BIODIVERSITY IN RIFFLES AND POOLS OF THE MARDI AND THE VIJAYPUR STREAMS, POKHARA, NEPAL: BENTHIC MACROINVERTEBRATE COMMUNITIES

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ABSTRACT

Macroinvertebrate communities from September 2003 to August 2004 were studied in riffles and pools of the Mardi and the Vijayapur streams, Pokhara, Nepal. A total of 47 genera (32 from the riffles and 34 from the pools) belonging to 38 families and 12 orders were recorded. The generic richness was lower (30 genera) in the Vijaypur stream than in the Mardi stream (38 genera).

Ephemeropteran, dipteran, and trichopteran were found predominant orders comprising 11, 8 and 8 genera respectively. Heptagenids, baetids and leptophlebids; chironomids, ceratopagonids and tipulids and hydropsychids, psychomyids and polycentropodids were dominant sub-groups/families among ephemeropterans, dipterans and trichopterans respectively. The dominant genera were, Heptagenia, Rhithrogena and Baetis; Tendipes, Culicoids and Simulium; Hydropsyche and Psychomyia; Psephenus and Heterlimnius; Octogomphus and Argia and Planaria among ephemeropterans, dipterans, trichopterans, plecopterans, coleopherans, odonates and tricladids respectively. The taxa occurred at both streams and sub-habitats were, Ephemera, Heptagenia, Rhithrogena, Ecdyonurus, Ephemerella, Baetis, Leptophlebia, Caenis; Tendipes, Culicoides, Simulium; Hydropsyche, Psychomyia, Psephenus, Heterlimnius and Planaria. Those occurred only in the Mardi stream (Site 1) were Habrophlebia, Siphlonurus; Glossosoma, Hydroptila, Leptocerus; Nemoura, Protonemura, Octogomphus, Argia and Gyraulus convexiculus, whereas, only in the Vijaypur stream (Site 2) were Centroptylum; Antocha, Psychoda, Tabanus, Agapetus and Ectopria. The lower taxa richness at the site having urban influence reflects perturbation of riverine environment due to urbanization and needs measures to control further deterioration.

Key words: Macroinvertebrates, stream bio-diversity, distribution, riffles, pools.

INTRODUCTION

The invertebrates living on, the bottom of the water body playing a vital role in the aquatic ecosystem are macro-invertebrates or macro-zoobenthos. Several investigators have pointed out that many aquatic insects were evolved in cool lotic waterbodies prior to spreading to warmer riverine and lacustrine environments (Hynes, 1970; Ward, 1992 and Wetzel, 2001). Some of these biota form the food of fishes, while others act as predators on young fishes and other

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aquatic fauna. Many researchers have focused their attention on the role of these bottom dwelling invertebrates as fish food, being the most diverse fauna of running waters (Mohan and Bisht 1991; Allan, 1995), some worked on their abundance for measuring diversity indices as biomonitors and indicators of water quality and environmental conditions of lotic waterbodies (Norris and Norris 1995, Dudgeon 1999), some others incorporated them into general models of structure and function of stream ecosystem (Fisher and Likens, 1973, Cummins and Meritt 1996) and recent works on riverine macro-invertebrate assemblage have concentrated on variations in population and community dynamics and secondary production in response to environmental variables (Minshall *et al.* 1985, Cummins 1992, Sharma *et al.* 2004).

Studies on macroinvertebrate fauna have been done by aquatic biologists (Das, 1971; Walsh *et al.,* 2001). Some works have been performed in Nepalese waterbodies (Sharma, 1975; Yadav and Rajbhandari 1982; Vaidya *et al.,* 1988; Ormerod *et al.,* 1994; Brewin *et al.,* 2000; Sharma *et al.,* 2006 etc.). However, those of the Mardi stream and Vijaypur stream in Pokhara valley probably have not yet been studied. The Mardi, a snow-fed high altitude stream flowing through the base of Himalayas and the Vijayapur, a spring-fed mid-hill stream flowing through the base of Mahabharat hills in Pokhara valley, Nepal represent typical Himalayan lotic ecosystem with unique physio-hydrological features such as, high velocity, low or moderate temperature, unstable river-bed substrata etc. Considering their importance in aquatic ecosystem and lack of literature, present work aims to explore the macro-invertebrate fauna of these streams.

STUDY AREA

Pokhara, "a beautiful valley of nature's paradise" in centro-western Nepal Himalaya, has many fascinating waterbodies-river, streams, creeks, lakes and ponds. It covers an area of about 200 sq.km. extending between 25° 07' and 28° 10' N latitude and 83° 50' and 84° 50' E longitude and lies 800 m asl (Tripathi 1984-85). The lotic waterbodies flowing through the valley are the Seti Gandaki river and its tributaries. The Mardi khola/stream and the Vijayapur khola/stream are its major tributaries (Fig. 1). Two sites were selected on these streams which are as follows:

SITE 1. MARDI KHOLA/STREAM

The first site was situated near the confluence of the Mardi khola with the Seti Gandaki river near Mardi, about 13 km. upstream from the densely populated Pokhara city area and about 25 km upstream from Site 2. It had erosion-sensitive banks on both the sides and the watershed area had forests, agricultural fields and villages. The stream-bed had less sand and gravels but with more stones and boulders.

SITE 2. VIJAYPUR KHOLA/STREAM

The second site was on the Vijaypur khola/stream near its confluence with the Seti Gandaki river, located about 12 km. downstream from the densly populated Pokhara city area and about 25 km downstream from the first site. The

banks on both the sides were found severely eroded. The watershed area had agricultural fields, poultry farms and villages. The surface run-off from the catchment area as well as the human activities such as, bathing, washing of various items including the vehicles releasing chemical substances into the water. The stream-bed was covered with pebbles, stones and boulders with less sand.

MATERIALS AND METHODS

Present work was performed from September 2003 to August 2004. The macroinvertebrates were sampled using Surber sampler (0.093 m^2). Five replicate samples were taken monthly from riffles and pools at each site. The samples were screened using the sieve (0.5 mm. mesh net), kept in polythene bags, preserved in 4% formalin and carried to the laboratory for further works. The samples were sorted group-wise and kept in vials containing 70% alcohol. The samples were identified to the lowest possible taxonomic level using taxonomic monographs/books (Edmondson, 1959; Needham and Needham, 1962; Mellanby, 1963; Pennak, 1978; Tonapi, 1980; Dudgeon, 1999 and Nesemann *et al.,* 2007).

RESULTS

Altogether 47 genera belonging to 38 families and 12 orders, viz., ephemeroptera, diptera, trichoptera, plecoptera, coleoptera, odonata, hemiptera, megaloptera, tricladida, plesiopora, rhynchobdellida and pulmonata were recorded during the study period (Table 1), comprising 32 genera from riffles and 34 genera from pools.

Ephemeropterans, dipterans and trichopterans comprising 11, 8 and 8 genera respectively were predominant groups/orders among the macroinvertebrates followed by odonates, plecopterans, coleopterans, pulmonates, hemipterans, megalopterans, tricladids, plesioporans, and rhynchobdellids comprising 5, 4, 4, 2, 1, 1, 1, 1 and 1 general respectively. Among ephemeropterans, the heptagenids, baetids and leptophlebids were found to be the dominant sub-groups/families comprising 3, 2 and 2 genera followed by ephemerids, ephemerellids, caenids and siphlonurids having representation of single genus each. Similarly, among dipterans, chironomids, ceratopogonids, tipulids, psychodids, tabanids, culicids, simulids and athericids were observed to have equal representation of single genus. Likewise, among trichopterans, hydropsychids, psychomyids, polycentropodids, hydroptilids, leptocerids and limnephilids were found to have single genus each, while glossosomatids were having representation of 2 genera. The dominant genera were, *Heptagenia, Rhithrogena, Baetis, Leptophlebia* and *Ephemera; Tendipes, Culicoides* and *Simulium; Hydropsyche* and *Psychomyia; Perla, Nemouria,* and *Protonemura; Psephenus* and *Heterlimnius; Octogomphus* and *Argia* and *Planaria* among ephemeropterans, dipterans, trichopterans, plecopterans, coleopterans, odonates and tricladids respectively.

The genera recorded from both the sites and sub-habitats (riffles and pools) were *Ephemera, Heptagenia, Rhithrogena, Ecdyonurus, Ephemerella, Baetis, Leptophlebia* and *Caenis; Tendipes, Culicoides* and *Simulium; Hydropsyche* and *Psychomyia; Pesphenus* and *Heterlimnius* and *Planaria* among

ephemeropterans, dipterans, trichopterans, coleopterans, and tricladids respectively. Whereas, the genera recorded from both the sub-habitats (riffles and pools) at Site 1 were, *Habrophlebia* and *Siphlonurus; Glossosoma, Hydroptila* and *Leptocerus; Perla, Nemouria* and *Protonemura; Octogomphus* and *Argia* and *Gyraulus* among ephemeropterans, trichopterans, plecoterans, coleopterans, odonates and hygrophilids respectively and those recorded from both sub-habitats at Site 2 were, *Centroptylum; Antocha, Psychoda* and *Tabanus; Agapetus; Ectopria* and *Corydalus* among ephemeropterans, dipterans, trichopterans, coleopterans and megalopterans respectively.

The genera recorded only from the pools at both the sites were, *Ophiogomphus* and *Tubifex* among odonates and plesioporans respectively. Those recorded only from the riffles at Site 1 were, *Polycentropus* and *Limnephilus; Isoperla* and *Corydalis* among trichopterans, plecopterans, and megalopterans respectively and those only from the pools were *Atherix; Dytiscus; Dromogomphus* and *Sympetrum* and *Corixa* among dipterans, coleopterans, odonates and hemipterans respectively. Whereas, those recorded only from the riffle at Site 2 was *Perla* among plecopterans and only from pool were *Hemiclepsis* and *Lymnaea* among rhynchobdellids and respectively.

The generic richness being lower (30 genera) at Site 2 (Vijaypur stream) than at Site 1 (Mardi stream) (38 genera) was most probably due to urban influence upon the aquatic ecosystem. The prominent human activities observed at the study sites were extraction of sand, stones, gravels, and breaking of boulders from the river-bed and banks, movement of heavy vehicles for transportation of extracted materials, electro-fishing, release of toxic substances from the agricultural fields (using chemical fertilizers and pesticides) and human settlements in the catchment areas and direct disposal of wastes into the stream water. The above activities most probably had influence on the abiotic and biotic components of the stream ecosystem particularly at Site 2, having lower generic richness, which indicates the perturbation of the aquatic environment due to urbanization and needs measures to control further deterioration.

DISCUSSION

Generally the ephemeropterans were found to be the dominant group among the macro-invertebrates followed by trichoptera, plecoptera, diptera, coleopteran, odonata, hemiptera, oligochaeta, megaloptera etc. in hill-streams having natural environmental conditions. The dominant representative families of insects reported were, baetidae, ephemeridae and ephemerellidae; chironomidae, ceratopogonidae and simuliidae; hydropsychidae and limnephilidae among ephemeropterans, dipterans and trichopterans. In mid-land streams, the aquatic insects, their larvae or nymphs constituted more than 85% of which ephemeropterans, trichopterans, dipterans and plecopterans contributed major part of the total faunal composition (Ormerod *et al.,* 1994; Sharma *et al.,* 2004). Similar composition and dominance of macroinvertebrates were observed in the present study, which could be attributed to the complex physiohydrological characteristics and zoogeographical factors.

There was increasing trend of taxa richness at upstream to downstream sites, maximum richness at the transition between montane and valley sites, a significant decrease at the valley sites and decline of habitat stability and diversity at the urban sites (Useeglio-P and Beisel 2002; Sharma *et al.,* 2004). In the present study, the generic richness was lower at the site having urban influence, which could be due to the diverse physiography along-with various abiotic and biotic factors including the human activities.

The riffle dominant taxa (ephemeroptera, trichoptera and plecoptera) were having higher taxa richness at riffle stations in comparison to the pool stations, where pool dominant taxa (diptera, odonata, coleoptera and oligochaeta) counted higher (Sunder 1997; Carter and Fend 2001). Similarly taxa richness was observed in the present work, which could be attributed to the heterogeneity of substrata, velocity of water etc.

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Table 1: Diversity of macroinvertebrates in the Mardi and the Vijaypur streams.

S.N.	Taxa	Station	Distribution 1	Sites 2
	Order: Ephemeroptera			
	Family: Ephemeridae			
01.	*Ephemera* Linnaeus	R	+	+
		P	+	+
	Family: Heptageniidae			
02.	*Heptagenia* Walsh	R	+	+
		P	+	+
03.	*Rhithrogena* Eaton	R	+	+
		P	+	+
04.	*Ecdyonurus* sp.	R	+	+
		P	+	+
	Family: Ephemerellidae			
05.	*Ephemerella* Walsh	R	+	+
		P	+	+
	Family: Baetidae			
06.	*Baetis* Leach	R	+	+
		P	+	+
07.	*Centroptylum* Westwood	R	-	+
		P	-	+
	Family: Leptophlebidae			
08.	*Leptophlebia* Eaton	R	+	+
		P	+	+
09.	*Habrophlebia* Stephens	R	+	-
		P	+	-
	Family: Caenidae			
10.	*Caenis* Eaton	R	+	+
		P	+	+
	Family: Siphlonuridae			
11.	*Siphlonurus* Eaton	R	+	-
		P	+	-
	Order: Diptera			
	Family: Chironomidae			
12.	*Tendipes* Meigen	R	+	+
		P	+	+
	Family: Ceratopogonidae			
13.	*Culicoides* Latreille	R	+	+
		P	+	+
14.	*Antocha* Osten Sacken	R	-	+
		P	-	+
	Family: Psychodidae			

S.N.	Taxa	Station	Distribution 1	Sites 2
	Family: Tipulidae			
15.	*Psychoda* Latreille	R	-	+
		P	-	+
	Family: Tabanidae			
16.	*Tabanus* Linnaeus	R	-	+
		P	-	+
	Family: Culicidae			
17.	*Culex* Linnaeus	R	-	-
		P	-	+
	Family: Simuliidae			
18.	*Simulium* Hagen	R	+	+
		P	+	+
Family: Leptidae (Athericidae)				
19.	*Atherix* Meigen	R	-	-
		P	+	-
	Order: Trichoptera			
	Family: Hydropsychidae			
20.	*Hydropsyche* Pictet	R	+	+
		P	+	+
	Family: Psychomyidae			
21.	*Psychomyia* Pictet	R	+	+
		P	+	+
	Family: Glossosomatidae			
22.	*Glossosoma* Curtis	R	+	-
		P	+	+
23.	*Agapetus* Curtis	R	-	+
		P	-	+
	Family: Polycentropodidae			
24.	*Polycentropus* Curtis	R	+	-
		P	-	-
	Family: Hydroptilidae			
25.	*Hydroptila* Dalman	R	+	-
		P	+	-
	Family: Leptoceridae			
26.	*Leptocerus* Leach	R	+	-
		P	+	-
27.	*Limnephilus* Leach	R	+	-
		P	-	-
	Order: Plecoptera			
	Family: Perlidae			
28.	*Neoperla* Needham	R	+	+
		P	+	-
	Family: Perlodidae			
29.	*Isoperla* Banks	R	+	-
		P	-	-

S.N.	Taxa	Station	Distribution 1	Sites 2
	Family: Limnephilidae			
	Family: Nemouridae			
30.	*Nemoura* Pictet	R	+	-
		P	+	-
31.	*Protonemura* sp.	R	+	-
		P	+	-
	Order: Coleoptera			
	Family: Psephenidae			
32.	*Psephenus* Haldeman	R	+	+
		P	+	+
33.	*Ectopria* Leconte	R	-	+
		P	-	+
	Family: Elmidae			
34.	*Heterlimnius* Hinton	R	+	+
		P	+	+
	Family: Dytiscidae			
35.	*Dytiscus* Linnaeus	R	-	-
		P	+	-
	Order : Odonata			
	Family: Gomphidae			
36.	*Ophiogomphus* Selys	R	-	-
		P	+	+
37.	*Octogomphus* Selys	R	+	-
		P	+	-
38.	*Dromogomphus* Selys	R	-	-
		P	+	-
	Family: Agrionidae			
39.	*Argia* Rambur	R	+	-
		P	+	-
40.	*Sympetrum* Newman	R	-	-
		P	+	-
	Order : Hemiptera			
	Family: Corixidae			
41.	*Corixa* sp.	R	-	-
		P	+	-
	Order: Neuroptera			
	Family: Corydalidae			
42.	*Corydalis* Latreille	R	+	+
		P	-	+
	Order: Tricladida			
	Family: Planaridae			
43.	*Planaria* Girard	R	+	+
		P	+	+

S.N.	Taxa	Station	Distribution 1	Sites 2
	Family: Libellulidae			
	Order: Haplotaxida			
	Family: Tubificidae			
44.	*Tubifex* Muller	R	-	-
		P	+	+
	Order : Rhynchobdellida			
	Family: Glossiphoniidae			
45.	*Hemiclepsis marginata* Moore	R	-	-
		P	-	+
	Order: Hygrophila			
	Family: Planorbidae			
46.	*Gyraulus convexiculus* Hutton	R	+	-
		P	+	-
	Family: Lymnaeidae			
47.	*Lymnaea andersoniana* Preston	R	-	-
		P	-	+

Abbreviations:

R = Riffle, P = Pool, 1 = Mardi khola, 2 = Vijayapur khola, (+) = Present and (-) = Absent

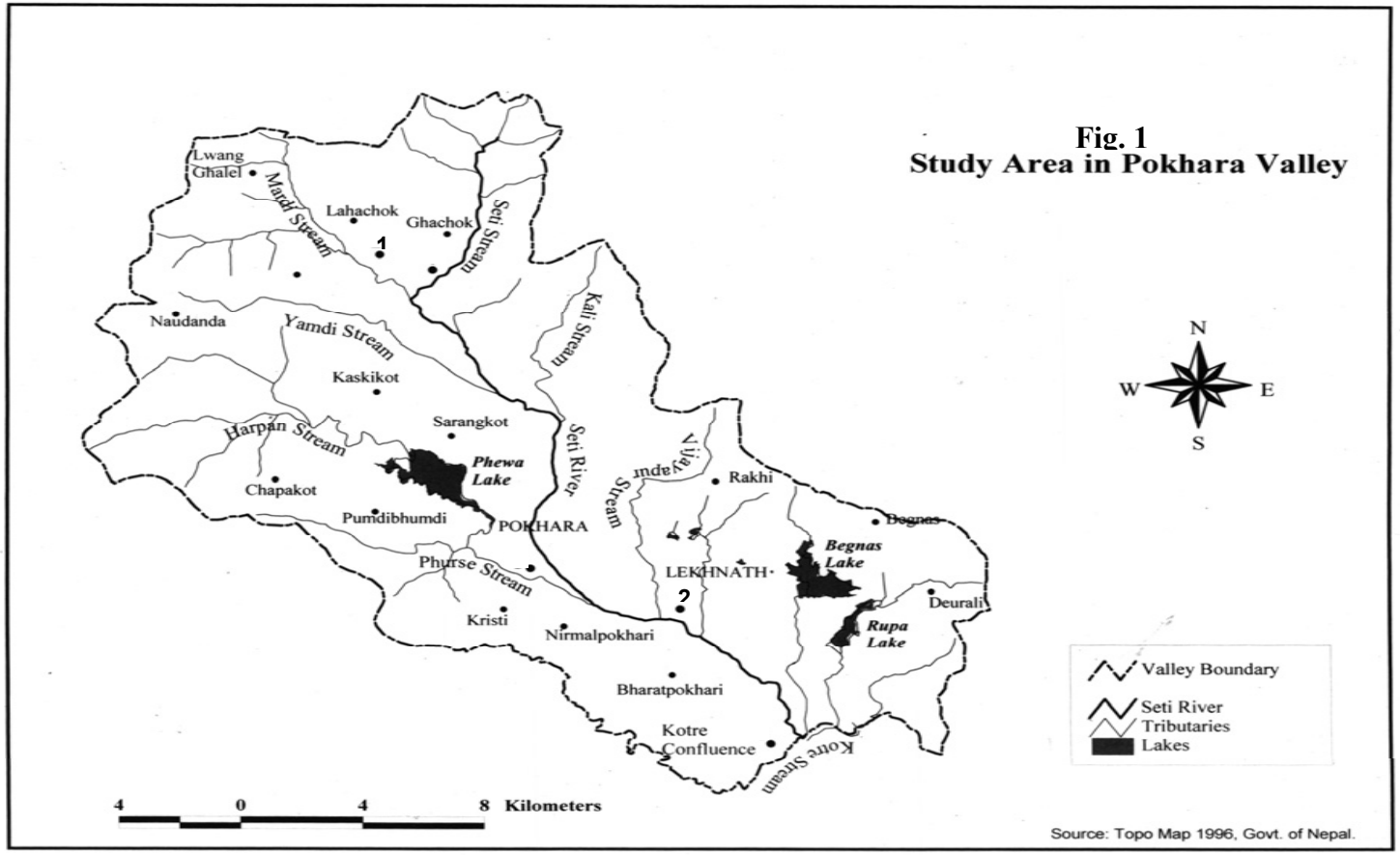
Fig. 1
Study Area in Pokhara Valley
Lwang Ghalel
Mardi Stream
Lahachok
Ghachok
Seti Stream
1
Naudanda
Yamdi Stream
Kaskikot
Kali Stream
Sarangkot
Harpan Stream
Phewa Lake
Seti River
Vijayapur Stream
Rakhi
Chapakot
Pumdibhumdi
POKHARA
Begnas
Begnas Lake
Phurse Stream
LEKHNATH
2
Deurali
Kristi
Rupa Lake
Nirmalpokhari
Bharatpokhari
Kotre Confluence
Kotre Stream
N
W
E
S
Valley Boundary
Seti River
Tributaries
Lakes
4 0 4 8 Kilometers
Source: Topo Map 1996, Govt. of Nepal.