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Research Article

Assessment of insect diversity in paddy fields of Uthamapalayam, Theni district, Tamil Nadu, India

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Abstract

The paddy field ecosystem is the primary habitat for insects that utilize the paddy crop as their food source from the seedlings to the harvesting phases. The diversity and abundance of insects vary in this ecosystem and the growth stages of the paddy plantation. In the present study, the insect diversity in paddy fields at Uthamapalayam, Theni district, Tamil Nadu, India were surveyed fortnight from December 2019 to February 2020. A total of 587 insects belonging to 26 species and nine orders, *viz*., Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Mantodea, Odonata, Orthoptera, and Thysanoptera were recorded. The most abundant order was Orthoptera and Coleoptera, and the least one was Thysanoptera. The diversity index represented by the Shannon-Weiner index ranged from 0.07 to 0.23, and the overall index was 1.26, and diversity evenness ranged between 0.26 and 0.42. Thus, assessing and recording insect diversity aims to build a strategic framework to monitor its biodiversity, which relies upon various factors.

Keywords: Insect diversity, paddy field, richness, diversity, evenness

Introduction

The richness of tropical insect fauna worldwide is beyond expectations, as insects are the significant components of animal diversity in terms of the number of species in most of the habitats and ecosystems (Stork, 1988). Nonetheless, only a few diversity studies consider insects (Yi et al., 2011), although they are essential components in monitoring ecosystems (Lawton et al., 1998, Losey & Vaughan, 2006). To comprehend the need and conserve biological diversity, there has been interest in evaluating the richness and diversity of the Indian entomofauna (Gadagkar et al., 1990; Muralirangan et al., 1993). Taxonomic identification of insects in diversity studies through parataxonomy and/or morphospecies is the need of the hour (Krell, 2004; Majka & Bondrup, 2006), as the biodiversity of an ecosystem is known through biological inventory, including entomofaunas.

The paddy field ecosystem is the essential natural habitat for many insects that utilize the paddy crop as their food source, from the planted seedlings to the harvested rice grains. The diversity and abundance of insects in this ecosystem vary according to abiotic and biotic factors and the growth stages of the paddy plant. Taxonomic and biological studies have been conducted on the various groups of insects found in the paddy field, including pests and non-pests of rice, those predating on the rice crop and weeds, and their parasites predators (Yano, 1978). The present study was formulated to survey the entomofauna and to evaluate the population dynamics of insects belonging to various insect order, family, genera, and species, and to calculate biodiversity indices to identify their abundance, richness, evenness, and dominance in paddy fields of Uthamapalayam, Theni district, Tamil Nadu, India.

Material and methods

Study area

Paddy fields numbering five at the bypass roads of Uthamapalayam (9.8086° N, 77.3281° E) Theni district, Tamil Nadu, India (Fig. 1) served as the study area to record the insect diversity based on the abundance of insect pests damaging the paddy fields. The study period was carried out for three months, from December 2019 to February 2020. Regular field trips were made fortnight during the period of study for the survey and collection of insects. Simultaneously, temperature and rainfall were recorded too. The collected specimens were preserved in 70% ethyl alcohol with proper labeling of locality and other details. Field record was maintained throughout the study period. The collected samples were stored in vials containing formalin and identified up to species level with taxonomic keys. Based on the taxonomy's inherent complexity, morphological characteristics were used to identify the specimens to species per family of each order. The specimens for each and everyday collection were treated separately and were put into vials for biodiversity count.

Light trap method

This technique was utilized to collect insects that are attracted to light. The light trap (50cm/0.5m diameter; and 1m height) comprised of a metal funnel with a central light source of 100w mercury lamp, with a jar containing chloroform at the base of the funnel (Fig. 2). The light trap was set at the ground in the middle of the paddy field and was run fortnight throughout the study period between 18:00 hours and 06:00 hours. The light attracted insects, which passed through the funnel and landed into the jar.

Sweep net method

Aerial and sweep nets were used for insect collection at regular intervals and immediately transferred to polythene bags. The net design in the present study was according to Noyes (1982) where the perimeter was 1.2m (about 45 inches) with a round frame. Nylon net material having very small mesh was used. The latter is a net bag composed of meshed materials with a lightweight handle used to collect flying insects, especially butterflies and dragonflies. The former is made of heavy materials such as canvas with heavier handles that can be dragged through dense vegetation to collect grasshoppers.

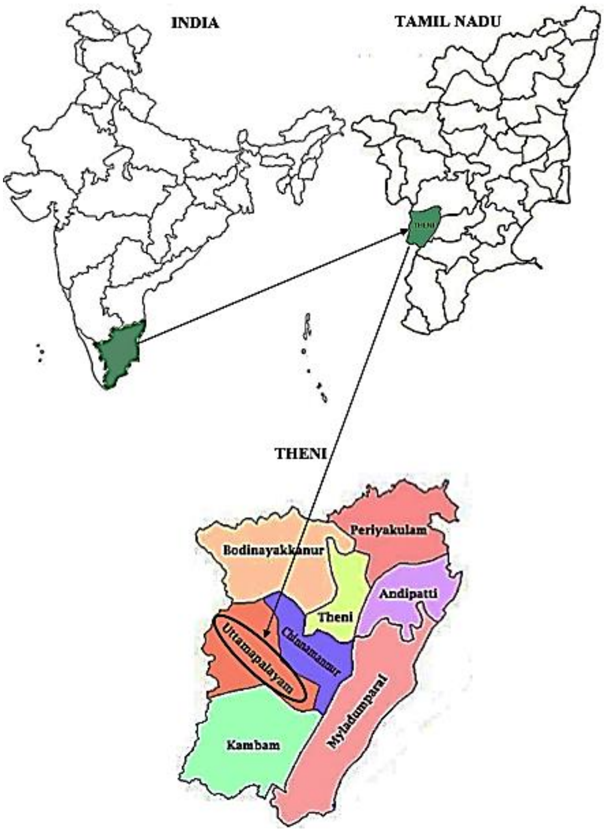

Figure 1. Map of the study area

Handpick method

This method was utilized to collect insects from leaf blades, flowers, dry leaves, and the ground stratum with fine forceps. Care was taken to ensure that no harm was caused to the insects. The ground area close to the plants was also searched. Collected insects were transferred to glass vials (5.2cm x 2.0cm).

Diversity indices

The indices for richness was represented by Hill's number species richness (Hill, 1973), Margalef (1958), and Menhinick (1964); for diversity by Brillouin, Hill (Hill, 1973), Shannon-Weiner (Shannon & Weaver, 1948), Simpson's, and species diversity; and for evenness, it was Alatalo (Alatalo, 1981), Heip (Heip, 1974; Heip & Engels, 1974), Pielou (Pielou, 1966), Sheldon (Sheldon, 1969) indices, and Shannon's evenness. Other diversity indices were worked out following Ludwig

& Reynolds (1988), *viz*., Berger-Parker dominance (%), community dominance index, Hill's number abundance (Hill, 1973), relative dominance (%), and relative frequency.

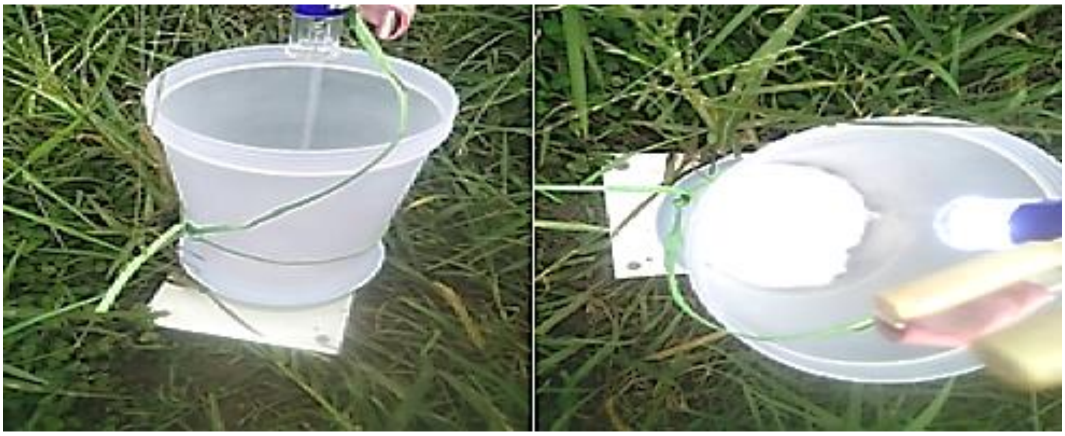

Figure 2. Light trap method

Results

A total of 587 insects belonging to 26 species and nine orders *viz*., Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Mantodea, Odonata, Orthoptera, and Thysanoptera were collected during the period of study (Table 1). Temperature and rainfall recorded during the period of study ranged from 26.5 to 27.5° C; and 113 to 245mm respectively (Fig. 3). The details of species in each order as a whole and month-wise (December 2019, January, and February 2020) are as follows. Coleopterans recorded five species with 120 individuals (50, 30, and 40). Dipterans recorded three species with 94 individuals (42, 35, and 17). Hemipterans recorded three species with 75 individuals (38, 24, and 13). Hymenopterans recorded two species and 30 individuals (7, 14, and 9). Lepidopterans recorded two species and 46 individuals (18, 16, and 12). Mantodeans recorded two species and 20 individuals (5, 8, and 7). Odonates recorded two species and 38 individuals (13, 15, and 10). Orthopterans were the most dominant order, with 145 individuals (58, 45 and 42) categorized under six species. Thysanopterans collected recorded one species and 19 individuals (4, 10, and 5). Concerning the comparative month-wise diversity, in December 2019, the most abundant order was Orthoptera, followed by Coleoptera, Diptera, Hemiptera, Lepidoptera, Odonata, Hymenoptera, and Mantodea. The least abundant order was Thysanoptera. In January 2020, it was again Orthoptera followed by Diptera, Coleoptera, Hemiptera, Lepidoptera, Odonata, Hymenoptera, Thysanoptera, and the least abundant order was Mantodea. For February 2020, the same trend followed in December 2019 (Fig. 3). The richness indices represented by Hill's number species richness, Margalef, and Menhinick, are presented in Table 2. The diversity indices were represented by Brillouin, Hill, Shannon-Weiner, Simpson's, and species diversity (Table 3). The overall Shannon-Weiner's diversity index was 1.26. Alatalo, Heip, Pielou, Shannon's evenness, and Sheldon's indices represented the present study's evenness indices (Table 4). Other indices show the Berger-Parker dominance (%), community dominance index, Hill's number abundance, relative dominance, and relative frequency (Table 5).

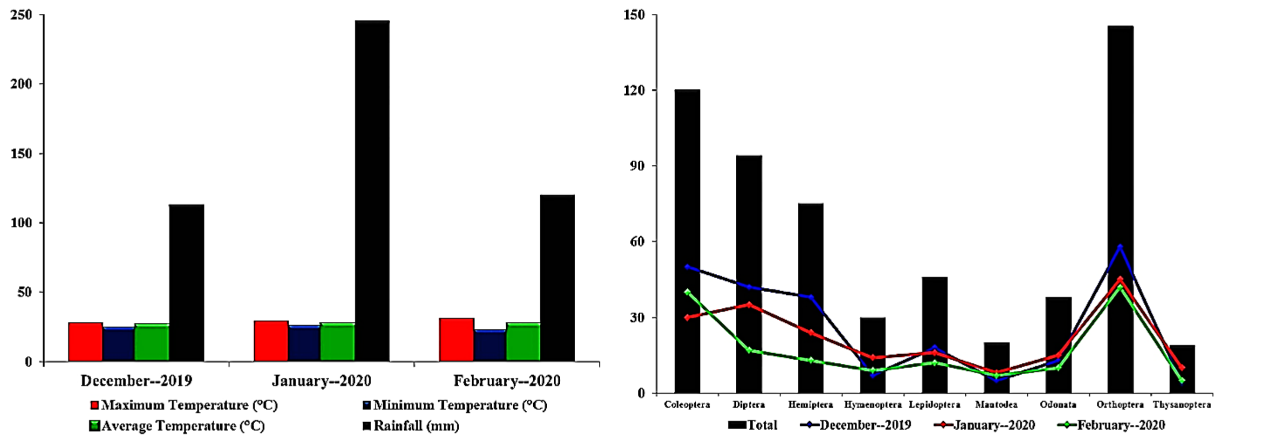

Figure 3. Environmental parameters in the study area (left); Month wise data in the study area (right)

Table 1. List of insects collected at the study area

No.	Common Name	Scientific Name	Family
Coleoptera			
1	Rice beetle	*Dyscinetus morator*	Scarabaeidae
2	Rice hispa	*Dicladispa armigera*	Chrysomelidae
3	Rice leptispa	*Leptispa pygmaea*	
4	Rice root weevil	*Echinocnemus oryzae*	Curculionidae
5		*Hydronomidus molitar*	
Diptera			
6	Rice gall midge	*Orseolia oryzae*	Cecidomyiidae
7	Rice whorl maggot	*Hydrellia philippina*	Ephydridae
8		*Hydrellia sasakii*	
Hemiptera			
9	Brown plant hopper	*Nilaparvata lugens*	Delphacidae
10	Rice ear head bug	*Leptocorisa acuta*	Alydidae
11	Rice leafhopper	*Nephotettix nigropictus*	Cicadellidae
Hymenoptera			
12	Scoliid wasp	*Campsomeriella annulata*	Scoliidae
13		*Campsomeriella collaris*	
Lepidoptera			
14	Rice leaf folder	*Cnaphalocrocis medinalis*	Crambidae
15	Rice skipper	*Pelopidas mathias*	Hesperiidae
Mantodea			
16	Asian mantis	*Hierodula patellifera*	Mantidae
17	Praying mantis	*Mantis religiosa*	
Odonata			
18	Globe skimmer	*Pantala flavescens*	Libellulidae
19	Marsh glider	*Trithemis aurora*	
Orthoptera			
20	Short-horned grasshopper	*Acrida exaltata*	Acrididae
21		*Acrotylus humbertianus*	
22		*Hieroglyphus banian*	
23		*Hieroglyphus oryzivorus*	
24		*Oxya japonica*	
25		*Oxya nitidula*	
Thysanoptera			
26	Rice thrips	*Stenchaetothrips biformis*	Thripidae

Table 2. Richness indices for the present study

Order	Hill's number species richness	Margalef's index	Menhinick's index
Coleoptera	5	1.92	0.46
Diptera	3	1.52	0.41
Hemiptera	3	1.07	0.35
Hymenoptera	2	0.68	0.37
Lepidoptera	2	0.60	0.29
Mantodea	2	0.77	0.45
Odonata	2	0.63	0.32
Orthoptera	6	2.31	0.50
Thysanoptera	1	0.76	0.44

Table 3. Diversity indices for the present study

Order	Brillouin's index	Hill's index	Shannon's index	Simpson's diversity	Species diversity index
Coleoptera	0.0006	0.06	0.12	0.04	0.008
Diptera	0.0007	0.04	0.10	0.02	0.005
Hemiptera	0.0008	0.02	0.07	0.01	0.005
Hymenoptera	0.001	0.01	0.16	0.002	0.003
Lepidoptera	0.001	0.02	0.12	0.006	0.003
Mantodea	0.001	0.01	0.23	0.001	0.003
Odonata	0.001	0.02	0.14	0.004	0.003
Orthoptera	0.0006	0.08	0.12	0.06	0.01
Thysanoptera	0.001	0.01	0.14	0.0009	0.001

Table 4. Evenness indices for the present study

Order	Alatalo's index	Heip's index	Pielou's index	Shannon's evenness	Sheldon's index
Coleoptera	0.33	0.63	0.25	0.26	0.22
Diptera	0.31	1.26	0.23	0.27	0.36
Hemiptera	0.26	1.26	0.18	0.29	0.35
Hymenoptera	0.39	2.52	0.29	0.37	0.58
Lepidoptera	0.34	2.52	0.25	0.32	0.56
Mantodea	0.47	2.52	0.33	0.42	0.62
Odonata	0.37	2.52	0.27	0.34	0.57
Orthoptera	0.33	0.50	0.25	0.25	0.21
Thysanoptera	0.37	3.52	0.26	0.42	1.15

Table 5. Other indices for the present study

Order	Berger-Parker dominance (%)	Community dominance index	Hill's number abundance	Relative dominance (%)	Relative frequency
Coleoptera	20.44	1.55	1.13	19.23	0.19
Diptera	16.01	1.32	1.11	11.53	0.16
Hemiptera	12.77	1.06	1.08	11.53	0.15
Hymenoptera	5.11	0.39	1.18	7.69	0.05
Lepidoptera	7.83	0.58	1.13	7.69	0.07
Mantodea	3.40	0.25	1.25	7.69	0.03
Odonata	6.47	0.48	1.16	7.69	0.05
Orthoptera	24.70	1.77	1.13	23.07	0.22
Thysanoptera	3.23	0.25	1.16	3.84	0.03

Discussion

Insects ecology is the scientific study of how insects, individually or as a community, interact with the surrounding environment or ecosystem since they have a wide distribution (Duane, 2006). Insects constitute a remarkably spacious group of organisms attributed mainly to their small size, which allows them to occupy niches not available to larger organisms. Insect abundance is crucial because it regulates insect communities' ecosystems (Savopoulous et al., 2012). Insects are critical natural resources in ecosystems, in addition to their role as efficient pollinators and natural/biological pest control agents (Strong et al., 1984; Buchs, 2003). Insect species are critical pointers in ecosystem management and their diversity and abundance play significant roles in the functioning of ecosystems (Rosina et al., 2014). Insects influence the nutrient and energy flow of ecosystems in many ways, most essentially as decomposers. Barbosa et al. (2005) pointed out that the distribution of the insect orders, *viz*., Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Odonata, and Orthoptera in all habitations are globally extensive in all habitats. Insect diversity accounts for a large proportion of all biodiversity on the planet. Coleopterans make up 40% of described insect species; however, entomologists suggest that dipterans and hymenopterans could be as diverse or more-so. Nevertheless, five insects' orders stand out in their levels of species richness: Coleoptera, Diptera, Hemiptera, Hymenoptera, and Lepidoptera, according to Barbosa et al. (2005), which correlated with the present study.

The distribution and abundance of insect species can be influenced by the climate, vegetation, and their interactions (Wolda, 1978). Food resources and climate conditions vary in space and time, directly affecting the diversity and distribution of insect populations (Goldsmith, 2007). Climate is one of the deciding elements in insect population fluctuations during the year (Wolda, 1978). In the tropics, there is a variation of climate conditions that can affect insects' seasonal patterns (Wolda & Fisk, 1981). One of the most critical factors in many regions is the change from the dry to the rainy season (Wolda, 1988). Other factors that influence the insect diversity, *viz*., temperature, relative humidity, wind speed, and sunshine, and its abundance depends on seasonal length, rainfall, temperature, surrounding vegetation, and agricultural practices (Pimentel & Wheeler, 1973). Weather parameters influence the entomofaunistic diversity greatly. Vijayababu et al. (2016) reported that climate change would fundamentally alter the agricultural ecosystem, leading to insect diversity changes and population levels. In the present study, insects' distribution was closely related to the type of vegetation in a particular region or habitat. Its abundance and distribution were regulated by abiotic and biotic factors and their interactions. Rainfall and temperature influence the development, reproduction, activity, and range of insect expansion. Precipitation is a crucial factor for increasing the insect population followed by temperature (Puttannavar et al., 2005). Glen (1954) reported that insects could survive during high or low temperatures during specific life cycles.

Diversity measurements such as the index of dominance, species richness, and species evenness form an integral part of the biodiversity investigation. The relation between the index of dominance and biodiversity lies in the fact that an area with low dominance indicates high diversity while that with high dominance will have less diversity (Joshi et al., 2014). Berger-Parker and community dominance indices are the measure of dominance by any one species; if any species is found to be exponentially abundant compared to the others in a community, then such species can be called dominant such a community may return high dominance index. This index reciprocal denotes an increase in the index's value accompanied by an increase in diversity and a reduction in dominance. Species richness is the oldest and the most straightforward concept of species diversity, which accounts for the number of species present in an ecosystem, community or region. It is, therefore, the base for most biodiversity assessments (Krebs, 2013). Shannon-Weiner index of diversity is considered to be the complete measure of diversity because it takes into account both the number of species and the abundance of each species during the present study in the paddy field, as it indicated a healthy environment, and the values ranged from 0.07 to 0.23, and the overall was 1.26. For Shannon-Weiner, the lower the index, the lower the diversity, whereas the higher the index, the higher the diversity, species richness, and evenness.

Similar reports were revealed by Usha and John (2015). Diversity evenness is a measure of how similar the abundance of different species/categories in a community ranged from zero to one. When evenness is close to zero, most of the individuals belong to one or a few species/categories. When the evenness is relative to one, it indicates that each species/category consists of the same number of individuals, and in the present study, the evenness ranged between 0.26 and 0.42. Similar reports were revealed by Usha and John (2015). Hill numbers show the relation between species richness indices and evenness indices (Hill, 1973). Richness indicated the number of species present in the paddy field, whereas evenness stood for each species' relative abundance in the same area (Vancaly, 1992).

It is important to note that biodiversity has a broader meaning than species diversity because it includes genetic diversity and ecosystem diversity. Nevertheless, species diversity is a large part of the focus of biodiversity. The quantity of various species inside a geographical region relies upon migration and adaptation to environmental conditions and how they modify the environment (Groombridge & Jenkins, 2002). Species diversity is a parameter of community structure involving species richness and their abundance for the given taxa (Wang et al., 2000) and that the reduction in species richness could be caused by the loss of a rare species and the reason for a decline in species diversity could be the increased dominance of one species (Price, 1984). Henceforth, species diversity and complexity of association among species are essential to the community's stability (Van Emden & Williams, 1974). Biological communities have a degree of organization represented by their specific abundance distribution or relative frequency of the environment's species. The biological diversity in one biological community possesses two components: species richness (existing species number) and homogeneity, which depends on the larger or smaller uniformity of the distribution frequency of extant species (Hurlbert, 1971). The importance of diversity indices is their application in monitoring studies of biological communities' dynamics and structural change detection when the community environment is modified, and the species have to adapt to the modifications to contribute to the conservation of biodiversity in agriculture ecosystems (Southwood, 1995).

Conclusion

Insect diversity represents their adaptability to a wide range of environmental conditions, and their dominance influences the structure of their community. Thus, evaluating and recording its diversity intends to develop a strategic framework for foreseeing key species' behavior to monitor its biodiversity that relies upon various factors. Further, this study can be an eye-opener to identify the potential pests of paddy and their seasonal abundance and provide adequate information that would be of incredible assistance to anticipate effective administration procedures that can be embraced by paddy cultivators Uthamapalayam of Theni district, Tamil Nadu, India.

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