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Diversity analysis of nocturnal lepidopteran insect fauna in rice eco-systems of district Jabalpur, Madhya Pradesh, India

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Abstract

Present study was conducted in district Jabalpur, Madhya Pradesh during the *kharif* season of year 2015 and 2016. Study was in special reference to insect diversity, species richness, abundance, evenness and similarity in two distinct and distant rice ecosystems -Farmer's Field in Panagar and Research Field in JNKVV Jabalpur. Farmer's Field was less disturbed area where farmers followed the traditional agricultural practices while Research Field was highly disturbed where high input intensive agricultural practices were followed. The insect diversity, species richness, abundance, evenness and similarity was found higher in Farmers's Field as compare to that in the Research Field. Study revealed that low input farming with minimum disturbance of eco-systems may be helpful to keep the natural balance of insect pests in nature.

Keywords: Insect diversity, rice, light trap, lepidoptera, eco-system

Introduction

Rice (*Oryza sativa*) is the staple food for half of the present of the world population [1]. Majority of the rice cultivation area in the world are also poverty stricken area [2]. Pesticide consumption in rice production continues to increase [3]. Incidence of pesticide toxicity to field workers and farmers [4] in rice field is widely acknowledged. Pesticide residue [5] and loss of bio-diversity [6] is a serious issue debated worldwide.

Rice is cultivated in 160 mha in the world [1]. In India it occupies an area of 43.1 mha [7]. Madhya Pradesh (MP) is an important rice growing Indian state with an acreage of 2.02 mha [8]. Rice is cultivated in eastern part of MP [9], which is predominantly tribal districts and rainfed. Assured minimum support price [8] and fodder for cattle [10] are the main attraction towards rice cultivation in bunded, unbunded, light and heavy fields in the state.

Status of minor insect pests of rice attaining major status [11] is an ecological warning, which needs to be seriously viewed. Elimination of insects from the ecosystem and natural replacement with lesser known insect is noticed [12] in recent times. Loss of natural enemies [13] that once kept insect pests under check is evident by yield loss [14] and economic distress due to increase input cost of pesticides applications.

About 800 insects species [15] are associated with rice ecosystem. Not all are detrimental [16] neither all are beneficial [17]. There are many insects that serves numerous environmental service [15]. There is insect diversity in rice field in various Agro-climatic Zones in India [18]. At ground level, there are different ecosystems and even rice eco-systems to be precise. Needless to mention here, that the insect biodiversity in irrigated rice eco-system is different [19] from that in rainfed rice eco-system [20]. Understanding of such diversified production ecosystems [21] and insect diversity in a climatic changing world [22] is very important. The present research is an effort to evaluate the present insect biodiversity in the rice ecosystems of Jabalpur.

Materials and Methods

Location

The present research work was carried during two cropping seasons of rice i.e. *Kharif* of 2015 and 2016 in Jabalpur district, MP. The climatic conditions prevalent in Jabalpur are essentially semi-arid and sub-tropical. The district is situated between 23.10°N – 79°57′E latitude and

23.17º N – 79.95ºE longitude, at an altitude of 411.78 m above the mean sea level. The annual rainfall varied from 1300 to 1400 mm with an average of 1350 mm. Ninety per cent of the total rainfall was received during June to September and the rest during October to January.
The research work was carried out at two distinct locations ie. Farmer's Field (FF) and Research Field (RF).

a. FF located in village- Jatwa, Panagar block of district Jabalpur was 12 kilometre away from the RF. The farmer followed the traditional cultivation practices. No use of insecticides, less use of fertilizers, minimum intercultural operation with limited irrigation. Rice-wheat cropping system was also followed in black soil. The farmer's field was surrounded by dense vegetation and illumination was less due to no light on the road of the village.
b. RF was located in the JNKVV campus. Breeder seed production is carried out in almost all the field of JNKVV, except research plots. Use of fertilizers, intercultural operations, weedicides and insecticides are a regular feature in these fields. Soil is black and irrigated, Rice-wheat cropping system is practiced. Research Field located in semi-urban area where light illumination due to street light during night was comparatively more than FF.

Insect collection

a. Jawahar light trap: Insects were collected by "Jawahar light trap" designed and developed by JNKVV, Jabalpur. Light trap was fitted with mercury vapour lamp (80 W) as light source. Dichlorvos 76 EC (fumigating agent) was placed in the collection tray to kill the trapped insects in the collection chamber. Two separate light traps were used for the study. One was placed in FF and while the other in RF. The traps were installed on the centre of the rice field on a board bund near the electric pole. The trap was operated by switching 'On' the power to illuminate the 80 W mercury bulb, daily from 6 pm to 6 am.

b. Collection and shorting of insects: Every morning the insects trapped in the collection chamber of the trap was collected by removing the collection tray. The insects from the collection tray were transferred to the specially procured plastic box with lid. The plastic box was carefully brought to the laboratory in the Department of Entomology, College of Agriculture, Jabalpur. The insects in the plastic box were emptied on the white sheet of paper spread on a galvanised tray. The tray was kept for 45 minutes in open space for lessening the fumigant effect and drying of insect specimen. After 45 minutes the insects collected and spread on the tray were subjected to sorting, counting, setting and identification. Daily observations were recorded throughout the *kharif* season of 2015 and 2016. Identification of insects were done by comparing with the specimens available in the Insect museum of the Department of Entomology, JNKVV, Jabalpur, with the help of experts in the Department of Entomology, University of Agricultural Science, Bangalore, Zoological Survey of India, Jabalpur, as with the help of published research papers and by following the Key developed by different scientists.

Diversity analysis

a. Biodiversity diversity index was calculated using the Shannon – Wiener diversity index (H) (1949)

$$H = - \sum pi\ Inpi$$

where pi = S / N, S is the total number of individuals of one species, N is the total number of all individuals in the sample and In = logarithm to base e

b. Species richness of insect was calculated using the Margalef index (D)

$$D = \frac{(S - 1)}{\ln N}$$

where S is the total number of species, N is the total number of individuals in the sample and ln is the logarithm to base e.

c. Evenness was calculated by using the Pielou's evenness index (E) by the formula

$$E = \frac{H}{\ln S}$$

where H is the Shannon-Wiener diversity index and S is the total number of species in the sample.

d. Simpson index (D) was used to determinerarity (diversity) information of species present on the sites by the formula.

$$D = \frac{\sum ni\ (ni-1)}{N\ (N-1)}$$

where ni is the total number of organisms of each individuals species and N is the total number of organisms of all species.

e. Sorensen similarity index was used to measures similarity in species composition for two sites, FF and RF by the equation.

$$C_s = \frac{2ab}{a + b}$$

where C_s is the coefficient of similarity, a is the number of species found in site A, b is the number of species present in site B and ab is the number of species shared by two sites.

f. Comparison between FF and RF communities based on the mean number of insect species was done using independent sample *t* – test. Significance was assessed at 0.05.

Results and Discussion

In FF, Lepidoptera was represented by 66 species and 13 families. Family Erebidae was the predominant and represented by 20 species followed by Sphingidae (12 species), Noctuidae (9 species), Crambidae (8 species), Geometridae (5 species), Eupterotidae (3 species), and Nolidae (2 species). Families Lasiocampidae, Saturniidae, Hyblaeidae, Derpanidae, Pieridae and Nymphalidae were represented by one species each. In RF, it was represented by 55 species and 12 families. Erebidae was the predominant family represented by 20 species followed by Sphingidae (8 species), Crambidae (7 species), Noctuidae (6 species), Geometridae (4 species), Eupterotidae (3 species), Lesiocampidae (2 species). Families Saturniidae, Hyblaeidae, Ypnomeutidae, Pieridae and Nymphalidae were represented by one species each (Table 1). In comparison to that in FF, RF was represented by just 55 species and 12 families. The reduction in the insect species was 16.7% while that of families was 20%. Pieridae and Nymphalidae butterfly families, and rest belonged to moth families which were collected in light trap. Most abundant groups of insect in both FF and RF were Erebidae (6222 and 4882 insects), Crambidae (4193 and 4712 insects) and Noctuidae (1489 and 2132 insects). The least abundant insect families in FF Lasiocampidae (2 insects), Pieridae (5 insects) and Derpanidae (7 insects) while in that RF it was Pieridae (2 insects), Saturniidae (3 insects) and Ypnomeutidae (11 insects) (Table 2). Family Erebidae (2.208), Sphingidae (1.911), Geometridae (1.249), Noctuidae (1.311), Nolidae (1.911) and Eupterotidae (1.001) had higher Shannon-Wiener index value in FF as compared to RF.

In RF only family Crambidae (0.984) and Lasiocampidae (0.579) showed high Shannon-Wiener index value as compared to FF. Five families ie. Sphingidae (1.831), Crambidae (0.839), Geometridae (0.846), Noctuidae (1.095), Nolidae (0.549) had high Margalef index value in FF, while only three familes ie. Erebidae (2.237), Eupterotidae (0.494) and Lasiocampidae (0.369) had high Margalef index value in RF. Sorensen similarity index was highest (100%) in family Erebidae, Eupterotidae, Saturniidae, Hyblaeidae, Pieridae and Nymphalidae (Table 2) followed by Crambidae (93%), Geometridae (88%), Sphingidae (80%), Noctuidae (80%) and Lasiocampidae (66%). A significant difference in the mean number of species between FF and RF was only in family Nolidae ($p<0.05$) and non-significant in rest of the families (Table 3).

FF had high species numbers (66) and family (13) in comparison to RF that was 55 insect's species and 12 families. Erebidae, Sphingidae, Geometridae, Noctuidae, Nolidae and Eupterotidae had high Shannon-Wiener index value in FF, while in RF that was only in family Crambidae and Lasiocampidae. Thus these six families had high diversity in FF, while it was only in two families in RF. Families Sphingidae, Crambidae, Geometridae, Noctuidae, Nolidae had high Margalef index value in FF, while it was in family Erebidae, Eupterotidae and Lasiocampidae in FF. Margalef index is the indicators of species richness. Margalef analysis revealed that five families had high species richness in FF and three families had high species richness in RF. A comparison of mean number of insect species between FF and RF within insect families indicated that the two communities differed significantly in some order. Ovawanda *et al* (2016) found that the organic rice farming ecosystem can increase species richness, species evenness and heterogeneity of insects. Dinesh *et al* (2018) studied the ecology of birds and insects in inorganic and organic rice ecosystem, with special reference to the species abundance, diversity, richness, evenness and similarity indices and found that organic cultivation supports bird diversity and beneficial insects. Maximum diversity, species richness, evenness and abundance of insect species was reported in low input area in Pakistan [25]. In comparison to the organic plantation, there was negative effect on butterfly and ground insect species diversity (Shannon index) and evenness (Shannon evenness index) in pesticide treated plantation [26]. The difference in diversity, species richness, abundance and mean number of insect species between two distinct ecosystems in the present study is on agreement with earlier reports may be due to intensive agricultural practices. Butterflies and moths are valuable indicators of environmental quality, considering their high degree of host-plant specialisation and vulnerability to habitat deterioration [27]. Numerous reports revealed that the combined removal of weeds and trees in intensive agricultural settings lead the decline of moth species due to removal of overwintering larvae [28, 29, 30, 31]. Intensive agriculture implies the systematic and widespread use of chemicals pesticides among others as it directly affects a considerable proportion of insect species [32, 33]. Least disturbances to ecosystem promote the species richness [34]. Organic folk rice webs tend to have greater mean species richness, predator diversity and predator-pest ratio [35]. Ovawanda *et al* (2016) also reported high species richness (22 to 33 species) in the organic rice field. The above findings confirms with the present findings in terms of more insect species richness in FF than RF. In RF disturbance in the ecosystem due to intensive agricultural practices lead to less number of insect fauna.

Table 1: Checklist of family, species and abundance of insect collected in light trap in rice ecosystems (farmer field and research field) during *kharif* 2015 and 2016

S. No.	Insect species collected	Number of insects collected in light trap	
		FF	RF
Order- Lepidoptera			
A. Family – Erebidae (20)			
1	*Utetheisa pulchella* (Linnaeus, 1758)	55	92
2	*Asota caricae* (Fabricius, 1775)	808	767
3	*Trigonodes hyppasia* (Cramer, 1779)	18	34
4	*Grammodes geometrica* (Fabraicius, 1775)	16	12
5	*Asota ficus* Fabricius, 1775	70	161
6	*Creatonotos gangis* (Linnaeus, 1763)	955	1134
7	*Euproctis similis* (Füssli,1775)	201	250
8	*Psalis pennatula* (Fabricius, 1793)	107	58
9	*Mocis undata* (Fabricius, 1775)	18	6
10	*Anomis fulvida* Guenée, 1852	12	21
11	*Digama hearseyana similis* Moore 1878	60	40
12	*Ophiusa trihaca* Cramer, 1780	6	3
13	*Perina nuda* Fabricus, 1787	85	46
14	*Pericyma crugeri* Butler. 1886	13	3

15	*Amata cyssea* (Cramer, 1782)	2312	778
16	*Lymantria sp.*	6	4
17	*Amerila astrea* Drury, 1773	36	46
18	*Spilarctia oblique* (Walker, 1855)	485	523
19	*Amsacta moorei* Butler, 1876	22	17
20	*Spalartica sp.*	937	887
B. Family – Sphingidae (12)			
21	*Polyptychus dentatus* (Cramer, 1777)	4	0
22	*Theretra Nessus* (Drury, 1773)	113	12
23	*Theretra gnoma* (Fabricius, 1775)	6	0
24	*Agrius convolvuli* (Linnaeus, 1758)	97	22
25	*Acherontia styx* Westwood, 1847	22	8
26	*Daphnis nerii* (Linnaeus, 1758)	18	6
27	*Theretra alecto,* (Linnaeus, 1758)	22	4
28	*Hippotion boerhaviae,* (Fabricius, 1775)	10	2
29	*Theretra oldenlandiae* (Fabricius, 1775)	88	76
30	*Nephele didyma* (Fabricius, 1775)	17	4
31	*Psilogramma menephron* (Cramer, 1780)	3	0
32	*Macroglossum belis* (Linnaeus, 1758)	6	0
C. Family – Crambidae (8)			
33	*Cnaphalocrocis medinalis,* (Guenee, 1854)	288	533
34	*Chilo partellus* (Swinhoe, 1885)	74	70
35	*Palpita vitrealis* (Rossi, 1794)	25	9
36	*Pygospila tyres* (Cramer, 1780)	6	0
37	*Spoladea recurvalis* (Fabricius, 1775)	3600	2896
38	*Scirpophaga incertula* (Walker, 1863)	162	1180
39	*Agathodes ostentalis* Guenee, 1852	12	11
40	*Sameodes cancellais* Zeller, 1852	26	13
D. Family – Geometridae (5)			
41	*Ascotis selenaria* Schiffermuller, 1775	28	9
42	*Hyposidra talaca* Walker, 1860	4	0
43	*Thalassodes quadraria* Guenee, 1852	26	18
44	*Biston suppressaria* (Guenee, 1858)	52	7
45	*Hyposidra sp.*	3	1
E. Family – Noctuidae (9)			
46	*Bastilla crameri* (Moore, 1885)	4	0
47	*Spodoptera litura* (Fabricius, 1775)	125	130
48	*Helicoverpa armigera* (Hübner, [1808])	87	132
49	*Chrysodeixis chalcites* (Esper,1789)	804	533
50	*Mythimna separata* Walker, 1865	368	1277
51	*Agrotis ipsilon* (Hufnagel, 1766)	6	0
52	*Anomis fulvida* Guenèe, 1852	21	12
53	*Calesia stillifera* Felder & Rogenhofer 1874	10	0
54	*Thysanoplusia orichalcea* (Fabricius, 1775)	64	48
F. Family – Nolidae (3)			
55	*Earias vittella* Fabricius 1794	6	0
56	*Carea angulata* Fabricius, 1793	15	0
57	*Xanthodes intersepta* Guenee, 1852	8	0
G. Family – Eupterotidae (3)			
58	*Eupterote lineosa* Walker, 1855	30	29
59	*Eupterote fabia* (Cramer, 1780)	10	9
60	*Eupterote sp.*	30	19
H. Family – Lasiocampidae (2)			
61	*Trabala vishnou* (Lefèbvre, 1827)	2	11
62	*Gastropacha pardale* Walker, 1855	0	4
I. Family –Saturniidae (1)			
63	*Antheraea paphia,* Linnaeus, 1758	6	3
J. Family – Hyblaeidae (1)			
64	*Hyblaea puera* (Cramer, 1777)	1061	1286
K. Family – Derpanidae (1)			
65	*Cyclidia substigmaria* Hubner, 1825	7	0
L. Family – Ypnomeutidae (1)			

66	*Atteva fabriciella* Swederus, 1787	0	11
M. Family – Pieridae (1)			
67	*Catopsilia pyranthe* Linnaeus, 1758	5	2
N. Family – Nymphalidae (1)			
68	*Melanitis leda ismene* (Linnaeus, 1758)	358	952

Table 2: Comparison of insect diversity from FF and RF communities based on different diversity parameters

Name of family	No of species		Abundance		Shannon index		Margalef index		Evenness		Simpson index		Sorensen Similarity index
	FF	RF	FF	RF	FF	RF	FF	RF	FF	RF	FF	RF	
Erebidae	20	20	6222	4882	2.208	2.059	2.175	2.237	0.737	0.687	0.209	0.152	1
Sphingidae	12	8	406	134	1.911	1.398	1.831	1.429	0.769	0.672	0.190	0.359	0.8
Crambidae	8	7	4193	4712	0.595	0.984	0.839	0.709	0.286	0.505	0.743	0.453	0.933
Geometridae	5	4	113	35	1.249	1.111	0.846	0.843	0.776	0.801	0.322	0.352	0.888
Noctuidae	9	6	1489	2132	1.311	1.103	1.095	0.652	0.596	0.615	0.364	0.429	0.8
Nolidae	3	0	29	0	1.019	0	0.594	0	0.928	0	0.364	0	0
Eupterotidae	3	3	70	57	1.001	0.998	0.470	0.494	0.911	0.908	0.378	0.383	1
Lasiocampidae	1	2	2	15	0	0.579	0	0.369	0	0.835	1	0.580	0.666
Saturniidae	1	1	6	3	0	0	0	0	0	0	1	1	1
Hyblaeidae	1	1	1061	1286	0	0	0	0	0	0	1	1	1
Derpanidae	1	0	7	0	0	0	0	0	0	0	1	1	0
Ypnomeutidae	0	1	0	11	0	0	0	0	0	0	1	1	0
Pieridae	1	1	5	2	0	0	0	0	0	0	1	1	1
Nymphalidae	1	1	358	952	0	0	0	0	0	0	1	1	1

Table 3: Comparison between FF and RF communities based on the mean number of insect species

Name of family	No of species		Mean		Standard Deviation		Error		t -value	p - value
	FF	RF	cc	RF	FF	RF	FF	RF		
Erebidae	20	20	311.1	244.1	569.46	369.55	127.33	80.39	0.445	0.33NS
Sphingidae	12	8	33.83	16.75	40.41	21.41	11.66	6.18	1.717	0.05NS
Crambidae	8	7	524.12	673.14	1246.62	1020.72	440.74	360.88	0.914	0.19NS
Geometridae	5	4	22.6	8.75	20.21	7.24	9.04	3.24	1.624	0.08NS
Noctuidae	9	6	165.44	355.33	265.37	425.22	88.45	141.74	-0.428	0.34NS
Nolidae	3	0	9.66	0	4.72	0	2.72	0	3.54	0.01*
Eupterotidae	3	3	23.33	19	11.54	19	6.66	5.77	0.49	0.32NS
Lasiocampidae	1	2	2	7.5	1.41	4..94	1	3.5	-1.786	0.16NS
Saturniidae	1	1	6	3	4.24	2.12	3	1.5	0.447	0.36NS
Hyblaeidae	1	1	1061	1286	750.24	909.33	530.50	643	-0.135	0.45NS
Derpanidae	1	0	7	0	4.94	0	3.50	0	1	0.25NS
Ypnomeutidae	0	1	0	11	0	7.77	0	5.50	-1	0.25NS
Pieridae	1	1	5	2	3.53	1.41	2.5	1	0.55	0.33NS
Nymphalidae	1	1	358	952	253.14	673.16	179	476	-0.584	0.33NS

Conclusion

There was high insect diversity, species richness and abundance in FF in comparison to that in RF. Numbers of species found were more in FF, than RF where high input intensive crop production was practiced. Low input farming with minimum disturbance of eco-systems may be helpful to keep the natural balance of insect pests in nature.

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