (2015). The art of Butterfly gardening: How to make your backyard into a beautiful home for butterflies.
Tschinkel, W. R. (2003). Subterranean ant nests: Trace fossils past and future? *Palaeogeography, Palaeoclimatology, Palaeoecology*. **192**(1-4): 321-333.
Ude, A. U., Eshkoor, R. A., Zulkifili, R., Ariffin, A. K., Dzuraidah, A. W., and Azhari, C. H. (2014). *Bombyx mori* silk fibre and its composite: A review of contemporary developments. *Materials and Design*, **57:** 298-305. https://doi.org/10.1016/j.matdes.2013.12.052
Van-Ham, C., Genovesi, P. and Scalera, R. (2013). *Invasive alien species: The urban dimension, case studies on strengthening local action in Europe*. IUCN European Union Representative Office, Brussels, Belgium.
Wetterer, J. K. (2009). Worldwide spread of the destroyer ant, *Monomorium destructor* (Hymenoptera: Formicidae). *Myrmecological News*, **12:** 97–108.

Wetterer, J. K. (2015). Geographic origin and spread of cosmopolitan ants (Hymenoptera: Formicidae). *Halteres*, **6:** 66-78.

Zakka, U., **Kemabonta, K. A.,** Ojiako, F. O. and Ezeano, U. C. (2017). Diversity of Odonata in Choba, Rivers State, Nigeria. *Nigerian Journal of Pure and Applied Sciences*, **9**(2): 97-104.