International Journal of Entomology Research
www.entomologyjournals.com
ISSN: 2455-4758
Received: 04-06-2024, Accepted: 25-06-2024, Published: 19-07-2024
Volume 9, Issue 7, 2024, Page No. 98-102

Diversity and ecological role of pollinating insects in agricultural systems in Kokrajhar, Assam

Danswrang Basumatary
Department of Zoology, Kokrajhar Govt. College, Kokrajhar, BTR, Assam, India

Abstract
Pollination is an essential ecological process that significantly enhances the yield of numerous food crops. This process largely relies on animal pollinators, with insects comprising a major portion. Pollinators play the most crucial ecological role in sustaining the world's plant diversity, associated organisms, and a significant portion of global agriculture. The East Himalaya region is recognized as a global biodiversity hotspot due to its vast richness in biodiversity. In this study, the diversity of insect pollinators associated with various crops in the agricultural fields of Kokrajhar district, a predominantly farming district in Assam that supports the livelihood of many residents was assessed and analyzed. Intensive searches for pollinators were conducted in the crop fields, and specimens were captured using sweep nets, hand-picking, and sticky traps for proper identification. Lepidopterans were the most diverse group, followed by Hymenopterans, while Dipterans and Coleopterans exhibited lower diversity. The foraging activity of hoverflies and bees peaked in the morning and afternoon, whereas butterflies were most active in the afternoon.

Keywords: Kokrajhar, pollination, diversity, insect pollinators, foraging

Introduction

Pollination is considered a critical service to our ecosystem, supporting the yield of many edible crops (Schulp *et al*., 2014) [26]. Pollinators play the most crucial ecological role in sustaining the world's plant diversity, associated organisms, and a significant portion of global agriculture. The East Himalaya region is recognized as a global biodiversity hotspot due to its vast richness in biodiversity. Previous studies have reported that pollinators contribute to the production of 35% of global food crops, including highly, moderately, and slightly pollinator-dependent crops (Klein *et al*., 2006) [15]. Approximately 75% of crops worldwide rely on animal pollination, with insects making up the majority (Choi *et al*., 2015) [5]. The global economic value of insect pollinators was estimated at $153 billion in 2005, accounting for 9.5% of agricultural crops used for human food (Meena *et al*., 2015) [17]. Most insect pollinators belong to three orders: Lepidoptera, Hymenoptera, and Diptera (Amit *et al*., 2018; Bashir *et al*., 2018) [3, 4].

Among Hymenopterans, honeybees are the most important pollinators, followed by wasps and flies (Bashir *et al*., 2018) [4]. Honeybees are particularly vital for the pollination of major crops, especially those that produce seeds. Many honeybee species are conserved and utilized for pollination worldwide. In Asia, 10 honeybee species have been reported, including Apis dorsata, found in the Himalayan foothills and valued for organic honey production, and Apis florea, which pollinates crops like cumin and coriander. Apis mellifera, a medium-sized honeybee, supports the pollination of crops like Nigella and fenugreek (Rogers *et al*., 2014) [23].

Previous studies have highlighted the significant contribution of wild bees to crop productivity, emphasizing that species richness and abundance are crucial for efficient pollination. Research indicates that species richness is a better indicator of pollination efficiency than abundance. While many studies focus on managed and wild bees, the role of non-bee species in pollination is less explored. Lepidopterans, Dipterans, Formicidae, and Coleopterans provide valuable pollination services, visiting 25-50% of flowers during foraging (Rader *et al*., 2016) [22].

Research shows that pollinator diversity significantly impacts pollination efficiency (Albrecht *et al*., 2012) [2]. The diversity of wild bees is strongly associated with the diversity of wild plants, indicating that plant species richness is key to sustaining pollinator diversity. Pollination services depend on pollinator diversity and species-specific traits, which ensure the effective use of floral resources (Widhiono *et al*., 2016) [28]. The reproductive rate of plants is influenced by pollinator diversity, with species richness and the number of seeds per fruit being critical factors (Hoehn *et al*., 2008) [12].

Pollination efficiency also depends on the foraging behavior, size, and inter-plant movements of pollinators. Flower color, nectar volume, pollen numbers, and phenology attract more pollinators, while flower clusters support pollen outcrossing by butterflies (Fontaine *et al*., 2006) [8]. Foraging behavior enables pollinators to transfer a mix of outcross and self-pollen, aiding fertilization. Insect pollinator abundance is directly proportional to outcrossing rates. Traditionally, plant-pollinator interactions are seen as mutualistic, benefiting both parties. However, some studies highlight antagonistic interactions, where pollinators consume floral resources, potentially harming plant fitness (Saunders, 2017) [25].

Insect pollinators also serve as bioindicators, monitoring environmental stress from parasites, diseases, predators, competitors, and physical and chemical factors like pesticides and habitat alterations (Kevan, 1999) [14]. Their presence provides a unique way to assess ecosystem health. In urban areas, insect pollinators facilitate the fertilization of plants in parks, home gardens, and other spaces, with wild bees being key pollinators in city green spaces (Hausmann *et al*., 2015) [11].

In Mexico, insect pollinators significantly enhance coffee plant production, as evidenced by higher fruit sets in open-pollinated fields. Farmer management practices influence pollinator diversity, suggesting that healthy practices can

boost diversity and crop yields while supporting biodiversity conservation (Vergara and Badano, 2009) [27]. Pollinators also improve the quantitative traits of onions, increase seed production in cumin, and enhance fruit set in Bael and sunflower crops. They are crucial for increasing seed set in Camphor basil (Devi *et al*., 2015) [6].

This research aims to assess the diversity of insect pollinators involved in pollinating various crops such as mustard, paddy, sesame, pulses, and vegetables like carrot, pea, and cabbage in the agricultural fields in an around Kokrajhar District of Assam.

Methodology

Study Area

This study was conducted in Kokrajhar District, located in Assam, India. Kokrajhar district is situated in the western part of Assam, India. It is part of the Bodoland Territorial Region and serves as its administrative center. The district is bordered by the districts of Dhubri and Bongaigaon to the south, Chirang to the east, and the international border with Bhutan to the north. Kokrajhar spans an area of approximately 3,169 square kilometers, characterized by a mix of plains and foothills.

The climate of Kokrajhar is subtropical, with hot and humid summers, a monsoon season with heavy rainfall, and mild winters. The summer season lasts from March to May, followed by the monsoon season from June to September, and the winter season from October to February. The Brahmaputra River and its tributaries significantly influence the district's hydrology and agriculture.

Agriculture in Kokrajhar relies heavily on traditional farming methods, though modern techniques are gradually being adopted. Pollination is a critical process in enhancing the yield of many crops grown in the district. The role of insect pollinators, such as bees, butterflies, and other insects, is crucial in this regard. These pollinators contribute significantly to the productivity of crops like mustard, pulses, and various vegetables. The district is well-known for producing a variety of fruits and crops, including paddy, oil seeds, pulses, wheat, and potatoes. Agriculture is the main source of income for most of residents, with a significant portion of the population engaged in farming.

Selection and Survey of Agricultural Fields

Field studies were conducted in the crop fields in and around Kokrajhar town. Three major fields were extensively surveyed, each supporting the cultivation of various crops, including:

- Paddy
- Mustard
- Sesame
- Various vegetables (peas, cabbage, carrot, etc.)
- Pulses

The surveys were carried out for at least one hour, two days a week, over a period of three months, covering an area of approximately 20 square meters. The study took place during the months of January, February, and March in 2024.

Collection and Identification

Insect pollinators were intensively searched in the crop fields using both active and passive sampling techniques. Active methods included the use of sweep nets and hand-picking, while sticky traps were employed as a passive technique for capturing pollinators. Insects were identified on the spot when possible, and any unidentified species were taken to the College laboratory for further identification. The specimens were preserved in 70% alcohol or in dry envelopes. Identification was carried out to the generic and species levels. The role of these insects in pollination was studied using referenced literature.

Results and Discussion

Table 1: List of insect Pollinators along with their Common name, Family & Order, associated with various crops in agricultural fields of Kokrajhar District, Assam

Sl. No.	Family	Order	Scientific name	Common name
1	Pieridae	Lepidoptera	*Colias erate*	Eastern pale clouded yellow
2			*Pieris rapae*	White butterfly
3			*Pieris canidia*	Indian cabbage white
4	Nymphalidae		*Danaus genutia*	Common tiger
5			*Danaus chrysippus*	Plain tiger
6			*Caligo illioneus*	Owl butterfly
7			*Enodia anthedon*	Northern Pearly Eye
8			*Danaus plexippus*	Monarch butterfly
9			*Melanitis leda*	Common evening brown
10	Papilionidae		*Papilio polytes*	Common mormon
11	Lycaenidae		*Zizina otis*	Lesser grass blue
12	Apidae	Hymenoptera	*Apis mellifera*	European honey bee
13			*Apis dorsata*	Giant honey bee
14			*Xylocopa*	Carpenter bee
15			*Apis florea*	Dwarf honey bee
16	Vespidae		*Vespula germanica*	Wasp
17	Syrphidae	Diptera	*Eupeodes corollae*	Hoverfly
18	Coccinellidae	Coleoptera	*Coccinella magnifica*	Ladybug

Table 2: Dominant Insect pollinators recorded from the observations made in agricultural fields of Kokrajhar District, Assam

Species (common name)	Order	Total records
Apis mellifera (European honey bee)	Hymenoptera	67
Apis florea (Dwarf honey bee)	Hymenoptera	54
Danaus chrysippus (Plain tiger)	Lepidoptera	32
Pieris canidia (Indian cabbage white)	Lepidoptera	24
Eupeodes corollae (Hoverfly)	Diptera	15
Papilio polytes (Common Mormon)	Lepidoptera	28
Danaus genutia (Common tiger)	Lepidoptera	12

In this investigation, I have identified a total of 18 species belonging to 8 families across 4 orders that act as insect pollinators in the agricultural fields of Kokrajhar district (Table 1). Lepidoptera was found to be the most diverse order of insect pollinators, with 11 species, followed by Hymenoptera with 5 species. Orders Diptera and Coleoptera exhibited minimal diversity, each represented by a single species.

A detailed breakdown of insect pollinators at the family level revealed that among Lepidopterans, 3 species belonged to the family Pieridae, 6 species to Nymphalidae, and one species each to Papilionidae and Lycaenidae. Among Hymenopterans, 4 species belonged to the family Apidae and 1 species to Vespidae. Diptera and Coleoptera each had one species, from the families Syrphidae and Coccinellidae, respectively.

The most prominent pollinating insects identified were Apis mellifera (67 individuals), followed by Apis florea (54 individuals), Danaus chrysippus (32 individuals), Pieris canidia (24 individuals), Eupeodes corollae (15 individuals), Papilio polytes (28 individuals), and Danaus genutia (12 individuals) (Table 2).

This findings strongly support previous research indicating that Lepidopterans are the most diverse insect pollinators in the agricultural fields of Kokrajhar District. The larger body size of butterflies facilitates effective pollen transfer as pollen adheres to their legs and proboscis when they visit flowers for nectar. This ensures efficient pollen deposition on the pistil during subsequent flower visits, making butterflies highly effective pollinators of crops (Hoehn *et al*., 2008) [12].

Hymenopteran species were the most abundant and second most diverse group of pollinators supporting crop pollination in the region. Honeybees, such as Apis mellifera, are excellent indicators of environmental quality due to their extensive foraging behavior, capable of detecting food sources within a 3-kilometer radius of their hives (Huo *et al*., 2017). Apis mellifera individuals actively participated in pollination tasks during our study, demonstrating their significance in crop pollination management based on flowering schedules and crop requirements. They are also commercially valuable due to their foraging efficiency and high honey production capacity (Agarwal, 2014). Apis florea, known for its preference for small flowers, and Apis dorsata play crucial roles in pollinating numerous seed species and horticultural crops.

Although Dipterans exhibited lower diversity, their presence, totaling 15 individuals, underscores their potential as crop pollinators. Hoverflies and bees were most active in morning and afternoon sessions, while butterflies exhibited peak activity in the afternoon, consistent with findings from previous studies (Siregar *et al*., 2016 [10].

Scope of Pollinator Diversity

Klein *et al*. (2007) noted that 87 of the top food crops and 35% of global agricultural production rely on animal pollination. Studies indicate that plants visited by a diverse pollinator community produce higher quality and quantity seeds (Gomez *et al*., 2007; Celep *et al*., 2020). However, pollinator populations are declining in many regions, a significant ecological issue highlighted by Potts *et al*. (2010) and Christmann (2019).

Pollinator Diversity Enhances Plant Productivity and Recruitment

Pollinator diversity is crucial for seed production in flowering plants (Blitzer *et al*., 2016). Research shows a positive correlation between reproductive success in natural plant communities and pollinator functional diversity (Albrecht *et al*., 2012; Frund *et al*., 2013) [2]. Plants visited by a diverse pollinator community produce superior seeds in both quality and quantity (Gomez *et al*., 2007; Celep *et al*., 2020).

Pollinator Diversity Alleviates Pollen Limitation in Natural Plant Communities

Pollen limitation can affect ecosystem functionality and influence the distribution and abundance of plant species (Bennett *et al*., 2018). A recent meta-analysis revealed that in the Anthropocene, ecologically and functionally specialized plants are particularly vulnerable to pollen limitation (Bennett *et al*., 2020). Therefore, preserving pollinator diversity is critical in our evolving world, as losing pollinators could lead to a decline in plants dependent on them.

Pollinator Diversity Improves Pollination Services

Pollination services are essential for the reproductive success of plants, significantly contributing to the maintenance of plant communities. Rodger *et al*. (2021) recently estimated that without pollinators, half of all flowering plants would experience an 80% or greater decline in fertility, and a third would fail to produce seeds entirely. Many studies have highlighted the critical role of biotic pollination in natural ecosystems.

Significance of Pollinator Diversity in Agricultural Productivity

Despite a large portion of human nutritional needs being met by a few staple crops that do not rely on pollinators (Ghazoul, 2005; Klein *et al*., 2007; Kleijn *et al*., 2015), research underscores that the loss of pollinators would result in malnutrition (Ellis *et al*., 2015; Potts *et al*., 2016). Although some researchers contend that crop pollination alone does not justify the conservation of wild pollinators (Richards, 2001; Ghazoul, 2005; Kleijn *et al*., 2015), growing evidence demonstrates that pollinator diversity is

vital for crop production, impacting both the quantity and quality of yields (Garibaldi *et al*., 2014; Cusser *et al*., 2016; Vasiliev & Greenwood, 2020).

Table 3: Importance of pollinator diversity in natural and agricultural ecosystems

Areas	Attributes	References
1. **Natural ecosystem**		
i.Overcomes pollen limitation	Enhances pollination and genetic diversity	Gomez *et al.* (2007), 2010
ii.Promotes seedling recruitment	Enhances plant diversity in the natural ecosystem	Fontaine *et al.* (2006); Lundgren *et al.* (2015)
2. Agricultural ecosystem		
i. Increases fruit sets of crops	Apple, almond, pumpkin, coffee, oilseed rape, jalapeno	Mallinger and Gratton (2015); Hoehn *et al*. (2008); Wietzke *et al*. (2018); Geeraert *et al*. (2020); Norfolk et al. (2016); Klein *et al.* (2003); Woodcock *et al*. (2019); Cohen *et al*. (2021)
ii. Increases quality of agricultural yield	weight of coffee, weight of cotton seeds, weight of mangoes, weight and sugar level of loquat fruit	Tremlett *et al*. (2020); Philpott *et al*. (2006); Cusser *et al*. (2016); Rafique et al. (2016); Ahmad *et al*. (2021)

Conclusion

This study revealed that Lepidopterans were the most diverse group of pollinating insects in the crop fields of Kokrajhar district, followed by Hymenopterans, which had the highest number of crop visitors. While Dipterans and Coleopterans exhibited less diversity, their contribution to pollination remains significant. Pollinators provide indirect support to a wide variety of other organisms, including yeasts and other microbes in nectar, fungal diseases of flowers, cleptoparasitic insects, other parasites, specialized predators and herbivores, and fruit- and seed-eating animals. This support greatly enhances the value of plant diversity. Any loss of this diversity would be catastrophic for Earth's biological heritage. A decline in pollinator diversity and availability could pose serious threats to crop pollination and reduce crop yields. Therefore, it is crucial for the local community to adopt conservation measures for pollinator species and implement effective crop management techniques that enhance the foraging activity of pollinators. This will help increase crop production not only in Kokrajhar district but also in other regions of the state.

Acknowledgement

The authors extend his heartfelt thanks to the entire staff of the Department of Zoology, Kokrajhar Govt. College, for their unwavering support, encouragement, and guidance throughout this study. He is also grateful to Kokrajhar Govt. College, Kokrajhar, Assam, for providing the necessary infrastructure to conduct this research. The author also thanks all the farmers and cultivators for their valuable support and coordination while performing the survey.

Conflict of Interest

The author declares no conflict of interest.

References

1. Agrawal TK. Beekeeping industry in India: Future potential. International Journal of Research in Applied, Natural and Social Sciences,2014:2:133-140.
2. Albrecht M, Schmid B, Hautier Y, *et al*. Diverse pollinator communities enhance plant reproductive success. Proceedings of the Royal Society B,2012:279:4845-4852.
3. Amit Jadhav J, Sreedevi, Kolla, Rajendra Prasad P. Insect pollinator diversity and abundance in sunflower ecosystem, 2018.
4. Bashir MA, Saeed S, Sajjad A, Khan KA, Ghramh HA, Shehzad MA, *et al*. Insect pollinator diversity in four forested ecosystems of southern Punjab, Pakistan. Saudi Journal of Biological Sciences, 2018.
5. Choi Sei Woong, Jung Chuleui. Diversity of Insect Pollinators in Different Agricultural Crops and Wild Flowering Plants in Korea: Literature Review. Journal of Apiculture,2015:30:191.
6. Devi S, Gulati R, Tehri K, Poonia A. The pollination biology of onion (Allium cepaL.)-A Review. Agricultural Reviews,2015:36(1):1.
7. Duara P, Kalita J. An investigation on the pollinating insects of medicinally important plants. Int. J. Life. Sci. Biotech. Phar. Res,2013:2:318–324.
8. Fontaine C, Dajoz I, Meriguet J, Loreau M. Functional Diversity of Plant–Pollinator Interaction Webs

Enhances the Persistence of Plant Communities. PLoS Biol,2006:4(1):e1.
9. Guo Y, Zhang X, Shao Y, Li J. Evaluation of diversity and abundance of pollinating insects on oilseed rape in major planting area of China. International Journal of Agricultural Policy and Research,2017:5(6):117-124.
10. Hafni Siregar Elida, Atmowidi Tri, Kahono Sih. Diversity and Abundance of Insect Pollinators in Different Agricultural Lands in Jambi, Sumatera. HAYATI Journal of Biosciences, 2016, 23.
11. Hausmann SL, Petermann JS, Rolff J. Wild bees as pollinators of city trees. Insect Conservation and Diversity,2015:9(2):97–107.
12. Hoehn P, Tscharntke T, Tylianakis JM, Steffan Dewenter I. Functional group diversity of bee pollinators increases crop yield. Proceedings of the Royal Society B: Biological Sciences,2008:275(1648):2283–2291.
13. Jean Baptiste, Noubissie Tchiagam. Role of Lepidoptera as pollinators on the breeding systems of Striga hermonthica (Del) Benth under the Guinea Savannah zone conditions. Annals of Biological Research,2012:3:2821-2828.
14. Kevan PG. Pollinators as bioindicators of the state of the environment: species, activity and diversity. Agriculture, Ecosystems & Environment,1999:74(1-3):373–393.
15. Klein AM, Vaissière BE, Cane JH, Steffan Dewenter I, Cunningham SA, Kremen, *et al*. Importance of pollinators in changing landscapes for world crops. Proceedings. Biological sciences,2006:274(1608):303-13.
16. Mandela HK, Tsingalia MH, Gikungu M, Lwande WM. Distance Effects on Diversity and Abundance of the Flower Visitors of Ocimum kilimandscharicum in the Kakamega Forest Ecosystem. International Journal of Biodiversity, 2018, 1–7.
17. Meena NK, Singh Balraj, Kant Krishna, Meena RD, Solanki Ramesh. Role of insect pollinators in pollination of seed spices: A review. International Journal of Seed Spices,2015:5:1-17.
18. NK Meena, G Lal, RS Meena, BM Meena, RD Meena. Pollinator's diversity and abundance on cumin (Cuminum cyminum L.) and their impact on yield enhancement at semi-arid regions,2018:6(4):1017-1021.
19. Perrot T, Gaba S, Roncoroni M, Gautier JL, Saintilan A, Bretagnolle V. Experimental quantification of insect pollination on sunflower yield, reconciling plant and field scale estimates. Basic and Applied Ecology, 2018.
20. Phukon M, Saikia B, Sorahia D. Pollinator diversity in North East India, sustainable use of bioresources in north- east india, College of Agriculture, Jorhat Assam Agricultural University Jorhat-785013, Assam, India, 2023, 149-160.
21. Pradesh. " International Journal of Agriculture Sciences,2016:8(39):1799-1801.
22. Rader R, Bartomeus I, Garibaldi LA, Garratt MPD, Howlett BG, Winfree R, *et al*. Non- bee insects are important contributors to global crop pollination. Proceedings of the National Academy of Sciences,2016:113(1):146– 151.
23. Rogers SR, Tarpy DR, Burrack HJ. Bee Species Diversity Enhances Productivity and Stability in a Perennial Crop. PLoS one,2014:9(5):e97307.
24. Satapathy SN, Umesh chandra. "Foraging behaviour and diversity of insect pollinators on bael (aegle marmelos correa.) at indo-gangatic plain of eastern uttar
25. Saunders Manu. Insect pollinators collect pollen from wind-pollinated plants: Implications for pollination ecology and sustainable agriculture. Insect Conservation and Diversity, 2017.
26. Schulp CJE, Lautenbach S, Verburg PH. Quantifying and mapping ecosystem services: Demand and supply of pollination in the European Union. Ecological Indicators,2014:36:131–141.
27. Vergara CH, Badano EI. Pollinator diversity increases fruit production in Mexican coffee plantations: The importance of rustic management systems. Agriculture, Ecosystems & Environment,2009:129(1-3):117–123.
28. Widhiono, Imam, Sudiana, Eming, Tri Sucianto, Edy. Insect pollinator diversity along a habitat quality gradient on Mount Slamet, Central Java, Indonesia. Biodiversitas,2016:17:746-752.