Macrozoobenthos of Basti Damar Stream in Rudraprayag District, Garhwal, Uttarakhand: Diversity and Habitat Analysis

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Abstract: Basti Damar gad is a spring fed tributary of river Mandakini which is quite conducive for biodiversity. As the stream was unexplored, it was taken as an opportunity to investigate the stream for its habitat quality and diversity of benthic organisms. Stream was studied at two different spots one in more or less rhithron zone and the other one in near potamon zone during the year 2019-20. Comparatively, the Spot No 2 had more density (836 individuals.m⁻²) and diversity (28 genus) of macrozoobenthos than spot No 1 (127 individuals. m⁻² and 28 genus) which may be due to better substratum heterogeneity dominated by mixed forest, small gravels, small bolder, low water velocity, high water temperature, low canopy of stream area and good survival rate of periphyton on bottom in the stream. Also the water quality at this spot (comparatively low current velocity, moderate temperature, good amount of DO and high alkalinity and pH) was supportive for flourishing biota. The observations were statistically analysed using coefficient of correlation, coefficient of determination, regression, species similarity, dominance and diversity indices.

Keywords: Macrozoobenthos • Basti Damar Stream • Diversity • Habitat ecology

Introduction

Biodiversity is a prominent attribute of the aquatic ecosystem for maintaining its stability and a mean of coping with any environmental change (Vinson and Hawkins 1998). In fluvial system, the macrozoobenthos are an important community that dwells at the bottom. Any change in water quality and habitat structure greatly influences the composition, abundance and diversity of these organisms. The macroinvertebrates have also been used in bio-monitoring program that make them particularly beneficial biota (Marzin, 2013). Long term assessment of the population diversity and variability of macrozoobenthos in relation to ecological parameter, especially in the spring fed streams, is required to establish their status, trends and productivity patterns.

The biodiversity baseline data are crucial to develop viable conservation and management strategies (Ward and Tockner 2001). Spring fed streams are the most common water spread throughout Himalayan states in India, because of its beneficial use as potable water, in agriculture and fishery. The conservation of benthic community is essential to maintain the structure and function of these streams as they are an important link of food web for other major biota and also utilize the bottom algae and detritus to make the water clean and suitable for other purposes (Dobriyal, 1985). Fair amount of literature is available on the relationship between
the macrozoobenthos and environmental variables on the fluvial system in different parts of the world (Resh et al., 1988; Barbour et al., 1996; Vinson and Hawkins, 1998; Jacobson et al., 2003; Silveira et al., 2006; Camara et al., 2012; Udawia, 2013; Akindele and Liadi, 2014; Kabore et al., 2016) and the Indian subcontinent (Sivaramkrihsnan et al., 1995; Sharma et al., 2004; Joshi et al., 2007; Abida et al., 2012; Negi and Mamgani, 2013; Sharma et al., 2013; Sagir et al., 2018).

The parent low order streams are the integral and important component of mountain ecosystems of Garhwal Himalayan region. The Bastai Damar is a typical headwater stream and is one of the several tributaries of the Mandakani River in Uttarakhand, India. Fast flowing water and low temperature with high dissolved oxygen characterizes these streams. Monitoring of aquatic insects can provide important insights into changes in stream quality (Rosenberg and Resh, 1993). Notable work on substratam heterogeneity and distribution pattern of benthic macroinvertebrate community in the various spring fed stream of Garhwal Himalaya in Uttarakhand has been carried out by Dobriyal et al. (2009, 2011), Rautela et al. (2006), Bahuguna and Dobriyal (2018), Balodi and Koshal (2015), Koshal et al. (2017) Bahuguna and Negi (2018). The drifting behavioral studies on aquatic insects are also conducted by Bahuguna et al. (2019, 2020). The aim of the present study is to depict the composition and variety of the macrozoobenthos in Basti Damar stream and their inter relations with habitat characteristics.

Material And Methods

Study area: Basti damaar Gaad is an important spring fed streams originating from the near Badhani Taal peak (Latitude 30.49° 85°94′ E, Longitude 78°91° 94′32′′ N) in district-Rudraprayag from Garhwal Himalaya.

Physico-chemical analysis: The physico-chemical parameters of the stream were conducted on two spots as per standard Method recommended by APHA (2005). The parameters investigated includes water temperature, current velocity, dissolved oxygen, pH, free CO₂, total Alkalinity and total hardness.

Macrozoobenthos Sampling
(a) Collection and preservation of macrozoobenthos: Macrozoobenthos were collected with the help of Surber sampler of one feet² area and preserved in suitable preservatives (4 % Formalin or alcohol as desired).
(b) Taxonomy of Macrozoobenthos: Macrozoobenthos were identified to genus level in common and up to species level wherever possible) with the help of available identification keys (Ward and Whipple, 1959; Needham and Needham, 1962; Hynes, 1977; Elliott, et al., 1988; Wallace, et al., 2003; Bouchard, et al., 2012; etc.).
(c) Diversity studies: Statistical analysis of the data was made with the help of PAST statistical software. Common statistical tools used were regression, correlation, similarity and diversity indices (Shannon and Wiener, Margalef, any other suitable indices).

Results and Discussion

Data related to density and diversity of macrozoobenthos in Basti damar stream at Spot no 1, sampled during two year period is presented in Table 1

It shows that a total of five orders of macrozoobenthos were recorded at this spot comprising 12 different genera. The maximum diversity was seen in order Ephemeroptera with highest of 4 genus and rest all 4 orders have 2 genus each. Highest density was observed in the month of December (127 individuals.m⁻²) followed by November (117 individuals.m⁻²) and October (114 individuals.m⁻²) and lowest in the month of August (17 individuals.m⁻²) followed by July (70 individuals.m⁻²). From the recorded data it is evident that density is maximum in winter season (i.e. 321 individuals) and minimum in Monsoon season (87 individuals) whereas diversity was maximum in the month of April and December where individuals from all 12 genus were recorded and minimum in the month of August with least of 8 genus (Table 1-3).
The diversity at Spot 2 is more than Spot 1. A total of 28 genus was recorded here. The maximum diversity was noticed in Ephemeroptera with 8 genus followed by order Trichoptera and Diptera with 5 genus each, Coleoptera with 4, Odonata with 3, Hemiptera with 2 genus and minimum 1 genus in Plecoptera (Table 4-6). Plecoptera and Hemiptera were two orders found only at Spot 2 with 3 genus. The highest number of individuals were observed in the month of December (836 individuals m⁻²), January (736 individuals m⁻²) and November (729 individuals m⁻²) and least in the month of August with only 37 individuals m⁻² in total from 15 genus. The diversity was observed maximum in the month of April, June and November represented by the individuals of all 28 genus and minimum in the month of August with individuals from only 15 genus.

Genus *Baeties, Caenis, Ecdyonurus, Heptagenia, Hydropsyche, Stenopsyche, Simulium, Tipula, Psephenus, Hydrophilus, Argia and Euphaea* were recorded from both the spots whereas *Ameletus, Atalophlebie, Ephemerella, Isonychia, Chimarra, Glossosoma, Rhyacophila, Berosous, Elmid, Antocha, Atherix, Chironomus, Zygonyx, Neoperla, Gerris* and *Heleocoris* were recorded only from the Spot 2 during the entire course of study. During the monsoon density was observed minimum with a total of only 242 individuals m⁻² whereas maximum was noticed during winters with a total of 2238 individuals m⁻².

Data related to density and diversity of macrozoobenthos in Basti damer stream at Spot no 2, sampled during two year period is presented in Table 4.

Species dominance and diversity indices for macrozoobenthos were presented in the Table 7 and 8 for sampling spots 1 and 2 respectively.

The maximum diversity was observed in order Ephemeroptera with highest of 4 genus and rest all 4 orders have 2 genus each in spot-1. For spot-2, the highest diversity was estimated in order Ephemeroptera with 8 genus followed by order Trichoptera and Diptera with 5 genus each, Coleoptera with 4, Odonata with 3, Hemiptera with 2 genus and lowest with 1 genus in Plecoptera. In basti Damar stream, Ephemeroptera were dominant taxa in both the spots. Ephemeroptera (may flies) was also reported dominant taxon in the Khand Gad by Kumar And Dobriyal (1996) and in Gaula gad of Kumaun region by Sunder (1997). Bahuguna and Negi (2018) also noticed that Ephemeroptera were dominant taxa in Kyunj Gad stream, a spring–fed tributary of river Mandakani. In this study, Trichoptera and Diptera were other dominant taxa in both spots. Nautiyal et al. (2015) noticed that Trichopterans were main taxa in the headwater section of the lesser Himalayan spring-fed streams.

Physico-chemical parameters are presented in the Table 9 and 10 for the Spot-1 and Spot-2 respectively.
Table 1: Macrozoobenthos density (units.m$^{-2}$) and diversity during April 2019 to March 2020 from Basti damaar Gad stream (Spot-1).

| SN | Name of the Order/Genus/Species | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar |
|----|---------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| A  | Ephemeroptera (units.m$^{-2}$)   |     |     |     |     |     |     |     |     |     |     |     |     |
| 1  | Baetis                            | 10  | 16  | 15  | 14  | 2   | 13  | 15  | 13  | 10  | 12  | 15  | 14  |
| 2  | Caenis                            | 5   | 9   | 12  | 10  | 3   | 7   | 5   | 6   | 8   | 5   | 9   | 12  |
| 3  | Ecdyonurus                        | 3   | 1   | 5   | 2   | 1   | 1   | 2   | 8   | 5   | 2   | 3   | 2   |
| 4  | Heptagenia                        | 15  | 17  | 16  | 15  | 1   | 12  | 13  | 10  | 17  | 10  | 13  | 16  |
|    | TOTAL                             | 33  | 43  | 48  | 41  | 7   | 33  | 35  | 37  | 40  | 29  | 40  | 47  |
| B  | Trichoptera (units.m$^{-2}$)      |     |     |     |     |     |     |     |     |     |     |     |     |
| 1  | Hydropsyche                       | 28  | 25  | 15  | 5   | 7   | 14  | 20  | 24  | 18  | 21  | 15  | 32  |
| 2  | Stenopsyche himalayana            | 4   | 3   | 2   | 2   | 1   | 6   | 10  | 2   | 2   | 3   | 2   | 1   |
|    | TOTAL                             | 32  | 28  | 17  | 7   | 8   | 20  | 30  | 26  | 20  | 24  | 17  | 33  |
| C  | Diptera (units.m$^{-2}$)           |     |     |     |     |     |     |     |     |     |     |     |     |
| 1  | Simulium                         | 16  | 15  | 15  | 15  | 1   | 13  | 25  | 24  | 27  | 19  | 18  | 17  |
| 2  | Tipula                           | 3   | 4   | 3   | 0   | 0   | 3   | 2   | 1   | 5   | 0   | 0   | 0   |
|    | TOTAL                             | 19  | 19  | 18  | 15  | 1   | 16  | 27  | 25  | 32  | 19  | 18  | 17  |
| D  | Coleoptera (units.m$^{-2}$)       |     |     |     |     |     |     |     |     |     |     |     |     |
| 1  | Psephenus tenulipes               | 15  | 16  | 18  | 5   | 0   | 15  | 20  | 24  | 28  | 22  | 20  | 14  |
| 2  | Hydrophilus                      | 2   | 1   | 0   | 0   | 1   | 1   | 0   | 2   | 2   | 0   | 0   | 1   |
|    | TOTAL                             | 17  | 17  | 18  | 5   | 1   | 16  | 20  | 26  | 30  | 22  | 20  | 15  |
| E  | Odonata (units.m$^{-2}$)          |     |     |     |     |     |     |     |     |     |     |     |     |
| 1  | Argia                             | 3   | 0   | 2   | 1   | 0   | 2   | 0   | 0   | 1   | 0   | 0   | 0   |
| 2  | Euphaea                          | 1   | 0   | 3   | 1   | 0   | 0   | 2   | 3   | 4   | 2   | 3   | 2   |
|    | TOTAL                             | 4   | 0   | 5   | 2   | 0   | 2   | 2   | 3   | 5   | 2   | 3   | 2   |
|    | TOTAL NO. OF SPECIES              | 105 | 107 | 106 | 70  | 17  | 87  | 114 | 117 | 127 | 96  | 98  | 114 |

Table 2: Order wise population of Macrozoobenthos (units.m$^{-2}$) at Spot no. 1 (1st order stream)

| Order       | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar |
|-------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Ephemeroptera | 33  | 43  | 48  | 41  | 7   | 33  | 35  | 37  | 40  | 29  | 40  | 47  |
| Trichoptera  | 32  | 28  | 17  | 7   | 8   | 20  | 30  | 26  | 20  | 24  | 17  | 33  |
| Diptera      | 19  | 19  | 18  | 15  | 1   | 16  | 27  | 25  | 32  | 19  | 18  | 17  |
| Coleoptera   | 17  | 17  | 18  | 5   | 1   | 16  | 20  | 26  | 30  | 22  | 20  | 15  |
| Odonata      | 4   | 0   | 5   | 2   | 0   | 2   | 3   | 5   | 2   | 3   | 2   |
| Total        | 105 | 107 | 106 | 70  | 17  | 87  | 114 | 117 | 127 | 96  | 98  | 114 |

Table 3: Season wise population of Macrozoobenthos (units.m$^{-2}$) at Spot no. 1 (1st order stream)

| Order       | Spring (March & April) | Summer (May & June) | Monsoon (July & August) | Autumn (Sept., Oct. & Nov.) | Winter (Dec., Jan. and Feb.) |
|-------------|------------------------|---------------------|-------------------------|-----------------------------|-----------------------------|
| Ephemeroptera | 80                     | 91                  | 48                      | 105                         | 109                         |
| Trichoptera  | 65                     | 45                  | 15                      | 76                          | 61                          |
| Diptera      | 36                     | 37                  | 16                      | 68                          | 69                          |
| Coleoptera   | 32                     | 35                  | 6                       | 62                          | 72                          |
| Odonata      | 6                      | 5                   | 2                       | 7                           | 10                          |
| Total        | 219                    | 213                 | 87                      | 318                         | 321                         |

Table 4: Macrozoobenthos density (units.m$^{-2}$) and diversity during April 2019 to March 2020 from Basti damaar Gad stream (Spot-2) (2nd Order Stream).

| S.No. | Name of the Order/Genus/Species | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar |
|-------|---------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| A     | Ephemeroptera                   | 20  | 19  | 15  | 0   | 4   | 19  | 25  | 24  | 31  | 28  | 27  | 24  |
| Order          | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
|---------------|------|-----|------|------|------|------|------|------|------|------|------|------|
| Ephemeroptera | 81   | 69  | 60   | 34   | 7    | 67   | 94   | 87   | 128  | 111  | 105  | 88   |
| Trichoptera   | 168  | 143 | 88   | 38   | 11   | 118  | 217  | 250  | 292  | 260  | 226  | 209  |
| Coleoptera    | 103  | 87  | 55   | 30   | 7    | 64   | 134  | 181  | 192  | 166  | 131  | 128  |
| Diptera       | 122  | 91  | 53   | 89   | 6    | 78   | 164  | 172  | 182  | 173  | 184  | 156  |
| Odonata       | 15   | 7   | 5    | 4    | 1    | 14   | 23   | 26   | 29   | 18   | 10   | 13   |
| Plecoptera    | 2    | 5   | 6    | 7    | 4    | 10   | 5    | 8    | 9    | 6    | 4    | 0    |
| Hemiptera     | 5    | 4   | 3    | 3    | 1    | 3    | 4    | 5    | 4    | 2    | 6    | 4    |

| Total         | 496  | 406 | 270  | 205  | 37   | 354  | 641  | 729  | 836  | 736  | 666  | 598  |

**Table 5:** Order wise population of Macrozoobenthos at Spot no. 2 (2nd order stream)

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At spot No 1, the upper reach area had water temperature fluctuations from 7.35±0.07°C (January) to 11.55±0.07°C (August) and at spot no 2, the lower reach from 9.35±0.05°C (January) to 17.3±0.14°C (August). pH fluctuated from 7.25±0.07 (August) to 7.8±0.14 (March) in Spot-1 and 7.5±0.04 (August) to 7.5±0.07 (January) in Spot-2. Current velocity was minimum 0.234±0.02 (January) and maximum 0.541±0.25 (August).
in Spot-1 and 0.216±0.04m.s⁻¹ (January) to 0.490±0.05 m.s⁻¹ (August) in Spot-2. DO values were in a range of 7.10±0.42 (August) to 9.69±0.99mg.l⁻¹ in spot-2 and total hardness fluctuated from 74.8±0.85 to 105.7±0.71mg.l⁻¹ in Spot-1 and 73.15±1.4 to 101.3±4.3mg.l⁻¹ in Spot-2.

Table 10: Physico-chemical parameters of water at sampling Spot 2 in spring fed stream Basti damaar (April,2019-March, 2020).

| Month | Apr.  | May  | Jun.  | Jul.  | Aug.  | Sep.  | Oct.  | Nov.  | Dec.  | Jan.  | Feb.  | Mar.  |
|-------|-------|------|-------|-------|-------|-------|------|-------|-------|------|-------|-------|
| Temperat | 12.7  | 14.15| 15.7 | 16.2 | 17.3 | 16.65 | 13.7 | 12.05 | 10.2 | 9.35 | 10.1 | 10.8  |
| ure     | ±0.28 | ±0.21| ±0.26 | ±0.14 | ±0.14 | ±0.21 | ±0.28 | ±0.07 | ±0.14 | ±0.07 | ±0.14 | ±0.12 |
| pH      | 7.35  | 7.3  | 7.45 | 7.25 | 7.15 | 7.35 | 7.45 | 7.45  | 7.45 | 7.5 | 7.35 | 7.30  |
| ±0.07  | ±0.0 | ±0.05| ±0.07 | ±0.04 | ±0.04 | ±0.09 | ±0.07 | ±0.07 | ±0.07 | ±0.07 | ±0.05 | ±0.00 |
| Velocity | 0.305 | 0.317| 0.343| 0.426| 0.490 | 0.310 | 0.280 | 0.267 | 0.253 | 0.216 | 0.242 | 0.260  |
| ±0.01  | ±0.05| ±0.02| ±0.04 | ±0.05 | ±0.05 | ±0.08 | ±0.07 | ±0.06 | ±0.02 | ±0.04 | ±0.02 | ±0.05  |
| D.O.    | 7.45  | 7.65 | 7.4  | 7.25 | 7.15 | 7.45 | 7.65 | 7.75  | 8.1 | 8.25 | 7.75 | 7.65  |
| ±0.8   | ±0.1  | ±0.0 | ±0.06 | ±0.06 | ±0.06 | ±0.05 | ±0.05 | ±0.35 | ±0.80 | ±0.05 | ±0.07 | ±0.15  |
| Total Alkalinity | 91.65 | 88.25| 86.95| 81  | 78.75 | 82.35 | 84  | 86.95 | 89.7 | 96.9 | 95.75 | 92.7  |
| ±0.64 | ±1.48| ±0.64| ±0.71 | ±0.78 | ±1.63 | ±0.28 | ±1.06 | ±0.57 | ±0.99 | ±0.64 | ±0.57 | ±0.09  |
| Total Hardness | 81.3  | 71.5 | 75.75| 74.7 | 73.15 | 80.8  | 88.5 | 90.5  | 96.25 | 101.3 | 97.45 | 84.05  |
| ±2.9 | ±1.7 | ±3.2 | ±2.8 | ±1.4 | ±2.8 | ±4.9 | ±3.4 | ±3.1  | ±4.3 | ±3.8 | ±4.2 | |

Statistical relationships between physico-chemical and macrozoobenthos were presented in the Figs 1-12. Relationship between water temperature and benthos and current velocity and benthos was observed negative and for rest parameters it was positive.

**Fig 1**: Regression between Temperature and Benthos (S1)

**Fig 2**: Regression between velocity and Benthos (S1)

**Fig 3**: Regression between pH and Benthos (S1)

**Fig 4**: Regression between DO and Benthos (S1)
Low density (17 individuals.m\(^{-2}\) in August) and diversity (12 genus) of macrozoobenthos at Spot 1 may be due to the prevailing substrate conditions (domination by sand, gravel substrate, big bolder, faster water current, low water temperature, dense canopy and low periphytonic bottom in the stream. At Spot-2, the higher density (836 individuals.m\(^{-2}\)) and diversity (28 genus) of...
Macrozoobenthos were perhaps due to better substratum heterogeneity dominated by mixed forest, small gravels, small bolder, low water velocity, high water temperature, low canopy of stream area and good survival rate of periphyton on bottom in the stream. During the present observation, it was noticed that density is highest in winter season (321 individuals.m$^{-2}$) and lowest in Monsoon season (87 individuals.m$^{-2}$). Baluni et al. (2018) noticed that the periphyton was minimum in August and maximum in January in the Khankra Gad stream. It is understood that the total alkalinity favours periphyton growth in moderately flowing mountain streams, and thereby it helps in increasing macrozoobenthos density during the winter session. Similar observations have been noticed by Kumar and Dobriyal (1996) for the macrozoobenthos diversity in various small streams in Garhwal region.

The density of a species is also influenced by several ecological factors such as adaptability, substrates that support for life, and other natural factors (Welch, 1952). The nature of substratum has a significant impact on the composition and distribution of the life surviving on it (Odum 1993). Kumar et al. (1998) stated that the macrozoobenthic density can be influenced by the heterogeneity in substratum. The number of species and their diversity changes depends on the ecological factors, such as the substratum, the depth of water, water current speed, and food availability (Kiss, 2002). When compared to structural simple substrate, such as a sand and bedrock, the physical substrate type (leaves, gravel, wood and macrophytes) generally support more diversity (Angradi, 1996; Hawkins, 1984; Baluni, et al. 2017). This can be a good explanation for the high abundance and diversity of macrozoobenthos at sampling spot-2 in Basti Damaar Gad, which has good macrophyte growth. The water temperature and current velocity had a negative correlation with zoobenthic density and total alkalinity, D.O., pH and total hardness demonstrated a positive relationship. Rai et al. (2019) found that pH and DO were the two most important variables explaining the variation in macroinvertebrate assemblages. The biotic environmental factors that influence the presence of macrozoobenthos in river cannot be separated from the ability of the species to compete in self-defense – in this case fighting over food availability and dominating the territorial area. It is said that if a type of macrozoobenthos can be controlled or dominated in a community, the level of diversity in the community is low. On the contrary, if the level of diversity in the community is high, the dominance of existing species is low. Thus, the level of species diversity may also be influenced by the degree of dominance of species present at the station. Based on the measurement, the abiotic factors of spring fed stream maintain that physico-chemical conditions are different in each measurement of the sampling spots. These conditions correspond to the station where macrozoobenthos is located; it is due to the aquatic ecosystem of the stream that is an integral component of the set of abiotic (physical-chemical) and biotic (living organisms) environment which are related and interact with each other to form a functional structure. The Shannon–Wiener index showed comparatively highest value during favorable December and January months and minimum during unfavorable July and August months on both spots. Similar observations were noticed in Kyunjia Gad stream from Garhwal region by Bahuguna and Negi (2018).

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