# Patterns of diversity and conservation status of freshwater fishes in the tributaries of River Ramganga in the Shiwaliks of the Western Himalaya

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**A short study was undertaken from December 2004 to April 2005, to assess the species diversity and composition of freshwater fishes in three tributaries of Ramganga river in the foothills of Western Himalaya. One tributary was within a protected area (PA; Corbett National Park); the other two were outside the PA (Lansdowne Forest Division). Cast nets were used for fish sampling, which was done from 9.00 a.m. to 5.00 p.m.**

**In total, 43 species belonging to eight families and five orders were recorded which included 29 species belonging to the threatened category. Family Cyprinidae was represented by the maximum number of species. Species richness and diversity was high in the PA. Similarity in fish composition varied from 60% to 70% across the tributaries. Dynamiting, poisoning and diverting water flows to collect fish are the major threats. Creating awareness, controlling illegal fishing and protecting the breeding grounds of fishes are some of the measures recommended to counter these threats.**

**Keywords:** Conservation, fish diversity, river ecology, species richness.

DETECTING community-level patterns fascinates community ecologists. Often for many practical purposes species or taxa richness is taken as an indicator of biological diversity[1]. For freshwater fishes, community-level patterns have been well documented in the recent past[2–10]. However, such studies in Asian rivers have been few[2–4,10,11]. In India, except for taxonomical information available from some of the major rivers systems, detailed ecological status of freshwater flora and fauna in most of the rivers is unknown. Few ecological studies on freshwater fishes that have been carried out so far have mainly come from the South Indian rivers. However, other important regions such as Western Himalaya and North East Himalaya have not been studied in detail.

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Shiwaliks Himalaya or Lower Himalaya has earlier been identified as an important coldwater fish-breeding area[12–14], but no detailed study on assessing the status of fish communities in this region has been undertaken. We describe here the community-level patterns in terms of diversity, species richness and species composition in the three tributaries of Ramganga river. This study also highlights the importance of rich river biodiversity in the fast degrading Himalayan landscape. To avoid the species loss and restore freshwater habitats, river systems should be given an urgent priority in the management planning.

The River Ramganga is one of the principal rivers from the Shiwaliks or Lower Himalaya. Khoh, Kolhu and Mandal are tributaries of the Ramganga. The study area falls in Lansdowne Forest Division (LFD) where Khoh and Kolhu flow close to the Kotdwar town, Pauri-Garhwal District and Mandal river flows in Corbett National Park (CNP), Nainital District, Uttarakhand. Both Khoh and Kolhu join at Saneh village, near LFD, and flow further downstream to Uttar Pradesh to meet River Ramganga (Figure 1 and Table 1).

Fishes were sampled throughout the day (9 a.m. to 5 p.m.) using cast nets with mesh size (1 cm × 1 cm and 1.5 cm × 1.5 cm), depending on topography, sampling segments spaced 100–200 m along each river. Fish identification to species level was done as described in the literature[15–17]. All fish caught in the cast net were kept in a bucket of water. Measurements such as total body length (cm) and body depth (cm) were taken and the fishes were released thereafter. Unidentified fish samples were preserved in 20% formalin solution and brought to the laboratory for further identification.

Venn diagrams were used to visually depict the number of shared and unique species in the three tributaries (Figure 2). Species richness for each tributary was estimated across replicate samples using *EstimateS* software version 7.0 (ref. 18) and *EcoSim*[19]. The difference in species abundance and distribution between tributaries was examined by $\chi^2$ test. The patterns of similarities in fish composition between tributaries were calculated using Sorenson's similarity indices to know how unique the rivers are.

River-wise status was given based on fish species found in each segment. River-wise status refers to the designation of 'very-rare', if the fish was found in 1–8 segments in a river; 'rare', if it was encountered in 9–16 segments; 'uncommon' for 17–24 segments and 'common' for 25–32 segments. The same threat categories were applied by pooling data across the three rivers to assess the current status, i.e. if the fish was found in 1–24 segments, it was found to be 'very rare'; 25–48 to be 'rare'; 49–72 to be 'uncommon' and beyond 72 segments it was considered 'common'.

In total, 43 species ($n$ = 12,330 individuals) belonging to eight families and five orders were recorded, of which two species could not be identified. Species richness was

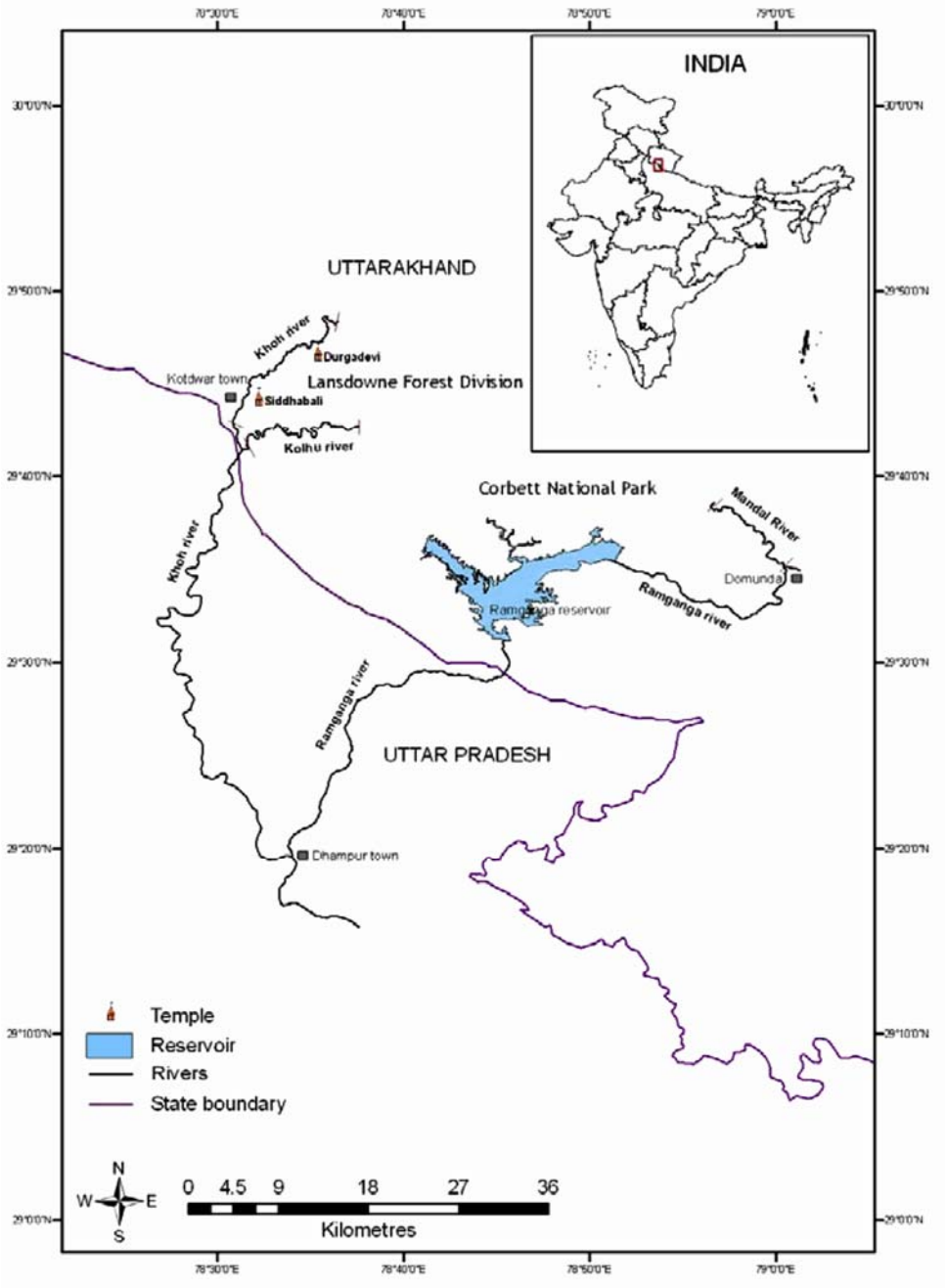


**Figure 1.** Study area.

**Table 1.** Detailed information on the rivers studied in Uttarakhand, India

| River | Location | Altitude (m) | Threats observed | Stretch (km) |
|---|---|---|---|---|
| Khoh* | 29°45′30.75″N, 78°32′13.48″E<br>29°48′19.71″N, 78°36′20.31″E | 408<br>737 | VR, F, SM, DW, D | 14 |
| Kolhu* | 29°41′30.73″N, 78°31′37.01″E<br>29°42′46.56″N, 78°37′33.65″E | 322<br>452 | VR, F, SM, D | 16.5 |
| Mandal† | 29°35′07.11″N, 79°00′28.67″E<br>29°38′35.71″N, 78°56′40.23″E | 479<br>608 | N | 16.0 |

VR, Vegetation removal; F, Fishing, SM, Sand mining; DW, Diversion of water; D, Dynamiting; N, None.
*In Corbett National Park. †In Lansdowne Forest Division (Non protected area).

**Table 2.** Families in the tributaries of Ramganga river

| Family | Order | Species | English name |
|---|---|---|---|
| Belonidae | Beloniformes | *Xenentodon cancila* | Freshwater garfish |
| Balitoridae | Cypriniformes | *Homaloptera rupicola* | Prashad loach |
| | | *Nemacheilus bevani* | Loach |
| | | *Nemacheilus botia* | Loach |
| | | *Nemacheilus garhwali* | Loach |
| | | *Nemacheilus montanus* | Loach |
| | | *Nemacheilus rubdipinnis* | Loach |
| | | *Nemacheilus rupecola* | Loach |
| | | *Nemacheilus submontanus* | Loach |
| Channidae | Perciformes | *Channa gachua* | Snake head |
| | | *Channa punctatus* | Spotted snakehead |
| Gobiidae | | *Glossogobius giuris* | Tank goby |
| Cobitidae | Cypriniformes | *Botia lohachata* | Y-loach |
| | | *Botia rostrata* | Gangetic loach |
| | | *Lepidocephalus guntea* | Guntea loach |
| Cyprinidae | Cypriniformes | *Barilius barila* | Barred baril |
| | | *Barilius barna* | Barna baril |
| | | *Barilius bendelisis* | Hamilton's baril |
| | | *Barilius schacra* | Schacra baril |
| | | *Barilius vagra* | Vagra baril |
| | | *Catla catla* | Catla |
| | | *Chagunius changunio* | Chaguni |
| | | *Crossocheilus latius latius* | Gangetic latia |
| | | *Garra gotyla gotyla* | Gotyla |
| | | *Garra lamta* | Lamta garra |
| | | *Labeo calbasu* | Blackrohu |
| | | *Labeo dero* | Kalbans |
| | | *Labeo dyocheilus* | Brahmaputra labeo |
| | | *Puntius sophore* | Spotfin swamp barb |
| | | *Puntius ticto* | Ticto barb |
| | | *Puntius vittatus* | Kooli barb |
| | | *Raiamas bola* | Indian trout |
| | | *Schizothorax progastus* | Dinnawah snowtrout |
| | | *Schizothorax richardsonii* | Alwan snowtrout |
| | | *Tor chelynoides* | Dark mahseer |
| | | *Tor mosal* | Putitor mahseer |
| | | *Tor putitora* | Golden mahseer |
| | | *Tor tor* | Tor mahseer |
| Mastacembelidae | Synbranchiformes | *Mastacembelus armatus* | Tire-track spiny eel |
| Sisoridae | Siluriformes | *Glyptothorax pectinopterus* | River cat |
| | | *Glyptothorax telchitta* | Telchitta |

highest in Mandal river in CNP (31) followed by Kolhu (28) and Khoh (26) rivers in LFD. Jackknife estimated species richness at 28 samples was highest in River Mandal ($37.85 \pm 3.12$) followed by Kolhu ($34.09 \pm 3.19$) and Khoh ($31.79 \pm 2.13$) rivers.

Sixteen species were common to the three rivers. River Mandal had 31 species, with seven species unique in it. Rivers Khoh and Kolhu had four and five species respectively, unique to them. All the three rivers shared 3–5 species with each other (Figure 1). The order Cypriniformes included 99.6% of the fish species. The family Cyprinidae dominated with 23 species followed by Balitoridae with eight species and Cobitidae with three species, besides other families such as Channidae, Sisoridae, Belonidae, Gobiidae and Mastacembelidae (Table 2).

The $\chi^2$ test showed that these rivers were not significantly different in terms of species abundance ($\chi^2 = 6.217$, $n = 10$, $P > 0.05$). The abundance of species across the rivers showed a left skew. About 25 species were rare, represented by less than 15 individuals out of a total 12,330.

*Barilius barila*, family Cyprinidae, was the most abundant species (94.90%) followed by *Tor putitora* (53.37%), *Barilius bendelisis* (38.27%) and *Garra gotyla* (26.23%). Other common species were *Schizothorax richardsonii* (16.94%), *Barilius barna* (16.46%), *Garra*

**Table 3.** Threat status of fishes in the tributaries of Ramganga (CAMP, 1998)

| Species | Threat status | Global distribution |
|---|---|---|
| *Barilius barila* | Vulnerable | India, Nepal |
| *Barilius barna* | Lower risk near threatened | India, Myanmar, Nepal, Bangladesh |
| *Barilius bendelisis* | Lower risk near threatened | India, Pakistan, Nepal, Sri Lanka |
| *Barilius scharca* | Vulnerable | India, Bangladesh, Nepal |
| *Barilius vagra* | Vulnerable | Afghanistan, Pakistan, Sri Lanka |
| *Botia lohachata* | Endangered | India, Pakistan, Nepal, Bangladesh |
| *Botia rostrata* | Lower risk near threatened | India |
| *Catla catla* | Not assessed | India, Pakistan, Myanmar, Sri Lanka |
| *Chagunius changunio* | Not assessed | India |
| *Channa gachua* | Not assessed | India |
| *Channa punctatus* | Lower risk near threatened | Afghanistan, Pakistan, Nepal |
| *Crossocheilus latius latius* | Data deficient | Endemic to India |
| *Garra gotyla gotyla* | Vulnerable | Pakistan, India, Myanmar, Bangladesh |
| *Garra lamta* | Not Assessed | India |
| *Glossogobius giuris* | Lower risk near threatened | East Africa, China, Japan, Sri Lanka |
| *Glyptothorax pectinopterus* | Lower risk near threatened | India, Pakistan, Nepal |
| *Glyptothorax telchitta* | Lower risk near threatened | India, Pakistan, Bangladesh, Nepal |
| *Homaloptera rupicola* | Not assessed | India |
| *Labeo calbasu* | Lower risk near threatened | Pakistan, Nepal, Bangladesh, Thailand |
| *Labeo dero* | Vulnerable | Nepal, Bangladesh, Pakistan |
| *Labeo dyocheilus* | Not assessed | Pakistan, Sri Lanka, Bangladesh |
| *Lepidocephalus guntea* | Not assessed | India |
| *Mastacembelus armatus* | Not assessed | Pakistan, Sumatra, Sri Lanka, Vietnam |
| *Nemacheilus bevani* | Not assessed | India |
| *Nemacheilus botia* | Lower risk near threatened | India |
| *Nemacheilus garhwali* | Not assessed | Endemic to India |
| *Nemacheilus montanus* | Endangered | Endemic to India |
| *Nemacheilus rubdipinnis* | Lower risk near threatened | India |
| *Nemacheilus rupecola* | Not assessed | Endemic to India |
| *Nemacheilus submontanus* | Lower risk near threatened | India |
| *Puntius sophore* | Lower risk near threatened | India, Pakistan, Myanmar |
| *Puntius ticto* | Lower risk near threatened | Pakistan, Thailand, Bangladesh |
| *Puntius vittatus* | Vulnerable | India, Pakistan, Sri Lanka |
| *Raiamas bola* | Lower risk near threatened | Bangladesh, Myanmar, Nepal |
| *Schizothorax progastus* | Lower risk near threatened | India, Pakistan, Nepal, Bhutan |
| *Schizothorax richardsonii* | Vulnerable | Afghanistan, Nepal, Pakistan, India |
| *Tor chelynoides* | Not assessed | India |
| *Tor mosal* | Endangered | India, Myanmar |
| *Tor putotora* | Endangered | Afghanistan, Bangladesh, Myanmar |
| *Tor tor* | Endangered | Pakistan, Nepal, Bangladesh, India |
| *Xenentodon cancila* | Lower risk near threatened | Pakistan, Sri Lanka, Myanmar |

CAMP, Conservation Assessment and Management Plan.

*lamta* (15.22%), *Puntius ticto* (7.72%), *Barilius vagra* (7.67%), and *Crossocheilus latius latius* (7.44%). Similarity (Sorensen's similarity indices) in species composition between Khoh and Kolhu rivers was 70.6%, between Kolhu and Mandal was 61.8% and between Mandal and Khoh was 64.3%.

Results show that species such as *B. barila*, *G. gotyla* and *T. putitora* were common in sampling segments of the three rivers. Overall five species were assessed as not very common, three were common, one was rare, and the remaining 34 species (approx. 64%) were very rare in three tributaries of River Ramganga. Approximately, 29 species were threatened, whereas 12 were not assessed in the Conservation Assessment and Management Plan (CAMP; IUCN-based) classification (Table 3)[20].

Most of the freshwater fish fauna of this region have a wider distribution. Of the 43 species reported, 14 are endemic to India (Table 3). However, the Western Ghats appears to be rich in fish diversity with 289 species[21], whereas 124 species are listed from the Western Himalaya[22] and a total of 218 species are reported from the whole of the Himalaya[14]. In this study we found that species richness was highest in Mandal river compared to Khoh and Kolhu rivers. Cyprinidae was the dominant family with *B. barila* being the most dominant species. Most species were rare (~ 64%) and very few were common (~ 15%).

Though the study period was short, we could observe that 22 species are also known from the Western Ghats and 33 are common to other Western Himalayan rivers[23].

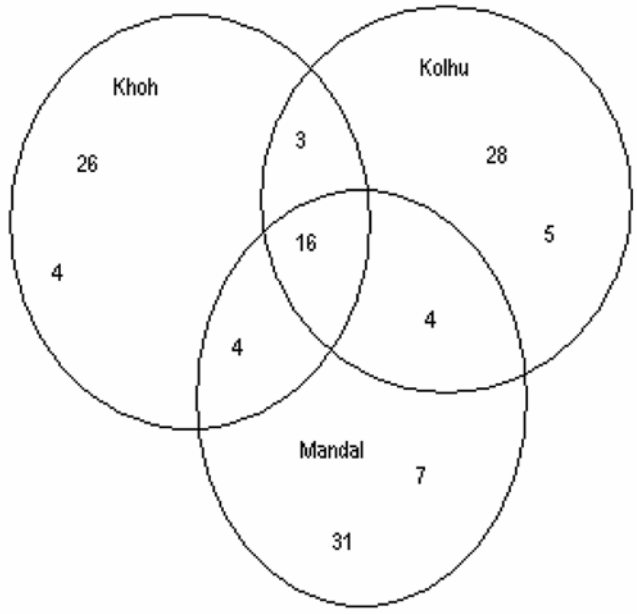


**Figure 2.** Venn diagram showing fish species common and exclusive to the three tributaries.

This may be because Mandal lies in CNP which has a better vegetation cover, abundant periphyton and macrobenthic invertebrate fauna in the river and is also relatively less disturbed from various illegal and destructive fishing activities compared to rivers in LFD. A recent study shows that the manipulating riparian vegetation influenced stream fish communities[24]. The removal of vegetation along the River Khoh by local communities could have reduced the fish species. It has been found that microhabitat parameters strongly correlated with species abundance and their distribution[2–4,25–27]. More studies on this aspect are required to understand the ecology of Himalayan fish fauna.

The present study has recorded coldwater species. During the winters when water level is at the lowest and water is highly transparent, all size groups of mahseers and schizothoracines are present in pools of rivers[12], but we found most of them in shallow habitats (rapids and riffles) in Khoh and Mandal rivers, whereas the mahseers and schizothoracines (*S. richardsonii* and *S. progastus*) were absent in the Kolhu river despite the presence of pools. Water temperature is a limiting factor which influences geographical and local occurrence of species within one water system[12]. In our study they form 17% of the total fish catch and *S. richardsonii* was the dominant species in all the three tributaries. This however, as shown by Sehgal[12] to be due to the inability to cope with a steep fall in temperature in winter months and resultant migration from headwaters to lower altitudes. Similarly, some of the wider temperature-tolerant species were common throughout the rivers, such as carps, mahseer and lesser barils[12].

There were some limitations to our study. It was difficult to catch all the species because of single sampling gear (cast net), sampling time and topography. Use of different sampling gears often enhances the chances of getting more species[3]. Seasonality and timing of sampling also influence fish catch, since more number of species were caught during night (72) than during the daytime (64). However, the present study does not cover night sampling because of field conditions.

The Himalayan or Golden Mahseer, an endangered and highly prized sport fish, is abundant and thriving in these waters. Hence some potential pools in these areas can be developed into eco-friendly angling sites such as Kolhuchaur. Endemic schizothoracines may be affected due to change in water temperature and to the probable effect of climate change. Therefore, it is necessary that habitat-specific plans for such species should be formulated with long-term ecological study.

Conservation measures, including stopping illegal fishing, dynamiting, poisoning, identifying crucial breeding habitats as fish sanctuary and creating mass awareness are needed to save the threatened fish fauna of this region.

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# Biomass production and carbon stock of poplar agroforestry systems in Yamunanagar and Saharanpur districts of northwestern India

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**Poplar (*Populus deltoides*) has gained considerable importance in agroforestry plantations of western Uttar Pradesh, Uttarakhand, Haryana, Punjab, and Jammu and Kashmir due to its deciduous nature, fast growth, short rotation and high industrial requirement. Poplar-based agroforestry systems are prevalent among farmers of Saharanpur (UP) and Yamunanagar (Haryana) districts of northwestern India. These systems are not only remunerative to the farmers, but also play an important role in the assimilation of atmospheric carbon dioxide in the form of biomass carbon stocks. An assessment of carbon storage vis-à-vis $CO_2$ assimilation by poplar plantations in agroforestry has been made for these two districts. Contribution of poplar plantations to carbon storage was found to be 27–32 t ha$^{-1}$ in boundary system, whereas it was 66–83 t ha$^{-1}$ in agrisilviculture system at a rotation period of 7 years in the two districts. Thus, poplar plantations make important contributions towards atmospheric $CO_2$ assimilation and hence play a significant role in the mitigation of atmospheric accumulation of greenhouse gases.**

**Keywords:** Agroforestry, biomass, carbon stock, carbon dioxide assimilation, poplar.

SEVERAL forms of agroforestry are common throughout the country that contribute to local communities and produce raw material for the industry. Pathak *et al.*[1] have given an account of the prominent agroforestry systems in different agro-climatic regions of India. Agrisilviculture and agrihorticulture systems in western and eastern Himalayan regions; agrihorti-silviculture systems in the upper and trans-Gangetic plains, and agrisilviculture and silvipastoral systems in the southern plateau and hilly regions are some of them.

*Populus deltoides* (poplar) has been successfully incorporated in agroforestry and has been extensively planted in farmlands in Uttar Pradesh (UP), Haryana and Punjab after 1980. Poplars are fast-growing trees; they recycle nutrients fast due to their shedding of a large quantity of leaves which decompose early[2]. Poplar trees are grown in agrisilviculture systems, where an agriculture crop is grown within rows of trees and on the field boundary. The

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