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Periphyton Distribution in the Microhabitat of Ladhiya Stream Kumaon Himalayas, Uttaranchal

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Abstract

In the present communication epilithic community structure in Ladhiya stream of Kumaon Himalayan region is described. The numerical abundance of various periphytic forms in relation to two microhabitats (riffle and pool) was evaluated. The numerical abundance (cells/cm^2) of periphyton was high in the shallow riffle with coarse substrate and moderate water flow. In riffle areas, abundance ranged between 0.09×10^4 and 43.56×10^4 cells/cm^2 whereas in pools it ranged from 0.5×10^4 cells/cm^2 to 1.2×10^4 cells/cm^2. Bacillariophyceae, Chlorophyceae and Cyanophyceae comprised the components of the community of periphyton. Multiple regression equation showed that periphytic biomass (cells/cm^2) is negatively correlated with the depth (r = -0.59, P <0.03) of the microhabitat and there was a non-significant negative correlation with pH (r= -0.08) and water velocity (r = -0.06). The study highlights periphyton assemblage and distribution pattern in relation to pool and riffle microhabitats of Ladhiya stream which is a potential stream in Kumaon Himalayas.
Key words : **Periphyton, Biomass, Assemblage, Microhabitat, Ladhiya stream.**

Benthic algae are important primary producers and are sensitive indicators of environmental change in lotic waters as the assemblage integrates physical and chemical disturbances to the stream reach (1). Benthic algae in streams form a critical link in aquatic ecosystems and disruptions at this link can profoundly influence the rest of the aquatic community (2). In addition of being primary producers, they also act as chemical modulators in aquatic ecosystems (3). Benthic algae may enter the food web either through direct consumption from the substrates by benthic invertebrates or through capture of drifting benthic algae by filter-feeders that strain the water column (4, 5). Although the studies on the benthic algae in different habitats like ponds, lakes, reservoirs, streams and rivers have received importance abroad (6–11) the ecological significance and role of periphyton have not received adequate attention in India. While periphyton in a few ponds, reservoirs, rivers and lakes have been studied (12–14), the information on periphyton in streams is scanty (15, 16). For undertaking a conservation program it is important to generate information on the status of the stream habitat. Among stream periphytic assemblage, Bacillariophyceae contribute a major share in the food spectrum of different life history stages of endangered *Tor putitora* and *Schizothorax richardsonii* (17) and hence the studies on the periphyton of hillstream is important.

Review of literature indicates that the habitat of *T. putitora* is mostly affected by modification in habitat (18) and the species has been listed as endangered (EN) according to Conservation Assessment and Management Plan (19). In streams, the riffle and pool microhabitats are important feeding habitat, for hill stream fishes. The small fish and early life stages of fish tend to be found predominantly in the shallow riffle or stream margin habitat, while later life stages and large fishes are more abundant in pools or mid channel habitats, normally consists of mosaic of various habitat types such as pools, riffles, glides and stream margin etc (20). The present paper deals with the results of investigation on the periphyton occurrence as an important biotic community, contributing to the food spectrum of hill stream fishes in different microhabitats of lotic stream Ladhiya Kumaon Himalayan region.

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Methods

Ladhiya is a Himalayan hilly stream originating at latitude 29° 22′ N and longitude 79° 45′ E, it merges with the Sharda River at latitude 29° 10′ N and longitude 80° 10′ E. The total length of the river is more than 70 km and the samples were collected from 12 locations (Fig. 1) covering pool and riffle microhabitats and the area studied was divided into various zones to represent the collected samples. At sampling site 12, Ladhiya is joined by a streamlet called Bisauria nala, which flows through a 3 km stretch of geologically unstable valley. During the monsoon season it brings a large amount of eroded materials in to the stream, resulting in mass mortality of fishes and destruction of habitat. *Tor putitora* and *T. tor* are the most important game fishes of the region; other fishes found in the region are *Labeo dero*, *Labeo dyocheillus*, *Mastacembellus armatus*, *Schizothorax kumaonensis*, *Schizothorax richardisonii*, *Garra gotyla*, *Nemacheilus rupecola*, *Psudoecheneis* sp., *Glyptothorax pectinoperus* and other fishes. The riparian zone of the stream is of mixed forest and agriculture; the forest cover includes *Pinus* sp, *Shorea robusta*, *Accacia catechu*, *Dalbergia sissoo*, *Quercus* sp., *Lantana* sp. and *Zizyphus* sp. The upper zones of forest were dominated by *Pinus* sp., the middle zones by *Lantana* sp. and *Quercus* sp., while the lower zones by *Accacia catechu*, *Dalbergia sissoo* and *Zizyphus* sp.

The sampling was performed covering a distance of 47.5 km of the stream considering representative microhabitats. At each site, five replicate periphyton samples were collected from microhabitats, which included pools and riffles. The replicates were collected randomly in the microhabitats that were homogeneous in depth, water flow and substratum size. For each microhabitat, mean water depth was evaluated by taking several depth measurements depending upon the area of habitat. Current velocity was measured with the ink drop method (21) (Zweimuller 1995). The substrate type was coded as follows: 0 for silt and clay, 1 for sand, 2 fo

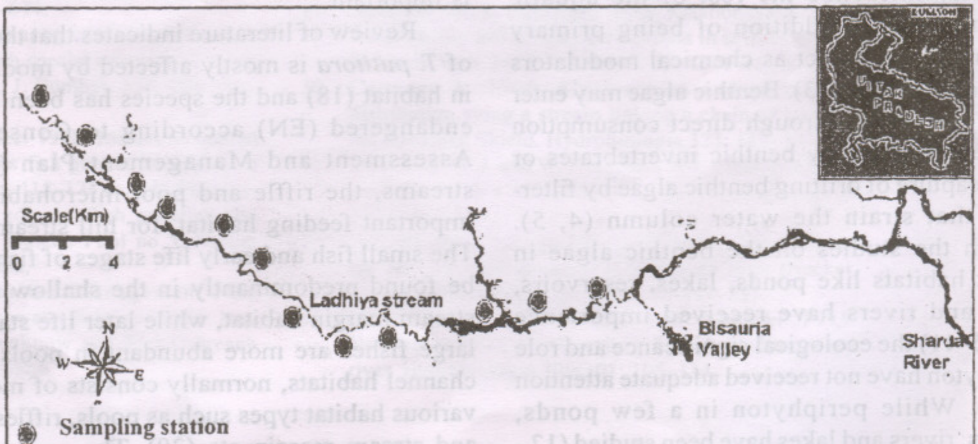

Figure 1. Map of Ladhiya stream showing sampling stations.

gravel, 3 for pebble, 4 for cobble, and 5 for boulder. Gravel and cobble were simply lifted and placed in a tray. The periphyton was scraped from an area of 2.5×7.5 cm. with a sharp scalpel and was fixed with 2% formalin. In the laboratory, the volume of the periphyton was measured after centrifuging. The sample was then transferred to a beaker containing a little water and the volume was made up to 10 ml. After thoroughly mixing, 1 ml sample was taken in a Sedgwick-Rafter plankton counting cell for microscopic examination. The counts of periphyton were done by the direct census method (22). The periphytic forms were identified up to generic level following Edmondson (23). The data were analyzed by SPSS 10.0.

Results

Physical Characteristics of Streams

The results indicate that the pH varied slightly (5.5±0.04 to 6.5±0.02) at different sites. The temperature of the surface stream water ranged from 18–24 C. The depth of pool and riffle microhabitats in various sampling locations were lower and ranged from 15±1.2 to 35±0.6 cm. The current velocities slow to swift and varied between 3.6±0.5 and 52±2.6 cm/s in pools and riffles. The channel width showed marked variation ranging from 80 m to 500 m and the pools riffle ratio was poor. The substrates of the sampling sites ranged from slightly coarse to a mixture of cobles and

Table 1. Periphyton biomass and composition in the microhabitat (mean±SD) attributes of Ladhiya stream. C, Chlorophyceae; Cy, Cyanophyceae; B, Bacillariophyceae; O, Others; OC, Organic carbon.

Sampling Station	Microhabitat	Mean depth (cm)	pH	Water velocity (cm/s)	Temp (C)	Periphyt on cells/cm²	Volume/ cm
1.	Riffle, Stone	20±2.0	6.2±0.06	33.00±3.5	20±2.1	51700	0.20
2.	Riffle, Stone	15±1.2	5.8±0.08	18.75±4.2	21±1.2	435600	0.28
3.	Pool, Stone	30±1.0	5.6±0.05	04.90±5.2	21±1.0	4600	0.04
4.	Riffle, Stone	20±0.9	6.0±0.05	38.70±4.0	20±1.5	29000	0.03
5.	Riffle, Stone	30±1.0	5.8±0.06	30.60±6.0	18±2.0	900	0.02
6.	Pool, Stone	35±0.6	5.5±0.04	03.60±0.5	18±1.4	8600	0.05
7.	Pool, Stone	30±1.1	6.0±0.06	33.75±3.5	18±1.4	16800	0.16
8.	Pool, Stone	30±0.5	5.8±0.04	16.00±4.6	19±1.6	5000	0.03
9.	Riffle, Stone	25±0.4	5.5±0.04	44.00±4.8	15±1.4	37100	0.18
10.	Riffle, Stone	20±0.8	6.0±0.02	26.66±2.5	20±0.8	8000	0.05
11.	Riffle, Stone	25±1.1	6.5±0.02	52.00±2.6	24±0.8	28000	0.17
12.	Riffle, Stone	20±0.6	6.5±0.04	45.00±3.0	22±1.1	36500	0.20

Sampling Station	Microhabitat	Substrate type (coded)	OC (%)	Periphyton composition (%) C	Cy	B	O
1.	Riffle, Stone	2.5	1.30	41.23	-	58.77	-
2.	Riffle, Stone	4.0	1.47	11.66	-	86.72	1.62
3.	Pool, Stone	1.8	0.74	-	08.94	88.31	-
4.	Riffle, Stone	2.5	0.76	41.22	-	57.50	1.28
5.	Riffle, Stone	1.8	0.35	-	15.25	84.75	-
6.	Pool, Stone	1.6	0.30	06.07	-	93.33	-
7.	Pool, Stone	3.0	0.80	12.38	06.66	80.96	-
8.	Pool, Stone	2.6	0.45	14.28	06.28	79.44	-
9.	Riffle, Stone	3.5	1.18	11.53	03.01	85.44	-
10.	Riffle, Stone	2.0	0.35	-	07.28	92.72	-
11.	Riffle, Stone	3.8	0.99	09.24	08.04	82.72	-
12.	Riffle, Stone	3.0	1.18	02.04	-	97.96	-

pebbles and ranged from 1.6 to 4.0 (coded). The organic matter of the various sites ranged from 0.33 to 2.53% and the organic carbon (dry weight) ranged from 0.35 to 1.47%.

Periphyton Biomass

The periphyton biomass, as volume of the attached algae varied among substrates. The highest periphyton volume (0.28 ml/cm^2) was observed in riffle cobbles and pebbles in site 2 while the lowest concentration was observed in riffles with fine substrate (0.02 ml/cm^2). The volume of the periphyton in various sites is reflected in total count as well. The density of periphyton in various microhabitats ranged from a minimum value of 0.09×10^4 to a maximum of 43.56×10^4 cells cm^2 (Table 1). The maximum density of periphyton was recorded in riffle cobble with coarse substrate from a mean depth of 15 cm. in the sampling site and the current velocity of the riffle microhabitat recorded was 18.75 cm/s. The minimum density of periphyton was recorded in the side pool microhabitats in which the depth was 30 cm with current velocity of 30.6 cm/s.

In the present study, the multiple regression equation showed that periphytic biomass (cells/cm^2) negatively correlated with the depth (r= -0.59, P<0.03) of the microhabitat types. A non significant negative correlation with pH (r= -0.08) and water velocity (r= -0.06) was also observed.

Assemblage

The periphyton assemblages were dominated by diatoms Bacillariophyceae (57.5–97.96%) followed by Chlorophyceae (2.04–41.23%) and Cyanophyceae (3.01–15.25%) (Table 1). Among life forms, motile planktonic algae were the most abundant. Among various periphytic groups, 15 belonged to Bacillariophyceae, 10 to Chlorophyceae and 3 to Cyanophyceae (Table 2). The rare occurrences of Protozoa (*Difflugia* sp., *Epistilis* sp.) and Rotifera (*Keratella* sp.) were also recorded. Among Bacillariophyceae *Diatoma* sp., *Cymbella* sp., *Navicula* sp. and *Cyclotella* sp. were dominant. The dominant genera under Chlorophyceae were *Clodophora* sp., *Ulothrix* sp., *Chaetophora* sp. and *Spirogyra* sp. Among Cyanophyceae, *Oscillatoria* sp., *Anabaena* sp. and *Rivularia* sp. were dominant forms. The only representative from Rotifera was *Keratella* sp.

Table 2. Diversity of periphyton in Ladhiya stream.

Bacillariophyceae	Chlorophyceae	Cyanophyceae
Diatoma sp.	*Cladophora* sp.	*Oscillatoria* sp.
Cymbella sp.	*Ulothrix* sp.	*Anabaena* sp.
Navicula sp.	*Chaetophora* sp.	*Rivularia* sp.
Cyclotella sp.	*Spirogyra* sp.	
Synedra sp.	*Microspors* sp.	
Gomphonema sp.	*Cosmarium* sp.	
Melosira sp.	*Closterium* sp.	
Nitzschia sp.	*Characium* sp.	
Eragilaria sp.	*Desmidium* sp.	
Pinnularia sp.	*Zygnema* sp.	
Amphora sp.		
Surirella sp.		
Rhopalodia sp.		
Tabellaria sp.		
Asteriorella sp.		

Discussion

In the present study, periphyton biomass and assemblage structure varied in different microhabitats studied. The study indicated among the two microhabitats of the stream the riffle sustains comparatively higher periphyton biomass than pools. The variations in algal biomass and assemblage composition between pool and riffle microhabitats due to the cumulative effect of various physicochemical factors like, light, temperature, current, rainfall, turbidity, substrate, depth and chemical components of the stream water. The scanning of literature indicates that a complex array of factors and interactions governs the development of benthic algal communities in streams and the competitive success of any one species is currently difficult to predict (24). The abundance of diatoms indicated that this group could withstand changes of physicochemical factors of the streams. Quinn et al. (25) reported that periphytic productivity decreases with increasing shade and suggested that energy derived from upstream sources may be the most important food in streams. Nikora et al. (26) found largest influence of stream velocity in periphytic mat selectivity and concluded that mechanism of the periphyton turbulence interaction is connected to a certain degree with viscous effects. There are reports that benthic algal communities grow faster and can accumulate more mass unless the force of moving water is too great and algae are sheared from the substratum (27, 28). In the present study the periphytic biomass showed peak value in the microhabitats having flow velocity of 18.75 cm/s.

The significant correlation of microhabitat features on periphyton have been studied by different authors. Significant relationships between periphytic chlorophyll and nutrients have been observed in streams in Japan and New Zealand (29). Cattaneo et al. (30) reported that substratum size of the stream had a significant role on periphyton biomasses. They showed a strongest difference between gravel and cobble periphyton biomass. A5-fold biomass difference between periphyton on cobbles and gravel was observed by Cattaneo et al. (30). High algal biomasses in the coarse substrate particularly cobble and rubbles in the riffle microhabitat were observed in the present investigation. This study corroborates with the findings of Cattaneo et al. (9) in which cobbles had the highest biomass and gravel the lowest. Increase in periphyton cover with stone size was also observed in other streams in North America (31) and Europe (32, 33), predominantly because of the higher stability of these during floods (32).

Our observations on periphytic algal assemblage composition showed predominant occurrence of Bacillariophyceae followed by Chlorophyceae and Cyanophyceae. In the present study, a total of 29 genera were encountered. Shayam Sundar et al. (15), in a study at Gaula river located at the foot hills of Kumaon Himalayas recorded 48 phytobenthic genera among which 30 belonged to Bacillariophyceae, 13 to Chlorophyceae and 5 to Cyanophyceae.

The present study indicates that among different types of microhabitats in the stream, riffle sustains comparatively higher periphyton biomass than pools. However, there may be variation of biomass depending upon the substrate type, depth and water flow. The availability of periphyton in the riffles with low water velocity provides ideal feeding habitat for the early life stages of *T. putitora*. The habitat degradation due to deforestation occurs throughout the Ladhiya valley and the study has indicated less periphyton cover in pools in most of the sampling stations. Therefore habitat restoration is needed for the degraded habitats. There is scope to use periphyton abundance as a tool in assessing the stream habitat status with regard to conservation of endangered fish in other areas.

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