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Study on Fish Ecology of the Seti Gandaki River Pokhara: II. Spatio-Temporal Variations in Fish Communities

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Abstract

Present paper deals with the spatio-temporal variations in distribution and abundance of fishes along the 30 km stretch of the Seti Gandaki river and its two major tributaries, Mardi Khola and Vijaypur Khola, in Pokhara Valley, Western Nepal. A total of 30 species of fishes belonging to 5 orders, 9 families and 22 genera were recorded from five sites on the river and its tributaries. Cyprinoids were predominant among fishes (17 spp.), siluroids (5 spp.), balitorids and cobitids (4 spp.), channioids (2 spp.), belonoids (one sp.) and mastacembeloids (one sp.). Among cyprinoids, mostly cyprinines were dominant groups (7 spp.) followed by rasborines (7 spp.), garrines (2 spp.) and schizothoracines (one sp.). There was increasing trend of species richness at upstream site (17 spp.). to downstream site (20 spp.) showing a longitudinal pattern. The total fish abundance and family-wise abundance at all the sites observed major peak during the spring and fall during the winter season in both the years of study. The average total density of fishes during the spring peak was highest (51.07/ha) at the upper tributary site and lowest (24.69/ha) at the urban site. According to the distribution pattern and abundance, the population status of the gamefish, mahseer [*Tor tor* (Ham)] has been endangered (E); that of game fishes [*Tor putitora* (Ham.) and *Chagunius chagunio* (Ham.)] and Zebra-fish [*Brachydanio rerio* (Ham.)] to are vulnerable (V); that of loach [*Lepidocephalus guntea* (Ham.)], cat-fishes [*Myersglanis blythii* (Day) and *Amblyceps mangois* (Ham.)] are rare (R).

Key words: fish ecology, spatio-temporal variations, fish communities, the Seti Gandaki river

Introduction

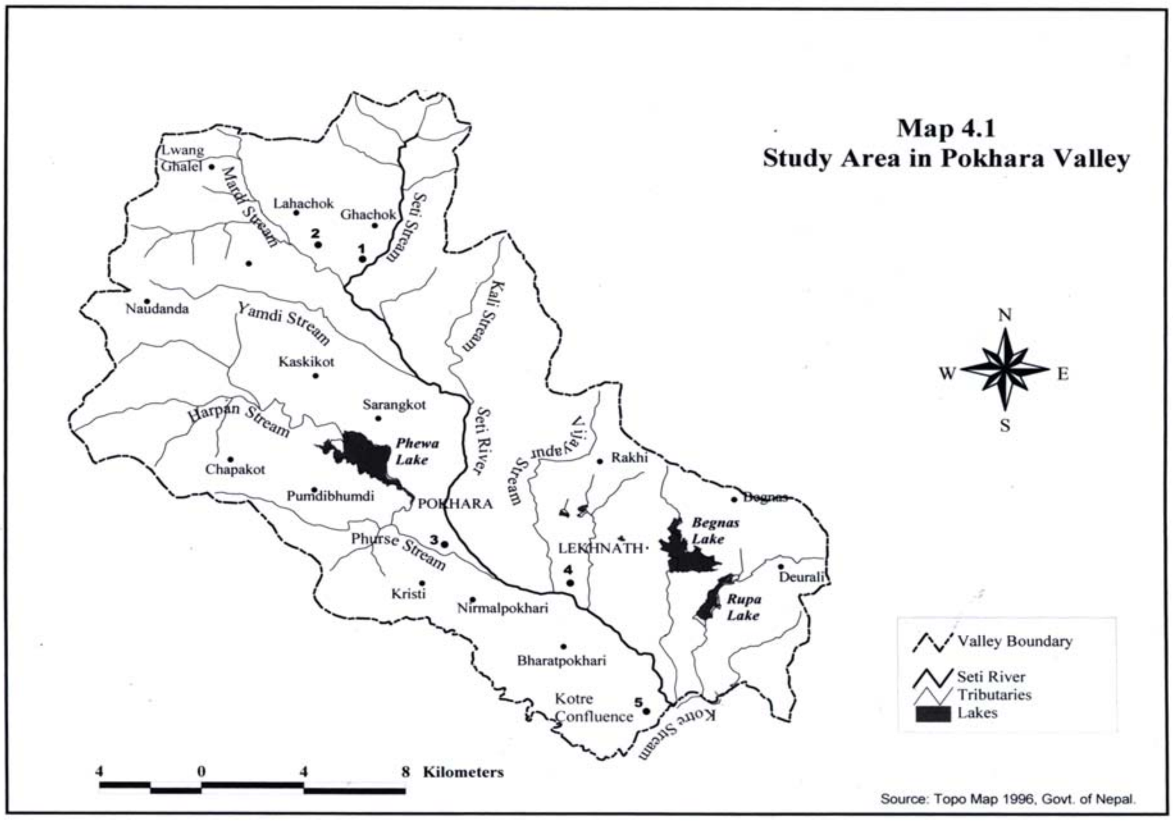
Pokhara valley, a place of natural paradise, is situated in Western Region of Nepal having many fascinating water resources-river, streams, creeks, lakes and ponds, so, known as, “water resources valley of Nepal”. It covers an area of about 200 sq. km., extending between 25^0 07' and 28^0 10' N Latitude and 83^0 50' and 84^0 50' E Longitude and lies above 800 m asl (Tripathi 1985). It is extended north-west to south-east for 25km and varies north to south between 8 to 15 km. The physiographic features of this valley are diverse due to presence of river, streams, lakes, caves, terraces, deep gorges, steep slopes and bounded by high Mahabharat and Himalyan ranges to its northern side. The lotie water bodies in Pokhara valley are the Seti Gandaki river and its tributaries. The river originates near the base of Mount Machhapuchhre (6,997m) and Mount Annapurna (7,525m) flowing downwards receives several tributaries and passes through the heart of Pokhara valley (Fig. 1) forming deep gorges. The catchment area of this river is about 600 sq. km, and a total length of about 112.6 km. It joins the Trishuli river at Gaighat (Sharma 1977). The major tributaries of this river are Mardi Khola and Vijaypur Khola. Mardi Khola, a snow-fed stream, originates from Mardi Himal (5,127m) extending about 25km in length, flows downwards and joins the Seti Gandaki river near Lahachok, about 15 km from the Pokhara city area. Vijaypur Khola, a spring-fed stream, arises at the foot-hills of Mahabharat range situated in the north-eastern side of the valley and is about 12 km in length. It flows downwards through the eastern part of the valley and joins the Seti Gandaki river about 13 km from the city area.

Ecological studies conducted on rivers and streams mostly included physico-chemical parameters but biological parameters were given little attention. So, river ecologists have also suggested the importance of biological monitoring of water bodies (Nikolsky 1963, Shrestha 1990, Allan 1995, Dudgeon 1999).

Fishes are important aquatic fauna serving as food, entertainment, biological control agents, animal feed, manure, decoration, sports, etc to human beings from the time immemorial. The lotic water bodies of the valley are the habitat, of several species of fishes.

Literature on fish species-diversity of Nepal include the works of Hamilton (1822) who was probably the first ichthyologist to give an authentic information of fishes of Nepal. Afterwards, Gunther (1861), Day (1878), Reagan (1907), Mukherjee (1931), Hora (1937), Menon (1949), Taft (1955), Dewitt (1960), Thapa and Rajbanshi (1968), Majumdar *et al*, (1972) and Shrestha (1981, 1994, 2001) reported fishes of Nepal. Similarly, Shrestha (1981, 1990), Rajbanshi (1982), Terashima (1984), Edds (1985, 1986), FRD (1994), Majupurias (1998), NARC and JICA (1998), Rai (2005), Swar (2005) and Majupurias (2006) reported fish and fisheries of Nepal.

Works on fish species-diversity and fisheries of Pokhara valley are those of Ferrow and Badgami (1980); Swar and Gurung (1988); John and Dhewajoo (1989); FRC (1992) and Pokharel (1998, 1999, 2006), who reported fishes of rivers, streams and lakes.



Map 4.1
Study Area in Pokhara Valley

Source: Topo Map 1996, Govt. of Nepal.

Study Area

The study sites are situated at different places along the lotic water bodies – the Seti Gandaki river and its tributaries (Fig. 1). Five sites were selected of which three on the Seti Gandaki river and two on its major tributaries, Mardi Khola and Vijayapur Khola, which are as follows:

Site 1: Lahachok area (Pre-urban Site)

The uppermost sampling site was in the main channel near the Lahachok village, about 19.5 km upstream from the urban or third site. The river banks on both the sides were erosion-sensitive and the watershed area had patchy forests, grasslands, agricultural fields and cremation spots. The river-bed had less sand and pebbles, but with more stones and boulders.

Site 2: Mardi Khola/stream (Upper tributary site)

This site was situated above the confluence of the Mardi stream with the Seti Gandaki river near Mardi about 19 km upstream from the urban or third site. It also had erosion-sensitive banks and the watershed area had forests, agricultural fields and village area. The stream-bed had less sand and gravels, but with more stones and boulders.

Site 3: Dobilla (Urban site)

The third site or urban site was situated near Dobilla, the south-western point of Pokhara valley below the lower part of densely populated city area and 4 km upstream from the fourth site. The watershed included the village area, grasslands, agricultural fields, municipal area and cremation spots. The municipal wastes, industrial wastes and agricultural wastes directly entered into the river through canals. River bed had sand, pebbles, gravels, stones and boulders.

Site 4: Vijaypur Khola (Lower tributary site)

This site was on Vijaypur Khola, located about 5.5 km upstream from the fifth site and 0.5 km from the confluence of this stream with the Seti Gandaki river. The banks were heavily eroded. The watershed area had agricultural fields, poultry farms and village area. The surface run-off from watershed area as well as the human activities such as bathing, washing of various items including vehicle released chemical substances into the water. Steam-bed was covered with pebbles, stones and boulders with less sand.

Site 5: Kotre area (Post-urban site)

The fifth site was on the main channel near Kotre in Tanahun district (the district boundary between Kaski and Tanahun districts) about 20 km south-east from Pokhara city. The watershed area had agricultural fields, Lekhnath municipality area, villages and cremation spots. The surface run-off from the above area carried dissolved chemical substances released from chemical fertilizers, pesticides and ashes which enter into the river. The river-bed had sand, gravels, stones and boulders.

Methodology

Fish sampling was done monthly and samples required for further study were collected from five sites, three on the Seti Gandaki river and two on its tributaries (one on Mardi Khola - upper tributary, and one on Vijaypur Khola - lower tributary) from September 2001 to August 2003.

Fishes were sampled at each site with the help of a cast-net (mesh 6mm) by an experienced fisherman following the techniques of Ricker (1968) and APHA (1998), For estimation of distribution and abundance of fishes, two - pass removal method (Seber and Le Cren 1967) was used. Each removal pass included moving first upstream and then downstream within a predetermined length (100 m) having six sub-sections of river / stream. The surface area of these sub - sections of river / stream was estimated using width and length of the sampled area. Sampling was performed with equal effort (time - half an hour) for each pass at each site to catch maximum number and species of fishes. The fishes were caught, examined and released unharmed into the water after identification and recording required data. The specimens, which required taxonomic verification, were collected and preserved in 10% buffered formalin and brought to the laboratory. Fishes were identified with the help of taxonomic monographs of Day (1878), Jayaram (1981) and Shrestha (1981, 2001). The abundance of fish was expressed as number per 0.1 ha. The criteria laid out by IUCN (1994) were followed for assessment of the status of fishes.

Results

Seasonal variations in number and percentage abundance of different families of fishes at various sampling sites for a period of two years are presented in Tables 1 to 5. A total of 30 species of fishes belonging to 5 orders, 9 families and 22 genera were recorded from the five sites on the Seti Gandaki river and its two major tributaries, Mardi Khola and Vijaypur Khola which are listed in Table 6.

Table 5. Mean Seasonal variations in number and percentage abundance of fishes at Post-urban Site/Site - 5 of Seti Gandaki river, during 2001-2003.

	No. 0.1ha^{-1}.									
Season	**Autumn (Sep.-Nov.)**		**Winter (Dec.-Feb.)**		**Spring (Mar.-May)**		**Summer (Jun.-Aug.)**		**Average**	
Taxa	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No**	**%**
Cyprinidae										
Cyprininae										
Neolissocheilus hexagonolepis	16.50	6.35	6.16	4.34	23.33	6.22	10.66	5.58	14.16	5.85
Puntius sophore	24.50	9.43	11.83	8.35	27.66	7.37	17.66	9.24	20.41	8.44
P. conchonius	27.83	10.71	17.50	12.35	43.50	11.59	22.16	11.60	27.74	11.47
Tor putitora	8.33	3.20	3.00	2.11	16.50	4.39	6.33	3.31	8.59	3.53
T. tor	6.16	2.37	2.00	1.41	8.33	2.22	4.00	2.09	5.12	2.11
Chagunius chagunio	8.49 (91.81)	3.26 (35.34)	4.00 (44.49)	2.82 (31.41)	14.16 (133.48)	3.77 (35.58)	6.16 (66.97)	3.22 (35.07)	8.20 (84.17)	3.39 (34.81)
Rasborinae										
Barilius bendelisis	28.99	11.16	19.83	14.00	41.33	11.01	24.50	12.83	28.66	11.85
B. vagra	12.99	5.00	7.33	5.17	28.83	7.68	9.49	4.97	14.66	6.06
B. barila	7.33	2.82	3.00	2.11	11.83	3.15	5.00	2.61	6.79	2.80
B. barna	6.33 (55.64)	2.43 (21.42)	2.00 (32.16)	1.41 (22.70)	8.33 (90.32)	2.22 (24.08)	5.00 (43.99)	2.61 (23.04)	5.41 (55.52)	2.23 (22.96)
Garrinae										
Garra annandalei	8.33	3.20	4.00	2.82	15.33	4.08	6.33	3.31	8.49	3.51
G. gotyla	24.49 (32.82)	9.42 (12.63)	16.50 (20.50)	11.65 (14.47)	37.83 (53.16)	10.08 (14.17)	18.66 (24.99)	9.77 (13.08)	24.37 (32.86)	10.07 (13.59)
Schizothoracinae										
Schizothorax richardsonii	8.33 (8.33) [188.60]	3.20 (3.2) [72.61]	2.00 (2.00) [99.15]	1.41 (1.41) [70.01]	13.00 (13.00) [289.96]	3.46 (3.46) [77.30]	6.33 (6.33) [142.28]	3.31 (3.31) [74.52]	7.41 (7.41) [179.96]	3.06 (3.06) [74.43]
Balitoridae										
Acanthocobatis botia	10.66	4.10	5.16	3.64	12.99	3.46	7.33	3.83	9.03	3.73
Schistura beavani	7.16 [17.82]	2.75 [6.86]	2.00 [7.16]	1.41 [5.05]	9.49 [22.48]	2.53 [5.99]	4.00 [11.33]	2.09 [5.93]	5.66 [14.69]	2.34 [6.07]
Bagridae										
Mystus bleekeri	11.83 [11.83]	4.55 [4.55]	9.49 [9.49]	6.70 [6.70]	12.99 [12.99]	3.46 [3.46]	8.33 [8.33]	4.36 [4.36]	10.66 [10.66]	4.40 [4.40]
Belonidae										
Xenentodon cancila	8.33 [8.33]	3.20 [3.20]	8.33 [8.33]	5.88 [5.88]	10.66 [10.66]	2.84 [2.84]	6.16 [6.16]	3.22 [3.22]	8.37 [8.37]	3.46 [3.46]
Channidae										
Channa orientalis	13.00	5.00	7.33	5.17	14.16	3.77	8.49	4.44	10.74	4.44
C. punctatus	8.33 [21.33]	3.20 [8.21]	4.00 [11.33]	2.82 [8.00]	9.49 [23.65]	2.53 [6.30]	6.00 [14.49]	3.14 [7.58]	6.95 [17.69]	2.87 [7.31]
Mastacembelidae										
Mastacembelus armatus	11.83 [11.83]	8.33 [8.33]	6.16 [6.16]	4.34 [4.34]	15.33 [15.33]	4.08 [4.08]	8.33 [8.33]	4.36 [4.36]	10.41 [10.41]	4.30 [4.30]
Total	**259.74**	**-**	**141.62**	**-**	**375.07**	**-**	**190.92**	**-**	**241.78**	

Numbers inside the parenthesis [ ] indicate the familywise and ( ) indicate the sub-familywise total and percentage abundance.

Cyprinoids (carps, minor carps, carp-minnows, sucker-heads and snow-trouts) were pre-dominant among fishes (17 species), followed by siluroids (5 species), loaches (4 species), gar fishes (1 species), snakeheads (2 species) and spiny eels (1 species). Among cyprinoids, mostly the cyprinines (carps and minor carps) were recorded to be dominant groups (7 species) followed by rasborines (carp-minnows / hill-trouts) (7 species), garrines / suckerheads) (2 species) and schizothoracines (snow-trouts) (1 species).

There was increasing trend of species richness at upstream site (Site 1) (17 species) to downstream site (Site 5) (20 species) in the present water bodies, showing a longitudinal pattern.

The total fish abundance as well as familywise abundance at all the sites observed major peaks during the spring season and fall during winter season in both the years of investigation. The average total density of fishes during the spring peak was highest (510. 70/0.1 ha) at the upper tributary site (site 2) and lowest (246.95/0.1 ha) at the urban site (site 3). This peak was mainly due to the family Cyprinidae.

The average density of cyprinoids was highest (225.68/ 0.1 ha) at site 4 and lowest (119.84/0.1 ha) at site 3. The contribution of cyprinoids to total fish population gradually declined in summer / monsoon and winter seasons. Among cyprinines, *Neolissocheilus hexagonolepis, Puntius sophore* and *P. conchonius* had 4.32, 6.64 and 7.10 in site 4 and 4.40, 3.83 and 5.25 in site 3, and among rasborines *Barilius bendelisis* and *B. vagra* had 12.91 and 10.78 in site 4 and 14.04 and 5.16 in site 3 as percentage (%) abundance and were dominant species at most of the sites. Similarly, the balitorids (hill-stream loaches) had highest density (35.78/0.1 ha) at site 4 and lowest (12.99/0.1 ha) at site 3. The contribution of balitorids to the total fish density declined till the end of summer/ monsoon season, then increased in autumn at the main channel sites, whereas it increased from spring till the end of autumn at the tributary sites. Among balitorids, *Acanthocobatis botia* and *Schistura beavani* had 8.92 and 2.72 respectively at site 4 and 7.74 at site 3 as percentage abundance and were dominant species.

The channioids (snake heads) had highest density (23.39/0.1 ha) at site 3 and lowest (12.12/0.1 ha) at site 1. The contribution of channoids to total fish density gradually declined in summer/monsoon season and winter season. *Channa orientalis* and *C. punctatus* had 6.89 and 7.04 respectively at site 3 and 4.04 at site 1 as percentage abundance. Likewise, the mastacembeloids (spiny-eels) had highest density (12.45/0.1 ha) at site 1 and lowest (9.78/0.1 ha) at site 4. The contribution of the mastacembeloid, *Mastacembelus armatus* to total fish population which had 4.15 at site 1 and 3.18 at site 4 as percentage abundance also declined in summer / monsoon and winter seasons.

The sisorids (hill-stream cat-fishes) had highest density (36.52/0.1 ha) at site 2 and lowest (8.41/0.1 ha) at site 4. The contribution of the sisorids, *Pseudecheneis sulcatus, Myersglanis blythii* and *Glyptothorax pectinopterus* to total fish density which had 4.57, 2.57 and 4.48 respectively at site 2 and 2.73 *(Glyptothorax)* at site 4 as percentage abundance, also declined in summer/monsoon and winter seasons. Similarly, the amblycipitids (hill-stream cat-fishes) had highest density (5.45/0.1 ha) at site 2 and lowest (4.87/ 0.1 ha) at site 1. The contribution of the amblycipitid, *Amblyceps mangois* to total fish population which had 1.69 at site 2 and 1.62 at site 1 as percentage abundance, also declined in summer/monsoon and winter seasons.

The belonoids (stony-eels) had highest density (11.57/ 0.1 ha) at site 4 and lowest (8.37/0.1 ha) at site 5. The contribution of the belonoid, *Xenentodon canclia* to total fish density which had 3.76 at site 4 and 3.46 at site 5 as percentage abundance, also declined in summer/monsoon and winter seasons. In the same way, the cobitids (hill-stream loaches) had density as 5.37/ 0.1 ha at site 2. The contribution of the cobitid, *Lepidocephalus guntea* to total fish density which had 1.66 at site 2 as percentage abundance, also declined in summer/monsoon and winter seasons. Likewise, the bagrids (catfishes) had 10.66/0.1 ha at site 5. The contribution of the bagrid, *Mystus bleekeri* to the total density which had 4.40 as percentage abundance, also declined during summer/monsoon and winter seasons.

According to the distribution pattern and abundance, the population status of the popular game fish, mahseer *(Tor tor)* was found to be endangered (E); that of important game fishes *(Tor putitora* and *Chagunius chagunio)* and Zebra-fish *(Brachydanio rerio)* to be vulnerable (V); and that of hill-stream loach

(Lepidocephalus guntea), hill-stream cat fishes *(Myersglanis blythii* and *Amblyceps mangois)* to be rare (R) (Table 6) (Shrestha, 2001).

Significant human activities observed at the above mentioned sites were extraction of sand and stones, breaking the boulders, movement of heavy vehicles for transportation of extracted materials, electro-fishing and introduction of chemicals/ pesticides for fishing (poisoning the water) near some sites (sites 3 and 4). The above activities certainly alter the abiotic as well as biotic components of water.

Discussion

Cyprinoids (carps, minor carps, carp minnows, suckerheads and snow trouts) have been reported to be dominant among fishes, followed by loaches, siluroids (hill stream catfishes), snake-heads, spiny-eels and gar-fishes. Among cyprinoids, mostly the cyprinines (carps and minor carps) were observed to be dominant groups followed by rasborines (carp minnows / hill-trouts), garrines (suckerheads) and schizothoracines (snow trouts) (Edds 1993, Pokharel 1999, Champasri 2003). Likewise, the cyprinines (carps and minor carps) and rasborines (carp minnows / hill-trouts) have been mentioned to contribute to a major portion of the fish biota (Edds 1993, Pokharel 2006, Shrestha 2001, Swar 2005). Similar pattern of species composition, family and group dominance was observed in the present work and also the important species, *Neolissocheilus hexagonolepis*, *Puntius sophore*, *P. conchonius*, *Barilius bendelisis*, *Garra gotyla* and *Schizothorax richardsonii* were found to be dominant forms at most of the study sites. The above mentioned species composition, group dominance and species dominance could be attriduted to complex physio-hydrological characterictics as well as in part to zoogeographical factors regarding the dispersal and dominance of Himalayan fishes, from the oriental realm, and Central Asia, after the early Tertiary upheavals that created these mountains and during interglacial periods of the Pleistocene respectively (Menon 1954, 1955, Edds 1993).

Edds (1993), (FRC 1992), Williams *et al.* (1996) and Kouamelan *et al.* (2003) mentioned increasing trend of species richness at upstream to downstream sites in various riverine water bodies. In the present study, the species richness of fishes was also observed in similar longitudinal pattern, which could be attributed to the diverse physiography with river-bank / bed heterogeneity, water velocity and discharge, gradient and depth, temperature and turbidity, various physico-chemical characterisitics and biotic inter-relationships of fishes, which constitute different ecological niches that fulfill the biological needs of the fish biota.

Livingson *et al.* (1991) and Kouamelan *et al.* (2003) reported higher species richness and abundance at main stem section of Choctawhatichee River system, Florida, USA and in West African basin, Ivory Coast, than at the tributary sites. However, Dobriyal and Joshi (1999) mentioned lower species richness in Mandakini river, Garhwal, India, than in its tributary, Nayar Stream. In the present study, the species richness values were lower at the upper and middle reaches but were higher at the lower reach in comparison to those of tributary sites, which could be attributed to habitat variation, physico-chemical properties and hydro-biological characteristics.

Various investigators such as, Edds *et al.* (2002) and Nislow *et al.* (2002) reported higher species richness and abundance during spring / summer season and lower during winter season in various lotic water bodies. In the present study, the temporal variations in species richness and abundance were similar to the above mentioned observations, which could be attributed to the seasonal climatic conditions that markedly change the hydrological regime, physico-chemical characteristics and biotic communities.

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