ISSN 1819-1894

Asian Journal of Agricultural Research

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Asian Journal of Agricultural Research 5 (5): 269-276, 2011
ISSN 1819-1894 / DOI: 10.3923/ajar.2011.269.276

Aquatic Biodiversity in the Paddy Fields of Kashmir Valley (J and K) India

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ABSTRACT

The aquatic biodiversity of the rice fields of Kashmir was investigated with special reference to plankton, nekton and benthic fauna. The study aimed at investigating the taxocoenosis and ecology of the various components of the aquatic biodiversity harbouring, the rice fields of Kashmir. The study encompassed a period of two successive crop cycles between Apr 2005 and Dec 2006. A total of 88 taxa were reported from the representative study sites. Phytoplankton was represented by 29 taxa, zooplankton comprised of 23 taxa and 1 larva, 29 taxa belonged to nekton and 7 taxa represented benthic fauna. The study was carried out at six representative study sites separated spatially and covering various administrative areas of the valley. The significance of paddy fields in preserving biological diversity of the region was highlighted.

Key words: Benthos, biodiversity, nekton, phytoplankton, rice fields, zooplankton

INTRODUCTION

Rice fields are dynamic, temporary and transitional ecosystems that have been managed by man in collaboration with nature since times immemorial. Developed with the sole motive of rice crop production these vast agro-ecosystems harbour a varied range of flora and fauna (Bahaar and Bhat, 2011). Besides providing food to more than half of the world's population, rice fields generate other minor produce including fish, medicinal plants, fodder etc. In addition to the economic benefits, rice fields play numerous ecological roles including maintenance of trophic structures, nutrient recycling, ground water recharge and most importantly harbours diverse floral and faunal communities (Dhyani *et al*., 2007). The most important thing about rice field biota is that they have evolved through centuries to adapt themselves to highly manipulated, eutrophic and transitional conditions of these unique ecosystems. During each crop cycle, tonnes of artificial fertilizers and numerous agro-chemicals including weedicides and pesticides are added to rice paddies. As a direct consequence to this, the hydrological and sedimental conditions change drastically which in turn places a huge stress on the environmental factors and biology of the biota. However, this peculiar flora and fauna has adapted itself to these dynamic changes and successfully colonize the rice fields. Being the most manipulated and frequently disturbed ecosystem, a curious mixture of flora and fauna can be observed within the rice field (Bahaar and Bhat, 2011). The periodic disturbance resulting from cultural operations and agrochemical use have a profound effect on the nutrient status, pH, O_2 concentration and the community composition of aquatic and terrestrial biota inhabiting these rice fields. The rice fields undergo various seral stages during the crop cycle while transforming from a terrestrial ecosystem to a wetland ecosystem and back. These cyclic changes have been occurring since times immemorial being managed by man so efficiently that no major detrimental effects on the various components of this ecosystem were reported. However, in the future, there is every likelihood that crop intensification may take a toll on the aquatic and terrestrial biota along with the physico-chemical environment that determines the productivity of this ecosystem. Agronomic practices serve as an over-riding factor that controls the overall ecology and biodiversity of the rice field ecosystem. These human interventions governing the hydrology and rice field ecology (Heckman, 1979; Bambaradeniya, 2000) have clearly revealed that agronomic practices change the physical, chemical and biological conditions in the rice field ecosystem, making them less favourable for certain organisms and more favourable for others (Bambaradeniya and Amerasinghe, 2003). The bio-ecological studies on the rice fields of Kashmir are scarce and the present investigation, which is first of its type in the region was carried out with the same backdrop. Emphasis was laid on carrying out the study in a multi-aspected ecosystem approach.

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

Plankton: Composite planktonic samples were collected by filtering 10 L of water (Lim *et al*., 1984; Madoni, 1987; Ferrari *et al*., 1991) along a 500 m line transect at each study site. Sampling was done at fortnightly intervals. The concentrated samples (100 mL) were preserved in Lugols solution and counted by drop count method. Identification was done under a stereoscopic binocular microscope with the help of available standard taxonomic references (Pennak, 1978; Rajapaksa and Fernando, 1982; Sharma, 1983; Martens, 1984; Madoni, 1987; Edmondson, 1989; Cox, 1996). The results were expressed as number per liter No. L^{-1}.

Nekton: A metal frame (25×25×5 cm) was lowered into the water column and slowly pulled out after 15 min when the disturbance caused due to placing the frame into water had minimized. At each site, 5 random samples were collected along a 500 m transect. The organisms were sorted manually, placed in separate containers and brought to the laboratory for further investigations. Soft bodied organisms were preserved in 4% formaldehyde while hard bodied forms like adult aquatic insects were dry preserved. Identification was done in accordance with Rajagopal and Rao (1955), Linsenmaier (1972), Pennak (1978) and Edmondson (1989).

Macrozoobenthos: Samples were collected randomly by carefully driving a high-sided square frame (20×20 cm) into the sediment (Southwood and Henderson, 2000). The sample was taken by digging out the sediment upto a depth of 10 cm. Five representatives samples were collected from each study site. The sediment was sieved through a 0.5 mm sieve. During the dry phase soil macrofauna was collected following Folgarait *et al*. (2003). Five soil monoliths of 15×15×10 cm were excavated manually at each study site on either side of the line transect. The soil block was placed in a tray, broken softly with hand and organisms sorted manually. The organisms were placed in a tray, hand sorted and kept in separate labelled containers. Soft bodied organisms were preserved in 4% formalin, whereas, hard bodied organisms were preserved in 70% ethanol. Density was calculated in terms of ind. m^{-2}. Identification of the samples was done following Rajagopal and Rao (1955), Pennak (1978) and Edmondson (1989).

RESULTS

The phytoplanktonic taxocoenosis was represented by 29 genera belonging to 3 families of Chlorophyceae, Bacillariophyceae and Cyanophyceae (Table 1). These families were comprised of

Table 1: Average population density No. L^{-1} of phytoplankton at the study sites

Taxa	Kupwara	Bandipora	Budgam	Srinagar	Pulwama	Anantnag
Chlorophyceae						
Closterium sp.	-	31	17	13	18	-
Cosmarium sp.	50	50	10	12	16	6
Euastrum sp.	-	-	14	7	8	18
Eudorina sp.	19	26	13	7	8	-
Oedogonium sp.	154	132	186	156	274	106
Gonium sp.	21	21	8	10	5	6
Pediastrum sp.	19	19	18	5	11	7
Platydorina sp.	20	-	15	10	15	-
Pleodorina sp.	22	37	11	14	10	-
Spirogyra sp.	318	576	494	461	553	388
Ulothrix sp.	76	131	143	176	197	126
Volvox sp.	10	22	16	12	11	8
Volvulina sp.	17	23	15	-	13	-
Zygnema sp.	198	160	323	221	371	246
Bacillariophyceae						
Caloneis sp.	19	41	14	15	10	-
Cymbella sp.	20	220	35	55	13	28
Diatomella sp.	31	30	-	-	24	-
Fragillaria sp.	80	333	83	61	59	91
Gyrosigma sp.	13	43	16	23	12	-
Meridion sp.	24	25	-	21	33	9
Navicula sp.	73	125	101	113	68	59
Nitzschia sp.	81	301	103	74	67	42
Pinnularia sp.	50	47	40	55	44	26
Stauroneis sp.	115	416	102	184	37	39
Synedra sp.	72	46	35	82	173	35
Cyanophyceae						
Anabaena sp.	81	105	21	-	129	105
Nodularia sp.	51	-	-	52	-	43
Nostoc sp.	-	82	102	106	84	91
Oscillatoria sp.	60	193	119	123	171	140

Table 2: Average population density No. L^{-1} of zooplankton recorded at the representative sites

Taxa	Kupwara	Bandipora	Budgam	Srinagar	Pulwama	Anantnag
Cladocera						
Alona sp.	25	44	93	84	65	80
Bosmina sp.	-	32	110	70	3	96
Ceriodaphnia sp.	93	28	118	76	109	104
Chydorus sp.	63	73	42	68	73	65
Daphnia sp.	152	84	198	85	140	113
Moina sp.	102	80	94	59	85	80
Moinodaphnia sp.	63	92	130	48	94	116
Pleuroxus sp.	76	53	36	81	67	74
Scapholeberis sp.	135	91	134	108	105	125
Protozoa						
Arcella sp.	101	105	75	101	77	-
Centropyxis sp.	141	148	118	128	169	75
Difflugia sp.	161	150	99	-	130	95
Pyxidicula sp.	87	41	-	71	88	50
Copepoda						
Cyclops sp.	133	139	118	128	109	167
Diaptomus sp.	22	-	36	21	46	36
Nauplius larva	5	13	8	11	7	9
Ostracoda						
Candona sp.	36	-	15	6	9	8
Cypris sp.	28	30	26	6	18	22
Ilyocypris sp.	-	-	-	-	-	5
Rotifera						
Brachionus sp.	8	8	7	11	15	8
Euchlanis sp.	7	-	-	5	5	-
Notholca sp.	17	25	12	80	35	18
Diptera						
Chironomous larva	10	8	5	7	5	5
Nematoda						
Unidentified nematode	-	2	-	-	6	2

14, 11 and 4 genera. Study sites Kupwara, Bandipora, Budgam and Srinagar registered a total of 26 taxa of phytoplankton, 28 taxa were recorded at site Pulwama, while 21 taxa were noticed at Anantnag.

The zooplanktonic community comprised of 23 genera and a larva, spread over seven groups (Table 2). These included Protozoa, Nematoda, Rotifera, Cladocera, Copepoda, Ostracoda and Diptera. Twenty one taxa were recorded at Kupwara, Bandipora, Budgam; 20 taxa were collected from Budgam; 23 and 22 taxa were registered at Pulwama and Anantnag, respectively.

Nektonic fauna in the rice fields of Kashmir included 26 genera belonging to nine different groups (Table 3). Coleoptera was represented by 10 taxa including *Berosus* sp., *Dytiscus marginalis.*, *Gyrinus* sp., *Helophorus* sp., *Hydrophilus* sp., *Laccobius* sp., *Laccophilus* sp., *Rhantus* sp. and 2 unidentified beetle species. Crustacea included *Branchinecta acanthopenes, Cyzicus* sp., *Eulimnadia* sp. and *Gammarus* sp. *Microvelia* sp., *Plea* sp. and *Sigara* sp. belonged to Hemiptera. Diptera was represented by Chironomous and mosquito larvae. Gastropoda included *Gyraulus circumstratus* and *Lymnaea stagnalis*. *Cyprinus carpio* and *Gambusia* sp. represented Cypriniformes. Acarina, Anura and Odonata were represented by *Atax* sp., tadpoles and dragonfly

Table 3: Average population density (ind/m^2) of nekton at the study sites

Taxa	Kupwara	Bandipora	Budgam	Srinagar	Pulwama	Anantnag
Coleoptera						
Berosus sp.	14	11	6	10	14	3
Dytiscus marginalis L.	2	2	1	1	5	-
Gyrinus substriatus	23	17	14	18	25	8
Helophorus sp.	9	8	4	7	2	7
Hydrophilus sp.	3	2	2	2	4	1
Laccobius sp.	10	6	5	5	8	4
Laccophilus sp.	5	5	2	5	-	2
Rhantus sp.	4	2	1	2	5	1
Unidentified	2	-	2	2	13	2
Unidentified	-	-	1	1	12	2
Crustacea						
Branchinecta acanthopenes	13	26	2	6	13	3
Cyzicus sp.	2	1	-	1	1	2
Eulimnadia sp.	2	6	1	-	-	-
Gammarus pulex	1	2	1	1	1	2
Hemiptera						
Microvelia sp.	3	3	-	1	2	1
Plea sp.	10	10	5	10	15	8
Sigara sp.	8	5	7	-	11	5
Diptera						
Chironomous larva	5	4	5	5	11	4
Mosquito larva	16	37	7	16	34	16
Gastropoda						
Gyraulus pankongensis	1	-	-	1	2	1
Lymnaea stagnalis	1	1	1	2	3	2
Cypriniformes						
Cyprinus carpio	1	1	-	1	-	-
Gambusia sp.	2	-	-	-	1	-
Acarina						
Atax sp.	5	6	4	3	3	4
Anura						
Tadpole	1	1	-	2	1	1
Odonata						
Dragonfly nymph	2	1	1	1	2	1

nymphs, respectively. Twenty two genera were recorded at sites Kupwara, Bandipora, Srinagar, Pulwama; 20 taxa were registered at site Budgam, while 19 taxa were collected from site Anantnag.

The macrozoobenthic analysis of the representative sites of rice fields of Kashmir revealed the presence of 7 taxa of macro zoobenthos (Table 4). These included 5 genera from Annelida, 1 genus belonging to Arthropoda and 1 representing Mollusca. Annelida was represented by *Allolobophora rosea, Bra nchuira sowerbyi*, *Hirudo* sp., *Lumbricus terrestris* and *Tubifex tubifex*. Arthropoda included Chironomous larva whereas, Mollusca was represented by *Bithynia tentaculata*. Kupwara, Bandipora, Srinagar, Pulwama, Anantnag registered a total of 6 taxa each, while 5 taxa were recorded at Budgam site.

Table 4: Average population density (ind/m^2) of macro-zoobenthos at the study sites

Taxa	Kupwara	Bandipora	Budgam	Srinagar	Pulwama	Anantnag
Annelida						
Allolobophora rosea	1	1	-	1	-	-
Branchiura sowerbyi	34	-	-	-	28	24
Hirudo sp.	1	1	1	1	1	1
Lumbricus terrestris	2	1	1	2	3	2
Tubifex tubifex	28	40	12	9	9	4
Arthropoda						
Chironomous larva	16	27	26	31	20	13
Mollusca						
Bithynia tentaculata	25	25	10	6	11	9

DISCUSSION

The overall phytoplanktonic analysis of the rice fields depicted an increasing trend upto the first half of early summer and after attaining a peak value exhibited almost a steady decrease till the end of aquatic phase. Abundant phytoplanktonic populations developed till the tillering phase as a result of high light and nutrient availability. The phytoplanktonic populations declined considerably after the tillering phase probably due to reduced insolation. Population density was observed to be low at all the study sites during the first week of crop cycle. Bacillariophyceae represented itself as the most dominant group followed by Chlorophyceae, while Cyanophyceae was the least dominant family. The development of diatoms in the initial stages of colonization may be attributed to the availability of solar radiations in ample quantities and lower water temperatures which are known to favour their growth and multiplication (Hickel, 1973). In addition to this, the puddling of soil releases large quantities of readily available nutrients into the flood waters which help in the luxuriant growth of Bacillariophyceae and Chlorophyceae (Kaul *et al*., 1978).

The zooplanktonic micro succession began with the flooding of rice fields. Initially, Protozoa was quantitatively the dominant group followed by Cladocera, Rotifera, Diptera and Copepoda. Average density registered an increasing trend upto midsummer, followed by a general decline thereafter. Peak populations coincided with rich densities of phytoplankton which act as food sources for the zooplankters. Further, the availability of congenial conditions including high levels of dissolved oxygen, moderate temperature and neutral to alkaline pH aided their luxurious growth (Wetzel, 2001; Cole, 1983). However, post tillering as the canopy grew thick, phytoplankton populations declined, DO levels receded and pH turned acidic, the zooplankton populations dropped significantly drawing support from Fores and Comin (1992) and Hutchinson (1967). A general overview of the rice field nektonic fauna depicted an increase in the average population density till the first half of early summer and a decline thereafter. The significant build-up of population density during early summer may be a probable consequence of a rich growth of crustaceans, mainly *Branchinecta acanthopenes*. Further, the availability of food materials in surplus quantities seems to have aided luxurious growth of nekton at this particular stage of aquatic phase. The most dominant component of the nektonic fauna in the flood water of the representative study sites was Coleoptera. During the aquatic phase, decomposing organic matter is found in rice fields in large quantities, these beetles by virtue of luxuriant food sources thrive successfully in the rice fields.

The overall analysis of the macro zoobenthic fauna of the representative study sites exhibited peak populations during late spring probably in response to thick populations of dipteran larvae that formed quantitatively the most dominant macro benthic component in this particular period. Population density depicted a decline from early summer probably as a consequence of growing compaction of the sediments which is known to hamper the survival of dipteran larva (Williams, 1984; Brunke and Gonser, 1999; Mallard *et al.*, 2000). In addition, the declining levels of soil organic matter may be held responsible for the decrease in the population of tubificids (Simpson *et al.*, 1993; Millbrink, 1980; Brinkhurst and Cook, 1980). The absence of earthworms further aided in declining the overall populations after late spring. Their disappearance could be attributed to the highly supersaturated conditions coupled with increasing acidity of the ecosystem (Astrid, 1983; Edwards and Bohlen, 1996).

CONCLUSION

While studying the biodiversity associated with the aquatic component of the rice fields of Kashmir plains, a total of 88 taxa were reported. These organisms belonged to various floral and faunal groups including phytoplankton (29 taxa), zooplankton (23 taxa, 1 larva), nekton (29 taxa), and macro-zoobenthos (7 taxa). The taxocoenosis was found to be fairly similar probably in response to the prevalence of similar climatic conditions. Slight variations in the community composition could likely be the outcome of local micro climatic interferences. The role of rice field agro-ecosystems in preserving the biodiversity of the region was evident.

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