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Community Structure and Distribution of Epigeal-cum-herb Layer Fauna in the Rice Fields of Kashmir (J and K) India

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ABSTRACT

The study attempts to identify the taxocoenosis and distribution of epigeal-cum-herb layer fauna harbouring the rice field ecosystems of Kashmir. The main objective of the study is to provide an overview of the community composition and distribution of various arthropod groups inhabiting the floristic element mainly the rice plants in the rice field ecosystems across the valley. The 6 sites were selected in Kupwara, Bandipora, Budgam, Srinagar, Pulwama and Anantnag districts of Kashmir. A total of 50 taxa belonging to 7 different orders and 29 families were reported during the study which commenced through 2 consecutive crop cycles. The taxocoenosis was dominated by Coleoptera (19 taxa) followed by Hymenoptera (9 taxa), Orthoptera (8 taxa), Diptera (6 taxa), Hemiptera (6 taxa), Neuroptera, Scorpionida (1 taxa each). Diversity was calculated using Shannon and Weiner Index (H') and Margalef Richness Index (d). Kupwara site registered maximium number of representative groups (44 taxa), this was followed by Bandipora (43 taxa), Pulwama (36 taxa), Srinagar (35 taxa), Budgam (34 taxa) and Anantnag (34 taxa). The quantitative dominance with respect to the total number of individuals collected at the various study sites exhibited the following order: Bandipora<Kupwara<Srinagar <Pulwama<Anantnag. The results pressed the need for recognizing and preserving rice fields as potential habitats for organisms that have successfully adapted to the highly manipulated and eutrophic conditions of rice paddies.

Key words: Community organization, density, distribution, diversity, rice fields

INTRODUCTION

Rice fields are highly dynamic temporary wetland agro-ecosystems that hold extreme ecologic and economic importance. These form an indispensable component of the landscape and culture of Kashmir valley. The total land area under rice cultivation in the valley of Kashmir is about 374000 acres (Masoodi, 2003). Rice (*Oryza sativa* L.) is a widely grown cereal that feeds millions of people globally (Kumar *et al*., 2008; Sie *et al*., 2008; Mulungu *et al*., 2011). It is the most important cereal crop (Choudhary *et al*., 2011). It is cultivated in a wide range of ecosystems under varying temperatures and water regimes (Manickavelu *et al*., 2006). These ecosystems harbour a diverse biota as ponds and have more species than rivers, streams and river flood plains. Rice fields together with their contiguous aquatic habitats and dry land, comprise a rich mosaic of rapidly changing ecotones, harbouring a rich biological diversity, maintained by rapid colonization as well as rapid reproduction and growth of organisms (Fernando, 1995). In the rice agro ecosystem, the core of the unit is the cultivated rice plant. It is part of a biological complex which includes other plants, micro-organisms, arthropods and other animals and man. These organisms represent the biotic or living part of the agro ecosystem. Surrounding them is a conditioning environment consisting of abiotic factors such as temperature and sunlight. Rice plants are unusually adapted to semi aquatic environments because of its well developed aerenchyma tissues that facilitate oxygen diffusion through continuous air spaces from shoot to root and avoid oxygen deficiency in roots (Tamang *et al*., 2011). The rice field is an ecosystem whose functioning depends to a great extent on a strong input of nutrients and subsidiary energy through the use of advanced cultivation techniques. Rice plants are exposed to diverse external stimuli throughout their life cycle (Nadarajah *et al*., 2009). The structural peculiarities of the rice field are due to the periods of flooding and drying out related to the cultivation cycle, the shallow depth of water associated with regular fluctuations of water level and the highly developed water-sediment interface (Madoni, 1987). The significance of rice fields in maintaining biodiversity has earlier been stated by Bambaradeniya *et al*. (2004), Segers and Sanoamung (2007) and Chittapun *et al*. (2009). Biodiversity is the key component for sustainable environment (Hossain *et al*., 2008). The changes in biodiversity cause concern for ethical, economical, ecological and aesthetic reasons (Shameem *et al*., 2010). Freshwater ecosystems have been experiencing declines in biodiversity far greater than terrestrial ecosystems (Nowrouzi and Valavi, 2011). Currently rice fields are under a serious threat of ecosystem transformation owing to rapid increase in population and accelerated urbanization. This phenomenon has put the biodiversity of rice fields at stake making it necessary to take immediate steps for the conservation of these man-engineered ecosystems (Bahaar and Bhat, 2011a). Further, due to adverse biotic, abiotic and soil factors the productivity of these agro-ecosystems is declining and unable to meet the ever increasing demands (Senguttuvel *et al*., 2010). Previous studies on the biodiversity of rice fields deal mainly with agronomic aspects. Comprehensive studies on the ecology and biodiversity of rice fields are scanty (Ghahari *et al*., 2010).

The entomofauna form one of the most important components of rice field ecosystem. Numerous taxa of insects are recorded in irrigated rice ecosystems (Kandibane *et al*., 2007). The insects play important roles especially as pollinators, decomposers and natural predators thus, maintaining the stability and uniqueness of these transitional ecosystems.Vegetation plays an indispensable role in determining the faunistic community structure of an ecosystem. The floristic elements and their phenology have a direct bearing on the type of fauna inhabiting a particular ecosystem. In a temporary ecosystem like rice field where two ecosystems develop in a quick succession following a definite cycle of vegetation and denudation, the faunistic composition shows a stark contrast between the aquatic and terrestrial phases and more often dominated by class Insecta. Insects form the leading consumers of plants. Some among them are the pests of agriculture everywhere in the world. Others serve as the chief predators of plant eaters, while still others variously decompose the humus, turn the soil and serve as food for vertebrates. A remarkable diversity of arthropoda inhabits the rice fields during the crop cycle and thereafter declines considerably in the fallow season. So, the objective of the study is to provide an overview of community composition and distribution of various arthropod groups.

MATERIALS AND METHODS

During the present investigation, 6 spatially variable study sites were selected in different administrative zones of Kashmir valley. The representative sites included:

- Kupwara (34°02'N; 74°16'E) in north west Kashmir
- Bandipora (34°06'N; 74°44'E) located in north Kashmir
- Budgam (34.63°N; 76.04°E) lying in south west Kashmir
- Srinagar (35°5'N; 74°47'E) in north east Kashmir
- Pulwama (33°53'N; 74°55'E) in south Kashmir and
- Anantnag (33.73°N; 75.15°E) situated towards south east of Kashmir province

The sampling period encompassed 2 consecutive crop cycles between April (2005) and December (2006). For the collection of herb layer fauna, 25×25 cm quadrats were laid at 5 randomly selected sites. The vegetation within the quadrats was covered with a mosquito net so that the active species could be prevented from escaping. The plants were clipped off using sharp scissors and brought to the laboratory in polythene bags where the shoots were spread over white sheets and the insects were sorted manually using forceps and brushes. Collection of epigeal fauna was done by direct searching of the organisms in randomly placed quadrats (25×25 cm). The insects were killed by exposing them to chloroform fumes in killing jars and were then stored for further investigations. Identification was done according to Linsenmaier (1972), Richards and Davies (1977) and Cartner (2006). Density was calculated as individuals/m^2.

RESULTS

The epigeal-cum-herb layer fauna included 50 genera belonging to 2 classes viz., insecta and Arachnida. The entomofauna was represented by 6 orders including Coleoptera (19 taxa), Hymenoptera (9 taxa), Orthoptera (8 taxa), Diptera (6 taxa), Hemiptera (6 taxa) and Neuroptera (1 taxa). Arachnida was solely represented by Scorpionida (1 taxa).

Coleoptera formed the most dominant order with 10 families including Coccinellidae, Chrysomelidae, Carabidae, Cerambycidae, Cetoniidae, Cleridae, Dynastidae, Elatridae, Hybosoridae and Staphylinidae. The taxocoenosis comprised of *Agelastica alni*, *Athous* sp., *Cetonia aurata*, *Chilocorus infernalis*, *Chlaneus* sp., *Coccinella septempunctata*, *C. undecimpunctata*, *Chrysolina* sp., *Halyzia tschitscherinia*, *Harpalus* sp., *Hybosorus* sp., *Oberia* sp., *Staphylinus* sp., *Pheropsophus* sp., *Phrynocaria* sp., *Phyllotreta* sp., *Scarities* sp., *Trichodes* sp. and *Xyloryctes* sp. Qualitatively, the maximum number of coleopteran taxa (17) was registered at Kupwara whereas, lowest number of 12 taxa was recorded at Budgam. Highest average density was depicted by *Staphylinus* sp. at Srinagar site (Table 1).

Hymenoptera was represented by 9 taxa belonging to 7 families including Apidae, Braconidae, Eumenidae, Formicidae, Ichneumonidae, Vespidae and Xylocopidae. The community composition included *Apanteles glomeratus*, *Apis* sp., *Eumenes* sp., *Lasius niger*.,*Odynerus* sp., *Ophion luteus*, *Vespa vulgaris*, *Vespa* sp. and *Xylocopa violacea*. Srinagar and Anantnag depicted lowest number of hymenopteran taxa (5) whereas, maximum number of taxa (9) was recorded at Bandipora. *Lasius niger* depicted a peak average density of 24.0 ind m^{-2} at Bandipora site.

Orthoptera was represented by 8 taxa belonging to 2 families viz., Acrididae and Tettigonniidae. Orthopterans included *Acrida exaltata*, *Aulachobothrus* sp., *Euconocephalus* sp., *Gastrimargus africanus*, *Gryllotalpa africanus*, *Mantis* sp., *Oxya hyla hyla* and *Phaneroptera* sp. Highest number of taxa was recorded as 8 taxa at Kupwara and Bandipora, whereas, Budgam, Pulwama, Anantnag depicted lowest number of taxa (4). *Oxya hyla hyla* registered a peak average density of 8.80 ind m^{-2} at Bandipora.

Table 1: Average population density (ind m^{-2}) of epigeal-cum-herb layer fauna recorded at various study sites

Taxa	Kupwara	Bandipora	Budgam	Srinagar	Pulwama	Anantnag
Coleoptera						
Agelastica alni	0.23	-	1.52	2.10	2.14	1.57
Athous sp.	0.28	-	0.38	0.66	0.80	0.52
Cetonia aurata	0.76	1.00	0.57	0.57	0.60	0.61
Chilocorus infernalis	0.71	-	0.47	0.76	-	-
Chlaenius sp.	0.19	-	-	-	0.42	0.28
Coccinella septempunctata	0.28	0.60	0.19	-	-	0.57
C. undecimpunctata	0.47	0.10	-	0.70	2.20	0.80
Chrysolina sp.	0.66	0.30	0.28	-	0.52	-
Halyzia sp.	1.23	0.70	-	0.60	-	0.52
Harpalus sp.	-	5.30	-	3.38	2.14	1.47
Hybosorus sp.	0.42	0.50	0.61	1.00	-	0.47
Onthophagus sp.	0.76	1.30	0.52	0.87	1.80	-
Staphylinus sp.	27.00	21.00	12.00	25.20	18.60	12.60
Pheropsophus sp.	-	-	-	-	0.23	0.23
Phrynocaria sp.	0.33	0.10	0.28	0.20	0.33	0.38
Phyllotreta sp.	1.23	0.80	-	2.00	0.38	1.42
Scarities sp.	0.71	0.70	-	0.38	0.80	0.76
Trichodes sp.	1.04	0.30	0.52	0.52	-	-
Xyloryctes sp.	0.28	-	0.85	-	1.10	0.71
Hymenoptera						
Apanteles glomeratus	0.66	1.70	0.33	-	-	0.42
Apis sp.	0.52	0.60	0.61	0.76	0.80	0.47
Eumenes sp.	0.14	0.30	-	-	0.14	-
Lasius niger	10.04	24.00	15.00	12.00	21.00	0.28
Odynerus sp.	-	1.00	0.23	0.20	0.33	-
Ophion luteus	0.52	0.30	0.28	0.23	0.28	-
Vespa vulgaris	-	0.60	-	-	-	0.33
Vespa sp.	0.19	0.10	-	-	-	6.47
Xylocopa violacea	0.47	0.50	0.42	0.60	0.42	-
Orthoptera						
Acrida exaltata	1.61	1.00	0.52	0.60	0.42	0.04
Aulachobothrus sp.	0.61	5.60	3.00	5.10	3.60	4.57
Euconocephalus sp.	1.57	1.50	0.38	0.15	0.20	0.38
Gastrimargus africanus	4.00	1.80	-	0.80	-	-
Gryllotalpa africanus	1.00	0.80	-	-	-	-
Mantis sp.	0.47	0.40	-	-	-	-
Oxya hyla hyla	7.00	8.80	4.33	8.47	6.0	7.20
Phaneroptera sp.	0.23	0.10	-	0.15	-	-
Diptera						
Eristalis tenax	0.28	1.00	0.19	0.42	0.47	0.38
Lucilia Caesar	1.00	1.20	0.28	0.47	0.42	-
Tipula erolacea	1.00	1.00	0.23	0.42	0.47	0.38
Sarcophaga carnaria	0.47	1.00	0.47	0.42	0.28	0.33
Scathophaga sp.	0.33	0.70	-	0.10	0.28	0.28
Sphaerophoria sp.	1.38	2.10	0.28	0.60	0.42	0.33
Hemiptera						
Beosus maritimus	0.61	0.30	0.19	-	0.38	0.47
Eurydema ventral	1.0	0.50	0.42	-	0.20	0.47

Table 1: Continued

Taxa	Kupwara	Bandipora	Budgam	Srinagar	Pulwama	Anantnag
Pentatoma sp.	0.70	0.50	0.38	0.33	0.28	0.47
Pyrrhocoris apterus	1.23	1.60	0.66	0.47	0.28	0.28
Tropidothorax leucepterus	0.40	0.40	0.28	0.57	0.42	-
Unidentified	-	-	0.10	-	-	-
Neuroptera						
Chrysopa carnae	1.85	0.70	0.70	0.60	0.47	0.42
Scorpionida						
Scorpiops sp.	-	0.10	-	-	-	-

Table 2: Biodiversity indices calculated for various study sites

Sites	Shannon and Wiener (1949) index (H')	Margalefs richness index (d)
Kupwara	2.66	5.83
Bandipora	2.66	5.52
Budgam	2.36	4.77
Srinagar	2.43	4.63
Pulwama	2.35	4.81
Anantnag	2.61	4.78

The 6 taxa of Diptera were recorded at the various study sites that belonged to 5 families. Taxocoenosis comprised of *Eristalis tenax*, *Lucilia caesar*, *Tipula erolacea*, *Sarcophaga carnaria*, *Scathophaga* sp. and *Sphaerophoria* sp. A maximum of 6 taxa was recorded at Kupwara, Bandipora, Srinagar, Pulwama whereas, a lowest of 5 taxa was registered at Budgam and Anantnag. Highest average density was registered at Bandipora by *Sphaerophoria* sp. (2.10 ind m^{-2}).

Hemiptera included 6 taxa belonging to 3 families viz., Pentatomidae, Lygaedae and Pyrrhocoridae. These included *Beosus maritimus*, *Eurydema ventrale*, *Pentatoma* sp., *Pyrrhocoris apterus*, *Tropidothorax leucepterus* and an unidentified hemipteran. A peak average density of 1.60 ind m^{-2} was depicted by *Pyrrhocoris apterus* at Bandipora. Budgam registered a maximum of 6 taxa whereas, Srinagar recorded a minimum of 3 taxa.

Neuroptera was solely represented by *Chrysopa carnae* which depicted its presence at all the study sites. Maximum average density was recorded at Kupwara as 1.85 ind m^{-2}. Scorpionida represented by *Scorpiops* sp. was registered only at Bandipora with an average population density of 0.10 ind m^{-2}. Average population density of total epigeal-cum-herb layer fauna depicted an increasing trend upto late summer (1st year) and midsummer (2nd year) i.e., during the peak growth phase of paddy crop. A gradual decline was recorded post harvest which continued till the onset of next cropping season. Quantitatively Bandipora formed the most dominant site recording an average total of 2002 individuals during the study period. This was followed by Kupwara (1581 ind), Srinagar (1532 ind.), Pulwama (1444 ind.), Budgam (1005 ind.) and Anantnag (988 ind.).

Table 2 depicts the values obtained from the biodiversity indices with respect to the various study sites. As per the results obtained from Shannon and Wiener (1949) diversity index, Kupwara and Bandipora were the most diverse sites, both registering a value of 2.66 (H'). Pulwama exhibited a lowest value of 2.35, forming the least diverse site. Margalefs Richness index (d) suggested Kupwara as the most diverse site with a calculated value of 5.83 (d) whereas, Srinagar formed the least diverse site obtaining a value of 4.63.

DISCUSSION

Arthropods forming the major components of biotic community occupy vital positions in food webs, dynamics of populations and communities (Latif *et al.*, 2009). A remarkable diversity of Arthropoda inhabits the rice fields during the crop cycle and thereafter declines considerably in the fallow season. Fifty genera of arthropods inhabiting the epigeal and herb layer component of the rice field ecosystem were recorded from the 6 representative study sites. Coleoptera was the most dominant order with 19 genera while as Neuroptera and Scorpionida formed the least dominant order. The dominance of Coleoptera over other arthropod groups in the rice fields of Kashmir has earlier been reported by Bahaar and Bhat (2011b). Most of the arthropods were reported only during the crop season i.e., when an abundant supply of food and shelter in the form of vegetation cover was available (Uka and Chukwuka, 2011). After the harvesting of crop, the fields were devoid of any vegetation. Fields were drained and as such no aquatic flora or fauna was found. This led to a drastic decline in the density and diversity of organisms that depended on the aquatic floral and faunal elements either directly or indirectly. Further, the decline in air temperature also led to decrease in the density and diversity of many arthropods.

Coleoptera being the largest of all orders of insects (Metcalf and Flint, 1932) is a very well adapted group occurring in almost all kinds of ecosystems. Water beetles are integral parts of the biotic component of any water body or wetland (Abdullah, 2010). Carabid beetles are used as indicator species for agricultural regions, forests, open lands and urbanizing areas (Abdullah and Shamsulaman, 2010). Almost every organic material is used by them. Animal wastes, mostly of herbivores is a continuously available resource in rice fields and supports characteristic community of macro invertebrates of which conspicuous are the coleopterans and dipterans (Bhat, 2003). Since abundant food materials are available in rice fields during the crop season, the coleopterans thrive well during the vegetation phase. However, post harvest, both the food and shelter become scarce as a consequence they migrate to other favourable places.The individuals of Hymenoptera were reported from the study sites during crop phase only save the Small Black Ant (*Lasius niger*) which registered its absence in the chilly winter alone. During the rest of months it depicted its presence in fairly good numbers owing to the availability of adequate food supply and friendly refuge all the year round. These ants are omnivorous in habit, feeding on seeds, nectar, insects, debris etc. (Riley, 1963). No individuals were recorded during the fallow period.

Orthopterans were recorded in much higher densities than other insect group. These were recorded only during the crop season. These insects feed on rice plants and deposit their eggs in soft soil. Since acridids are active during daytime, they were recorded from all study sites in higher numbers while as tettigonids being nocturnal were recorded in much less numbers. These insects are very active and prefer warmth. Areas rich in moisture are particularly appropriate as swarming grounds. With abundant food reserves and favourable swarming grounds, rice fields act as a preferred harbour for orthopterans. Dipteran peak densities registered during the vegetation phase could be attributed to availability of congenial conditions including availability of food, shelter among the plants and high atmospheric temperature (Bahaar and Bhat, 2011c).

Hemiptera owing to rich sources of food materials, successfully colonized rice fields during crop phase. However, post harvest these leave the rice fields as a consequence of decline in food material and shelter. Neuroptera was represented solely by *Chrysopa carnae* belonging to Chrysopidae. They grow successfully in rice-fields during the crop-cycle when ample quantities of food material are available for their larval forms. They were not recorded during the fallow season probably due to scarcity of food and decrease in air temperature. *Scorpiops* sp. was recorded from only 1 study site during the crop season. Since this animal fundamentally belongs to forest hemiedaphon (Bhat, 2003) its presence at Bandipora could be presumably a consequence of the close proximity of this area to forests.

Among the various study sites, Kupwara and Bandipora formed the most diversity rich sites which could be a probable consequence simpler agricultural methods adopted by the farmers. Further, being in close proximity with forest area, coupled with irrigation water from hill streams, diversity seemed to be on relatively higher site. The least diversity registered at Srinagar and Pulwama could be attributed to higher use of agrochemicals especially insecticides and weedicides at these sites. Srinagar forms the capital city of Kashmir province where levels of air and water pollution are relatively higher.

CONCLUSION

In order to study the epigeal-cum-herb fauna of the rice fields of Kashmir, 6 study sites were selected in different parts of the valley. The study revealed the presence of 50 taxa with Coleoptera as the most dominant group represented by 19 taxa. The overall interpretation of the results indicated towards the significance of rice fields as potential habitats for a diverse array of opportunistic nektonic fauna that have adapted to the harsh and highly disturbed environment of these shallow ecosystems that remain fallow for almost one-third of the year. The general community composition was fairly similar at all the representative sites which could be a probable consequence of existence of a similar agro-climatic zone. Further, the rice fields are interconnected through continuous corridors which make the taxocoenosis fairly homogenous. Slight variations were evident in the community organizations of different study sites which could be a probable function of micro-climatic variations.

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