RESEARCH ARTICLE

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Spatial Insect Biodiversity and Community Analysis in Selected Rice Fields of North Bihar

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ABSTRACT

Rice is a major food crop of India. The rice cultivation has maintained its priority status in the agricultural sector of the country. The intensive management practices adopted by the practitioners have resulted in genetic erosion, thus affecting the species composition of the rice field ecosystems. There is obvious difference in species composition and community structure in upland and lowland rice fields and lowland fields has minimum pests affecting production of yield per hectare. This paper presents a work carried out on the biological diversity of lowland rice field ecosystems of India, and proposes the need for conservation strategies to ensure the sustainability of these rice growing ecosystems in the long run.
***Key words**: Aquatic insect, Rice field ecosystem, biodiversity, community analysis*

INTRODUCTION

The rice fields in India fall into three major categories based on the water regime as under major irrigation schemes, minor irrigation schemes and rainfed. The majority of rice fields in the wet zone are rainfed, while the ones in the intermediate and dry zones are irrigated, by minor or major irrigation schemes. Most of the irrigated rice fields are usually successors of shallow marshes or a lowland area that can be supplied with adequate water (Fernando, 1993). They are characterized by the presence of a standing water body, which is temporary and seasonal. Hence, scientists have viewed flooded rice fields as agronomically managed marshes (Fernando, 1996), or a type of freshwater marsh with a cultivated grass (Odum, 1977). Temporary fresh waters are generally defined as bodies of fresh water that experience a recurrent dry phase of varying length that is sometimes predictable in both its time of onset and duration (Williams, 1996). Therefore, rice fields, being temporary aquatic habitats with a generally predictable dry phase, can be scientifically defined as an agronomically managed temporary wetland ecosystem (Bambaradeniya, 2000). They are temporary and seasonal aquatic habitats, managed with a variable degree of intensity (Halwart, 1994).

The ecosystem diversity of rice field is due to the variation of the environmental conditions and management conditions. The rice field biodiversity is usually synonymous to species diversity due to the easiness of assessment of the species category, which is also identified as insect pests, weeds, natural enemies and neutral forms. Bambaradeniya, *et al.,* (2004) reported 494 species of invertebrates belonging to 10 phyla, 103 species of vertebrates, 89 species of macrophytes, 39 genera of microphytes and 3 species of macrofungi from an irrigated rice field ecosystem in India. The aquatic organisms found in the rice fields of India covers the entire spectrum of fresh water invertebrates, and that arthropods are the main terrestrial faunal species. About 130 species of phytophagous insects have been recorded in rice fields. More than 50% of the terrestrial arthropod species in rice fields consisted of predators, with spiders being the dominant predatory group. About 103 species of vertebrates recorded from an irrigated rice field ecosystem in India.

The conservation of rainfed rice field biodiversity needs an integrated approach that includes ecosystem, species, genetic and cultural aspects. The survey on biodiversity in such ecosystem contributes to sustain a rich biodiversity. This paper is also a effort to investigate aquatic insect diversity in rice field for further conservation policies that would help minimizing the loss of biodiversity due to human and other activities in the future.

METHODS AND MATERIALS

The insect biodiversity was calculated using the Shannon-Weaver and Simpson's diversity indices and Hill's diversity numbers (Shannon and Weaver, 1949; Simpson, 1949; Hill, 1973) along with various multivariate analyses which are described as:

Shannon-Weaver diversity index (H) was used to determine which sample has more abundant species. A species diversity study takes into account the number of species (species richness) and the importance of individuals in species (evenness) (Vandermeer, 1981). Shannon's index accounts for both abundance and evenness of the species present. The proportion of species *i* relative to the total number of species (p_i) was calculated, and then multiplied by the natural logarithm of this proportion ($\ln p_i$). The resulting product was summed across species, and multiplied by-1. H is a more reliable measure as sampling size increases. The addition of the calculation of evenness (J) or equitability (*EH*) was also applied.

Shannon's equitability (EH) was calculated by dividing H by H*max* (here H*max* = lnS). $J=EH=H/H_{max}=H/\ln S$

The evenness index measures how evenly species are distributed in a sample. When all species in a sample are equally abundant an evenness index will be at its maximum, decreasing towards zero as the relative abundance of the species diverges away from evenness (Sebastian *et al.*, 2005). It means evenness assumes a value between 0 and 1with 1 being complete evenness i.e., a situation in which all species are equally abundant.

Simpson's diversity index (D) was used to determine which sample has more rare species. It is a simple mathematical measure that characterizes species diversity (rarity) in a community as-

$$S=(1-D) = 1 - \sum[\ n_i\,(n_i-1)/\ N\,(N-1)]$$

where pi is the proportional abundance of the ith species and is given by $p_i = n_i/N$, i= 1,2,3, …….S and n_i is the number of individuals of i^{th} species and N is the known total number of individuals for all S species in the population. Simpson's index varies from 0 to 1 and gives the probability that two individuals drawn at random from an infinitely large population belong to the different species. For a given species richness (S), eveness (J) increases as D decreases, and for a given eveness, D decreases as richness increases.

Hill's diversity numbers in order to represent number of abundant species in samples and also to represent species maximum in abundance Hill's diversity numbers were used. In equation form, Hill's diversity numbers are

$$H_\alpha = (\sum p_i^\alpha)^{1/(1-\alpha)}$$

Where, pi is the proportion of individuals belonging to ith species. Hill shows that the 0th, 1st and 2nd order of these diversity numbers (i.e., A=0, 1 and 2) coincide with three of the most important measures of diversity. Hills diversity numbers are Number 0: N_0=S, where S is the total number of species, so, N_0 is the number of all species in the sample regardless of their abundance, Number 1: N_1=eH, where H is the Shannon's index and N_1 is the measure of number of abundant species in the sample. N_1 will always be intermediate betweenN_0 and N_2, and Number 2: $N_2=1/\lambda$, where λ is Simpson's index and N_2 is the number of species maximum in abundance in a sample.

The estimated species richness was calculated to determine whether the sampling sites had been sufficiently sampled or not. To calculate the estimated number of species the procedure laid out by Chao was followed.

RESULTS AND OBSERVATIONS

The values of various diversity components for various insect orders are given in table 2. It is clear that in case of Coleoptera the values of S, N, H, D & J were 103, 26069, 3.082, 0.0962 and 0.619 respectively. The (H) value indicated that Coleoptera had less number of abundant species (N1=21) in which 10 were maximum in abundance (N2). The lower value of J indicated that species in Coleoptera were distributed with a low (62%) eveness with dominance of few species among which *Psammobius* sp. and *Berosus* sp.1 occurred maximum in abundance. Due to a lower evenness the rarity (D) was high (Table 1, Fig. 1).

Table 1: Diversity of insect orders

Insect Order	S	N	H	D	J	N1	N2
Coleoptera	103	26069	3.082	0.096	0.619	21	10
Diptera	64	6533	3.357	0.056	0.800	28	17
Hemiptera	58	4112	2.464	0.148	0.607	11	06
Collembola	13	9071	1.282	0.290	0.925	3	3
Trichoptera	9	6212	1.280	0.288	0.920	3	3
Odonata	16	3448	1.960	0.240	0.708	7	4
Ephereroptera	02	194	0.479	0.697	0.692	1	1

Where, S=Species richness, N=Species abundance, H=Shannon's index, D=Simson's index, J=Evenness, N1 & N2=Hill'snumbers of diversity (N1=Number of abundant species & N2=Number of species maximum in abundance.

For Diptera the values of S, N, H, D & J were 64, 6533, 3.357, 0.056 and 0.800 respectively. In this case the value of (H) was more than that for Coleoptera. This showed that in Diptera, number of abundant species (N1=28) was high than for Coleoptera. Among these species 17 species were maximum in abundance (N2). But a lower value of (D) indicated that number of rare species was less than that of Coleoptera. Due to this low rarity the species were distributed with high evenness of about 81% with 19% dominance of *Anopheles subpictis* and *Chironomid* species (Table 1, Fig. 1).

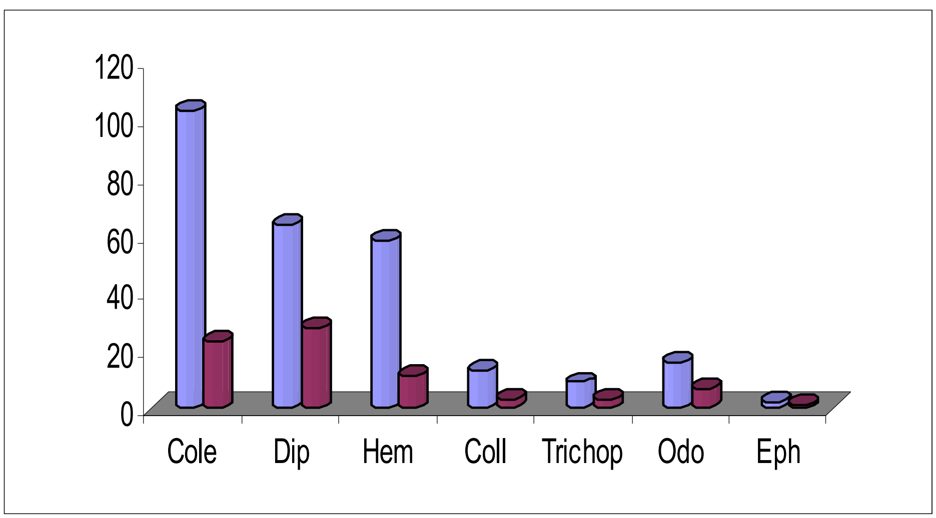

Fig. 1: Comparison of (a) insect species richness and (b) abundance of various insect orders: Cole (Coleptera), Dip(Diptera), Hem(Hemiptera), Odo(Odonata), Coll(Collembola), Trichop(Trichoptera) and Eph(Ephemeroptera).

Hemiptera is also one of the most important insect orders because its member species include not only rice pest but predators of rice pest insects as well. The values of S, N, H, D & J were 58, 4112, 2.464, 0.148 and 0.607 respectively. The low value of (H) as compared to Diptera indicated that there were less number of abundant species (N1=11). Among these abundant species 6 species (N2) were maximum in abundance. A high value of (D) explained presence of rare species in enormous quantity in comparison with Diptera. Due to presence of more number of rare species value of (J) also reduced which illustrated that species were distributed with low evenness of about 61% evenness and with the dominance of *Callicorixa* sp., *Micronecta* sp. and *Corixa* sp. in which all are predatory species (Table 1, Fig. 1).

Odonata is the insect orders whose all members are well known predators in both of naiads and adult stages of their life cycles (Benke, 1976). The values of S, N, H, D & J were 16, 3448, 1.9649, 0.2428 & 0.7087 respectively. Here, the low value of (H) in comparison with Orthoptera indicated that it had less number of abundant species (N1=7) in which only 4 species were maximum in abundance (N2). On the other hand high value of (D) showed that there was high number of rare species. This high rarity lowered the value of (J) which indicated that the species were distributed with a comparatively low evenness of about 71% (as compared to Orthoptera) with dominance of *Agriocnemis* sp. along with *Agriocnemis pygmaea* and *Agriocnemis femina femina* (Table 1, Fig. 1).

Trichoptera is the insect order which all members are morphologically related to Lepidopteran insects. The values of S, N, H, D and J were 13, 9071, 1.282, 0.290 and 0.925 respectively. The lower value of (H) in respect to Hemiptera indicated that it contains less number of abundant species. There was high number of rare species (Table 1, Fig. 1).

Ephemeroptera consisted of only one species and hence the diversity analysis was not possible (Table 1, Fig. 1).

DISCUSSIONS

As biodiversity in an area is based on both the number of individuals (abundance) and the number of species present (Jana, *et al*., 2006). The results show that among three districts, Site 3 had greater values for species richness and abundance as compared to other sites leading to propagate a diverse insect fauna besides supporting a high number of rare species as compared to Site 2 and Site 1. The differences of the diversity between the Site 1 and Site 2 and of Site 2 and Site 3 were statistically non-significant. Overall species richness and abundance in Site 1 was less and in Site 3 was high whereas Site 2 lied in between the two sites as for as its role in supporting insect diversity (species richness and abundance) was concerned. The reason for high diversity in Site 3 is due to the facts that it was less developed (fewer industries having less industrial emissions and less land fragmentation due to housing societies and other infrastructure) as compared to Site 1 and Site 2.

The rich biodiversity associated with the rice field agro-ecosystems could be compatible with conservation objectives and meets the requirements/interests/emphases of agroecologists as well as conservation biologists (Bambaradeniya, *et al.,* 2004). Bambaradeniya, *et al.,* (2004) further stated that flooded rice fields serve as ecotones that lie between land and water and hence, they provide an important feeding habitat for fauna and could contribute to enhance the biodiversity especially in the urban and sub-urban areas. McNeely and Scherr (2001) reported of the growing interest in concepts of eco-agriculture where agricultural systems are managed as both a food production and biodiversity conservation system.

Conservation of biodiversity of rice fields needs an integrated approach to include ecosystem, species, genetic and cultural diversity aspects. Conservation of these ecosystems is essential. In this regard the water logged rice field ecosystems in the India would be the priority concern due to high level of siltation and conversion to other land uses. Species diversity of rice fields has been addressed to some level where as genetic diversity of rice has been approached via *in situ*, *ex situ* and *circa situm* mechanisms. The surveys on biodiversity associated with the rice field agro-ecosystem conducted to-date have clearly demonstrated that the rice field ecosystem contributes to sustain a rich biodiversity, including unique as well as threatened species. The sustenance of the rice field ecosystem could be assured only by developing and adopting environmentally friendly technologies that would help minimizing the loss of biodiversity due to human and other interventions in the era of modern agriculture.

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