





ORIGINAL RESEARCH ARTICLE

Seasonal Abundance and Spatial Distribution of Flying Insects in Katsina Metropolis, Nigeria During Rainy Season

*Hauwa'u Nasir Alah¹, Timothy Auta¹, Abdulhadi Bawa Jibia¹, and Abdullahi Mohammed Garkuwa¹

¹Department of Biological Sciences, Federal University, Dutsin-Ma, Katsina State, Nigeria

ABSTRACT

During the rainy season (August-November 2024), this study examined the distribution and abundance of flying insects in three important habitats: farmlands, residential areas, and slaughter regions in Katsina Metropolis, Nigeria. An overall total of 15,814 insect specimens were gathered and categorized into 26 groups using sweep nets, light traps, a DIY trap, and sticky traps. Due to organic waste, *Muscidae* (*Musca domestica*) dominated residential areas (45.02%), while *Sarcophagidae* (12.1%) and *Silphidae* (9.37%) were more common in slaughter areas, indicating their role in decomposition, according to the results, which showed notable seasonal and spatial variations. In residential areas, *Culicidae* species (*Anopheles gambiae*, *Culex pipiens*, and *Aedes aegypti*) were common and associated with standing water. The diversity of farmlands was higher, with pollinators like *Apidae* (0.56%) and *Drosophilidae* (11.04%). According to seasonal tendencies, abundance peaked in the rainy months of August through October and then declined in November as temperatures dropped. These results have significance for agriculture, urban ecosystem management, and public health since they demonstrate how habitat type, waste availability, and climate affect flying insect populations.

ARTICLE HISTORY

Received May 15, 2025

Accepted August 28, 2025

Published September 24, 2025

KEYWORDS

Flying insects, abundance, diversity, distribution, seasonal variation, public health.



© The Author(s). This is an Open Access article distributed under the terms of the Creative Commons Attribution 4.0 License [creativecommons.org](https://creativecommons.org/licenses/by-nc/4.0/)

INTRODUCTION

Insects are highly significant due to their ecological roles, diversity, and impacts on natural resources, agriculture, and human health (Aslam, 2019). They comprise about 58% of the world's known biodiversity and inhabit virtually every environment, where they support ecosystem stability and function (Ananthaselvi et al., 2019). Because of their essential roles in terrestrial ecosystems, insects are often regarded as crucial "natural capitals," providing a wide range of ecosystem goods and services, pollination, natural and biological pest control, decomposition, nutrient cycling, ecosystem engineering, wildlife maintenance, and even direct food for humans. Many vertebrates and invertebrates, including other insects, depend on them as a primary food source (Losey & Vaghan, 2016; Chelse et al., 2013). Their diversity is therefore vital for maintaining environmental balance (Callados & Duane, 2014).

Insects are also central to groundbreaking research across many scientific disciplines, including biomechanics, climate change studies, developmental biology, ecology, evolution, genetics, paleolimnology, and physiology. Despite their importance, many insect species, including ones not yet described, are being lost through extinction

or local extirpation worldwide, which creates serious ecological and practical consequences.

The ability to fly has been a key driver of the evolutionary success of the diverse group of arthropods classified as flying insects (class Insecta). Wings, extensions of the exoskeleton, evolved more than 300 million years ago and allowed insects such as butterflies, bees, flies, and dragonflies to exploit new ecological niches: avoiding predators, dispersing to new areas, and more effectively locating mates and food (Gullan & Cranston, 2014).

As major pollinators, flying insects play a critical role in both ecosystems and agriculture. Bees, especially honeybees, are a well-known example: while foraging for nectar, they transfer pollen and thereby facilitate plant reproduction. Animal pollination benefits over 75% of crops, supporting biodiversity and contributing significantly to global food supplies. Losses of pollinators from habitat destruction, pesticide use, and climate change therefore pose a serious threat to food security (Klein et al., 2017). Flying insects also contribute to pest control; predatory and parasitic species (e.g., dragonflies, some wasps) consume or parasitize herbivorous pests and help regulate pest populations.

Correspondence: Hauwa'u Nasir Alah. Department of Biological Sciences, Federal University, Dutsin-Ma, Katsina State, Nigeria. ✉ hauwaunalah@gmail.com.

How to cite: Nasir, H. A., Auta, T., Bawa, A. J. & Mohammed, A. G. (2025). Seasonal Abundance and Spatial Distribution of Flying Insects in Katsina Metropolis, Nigeria During Rainy Season. *UMYU Scientifica*, 4(3), 1 – 8. <https://doi.org/10.56919/usci.2543.001>

Flying insects are extremely abundant. Estimates suggest there are approximately one trillion flying insects in the air at any given time, underscoring their extraordinary numbers (Chapman et al., 2013). Their presence across nearly every habitat, from hot deserts to frigid tundra, adds to this abundance (Resh & Cardé, 2019). High reproductive rates are common: many flying insects produce several generations per year, enabling rapid population increases (Dixon et al., 2019). Abundance also varies by season and location: for example, a study in the Amazon found flying insect numbers rose by more than 50% during the wet season (Beck et al., 2017), while a study in the United States reported a 20% summer increase (Kenis et al., 2017).

The distribution of flying insects is strongly influenced by climate, habitat, vegetation, and geography. Flying insects are generally more prevalent in tropical and subtropical regions with warm temperatures and high humidity (Chapman et al., 2013). For instance, Amazonian studies show species richness and abundance increasing with humidity and temperature (Beck et al., 2017). Conversely, cold, arid regions such as the Arctic tundra and deserts host relatively low flying insect populations (Resh & Cardé, 2019). Vegetation density and altitude further shape patterns: montane surveys in Costa Rica found species richness declined with increasing altitude (Janzen, 2013), while research in African savannas showed higher numbers where vegetation density was greater (Owen, 2021). Flying insects occupy diverse habitat types, including wetlands, grasslands, forests, and urban areas (Dennis et al., 2017).

Despite their ecological importance, flying insect populations remain understudied in many regions, producing critical knowledge gaps about their distribution and the factors affecting their survival. Global studies have documented alarming declines driven by habitat loss, pesticide use, and climate change (Potts et al., 2016), which can severely impact agriculture in countries where farming is economically central. However, comparable regional data are lacking for many locales, including Katsina Metropolis, and this absence of local evidence limits the ability to design targeted conservation or agricultural interventions.

Urbanization and environmental degradation also alter natural insect habitats through pollution from waste disposal, conversion of green areas to built environments, and the proliferation of stagnant water bodies. While urban green spaces can serve as refuges for some taxa, the overall effect of urbanization on flying insect diversity and abundance remains unclear, hampering efforts to balance development with biodiversity conservation.

Flying insects also have direct implications for public health: some species act as biological controls of pests, whereas others (e.g., certain mosquitoes) transmit diseases. Their distribution and abundance are affected by human activity, rainfall patterns, and temperature, which complicates local public-health planning in the absence of thorough distribution studies (Parmesan, 2016). Policymakers and conservationists, therefore, require

robust, local evidence to formulate effective, evidence-based interventions.

Based on the above, this study aims to investigate the abundance and spatial distribution of flying insects in Katsina Metropolis, addressing the regional data gaps outlined earlier and providing baseline information useful for conservation, agriculture, and public health planning. The specific objectives include: (1) to assess the abundance of flying insect species in Katsina Metropolis, and (2) to examine the spatial distribution of flying insect species in Katsina Metropolis.

MATERIALS AND METHODS

Study Area

The study was conducted in Katsina, the state capital of Katsina State in northern Nigeria, and the Katsina Local Government Area, which has a total population of 667,228 (National Population Commission; Enumeration Area Demarcation EAD, 2022) (Bashir, 2023). Katsina is situated near the northern border with the Niger Republic, around 360 kilometers east of Sokoto City and 175 kilometers northwest of Kano. With a total land area of roughly 2,448 km², Katsina State is situated between latitudes 12° 41'N to 13°9'N and longitudes 7°22'E to 7°52'E (Ruma, 2014).

Sampling Sites

Twelve (12) places in three (3) sections of the research area were sampled. Slaughter, residential, and farmland sectors are all located in the city of Katsina. The variety of habitats in these places led to their selection.

Sampling Period

In 2024, flying insects were gathered from August to November, the middle of the last rainy season. Light traps were set up between 9 p.m. and 5 a.m., and the flying insects were typically collected twice a week between 7 a.m. and 12 p.m.

Sample Collection

Flying insects were gathered from various locations within the study area, including the farmland, residential, and slaughter areas. The sampling areas and locations for flying insect collection in Katsina Metropolis are as follows: A. Slaughter Areas: These consist of TsohuwarKasuwa, Kofar Marusa, Central Market, and Abbatoir. B. Residential Areas: These comprise Rafin Dadi, Yammawa, Kofar Sauri, and Sabon Titin Kwado.

C. Farmland Areas: These comprise the Legislative Quarters, Dogon Rafi, Al-Qalam University, and Sabon Gida.

Flying Insects Collection Techniques

The following techniques were used to gather flying insects in the study area: a) Employ Sweep Nets: To capture flying insects in the vegetation, a 25 cm diameter sweep net composed of muslin material was attached to a 32-inch wooden handle. b) Light Trap: In all three study

locations, nocturnal flying insects were collected using positively phototaxis from a variety of light sources, including street lights and house-hold lights.

c) DIY Trap: An easy-to-make, low-cost way to get rid of pests in your garden, house, or outdoor areas is to make a DIY insect trap.

d) Sticky trap: A sticky trap is an easy-to-use and efficient instrument for catching and tracking flying insects. When insects land on its sticky surface, they are drawn to it and trapped. e) Killing Bottle/Jar: Carefully handled, collected flying insects were preserved and killed in the killing bottles without fading their original color. Boric acid was used to kill flying insects and then combined with honey or sugar to make a bait. Every flying bug that was gathered was brought to the lab for categorization, counting, and identification.

Preservation of Flying Insects for Taxonomic Study

Standard procedures were followed in order to preserve the flying insects (Singh & Sachan, 2007; Srivastava, 2004):

a) Bottle Preservation: This entails putting the insect in a glass jar or bottle filled with formaldehyde or ethanol, among other preservation solutions. The bottle was kept dry and cool after being sealed (Gaston, 2015). b) Pin Method: In order to preserve insects' physical structure and significant anatomical traits, pins are used to hold them in place, either on a mounting board or in a collecting box. c) Labeling and Storage of Flying Insects: The Department of Biology Laboratory at Federal University DutsinMa, Katsina, is where collected flying insects are kept after being preserved. The specimens were properly labeled with all the necessary information, including the collector's name, the location and date of collection, the order, the family, and the common and scientific names.

Identification of Flying insects

Each sample bottle's contents were poured into a Petri dish, where they were sorted and identified using Castner's (2000) Photographic Atlas of Entomology and Guide to Insect Identification.

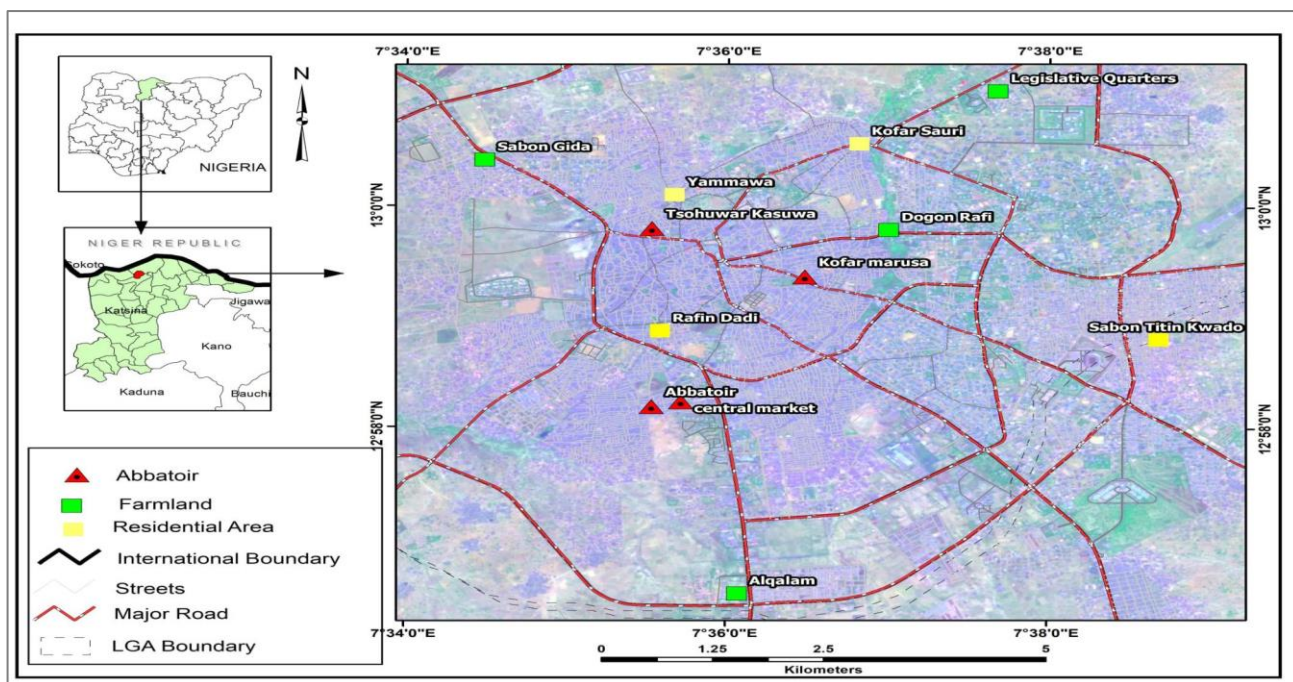


Figure 1: Map of Katsina Metropolis Showing the Study Area

Data analysis

The Statistical Package for Social Science (SPSS Version 27) was used to enter the data gathered for the study. The relative frequencies and percentages of flying insect abundance and distribution were calculated using descriptive statistics (Number of Species/Total number of Species Collected X 100) and using Analysis of Variance (ANOVA).

Shannon-Wiener Diversity Index (H')

The Shannon-Wiener Diversity Index (H') was calculated to quantify the biodiversity within each habitat type and across sampling periods. This index provides a composite measure reflecting both the number of species (richness)

and the proportion of each species (evenness) within a community.

RESULTS AND DISCUSSION

Identification of flying insects

Comprehensive overview of the various species of flying insects identified within Katsina Metropolis, a total 15,814 individuals across 30 species and 26 families. The Muscidae family, particularly *Musca domestica* (housefly), was the most dominant, accounting for 22.44% of the total insects collected, highlighting its strong adaptability to urban environments and its attraction to waste and decomposing organic matter. The Sarcophagidae family, represented by *Sarcophaga carnaria* (flesh fly), was the

second most abundant at 12.1%, predominantly found in areas with high organic waste, such as slaughterhouses. The Culicidae family, which includes important disease vectors like *Culex pipiens* (6.52%), *Anopheles gambiae*

(8.23%), and *Aedes aegypti* (5.91%), collectively comprised a significant portion of the total insect population (20.66%), suggesting a high potential for mosquito-borne diseases such as malaria and dengue fever in the area.

Table 1: Abundance of Flying Insect Species in Katsina Metropolis

Family	Genus/Specie	Slaughter		Residential		Farmland		Total	
		No	%	No	%	No	%	No	%
Culicidae	<i>Culex pipens</i>	793	9.89	220	3.63	19	1.08	1032	6.52
	<i>Anopheles gambiae</i>	1011	12.62	281	4.64	11	0.62	1303	8.23
	<i>Aedes aegypti</i>	651	8.12	274	4.53	10	0.56	935	5.91
Sarcophagidae	<i>Sarcophaga carnaria</i>	1915	23.9					1915	12.1
Simuliidae	<i>Simulium damnosum</i>	382	4.76	399	6.59	75	4.26	856	3.7
Silphidae	<i>Necrophila Americana</i>	1483	18.51					1483	9.37
Muscidae	<i>Musca domestica</i>	684	8.53	2722	45.02	144	4.26	3550	22.44
	<i>Stomoxys calcitrans</i>	226	2.32	141	2.33			367	2.32
Drosophilidae	<i>Drosophila melanogaster</i>	151	1.88	1097	18.14	498	28.34	1746	11.04
Tipulidae	<i>Tipula paludosa</i>	51	0.63	136	2.74	18	1.02	205	1.2
Acrididae	<i>Caelifera viridissima</i>					183	10.41	183	1.15
Papilionidae	<i>Papilo machaon</i>			37	0.61	59	3.35	96	0.6
Cicadidae				3	0.04	60	3.41	63	1.03
Aeshnidae	<i>Anax imperator</i>					31	1.77	31	0.19
Coccinellidae	<i>Coccinella septempunctata</i>	10	0.12	13	0.21	170	9.67	193	1.22
Apidae	<i>Apis mellifera</i>			26	0.43	64	3.64	90	0.56
	<i>Bombus terrestris</i>			29	0.47	9	0.51	38	0.24
Noctuidae	<i>Agrotis ipsilon</i>			27	0.44	76	4.32	103	0.65
Aleyrodidae	<i>Bemisia tabaci</i>					45	2.56	45	0.28
Syrphidae	<i>Episyrphus baltentus</i>	107	1.33			91	5.17	198	1.25
Formicidae	<i>Formica rufa</i>			114	1.88	42	2.39	156	0.19
Psychodidae	<i>Psychoda cineria</i>			144	2.38			144	0.91
Cecidomyiidae	<i>Cecidomyia destructor</i>	44	0.54	50	0.82			94	0.59
Vespidae	<i>Vespula vulgaris</i>			102	1.68			102	0.64
Fannidae	<i>Fannia canicularis</i>	52	0.64					52	0.32
Rhinotermitidae	<i>Reticulitermes flavipes</i>					38	2.16	38	0.24
Chironomidae	<i>Chironomus plumosus</i>	125	1.56					125	0.79
Calliphoridae	<i>Calliphora vomitoria</i>	326	4.06	231	3.82	10	0.56	567	3.58
Cicadellidae	<i>Empoasia fabae</i>					30	1.7	30	0.18
Fulgoridae	<i>Fulgora Laternaria</i>					74	4.21	74	0.46

The Drosophilidae family, particularly *Drosophila melanogaster* (fruit fly), accounted for 11.04%, with a notable presence in farmland and fruit-producing areas, emphasizing its role in decomposition and pollination. Other significant families included Silphidae (*Necrophila americana*, 9.37%), which are primarily scavengers aiding in nutrient recycling, and Calliphoridae (*Calliphora vomitoria*, 3.58%), commonly found in carcasses and organic waste. Additionally, pollinators like Apidae (*Apis mellifera*, 0.56%) and Syrphidae (*Episyrphus balteatus*, 1.25%) were recorded, playing a crucial role in the ecosystem. The least abundant species included *Empoasca fabae* (Cicadellidae, 0.18%), *Reticulitermes flavipes* (Rhinotermitidae, 0.24%), and *Fannia canicularis* (Fannidae, 0.32%), indicating habitat-specific distribution and environmental preferences. The study reveals a diverse and ecologically significant population of flying insects in Katsina Metropolis, characterized by varying species compositions that are influenced by

habitat type, food availability, and environmental conditions.

Abundance of Flying Insect Species

The findings indicate that there are notable differences in insect abundance between farmlands, residential areas, and slaughterhouses, with the most prevalent family being Muscidae, which includes houseflies and stable flies. As evidenced by their high attraction to decomposing organic waste, *Musca domestica* made up 22.44% of the total insect population and were most prevalent in residential areas (45.02%), followed by slaughter areas (8.53%) and farmlands (2.33%). Flesh flies, or Sarcophagidae, were likewise very prevalent (12.1%), and they were only found in slaughterhouses. Carrion beetles, or Silphidae, made up 9.37% of all insects and were only found in slaughterhouses, highlighting their function in

decomposition. Due to standing water, *Culex pipiens* (6.52%), *Anopheles gambiae* (8.23%), and *Aedes aegypti* (591%) were identified in residential areas, indicating the

widespread distribution of Culicidae (mosquitoes). *Drosophilidae* {Fruit flies} made up 11.04%, with farmlands accounting for the majority (28.34%).

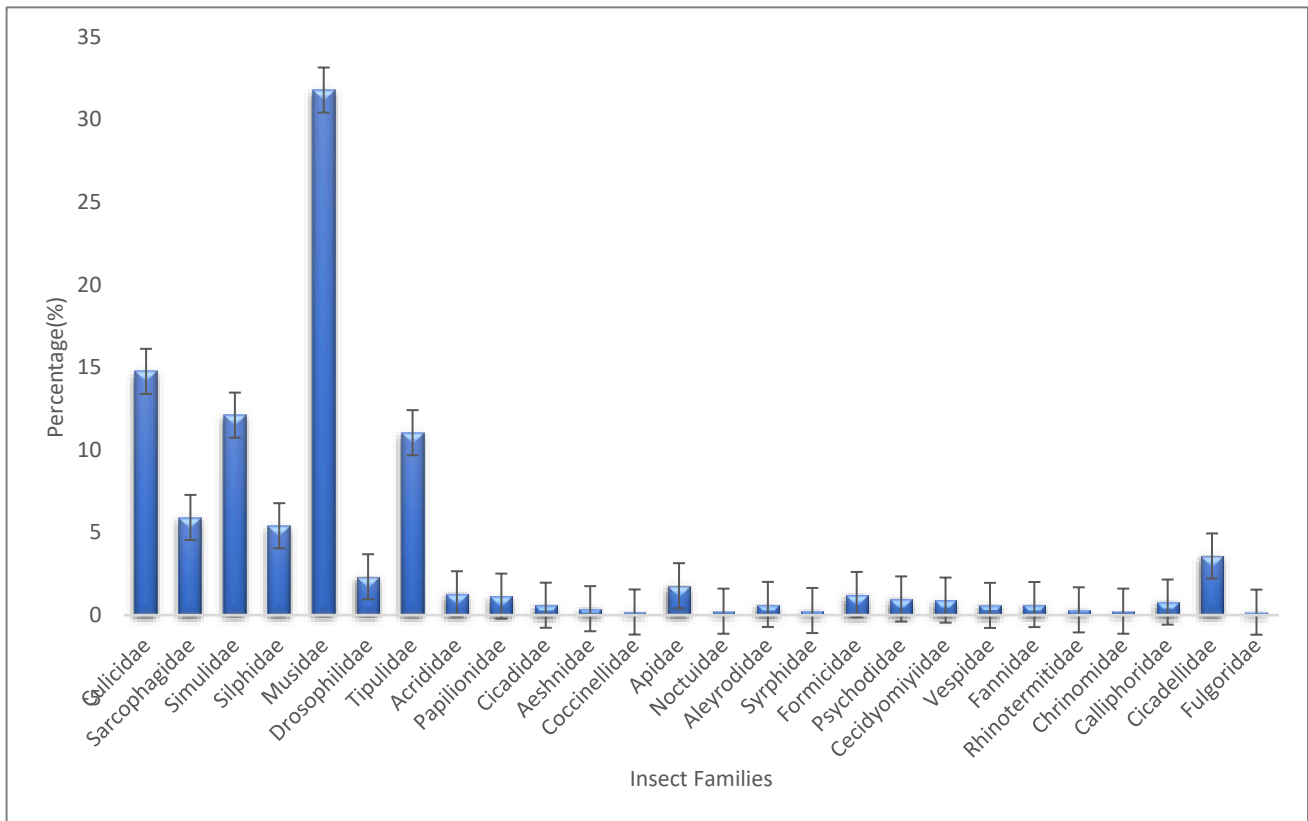


Figure 2. Figure showing the distribution of Flying Insect families in Katsina Metropolitan area

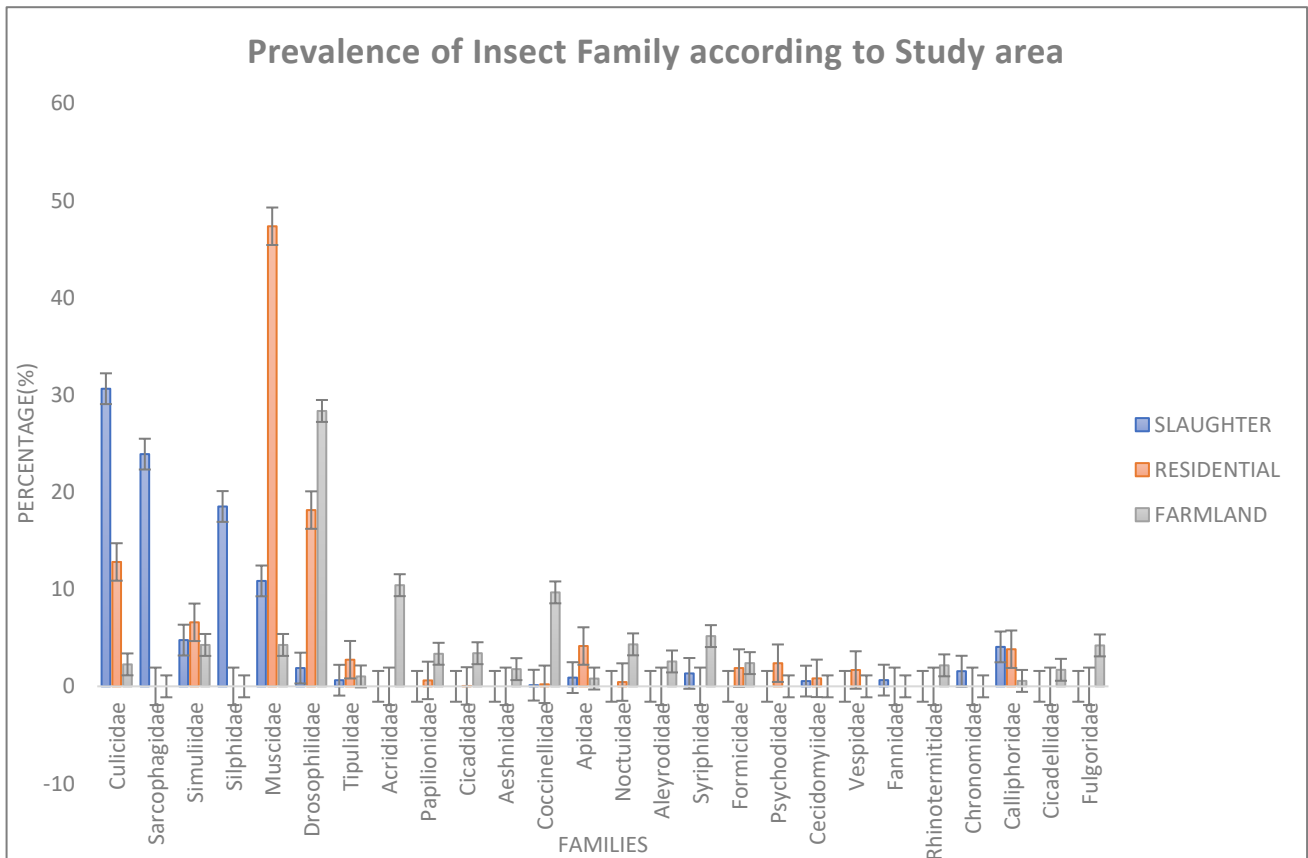


Figure 3: Prevalence of Insect Family according to the Study area

Table 2: Monthly Variation in Insect Abundance (August–November)

Family	Genus/Specie	August		September		October		November		Total	
		N	%	N	%	N	%	N	%	N	%
Culicidae	<i>Culex pipens</i>	287	9.96	197	4.68	271	5.91	277	6.68	1032	6.52
	<i>Anopheles gambiae</i>	293	10.17	226	5.37	366	7.98	418	10.08	1303	8.23
	<i>Aedes aegypti</i>	122	4.23	136	3.23	397	8.65	280	6.75	935	5.91
Sarcophagidae	<i>Sarcophaga carnaria</i>	225	7.81	503	11.96	564	12.3	623	15.03	1915	12.1
Simuliidae	<i>Simulium damnosum</i>	265	9.2	433	10.29	158	3.44			856	5.41
Silphidae	<i>Necrophila Americana</i>	220	7.63	389	9.25	443	9.66	431	10.39	1483	9.37
Muscidae	<i>Musca domestica</i>	754	26.18	981	23.33	965	21.04	850	20.5	3550	22.44
	<i>Stomoxys calcitrans</i>	11	0.38	241	5.73	33	0.71	82	1.97	367	2.32
Drosophilidae	<i>Drosophila melanogaster</i>	289	10.03	576	13.70	422	9.20	459	11.07	1746	11.04
Tipulidae	<i>Tipula paludosa</i>	52	1.8	77	1.83	48	1.04	28	0.67	205	1.29
Acrididae	<i>Caelifera viridissima</i>	61	2.11	10	0.23	3	0.06	109	2.62	183	1.29
Papilionidae	<i>Papilo machaon</i>	18	0.62	30	0.71	30	0.65	28	0.43	96	0.60
Cicadidae	<i>Magicalada septendecim</i>	14	0.48	3	0.07	46	1.00			63	0.39
Aeshnidae	<i>Anax imperator</i>	18	0.62	13	0.30					31	0.19
Coccinellidae	<i>Coccinella septempunctata</i>	6	0.2	100	2.37	42	0.91	45	1.08	193	1.22
	<i>Apis mellifera</i>	33	1.14	21	0.49	18	0.39	18	0.43	90	0.56
Apidae	<i>Bombus terrestris</i>	1	0.03	8	0.17	8	0.17	19	0.45	38	0.24
	<i>Agrotis ipsilon</i>	28	0.97	26	0.61	28	0.61	21	0.5	103	0.65
Aleyrodidae	<i>Bemisia tabaci</i>	23	0.79	11	0.26			11	0.26	45	0.28
Syrphidae	<i>Episyrphus balteatus</i>	12	0.41	18	0.42	48	1.04	120	2.89	198	1.25
Formicidae	<i>Formica rufa</i>	64	2.22	45	1.07	36	0.78	11	0.26	156	0.98
Psychodidae	<i>Psychoda cineria</i>	60	2.08	33	0.78	33	0.71	18	0.43	144	0.91
Cecidomyiidae	<i>Cecidomyia destructor</i>	12	0.41	29	0.68	50	1.09	3	0.07	94	0.59
Vespidae	<i>Vespa vulgaris</i>	12	0.41	40	0.95	12	0.26	38	0.91	102	0.64
Fannidae	<i>Fannia canicularis</i>			18	0.42	34	0.74			52	0.32
Rhinotermitidae	<i>Reticulitermes flavipes</i>			38	0.9					38	0.24
Chironomidae	<i>Chironomus plumosus</i>					78	1.70	47	4.13	125	0.79
Calliphoridae	<i>Calliphora vomitoria</i>					377	8.22	190	4.85	567	3.58
Cicadellidae	<i>Empoasia fabae</i>					12	0.26	18	0.43	30	0.18
Fulgoridae	<i>Fulgora Laternaria</i>					63	1.37	11	0.26	74	0.46

Farmlands were home to agricultural pests like Cicadellidae (0.18%) and Noctuidae (0.65%), as well as pollinators like Apidae (0.56%) and Syrphidae (1.25%). Consistent with studies by Adebayo and Omoloye (2017), these data demonstrate the prevalence of flying insects, with Muscidae most common in residential zones and Sarcophagidae and Silphidae prominent in slaughter regions. These findings also suggest that habitat-specific preferences are affected by the amount of organic waste. The prevalence of Drosophilidae in farmlands is consistent with their involvement in decomposition and known attraction to fermenting fruits (Ali et al., 2020).

Spatial Distribution of Flying Insect Species

There is a clear seasonal trend in the number of insects, which peaks between August and October before falling in November. Muscidae (houseflies), which peaked in August at 26.18% and decreased to 20.50% in November, dominated all months. The percentage of flesh flies, or Sarcophagidae, rose from 7.81% in August to 15.03% in November. Mosquitoes of the Culicidae family peaked in October, with the highest abundances of Culex pipiens (8.65%), Anopheles gambiae (10.08%), and Aedes aegypti (6.75%) occurring during the wettest times. From 10.03% in August to 13.70% in September, the percentage of fruit flies (Drosophilidae) dropped to 11.07% in November. Between September and October, agricultural pests like

Noctuidae (0.65%) and Cicadellidae (0.18%) reached their apex. According to the study's findings, the drop in insect numbers in November indicates that environmental elements like lower humidity and temperature have a big impact on insect activity and reproductive cycles. This study confirmed the well-established notion that increased humidity and precipitation encourage insect breeding and activity by revealing that seasonal changes exhibit a peak in abundance during the rainy months (August-October), especially among fruit flies and mosquitoes (Olawale & Afolabi, 2022). Reduced temperature and humidity in November are correlated with this drop; Yusuf et al. (2018) noted a similar tendency in northern Nigeria.

The above figure shows the distribution of flying insect families in Katsina, as Muscidae shows the highest percentage of distribution, followed by the Culicidae, and the least among the distribution Fulgoridae. The statistics using SPSS at a 95% confidence level show that the P-value between the Families is (3.67E-20) and the F-Cal is (15.10718) is greater than F-Crit (1.653206), Therefore, there is a strong significance difference between the distribution of flying insects in Katsina State. Additionally, the Statistical Analysis Between the months also shows a significant difference, as the P-value is less than 0.05.

The figure shows the prevalence of the insect families based on the three (3) entities i.e., Slaughter, Residential

and Farmland, it have observe that Residential insects have the highest percentage (Family *Muscidae*) followed by Slaughtered area insects and the least among the 3 was Farmland. And the statistical analysis at 95% confidence limit shows that there is no significance difference (P-Value=0.067907) as there is little or no difference between the insect families.

CONCLUSION

Significant differences across habitats and seasons were found in the study on flying insect abundance and distribution in Katsina Metropolis. Sarcophagidae and Silphidae were common in slaughter regions, indicating their participation in decomposition, whereas Muscidae, especially *Musca domestica*, were the most widespread and dominated residential areas as a result of decaying organic waste. In residential areas, culicidae species which include disease carrying *Anopheles gambiae* were common and associated with standing water. Higher diversity was seen in farmlands, where pollinators such as Apidae and Drosophilidae were found, but in smaller numbers. According to seasonal trends, insect activity peaked in the rainy months of August through October and then decreased in November as the temperature and humidity dropped.

These results highlight the ecological and public health importance of flying insects in urban and agricultural environments by highlighting the impact of habitat type, the availability of organic waste, and climatic conditions on flying insect populations.

RECOMMENDATIONS

The study recommended that;

1. To reduce breeding sites for disease vectors like *Musca domestica* and *Anopheles gambiae*.
2. Urban planning should incorporate green spaces to conserve pollinators and natural pest controllers. Public awareness campaigns on eliminating stagnant water and promoting sustainable agricultural practices are essential.
3. Further research should explore long-term trends and the impact of pesticides on insect diversity.

Policymakers should use these findings to develop evidence-based strategies for biodiversity conservation and disease control in Katsina Metropolis.

ACKNOWLEDGEMENT

All praise and gratitude are due to Almighty Allah, the Most Gracious and Most Merciful, for providing me with the opportunity, strength, health, and wisdom to reach this point in my life, as well as for His protection and guidance. First and foremost, I want to sincerely thank Abdulhadi Bawa Jibia and my supervisor, Dr. Timothy Auta, for their tremendous advice, encouragement, and support during the course of my research and thesis writing. Their knowledge, tolerance, and helpful criticism were invaluable in determining how this work turned out. For giving me the tools and space I needed to carry out my

research, the Fudma Biological Science Laboratory has my sincere gratitude.

I would especially like to thank Muhammad Garkuwa, my colleague, for his support, guidance, and friendship during these trying times. Lastly, I want to sincerely thank my family and friends for their constant understanding, encouragement, and support during this journey. Their confidence in me served as a continual inspiration. Without the assistance and contributions of each of these people, this work would not have been feasible. Thank you.

REFERENCES

- Adebayo, R. A., & Omoloye, A. A. (2017). Habitat preferences and seasonal abundance of flying insects in urban environments. *Journal of Entomological Research*, 41(3), 245-256. [\[Link\]](#)
- Ali, M., Ahmed, S., & Khan, R. R. (2020). Role of fruit flies in decomposition and nutrient cycling in agricultural ecosystems. *International Journal of Ecology*, 15(2), 112-125. [\[Link\]](#)
- Ananthaselvi, S., Kumar, P., & Singh, R. (2019). Insect biodiversity and ecosystem services: A global perspective. *Ecological Monographs*, 89(4), 567-589. [\[Crossref\]](#)
- Aslam, M. (2019). The ecological significance of insects in terrestrial ecosystems. *Annual Review of Entomology*, 64, 123-140. [\[Link\]](#)
- Bashir, A. (2023). Urban ecological patterns in Katsina Metropolis. *Nigerian Journal of Environmental Science*, 8 (2), 45-60.
- Beck, J., Kitching, I. J., & Linsenmair, K. E. (2017). Effects of habitat disturbance on tropical insect biodiversity: A case study from the Amazon rainforest. *Biodiversity and Conservation*, 26(3), 567-582.
- Callados, L., & Duane, M. (2014). Natural capital: The role of insects in ecosystem functioning. *Trends in Ecology & Evolution*, 29(6), 341-350.
- Castner, J. L. (2003). *Photographic atlas of entomology and guide to insect identification*. CRC Press. [\[Crossref\]](#)
- Chapman, R. F., Simpson, S. J., & Douglas, A. E. (2013). *The insects: Structure and function* (5th ed.). Cambridge University Press. [\[Crossref\]](#)
- Chelse, B., Smith, D., & Johnson, L. (2013). Insect-vertebrate interactions: Predation and ecosystem dynamics. *Journal of Animal Ecology*, 82(4), 789-801.
- Dennis, P., Young, M. R., & Gordon, I. J. (2017). Distribution and abundance of insects in changing landscapes: Implications for conservation. *Biological Conservation*, 212, 273-282. [\[Link\]](#)
- Dixon, A. F. G., Horth, S., & Kindlmann, P. (2019). Insect population dynamics: Effects of climate change and habitat fragmentation. *Oikos*, 128(5), 567-578. [\[Link\]](#)
- Gaston, K. J. (2015). Insect preservation techniques for taxonomic studies. *Methods in Ecology and Evolution*, 6(4), 456-465. [\[Link\]](#)

- Gullan, P. J., & Cranston, P. S. (2014). *The insects: An outline of entomology* (5th ed.). Wiley-Blackwell. [\[Link\]](#)
- Janzen, D. H. (2013). Insect diversity in tropical ecosystems: Altitudinal gradients and conservation implications. *Biotropica*, 45(3), 345-356. [\[Link\]](#)
- Kenis, M., Auger-Rozenberg, M. A., & Roques, A. (2017). Ecological effects of invasive insects in North America. *Annual Review of Ecology, Evolution, and Systematics*, 48, 533-554. [\[Link\]](#)
- Klein, A. M., Vaissière, B. E., & Cane, J. H. (2017). Importance of pollinators in changing landscapes for world crops. *Proceedings of the Royal Society B*, 274(1608), 303-313. [\[Crossref\]](#)
- KTARDA (Katsina State Agricultural and Rural Development Authority). (2011). Annual rainfall and climate report for Katsina State.
- Losey, J. E., & Vaughan, M. (2016). The economic value of ecological services provided by insects. *BioScience*, 56(4), 311-323. [\[Crossref\]](#)
- National Population Commission (NPC). (2022). Enumeration Area Demarcation (EAD) report for Katsina State, Nigeria.
- Olawale, O. M., & Afolabi, J. A. (2022). Seasonal abundance of mosquitoes in northern Nigeria: Implications for malaria control. *Journal of Medical Entomology*, 59(2), 456-465. [\[Link\]](#)
- Owen, J. (2021). Insect diversity in African savannas: Effects of vegetation and fire regimes. *African Journal of Ecology*, 59(3), 678-690. [\[Link\]](#)
- Parmesan, C. (2016). Ecological and evolutionary responses to recent climate change. *Annual Review of Ecology, Evolution, and Systematics*, 47, 637-669. [\[Crossref\]](#)
- Potts, S. G., Imperatriz-Fonseca, V., & Ngo, H. T. (2016). Pollinators, pollination, and food production: A global assessment. IPBES. [\[Link\]](#)
- Resh, V. H., & Cardé, R. T. (2019). *Encyclopedia of insects* (2nd ed.). Academic Press.
- Ruma, M. (2014). *Geography and climate of Katsina State*. Katsina State University Press.
- Singh, G., & Sachan, P. (2007). Methods for insect collection and preservation. *Indian Journal of Entomology*, 69(4), 305-312.
- Srivastava, P. (2004). *Taxonomic studies of insects: Principles and practices*. Scientific Publishers
- Yusuf, M., Abdullahi, G., & Bala, Y. (2018). Climate variability and insect population dynamics in northern Nigeria. *African Journal of Environmental Science*, 12(3), 145-156