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A Study on Pollinating Insect Diversity in Selected Areas of Pudunagaram Village, Palakkad, Kerala, India

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Short Research Article

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ABSTRACT

The present study on Pollinating insect diversity of selected areas of Pudunagaram village, Palakkad, Kerala was conducted for a period of six months from January 2022 – June 2022. Two sites were selected which are diverse in habitats; one is Mangode, the home garden where floral plants were cultivated, and the second is Karippode, the forest area with wild plants. Visual observation and hand- picking methods were used for collection. A total of 49 species belonging to 5 orders and 15 families were recorded of which Order Lepidoptera was dominant with 29 species. In site-1 family Nymphalidae and in site-2 Apidae was dominant. The Shannon diversity index study revealed that insect diversity is slightly higher in site-1 (2.313) as compared to site-2(2.25).

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Keywords: Pollinating insects; Lepidoptera; Nymphalidae; Karipode; Mangode; The Shannon diversity index; Conservation.

1. INTRODUCTION

Insects are the primary pollinators of most of the plants. The pollinating insects include all families of bees, most aculeate wasps, ants, numerous fly families, various families of butterflies and moths (lepidopterans), and many beetle families. Insects show an astonishing taxonomic diversity and are abundant in almost all environments across the globe (Nigel *et al.,* 2015). Insect pollination is a globally essential ecosystem service, offering substantial economic, aesthetic, and cultural benefits to human society while supporting crucial ecological processes in terrestrial ecosystems. Insect pollinators such as bees, butterflies, flies, beetles, and moths are essential for plant reproduction and the overall functioning of ecosystems. The diversity of insect pollinators is crucial for effective pollination, enhances genetic variability in plants, fostering adaptation and resilience. Additionally, it supports healthy ecosystems by maintaining balance within the food web and increasing environmental stability.

Several studies have been conducted on different aspects of pollination and insect visitors till date. According to the report by Divija *et al.,* (2002), a study on the diversity and foraging behavior of floral visitor assemblages in onion (*Allium cepa*) revealed that the pollinator community consists of 30 hymenopteran species, 16 dipteran species, 8 lepidopteran species, 4 hemipteran species, and 1 coleopteran species. Pandurangan (2003) conducted studies on the rescue and restoration of endemic, rare, and threatened medicinal plants in the Agasthya Malai, Kulamavu, and Wayanad medicinal plant conservation areas of the Western Ghats in Kerala. His findings revealed that bees play a significant role in pollinating many of these plants.

Similarly, Sasidharan and Kunchikannan (2010) studied bee faunal diversity in the Nilgiris region of the Western Ghats, Tamil Nadu, documenting the occurrence of approximately 92 bee species. Thakur and Mattu (2010) studied the role of butterflies as flower visitors and pollinators in the Shiwalik Hills of the Western Himalayas. They recorded 87 butterfly species visiting 51 flowering plant species, with Nymphalids and Pierids visiting 18 species each, Lycaenids visiting 13, Hesperiids visiting 8, and Papilionids and Danaids visiting 4 species each. Flowers from the Asteraceae family attracted the highest number of butterfly species. Rianti *et al.,* (2010) studied the diversity and effectiveness of insect pollinators of *Jatropha curcas* (Euphorbiaceae) and identified nine species from three orders: Hymenoptera, Lepidoptera, and Diptera. Among these, four Hymenoptera species—*Prenolepis*, *Apis dorsata*, *Xylocopa confusa*, and *Apis cerana*—were the most abundant. Bees, particularly *X. confusa*, *A. cerana*, and *A. dorsata* of the Apidae family, were the most effective pollinators due to their high visitation frequency.

In Kerala, there have been only a few studies on the insect pollinators of specific plants and their ecological requirements. Chaudhary and Kumar (2000) studied floral biology, foraging behavior, and honeybee pollination in *Elettaria cardamomum* at Kadasikadavu, Idukki District, Kerala, identifying Apoidea as the dominant flower visitors, comprising over 99% of the total. Binoy *et al.,* (2014) studied insect pollinators and foraging patterns in *Catharanthus roseus* and *Pentas lanceolata* in Thrissur District, Kerala. They identified eight pollinator species from two orders and five families, including five Lepidoptera species and three Hymenoptera species. Bijoy *et al.,* (2019) recorded 37 solitary non-*Apis* bees from 19 species, 7 genera, and 3 families in Chittur Taluk, Palakkad, highlighting their role in pollinating wind-pollinated rice plants. Unni *et al.,* (2021) found that *Apis cerana* was the primary pollinator of pumpkin flowers (92%) in Kasaragod, with *Apis dorsata* contributing 8%. Nine ant species also visited the flowers after anthesis. Vinaya and Bijoy (2022) conducted research on the foraging activity and breeding system of *Avicennia officinalis* L. (Avicenniaceae) in Chettuwa, Thrissur, Kerala, identifying 15 foraging insect species from three orders: Hymenoptera, Diptera, and Lepidoptera.

Diversity studies are increasingly important as many species are lost each year due to habitat destruction, land use changes, deforestation, pollution, climate change, invasive species, and pesticide use. Therefore, biodiversity studies serve as valuable references for guiding conservation programs.

2. MATERIALS AND METHODS

The present study was conducted between January and June 2022, from 6:30 AM to 6:30 PM, in Pudunagaram village, located in the

Palakkad district. Most butterfly activity was recorded between 10:00 AM and 3:00 PM. The survey of pollinating insect diversity was carried out at two sites: Site 1- Mangode and Site 2 - Karippode. Observations were made exclusively on sunny days, with temperatures ranging from 30°C to 35°C.Butterflies were counted using the transect method. A 500-meter transect was established at each site and divided into five sectors of 100 meters each.

2.1 Study Area

The study was conducted in Pudunagaram village located in Chittur taluk, Palakkad district. Pudunagaram is a town and gram panchayat in the Palakkad district, of Kerala. Two sites were selected for this study which are, 1. Mangode - Diversity of pollinating insects in home garden (Picture-1). 2- Karippode- Diversity of pollinating insects in wild region (Picture-2). Mangode, 5.8 km from Pudunagaram, is a residential area with some agricultural land. Despite its housing focus, it supports diverse pollinators due to abundant ornamental and vegetable plants in home gardens, making it ideal for pollinator diversity studies. Karippode is another study site located 5.5 km away from Pudunagaram and 2.6 km away from Mangode. Diversity studies were carried out in this site with special consideration to wild flower pollinators.

2.2 Methods Used

Visual observation, hand-picking, and photography were the methods used for insect collection. Butterflies were identified using standard references, including *A Naturalist's Guide to the Butterflies of India* by Peter Smetacek and the e-book *Butterflies of the Western Ghats* by Dr. Raju Kasambe, with additional assistance from entomology experts.

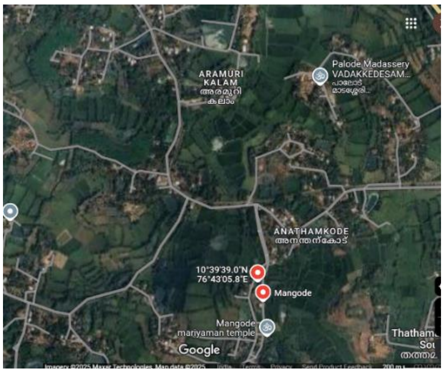
2.3 Statistical Analysis of Data

The Shannon-Wiener Index was used to calculate the diversity index. Shannon Weiner Index- A diversity index, taking in to account the number of individuals as well as number of taxa. Varies from 0 for communities with only a single taxon to high values for communities with many taxa, each with few individuals.

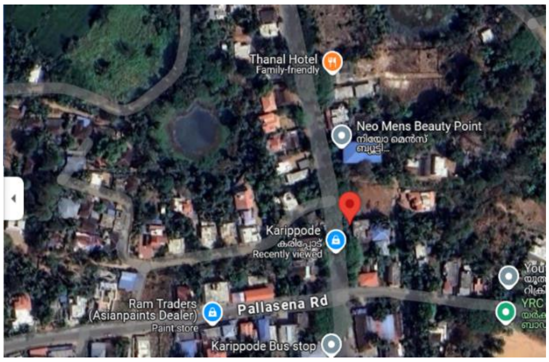
- It shows the species richness in a community.
- If the community is dominated by one species, then the diversity will be low

The Shannon-Weiner index, or Shannon diversity index, is calculated using the formula:

$H' = -\sum (p_i * \ln(p_i))$, where pi is the proportion of individuals belonging to species i, and ln is the natural logarithm.



Picture 1. Mangode (Site-1)



Picture 2. Karippode (Site-2)

Sampling Site 1- Mangode

Sampling Site 2- Karippode

3. RESULTS AND DISCUSSION

In the present study, conducted over a six-month period from January 2022 to June 2022 in two locations within Pudunagaram village, Palakkad district, Kerala, observations were systematically recorded.

A total of 49 insect species belonging to 5 orders and 15 families were documented from the selected sites in Pudunagaram village (Plate 1-6). The observed orders included Hymenoptera, Coleoptera, Lepidoptera, Diptera, and Heteroptera. In Hymenoptera, three families Apidae, Formicidae, and Megachilidae were recorded, with Apidae being most abundant in site 2, where wildflowers were present. Coleopteran families Coccinellidae and Chrysomelidae were noted as flower visitors. Lepidoptera was represented by seven families, with Nymphalidae showing the highest abundance in site 1. The family Nymphalidae was found to be the most dominant group in most of the studies, as reported by Nandana & Roopavathy (2019), Dalie *et al.,* (2023), Siny &Nandini (2023), and Jayasree *et al.,* (2023). Other Lepidopteran families included Hesperiidae, Pieridae, Lycaenidae, Papilionidae, Crambidae, and Sphingidae. Similar reports were found in the study by Deeksha *et al.,* (2022). In Diptera, Tephritidae and Syrphidae were observed, both showing low abundance along with Alydidae from the order Heteroptera. One vulnerable species, *Tirumala limniace*, belonging to the family Nymphalidae, and one Near Threatened species, *Euchrysops cnejus*, from the family Lycaenidae, both under the order Lepidoptera, were also documented in the present study. Table 1 presents the list of pollinating insect species recorded from the two sites, along with their order, family, common name, and IUCN status.

Site- 1 has diverse floral vegetation, including various ornamental, garden, and vegetable crop flowers. The study period coincided with the cultivation period of several vegetable crops, which attracted a variety of insects to the site. A total of 35 species were documented at Site 1, including 23 Lepidoptera species, 8 Hymenoptera species, 3 Diptera species, and 1 Heteroptera species. Ornamental and garden plants have bright, colorful flowers that attract many insects. These insects help in pollination and, in return, get nectar as food. Some plants also have pleasant scents that attract insects. Hymenopterans, especially bees from the Apidae family, visited vegetable crop flowers more frequently than garden flowers. This may be due to higher nectar content and better flower synchrony, which makes nectar collection easier for them. Three species of Formicidae (ants) were observed on flowers, while Coleopterans (beetles) were not found at this site. Other butterfly species recorded included 4 species of Hesperiidae, 3 species of Pieridae, and 3 species of Papilionidae. Moth pollination was rarely observed, likely because the study was conducted between 6:00 AM and 6:00 PM and usually moths are nocturnal in habit. Still, two moth families Crambidae and Sphingidae were recorded. Figs 1 and 2 show pie diagrams illustrating the numerical abundance of pollinating insects from different families at Site 1 and Site 2, respectively.

Site- 2 focuses on wildflower pollinators, which play a key role in maintaining the effective functioning of ecosystems. A total of 29 species were recorded, including 15 species of Lepidoptera, 10 species of Hymenoptera, 3 species of Coleoptera, and 1 species of Diptera. The area had less human activity, which allowed more wild plants to grow. Most of these had smaller, less visually attractive flowers compared to garden plants. Observing these small flowers requires careful attention. It was noted that many butterflies preferred visiting tree flowers over shrub flowers, while bees were seen pollinating both. At this site, the Apidae family was observed in the highest numbers (24%), followed by the butterfly families Hesperiidae and Nymphalidae (13% each). Three species of Coleopterans were recorded, including one species from the family Coccinellidae and two from Chrysomelidae. One moth species from the family Crambidae was also recorded. Additionally, *Bactrocera dorsalis*, a member of the Dipteran family Tephritidae, was observed. Food availability and habitat changes are believed to influence variations in species abundance. The conservation of honey bees, other domesticated bees, wild bees, and additional pollinators is a critical issue in the global context of sustainable agriculture and ecosystem productivity.

Documenting the diversity and geographic distribution of pollinators across various regions of India is crucial for developing effective strategies to conserve and enhance their populations (Tandon *et al.,* 2020). India is home to more than 700 bee species with only five are classified as social bees (Orr *et al.,* 2021), highlighting the vast unexploited potential of alternative pollinators to enhance agricultural productivity. As per the studies of Shivana (2002)

Table 1. List of Pollinating insect species obtained from two sites with Order, Family, and Common name and IUCN status

Order	Family	Sl.No.	Species	Common Name	IUCN Status	Site-1	Site-2
Hymenoptera	Apidae	1	Apis dorsata Fabricius,1793	Giant honey bee.	LC	✓	
Hymenoptera	Apidae	2	*Apis mellifera scutellata* Lepeletier,1836	East African lowland honey bee.	DD	✓	✓
Hymenoptera	Apidae	3	*Apis melliferaligustica* Spinola,1806	Italian bee.	DD	✓	✓
Hymenoptera	Apidae	4	*Apis mellifera capensis* Eschscholtz,1822	Cape honey bee	LC		✓
Hymenoptera	Apidae	5	*Apis mellifera carnica* Pollman,1879	Carniolan honey bee.	DD		✓
Hymenoptera	Apidae	6	*Apis florae* Fabricius, 1787	Red dwarf honey bee.	LC		✓
Hymenoptera	Apidae	7	*Apis andreniformis* Smith,1858	Black dwarf honey bee.	DD	✓	✓
Hymenoptera	Apidae	8	*Meliponula ferrunginea* (Lepeletier, 1836).	Stingless bee.	NE	✓	
Hymenoptera	Apidae	9	*Bombus impatiens* Cresson,1863	Common eastern bumble bee	LC		✓
Hymenoptera	Formicidae	10	*Camponotus compressus* (Fabricius,1787)	Indian Black Ant.	NE	✓	✓
Hymenoptera	Formicidae	11	*Oecophylla smaragdina* (Fabricius,1775)	Weaver ant.	NE	✓	
Hymenoptera	Formicidae	12	*Crematogaster scutellaris* (Oliver, 1792)	The saint valentine ant.	NE	✓	✓
Hymenoptera	Megachilidae	13	*Megachile rotundata* (Fabricius,1787)	Leaf cutting bee.	LC		✓
Coleoptera	Coccinellidae	14	*Epilachna varivestis* Mulsant, 1850	Mexican bean beetle.	NE		✓
Coleoptera	Chrysomelidae	15	*Aulacophora foveicollis* (Lucas, 1849)	Red pumpkin beetle	NE		✓
Coleoptera	Chrysomelidae	16	*Crioceris duodecimpunctata* (Linnaeus,1758)	Spotted asparagus beetle	NE	✓	✓
Lepidoptera	Hesperidae	17	*Potanthus Omaha* (Edward, 1863)	Lesser dart.	NE	✓	✓
Lepidoptera	Hesperidae	18	*Borbo cinnara* (Wallace,1866)	Rice swift.	LC	✓	
Lepidoptera	Hesperidae	19	*Pelopidas mathias* (Fabricius,1798)	Small branded swift.	LC	✓	
Lepidoptera	Hesperidae	20	*Tagiades gana* (Moore,1865)	Suffused snow flat.	LC		✓
Lepidoptera	Hesperidae	21	*Choranthus capucinus* (Lucas 1856)	Monk skipper.	NE	✓	✓
Lepidoptera	Hesperidae	22	*Polites vitex* (Geyer, 1832)	Whirlabout	LC		✓
Lepidoptera	Nymphalidae	23	*Tirumala limniace* (Cramer,1775)	Blue tiger	VU	✓	✓
Lepidoptera	Nymphalidae	24	*Danaus genutia* (Cramer,1779)	Common tiger	LC	✓	
Lepidoptera	Nymphalidae	25	*Junonia lemonias* (Linnaeus, 1758)	Lemon pansy.	LC		✓
Lepidoptera	Nymphalidae	26	*Parantica aglea* (Stoll,1782)	Glassy tiger	LC	✓	✓
Lepidoptera	Nymphalidae	27	*Euploea core* (Cramer, 1780)	Common crow.	LC	✓	

Order	Family	Sl.No.	Species	Common Name	IUCN Status	Site-1	Site-2
Lepidoptera	Nymphalidae	28	*Danaus chrysippus* (Linnaeus,1758)	Plain tiger.	LC	√	
Lepidoptera	Nymphalidae	29	*Neptis hylas* Linnaeus, 1758	Common sailor.	NE		√
Lepidoptera	Nymphalidae	30	*Junonia atlites* (Linnaeus,1763)	Grey pansy.	LC	√	
Lepidoptera	Pieridae	31	*Eurema hecabe*(Linnaeus,1758)	Grass yellow	LC		√
Lepidoptera	Pieridae	32	*Catopsilia florella* (Fabricius, 1775)	African migrant	LC	√	
Lepidoptera	Pieridae	33	*Delias eucharis* (Drury, 1773)	Common Jezebel	LC	√	
Lepidoptera	Pieridae	34	*Phoebis philea* (Linnaeus, 1763)	Orange- barred sulphur.	NE	√	
Lepidoptera	Lycaenidae	35	*Castalius rosimon* (Fabricius,1775)	Common Pierrot	NE	√	√
Lepidoptera	Lycaenidae	36	*Talicada nyseus* (Guerin,1843)	Red pierrot	NE	√	√
Lepidoptera	Lycaenidae	37	*Euchrysops cnejus* (Fabricius,1798)	Gram blue.	NT	√	
Lepidoptera	Lycaenidae	38	*Jamides celeno* (Cramer,1775)	Common cerulean	NE	√	
Lepidoptera	Lycaenidae	39	*Tarucus nara* (Kollar, 1848)	Striped Pierrot	LC	√	√
Lepidoptera	Papillionidae	40	*Pachliopta aristolochiae* (Fabricius, 1775)	Common Rose	LC	√	
Lepidoptera	Papillionidae	41	*Troides Helena* (Linnaeus,1758)	Common bird wing	LC		√
Lepidoptera	Papillionidae	42	*Papilio polymnestor* Cramer,1775	Blue mormon	LC	√	√
Lepidoptera	Papillionidae	43	*Papilio demoleus* Linnaeus,1758	Lime butterfly	NE	√	
Lepidoptera	Crambidae	44	*Spoladea recurvalis* (Fabricius,1775)	Beet webworm moth	NE	√	√
Lepidoptera	Sphingidae	45	*Daphnis nerii* Linnaeus, 1758	Hawk moth.	NE	√	
Diptera	Tepheritidae	46	*Bactrocera dorsalis* (Hendel, 1912)	Oriental fruit fly.	NE	√	√
Diptera	Tepheritidae	47	*Bactrocera curcubitae* (Coquillett,1849)	Melon fly	NE	√	
Diptera	Syrphidae	48	*Eristalis tenax* (Linnaeus, 1758)	Drone fly.	NE	√	
Heteroptera	Alydidae	49	*Leptocorisa oratoria* (Fabricius,1764)	Rice ear bug	NE	√	

LC - Least Concern VU -Vulnerable NT -Near Threatened NE- Not Evaluated DD- Data Deficient

1. Apis dorsata

2 .Apis mellifera scutellata

3. Apis mellifera ligustica

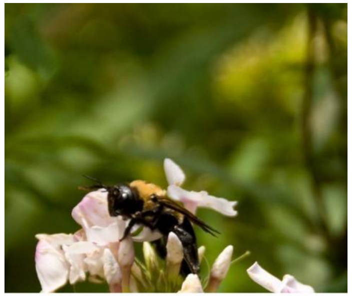
4. Apis mellifera capensis

5. Apis mellifera carnica

6. Apis florea

7. Apis andreniformis

8. Meliponula ferrunginea



9 .Bombus impatiens

Plate 1. Microphotographs of insects (Order: Hymenoptera)

10. Camponotus compressus

11. Oecophylla smaragdina

12. Crematogaster scutellaris

13. Megachile rotundata

14. Epilachna varivestis

15. Aulacophora foveicollis

16. Crioceris duodecimpunctata

Plate 2. Microphotographs of insects (Order: Coleoptera)

17. Potanthus omaha

18. Borbo cinnara

19. Pelopidas mathias

20. Tagiades gana

21. Choranthus capucinus

22. Polites vitex

23. Tirumala limniace

24. Danaus genutia

25. Junonia lemonias

Plate 3. Microphotographs of insects (Order: lepidoptera)


26. Parantica aglea


27. Euploea core


28. Danaus chrysippus


29.Neptis hylas


30. Junonia atlites


31. Eurema hecabe


32. Catopsilia florella


33. Delias eucharis


34. Phoebis philea

Plate 4. Microphotographs of insects (Order: lepidoptera)

35. Castalius rosimon

36. Talicada nyseus

37. Euchrysops cnejus

38. Jamides celeno

39. Tarucus nara

40. Pachliopta aristolochiae

41.Troides helena

42. Pailio polymnestor

43. Papilio demoleus

Plate 5. Microphotographs of insects (Order: Diptera)


44. *Spoladea recurvalis*


45. *Daphnis nerii*


46. *Bactrocera dorsalis*


47. *Bactrocera curcubitae*


48. *Eristalis tenax*


49. *Leptocorisa oratoria*

Plate 6. Microphotographs of insects (Order: Heteroptera)

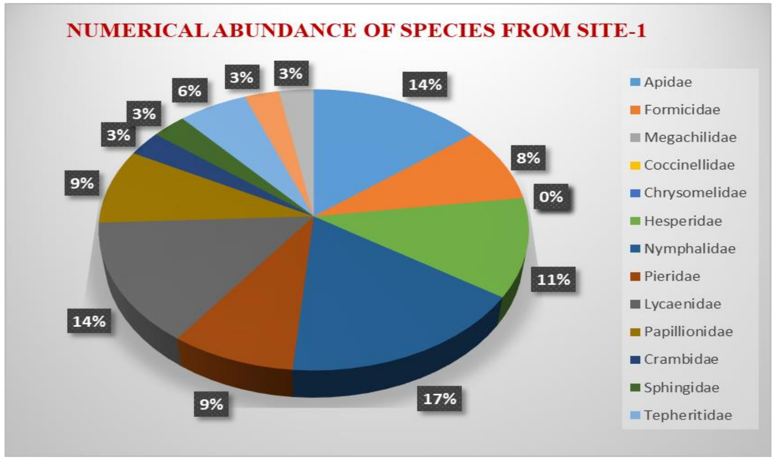


Fig. 1. Pie diagram showing the numerical abundance of pollinating insets of different families from site -1

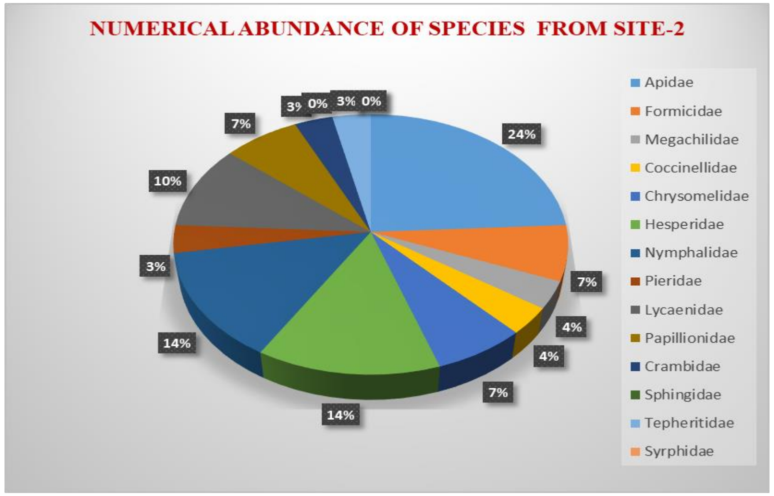


Fig. 2. Pie diagram showing the numerical abundance of pollinating insets of different families from site -2

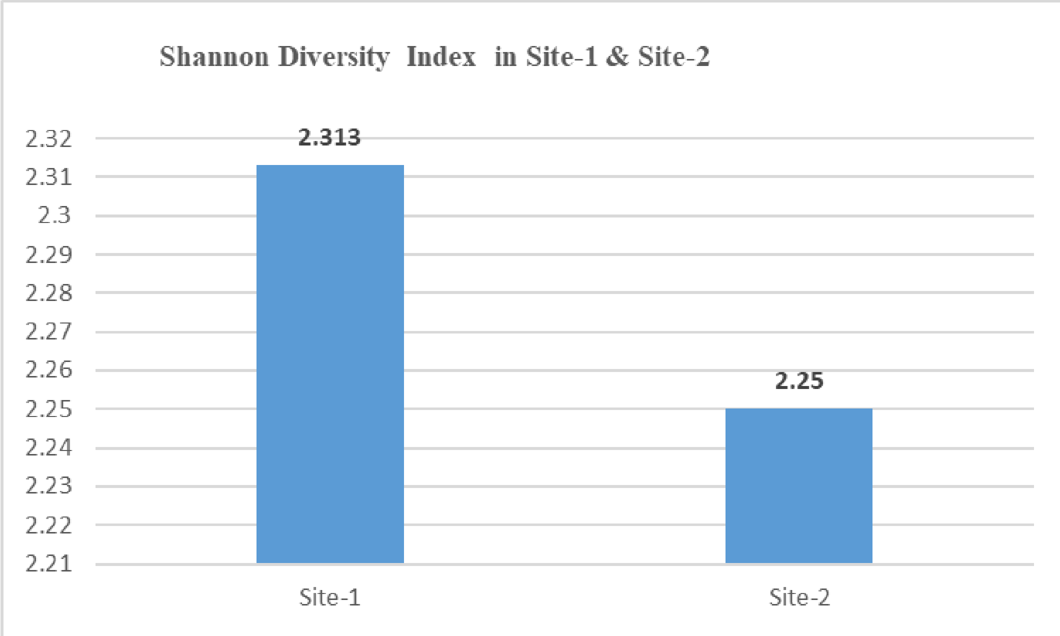


Fig. 3. Bar Diagram Showing Difference in Shannon Diversity Index

understanding the habitat and floral preferences of solitary bees is crucial for replicating natural habitats and promoting pollinator diversification within agricultural systems. Several studies have demonstrated a significant increase in crop yield resulting from enhanced pollinator assemblages in agricultural fields located near forest patches (Aizen and Feinsinger, 2003; Vergara and Badano, 2009). Restoration of fragmented forests can not only enhance pollinator diversity but also improve foraging efficiency which has a direct effect on improving fruit and seed production. (Blüthgen and Klein, 2011).

Rianti *et al.,* (2010) investigated the insect pollinators of *Jatropha curcas* (Barbados nut) and found a positive correlation between pollinator abundance and the number of flowers, leading to increased fruit and seed set production. Insect visitor diversity was highest in the morning and afternoon compared to noon. Mukherjee *et al.,* (2015) found a positive correlation between butterfly density and flower density, highlighting *Lantana camara* as an important resource for butterflies. Similarly, Siregar *et al.,* (2016) observed that higher flower density attracted more insect pollinators in rubber and oil palm plantations compared to jungle rubber. Plant–insect interactions are crucial for the pollination process and for improving yield in both wild and cultivated plants. Binu *et al.,* (2022) studied butterfly-plant diversity in the Malappuram District of Kerala and found that approximately 33 plant species, belonging to 18 families and 29 genera, were pollinated by various kinds of butterflies.

In the present study, Fig. 3 shows that both the numerical abundance of pollinators and the Diversity Index are higher at Site 1 (2.313), which is rich in a variety of flowering plants, compared to Site 2 (2.25). Pollinator insect diversity tends to be greater in areas with abundant food sources and more attractive flowers.

4. CONCLUSION

Insect pollination maintains genetic diversity in plant populations and provides benefits such as increased fruit quality and quantity, along with improved seed production and fertility, which enhances the vigor of the next generation (Kearns *et al.,* 1998; Albrecht *et al.,* 2012). It also holds significant economic value for humans by boosting the yield and health of cultivated crops, underscoring its importance for global agriculture. (Lautenbach *et al.,* 2012). Additionally, insect pollination contributes to the aesthetic and cultural value of landscapes by supporting diverse floral ecosystems (Wratten *et al.,* 2012). Several reports indicate that habitat loss, climate stress, invasive species, chemical pesticide use, competition, and starvation are major threats to pollinator populations. Conservation efforts and integrated pest management (IPM) strategies positively impact insect pollinator populations in India. However, further studies are needed to integrate practices such as public awareness programs, pollinator-friendly approaches, climate-smart agriculture, disease management, natural pest control, and reduced pesticide use.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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