Journal of Research & Development, Vol. 4 (2004)
ISSN 0972-5407

Macro-Crustaceans in Relation to Paddy Field Environment

Arshid Jehangir and G. A. Bhat
Centre of Research for Development and Postgraduate Department of Environmental Sciences, University of Kashmir, Srinagar-190006 J&K, India.

ABSTRACT

The paddy fields of Kashmir, which harbour a large number of species and contribute to biodiversity of the region, are reportedly showing decline in species abundance. After studying various physico-chemical parameters of waters and soil of the representative paddy fields, macro-crustaceans were seen to be existing in higher population densities in the paddy fields of rural areas where not much weedicides, pesticides and chemical fertilizers were being added as compared to those of suburban areas where addition of chemical fertilizers and pesticides is a common practice.

Keywords :- *Triops cancriformis, Branchionecta acanthopenes*, paddy fields.

INTRODUCTION

Loss of biodiversity as a result of human interventions is now a major concern the world over. Many types of human activities in biosphere including monocultures, industries, deforestation, and urbanization have tended to reduce biodiversity. As a result of these and many other activities, extinction of many species of both plants as well as animals has occurred. The paddy fields of valley of the Kashmir, especially those located at relatively low elevations in the close vicinity of human settlements and comprising major component of rural agro ecosystems are subject to changes in their ecological nature.

The paddy fields which shelter a large number of species and add to the biodiversity are showing decline in many species (Giudicelli and Alain, 1998). The use of weedicides / pesticides and chemical fertilizers is threatening the life of many species in these wetlands (Lahr, 1998). Though, few species of seasonally occurring macro-crustaceans in paddy fields have received an attention only up to the level of their taxonomic determination (Srivastava, 1964; Das, 1970; Malhotra and Duda, 1970; Tiwari, 1972; Reshi, 1976 Nath, 1980) and no study on their ecology or economy has been carried out. There is great recognition of the importance of macro-crustaceans particularly in the paddy fields and a growing concern about their obvious

and rapid disappearance from the environment. The present investigation is an attempt in this direction and is concerned mainly about the two macro-crustaceans, *Triops(Apus) cancriformis* and *Branchionecta acanthopenes*, found during late spring and early summer in the paddy fields of the valley of Kashmir.

The present investigation is attempted to assess the impact of various physico-chemical factors of paddy field soils and waters on the population of these crustaceans.

MATERIAL AND METHODS

The present study was conducted in the paddy fields of Northwest suburban areas of Srinagar city and five sites 34°.1′ - 34°.3′N latitude and 74°.4′ – 74°.6′E longitude at an altitude of 1560 - 1620 m (asl) were selected.

Site I: Paddy field located near the residential houses in Burzuhama village. Before the cultivation of paddy, mustard was grown in this field.

Site II: This site was located on the outskirts of the village Gausu far away from residential houses. Mustard was also grown here before paddy.

Site III: A perennial spring in the center of an orchard near Site II. The spring was 2.5 m in width and 0.7 m in depth.

Site IV: A paddy field of Narribatpora near the road-side. Before cultivation of paddy no crop was grown here as a rabbi crop.

Site V: A paddy field was selected at Shalimar slightly away from road and residential houses. No crop was grown here before paddy.

In June two additional sites were selected and studied in order to make certain cross checks on the presence of these crustaceans.

Site IVa: This site was selected adjacent to the site IV.

Site VI: A paddy field was selected in the rural areas of Kangan in hilly terraces away from the residential houses in order to assess the exact occurrence of the crustaceans.

Macro-crustacean populations were censused by simple quadrat method using a 25cm^2 quadrat and computing the number per meter square area.

Study of water characteristics

The water samples were collected on monthly basis in one liter polyethylene bottles from April to July from the selected sites. Some of the parameters viz. Temperature and fixation of Dissolved Oxygen was done at the site. The analysis of other parameters (pH, Conductivity, Dissolved Oxygen ,Carbon dioxide, Ca^{++}, Mg^{++}, total Hardness, total Alkalinity, Cl^-, Nitrate Nitrogen & total Phosphate Phosphorous) was performed in the laboratory within 24 hours. The analysis was done according to standard methods of Mackreth (1963), Golterman and Clymo (1979) and A.P.H.A. (1998).

Study of soil characteristics

Composite surface soil samples were collected randomly at a depth of 0cm - 15cm with the help of hoe from different sampling sites (paddy fields only) from April to July. The soil samples were taken in thick polyethylene bags to the laboratory. The samples were air dried and then ground using pestle and mortar and sieved through a 0.2 mm mesh sieve and stored in thick quality polyethylene bags for determination of different soil parameters (pH, Conductivity, Moisture Content, Field Capacity, Loss on Ignition and total Phosphate Phosphorous) following the standard procedures given by (Sunita and Sumanjeet,1999; Gupta, 2000).

RESULTS

As water is directly exposed to solar radiations the fluctuations in the water temperature follows directly the atmospheric temperature. The temperature varied from minimum of 16°C at site III in April and maximum of 27°C at site V in June and site IV in July. The pH of the paddy fields remained neutral to slightly alkaline ranging from 7.04 at site V in April to 8.70 at site II also in April. Conductivity values fluctuated from 254 $mScm^{-1}$ at site I in May to 590 $mScm^{-1}$ at site II in July. Dissolved oxygen was present in significant amounts except at site III (perennial spring) less than 3mg/l to maximum of 14.92 mgl^{-1} at site II during April. Free Carbon dioxide, Ph and Total alkalinity were directly related to each other. Calcium (30.27 mgl^{-1} to 100.92 mgl^{-1}) was found as a major component of Hardness and remained higher than magnesium (6.82 mgl^{-1} to 39.85 mgl^{-1}) values except at site IV during April. The total hardness was found in the range of 138 mg/l to 356 mg/l. Deviation was also observed in the alkalinity values which ranged from 102 mg/l to 455 mg/l. Chloride content was also high ranging between 10 mg/l to 48.30 mg/l. Analysis of nitrates (292 mgl^{-1} to 1434 mgl^{-1}) and total phosphate phosphorous (105 mgl^{-1} to 1102 mgl^{-1}) was done only in the month of June and were minimum at site III.(Table 1).

Table 1 . Physico-Chemical Features of Paddy Field Water

S.No.	Parameters	April					May					June							July				
		SI	*SII*	*SIII*	*SIV*	*SV*	*SI*	*SII*	*SIII*	*SIV*	*SV*	*SI*	*SII*	*SIII*	*SIV*	*SIVa*	*SV*	*SVI*	*SI*	*SII*	*SIII*	*SIV*	*SV*
1	Water temp. C°	18.5	18	16	19	19.5	23	22.5	21	24	24	26	25.5	23	26.5	26.5	27	26	Dry	26.5	24	27	Dry
2	pH	8.06	8.7	6.96	8.16	7.04	7.89	7.22	7	7.19	7.22	8.04	7.5	7	7.84	8.47	7.15	7.11	-	7.41	7.29	7.63	-
3	Cond. (μScm^{-1})	282	480	460	429	430	254	449	499	492	294	310	390	504	400	260	290	260	-	590	480	570	-
4	D.O. (mgl^{-1})	10.5	14.9	2.92	4.8	5	12.8	9.6	2.8	5.6	9.6	12	8.8	2.8	7.26	7.2	9.2	9.2	-	3.6	2.4	5.2	-
5	CO_2 (mgl^{-1})	6.2	A	15.8	12.6	14	7	6	8	20	14	5.4	16	36.1	24	2.01	14	12	-	14	14	10	-
6	Ca^{2+} (mgl^{-1})	49.6	83.8	85.8	30.3	49.6	48.8	85.8	101	53	61.4	42.1	48.7	45.4	60.6	57.2	47.9	41.2	-	58.9	60.8	58.9	-
7	Mg^{2+} (mgl^{-1})	14.1	35.6	20.4	32.6	30.1	6.82	26.6	14.5	31.5	11.8	12.4	9.77	26	23.5	17.8	8.3	8.5	-	32.3	39.9	38.1	-
8	T. H. (mgl^{-1})	182	356	299	210	248	150	324	312	262	202	156	162	222	248	216	154	138	-	280	316	304	-
9	T. A. (mgl^{-1})	214	187	226	262	412	206	436	455	298	271	126	140	290	222	226	128	102	-	244	326	224	-
10	Cl^- (mgl^{-1})	31.6	21.6	14.6	48.3	19	18.5	14	13	30	15	19	19	19	24	29.1	22	26	-	10	10.3	11	-
11	NO_3 - N (μgl^{-1})	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1103	1420	292	1434	1057	1237	1361	ND	ND	ND	ND	ND
12	TPP (μgl^{-1})	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1102	926	105	752	346	426	265	ND	ND	ND	ND	ND

DO = Disolved oxygen; T.H. = Total Hardness; T.A. = Total Alkalinity; TPP = Total Phosphate Phosphorous; ND = Not Done

Table 2. Physico-Chemical Features Of Paddy Field Soil

S.No.	Parameters	April				May				June						July			
		SI	*SII*	*SIV*	*SV*	*SI*	*SII*	*SIV*	*SV*	*SI*	*SII*	*SIV*	*SIVa*	*SV*	*SVI*	*SI*	*SII*	*SIV*	*SV*
1	pH	6.84	6.73	6.63	6.94	7.02	6.77	6.56	6.99	7.4	7.25	7.33	7.37	6.56	6.14	7.14	7.21	7.14	6.28
2	Conductivity ($mScm^{-1}$)	0.43	0.74	0.32	0.4	0.4	0.68	0.31	0.68	0.46	0.68	0.79	0.62	0.36	0.21	0.5	0.54	0.94	0.27
3	Moisture content (%)	15.4	14.3	15.4	14.1	15.8	14.3	15.3	14.5	13.8	24	16.8	13.4	21.7	13.2	14.9	17.9	16.8	14.4
4	Field capacity (%)	40.8	47.2	45.2	55.6	48	58	50	59.2	48.7	59.4	58.1	53.5	54	43.6	60.9	53.2	59.5	61.4
5	Loss on ignition (%)	9.53	12.2	10	11.1	17.5	18.8	11.7	13.6	18.1	22.1	20	30.9	24.4	3.2	19	23.1	22	24.8
6	TPP (mg/g)	510	2145	130	363	182	271	219	46	4408	3546	2442	407	210	565	1401	282	649	1404

Fig. 1. *Thaps canoriformis*

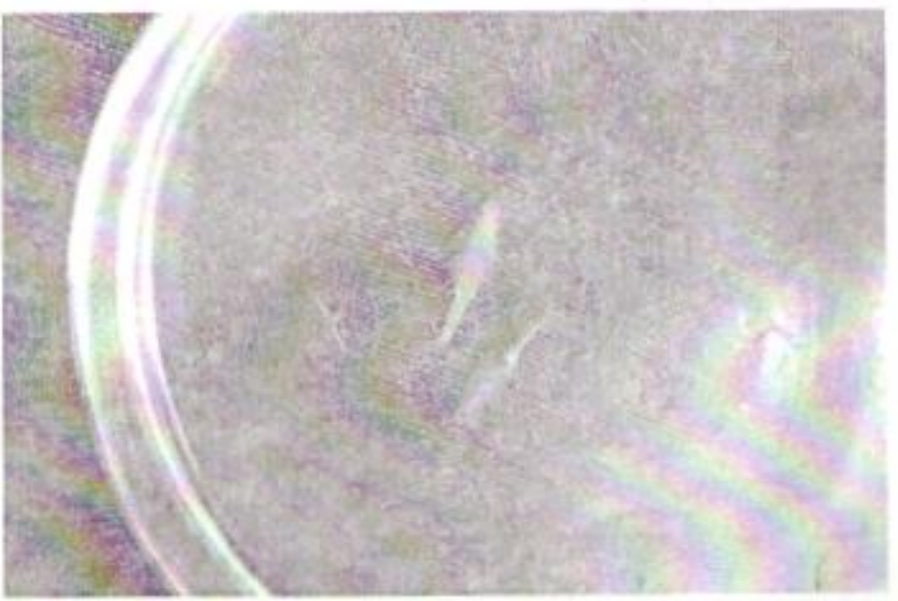

Fig. 2. *Branchionecta acanthopenes*

Table 3. Population Density (Individuals / m²) of *Triops cancriformis* and *Branchionecta acanthopenes*.

June	SI	SII	SIII	SIV	SIVa	SV	SVI
Triops cancriformis	-	-	-	-	-	-	18
Branchionecta acanthopenes	26	13.6	-	-	77.2	-	112.4

The pH values of the soils ranged from slightly acidic to neutral between 6.14 to 7.40. The conductivity values of soil samples were generally high ranging between 0.21mS/cm to 0.94 mS/cm. Field capacity was more than three times the values of moisture content. The organic mater increased from 3.20 % to 30.89 % from April to July in the paddy field soils. Total phosphate phosphorous of soils ranged between 46 µg/g at site V in May to 4408 µg/g at site I during June.(Table 2).

The macro-crustaceans appeared in the paddy fields from ending May to mid June. The macro-crustaceans were totally absent at site III, site IV and site V (Table. 3). *Triops cancriformis* (Fig.1) was present only at site VI (rural area) with 18 organisms/ m² area of paddy fields and was absolutely absent from all other sites. *Branchionecta acanthopenes* (Fig. 2) was found at four sites only with maximum density of 112.4 organisms/m² of paddy fields at site VI (rural area) and totally absent site III, IV and V. The species also showed variation in their colour with white (male) and red orange (female) in suburban areas (Fig. 2). While in the rural areas the species were white (male), blue and red orange (females) coloured, as observed by Czeczuga and Czerpak, (1970). (Table 1).

DISCUSSION

Paddy fields are man-made ecosystems subjected to continuous environmental fluctuations due to flooding / flushing of water and various agricultural practices (pesticides/fertilizers). Difference in temperature, hydrology and water chemistry may be reflected on local species composition and appearance as was also reported by Eder *et al.* (1997). During the present study macro-crustaceans appeared only when the water temperature was above 25°C. The water temperature showed gradual rise from April to July. Temperature in the major physical variable affecting the birth rate in nature (Edmondson,1956). The length of time from hatching to maturity is markedly influenced by temperature in the macro crustaceans. The pH of the water was within the range of 7.00-8.00 which is regarded as the best medium for the support diversified aquatic flora and fauna as also stated by Arnemoro (1964). The

lower conductivity values of 260 $mScm^{-1}$ was recorded at site IV-a and site VI in June where macro-crustaceans were present in greater abundance. The low levels can be attributed to the high consumption of food by the macro crustaceans as *Triops* were found in pools with high conductivities (Hamer and Martins, 1998).Dissolved oxygen concentration in water is dependant on a number of factors viz. temperature, salinity and decomposition activity (Reid and Wood, 1976). As the water level in paddy field is very shallow and continuous flushing of water occurs, the Dissolved oxygen concentration in paddy fields was very high (above 7 mgl^{-1}). In general D.O. touched the super saturation levels because of high algal growth, large surface area exposition and influx of irrigation water rich in D.O. concentration (Rather, 1987). Free carbon dioxide detected only when pH was below 8.60.Similar findings were reported by Reid (1961) in fresh waters. A water sample off all the sites exhibited high calcium values (30.27 mg/l to 100.92 mg/l) as was observed by Zutshi *et al.* (1980) in the waters of some Kashmir lakes. The magnesium remained generally low than calcium which may be due to uptake of this ion by plants in the formation of chlorophyll magnesium porphyrin metal complex and also in enzymatic transformation as has been reported by Wetzel (1975). *Triops* was found at site VI in rural area having the lowest total hardness values than other sites. *B. acanthopenes* was also seen to inhabit waters having lower hardness values. Total alkalinity appeared to be mainly of bicarbonate type due to the presence of high load of organic material (Mitchaell and Marshal, 1974). The minimum values at site I, II, V & VI (Table 1) were due to the active utilization of bicarbonates in the carbon assimilation by algae and other aquatic plants in paddy fields as also observed by Srivastava (1977). Site-VI recorded lower alkalinity values and represented both types of species. Chloride content was high at the sites where these crustaceans were present and is also attributive to the presence of organic matter of animal origin (Verma, 1969; Cole, 1983).Nitrate nitrogen and total phosphate phosphorous values were high except at site III due to addition of fertilizers and organic manure (cattle manure). According to Chen (1972) sediments add appreciable amount of NO_3-N to water. Due to increased content of NO_3-N and TPP the algal-communities were abundant in the field (Fujita and Nakahara, 1999; Rather, 1987) which served as food for macro-crustaceans. TPP values were generally low than NO_3-N values but site I had high TPP values which may be due to the domestic affluent from the nearby residential houses. Though NO_3-N values may be toxic to many vertebrates but it seems that crustaceans are well adapted to the high levels of NO_3-N.

Although these macro-crustaceans are fresh water organisms and spend their whole life cycle in water (Giudicelli and Thiery, 1998), analysis of soil samples was very important because of the fact that, these organism lay their eggs which can remain resistant for several years in the soil and another factor is the dispersal of egg by

wind and birds (Franzen, 1998) from one field to the other when the soil is dry. So physical and chemical properties of the rice field soils are very important so for as the presence, development and hatching of eggs in concerned (Shinokawa, 1997) and are influenced by the organic and inorganic source of nutrients (Thomas, 1997). The pH values of soil ranged from 6.14 to 7.40 and closely followed the pH of water and can be due to continuous flooding of soil with water (Crozier, 1999). *Triops cancriformis* was present only in slightly acidic soils while *Branchionecta acanthopenes* was present in both, slightly acidic to neutral soils. Though lowest conductivity was again recorded at site VI where both species were present. Mineralization of soil organic matter depends on temperature and moisture (Trasar *et al.*, 1999). Moisture content and field capacity did not show much variation from April to July and were in the ratio of Field capacity = 3 times Moisture content (Table 2). Soil desiccation increases egg floating and floating eggs have a higher hatching rate than sinking eggs (Shinokawa, 1997). Lowest values of moisture content, field capacity and organic carbon were recorded at sites where both the crustaceans occurred. The total phosphate phosphorous values increased from April to July as it is with the advancement in the age of plants, the phosphorus contents increases in the soil as a result of low uptake of nutrients by plants. The values for phosphorus were in fair agreement with the finding of Patnaik and Nanda (1969). The crustaceans were present in the soils having higher values of TPP.(Table 2).

Though various parameters of water and soil show their effect on the growth and development of macro-crustaceans, the parameters did not remain static due to the interference of man in these ecosystems and due to influx of irrigation water and periodic dressing of fields by fertilizers. During the present investigation macro-crustaceans were present in those soils in which organic compost (cattle manure) was added in higher quantities as was reported by Rishi (1976). Sites I, II and VI received more organic manure than other sites.

The macro crustaceans appeared in the fields in the first week of June in suburban areas and disappeared completely in the 3rd week. While in the rural areas they appeared in mid June as against the earlier investigation of finding them in April to May (Malhotra and Duda, 1970; Reshi, 1983.). In general the physico-chemical characters of water (Table 1) and soils (Table 2) of various sites appears to be getting reflected in the species composition and appearance /disappearance of the crustaceans as was shown also by Eder *et al.* (1997).

Triops cancriformis populations for isolated and are becoming rare in the paddy fields and are endangered. The *Branchionecta acanthopenes* is also becoming rare. The study showed that these crustaceans are rare and appear to be endangered as

also reported by Maier (1988) in Germany. He noticed that most populations of Branchiopods are isolated and close to extinction.

The crustacean becoming rare from the paddy fields may also be attributed to the continuous application of herbicides/pesticides for several years in the suburban paddy fields which have eliminated the species, as they are most sensitive to the insecticides (Mullie *et al.*,1997 and Lahr, 1998). Intercropping may also be the cause of disappearance of these crustaceans from the paddy fields, as intercropping is potential control of insect pests. Extermination of entire population may also occur by landfills, drainage, acidification, environmental toxins or even presence of predators in the paddy fields (Hamer and Martins, 1998).

Presently they are rare and threatened ones because of their weird appearance in the paddy fields and an intensive study including the effects of weedicides/pesticides, fertilizers and other causes such as presence of food and predators and their role in paddy fields is required to understand their cause of disappearance from these habitats.

ACKNOWLEDGEMENT

The authors are highly thankful to Head, P.G. Department of Environmental Sciences for providing all necessary facilities for the accomplishment of this work.

REFERENCES

A.P.H.A. 1998. *Standard methods for the examination of water & waste water (20th edition)*. American Public Health Asso. N.Y., U.S.A.

Arnemora, R. 1964. Limnilogical studies in Hyttodammen, I: physical and chemical conditions. *Rept. Inst. Freshw. Res. Drottningholm*, **45**:51-93.

Chen, P. 1972 Nitrification in lake segments. *J. Envoirn. Qual.* **1** (2):151-154.

Cole, G. A. 1983 *Text book of Limnology*. C.V. Mosby Company, Saint Louis.

Crozier, C. R. 1999. Nutrient and pH stratification with conventional and no till management. *Communication in soil science and plant analysis* **30** (1-2) : 65-74.

Czeczuga, B. and Czerpak, R. 1970. *Apus cancriformis* caratenoids (Crustacea: Branchiopoda). *Hydrobiologia* **35**: 163-173.

Das, S. M. 1970. On the new species of *Apus* (crustacea: Branchipoda) from Kashmir. *Ieth*,

10 (1-2):5-7.

Eder, E., Walter, H. and Goltwald, R. 1997. Distribution and phenology of large Branchipods in Austria. *Hydrobiologia 35 (0) Dec.* **30**:13-22.

Edmondson, W. T. 1956. The relation of photosynthesis by phytoplankton to light in lakes. *Ecology.* **57**:161-174.

Franzen, Ake 1998. Branchiopods crustacean in temporary waters. *Fauna oeh Flora* **93**(1): 1-8.

Fujita, Yuka and Nakahara, H. 1999. Seasonal variations of algal communities in the paddy water and air dried paddy soil. *Japanese journal of limnology 60 (1)* 67-76.

Giudicelli, J. and Alain Thiery 1998. Fauna of temporary ponds, its originality and value for the biodiversity of the Mediterranean continental waters. *Ecologia Mediterranean* **24**(2): 135-143.

Golterman, H. L. and Clymo, R. S. 1979. *Method for physical and chemical analysis of fresh-waters.* IBP Hand Book No. 8, Blackwell Oxford 166.pp.

Gupta, P. K. 2000. *Method in Environmental Analysis-water, soil and air.* Agrobios (India), Jodhpur.

Hamer, M. L. and Martins, K. 1998. The large Branchiopoda (crustacean) from temporary habitats of the Drakensberg region South Africa. *Hydrobiology* **384**(0) : 151 –165.

Lahr, Joost 1998. An ecological assessment of the hazard of right insecticides used in Desert Locust control to invertebrates in temporary ponds in the Sahel. *Aquatic Ecology 32 (2)*:153-162.

Maier, Gerhard 1998 The status of large Branchiopods (Anastraca, Notostraca, Conchostraca) in Germany. *Limnologia* **28** (2): 223-228.

Malhotra, Y. R. and Duda, P. L 1970 A new fairy shrimp, *Branchinecta acanthopenes* n.sp (Anostraca, Branchinectidae) from India. *Crustaceana*, **18** : 173-176.

Mackereth, F. J. H. 1963. Water Analysis for Limnologists. *Fresh water Biol Assoc. Sci. Pub.* No.21

Mitchall, D. S. and Marshell, B. E. 1974. Hydrobiological observations on 3 Rhodesian requirements of certain fresh water fishes. *Ecology.* **23**:319.

Mullie, W., Diallo, A., Baba, G. and Ndiaye, M. D. 1997. Environmental hazards of mobile ground spraying with Cyanophus and fenthion for Quelea control in Senegal. *Ecotoxicology and Environmental Safety* **43**(1):1-16.

Nath, S. 1980. Extension of range of *Triops cancriformis* (Bosc) (Branchiopoda, Notostraca, Apodidae) Poonch valley (Jammu & Kashmir state). *J. Bombay. Nat. Hist. Soc.*, **76**(3): 543-544.

Patnaik, S. and Nanda, B. B. 1969. Uptake nutrients in relation to growth of high yielding rice varieties under tropical conditions. *Ind. J. Agric. Sci.* **39**:341-352.

Rather, M. 1987. *Rice field ecology and effect of algalisation on some temperate rice varieties*. Ph. D. thesis University of Kashmir.

Reid, G. K. 1961. *Ecology of inland waters and estuaries*. Rienhold N.Y.

Reid, G. K. and Wood, R. D. 1976. *Ecology of inland waters and estuaries, seasonal*. D. Van. Nostrand and Co. N.Y.

Rishi, N. D. 1976. Record of two non-insect pests of crops. *J.Sci.K.Univ., 6(1-2)* Abst. Proc. Indian Sci. Cong. Part III, 62 & 63 session.

Rishi, N. D. 1983. Studies on the bioecological correlation of non- insect fauna of submountain ranges of the Kashmir valley. *Pro.WKshp. High Alt. Ent & Wildl. Ecol. Zool. Suv. India.*: 353-357.

Shinokawa, T. 1997. Effects of dry & wet soil conditions in hatching rate in Asian tadpole shrimp, *Triops granarius*. *Japanese Journal of Applied Entomology and Zoology* **41**(4): 237-239.

Srivastava, A. S. 1964. Non-insect pests. In: *Entomology in India*, Ent. Soc. India; pp. 437.

Srivastava, P. D. 1977. *Economic zoology*. Commercial Pub.House, New Delhi.

Sunita and Sumanjeet, K. 1999. *Laboratory manual for environmental chemistry*. S. Chand & Company Ltd. New Delhi.

Tiwari, K. K. 1972. Taxonomic status of two recently described branchiopoda from Kashmir, India. *Crustaceana*, **23** (3): 311-314.

Thomas, M. 1997. Physical and chemical properties of rice soils as influenced by organic and inorganic source of nutrients. *Indian journal of Agricultural Research* **31**(4): 257-261.

Trasar, C., Leiros, M. C. and Gilsotres, F. 1999. Dependence of minerlization of soil organic matter on temperature and soil moisture. *Soil Biology and Biochemistry* **31** (3): 227-335.

Verma, M. 1969. Hydrobiological studies of a tropical impoundment, Tekanpur reservoir, Gwalior, India, with respect to the breeding of Indian carps. *Hydrobiol.* **34**.Fasc:3-4.

Wetzel, R. G. 1975. *Limnology*: W.B. Saunders Co.

Zutshi, D. P. Subla, B. A., Khan, M. A. and Wanganeo, A. 1980 Comparative limnology of 9 lakes of Jammu and Kashmir Himalayas. *Hydrobiologia*. **72**(1-2): 101-112.