Journal of Mountain Research, Vol.1 pp.39-49, 2006

BENTHIC MACROINVERTEBRATE COMMUNITY IN THE MOUNTAIN STREAMS: LONGITUDINAL PATTERNS OF DISTRIBUTION IN WEST HIMALAYA (GANGETIC DRAINAGE-MANDAKINI BASIN)

PRAKASH NAUTIYAL AND V.P. SEMWAL

Department of Zoology, H. N. B. Garhwal University, Srinagar Garhwal Uttaranchal-246174 (INDIA)

ABSTRACT

The present study focused on the longitudinal distribution patterns of benthic macroinvertebrate community at the basin scale. The patterns were observed with respect to forest type and subsequently to altitude and stream length in the Mandakini basin (30°17' to 30°49' North and longitude 78°49' to 79°32' East). Nine stations selected on seven streams draining four sub-basin were sampled from May 1999 to December 2000. Sampling was conducted for 20 months in continuation and 900 samples were obtained in this tenure (5 quadrates of 1 ft^2 per site x 9 sites x 20 months). The density levels were higher in the Kakra and Swar. The Rawan and Byung were characterized by relatively lower density. The mean density of benthic macroinvertebrate attained a peak during winter (January) and fall during monsoon (July and August) at the all stations. Dominance of individual group of insects (orders) at different sampling station in different streams are discussed with possible reasons thereof.

INTRODUCTION

Research efforts have focused on macrodistributional patterns of benthic invertebrate assemblages within drainage basin (Hawkes, 1975) and in larger biogeographical studies within and among drainage basins (Wright *et al.*, 1984; Corkum, 1990). Longitudinal distribution was explained on the basis of the River Continuum Concept (Vannote *et al.*, 1980) using drainage basin as a frame – work within which a continuously integrated series of physical gradients along a river were associated with changes in functional feeding mechanism of invertebrates.

Such studies have been initiated recently in the Himalayan streams, which are of global importance to bio-diversity (Ormerod *et al.*, 1994; 1997; Suren, 1994; Rothfritz *et al.*, 1997; Cantonati et al, 2001; Nautiyal, Kala and Nautiyal 2004). Biodiversity in the Himalayan mountains is globally significant due to pronounced endemism, habitat heterogeneity and bio geographic location (Myers 1990, Myers *et al.*, 2000). Mountains present an entirely different landscape as they provide biome gradations analogous to latitude differences. In the mountain streams of India, spatial scales have been examined with respect to small patches within a single stream (Badola and Singh, 1981; Nautiyal, 1984; 1986; Negi and Singh 1990; Gusain, 1994; Kishore *et al.*, 1998; Kishore *et.al.*, 2004, or longitudinally (Singh and Nautiyal, 1990; Singh *et al.*, 1994; Gusain, 1994; Nautiyal, 1997; Nautiyal *et al.*, 1997a; Julka *et al.*, 1999, Nautiyal *et al.*, 2004). In Garhwal region studies on the longitudinal distribution have been made only on the glacier-fed rivers (the Bhilangana, Bhagirathi-Ganga). Hence, studies were initiated on the longitudinal patterns of benthic macroinvertebrate community in springfed streams which are smaller in length. Mandakini basin was most ideal for the present study, as it is small in size, close to the snow line and exhibits a rapid transition from alpine to sub-tropical conditions within a very short distance to north.

MATERIALS AND METHODS

Study Area: The Mandakini basin is located between latitude 30°17' to 30°49' North and longitude 78°49' to 79°32' East. This basin lies juxtaposed to the Bhagirathi basin in the West and the Alaknanda in the East. The river Mandakini is Vth order at Soneprayag while VII order tributary of the Alaknanda at Rudraprayag. Mandakini basin has few glacierfed and numerous springfed tributaries, which drain a large area of the basin. There are numerous perennial and seasonal tributaries of different order, usually (III to IV) between Soneprayag to Rudrapryag.

Sampling for benthic macroinvertebrate community: Nine stations selected on seven streams draining four sub-basin were sampled from May 1999 to December 2000. Geographical location and other characteristics of sampling stations are presented in Table 1. Sampling was conducted for 20 months in continuation and 900 samples were obtained in this tenure (5 quadrates of 1 ft^2 per site x 9 sites x 20 months). The substratum in the form of small boulders, cobbles and pebbles were lifted carefully from the marked area and washed in a bucket full of water by dipping it a number of times to dislodge the attached fauna. The fauna that remained attached to substrate surface were removed with the help of brush. The bucket water was filtered through 0.5 mm sieve to retain benthic macroinvertebrates (Singh and Nautiyal 1990, Habdija *et al.*, 1997). The samples were preserved in 5% formalin for further analysis. Various benthic taxa were identified to family level with the help of different keys (Burks 1953, Pennak 1953, Edmunds *et al.*, 1976, Macan 1979). Family level studies have been successfully used to describe bio geographical patterns across large areas (Corkum, 1989). Relative abundance of various taxa at above stated sites during each month was computed as percentage of total benthic macroinvertebrate count from 5 samples.

Temporal variations in density: The mean density of benthic macroinvertebrate attained a peak during winter (January) and fall during monsoon (July and August) at the all stations. Owing to common peak there was no difference from sub-basin to sub-basin and from upstream to down-stream stations. The mean density of benthic macroinvertebrate attained a peak during winter (January) and fall during monsoon (August) at all the stations. The density of benthic macroinvertebrate community increased from January to May and decreased from September to December. Similar trend has been observed for biotic (including benthic) communities of the glacier and spring fed rivers and streams of Garhwal region (Nautiyal 1984, 1986; Singh and Nautiyal, 1990; Singh *et al.*, 1994; Nautiyal *et al*; 1996; Kishor *et al.*, 1998, 2004).

Taxonomic Composition

The streams Kakra (AK-51%, DV-34%, PB-31%), Rawan (R1-40%) and Byung (BG-45%) were dominated by Trichoptera while the Swar (S1-35%, S2 38%) by Ephemeroptera. Despite this big similarity, streams differed on account of prevailing abundance of the dominant taxon (Fig. 3). The Diptera and Coleoptera come next in order but the Diptera were more in abundance (10-15%) while the later 5-9% only. Diptera exceeded in the Kakra and Swar. Similarly, Coleoptera was most abundant at R1 in the Rawan. Plecoptera was next in order 2-4% being quite high (44%) at R2 and least (2%) in Swar. Among Neuroptera and Lepidoptera the later was exceptionally high (35%) in Swar (S1).

Longitudinal variations: In the Mandakini basin the Ephemeroptera increased with the downward flow of the stream in the Kakra, Rawan and Swar (Fig. 2). The magnitude of increase was high in the Rawan (23-34%) followed by Kakra (20-33%) and Swar (35-38%). Longitudinally, the Trichoptera decreased considerably in the Rawan (40-32%) and the Kakra (51-35%) and increased slightly in the Swar basin (32-33%). Diptera decreased from (15-11%) in the Swar, remained constant in the Rawan (13%) and increased in the Kakra (12-14%). The Coleoptera declined in the Rawan (15-8%), Swar and Kakra (8-6%). Lepidoptera declined in the Swar (3.5-1.9%) but was constant in the Rawan (1.7-2.0%) and Kakra (1.8-1.2%). The abundance of Plecoptera increased marginally in the Kakra (3.2-3.3%) Rawan (3.8-4.4%) and Swar (2.1-3.4%).

It is an established fact that the Kryal, rithral and such categories of streams are dominated by specific group of organisms as the stream descends from its source. However, the Ephemeroptera precede Trichoptera in alpine glacierfed stream (Ward 1994). In the alpine springfed streams Ephemeroptera, Plecoptera and Trichoptera dominated drifts in early spring and autumn, while

Diptera in summer (LaPerriere 1994). This is in striking contrast to the present situation where steams of the high altitude in the Mandakini basin were dominated by Trichoptera.

Both the biome dependency (Ross 1963, Corkum 1989) and the longitudinal gradient or Continuum Concept models (Hawkes 1975, Vannote et al, 1980) may be used to predict the spatial distributional patterns of insects (at a coarse level of identification) along rivers. The biome dependency hypothesis predicts that similar assemblages of macroinvertebrates are most likely to occur at sites along rivers if the drainage basins occupy the same biome. The relationships that are derived for one biome are not expected to apply to other biome because of the overriding importance of climate and vegetation (biome features) on the stream invertebrate community. In contrast, the longitudinal or continuum models predict that invertebrate assemblages will change along the length of rivers. These longitudinal spatial patterns are expected to be consistent from biome to biome. The latter view receives support from the present observation that Trichoptera decreased while the Ephemeroptera increased longitudinally, in the Kakra, Rawan and Swar streams representing respective sub-basins. Differences in the abundance pattern of Trichoptera and Ephemeroptera and other orders can be attributed to altitude. This statement receives support from the fact that Kakra dominated by Trichoptera was located at higher elevation compared with Swar dominated by Ephemeroptera at lower elevation. Moreover, the Kakra at higher elevation (880-2440 m) differed from the Swar at lower elevation (733-1400 m) by virtue of the unequal proportions of Ephemeroptera and Trichoptera (20-23%, 31-51%) in the former compared with balanced share (35-38%, 32-33%) in the latter, thus lending support to the role of altitude which is reflected in the forest type and consequently the organic load in the stream thereby influencing the taxonomic composition of the community.

ACKNOWLEDGEMENTS

The authors acknowledge the financial support in the form of research projects granted by GBPIHED, Almora and DST, New Delhi. Such wide scale studies could hardly be accomplished without financial support of desired magnitude. I thank Professor H. R. Singh, Vice Chancellor University of Allahabad, for his valuable suggestions. and Prof. Asha Chandola-Saklani, Head Department of Zoology, H. N. B. Garhwal University, Srinagar for the academic support.

REFERENCES

Badola, S. P. and Singh, H. R. 1981. Hydrobiology of the river Alaknanda of the Garhwal Himalaya. *Indian Journal of Ecology* 8 (2): 269-276.

Burks, B. D. 1953 *The Mayflies or Ephemeroptera of lilinois*. Bull. Ill. *Nat. His. Surv.* 26: 1-215.

Cantonati, M., Corradini, G., Jüttner, I. & Cox, E. J. (2001). Diatom assemblages in high mountain streams of the Alps & the Himalaya. *Nova Hedwigia Beiheft* 123: 37-61

Corkum. L. D. 1989 Patterns of benthic invertebrate assemblages in rivers of northwestern North America. *Freshwater Biology* 21:191-205.

Corkum. L. D. 1990 Intrabiome distributional patterns of lotic macroinvertebrate assemblages. *Canadian Journal of Fisherles Aquatic Sciences* 47: 2146-2157.

Davis, J. R. 1997. Revitalization of northcentral Taxas river as indicated by benthic macroinvertebrate communities. *Hydrobiologia* 346: 95-117.

Edmunds, G. F., Jensen, S, L, and Berner, L. 1976. *The mayflies of North and Central America.* Univ Minnesota Press, Mineapalis. 330.

Gusain, M. P. 1994, *Migration routes-River Alaknanda* p. B147-168. In: *Mahseer-The Game Fish,* Nautiyal P., ed. Jagdamba Prakashan, Dehradun,

Habdija, I., Radanovic, I. and Habdija, B. P. 1997. Longitudinal distribution of predatory benthic macroinvertebrates in Karstic river. *Archiv fiir Hydrobiol*, 4: 527-546.

Hawkes, C. P., 1975. River zonation and classification. In: *River Ecology* (Whitton, B. A. ed. Blackwell Scientific Publications, Oxford.

Hynes, H. B. N. 1970. The Ecology of RunningWater. Liverpool University Press, Liverpool. 555 pp.

Julka, J. M., Vasisht, and Bala, B.1999. Distribution of aquatic insects in a small stream in northwest Himalaya, India. *Journal of the Bombay Natural History Society* 96 (1): 55-63.

Kishor, B., Bhatt, J. P., Rawat, V. S. and Nautiyal, P. 1998. Stream Regulation: Variations in the density of benthic macroinvertebrate fauna of Ganga in lateral canals at Hardwar. *Journal of Hill Research* 11(1): 62-67.

Kishor, B., Nautiyal, P.,Nautiyal, R., & Singh, H. R. 2004. Stream regulation: Variations in density, composition and diversity of benthic macroinvertebrates occurring in the up and downstream section of the impounded zone of the river Ganga in the foothills. *Tropical Ecology* 45 (2), 251-261.

LaPerriere, I. D. 1994 Benthic ecology of a spring fed river of interior Alaska. *Freshwater Biology* 32, 349-357.

Macan, T. T. 1979. *A key to the nymphs of the British species of Ephemeroptera with notes on their ecology.* Freshwater Biological Association Scientific Publication. No. 20 (3rd ed.) 5-80.

Myers, N. 1990. The biodiversity challenge: expanded hot-spots analysis. *Environmentalist* 10, 243-256.

Myers, N., R. A., Mittermeier, C. G., Mittermeier, G. A. B. da Fonseca and J. Kent. 2000. Biodiversity hotspots for conservation priorities. *Nature* 403:853-858.

Nautiyal, P. 1984, *Studies on the riverine ecology of the torrential waters in Indian uplands of Garhwal region. 2. Seasonal fluctuations in diatom density. Proc. Indian Acad. Sci. Anim.* Sci., 93, 671-674

Nautiyal, P. 1986, *Studies on the riverine ecology of the torrential waters in Indian uplands of Garhwal region- Floristic faunistic survey. Trop. Ecol.*, 27, 157-165.

Nautiyal, P. 1997, *Migratory phenomenon of the endangered Himalayan Mahseer Tor putitora in relation to the Ecology of the river Ganga,* Final Technical Report of Research Project No. 14/28/92- submitted to the Ministry of Environment Forests New Delhi under Man & Biosphere Program, 106 pp

Nautiyal, P. 2001. Ecology of mountain streams and rivers in Garhwal Himalaya, p. 393-417. In: *Ecology and Conservation of Lakes, Reservoirs and Rivers,* Kumar A ed. A B D Publishers,Jaipur.

Nautiyal, P., Kala, K. and Nautiyal, R. 2004 A preliminary study of the diversity of diatoms in streams of the Mandakini basin (Garhwal Himalaya) p. 235-269. In: Proceedings 17 Internat. Diatom Symp. Ottawa (M Poulin [ed.], Biopress Limited, Bristol

Nautiyal, P., Bhatt, J. P., Kishor, B., Rawat, V. S., Nautiyal, R. and Singh, H. R. 1997 a. Assessment of fish food resource in relation to the migratory habits of *Tor putitora* [Ham.] found in the impounded sections of the river Ganga between Rishikesh and Hardwar. *Proceedings National Academy Science* 67 [B], 203-212.

Nautiyal, P., Bhatt, J. P., Kishor, B., Rawat, V. S., Nautiyal, R. Badoni, K. and Singh, H. R. 1997b Altitudinal variations in phytobenthos density and its components in the cold water mountain river Alaknanda-Ganga. *Phykos* 36 (1&2), 81-88

Nautiyal, P., Shivam, A., Rawat, G., S, K. R., Verma, J. and Dwivedi, A. C. 2004 Longitudinal Variation in the Structure of Benthic Communities in the Upland Vindhyan and Himalayan Rivers : River Continuum Concept approach. National *Journal of Life Sciences* 1, 85-88

Negi, D. S. 1995 Mandakini Ghati ke Samakalit Vikas ka ek Adhyayan. D. Phil Thesis H N B Garhwal University, Srinagar Garhwal pp165.

Negi, M. and Singh, H. R. 1990 Substratum as a determining factor for bottom fauna in the river Alaknanda. *Proceedings of the National Academy of Science India* B 56, 417-423

Ormerod, S. J., Rundle, S. D., Wilkinson, S. M., Daly, G. P., Dale, K. M. and Jüttner, I. 1994. Altitudinal trends in the diatoms, bryophytes, macroinvertebrates and fish of a Nepalese river system. *Freshwater Biology* 32, 309-322.

Ormerod, S. J., Baral, H. S., Brewin, P. A., Buckton, S. T., Juttner, I., Rothfritz, H., and Suren, A. M. 1997. River Habitat Surveys and Biodiversity in the Nepal Himalaya. p 241-250. In: *Freshwater*

Quality: Defining the Indefinable, Boon P. J. & Howell, D. L. eds. HMSO, Edinburgh.

Pennak, R. W. 1953 *Fresh Water Invertebrates of the United States.* 2nd edition. John Wiley & Sons, New York 512-733.

Cantonati M., Corradini G., Jüttner I. and Cox E. J. 2001. Diatom assemblages in high mountain streams of the Alps and the Himalaya, *Nova Hedwigia Beih* 123, 37-61

Ramusino, C. M., Villa, S. and Calamari, D. 1995. River continuum concept and correspondence analysis to study alpine stream macroinvertebrate community. *Mem. dll'Istituto Italiano di Idrobiol* 53, 101-114

Rothfritz, H., Jüttner, I., Suren, A. M. & Ormerod, S. J. 1997. Epiphytic and epilithic diatom communities along environmental gradients in the Nepalese Himalaya: implications for the assessment of biodiversity and water quality. *Archiv für Hydrobiologie* 138, 465-482.

Ross, H. H.1963. Stream communities and terrestrial biomes. *Archiv für Hydrobiologie*. 59, 235-242.

Singh, H. R. and Nautiyal, P. 1990. Altitudinal changes and the impact of municipal sewage on the community structure of macrobenthic insects in the torrential reaches of the river Ganges in the Garhwal-Himalaya (India). *Acta Hydrobiologica* 32, 407-421.

Singh, H. R., Nautiyal, P., Dobriyal, A. K., Pokhriyal, R. C., Negi, M., Baduni, V., Nautiyal, R., Agrawal, N. K., Nautiyal, P. & Gautam, A. 1994 Water quality of river Ganga (Garhwal Himalaya). *Acta Hydrobiologica* 36(1), 3-15.

Suren, A. M. 1994. Macroinvertebrate communities of streams In Western Nepal: effect of altitude and landuse. *Freshwater Biology* 32, 323-336.

Vannote, R. L., Minshall, G. W., Cummins, K. W., Sedell, J. R. and Cushing, C. E. 1980 The River Continuum Concept. *Canadian Journal of Fisheries & Aquatic Sciences* 37, 130-13.

Ward, J. V. 1994. Ecology of alpine streams. *Freshwater Biology*, 32, 277-294.

Wright, J. F., Moss, D., Armitage, P. D. and Furse, M. T. 1984. A preliminary classification of running-water sites in Great Britain based on macroinvertebrate species and the prediction of community type using environmental data. *Freshwater Biology* 14, 221-256.

(Received- February, 2006; Accepted- August, 2006)