JoTT Communication 4(9): 2875–2882

Evaluation of macrobenthic fauna in hill stream environment of Western Himalaya, India

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Date of publication (online): 26 August 2012
Date of publication (print): 26 August 2012
ISSN 0974-7907 (online) | 0974-7893 (print)

Editor: Humphrey Smith

Manuscript details:
Ms # o2725
Received 07 March 2011
Final received 27 June 2012
Finally accepted 02 July 2012

Citation: Sharma, I. & R. Dhanze (2012). Evaluation of macrobenthic fauna in hill stream environment of Western Himalaya, India. *Journal of Threatened Taxa* 4(9): 2875–2882.

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Author Contribution: The study: Both authors conducted the present study. Current paper: IS worked out for the frame work of paper and writing of mss; RD worked out for the writing and statical analysis of the mss.

Acknowledgments: The authors are grateful to Dr. K. Venkataraman, Director, Zoological Survey of India, Kolkata and Dr. A.K. Sidhu, Offiicer-in-charge, HARC, Zological Survey of India, Solan (H.P.) for facilities and encouragement. We are thankful to State Council for Science and Technology and Environment, Shimla and Director-cum-chief Warden Fisheries, Bilaspur (H.P.) for financial grant to conduct the study. We are also thankful to Dean College of Veterinary and Animal Science, CSKHPKV, Palampur for the facilities. The authors are thankful to the reviewers for useful suggestions.

Abstract: The purpose of this study is to evaluate seasonal occurrence of macro-benthic fauna in the tributaries of river Beas. The seasonal diversity of macrobenthic fauna was calculated in relation with physico-chemical parameters which revealed that benthic diversity is largely controlled by temperature, water current and volume of water. The width and depth of the streams exhibited an inverse relation with benthic fauna. An inverse relation between temperature and benthos was recorded at the sites located at higher elevation whereas a direct relation was inferred at the lower elevation. The peak of benthic fauna was recorded during winter season at all sampling sites. The benthic fauna was mainly represented by eight groups out of which four are highly distributed at all the sites among which Ephemeroptera were most dominating taxa in the River. Simple correlations were applied for benthos and abiotic factors, which revealed that water temperature, dissolved oxygen, alkalinity, depth and width influenced the invertebrate's distribution and abundance.

Keywords: Abundance, altitude, benthos, species diversity.

INTRODUCTION

The benthic fauna forms an important source of food for fish and exhibits a remarkable diversification in their assemblage and life cycles especially in upland waters. It is mainly influenced by the abiotic factors and helps significantly in the estimation of the production potential of aquatic ecosystem. It converts the organic detritus into invertebrate biomass, which provide direct food energy to the fishes. Though an appreciable amount of literature on benthic fauna is available from fresh water of Indian subcontinent (Singh & Singh 1996; Srivastava & Singh 1996; Singh 1997; Srivastava & Desai 1997), works reported from upland waters of Himachal Pradesh are scattered in nature (Sehgal 1983; Kumar 1987; Dhanze et al. 1998, 2001). The hill streams comprise many sub habitats from rapids to slow flowing, which influence the diversity of benthic fauna. Thus, the present study attempts to determine the seasonal distribution of macro benthic fauna in different tributaries of Beas drainage system as it contains diversified fish fauna.

MATERIAL AND METHODS

The five snow-fed northern tributaries of Beas drainage system were selected for the present study from 2007 to 2008. A total of 20 sampling sites (Fig.1) were selected, three on Dehar stream (Kotla, 360msl; Dehar bridge, 340msl and Har Village, 300msl), three on Gaj (Rajol, 550msl; Lunj, 340msl and Jarpal-Bassa 240msl), six on Banner

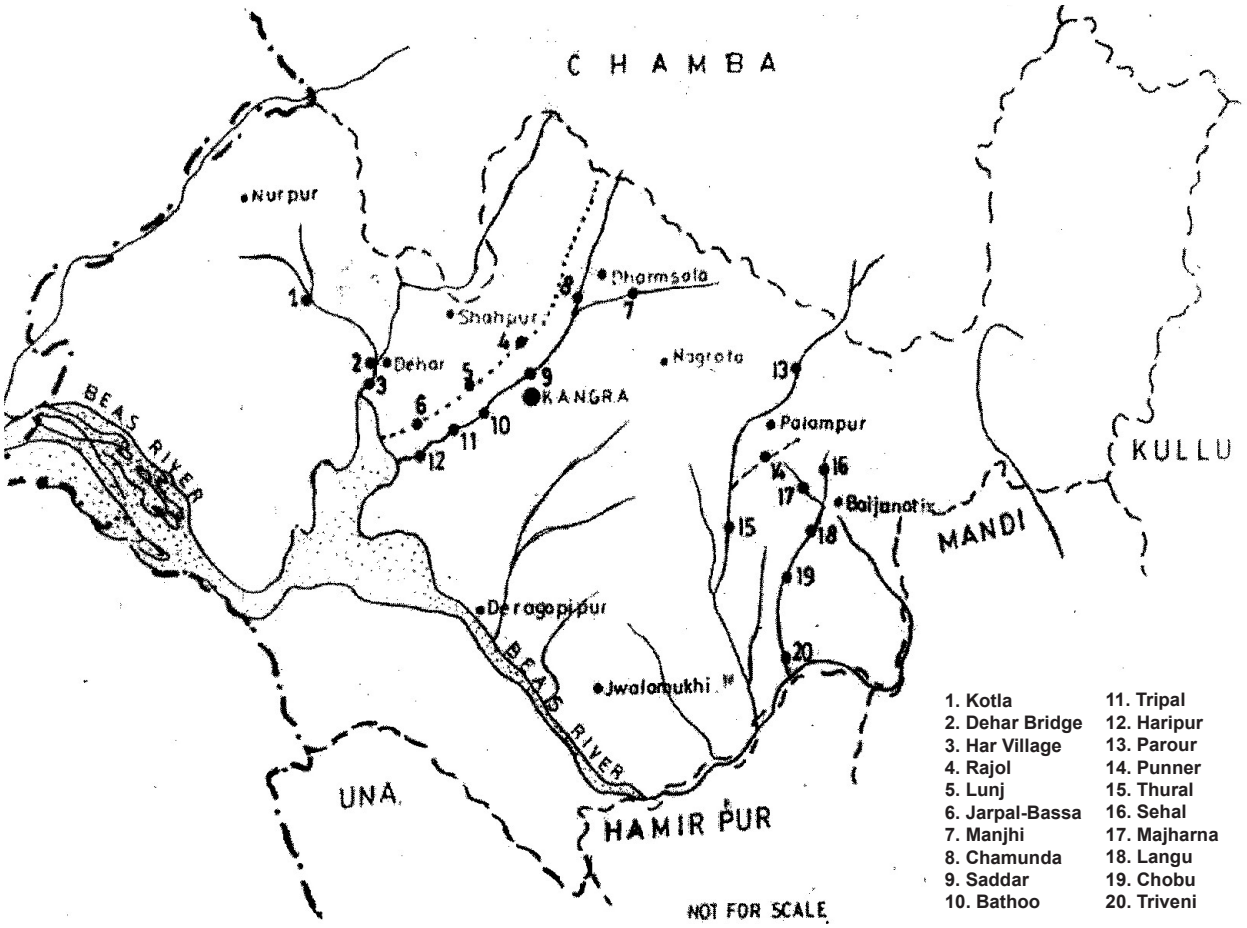

Figure 1. Sampling sites in the streams of Beas River

(Chamunda, 900msl; Manjhi, 600msl; Saddar, 490msl; Bathoo, 275msl; Tripal, 250msl and Haripur, 210msl), three on Neugal (Parour, 800msl; Punner, 650msl; Thural, 350msl) and five on Binwa (Sehl, 890msl; Langu, 810msl; Majharna, 790msl; Chobu, 540msl and Triveni, 390msl). These sites are located between upstream and its confluence with Beas and sampling was done in every month from March 2007 to February 2008. Benthos, mud and stone samples were collected by dredging one square meter area and were sieved through a metallic gauge and transferred to enameled trays for sorting and separation of individual organisms from debris and stones. The faunal elements were fixed in 4% formalin for further investigations. Identification of benthic organisms is based on the publications of Ward & Whipple (1959) and of Subramanian & Shivaramakrishnan (2005). The abiotic factors pH, dissolved oxygen, free carbon dioxide, alkalinity, hardness, chloride were estimated by following standard methods APHA (1985) and simple product-moment correlation was applied for benthos and abiotic factors. Simpson's diversity index (1949) was applied for calculation of species richness and species diversity. Data were analyzed statistically by calculating correlation coefficients (r) and applying student t test at 5% level of significance.

RESULTS

Dehar Stream

The maximum number of individuals per square meter of water was reported during winter except at Kotla (Fig. 2). The lowest population was reported during rainy season due to change of substratum. The dominating group was Ephemeroptera which showed its existence throughout the year with few exceptions and it varied from 28.8 to 88% of total benthos at various sites of this stream (Fig. 3). The next dominating group was Diptera, reported throughout the study period and the percentage of this group varies from 13 to 52% of total benthos at different sampling sites. The peak

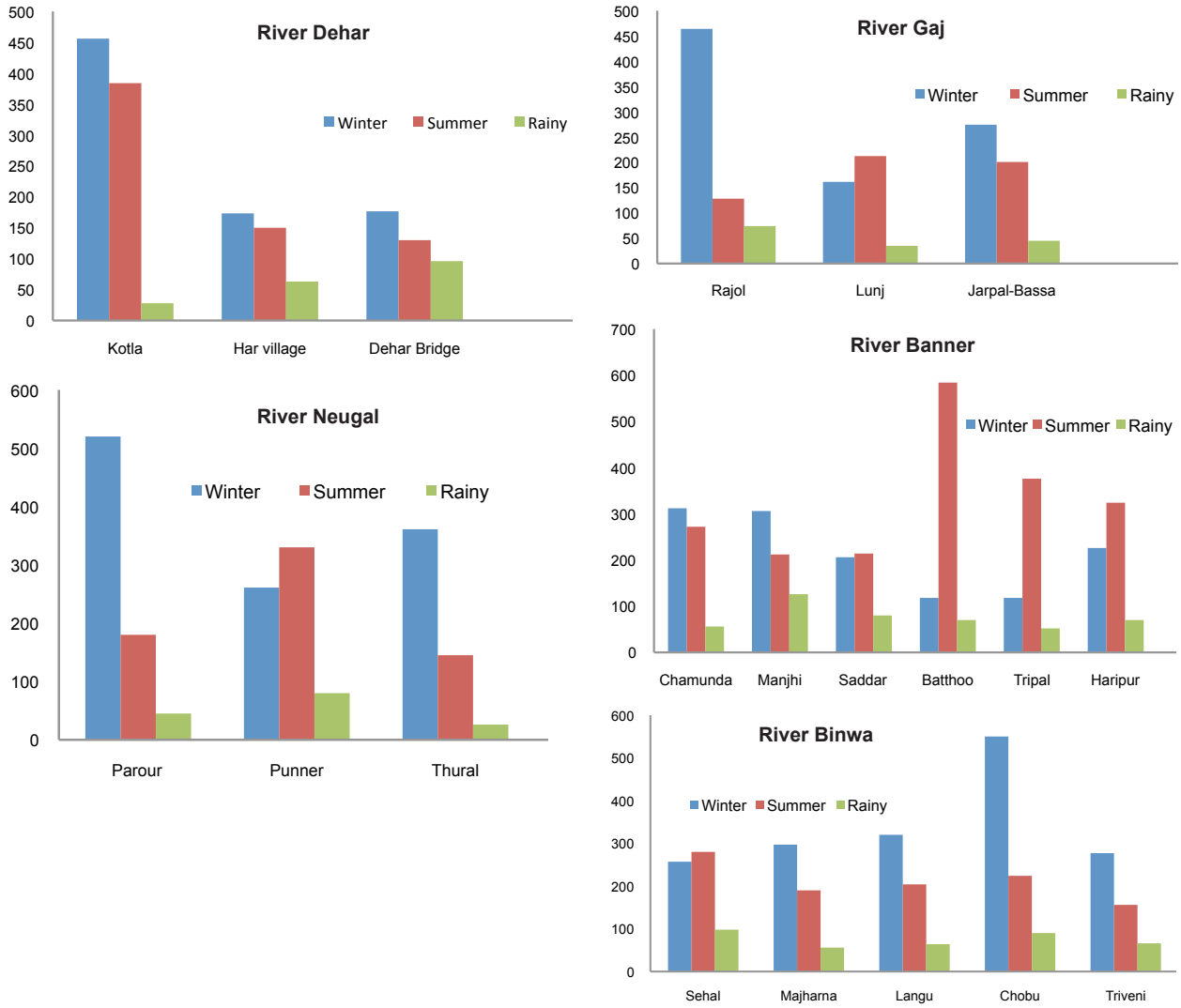

Figure 2. Seasonal variation of macrobenthic fauna in different tributaries of river Beas

population of Diptera was recorded during summer at all the sites, except at Har Village where overall population of this group was also less (Fig. 4.). The co-dominating group was Trichoptera, its population was high (6.5 to 29% of total benthic fauna) during winter but was found absent in summer except at Kotla. The Coleoptera were mainly noticed during the winter season and constituted 0.76 to 24.74% of total benthic fauna at Har Village site, but were rare at other two sites. The Odonata were reported only from Dehar Khud Bridge during rainy season. The benthic population of this stream exhibited a positive and significant correlation with dissolved oxygen (r = +0.88) but negative and statistically non significant correlation with water temperature (r = -0.52), alkalinity (r = -0.305), average depth of the stream (r = -0.45) whereas significant correlation with average width of the stream (r = -0.706) and water velocity (r = -0.83) (Table 1).

Gaj Stream

The total number of individuals per square meter of water was high during the winter season at all the sites, though Lunj and Rajol were comparatively rich in macrobenthic fauna (Fig. 2). The Ephemeroptera was the dominating group and varied from 32 to 80% of total benthos at all the selected sites (Fig. 3). This revealed the richness of Ephemeroptera at Lunj and its maximum was recorded during the summer season, except at Rajol where maxima were noticed during winter and rainy seasons. The Diptera were the next dominating group and varied between 12 to 60% of total benthos at all the selected sites (Fig. 4). Thus, it is inferred that Rajol is a polluted site, being rich in

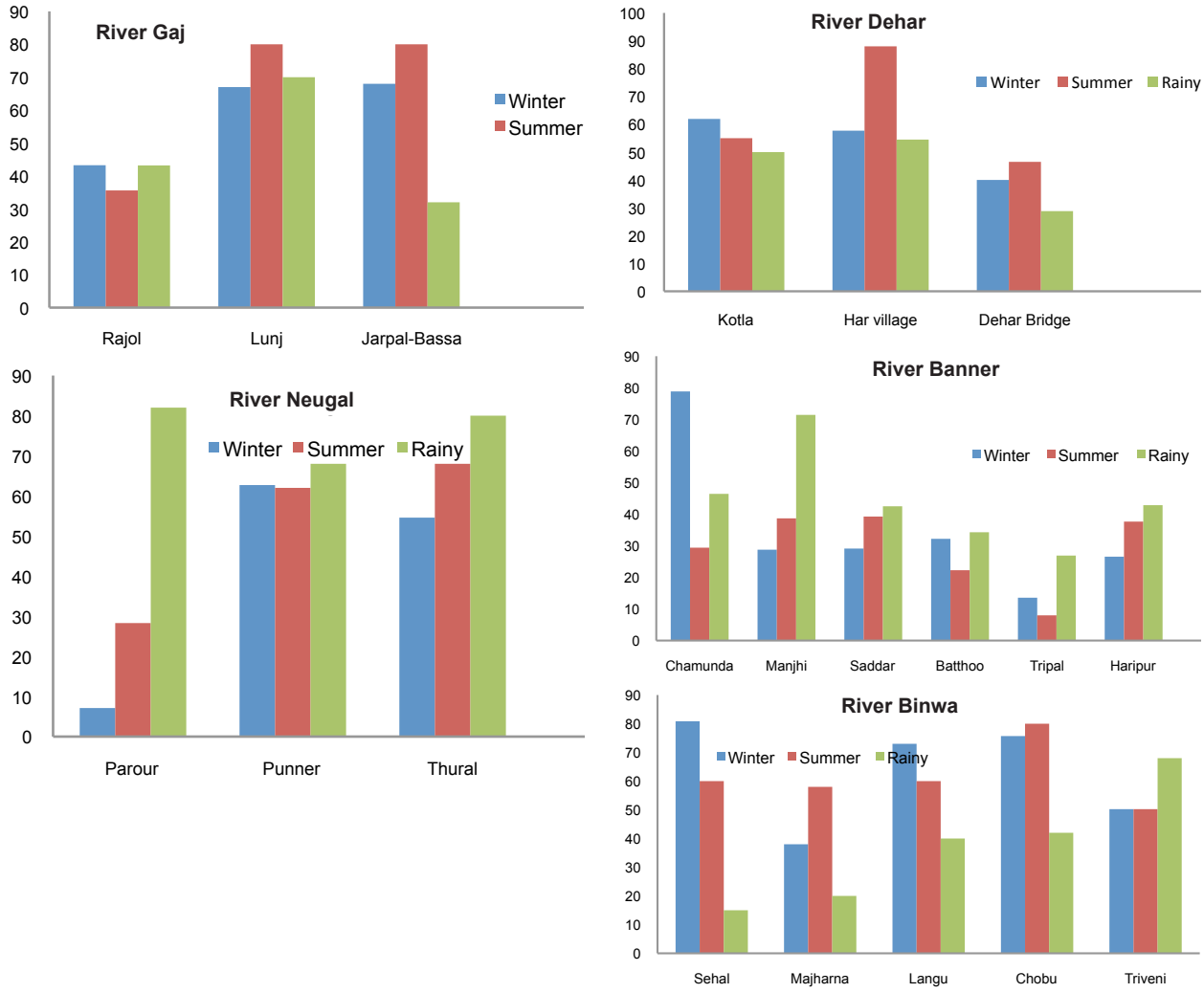

Figure 3. Seasonal variation in the percentage of Ephemeroptera in different tributaries of river Beas

Diptera. The maxima of this group were recorded in different seasons at different sites. The Trichoptera, a co-dominating group were reported mainly during winter season, except at Rajol, and the population varied between 2 to 14.49% of total benthos. Another co-dominating group were Coleoptera and the population was also noticed during winter months only except at Lunj. The benthos population of this stream inferred a positive and significant correlation with dissolved oxygen (r = +0.82) but negative and significant relation with average width of the stream (r = - 0.86) but non significant with water temperature (r = -0.57), alkalinity (r = -0.29), average depth of the stream (r = -0.22) and water velocity (r = -0.52) (Table 1).

Banner Stream

This stream showed an altitudinal variation in total number of individuals per square meter of water. As a result the winter peak was noticed upstream, whereas the summer peak was observed downstream (Fig. 3). The maximum number of individuals was recorded from Bathoo during summer and minimum from Chamunda and Tripal during rainy season. The percentage of Ephemeroptera in total benthic population varied from 14.74 to 72.57% of total benthic population at various sampling sites (Fig. 3). Thus, it depicted richness of Ephemeroptera at Tripal and their maximum number was observed in summer at all the sites except at Manjhi. The next dominating groups were Diptera which vary in relation to total benthic fauna from 7.98 to 78.85% of total population of benthos at different sites (Fig. 4). Further, Chamunda and Manjhi were

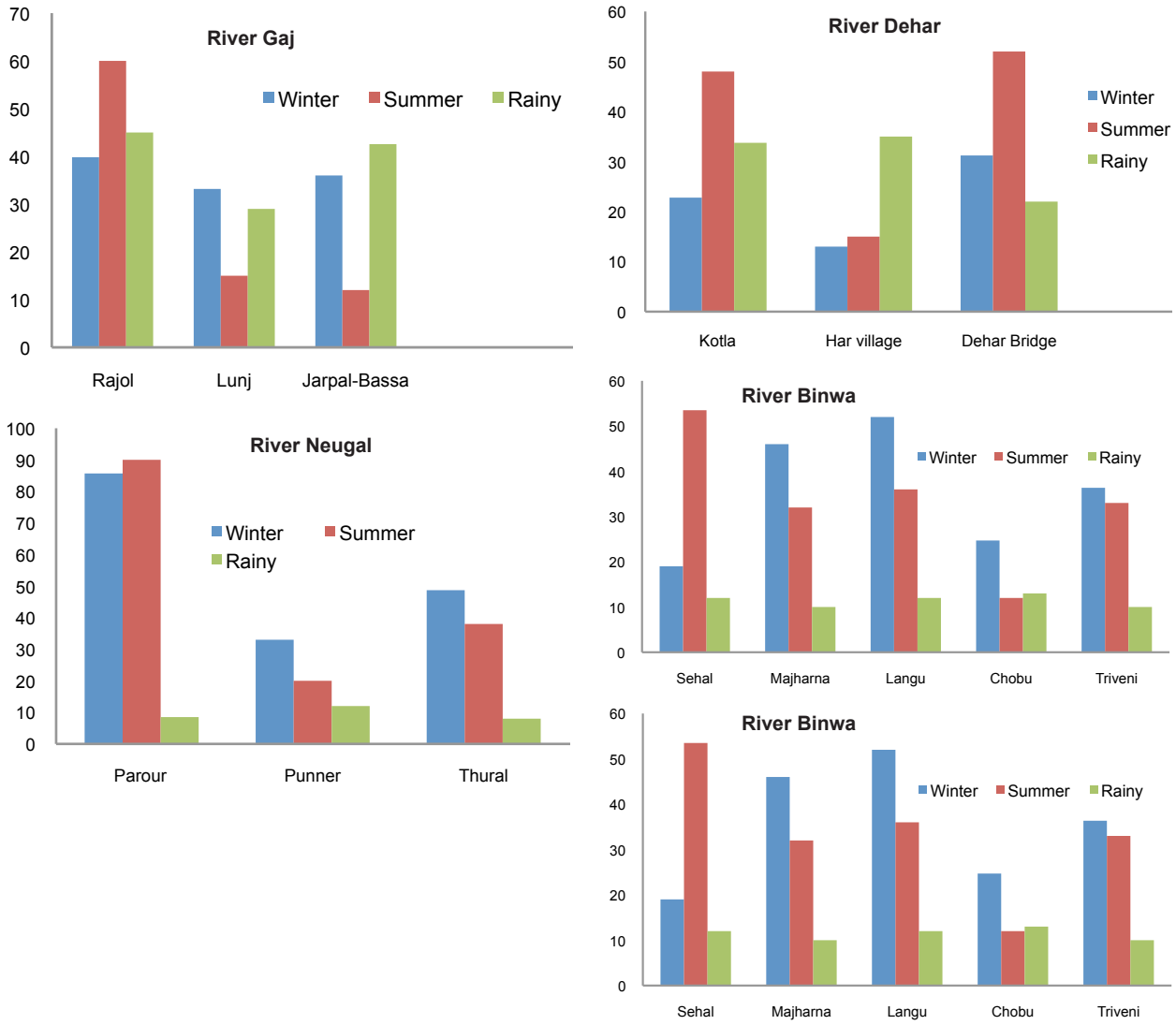

Figure 4. Seasonal variation in the percentage of Diptera in different tributaries of river Beas

richer in Diptera populations and minimum numbers were noticed at Tripal. The maxima of this group were reported during rainy season at all the sites except at Chamunda. The Trichoptera, a co-dominating group, were reported almost in all the seasons except at Haripur and Manjhi where their existence was reported during summer and winter months respectively. Coleoptera were reported only from Haripur, Saddar and Manjhi in different seasons. Their population was less at Haripur i.e. 1–2 % whereas maxima were noticed at Saddar (1–5.6 %) in winter. Gastropoda were observed in summer season at Saddar and Chamunda, but in winter and summer at Haripur, and constituted 0.78 to 3.4% of total benthic fauna. The Odonata were seen only at Tripal and Bathoo during winter season but their maximum population was reported from Tripal where it formed 0.16 to 40% of total benthos. The total population of benthos exhibited a positive and significant correlation with dissolved oxygen (r = +0.62) but non significant with alkalinity (r = +0.46). The negative and significant correlation has been noticed for average width of the stream (r = -0.86) and water velocity (r = -0.65) whereas non significant relationship with water temperature (r = -0.15) and average depth of the stream (r = -0.51) (Table 1).

Neugal Stream

The benthic fauna of this stream showed the highest population at Parour during winter and decreasing trends were recorded down stream (Fig. 2). Another winter peak was observed at all the sites except at Punner. The lowest number of benthos

Table 1. Abiotic factors of different tributaries of river Beas and their correlation with the benthos

	Parameters					
	Water temperature ^{0}C	Dissolved oxygen (mg/l)	Alkalinity (mg/l)	Water velocity (m/s)	Avg. depth (cm)	Avg. width (m)
Dehar						
Range	13.7–24.3	7.8–13	50.3–63.3	-1.83	53.3 – 62	41.67 – 78.67
Mean	19.56	10.1	55.81	1.38	55.78	53.3
Correlation	**-0.51855**	**0.883306**	**-0.30488**	**-0.83553**	**-0.45883**	**-0.70632**
T-STAT	1.91776	5.958343	1.633	1.01231	3.15523	4.80879
Gaj						
Range	17–25. 3	8.2–15	48.67–64.8	0.87–1.9	65.8 – 90.2	26 – 45.3
Mean	21.63	10.4	55. 28	1. 34	77. 66	34.85
Correlation	**-0.57367**	**0.819675**	**-0.29349**	**-0.52183**	**-0.22467**	**-0.84065**
T-STAT	2.21481	4.524987	0.72912	0.97085	4.9086	1.93444
Banner						
Range	13–22.6	7–13.5	38.8–67	0.6–2.3	42.5- 92.5	27 – 45
Mean	18.94	10	49.31	1.17	63. 38	32.85
Correlation	**-0.15181**	**0.62419**	**0.458622**	**-0.65205**	**-0.51349**	**-0.86396**
T-STAT	0.48569	2.526472	1.89235	1.632049	5.42562	2.71963
Neugal						
Range	11–23	8–14.27	28–41.33	0.44–1. 27	19.58- 34.67	14. 3 – 41. 3
Mean	18.83	10.35	36.47	0.77	26.03	22.56
Correlation	**-0.78068**	**0.803419**	**-0.01802**	**-0.25583**	**-0.67609**	**-0.49611**
T-STAT	3.95043	4.267006	2.89547	0.05698	1.8069	0.83684
Binwa						
Range	12.2–24.4	8.2–13. 4	26. 4–51. 4	0.68–2.08	22.4 – 43.6	23.2 – 39.8
Mean	18.88	9.46	37.48	1.12	31.12	29.5
Correlation	**-0.90506**	**0.796629**	**0.421297**	**-0.78831**	**-0.20916**	**-0.82246**
T-STAT	6.72975	4.167558	0.67638	1.468989	4.57234	4.05153

was recorded during the rainy season at all the sites but higher numbers were reported at Punner and lower numbers at Thural in the same season, due to differences in water velocity and volume of water. The percentage population of Ephemeroptera varied between 7.12 to 82% of total benthic fauna at various sites. The population of Ephemeroptera exhibited an increasing trend downstream similar to that of river Banner and the species richness of Ephemeroptera was noted during rainy season at all the sites (Fig. 3). The percentage of Diptera varied between 8 and 90% and a winter peak was observed almost at all the sites (Fig. 4). Trichoptera were mainly noticed during the winter and constituted 1.13 to 41% of the total benthic population. The minima were recorded at Punner and maxima at Parour in winter. Though Coleoptera were found during winter months at all the sites, at Punner their presence was noticed during summer also. The percentage of population was much less at Parour (0.01 to 0.35%) but higher at Punner (0.55 to 3.7%). The benthic population of this stream showed a positive and statistically significant correlation with dissolved oxygen (r = +0.803) but negative and statistically significant correlation with water temperature (r = -0.78) and average depth of the stream (r = -0.676). Further, negative and non significant correlation was noticed with alkalinity (r = -0.02), average width of the stream (r = -0.496), and water velocity (r = -0.256) (Table 1).

Binwa Stream

The benthic fauna of this river showed a winter peak at all the selected sites except at Sehal that is upstream. The maximum benthos was collected from Chobu and minimum from Triveni. The increasing trends of benthic population were noticed downstream except at Triveni due to high water velocity. A winter peak of Ephemeroptera was noticed at all the selected sites except at Majharna and Triveni. Its population varies between 15 to 80.85% of total benthos at various sites (Fig. 3). These parameters showed that Chobu and Langu sites were richer in Ephemeroptera. The next dominating group was Diptera which showed winter dominancy at all the sites except at Sehal. The percentage of Diptera in total benthic population varied between 12 to 53.5% at different sampling sites (Fig. 4). The Coleoptera, a co-dominating group, were noticed from Sehal, Majharna and Triveni sites of this river and constituted 0.74 to 15.6% of total benthic fauna at different sites and the maxima were observed

during winter at Majharna and minima at Sehal. This group was reported mainly during winter from all the sites with a few exceptions. Another co-dominating group was Trichoptera which were mainly observed during summer and winter months from all the sites and constituted 8.6 to 29.82% of total benthic fauna. The maxima were noticed at Chobu and minima at Triveni. Plecoptera were seen only once at Majharna during summer and constituted 1.06% of total benthic fauna. The positive and statistically significant correlation has been noticed between total benthos and dissolved oxygen (r = + 0.796629) and alkalinity (r = + 0.421297) though negative and statistically significant correlation have been reported between benthic fauna and water temperature (r = -0.905), average width of the stream (r = -0.822) and water velocity (r = -0.788) (Table 1). The non significant correlation was found with alkalinity (r= 0.42) and average depth of the stream (r= -0.20916).

DISCUSSION

The present study reveals that the benthic fauna mainly dominates during winter at all the studied sites (except for a few) and lowest numbers were observed during the rainy season, due to influx of more water and high water velocity. Pathani & Upadhyay (2006) reported a high percentage of zoo benthos in summer, but in the present study it was evident only for those sites situated at lower altitudes. Further, they have also noticed low quantity of zoo benthos in the rainy season and confirmed the present findings. The benthic fauna is mainly represented by eight groups out of which four are highly distributed at all the sites. The relative abundance of different groups in the different tributaries of Beas exhibited that the relative abundance of Ephemeroptera are high at Banner and Binwa, while Diptera and Tricopetra are more at Neugal (Table 2). They (Ephemeroptera, Trichoptera, Diptera, Coleoptera) show an Inverse relation with temperature, when the difference in winter and summer temperature is small, but at lower altitudes, where the differences are greater, the relation is direct. Most of the sites of River Beas are rich in Ephemeroptera (Fig. 3) mainly *Baetis* and *Ephemerella* (Har, Lunj, Tripal, Thural, Punner and Chobu). The Ephemeroptera are inhabitants of freshwater, rich in oxygen and associated with clean water quality as reported by Emere & Nasiru (2009) and Tonapi (1980). Further, Emere & Nasiru (2009) also reported that Ephemeroptera were recovered only during the rainy season. This could be due to dilution during the rains, which caused some improvement in the water quality. In the present study the maximum population of Ephemeroptera was noticed during the rainy season at all the sites of Neugal and Triveni of Binwa. Diptera are mainly represented by the families Chironomidae and Choboridae and dominate in different seasons at different sites. The maximum population was reported from Chamunda and Manjhi of River Banner, Rajol of Guj, Kotla and Dehar Khud bridge of Dehar, Parour of Neugal and

Table 2. Taxa diversity using Simpson diversity index

Taxa	Gaj		Dehar		Banner		Neugal		Binwa	
	No.	n(n-1)	No.	n(n-1)	No.	n(n-1)	No.	n(n-1)	No.	n(n-1)
Annelida					2	2				
Arthrooda Insecta										
Odonata					44	1892				
Ephemeroptera	1440	2072160	1695	2871330	3237	10474932	1373	1883756	2757	7598292
Plecoptera				20	380					
Trichoptera	168	28056	267	71022	555	307470	626	391250	240	57360
Coleoptera	60	3540	56	3080	30	870	25	600	64	4032
Diptera	815	663410	791	624890	2101	4412100	1598	2552006	1461	2133060
Mollusca Gastropoda				23	506			2	2	
Total(n)	2483	2767166	2809	3570322	6012	15198152	3622	4827612	4524	9792746
Diversity index (D)	0.55		0.547		0.579		0.632		0.521	

Sehal as well as Langu of Binwa (Fig. 4). Verma & Saksena (2006) reported that populations of Diptera (particularly *Chironomus* and *Tubifex*) indicate the effect of pollution and this coincides with the present observations, as during the study period mainly animal origin pollution from live stock was noticed at the aforementioned sites. Further, the present studies showed that the population of Ephemeroptera has decreased over the years and thus it shows that the trend of water of some of these streams is shifting towards pollution. This is confirmed by the lesser number of Ephemeroptera in the present study, compared with the findings of Dhanze et al. (1998, 2001). A significant positive correlation was noticed between benthos and dissolved oxygen at all the sites and confirmed the results of Joshi et al. (2007). The dissolved oxygen, water temperature, width and water velocity showed a strong correlation with benthos; however a strong correlation between depth and benthos was also observed at Banner and Neugal only. Pires et al. (2000) reported that temperature, conductivity, depth and width influenced the invertebrates' distribution and abundance and confirmed the present findings. Further Dinakaran & Anbalagan (2010) also reported that climate and altitude are considered as the major factors responsible for macro invertebrate distribution. In the present study, the species diversity was more at Neugal and Banner but less at Binwa (Table 2).

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