International Journal of Innovative Biosciences Research 14(4):10-20, Oct.-Dec., 2026

© SEAHI PUBLICATIONS, 2026 www.seahipublications.org **ISSN: 2467-8457**

DOI:10.5281/zenodo.23568627

Insect Pollinator Communities in Mixed and Monoculture Farms in Sub-Saharan Africa: A Case Study from Igwuruta, Rivers State, Nigeria

Jackson, M.[1], Onwuteaka, J. N.[2], and Moslen, M.[3]

[1,2,3]Department of Animal and Environmental Biology,
Faculty of Science,
Rivers State University, Port Harcourt, Nigeria

ABSTRACT

Insect pollinators are essential for global food security and ecosystem functioning, yet their communities face unprecedented threats from agricultural intensification across Sub-Saharan Africa. This study assessed insect pollinator community composition, abundance, diversity, and foraging behaviour in mixed and monoculture farms in Igwuruta, Ikwerre Local Government Area, Rivers State, Nigeria. Field surveys were conducted across three stations (two mixed farms, one monoculture farm) during wet (July-September 2023) and dry (November 2023-January 2024) seasons using visual observation and sweep netting methods. A total of 1,951 individual insects representing 20 species across five orders (Coleoptera, Diptera, Hymenoptera, Lepidoptera, and Orthoptera) were recorded. Lepidoptera (34.34%) and Diptera (29.54%) were the dominant orders. Mixed farms consistently supported higher species diversity (Shannon-Wiener H = 1.713 wet season) compared to the monoculture farm (H = 1.293 wet season). Seasonal variation significantly influenced pollinator communities, with higher abundance and diversity during wet seasons. Maize and cassava attracted the highest visitation rates, with Common Albatross (Appias sp.) showing strong preference for maize (92 visits). The study reveals that mixed farming systems enhance pollinator diversity in tropical agroecosystems, providing evidence for sustainable agricultural practices that support both biodiversity conservation and crop productivity in Sub-Saharan Africa.

Keywords: Insect pollinators, mixed farming, monoculture, biodiversity, Sub-Saharan Africa, agroecosystem, seasonal variation

1. INTRODUCTION

Insect pollinators play a critical role in maintaining global biodiversity and ensuring food security, with approximately 80% of flowering plants depending on animal-mediated pollination services (Geeraert *et al.,* 2020; Wardhaugh, 2015). In Sub-Saharan Africa, where agriculture remains the primary livelihood for the majority of rural populations, insect pollinators are indispensable for crop production and ecosystem stability (Gemeda, 2021). Despite their ecological and economic importance, pollinator communities across the region face unprecedented threats from agricultural intensification, habitat loss, pesticide exposure, and climate change (Ayansola, 2025; Adesope *et al.,* 2024).

The distinction between mixed cropping systems and monoculture farming represents a significant axis of variation in agricultural landscapes, with profound implications for insect pollinator communities (Shi *et al.,* 2023). Mixed cropping systems, which involve the cultivation of multiple crop species in the same field, provide diverse floral resources, extended flowering periods, and greater structural heterogeneity

compared to monocultures (Fijen *et al.,* 2025). Research across temperate regions has consistently demonstrated that diversified farming systems support higher pollinator species richness and abundance (López-Vázquez *et al.,* 2025). However, empirical evidence from tropical Africa remains scarce, particularly from the Niger Delta region of Nigeria (Amadi-Robert, 2023).

Nigeria is currently experiencing a pollination services crisis driven largely by agricultural expansion and unsustainable farming practices (Adesope *et al.,* 2024). The conversion of natural habitats to agricultural land, widespread pesticide use, and monoculture farming have contributed to documented declines in insect pollinator populations (Ayansola, 2025). In Igwuruta, Ikwerre Local Government Area, Rivers State, agricultural systems are characterised by a mix of mixed cropping and monoculture practices, yet no empirical study has assessed how these farming systems affect pollinator communities (Ifeanyi-Obi & Iferobia, 2024).

The ecological significance of this study extends beyond local agricultural productivity. The Niger Delta region forms part of the Guinea-Congolian rainforest zone, one of the world's most biodiverse and ecologically significant regions (Gbarakoro & Okene, 2020). Insect pollinators in this region face multiple stressors, including oil pollution, deforestation, and urbanisation, making understanding their community dynamics essential for conservation planning (Ugo-Kamalu, 2026). Furthermore, the socio-economic implications are substantial, as pollinator-dependent crops provide 83-88% higher production values compared to pollinator-independent crops in Nigeria (Shi *et al.,* 2023).

This study aimed to assess insect pollinator communities in mixed and monoculture farms in Igwuruta, Rivers State, Nigeria. The specific objectives were to: (i) identify and document insect pollinator species composition; (ii) determine relative abundance patterns; (iii) assess diversity indices (species richness and evenness); (iv) examine foraging behaviour on crops; and (v) evaluate seasonal variation effects on pollinator networks.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted in Igwuruta, Ikwerre Local Government Area, Rivers State, Nigeria, located at Latitude 4.9563°N and Longitude 7.0243°E (Figure 1). Igwuruta is a rapidly urbanising area and among the five fastest-growing agricultural development zones in Rivers State (Mbata, 2016). The landscape is characterised by low-intensity arable farming and pasture grazing fields. The climate is tropical monsoon with lengthy and heavy rainy seasons and very short dry seasons. Three study stations were selected: Station 1 (Mixed Farm 1) in Alaminli-Igwurutali with maize, okro, and melon; Station 2 (Mixed Farm 2) in Omuolu-Igwurutali with maize, okro, and cassava; and Station 3 (Mono Farm) in Omouluta-Igwurutali with cassava only.

2.2 Ethics Statement

Permission to conduct the field survey was obtained from the Community Development Committees (CDC), the institution empowered to manage and control development and security profiles in the community.

2.3 Sampling Design

Each study location was divided into two line transects (A and B) running equidistant from North to South. Insect pollinator observations and collections were conducted during morning hours (6:30-9:30 a.m.) and evening hours (3:00-6:00 p.m.) over 36 sampling rounds per season across both wet (July-September 2023) and dry (November 2023-January 2024) seasons. This yielded 72 total sampling rounds.

2.4 Data Collection Methods

Two complementary methods were employed: (i) visual observation and counting of pollinators actively foraging on flowers; and (ii) hand sweep netting. All necessary precautions were taken to minimise insect destruction during identification. Species identification was performed using the Insect Identification Guide developed by Shi *et al* (2022) and Van-Huis (2015). Digital photography documented flowering plant communities and insect pollinator network characteristics.

2.5 Data Analysis

Insect pollinator composition was determined using the Pollinator Composition Multiple Insects Bar method (Ye *et al*., 2020). Species relative abundance (SRA%) was calculated using the Das-Jha Relative Abundance Index: SRA% = (PVL / TP-VAL) × 100

where PVL = population of a particular species visiting a location, and TP-VAL = total population of all species visiting the locations.

Diversity was measured using Simpson's Diversity Index and Shannon-Wiener Diversity Index (H). Species richness was computed using Margalef Richness Index, and evenness using Pielou's Evenness Index (J). Similarities and dissimilarities were assessed using Sørensen Similarity Index. Seasonal variation and differences between subject effects were determined using ANOVA.

3. RESULTS

3.1 Insect Pollinator Composition

A total of 1,951 individual insects representing 20 species across five orders were recorded across the three study stations. Lepidoptera showed the highest proportion (34.34%), followed by Diptera (29.54%), Hymenoptera (18.55%), Coleoptera (13.83%), and Orthoptera (3.68%) (Table 1). The most abundant species was Common Albatross (Appias sp.) with 11.02% relative abundance, followed by Black-spot Bematistes butterfly (Bematistes macaria) (9.53%), Common wasp (Vespula sp.) (8.35%), and Dancing Acraea (Acraea serena) (8.20%). The least abundant species were Lady beetle (Coccinella sp.) (0.92%) and Bush cricket (Phaneroptera falcata) (0.67%).

Table 1: Insect Pollinator Species Composition and Relative Abundance Across Study Stations

S/No	Common Name	Order	Scientific Name	Frequency	Relative Abundance (%)
1.	Flea beetle	Coleoptera	Altica sp.	120	6.15
2.	Lady beetle	Coleoptera	Coccinella sp.	18	0.92
3.	Common leaf weevil	Coleoptera	Phyllobius sp.	33	1.69
4.	Red-necked false blister beetle	Coleoptera	Asclera ruficollis	99	5.07
5.	Black soldier fly	Diptera	Hermetia illucens	125	6.41
6.	Common house fly	Diptera	Musca domestica	117	6.00
7.	Fruit flies	Diptera	Drosophila spp.	64	3.28
8.	Common flesh fly	Diptera	Sarcophaga sp.	85	4.36
9.	Thick-headed fly	Diptera	Physocephalia nigra	117	6.00
10.	Green bottle fly	Diptera	Lucilia sericata	68	3.49
11.	Carpenter bee	Hymenoptera	Xylocopa sp.	66	3.38
12.	Common wasp	Hymenoptera	Vespula sp.	163	8.35
13.	Fire ant	Hymenoptera	Solenopsis sp.	105	5.38
14.	Black garden ant	Hymenoptera	Lasius niger	28	1.44
15.	Dancing Acraea	Lepidoptera	Acraea serena	160	8.20
16.	Black-spot Bematistes butterfly	Lepidoptera	Bematistes macaria	186	9.53
17.	Common albatross	Lepidoptera	Appias sp.	215	11.02
18.	White-barred Acraea	Lepidoptera	Acraea encedon	109	5.59
19.	Variegated grasshopper	Orthoptera	Zonocerus variegatus	60	3.08
20.	Bush cricket	Orthoptera	Phaneroptera falcata	13	0.67
	Total			**1,951**	**100.00**

Source: Data from fieldwork

In Station 1 (Mixed Farm), Lepidoptera was highest (31.8%), followed by Diptera (26.7%), with Orthoptera least (4.1%). In Station 2 (Mixed Farm), Diptera was highest (37.5%), followed by Lepidoptera (28.7%), with Orthoptera least (3.4%). In Station 3 (Mono Farm), Lepidoptera was highest (41.8%), followed by Diptera (31.1%), with Orthoptera least (7.0%). Morning collections recorded 1,310

individuals while evening collections recorded 641 individuals, indicating significantly higher pollinator activity in morning hours.

3.2 Species Relative Abundance Patterns

Relative abundance varied by station and season, with a few species dominating the community (Table 2). In Station 1, Common Albatross was consistently among the most abundant species during wet season morning (9.3%), wet season evening (4.8%), and dry season morning (8.9%). In Station 2, Green bottle fly (Lucilia sericata) dominated during wet season morning (10.1%), while Common Albatross dominated during dry season morning (7.7%). In Station 3 (Mono Farm), Black-spot Bematistes butterfly was dominant across all sampling periods, with relative abundance values ranging from 6.2% to 9.9%.

Table 2: Two Highest and Two Lowest Species Relative Abundance (SRA%) by Station and Season

S/No	Season/Time	Highest SRA Species	SRA%	Lowest SRA Species	SRA%
Station 1 (Mixed)					
1.	Wet Morning	Appias sp.	9.3	Coccinella sp.	1.0
2.		Acraea serena	6.5	Lucilia sericata	1.0
3.	Wet Evening	Appias sp.	4.8	Sarcophaga sp.	0.2
4.		Asclera ruficollis	3.8	Lucilia sericata	0.5
5.	Dry Morning	Appias sp.	8.9	Xylocopa sp.	1.4
6.		Solenopsis sp.	6.8	Phyllobius sp.	1.0
7.	Dry Evening	Vespula sp.	2.7	Zonocerus variegatus	1.0
8.		Appias sp.	2.4	Phaneroptera falcata	0.3
Station 2 (Mixed)					
1.	Wet Morning	Lucilia sericata	10.1	Asclera ruficollis	1.4
2.		Drosophila spp.	8.7	Coccinella sp.	0.6
3.	Wet Evening	Drosophila spp.	3.9	Phaneroptera falcata	0.3
4.		Lucilia sericata	3.4	Coccinella sp.	0.0
5.	Dry Morning	Appias sp.	7.7	Coccinella sp.	2.1
6.		Bematistes macaria	7.4	Zonocerus variegatus	1.2
7.	Dry Evening	Altica sp.	3.0	Zonocerus variegatus	0.9
8.		Bematistes macaria	2.7	Coccinella sp.	0.6
Station 3 (Mono)					
1.	Wet Morning	Bematistes macaria	9.9	Lucilia sericata	3.3
2.		Hermetia illucens	6.6	Sarcophaga sp.	2.6
3.	Wet Evening	Bematistes macaria	7.3	Appias sp.	1.3
4.		Hermetia illucens	5.0	Altica sp.	1.0
5.	Dry Morning	Bematistes macaria	8.3	Musca domestica	1.3
6.		Acraea encedon	7.1	Solenopsis sp.	1.7
7.	Dry Evening	Bematistes macaria	6.2	Musca domestica	0.8
8.		Acraea encedon	5.4	Solenopsis sp.	0.4

Source: Data from fieldwork

3.3 Species Diversity Indices

Diversity analysis revealed that mixed farms consistently supported higher pollinator diversity compared to the monoculture farm (Table 3). During the wet season, Station 2 recorded the highest Shannon-Wiener Diversity Index (H = 1.713), while Station 3 recorded the lowest (H = 1.293). Species richness followed a similar pattern, with Station 2 having the highest Margalef Richness Index (d = 3.062) and Station 3 the lowest (d = 1.926). Pielou's Evenness Index was highest in Station 2 (J = 0.291) and lowest in Station 1 (J = 0.223).

Table 3: Insect Pollinator Diversity Indices Across Study Stations During Wet and Dry Seasons

S/No.	Parameter	Station 1 (Mixed)	Station 2 (Mixed)	Station 3 (Mono)
Wet Season				
1.	Total Insects (N)	418	357	302
2.	Species Richness (S)	18	19	12
3.	Shannon-Wiener (H)	1.346	1.713	1.293
4.	Margalef Richness (d)	2.817	3.062	1.926
5.	Pielou's Evenness (J)	0.223	0.291	0.226
Dry Season				
1.	Total Insects (N)	293	337	241
2.	Species Richness (S)	18	17	13
3.	Shannon-Wiener (H)	2.219	1.540	1.427
4.	Margalef Richness (d)	2.993	2.749	2.188
5.	Pielou's Evenness (J)	0.391	0.265	0.260

Source: Data from fieldwork

During the dry season, Station 1 recorded the highest Shannon-Wiener Diversity Index (H = 2.219), while Station 3 again recorded the lowest (H = 1.427). Species richness was highest in Station 1 (d = 2.993) and lowest in Station 3 (d = 2.188). Pielou's Evenness Index was highest in Station 1 (J = 0.391) and lowest in Station 3 (J = 0.260).

3.4 Foraging Behaviour and Crop Visitation

Insect pollinator visitation rates varied significantly among crop species. Maize was the most visited crop in Station 1 (520 visits) and Station 2 (516 visits), while cassava had the highest visits in Station 3 (543 visits). In mixed farms, melon (111 visits) and cassava (97 visits) followed maize, while okro was the least visited (80-81 visits). Common Albatross (Appias sp.) showed strong preference for maize, recording 92 visits in Station 1 and 73 visits in Station 2. Green bottle fly (Lucilia sericata) and Fire ant (Solenopsis sp.) were the most frequent visitors to okro in Stations 1 and 2, respectively. Black soldier fly (Hermetia illucens) and White-barred Acraea (Acraea encedon) were the primary visitors to melon. Carpenter bee (Xylocopa sp.) and Black-spot Bematistes butterfly were the highest visitors to cassava in Stations 2 and 3.

3.5 Similarity Analysis

The Sørensen Similarity Index revealed high similarity in species composition between mixed and monoculture farms. Of the 20 species recorded, 16 were shared across all three stations. Species present in mixed farms but absent in the monoculture farm included Lady beetle (Coccinella sp.), Red-necked false blister beetle (Asclera ruficollis), Fruit flies (Drosophila spp.), Carpenter bee (Xylocopa sp.), Dancing Acraea (Acraea serena), and White-barred Acraea (Acraea encedon). Black garden ant (Lasius niger) was present only in mixed farms, while Bush cricket (Phaneroptera falcata) was recorded only in Station 2.

3.6 Seasonal Variation

Seasonal variation significantly influenced pollinator communities across all stations. Wet season totals were higher than dry season totals in all stations: Station 1 (418 vs. 293), Station 2 (357 vs. 337), and Station 3 (302 vs. 241). Morning activity exceeded evening activity in both seasons across all stations. In Station 1, morning collections represented 65.3% of wet season and 71.3% of dry season totals. Similar patterns were observed in Stations 2 and 3, with morning activity consistently higher than evening activity.

4. DISCUSSION

4.1 Species Composition and Taxonomic Distribution

The identification of 20 insect pollinator species across five orders reveals a moderately diverse pollinator community within the studied agroecosystems. The dominance of Lepidoptera and Diptera across both farm types is particularly noteworthy, as these orders often serve as critical pollinators in tropical agricultural landscapes where bee diversity may be limited by habitat simplification (Matengo *et al.,* 2026). This finding contrasts with temperate studies where Hymenoptera (particularly bees) typically dominate pollinator communities (Kovács-Hostyánszki *et al.,* 2016). The regional specificity of pollinator communities in tropical Africa highlights the need for context-specific conservation strategies rather than simply extrapolating findings from temperate regions.

The presence of five distinct taxonomic orders suggests that these farms support a functionally diverse pollinator assemblage. Hymenoptera, though not the most diverse order in this study, are globally recognised as the most efficient pollinators due to their specialised morphological and behavioural adaptations for pollen transfer (Ferrante *et al.,* 2025; ElAbdouni *et al.,* 2022). Diptera, particularly syrphid flies, are increasingly acknowledged for their pollination services in agroecosystems, often serving as effective pollinators when bee populations are depressed by agricultural intensification (Orford *et al.,* 2015). The inclusion of Coleoptera and Orthoptera, while less commonly associated with pollination, indicates that these farms harbour a broader spectrum of flower-visiting insects than might be expected in highly simplified agricultural landscapes.

The dominance of Lepidoptera in Station 1 and Station 3, and Diptera in Station 2, suggests that these orders have considerable influence on pollinating crops in traditional Igwuruta agricultural systems. This finding is consistent with Matengo *et al.* (2026) in Zimbabwean cropping systems, who found Lepidoptera (55.2%) to be the dominant order, highlighting the regional significance of butterflies and moths as agricultural pollinators in Sub-Saharan Africa. The relatively lower influence of Coleoptera, which comprises different bee species that are dominant pollinators in European agricultural landscapes (Decourtye *et al.,* 2010), suggests fundamental differences in pollinator community assembly between tropical and temperate agroecosystems.

4.2 Patterns of Species Relative Abundance and Dominance

The finding that species relative abundance varied by station and season, with a few species dominating the community, is consistent with the broader ecological principle that most communities are characterised by a few abundant species and many rare ones (Pardee *et al.,* 2023). The Common Albatross (Appias sp.) and Black-spot Bematistes butterfly (Bematistes macaria) emerging as among the most abundant species indicates that certain Lepidoptera species are particularly well-adapted to these agricultural environments. Arya *et al.* (2023) similarly found that Pieris canidia indica constituted 38.3% of total butterfly individuals in Kumaun agroecosystems, demonstrating that dominance by a single species is a common pattern in agricultural pollinator communities.

The higher total insect pollinator activity observed in mixed farms compared to the monoculture farm aligns with a growing body of evidence supporting the benefits of crop diversification for pollinator abundance (Shi *et al.,* 2023; El-Sheikh *et al.,* 2025). Several mechanisms may explain this pattern. First, crop diversity provides a greater variety of floral resources including different flower morphologies, colours, scents, and phenologies, which can support a broader range of pollinator species and sustain higher population densities throughout the growing season (Fijen *et al.,* 2025). Second, mixed farms often incorporate non-crop vegetation, such as field margins and hedgerows, which provide additional foraging resources and nesting habitats (Božek *et al.,* 2023). Third, the structural complexity of mixed farms may create more favourable microclimatic conditions for pollinator activity, including reduced wind exposure and moderated temperatures (Proesmans *et al.,* 2024).

The dominance of a few species within the pollinator community raises concerns about functional redundancy and ecosystem resilience. If the most abundant species are also the most effective pollinators, their dominance may be beneficial for crop pollination. However, if dominant species are less effective pollinators or are particularly susceptible to environmental stressors, their decline could have disproportionate impacts on pollination services (Ferrante *et al.,* 2025). The concept of pollination

redundancy suggests that diverse communities are more resilient to disturbances because different species can compensate for the loss of others (El-Sheikh *et al.,* 2025).

4.3 Diversity Indices and Farm Type Effects

The higher Shannon-Wiener diversity index and Margalef species richness observed in mixed farms compared to the monoculture farm provide strong evidence that crop diversification enhances pollinator diversity in tropical agroecosystems. This finding is consistent with a substantial body of literature demonstrating positive relationships between habitat heterogeneity and biodiversity (Shi *et al.,* 2023; Sritongchuay *et al.,* 2025). The Shannon-Wiener index integrates both species richness and evenness, making it a robust measure of community diversity. The higher values observed in mixed farms suggest not only that more species are present but also that individuals are more evenly distributed among species. The seasonal shifts in diversity, with higher values during the wet season compared to the dry season, underscore the importance of seasonal dynamics in shaping pollinator communities. Wet season conditions, characterised by higher rainfall, increased floral resources, and more favourable temperatures, typically support greater insect activity and reproductive success (Kingazi *et al.,* 2025). Research in tropical agroecosystems has consistently found that wet seasons support higher pollinator abundance and species richness than dry seasons (Otieno *et al.,* 2022). The wet season also typically coincides with the flowering periods of many tropical crops, creating synchrony between floral resource availability and pollinator activity (Katumo *et al.,* 2022).

The ecological significance of higher pollinator diversity in mixed farms has important implications for ecosystem functioning and resilience. Diverse pollinator communities are more likely to contain species with complementary foraging traits, ensuring effective pollination across a range of crop species and environmental conditions (Fijen *et al.,* 2025). Diversity also provides insurance against environmental fluctuations, as different species may respond differently to stressors such as drought, heat waves, or pesticide exposure (Pardee *et al.,* 2023). Furthermore, diverse communities are better able to track spatial and temporal variation in floral resources, maintaining pollination services even when individual species are scarce (López-Vázquez *et al.,* 2025).

4.4 Foraging Behaviour and Crop Visitation

The highest visitation rates observed on maize and cassava crops, with Common Albatross showing a strong preference for maize, reveal important patterns in pollinator-plant interactions within these agroecosystems. While maize (Zea mays) is primarily wind-pollinated, it produces abundant pollen that can attract insects, particularly during the flowering stage (Jarvinen *et al.,* 2022). The attraction of butterflies to maize suggests that these insects may be foraging for nectar or pollen, potentially contributing to cross-pollination even in predominantly wind-pollinated crops. This finding has implications for understanding the full range of ecosystem services provided by pollinators in agricultural systems.

Okro, known for its curly yellow and reddish flowers, is highly attractive to insect pollinators, particularly Green bottle fly (Lucilia sericata) and Fire ant (Solenopsis sp.). Melon also produces vibrant yellow flowers and clusters of white flowers that are excellent for attracting insect pollinators, especially Black soldier fly (Hermetia illucens) and White-barred Acraea (Acraea encedon). Cassava (Manihot esculenta) is not typically considered an insect-pollinated crop, as it is vegetatively propagated and its flowers are relatively inconspicuous. However, cassava does produce flowers that can attract insects, and some studies have documented insect visitation to cassava flowers (Katumo *et al.,* 2022).

The strong preference of Common Albatross for maize raises questions about the ecological and evolutionary factors driving this association. Butterflies are generally attracted to flowers based on visual cues (colour, shape) and olfactory cues (scent), as well as the quality and quantity of nectar rewards (Gruter & Ratneiks, 2011). Maize may provide a reliable nectar source during its flowering period, or its pollen may be particularly nutritious for certain butterfly species. This finding underscores the importance of distinguishing between flower visitors and effective pollinators when assessing pollination services in agricultural systems.

The consistent finding that pollinator foraging activity was higher during morning hours and the wet season reveals clear temporal patterns in pollinator behaviour. Morning peaks in activity are commonly

observed among diurnal pollinators and are typically associated with favourable environmental conditions including moderate temperatures, higher humidity, and the availability of freshly opened flowers (Matengo *et al.,* 2026). Research on cucumber and bitter gourd flowers found that maximum pollinator activity occurred between 09:00 and 10:00, when relative humidity was around 76% (Shi *et al.,* 2023). The higher activity during the wet season aligns with the seasonal patterns observed for abundance and diversity, as wet season conditions create more favourable conditions for insect activity and reproduction.

4.5 Similarities and Dissimilarities in Pollinator Communities

The Sørensen Similarity Index revealed high similarity in species composition between mixed and monoculture farms, with 16 of 20 species shared across all stations. This observation is particularly intriguing given the stark environmental conditions that typically differentiate these farming systems. The similarity in pollinator composition suggests that both mixed and monoculture farms provide suitable habitats for a similar suite of species, possibly due to shared climatic conditions and the presence of similar floral resources in the surrounding landscape (Shi *et al.,* 2023).

The finding that certain species were present in mixed farms but absent in the monoculture farm suggests that mixed farming systems may support a wider range of pollinator species, particularly those with more specialised resource requirements. Lady beetle (Coccinella sp.), Red-necked false blister beetle (Asclera ruficollis), Fruit flies (Drosophila spp.), Carpenter bee (Xylocopa sp.), Dancing Acraea (Acraea serena), and White-barred Acraea (Acraea encedon) were recorded only in mixed farms. This pattern is consistent with the hypothesis that diverse cropping systems provide complementary floral resources and greater structural heterogeneity, supporting a broader range of pollinator species (Fijen *et al.,* 2025).

However, the absence of significant differences in pollinator networks between mixed and monoculture farms during both dry and wet seasons is noteworthy. This result is particularly intriguing given the established understanding that agricultural practices can influence biodiversity and ecosystem services (Gay *et al.,* 2024). One possible explanation for the lack of significant differences may be related to the specific characteristics of the local environment and agricultural practices. Igwuruta's climate, characterised by distinct wet and dry seasons, may provide a relatively stable habitat that supports a diverse range of pollinators regardless of the farming system employed (Ifeanyi-Obi & Iferobia, 2024).

The implications of the absence of a significant difference suggest that farmers in the Igwuruta area might not need to prioritise mixed farming solely for the enhancement of pollinator diversity. Instead, this insight encourages a broader perspective on sustainable agricultural practices. Farmers could focus on other aspects of farming that influence productivity and ecological balance, such as soil health, crop rotation, and pest management, rather than merely the structure of their pollinator networks (Nasare *et al.,* 2024). However, it is important to note that the high similarity in species composition does not necessarily mean that mixed and monoculture farms provide equivalent pollination services, as the abundance and effectiveness of individual pollinator species may differ between systems.

4.6 Seasonal Variation and Temperature Effects

Temperature is a key driver of seasonal variation in insect pollinator activity. In Igwuruta farmland, the typical tropical climate features distinct wet and dry seasons, each characterised by varying temperature and humidity levels. During the dry season, elevated temperatures may lead to increased insect pollinator activity by some species, particularly bees and butterflies (Yang *et al.,* 2020). Conversely, extreme heat can also deter some pollinators, leading to reduced visitation rates (Woodcock *et al.,* 2019). The temperature data collected during this study showed relatively stable patterns across stations, with morning temperatures ranging from 23-27°C and evening temperatures ranging from 23-28°C.

In mixed farms, a diverse array of flowering plants provides a stable resource base for insect pollinators throughout the year. This diversity can mitigate the negative effects of temperature extremes, allowing for a more stable composition of pollinator species (Kingazi *et al.,* 2025). For instance, while certain species may decline due to heat stress, others that are more heat-tolerant can thrive, resulting in a more resilient insect pollinator community. In monoculture farms, the reliance on a single crop type can lead to significant fluctuations in insect pollinator abundance. During flowering periods, these farms may attract high numbers of a specific insect pollinator species; however, outside of this period, the lack of floral diversity can result in abrupt declines in abundance (Fijen *et al.,* 2025).

The organisation of insect pollinator networks in Igwuruta has significant implications for promoting mixed farming. This can enhance insect pollinator diversity, leading to improved insect pollination services and crop yields. Farmers in the area can be encouraged to incorporate hedgerows, wildflower strips, and diverse planting schemes to attract and sustain pollinator populations (Parmentier *et al.,* 2024). In contrast, monoculture farming practices may require interventions such as supplemental planting of flowering species to support pollinators. Education and awareness programs could be established to inform farmers about the benefits of pollinator-friendly practices, emphasizing the long-term advantages of biodiversity in agricultural systems (Balogun *et al.,* 2026).

4.7 Implications for Sub-Saharan African Agriculture

The findings of this study have important implications for agricultural sustainability and biodiversity conservation in Sub-Saharan Africa. The demonstration that mixed farming systems support higher pollinator diversity than monoculture systems provides evidence for promoting crop diversification as a strategy for enhancing pollination services while maintaining agricultural productivity (Amadi-Robert, 2023). This is particularly relevant given the growing human population and increasing food demand in the region, which requires sustainable intensification approaches that do not compromise ecosystem services (Gemeda, 2021).

The dominance of Lepidoptera and Diptera in this study highlights the need to consider the full range of pollinator taxa in conservation planning, rather than focusing exclusively on bees (Rader *et al.,* 2016). While bees are important pollinators in many systems, butterflies, moths, and flies also contribute significantly to pollination services in tropical agroecosystems (Orford *et al.,* 2015). Conservation strategies should therefore aim to protect and enhance habitats that support diverse pollinator communities, including a range of specialist and generalist species (Fijen *et al.,* 2025).

The seasonal patterns observed in this study underscore the importance of considering temporal dynamics in pollinator conservation and management. The higher diversity and abundance during the wet season suggest that pollinators may face resource bottlenecks during the dry season when floral resources are limited (Kingazi *et al.,* 2025). Management interventions that extend the availability of floral resources into the dry season could help sustain pollinator populations throughout the year. This could include planting drought-tolerant flowering species, maintaining irrigation during dry periods, or preserving natural vegetation that provides resources during resource-scarce periods (Božek *et al.,* 2023).

The high similarity in species composition between mixed and monoculture farms suggests that landscape-level factors may play a more important role in shaping pollinator communities than local farm management practices (Shi *et al.,* 2023). This highlights the need for landscape-scale approaches to pollinator conservation that consider the composition and configuration of habitats across entire agricultural landscapes. Maintaining and restoring semi-natural habitats such as field margins, hedgerows, and fallow areas can support diverse pollinator populations that can spill over into adjacent crops, enhancing pollination services (Parmentier *et al.,* 2024).

5. CONCLUSION AND RECOMMENDATIONS

This study demonstrates that mixed farming systems in Igwuruta support higher pollinator diversity, abundance, and species richness compared to monoculture systems, though significant similarities exist across farm types due to shared climatic conditions. The dominance of Lepidoptera and Diptera over traditionally recognised pollinators like honeybees highlights the regional specificity of pollinator communities in tropical agricultural landscapes. Seasonal variations, particularly the wet season, enhance pollinator activity and diversity, while temperature serves as a critical driver of these patterns.

The findings underscore the importance of context-specific conservation strategies and the need to maintain diverse floral resources across agricultural landscapes to support resilient pollinator populations and sustainable crop production. By documenting the composition, abundance, diversity, and foraging behaviour of insect pollinator communities in Igwuruta, this study contributes to understanding the ecological status of these communities and their capacity to provide pollination services in an increasingly degraded landscape.

The study recommends that farmers adopt mixed farming practices and implement conservation strategies that protect and enhance insect pollinator habitats. Agricultural policies and practices should be designed to encourage mixed farming, as this supports higher biodiversity and contributes to improved food security in agricultural ecosystems. Future research should employ complementary sampling methods to capture a more complete picture of pollinator diversity, investigate functional pollination effectiveness, and establish long-term monitoring programmes to detect population trends and assess the impacts of agricultural intensification and climate change.

REFERENCES

Adesope, O. M., Matthews-Njoku, E. C., & Oguzor, N. S. (2024). Agricultural practices and pollinator conservation in Nigeria. *Journal of Agricultural Extension, 28*(2), 45-58.

Amadi-Robert, C. (2023). Pollinator-friendly farming systems in the Niger Delta: Challenges and opportunities. *Nigerian Journal of Agriculture, 54*(3), 112-125.

Arya, M. K., Joshi, P. C., & Bhandari, R. (2023). Butterfly diversity and their role in pollination in Kumaun agroecosystems. *Journal of Insect Conservation, 27*(4), 567-578.

Ayansola, A. A. (2025). Pollination services crisis in Nigeria: Drivers and consequences. *African Journal of Agricultural Research, 20*(1), 23-35.

Balogun, T. F., Adebayo, O. S., & Ogunwale, A. B. (2026). Eco-safe farming practices for pollinator conservation in Nigeria. *Journal of Sustainable Agriculture, 48*(2), 178-192.

Božek, M., Denisow, B., Strzałkowska-Abramek, M., Chrzanowska, E., & Winiarczyk, K. (2023). Non-forest woody vegetation: A critical resource for pollinators in agricultural landscapes—A review. *Sustainability, 15*(11), 8751.

Decourtye, A., Mader, E., & Desneux, N. (2010). Landscape enhancement of floral resources for honey bees in agro-ecosystems. *Apidologie, 41*(3), 264-277.

ElAbdouni, I., Lhomme, P., Christmann, S., Dorchin, A., Sentil, A., Pauly, A., Hamroud, L., Ihsane, O., Reverte, S., Patiny, S., Wood, T. J., Bencharki, Y., Rasmont, P., & Michez, D. (2022). Diversity and relative abundance of insect pollinators in Moroccan agroecosystems. *Frontiers in Ecology and Evolution, 10*, 581-590.

El-Sheikh, W. E. A., Abdel-Moniem, A. S. H., Sleem, H. A. S., & El Kenawy, A. H. (2025). Influence of mixed cropping systems on pollinator diversity and abundance in agroecosystems. *Egyptian Academic Journal of Biological Sciences, 18*(2), 133-143.

Ferrante, M., Kirsch, F., & Westphal, C. (2025). Stable insect pollinator communities in different white clover populations suggest potential win-win scenarios for crop yield and biodiversity. *Agriculture, Ecosystems & Environment, 378*, 109295.

Fijen, T. P. M., Eeraerts, M., & Osterman, J. (2025). Crop diversification for insect pollinator conservation. *Landscape Ecology, 40*, 19.

Gay, C., Gaba, S., & Bretagnolle, V. (2024). The structure of plant-insect pollinator networks is affected by crop type in a highly intensive agricultural landscape. *Agriculture, Ecosystems & Environment, 358*, 108759.

Gbarakoro, T. N., & Okene, P. F. (2020). Assessment of insect functional groups of mangroves parts at Asarama, Andoni, Rivers State, Nigeria. *European Journal of Agriculture and Forestry Research, 5*(4), 32-55.

Geeraert, L., Aerts, R., & Berecha, G. (2020). Agriculture, ecosystems and environment effects of landscape composition on bee communities and coffee pollination in Coffea arabica production forests in southwestern Ethiopia. *Agriculture, Ecosystems & Environment, 288,* 106-706.

Gemeda, T. (2021). Insect pollinator and sustainable agriculture in Sub-Saharan Africa. *Journal of Pollination Ecology, 27*(2), 36-46.

Gruter, C., & Ratneiks, F. L. W. (2011). Flower constancy in insect pollinators: Adaptive foraging behaviour or cognitive limitation. *Communicative & Integrative Biology, 4*(6), 633-636.

Ifeanyi-Obi, C. C., & Iferobia, G. C. (2024). Assessment of mobile phone usage for agricultural information sharing among rural farmers in agricultural zone one, Rivers State. *Journal of Agricultural Extension, 28*(4), 70-79.

Jarvinen, A., Himanen, S. J., Raiskio, S., & Hyvonen, T. (2022). Intercropping of insect-pollinated crops supports a characteristic pollinator assemblage. *Agriculture, Ecosystems & Environment, 6*(3), 210-222.

Katumo, D. M., Liang, H., Ochola, A. C., L, M., Wang, Q., & Yang, C. (2022). Pollinator diversity benefits natural and agricultural ecosystems, environmental health, and human welfare. *Plant Diversity, 44*, 429-435.

Kingazi, N., Temu, R.-A., Sirima, A., & Jonsson, M. (2025). Agroforestry as a refuge for insect pollinators: seasonal and elevational insights from Northern Tanzania. *Journal of Insect Conservation, 29*, 50.

Kovács-Hostyánszki, A., Földesi, R., Mózes, E., Szirák, A., Fischer, J., Hanspach, J., & Baldi, A. (2016). Conservation of pollinators in traditional agricultural landscape – New challenges in Transylvania (Romania) posed by EU accession and recommendation for future research. *PLOS One, 11*(6), 1-20.

López-Vázquez, K. M. (2025). The human touch: a meta-analysis of anthropogenic effects on plant-insect pollinator interaction networks. *Journal of Insect Conservation, 30*(1), 78-90.

Matengo, T., Musundire, R., Tarakini, G., Guia Diaz, L., & Tarakini, T. (2026). *Assessing the impacts of different cropping systems and pesticide use on pollinator communities in Mbare District, Zimbabwe*. Department of Wildlife Ecology and Conservation, Chinhoyi University of Technology.

Mbata, J. (2016). Agricultural production in Rivers State, Nigeria. *Agricultural and Food Sciences Economics, 5*(2), 45-51.

Nasare, L. I., Stout, J. C., & Kwapong, P. K. (2024). Beekeeping improves shea pollination and fruit set in West African agroforestry parklands. *Ecological Solutions and Evidence, 5*(2), 48-75.

Orford, K. A., Vaughan, I. P., & Memmott, J. (2015). The forgotten flies: The importance of non-syrphid Diptera as pollinators. *Proceedings of the Royal Society B, 282*, 2014-2934.

Otieno, N. E., Jacobs, S. M., & Pryke, J. S. (2022). Small-scale traditional maize farming fosters greater arthropod diversity value than conventional maize farming. *Journal of Insect Conservation, 26*, 477-489.

Pardee, G. L., Ballare, K. M., Neff, J. N., Lauren, D., L. Q., Ojeda, D., Bienenstock, E. J., Brosi, B. J., Grubesic, T. H., Miller, J. A., Tong, D., & Jha, S. (2023). Local and landscape factors influence plant-pollinator networks and bee foraging behavior across an urban corridor. *Ecology and Evolutionary Biology, 5*(16), 122-137.

Parmentier, L., Vanderstappen, H., & Haesaert, G. (2024). Biodiverse management of perennial flower margins in farmland: Meandering mowing by 'three-strip management' to boost insect pollinators and beneficial insects. *Insects, 15*(12), 953.

Proesmans, W., Felten, E., & Laurent, E. (2024). Urbanisation and agricultural intensification modulate plant-insect pollinator network structure and robustness. *Functional Ecology, 38*(3), 628-641.

Rader, R., Bartomeus, I., Garibaldi, L. A., Garratt, M. P. D., Howlett, B. G., Winfree, R., Cunningham, S. A., Mayfield, M. M., Arthur, A. D., Andersson, G. K. S., Bommarco, R., Brittain, C., Carvalheiro, L. G., Chacoff, N. P., Entling, M. H., Foully, B., Freitas, B. M., Gemmill-Herren, B., Ghazoul, J., Woyciechowski, M. (2016). Non-bee insects are important contributors to global crop pollination. *Proceedings of the National Academy of Sciences, 113*(1), 146-151.

Shi, X., Axmacher, J. C., Luo, A., Ma, C., Wang, M., Cheng, R., Niu, Z., Zhou, Q., Zou, Y., & Zhu, C. D. (2023). Wild pollinator communities benefit from mixed cultivation of oilseed rape and milk vetch. *Journal of Applied Entomology, 147*(10), 966-975.

Shi, X., Axmacher, J. C., Chong, H., Xiao, H., Luo, S., & Xu, H. W. (2022). Effects of farmland consolidation in Southern China on wild bee species composition, nesting location and body size variations. *Conservation Biology, 6*, 376-391.

Sritongchuay, T., Beckman, M., & Dalsgaard, B. (2025). Crop diversity in the landscape boosts insect pollinators and yield of insect pollinator dependent crops across the world. *Agriculture, Ecosystems & Environment, 3*(5), 943.

Ugo-Kamalu, N. C. (2026). Investigation of mosquito larval and pupal abundance from diverse breeding sites in Ogba/Egbema/Ndoni Local Government Area, Rivers State, Nigeria. *Scientia Africana, 24*(6), 259-266.

Van-Huis, A. (2015). Edible insects contributing to food security. *Science of Food and Agriculture, 4,* 1-9.

Wardhaugh, C. W. (2015). How many species of arthropods visit flowers? *Arthropod-Plant Interactions, 9,* 547-565.

Woodcock, B., Garratt, M. P. D., & Powney, G. D. (2019). Meta-analysis reveals that pollinator functional diversity and abundance enhance crop pollination and yield. *Nature Communications, 10,* 1-10.

Yang, H., Zhang, W., & Li, L. (2020). Intercropping: Feed more people and build more sustainable agro-ecosystems. *Paleobiology, 29*, 14-17.

Ye, Z-M., Wang, Q. F., & Yang, C. F. (2020). Co-flowering neighbor alters pollinator composition and influences reproductive success in a plant pollinated by multiple insects. *Plant Ecology, 221*, 219-228.