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# Ecology of Zooplankton in the Rice Field Agro-ecosystems of Kashmir Valley (J and K) India.

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**ABSTRACT-**The present study is an attempt to investigate the taxocoenosis and ecological attributes of zooplankton harboring the rice field agro-ecosystems of Kashmir. The main objective was to investigate the overall community composition of the yet unexplored zooplanktonic fauna of the rice field ecosystems of the valley. The study was carried at 6 spatially variable study sites located in different administrative zones of the valley. The investigation comprised of 8 fortnightly sampling spread over a complete cultivation cycle between May and August (2007). The overall zooplanktonic analysis of the rice fields revealed the presence of 28 genera belonging to 4 phylas. Arthropoda was the most dominant both qualitatively as well as quantitatively. It was represented by 15 genera and 1 larva distributed over 4 classes. Diversity was calculated by Shannon-Wiener Index (H') and Margalefs Richness Index (d). Pulwama was the most diverse site whereas, Budgam was the least diverse site based on the results of biodiversity indices. Qualitatively, the dominance pattern registered by various study sites depicted the following trend: Bandipora, Budgam<Kupwara, Srinagar<Anantnag<Pulwama. The significant contribution of rice field ecosystems in maintaining the overall biodiversity of a region was highlighted.

**Key words**: Diversity, Ecology, Kashmir, Phytoplankton, Rice fields.

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## INTRODUCTION

Rice fields are aquatic ecosystems that are managed by man as monocultures. These temporary wetlands act as terrestrial ecosystems for one part of the year. Besides providing food and employment to millions of people, these ecosystems act as potential habitats for numerous aquatic, amphibious and terrestrial biota. Rice cultivation not only supports the economy of the valley, its roots are deeply embedded in the life and culture of Kashmir and its people. Although the soils of the valley are fertile enough to support a great variety of agricultural and horticultural produce, yet rice occupies a special position in the Kashmiri cuisine and undoubtedly is the chief staple crop of the valleyites. The natives of Kashmiri employ much of their energy and efforts in cultivating rice which forms their most important staple food (1). In his book, he has elaborately mentioned the cultivation practices and various varieties of rice used during those times. Though the cultivation practices have more or less remained the same, but the numerous rice varieties recorded by him are either extinct now or may be found in the seed banks of agricultural universities and research institutes. In Kashmir the crop cycle begins from April and lasts for about 120-150 days. Cultural operations begin with the sowing of seeds in nursery beds. For raising nurseries, the soil is flooded and ploughed thoroughly to get a soft and uniform level of sediments. The study of biodiversity associated with agro-ecosystems such as rice fields is of significance for agro-ecologist and conservation biologists, since maintenance of biological diversity is essential for productive agriculture, and ecologically sustainable agriculture is in turn essential for maintaining biological diversity (2). Rice fields have some peculiarities which make them particularly interesting for ecological studies: precise, clear boundaries, both physical and ecological; manageable dimensions at the human scale; great variety of changes in a short period of time; strong interactions between biological and geochemical components (3). However, the artificial and temporary nature of rice field renders it a difficult ecosystem to study, as agrochemical use and frequent disturbances interrupt observations of community structure,

population successions and nutrient cycling (4). 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 in the same backdrop.

## MATERIAL AND METHODS

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

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

The sampling period encompassed a single cycle between May and August (2007). Standard methods were employed for carrying out the investigation. Composite samples were collected by filtering 10 l of water (5, 6) along a 500 m line transect at each of the 5 sub-sites. Sampling was done at fortnightly intervals during a complete crop cycle which comprised a total of 8 fortnightly observations between late spring and late summer. 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 (7, 8, 9, 10). The results were expressed as number per litre (n\l). Shannon-Wiener Index (H') was performed as per Shannon and Wiener (11), and Margalefs Richness Index (d) was calculated as prescribed by Margalef (12).

## RESULTS

The zooplanktonic community was composed of 24 taxa and a larva spread over 3 phyla and 6 orders with phylum Arthropoda being the most dominant both qualitatively as well as quantitatively. It was represented by 4 classes including Cladocera with 9 taxa. Protozoa included 4 taxa. Copepoda was represented by 2 taxa and *Nauplius* larva. Ostracoda was represented by 3 taxa. Phylum Rotifera included 3 taxa, Diptera was represented by Chironomous larvae and Nematoda included *Hirschmanniella oryzae* (Table 1). Among the zooplankton Cladocera was represented by 9 genera including *Alona* sp., *Bosmina* sp., *Ceriodaphnia* sp., *Chydorus* sp., *Daphnia* sp., *Moina* sp., *Moinodaphnia* sp., *Pleuroxus* sp., *Scapholeberis* sp . Highest average values were depicted by *Daphnia* sp. (198n/l) at Budgam site where as, lowest values were registered by *Bosmina* sp. (3n/l) at Pulwama. Total Cladocera registered highest values post tillering followed by a general decline till the end of cultivation phase. Protozoa included 4 taxa i.e., *Arcella* sp., *Centropyxis* sp., *Difflugia* sp., and *Pyxidicul*a sp. Highest average values were registered by *Centropyxis* sp. as 169n/l. *Pyxidicula* sp. registered lowest average values as 41n/l. Total Protozoa registered peak values during the onset of crop cycle i.e., during late spring, followed by a gradual decline till the end of crop phase. Copepoda was represented *Cyclops* sp., *Diaptomus* sp., and *Nauplius* larva. *Cyclops* sp. registered the maximum average population density of 167n/l. Total Copepoda depicted an increasing trend upto 1st fortnightly observation of midsummer. After attaining peak values, total copepods recorded a decline in population density which continued till the second half of late summer. *Candona* sp., *Cypris* sp. and *Ilyocypris* sp. represented Ostracoda. Total ostracods depicted an increasing trend up to midsummer followed by a decline in the population density. Rotifera which was represented by the single order Plioma included *Brachionus* sp., *Euchlanis* sp., and *Notholca* sp. Total Rotifera registered highest population density in the 2nd observation (second half of late spring) followed by a declining trend which continued till the end of study period. Diptera was represented by the sole taxa of Chironomous larva registering highest population density during the initial observation. A general decline was recorded from the second fortnightly observation of late spring. Complete absence was registered from midsummer onwards. The nematode *Hirschmanniella oryzae* was reported from Bandipora, Pulwama and Anantnag sites.

Total zooplankton depicted an increasing trend in the population density till 5th observation (1st half mid-summer) followed by a steady decline thereafter during the first cultivation cycle. During the successive cycle, the total population density of zooplankton registered an increase till the later half of early summer (4th observation). A gradual decline was recorded during the following observations which continued till the end of investigation.

As per the results of Shannon-Wiener Index (H') Pulwama was the most diverse site whereas, Budgam was the least diverse site. Dominance pattern exhibited the following trend: Pulwama

(H'=2.795) > Srinagar (H'=2.772) > Anantnag (H'=2.758) > Kupwara (H'=2.736) > Bandipora (H'=2.704) > Budgam (H'=2.697). Similar results were obtained from Margalefs Richness Index (d) according to which Pulwama was the most diverse site and Budgam was the least diverse site (Table 2).

## DISCUSSION

The zooplanktonic micro succession began with the flooding of rice fields. Initially, Protozoa was quantitatively the dominant group followed by Cladocera, Rotifera, and Diptera. During the initial observations, Ostracoda were completely absent. They showed maximum population numbers only after the tillering phase. Marked fluctuations were registered in their population densities. The population dynamics of this group is not clearly known, though some species exhibit distinct seasonal periodicity (13). Protozoan populations developed sufficiently in the clear water column during field preparation and soon after transplantation (14). Cladocera, the moderately dominant group was initially dominated by filter feeders like *Daphnia* sp., *Moina* sp., *Ceriodaphnia* sp., up to the tillering phase. These forms began receding from tillering onwards and were more or less replaced by detrivorous species like *Scapholeberis* sp., *Pleuroxus* sp., *Chydorus* sp., and *Alona* sp. that were completely absent during the open-water period. During the early stages of crop growth when enough of the incident solar radiation reaches the water column, phytoplankton were abundant and as a result efficient filter feeding species belonging to Daphnidae and Bosminidae were dominant (3). However, after tillering, as the rice crop attains its maximum biomass and the canopy limits solar radiation, subsequently phytoplankton density lowers and as a result filter feeders give way to detritovorous forms including *Chyodorus* sp., *Pleuroxus* sp., *Alona* sp., and *Scapholeberis* sp. As the successive stages advanced and decomposition of algae and weeds set in, detritovorous species mainly represented by Chyodoridae replaced the filter feeders (6). Rotifera represented by 3 genera showed stable populations up to the tillering phase and then declined steadily. Rotifers act as a potential food for copepods and their low densities may be attributed to predation by copepods coupled with the inhibitory effects caused by chemical compounds secreted by hydrophytes (15) and the lower levels of dissolved oxygen and higher water temperature (16). Copepoda represented by *Cyclops* sp., *Diaptomus* sp., and *Nauplius* larva, initially showed lower populations but then went on increasing significantly up to the harvesting stage. The increase in the mean population density of copepods towards the later stages of crop cycle may probably be due to increase in cladocerans which act as a source of food for copepods (17). Diptera was the least dominant group. Since chironomids graze on algae, the decrease in their population density towards later stages may be due to decrease in the density of palatable algae. Chironomous larvae breed in soft and organic matter rich sediments and as such their populations show maximum densities in the earlier stages when sediments are softer. However, as the sediments grew compact, chironomid densities dropped considerably as they found it difficult to thrive in hard sediments. The plant pathogenic nematode *Hirschmanniella oryzae* recorded at 3 study sites showed occasional presence which may be due to the fact that this nematode resides in the root-soil complex of the plant and may have escaped into the water component. Diversity indices depicted Pulwama as the most diverse site since qualitatively it was the most dominant site with 23 taxa.

## CONCLUSION

The results were indicative of the significance of rice fields in maintaining the biodiversity of a region. A diverse array of zooplanktonic biota adapted to the harsh and highly disturbed environment of these shallow ecosystems was reported. 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. Rice fields form the largest fresh water ecosystems of the valley. These habitats are currently facing the threat of ecosystem transformation and need to be preserved for safeguarding the biodiversity of this region.

Table 1: Average population density (n/l) of zooplankton at the representative sites.

| S. No. | Taxa | Kupwara | Bandipora | Budgam | Srinagar | Pulwama | Anantnag |
|---|---|---|---|---|---|---|---|
| **I.** | **Cladocera** | | | | | | |
| 01. | *Alona* sp. | 25 | 44 | 93 | 84 | 65 | 80 |
| 02. | *Bosmina* sp. | - | 32 | 110 | 70 | 3 | 96 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 03. | *Ceriodaphnia* sp. | 93 | 28 | 118 | 76 | 109 | 104 |
| 04. | *Chydorus* sp. | 63 | 73 | 42 | 68 | 73 | 65 |
| 05. | *Daphnia* sp. | 152 | 84 | 198 | 85 | 140 | 113 |
| 06. | *Moina* sp. | 102 | 80 | 94 | 59 | 85 | 80 |
| 07. | *Moinodaphnia* sp. | 63 | 92 | 130 | 48 | 94 | 116 |
| 08. | *Pleuroxus* sp. | 76 | 53 | 36 | 81 | 67 | 74 |
| 09. | *Scapholeberis* sp. | 135 | 91 | 134 | 108 | 105 | 125 |
| **II.** | **Protozoa** | | | | | | |
| 10. | *Arcella* sp. | 101 | 105 | 75 | 101 | 77 | - |
| 11. | *Centropyxis* sp. | 141 | 148 | 118 | 128 | 169 | 75 |
| 12. | *Difflugia* sp. | 161 | 150 | 99 | - | 130 | 95 |
| 13. | *Pyxidicula* sp. | 87 | 41 | - | 71 | 88 | 50 |
| **III.** | **Copepoda** | | | | | | |
| 14. | *Cyclops* sp. | 133 | 139 | 118 | 128 | 109 | 167 |
| 15. | *Diaptomus* sp. | 22 | - | 36 | 21 | 46 | 36 |
| 16. | *Nauplius* sp. | 5 | 13 | 8 | 11 | 7 | 9 |
| **IV.** | **Ostracoda** | | | | | | |
| 17. | *Candona* sp. | 36 | - | 15 | 6 | 9 | 8 |
| 18. | *Cypris* sp. | 28 | 30 | 26 | 6 | 18 | 22 |
| 19. | *Ilyocypris* sp. | - | - | - | - | - | 5 |
| **V.** | **Rotifera** | | | | | | |
| 20. | *Brachionus* sp. | 8 | 8 | 7 | 11 | 15 | 8 |
| 21. | *Euchlanis* sp. | 7 | - | - | 5 | 5 | - |
| 22. | *Notholca* sp. | 17 | 25 | 12 | 80 | 35 | 18 |
| **VI.** | **Diptera** | | | | | | |
| 23. | Chironomous larva | 10 | 8 | 5 | 8 | 5 | 5 |
| **VII.** | **Nematoda** | | | | | | |
| 24. | *Hirschmanniella oryzae* | - | 2 | - | - | 7 | 3 |

Table 2: Biodiversity indices for the representative sites

| S. No. | Index | Kupwara | Bandipora | Budgam | Srinagar | Pulwama | Anantnag |
|---|---|---|---|---|---|---|---|
| 01. | Shannon-Wiener Index (H') | 2.736 | 2.704 | 2.697 | 2.772 | 2.795 | 2.758 |
| 02. | Margalefs Richness Index (d) | 2.744 | 2.666 | 2.604 | 2.803 | 3.019 | 2.912 |

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## CO-AUTHOR CONTRIBUTION

G. A. Bhat developed the concept and supervised the study. S. W. N. Bahaar carried out the field, lab work and conducted all statistical analysis.