Seasonal variation in benthic macro-invertebrates and their correlation with the environmental variables in a freshwater stream in Garhwal region (India)

Parkash Chand Joshi[1], Ram Krishan Negi[1], Tarana Negi[2,*]

[1]*Department of Zoology and Environmental Sciences*, *Gurukula Kangri University*, *Hardwar* (*UA*) 249404, *India*; [2]*Department of Zoology*, *Govt. P. G. College*, *Jind* (*Haryana*)

Received November 29, 2007

Abstract

Seasonal changes in the pattern of abundance of benthic macro-invertebrates were studied and their correlation with various environmental variables was also estimated. Benthic faunal density was recorded maximum during winter months with Ephemeroptera as the most abundant order at all the sites followed by Plecoptera, Coleoptera, Diptera, Trichoptera, Megaloptera and Odonata. Level of species richness was found dependant on the abiotic factors like temperature, hardness, pH, dissolved oxygen, chlorides and phosphorus. [Life Science Journal. 2007; 4(4): 85 – 89] (ISSN: 1097 – 8135).

Keywords: macro-invertebrates; benthos; Hinval stream

1 Introduction

Stream macro-invertebrates have been used extensively for biomonitoring of numerous environmental stresses (Rosenberg and Resh, 1993) and thus have received considerable attention in the study of running water ecosystems (Cummins, 1992). They are sensitive to watershed conditions and exhibit sufficient stability in assemblage structure over time to make them useful as long-term monitors of stream health (Richards and Minshell, 1992) and indicators of water quality (Resh, 1995; Gauffin and Tarzwell, 1952; Wilhm and Dorris, 1968). Hynes (1960) opined that the density of benthos in a water body is a useful index of water quality although density may fluctuate widely with changes in the seasons.

There is practically no data available on limnobiotic components of contributing tributaries of Ganga River from Garhwal region and whatever is reported is fragmentary (Sharma *et al*, 1990; Singh, 1991; Nautiyal, 1986). Considering above facts, present study on seasonal variation of benthic invertebrates and their relation with environmental variables from Hinval freshwater stream in Garhwal region of Uttarakhand, India, was undertaken.

2 Materials and Methods

The benthic macro-invertebrates were sampled every month from March, 2005 to February, 2007 at three selected sites of the stream and fourth sample was collected from Ganga River water at Shivpuri to compare and evaluate the benthic macro-invertebrates seasonal variation. Benthic macro-invertebrates were collected by enclosing one square meter area of stream bottom at each site with square meshed cloth. The bottom stones and gravel were upturned to dislodge the aquatic life. Each animal was then brush picked and preserved in 5% formaline and were identified according to Ward and Whipple (1992), APHA (1998) and Pennack (1978) up to the genera level.

Species richness has been calculated on the basis of number of species available at each site. By using the method of least squares and Karl Pearson, the regression equation, coefficient of correlation and standard devia-

*Corresponding author. Tel: 09837-349206; 01334-245940; Email: negi_gkv@rediffmail.com

tion values between species richness and abiotic factors were calculated using SPSS (version 10).

3 Results

During the period of study, a total of 29 genera belonging to 7 orders of benthic fauna were recorded. The most abundant order having maximum number of genera recorded was Ephemeroptera at each site followed by Plecoptera, Coleoptera, Diptera, Trichoptera, Megaloptera and Odonata. *Baetis* and *Stenonema* sps (Ephemeroptera), *Acronuria* sps (Plecoptera) and *Psephenus* sps (Coleoptera) were found to be very common at all sites. Figures 1, 2, 3 and 4 postulate the seasonal variation of benthos for the period of study at each site. From the above observations, it is inferred that maximum number of genera in each order were recorded during the winter months followed by summer and monsoon seasons.

The correlation between species richness *vs*. abiotic factors for each site have been presented in Table 1. A strong negative correlation between species richness and environmental factors like water and air temperature at

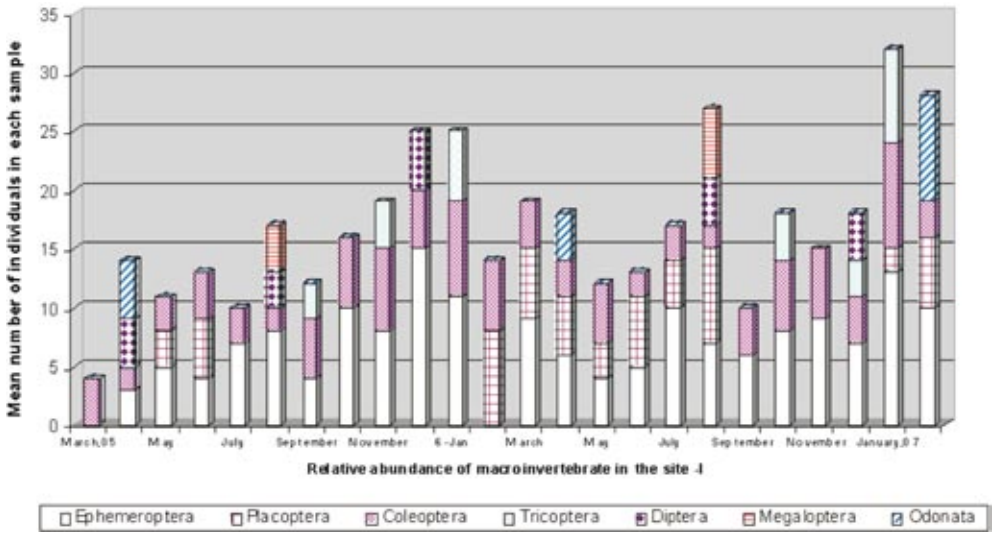

Figure 1. Relative abundance of macro-invertebrates in Hinval freshwater stream at site I of Garhwal region at Uttarakhand, India.

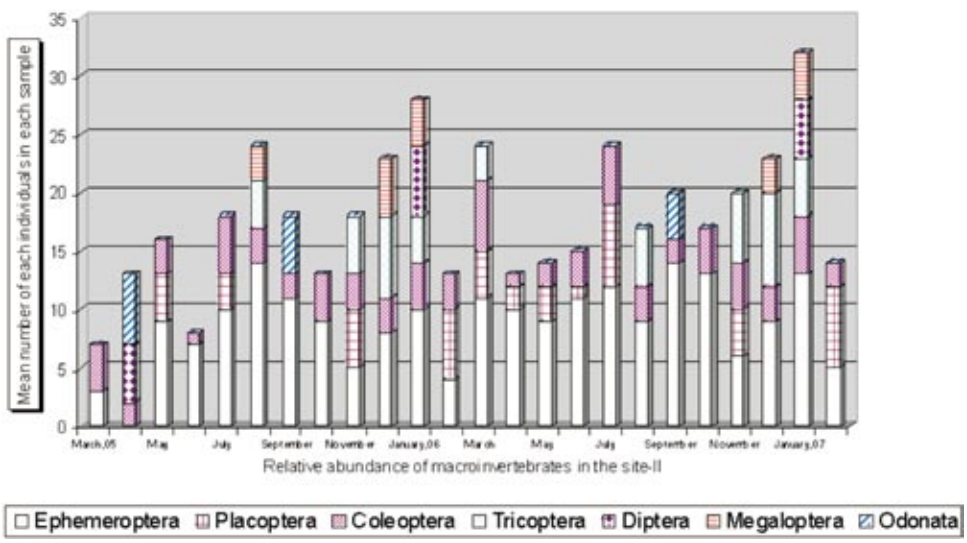

Figure 2. Relative abundance of macro-invertebrates in Hinval freshwater stream at site-II of Garhwal region at Uttarakhand, India.

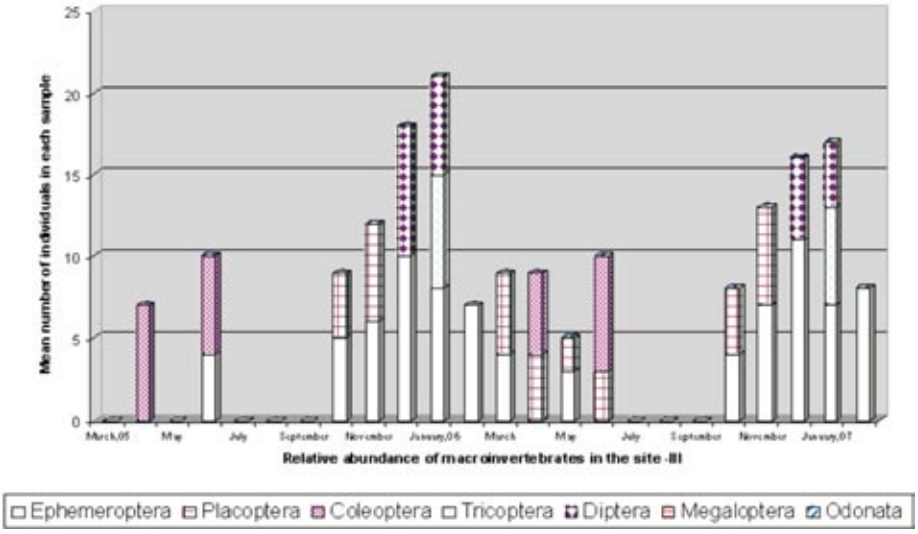

Figure 3. Relative abundance of macro-invertebrates in Hinval freshwater stream at site-III of Garhwal region at Uttarakhand, India.

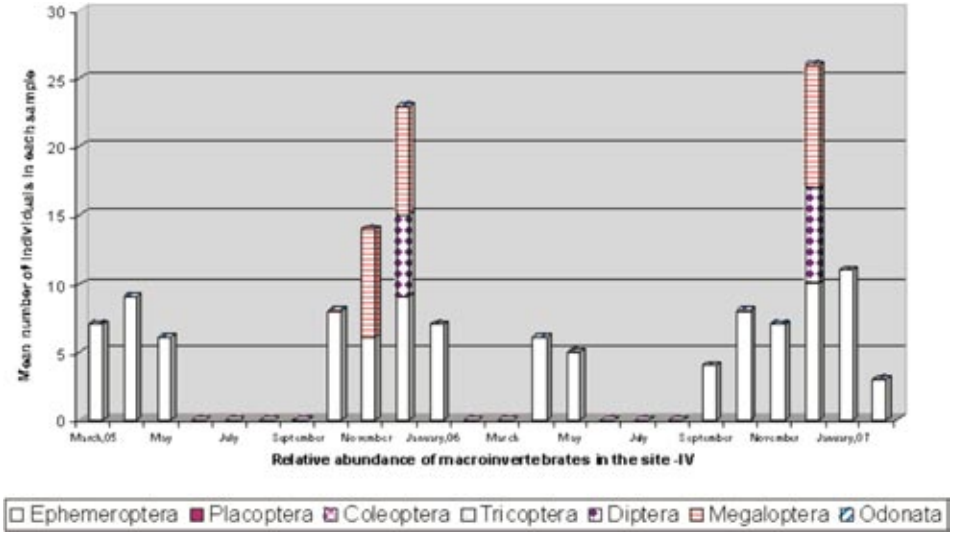

Figure 4. Relative abundance of macro-invertebrates in Hinval freshwater stream at site-IV of Garhwal region at Uttarakhand, India.

site-I ($r = -0.539^{++}$, $r = -0.567^{**}$) and site-III ($r = -0.608^{**}$, $r = -0.574^{**}$) was found. At site-II, a moderate negative correlation between these factors ($r = -0.468^{*}$, $r = -.0437^{*}$) was recorded. pH showed moderate negative correlation at site-III ($r = -0.456^{*}$) and site-IV ($r = -0.410^{*}$), however, a strong positive correlation between species richness and hardness at site-I ($r = +0.673^{**}$) and site-IV ($r = +0.583^{**}$) and with chlorides at site-III ($r = +0.554^{**}$) was observed. Phosphorus has strong negative correlation with species richness at site-IV ($r = -0.527^{**}$) and dissolved oxygen showed a positive correlation at site-III ($r = +0.695^{**}$) and site-II ($r = +0.436^{*}$). Free CO_2, TDS, alkalinity and nitrates did not show any correlation with species richness.

4 Dicussion

The maximum density of benthic fauna was observed during winter months, this can be related to the availability of phytoplankton population in the form of food supply as also observed by Joshi *et al* (1996) on Ganga

Table1. Species richness *vs*. abotic factors of Hinval freshwater stream in Garhwal region

Correlation	Parameters												
	Water temp (°C)	Air temp (°C)	pH	Dissolved oxygen (mg/l)	Free CO_2 (mg/l)	Total hardness (mg/l)	Calcium (mg/l)	Magnisium (mg/l)	TDS (mg/l)	Alkalinity (mg/l)	Chlorides (mg/l)	Phosphates(mg/l)	Nitrates (mg/l)
Site-I													
Correlation coefficient	– .539**	– .567**	– .122**	.357	– .284	– .308	.673**	– .268	– .050	.261	.021	.004	.075
Standard deviation	5.225	6.832	0.520	1.514	0.740	41.46	15.810	9.841	25.735	37.245	3.156	0.274	0.252
Mean	20.08	26.95	8.33	9.89	0.25	172.18	33.86	20.77	133.15	178.23	9.33	0.50	0.38
Range	12.0 – 28.0	17.0 – 40.0	7.5 – 9.2	7.3 – 12.17	0.0 – 2.3	107.5 – 269.0	12.02 – 69.07	9.98 – 47.5	94.5 – 180.02	110.0 – 227.5	4.54 – 16.68	0.1 – 0.92	0.025 – 0.90
Site-II													
Correlation coefficient	– .468*	– .437*	.051	.436*	– .208	– .427*	.448	– .366	– .118	– .071	.152	.071	.00
Standard deviation	4.950	7.672	0.610	1.574	0.383	39.783	13.493	12.609	26.835	51.339	3.179	0.286	0.231
Mean	20.25	28.02	8.25	9.49	0.1	168.56	29.97	21.77	139.17	172.29	9.44	0.459	0.367
Range	12.6 – 28.0	17.4 – 44.0	7.0 – 9.1	7.2 – 12.9	0.0 – 1.2	116.0 – 258.5	12.41 – 58.5	6.57 – 50.92	103.3 – 194.7	71.0 – 242.3	3.83 – 16.1	0.06 – 0.92	0.01 – 0.8
Site-III													
Correlation coefficient	– .608**	– .574**	– .456*	.695**	– .257	– .321	.221	– .350	– .315	.244	.554**	.053	.234
Standard deviation	6.071	6.887	0.840	1.319	1.221	9.432	11.279	11.913	28.716	49.551	4.572	0.313	0.214
Mean	18.54	25.87	8.33	9.25	0.56	139.99	28.54	15.33	110.544	137.63	11.62	0.48	0.33
Range	7.0 – 29.0	12.0 – 39.0	7.2 – 10.3	7.4 – 12.06	0.0 – 3.64	94.0 – 244.0	12.61 – 47.1	3.4 – 42.13	72.5 – 174.8	37.5 – 215.0	3.82 – 18.2	0.07 – 0.96	0.02 – 0.73
Site-IV													
Correlation coefficient	– .065	– .156	– .410*	.283	– .054	.583**	.044	.448*	.344	.134	.325	– .527**	– .009
Standard deviation	5.108	8.410	0.900	2.299	1.713	28.541	6.782	5.957	24.642	32.606	3.480	0.339	0.175
Mean	14.62	23.41	8.21	10.56	1.28	85.48	19.62	8.88	73.68	102.5	7.57	0.41	0.28
Range	6.0 – 21.0	11 – 44.0	7.3 – 10.0	8.3 – 16.7	0.0 – 4.9	60.0 – 165	7.61 – 30.72	2.92 – 21.53	37.7 – 27.5	57.5 – 180	2.13 – 15.1	0.02 – 0.93	0.02 – 0.6

**Sigificant at 0.01 level; *Significant at 0.05 level

River. On the other hand decline in the density of benthic fauna during monsoon months may be due to increase load of suspended solids, reduced transparency and increased water flow. Similar findings have also been observed by many workers (Donald *et al*, 1982; Duffield and Nelson, 1993).

Relationship between macro-invertebrate community structure and environmental variables has been the subject of numerous investigations (Tate and Heiny, 1995; Wright *et al*, 1984; Omerod, 1987; Gower *et al*, 1994). Poff and Ward (1989) identified streamflow variability as a major factor affecting other abiotic and biotic factors that regulate lotic macrozoobenthic patterns.

Brown and Brown (1994) and Richards *et al* (1993) suggested that many variables, including conductivity, dissolved oxygen, pH, current velocity, substrate type, depth and water temperature affect the invertebrate production in response to changes in flow regime.

Hynes (1970) had discussed in general the changes in faunal composition with longitudinal distance in lotic ecosystems and also mentioned oxygen, temperature and nature of substratum as possible contributor to this change.

Pires *et al* (2000) concluded that some of the environmental variables like temperature, conductivity, depth and width influenced the invertebrate distribution and abundance within the Guadiana River Basin. They also reported that Ephemeroptera and Plecoptera were found most abundant at the sites where water quality was good and conditions were acceptable as these groups are sensitive to water quality as contrast to the group Diptera which was associated with poor water quality as they are more resistant to pollution, also observed by Depiereux *et al* (1983). During the present study, most abundant orders recorded are Ephemeroptera and Plecoptera at all sites which indicate good water quality as well as favourable conditions for biotic communities which is in line with the above observation. It is thus concluded that the level of species richness is dependent on the abiotic factors like temperature, hardness, pH, chlorides, phosphorus and dissolved oxygen. However, the importance of habitat types, pollution, biotic factors and anthropogenic activities can not be ruled out.

References

1. APHA. Standard Methods for the Examination of Water and Waste Water. 20th Edition. American Public Health Association. 1998.
2. Brown AJ, Brown KW. Distribution of insects within riffles of streams. Freshwat Invert Biol 1994; 3: 2 – 11.
3. Cummins KW. Invertebrates. In Calow P, Petts GE (eds). The Rivers Handbook. Blackwell Science, Oxford. 1992; 234 – 50.
4. Depiereux E, Feytmans E, Micha JC. Utilisation critique de l'analyse en composantes principales et du cluster analysis pour la description d'échantillons d'invertébrés benthiques en eau douce. Oikos 1983; 40: 81 – 94.
5. Donald JO, Jones RN, Moughan OE. Species composition and relative abundance of benthic invertebrates in Glover Creek, Southeast Oklahoma. Proc Okla Acad Sci 1982; 62: 18 – 21.
6. Duffield RM, Nelson CH. Seasonal changes in the stonefly (Plecoptera), copmponent of the diet profile of trout in Hunting Creek, Maryland, USA. Aquat Insects 1993; 15: 141 – 8.
7. Gaufin AR, Tarzwell CM. Aquatic invertebrates as indicators of stream pollution. Pub Health Rep 1952; 67: 57 – 64.
8. Gower AM, Myers G, Kent M, Foulkes ME. Relationships between macroinvertebrate communities and environmental variables in metal contaminated streams in south-west England. Freshwat Biol 1994; 32: 199 – 221.
9. Hynes HBN. The Biology of Polluted Waters. Liverpool University Press, Liverpool. 1960.
10. Hynes HBN. The Ecology of Running Waters. University of Toronto Press, Toronto. Canada. 1970.
11. Joshi BD, Bisht RCS, Joshi N, Singh R. A study of planktonic and benthic components of three selected tributaries of river Ganga between Devprayag and Rishikesh. Him J Env Zool 1996; 10: 23 – 6.
12. Nautiyal P. Studies on the riverine ecology of the torrential waters in Indian uplands of the Garhwal region.3. Flowristic and Faunistic Survey. Trop Ecol 1986; 27:157 – 65.
13. Omerod SJ. The influence of habitat and seasonal sampling regimes on the ordination and classification of macroinvertebrate assemblages in the catchment of the river Wye, Wales. Hydrobiologia 1987; 150: 143 – 51.
14. Pennack RW. Freshwater Invertebrates of United States. John Wiley and Sons, New York. 1978.
15. Pires AM, Cowx IG, Coelho MM. A benthic macroinvertebrate community of intermittent streams in the middle reaches of the Guadiana Basin (Portugal). Hydrobiologia 2000; 435: 167 – 75.
16. Poff NL, Ward JV. Implications of streamflow variability and predictability for lotic community structure: a regional analysis of streamflow patterns. Can J Fish Aquat Sci 1989; 46: 1805 – 17.
17. Resh VH. Freshwater macroinvertebrates and rapid assessment procedures for water quality monitoring in developing and newly industrialized countries. In Davis WS, Simon TP (eds), Biological Assessment and Criteria. Lewis Publishers, England. 1995; 167 – 77.
18. Richards C, Minshall GW. Spatial and temporal trends in stream macroinvertebrate species assemblages: The influence of watershed disturbance. Hydrobiologia 1992; 241: 173 – 84.
19. Richards C, Host GE, Arthur JW. Identification of predominant environmental factors structuring stream macroinvertebrate communities within a large agricultural catchment. Freshwat Biol 1993; 29: 285 – 94.
20. Rosenberg DM, Resh VR. Freshwater Biomonitoring and Benthic Invertebrates. Chapman and Hall, New York. 1993.
21. Sharma RC, Gausain OP, Juyal CP. In: River Pollution in India (Ed) Trivedi RK, Ashish Publ. House, New Delhi II. 1990.
22. Singh HR. In: Advances in Limnology. Narendra Publ. House, New Delhi. 1991; 322.
23. Tate CM, Heiny JS. The ordination of benthic invertebrate communities in the South Platte River Basin in relation to environmental factors. Freshwat Biol 1995; 33: 439 – 54.
24. Ward HB, Whipple GC. Freshwater Biology (second edition) (ed. Edmondso WT). International Books and Periodicals Supply Service, New Delhi. 1992.
25. Wilhm JL, Dorris TC. Biological parameters for quality criteria. Bioscience 1968; 18: 477 – 81.
26. Wright JF, Moss D, Armitage PD, Furse MT. A Preliminary classification of running water sites in Great Britain based on macroinvertebrate species and the predition of community type using environmental data. Freshwat Biol 1984; 14: 221 – 56.