CONSERVATION STATUS OF FISHES IN THE TRIBUTARIES OF RAMGANGA WITH SPECIAL REFERENCE TO GOLDEN MAHSEER *(Tor putitora)* Hamilton

Dissertation Submitted to

Saurashtra University, Rajkot

In partial fulfillment of

Master's Degree in Wildlife Science

By

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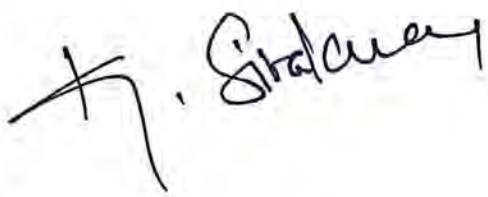
Wildlife Institute of India

June 2005

Certificate

This is to certify that *Sh. Vidyadhar M. Atkore* of the Wildlife Institute of India, Dehradun has carried out an original research work titled **'Conservation status of fishes in the tributaries of Ramganga with special reference to Golden Mahseer (*Tor putitora*) Hamilton'** in partial fulfillment of the M. Sc (Wildlife Science) degree of Saurashtra University, Rajkot. The study was conducted under our supervision from November 2004 to June 2005. We also certify that this research work has not been submitted for the award of any other degree to any other university.



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CONTENTS

SUMMARY

A common goal in the studies of community ecology is to uncover patterns of species abundance or distribution and determining the factors that are responsible for them. Himalayan waters are unique in the ichthyofaunal diversity. To know what species are here, fish sampling was carried out with help of cast net. Three rivers were identified for the stratified fish sampling. Each river was divided at two hundred meter distance apart. Each segment was sampled thrice though out study period. Morphometric measurements were taken in the field. Habitat parameters were also recorded as on same day of fish sampling.

Result shows that Mandal River had more species richness followed by Khoh and Kolhu. Forty three species belonging to five orders and ten families (four species yet to identify) were recorded in the study river. Of these, approximately 80 % were classified into the rare category. *Tor putitora*, *Garra gotyla Barilius barila*, and *Scizothorax richardsonii* are listed in the IUCN Red list. However, endangered golden mahseer was one of the commonest fish. The reason could be the preferred spawning habitat ground or abundant food availability. Population estimation was estimated by using Jolly Seber method, resulted high standard error. Low number of recapture sessions could be the reason.

Mostly juveniles of 6-10 cm size classes were abundant in all three rivers followed by 11-15 cm group. The total length measured for Golden mahseer varies from 3 cm to 28 cm.

The condition factor was calculated based on the available size class. Result showed that 20-25 cm size classes of golden mahseer were in better condition in the Study Rivers. However, condition for size class 0-5 cm fish was better in Kolhu River than others. The 6-10 cm size class, 15-20 cm and 21-25 cm were doing better in the Mandal than two rivers.

Strong conservation measures are required to protect these highly endangered fishes in Garhwal Himalaya.

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List of Tables **Page No.**

List of Figures **Page No.**

CHAPTER - I

INTRODUCTION

Fishes are probably more diverse at all taxonomic levels and have more species than all other vertebrate group combined. Fish community ecology has been studied in a wide array of habitats and ecological regions. Patterns in abundance, diversity, and distribution are the most commonly assessed fish community characteristics. Knowledge of these attributes interests ecologists because of their implications for conservation. For stream fishes, maximum assemblage's complexity is found in the tropical streams, where 100+ species can occur within a short stretches of river (Matthews, 1998). The Amazon River basin has the world's richest freshwater fish fauna, with more than 1,300 species (Lowe-McConnell, 1987). The distribution of fishes in small streams is characterized by large faunal changes within relatively short distances (Sheldon, 1968). The presence of such water bodies is crucial for tiny aquatic life-forms. However, their ability to move in response to climate or geological change is limited to connectivity of fresh waters (Unmack, 2001).

Of the 20,000 fish species known to the science, over 40 percent live in freshwater and the majority of these live in waters lying within the tropics (*i. e.* between latitudes 23 $1/2^0$ N to 23 $1/2^0$ S). There are about 6650 species of primary freshwater fishes, belonging to families totally restricted to freshwater, and about 6200 of these belong to the super order group known as the Ostariophysi; there are another 1625 species of secondary freshwater fishes (freshwater representative of marine groups), plus 115 diadromous species, which move between free water and the sea. This astonishingly high number of species of freshwater fishes reflects the degree of isolation possible in freshwater environments (Lowe-McConnell, 1975). Due to the

varying nature of their environment, fish have evolved into a number of different forms. Fish contribute to the food of many invertebrates as well as human beings and due to this; it is a sector of the fish fauna, which is under the greatest threat. Moreover, fish habitat is fragile in nature. However, a number of reviews of the needs of fish conservation in several countries have started to appear in recent years (Maitland 1993, FAO 1999).

Freshwater constitutes only 2.5% of the total volume of water on Earth (Sandra, *et al* 1996). On the basis of distribution, Indian fish fauna may be broadly classified under two groups; freshwater and marine, estuarine forms being either of two in the region. Freshwater fish fauna of India, primarily freshwater fishes particularly those of the order *Cyprinidae* forms and *Ostariophysi*. The typical Himalayan Icthyofauna like *Nemacheilus*, *Garra*, *Tor*, etc. have undoubtly originated somewhere in the South of China and dispersed into regions lying along the Alpines- Himalayan system and its southern loops ramifying into Europe, Western Asia and other associated mountains (Hora, 1951). Studies of freshwater fishes in the Indian subcontinents have been limited to scattered work on commercial fishery (Bhat, 2003), taxonomy capture fisheries or aquaculture (Arunachalam, *et al* 2003). Out of the 2,500 species of freshwater fishes that have been recognized in the Indian subcontinent, 930 are categorized as freshwater species (Jayaram, 1999). Substantial literature on fish identification and systematic is now available in India starting with Hora (1920-1950), Talwar & Jingran (1991), and Jayaram (1999) (Bhat, 2003). According to the assessment of the CAMP workshop, a total of 227 Indian freshwater fishes are in threatened category of the IUCN Red list (Anonymous, 1997). The fishes of the Himalayan ecosystem are distinctive in possessing special features for survival in the torrential environments. Probably the nature of the water currents is responsible of the differentiation in species. The fish species distribution in the Himalayan streams depends

on the flow rate, nature of substratum, water temperature and the availability of food, Menon (1954). The distribution pattern of Himalayan fish to it's the river morphological characteristics enable them to inhabit the torrential streams and thus have contributed to the Icthyofaunal diversity in the ecosystem (Sehgal, 1999). The natural fish populations of several Indian rivers including hill streams are declining both quantitatively and qualitatively (Joshi, 1994). The hilly region of Uttar Pradesh (Uttaranchal State now) area has been studied by numerous workers to explore fish fauna but mention may be made of a few such as Hora (1937), Hora & Mukherjee (1936), Menon (1949, 1974), Pant (1970), Singh *et al.*, (1983) and Singh (1990) (Khan, 2000 & references there in). Studies of fish population structure in the Ramganaga upstream habitats have been fewer (Khan, 2000). Ramganga is main ground of breeding Golden mahseer (*Tor putitora*) (Johnsingh, & Negi 1997).

Though, numerous studies have investigated stream flow in relation to fish communities and its populations (Hunter, 2003). Because the most dramatic temporal variability in the physical environment of stream ecosystems is fluctuating flow (Schlosser, 1991) which could influence the fish community. Therefore, understanding the patterns of fish community structure along with environmental factors in the Ramganga upstream is highly important for the conservation of the golden mahseer and its associates. Hence, this study was designed for studying distribution pattern of fishes found in this region. I framed my research questions to know

a) How freshwater fishes are distributed in the Ramganga tributaries?

b) What is the status of these fishes?

c) What is the available size class and Condition factor for Golden mahseer?

CHAPTER - II

OBJECTIVES

In order to meet above-mentioned issues, this study was conducted with following objectives in the tributaries of Ramganga *i.e.* - Kotri (Kolhu), Khoh and Mandal River:

1) To describe the distribution pattern of certain threatened fishes in this region.
2) To describe the population structure of Golden mahseer and its condition factor in this region (based on length-weight relationship).

CHAPTER - III

STUDY AREA

The study area falls in the Landsdowne Forest Division, and Corbett National park Uttaranchal. The Lansdowne forest division is situated in the Pauri-Garhwal district where as Corbett National Park is in the Nanital district of Uttaranchal State. This region is representative of lower Himalayas (Srivastava, 1975). The climate varies from Sub tropical in the plains to temperate upto 1675 meter elevation. From November to February the nights are cold with much frost and dew.

The climate of the region is characterized by following seasons:

a) The summer season: March to Mid June

b) The rainy season: Mid June to October

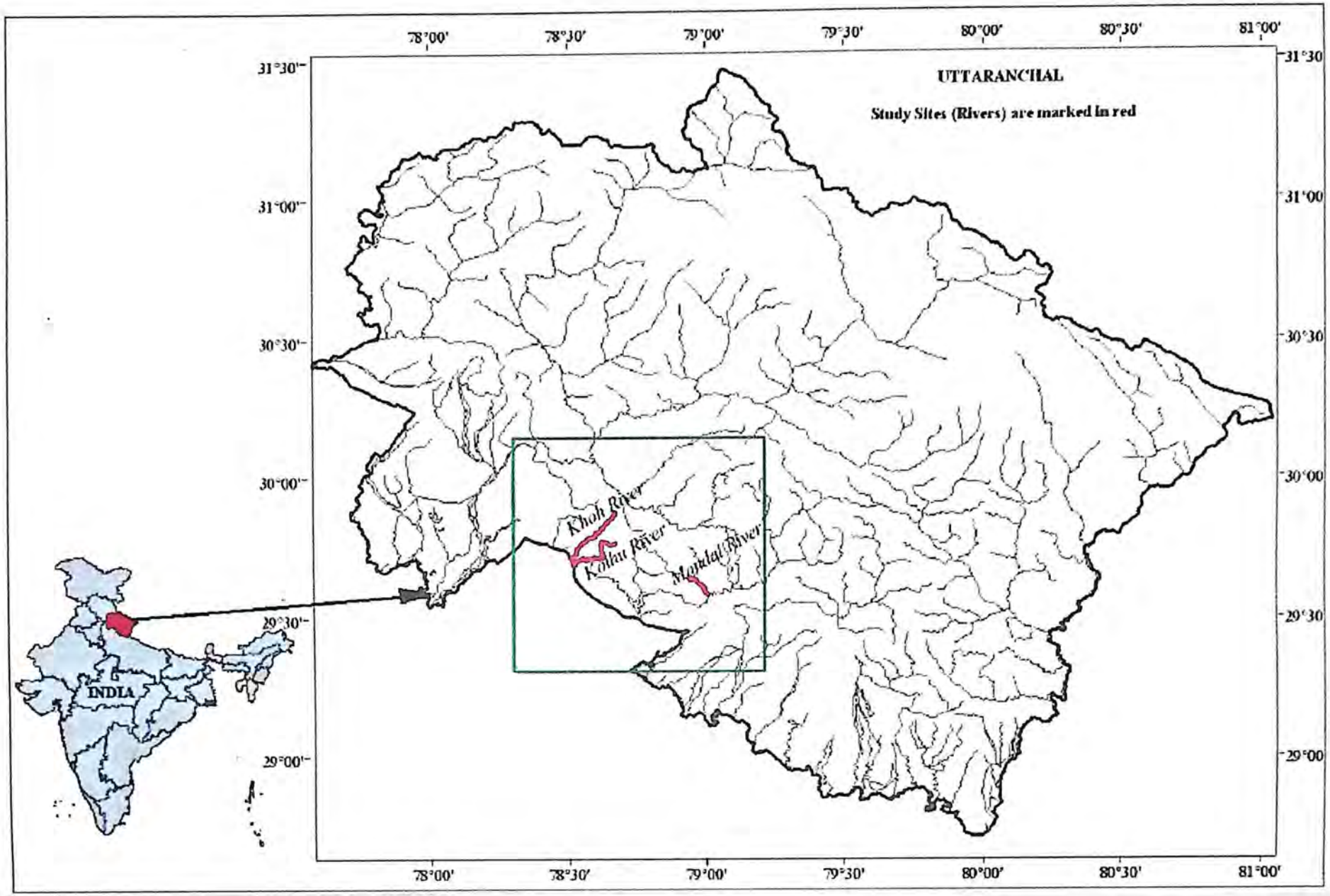
c) The winter season: End of September to December (Uniyal, 2003).

3.1 General description of the Study Rivers

The river Ramganga drains south-western Kumaun Himalaya. It is a tributary of the river Ganga, originates from the high altitude zone (altitude 800m-900m) in the North-West par of district Almora close to the district Chamoli. It travels a distance of about 300 km through the wide valleys (altitude 500m-700m) of district Almora and Nainital to enter the tarai area (Joshi, 1994). The river Ramganga is one of the principal rivers from Shivaliks or Lower Garhwal Himalaya, rich in the fish diversity. There is no detailed fish species account in the tributaries of Ramganga River. Two hundred and eighteen fish species are listed for the whole Himalayas (Sehgal 1999). The fauna of the Southern Himalayas was derived from a younger and vigorous stock, which has already become specialized in southern eastern Asia of life in torrential

streams (Khan, 2000). The lotic waters of the Kumaon Himalayas are rich in fish diversity though hydrological reports delineating the deteriorating quality of the upland stream water are on the records (Joshi, 1994). Similarly, the distributional pattern of fish fauna in a relation to the Garhwal and Kumaon Division of Western Himalaya is interesting as hill stream fauna of Garhwal is more diverse than the Kumaon Division (Husain, 1995).

The rivers Mandal, Khoh and Kotdi / Kolhu are tributaries of river Ramganga. The river Khoh is situated in between N 29^0 45' 27.0" & E 78^0 32' 22.4", and N 29^0 48'22.1" & E 78^0 36'18.5" in the southern part of the district Pauri (Garhwal) of Uttaranchal. River originates from Dwarikhal in the North and drains through Shiwalik ranges. The river enters in to the Bhabar area from where it becomes a tributary of Ramganga (Joshi, 1978). The Kotdi (here onward as Kolhu river) river was formed by three seasonal sots which feds in the monsoon season at Dhimki in Lansdowne Forest Division. The river is situated in between N 29^0 41 39.2 & 79^0 00'.34.1" E 078^0 31' 42.3" to N 29^0 42' 46.3" & E 078^0 37' 41.0" (lower stream to upstream). Corbett National Park is characteristic of the Himalayan mountain system. Corbett's northern areas are lined by the Lesser Himalayan chain, which extends from Pakistan, through Jammu and Kashmir, Himachal, Uttaranchal, Nepal, Sikkim, Bhutan, and to Arunachal. The Lesser Himalayas are quite high, with an average altitude of 1800 m and are made up of crystalline rocks. The vegetation includes cold-climate tree species like pine, oak, and rhododendron. However, most of the Park lies in the Outer-Himalayan or Siwalik region. The Shivaliks are the southernmost of the Himalayan ranges and are much lower than the Lesser Himalayas. They are formed of sedimentary rocks and are hence crumbly and unstable. The Shivaliks form the largest ridge across the park, running east to west from Dhangarhi to Kalagarh. between N 29^0 35' 05.0" E 79^0 00'.34.1" to N 29^0 38' 9.9 " E 78^0 57' 09.7" Domunda


UTTARANCHAL
Study Sites (Rivers) are marked in red
Khoh River
Kolhu River
Mandal River
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78°30'
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79°30'
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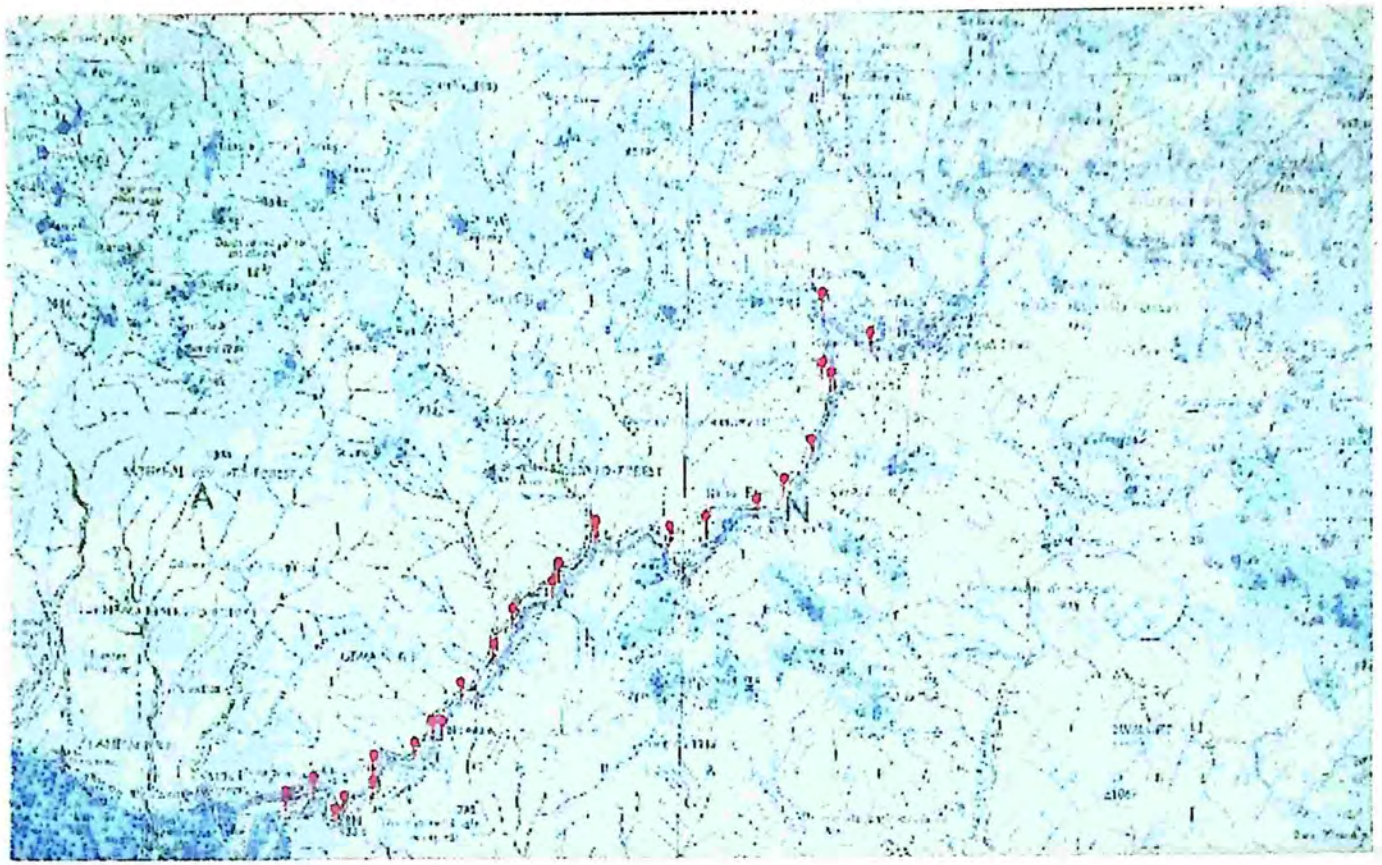
29°00'

I Khoh River : Sampling Locations



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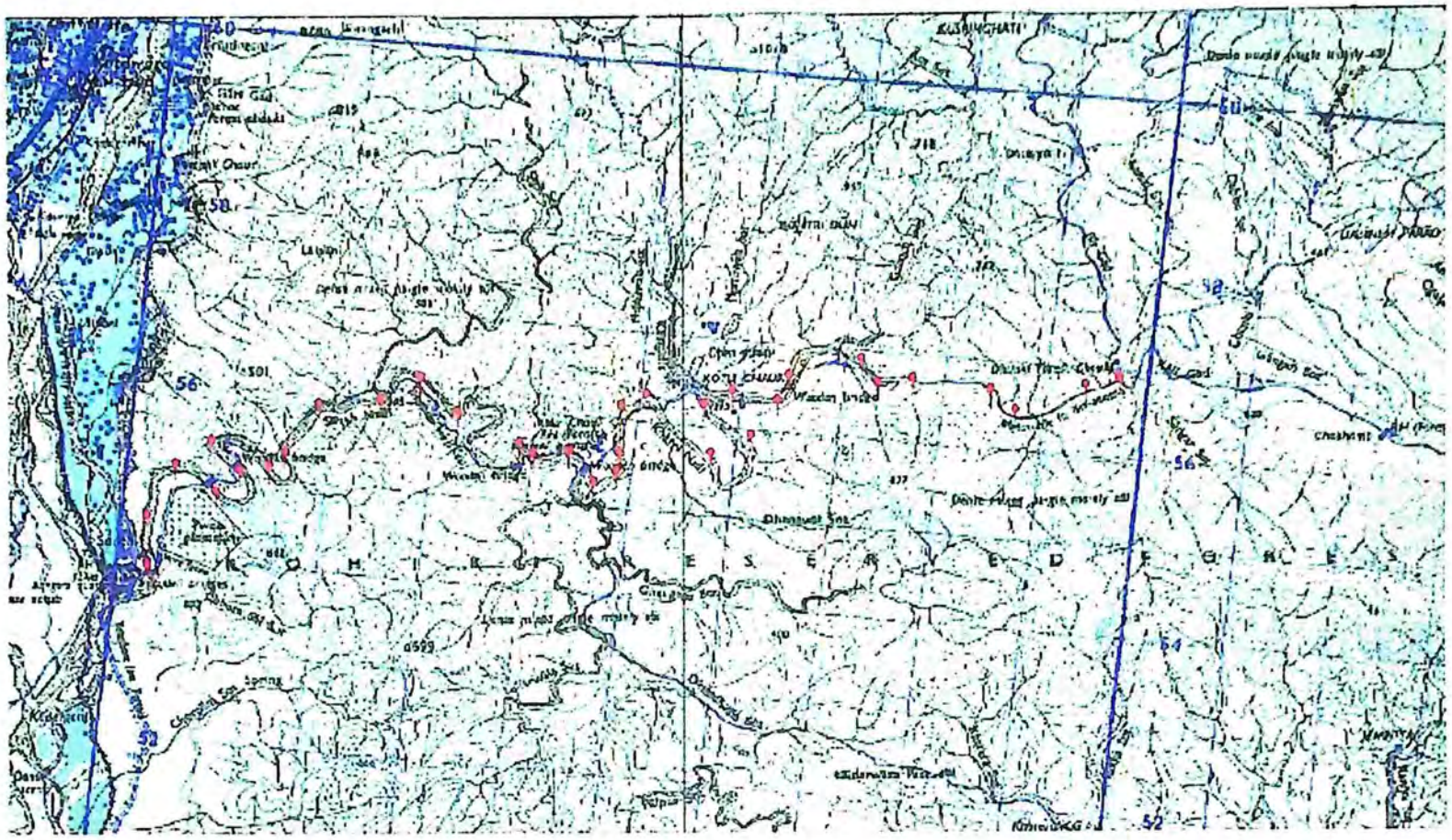
II Kolhu River : Sampling Locations



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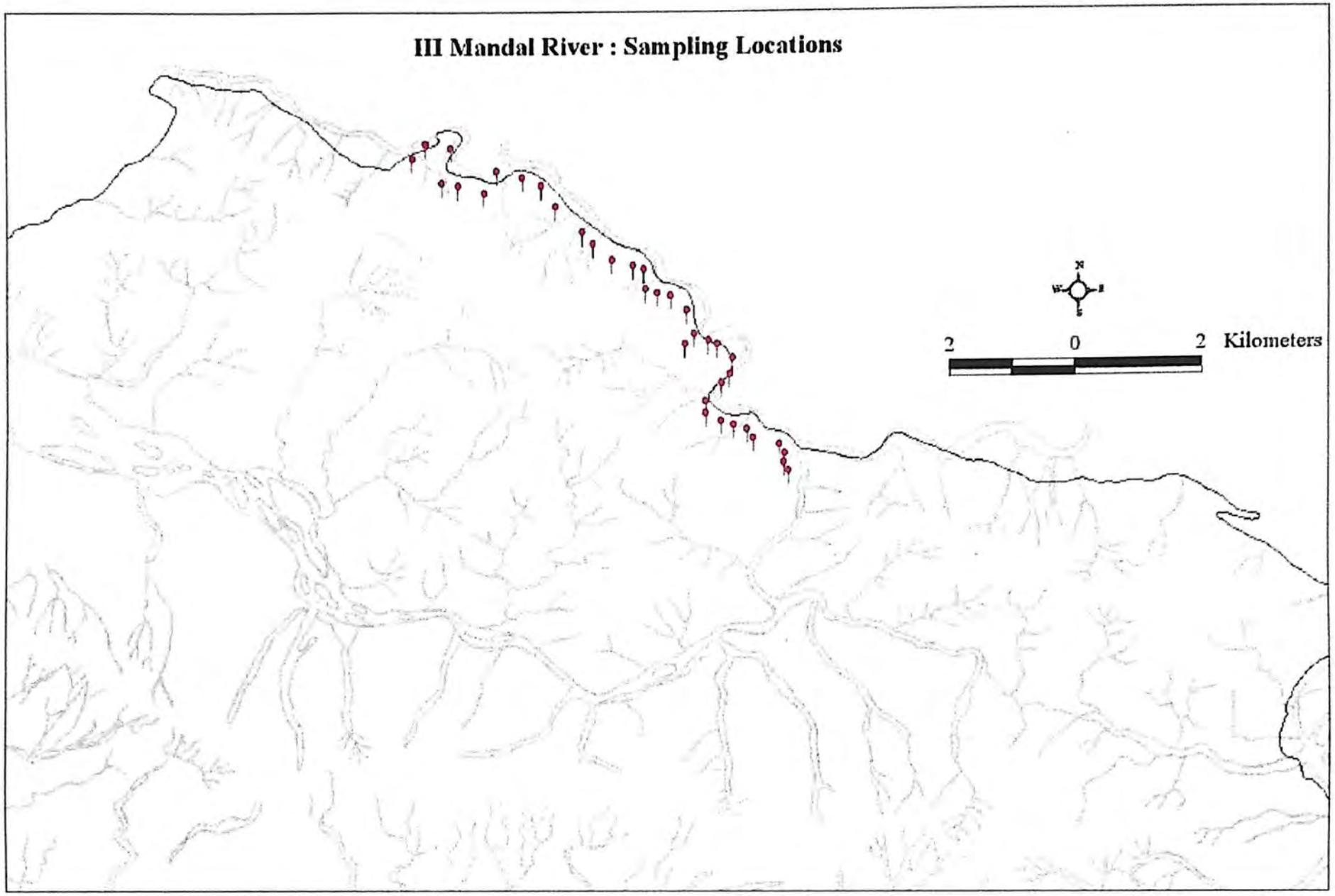
III Mandal River : Sampling Locations
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Kilometers

to Maidavan village. The Mandal rises in the eastern heights in Chamoli district and flows from North to East of Corbett National park, where river meet to Ramganaga and flows towards the eastern part where one small river Kali joins to river Mandal at Maidavan in the buffer zone of the Corbett National Park.

CHAPTER - IV

FIELD METHODS

Fish sampling

Fish were sampled in the tributaries of Ramganga River for the full winter season and part of summer (2004-05). Permanent sampling segments were established in the Study Rivers such as Khoh, Kolhu and Mandal. These segments were sampled thrice during the study period. The total length of the river sampled were 14 km, 16.5 km and 16 km. All rivers were segmented into, 28, 33 and 32 at two hundred meter distance respectively. The total length of each segment was 200 meter. Locally available cast nets were used for sampling which differ in the sinkers and thus in the weights. Cast nets with Iron beads (sinkers) were used mainly for the fish collection. The mesh size was 1cm X 1cm. Efforts was made to get small to large individuals. In each segments two persons with a cast net involved in fishing for two hours. Net was casted for 25 times in each segments. Apart from netting thirty minutes was spent on catching fish with hands and by moving stones in each segment. Same efforts were used in all the rivers in all occasions.

Morphometric measurements

Identification was done at species level that followed by Talwar & Jhingran (1991), Srivastava (1980) and Sunder *et al* (1999). Fishes were counted and morphometric characteristics such as total length (cm), body weight (gm), body depth (cm), and head length (cm) were measured for size class determination and condition factor estimation. All fish caught in the net were released back into the water immediately after taking these measurements. Fish samples were preserved in 20% formalin solution and kept in the laboratory for identifications.

Marking

As soon as fish were caught they were placed in a bucket with water. Fishes were marked by clipping the less than half of the caudal fin and released immediately. This marking exercise was done to estimate the population size of fish.

Environmental parameters

Habitat sampling was conducted on the same day and same location as fish sampling. The main habitat parameters measured were stream width (cm), stream depth (cm), water velocity, and surface water temperature. Water surface temperature was measured by using thermometer. Water turbidity was recorded as presence an absence using Secchi disc. Similarly, alkalinity was measured using pH paper. Stream velocity was categorized into very fast, fast, medium, slow and very slow after analyzing the data from water velocity meter. Where as for the substratum was categorized into bedrock (> 50 cm) = 1, boulders (25-50 cm) = 2, cobbles (6-25 cm) = 3, coarse and fine gravels (0.2 to 6 cm) = 4, and sand silt = 5 (Patterson, & Morrison 1993).

Status Assessment

River wise status for the fish species were given based on their abundances in each segment. If the fish found in the 1- 8 segments it was considered to be very rare, if it was encountered in 9-16 segments then it was considered to be rare, similarly for 17-24 to be uncommon and from 25-32 segments it was considered to be common. This status was applied for all rivers. Thus overall status was given if the fish found in 1-24 segments it was to be very rare, 25-48 to be

rare, between 48-72 to be uncommon and beyond 72 segments it was considered to be common.

Since the effort per segment was the same; the relative abundance of fish per segment was calculated pooling all individuals which have been caught in a session.

Population Assessment

Capture-Mark-Recapture method

A small reconnaissance was carried out for a week period in the river Kolhu to study recapture rate. Recaptures during this trial found were few. Initially rubber bands were used to recognize the marked fish but found unsuitable and there was higher chance of mortality of small sized fishes. Therefore, I have adopted the widely used simple method of marking i.e. fin clipping. I have clipped the caudal fin of fishes up to 50% in length.

In the Khoh River first capture was carried out for 14 days. First and second recapture session was carried out for the same period i.e. 14 days. The time interval between first and second recapture was 37 and 36 days. In the Kolhu, capture was carried out for 15 days. First and second recapture sessions were also carried out for the same periods. The interval between first and second recapture was 30 and 32 days. In Mandal, first capture was for 9 days. First and second recapture were also for 8 days each. The time intervals between them were 25 and 32 days.

DATA ANALYSIS

Species richness

To study fish species richness in three rivers, Jackknife 1 was used as it gave small standard deviations. The Ecosim software used for estimating species richness. (Gotelli& Entsminger 2004).

Length-weight relationship

Length-weight relationship was estimated using regression analysis method. Three river sites were compared for full winters and part of summer (November, 2004 to April, 2005). L-W relationship was estimated for *Tor putitora* for all individuals caught in the rivers. Huxley (1924) first proposed the allometric growth formula to describe the relationship between length and weight in the form $W = a L^b$ Where, W stands for weight, L for Length, a is constant and b is the exponent. This equation can be expressed logarithmically as suggested by LeCren (1951), $\log W = \log a + b \log L$, Where a is a constant being initial growth and b is the growth coefficient. The values of a and b is to be determined by the formula $a = y - b x$, and $b = S xy - n xy / S x^2 - n (x)^2$. This size relationship/conversions i.e. (length to weight) helps to understand the growth rates, age structure, and other aspects of population dynamics (Kohler *et al* 1996).

Condition Factor

Condition factor (Kn) was determined for the collected individuals of *Tor putitora* across the rivers. Since the data was not normally distributed across size and rivers, Kruskal Wallis test was used to check weather the condition factor of *Tor putitora* was same in all the rivers.

Individual variations from general length and weight relationship have been studied under the general name 'condition factor' (LeCren, 1951). The relative condition factor is (Kn) is an important aspect of fishery biology. It was assessed by using equation $Kn = Wt/ Lt^b$ in other words it is the ratio of length to weight of the fish. The higher value of the condition factor indicates the well being of fish. The value of condition factor is useful in explaining differences among individuals of the same length, differences arising from seasonal changes in relation to the age and sex of fish and differences between condition if individuals of the same species in different habitat condition. Such changes in condition have usually been analyzed by means of condition factor or K factor or Ponderal index which has been calculated by using different formulae by various workers. However, Kulkarni & Oagle (1994) has observed the hatching and larval growth in case of Deccan mahseer (*Tor kudree)* that differ with proportion of body weight Hile (1936) and Beckman (1948) proposed the following formula to determine the condition factor:

$K = W \times 10^5 / L^3$

Where, K = condition factor, W = weight of fish, L = length of fish

The number 10^5 is a factor to bring the ponderal index (K) to near unity (Carlander, 1970) (Biswas, 1993). According to Le Cren (1951) the relative condition factor is affected by length as well as several other factors like environment, feeding and breeding.

Capture-Mark-Release

Petersen Estimate

The simplest mark recapture estimate of numbers calls for marking on one occasion and recording the proportion of marked animals in a sample captured on a second occasion. As per

Petersen, the estimate is underpinned by the axiom of sampling theory: that the proportion of entities in the population that have a certain characteristics can be estimated from the proportion of these in a sample of the population. Within the limits of sampling variation, M/ N = m/n, Where, M animals are marked in a population of size N (N being unknown) and m marked animals are recaptured in a subsequent sampling of n animals. It takes little manipulation to convert this equation to a form estimating population size.

$N = M/ m /n$ or $N = Mn / m$, since the number of marked individuals to be recaptured is not decided prior to recapture I have used the modified Petersen method (Bailey, 1951).

$N = M (n+1)/m+1$. The standard error was also estimated using Bailey (1951).

S. E. = $v (M2 (n+1) (n-m)/ (m+1)^2 (m+2)$

The Jolly-Seber Method

When marked animals are recaptured for two or more occasions a stochastic analysis developed independently by Jolly (1965) and Seber (1965) allows an elegant estimation of the parameters of the open population. The analysis differs in kind from those of Petersen's and Bailey. They treat a probability of dying of say, 10 percent as if it removed exactly 10 animals from a population of 100. Their models are deterministic. The Jolly Seber model on other hand treats10 percent probability of dying as removing exactly 10 percent of animals only over a large numbers of runs. In the short term it might reduce a population of 100 by 6, 10, 13, 14, or some other number, each of which can itself be assigned a probability.

Although this method gives no explicit solution for population size on the first or last sampling occasion these total can be approximated by a method no less precise than that used in Bailey's

triple catch analysis. Even though, I could carry out only two recapture sessions I have tried to use the Jolly-Seber to estimate the population and compare the data with Bailey's estimate.

CHAPTER – V

RESULTS

Status of fish species in the Ramganga River

During my entire study period I could catch and released 12636 fishes belonging to forty three species. Of these, 43 species representing six orders and nine families and remaining two species are yet to be identified.

Result shows that the species such as *Barilius barila, Garra gotyla,* and *Tor putitora* were commonly abundant in all the rivers and these were found in most of the sampling segments (Table 1 in Appendix – I). Overall five species were assessed as not very common, three were common, one species was rare, and remaining 34 species were very rare in the tributaries of Ramganga. Approximately 64 % of fish were very rare in the tributaries of the Ramganga (Table 1 in Appendix – I) Figure 1.

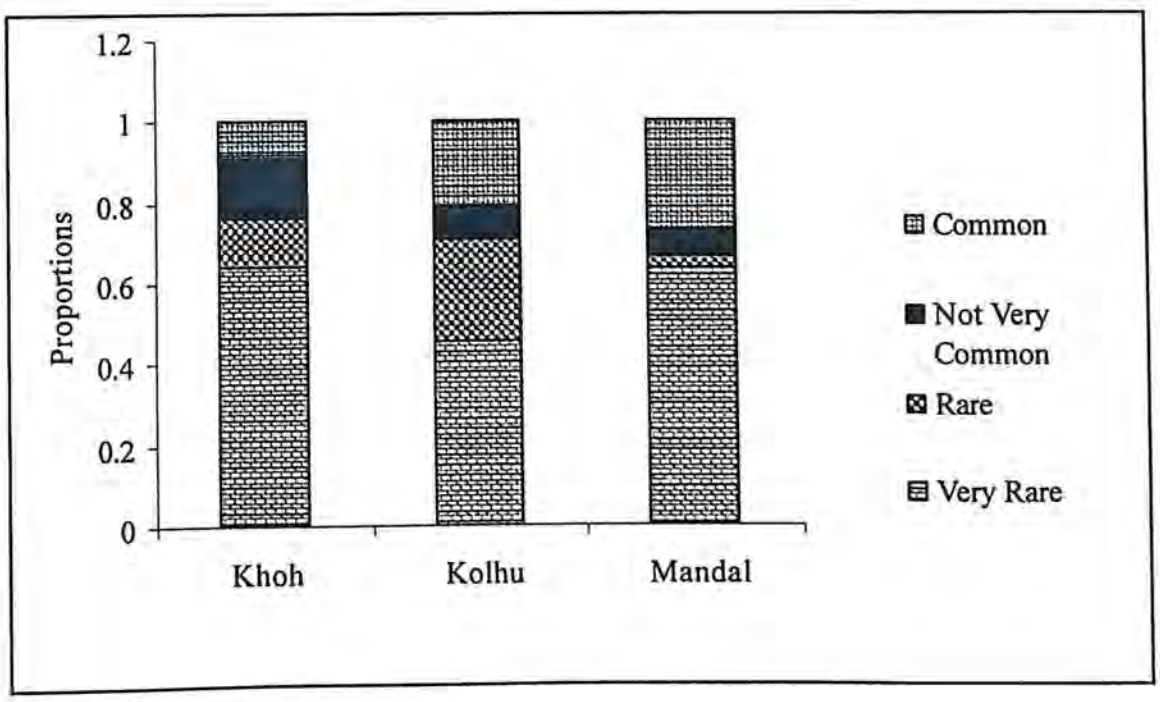

Figure 1: Proportion of different categories of fishes in the rivers.

More ever, to check the current status fishes were then compared with IUCN based classification given for threatened categories of fishes for the India. (Anonymous, 1997). It was found that, *Barilius barila, Barilius vagra, Barilius sharca, Garra gotyla gotyla, Labeo dero, Labeo dyochelius, Puntius vittatus, Schizothorax richardsonii,* were listed under *vulnerable* category. *Botia lohachata, N. montanus,* and *Tor putitora* listed under as endangered category. Where as *Barilius barna, B. bendelisis, Glossogobius girius, Glyptothorax telchitta, G. pectinopterus Puntius ticto, Schizothorax progastus,* and *Xenentodon cancila* were listed as Lower-risk threatened category. *Crossocheilus latius latius* comes under the data deficient category (Table 1 in Appendix – I).

Distribution pattern and habitat of fish

5.2.1 Fish species distribution in the Mandal, Khoh, and Kolhu Rivers

In a total, 43 species recorded in the tributaries of Ramganga i.e. Khoh, Kolhu and Mandal rivers. More number of species recorded in Mandal but less number of species occurred in Khoh. It was found that fifteen species (Table 1) were common among all three rivers (Fig 2).

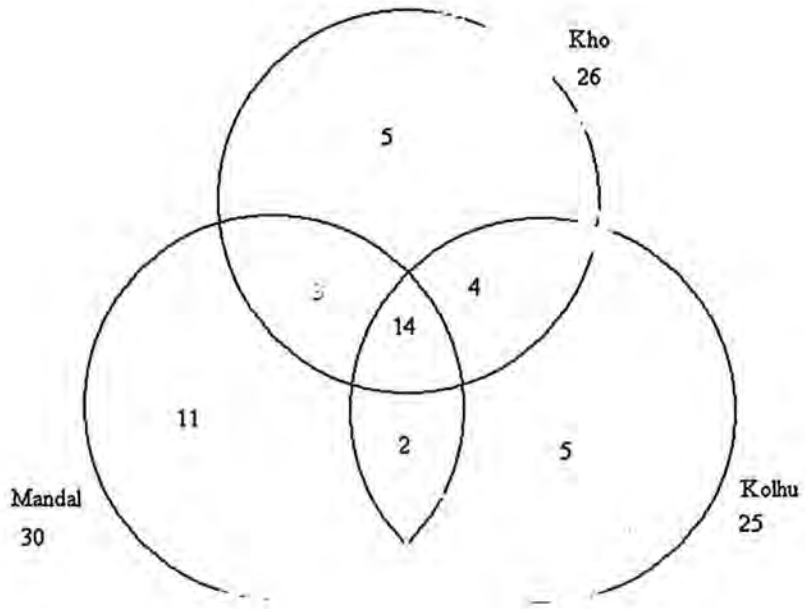

Figure 2: Fish species richness and its overlapping pattern in the Ramganga tributaries

The species richness per segment of a river was more in the Mandal River followed by Khoh and Kolhu (Table 2). However, there was no significant differences in the species richness between rivers ($X^2 = 4.785$, df = 2, p = 0.091, Table 3). Number of individuals caught per segment (relative abundance) was significantly high in the Mandal River followed by Khoh and Kolhu (Table 3). Environmental parameters of these three rivers shows that all three rivers have similar water flow, water level and temperature but there was significant differences in respect of substratum, turbidity and water column width (Table 2 & 3).

Table 2. Mean value of species richness, relative abundance, and habitat variables in each segment of all three study rivers

	Khoh	Kolhu	Mandal
Species richness	4.4	3.6	4.7
Relative abundance	53.9	23.7	57
Water Velocty	Medium	Medium	Medium
pH	7.2	7.4	7.6
Substratum	Boulders, Cobbles & coarse & fine Gravels	Cobbles & coarse & fine gravels	Cobbles & coarse & fine gravels
Turbidity	Clear	Clear to not clear	Clear
Temperature	15.9^0 C	16.2^0 C	17^0 C
Water width	34.2	42.6	60.1
Water depth	42.9	46.1	44.8

Tab le 3. Relative abundance and habitat parameters across all rivers.

	Sp. rich	Rel ab.	Width	Depth	Temp	Sub.type	pH	Velo.	Turb.
$?^{2\,a,b}$	4.785	22.19	43.71	2.64	3.41	30.260	22.63	1.44	66.28
df	2	2	2	2	2	2	2	2	2
Asy Sig.	0.091	0.000	0.000	0.266	0.181	0.000	0.000	0.486	0.000

a Kruskal Wallis Test

b Grouping Variable: River

Mandal River Ichthyofauna

Mandal River shows greater diversity in terms of fish species richness. In total, 30species were recorded, of these, eight species such as *Channa gachua, Channa puctatus, Glyptothorax pectinopterous, Homaloptera rupecola, Nemacheilus rupecola, Xenetodon cancila*, and one more gounch like (unidentified), *Labeo calbasu*. Fish were found only in this Mandal River. Elevan species exclusively present in Mandal. Khoh & Kolhu River possesses five unique species. Two species which was found in Mandal were also caught in Kolhu River (Fig 2) but not in Khoh River.

Species richness and relative abundance of fish was uniformly distributed from lower stream to upstream of the Mandal River. Data analysis shows that there were no significant differences between the segments in respect of these two variables (Table 4). Habitat and environmental parameters were also almost similar throughout the river starts from lower stream to up-stream (Table 4).

Table 4. Relative abundance and habitat parameters of Mandal River across all segments and sampling periods.

	Sp. rich	Rel ab.	Width	Depth	Temp	Sub.type	pH	Velo.	Turb.
$?^{2\,a,\,b}$	24.95	17.95	23.89	24.41	29.86	26.44	8.77	26.52	0.00
df	31	31	31	30	31	23	8	31	31
Asig*	0.77	0.97	0.81	0.60	0.52	0.28	0.36	0.69	1.00

a Kruskal Wallis Test

b Grouping Variable: Segments

Asig* Asymptotic significance

Kolhu River Icthyofauna

In a total 25 species were recorded in the Kolhu River, of these, five species such as *Barilius sharca, Catla catla, Tot mosal,* and *Crossocheilus latius latius* were found only in this river. (Table 4, Fig 2).

As like Mandal, species richness and relative abundance of fish was uniformly distributed from lower stream to upstream of the Kolhu River. Data analysis shows that there were no significant differences between the segments in respect of these two variables (Table 5). Habitat and environmental parameters were also almost similar throughout the river starts from lower stream to up-stream (Table 5).

Table 5. Relative abundance and habitat parameters of Kolhu river across all segments and sampling periods.

	Sp. rich	Rel ab.	Width	Depth	Temp	Sub.type	pH	Velo.	Turb.
$?^{2\,a,b}$	24.95	31.98	30.63	23.58	11.15	30.86	27.9	8.62	6.00
df	32	32	29	30	29	30	25	31	32
Asig*	0.48	0.46	0.38	0.79	0.99	0.42	0.31	1.00	1.00

a Kruskal Wallis Test

b Grouping Variable: segments

Asig* Asymptotic significance

Khoh River Icthyofauna

In a total, 26 species were caught in this river, of these, five species such as *Nemacheilus botia*, *Puntius vittatus, Schizothorax progastus* and Golden color fish (unidentified) species were found only in this river. (Fig 2). As like Mandal and Kohlu, species richness and relative abundance of fish was uniformly distributed from lower stream to upstream in the Khoh River also. Data analysis shows that there were no significant differences between the segments in respect of these two variables (Table 6). Habitat and environmental parameters were also almost similar throughout the river starts from lower stream to up-stream (Table 6).

Table 6. Relative abundance and habitat parameters of Khoh River across all segments and sampling periods.

	Sp. rich	Rel ab.	Width	Depth	Temp	Sub.type	pH	Velo.	Turb.
$?^{2\,a,b}$	31.04	15.07	30.43	28.51	16.02	28.71	30.20	31.18	0.00
df	27	27	27	27	27	27	26	27	27
Asig*	0.26	0.96	0.29	0.38	0.95	0.37	0.25	0.26	1.00

a Kruskal Wallis Test

b Grouping Variable: segments

Asig* Asymptotic significance

Sorensen's similarity for species composition among the rivers: similarity in species composition in Khoh-Kolhu was 70.58% (Sorensen's Index), Kolhu-Mandal it was 61.81% and between Mandal-Khoh was 64.28%.

Species Richness

Jackknife estimator was used to estimate species richness for three rivers. Jackknife 1 was used as it gave small standard deviations. Mandal seems to have the maximum number of species, followed by Kolhu and Khoh (Fig. 3).

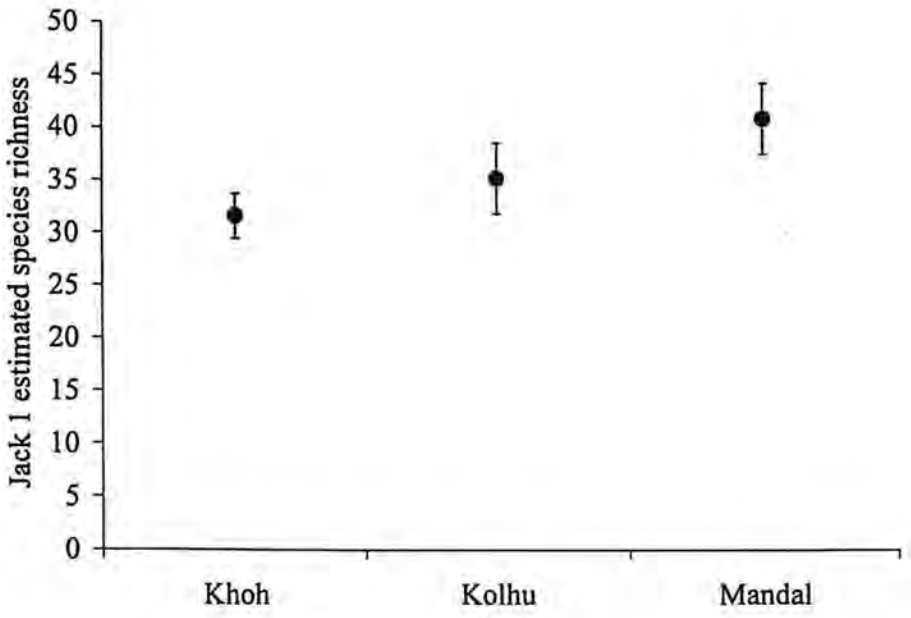

Figure 3: Jacknife estimator showing Rarefaction graph for Species richness

CHAPETR- VI

Length weight relationship, condition factor, and population structure of *Tor putitora* (Hamilton) among the three rivers

Abundance of Golden mahseer *Tor putitora*

After having three sessions of samplings, I could catch 2630 *Tor putitora* in all three rivers. Of these, 302 individuals from Khoh river, 212 individuals from Kolhu and 2116 individuals from Mandal river. Mandal River had significantly higher number of golden mahseer than other two rivers.

Length –weight relationship of *Tor putitora*

The total length and weight of fish was measured for all 2616 individuals. The total length was varied from 3 cm to 28 cm and weight was varied from 2 g to 140 gm. Length-weight relationship for *Tor putitora* in the river Khoh was determined to be $Wt = Lt^{1.0207}$ (fig.4). This equation corresponds to the logaritimized form, ln Wt = 1.0207*ln Lt, with constant 0 (r^2 = 0.6337).

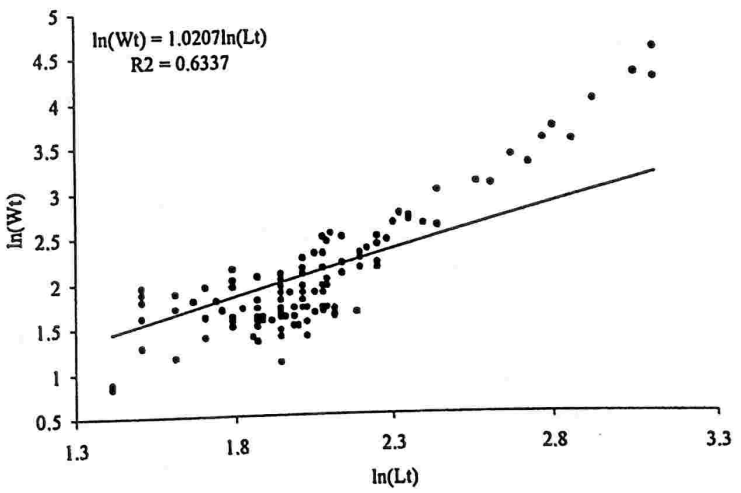

Figure 4: Length-weight relationship for *Tor putitora* in the Khoh River.

The length-weight relationship for *Tor putitora* in the river Kolhu was determined to be Wt = $Lt^{1.0481}$ (fig.5). This equation corresponds to the logaritimized form, lnWt = 1.0481*lnLt, with constant 0 (r^2 = 0.6663).

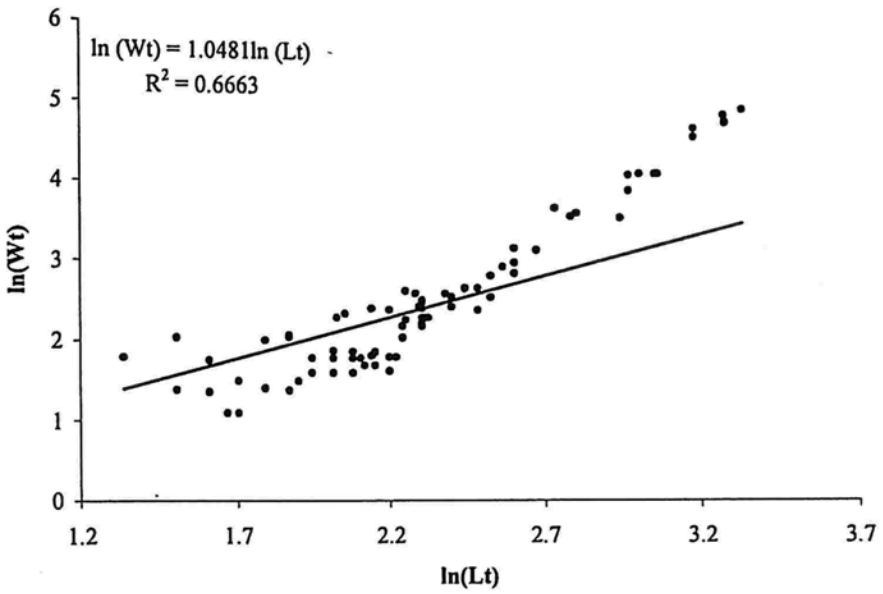

Figure 5: Length-weight relationship for *Tor putitora* in the Kolhu River.

The length-weight relationship for *Tor putitora* in the river Mandal was determined to be Wt = $Lt^{1.0054}$ (fig.6). This equation corresponds to the logritimized form, lnWt = 1.0054*lnLt, with constant 0 (r^2 = 0.6119).

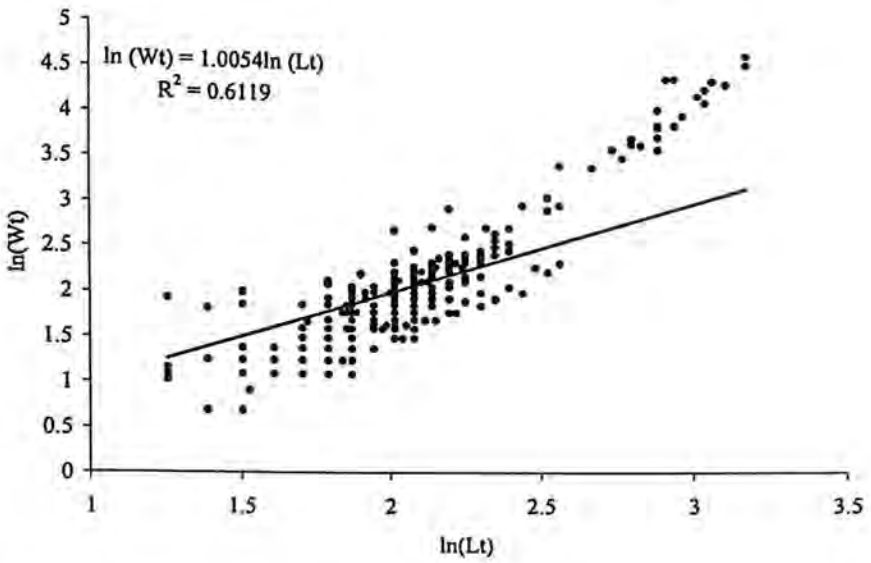

Figure 6: Length-weight relationship for *Tor putitora* in the Mandal River.

Size classes of *Tor putitora* among the three rivers sampled

Golden mahseer sized between 6-10 cm (total length) group was dominated in all three rivers (Figure 7, 8, 9 & 10) followed by 11-15 cm group. Only in Kolhu, 26-30 cm sized golden mahseer were caught but not in the Mandal and Khoh rivers. In other words, these three rivers supported only fingerlings and juveniles of golden mahseer rather than adults during study period i.e. in winter 2004-2005.

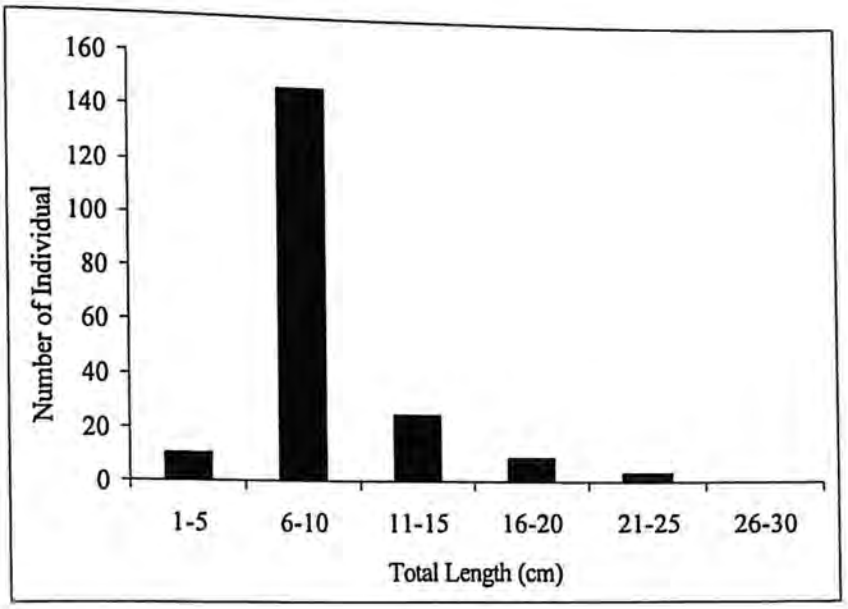

Figure 7. Size class distribution of *Tor putitora* in Khoh River

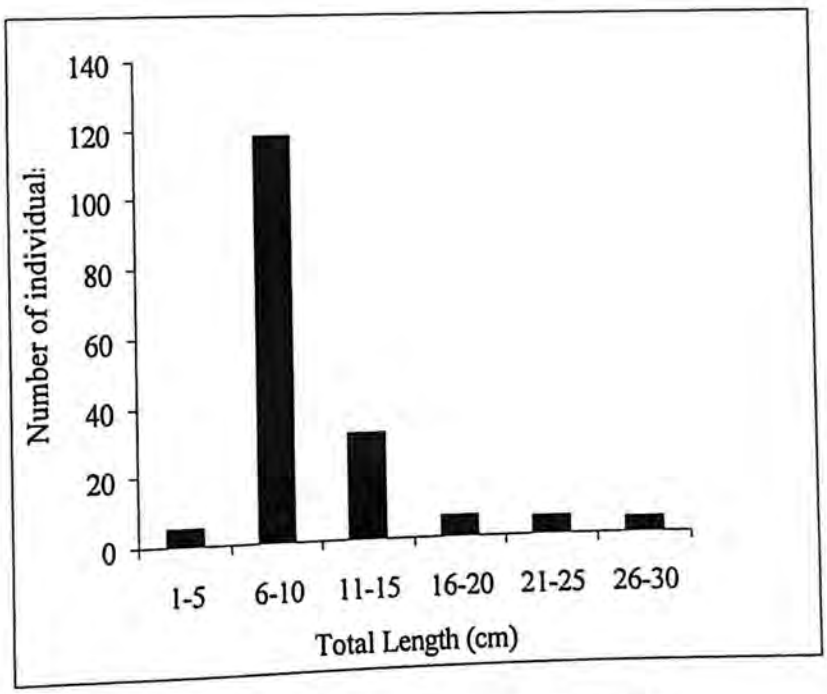

Figure 8. Size class distribution of *Tor putitora* in Kolhu River.

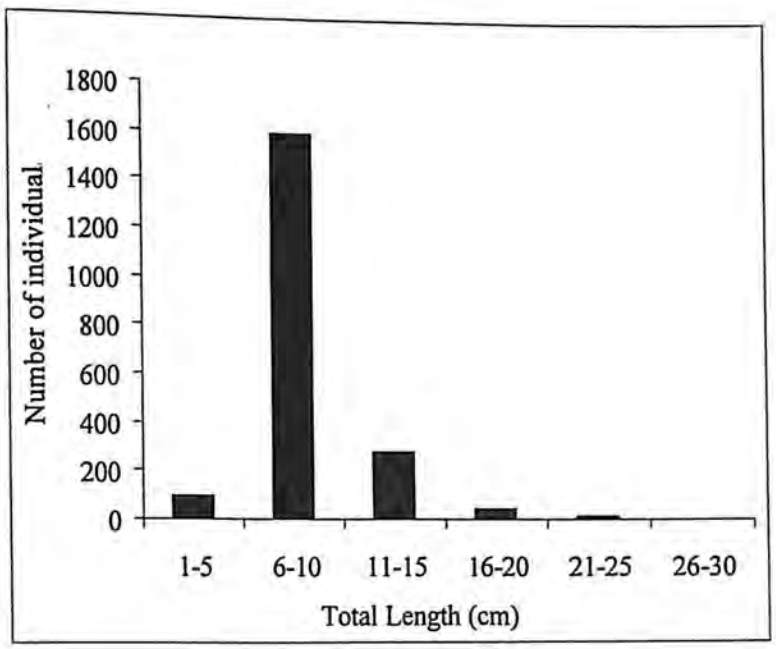

Figure 9. Size class distribution of *Tor putitora* in Mandal River

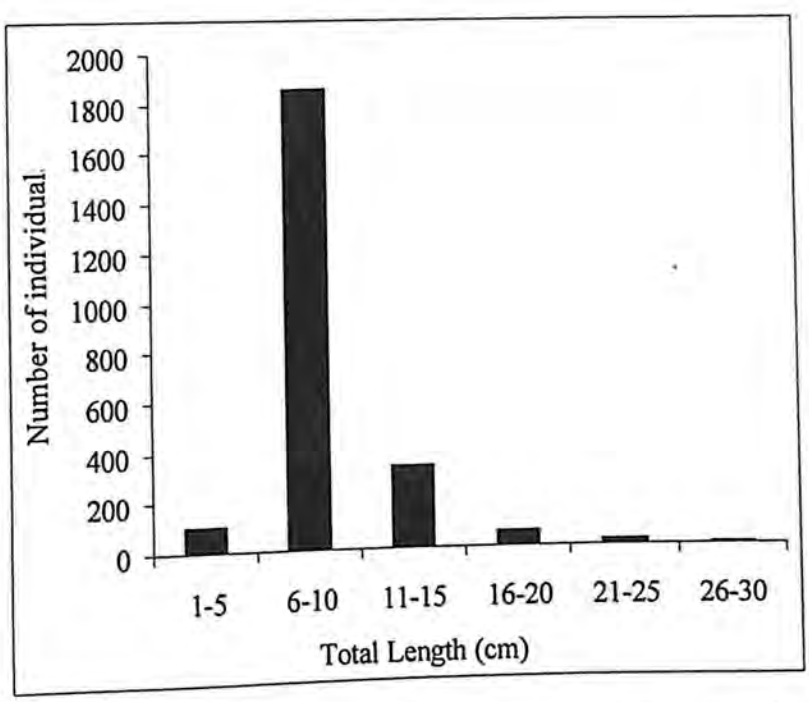

Figure 10. Size class distribution of *Tor putitora* in all three rivers.

Condition Factor of *Tor putitora*

The condition factor of golden mahseer (Kn) was better in the size classes having above 21-25 cm long body length in the study areas i.e. Kn>3 but the condition factor of young ones which were shorter than 20 cm long was not good and Kn value was varied from 0.8 to 2.7 in this size classes. However, the condition factor of 0-5 cm size class fish was better in Kolhu River than other two rivers (Fig 11). The size classes 6-10 cm, 16-20 and 21-25 cm were doing better in Mandal than other two rivers (Fig 12, 14 & 15) but the river Khoh may be better for fishes between 11-15 size classes (Fig 13).

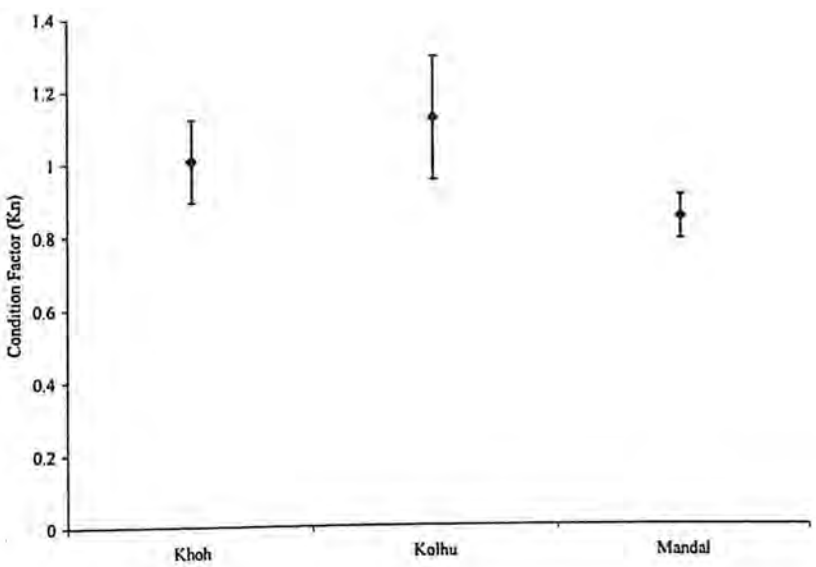

Figure 11. Condition factor (Kn) of Golden mahseer of 0-5 cm size class fishes in the all three rivers.

Note- One-way ANOVA result is not significant, no differences in condition factor (Kn) of fishes across three rivers for size class 0-5 cm (df 2, 53, $F = 1.480$, $p > 0.05$).

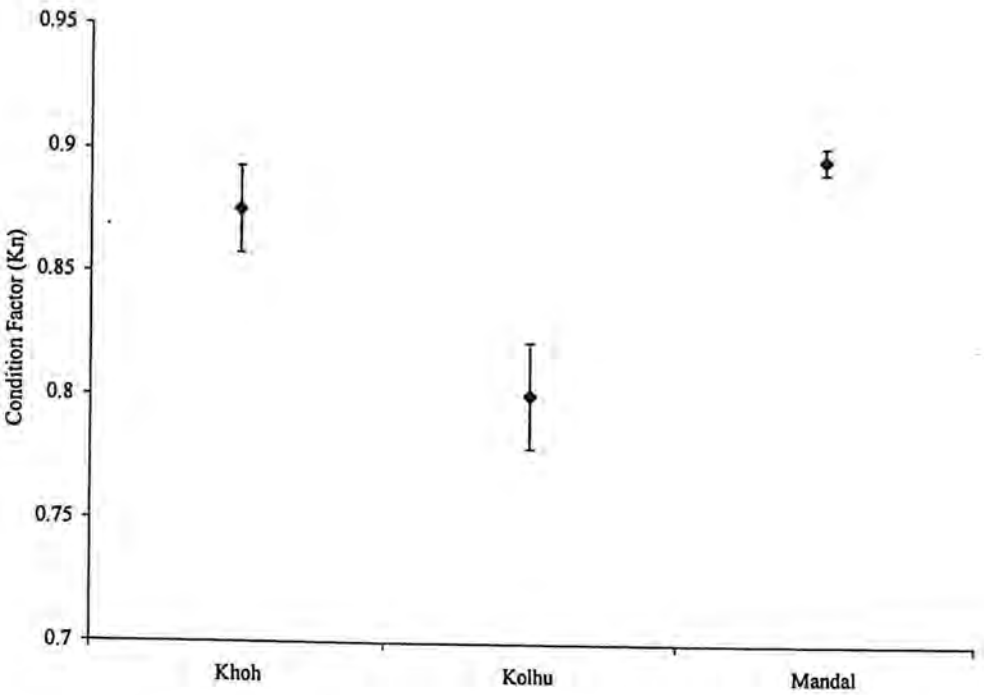

Figure 12. Condition factor (Kn) of Golden mahseer of 6-10 cm size class fishes in the all three rivers.

Note- One-way ANOVA shows significant differences among three rivers in condition factor (Kn) for this size classes ($df = 2, 1658$, $F = 11.59$, $P < 0.01$). Tukey's test shows significant differences between River Khoh and Kolhu and Kolhu and Mandal.

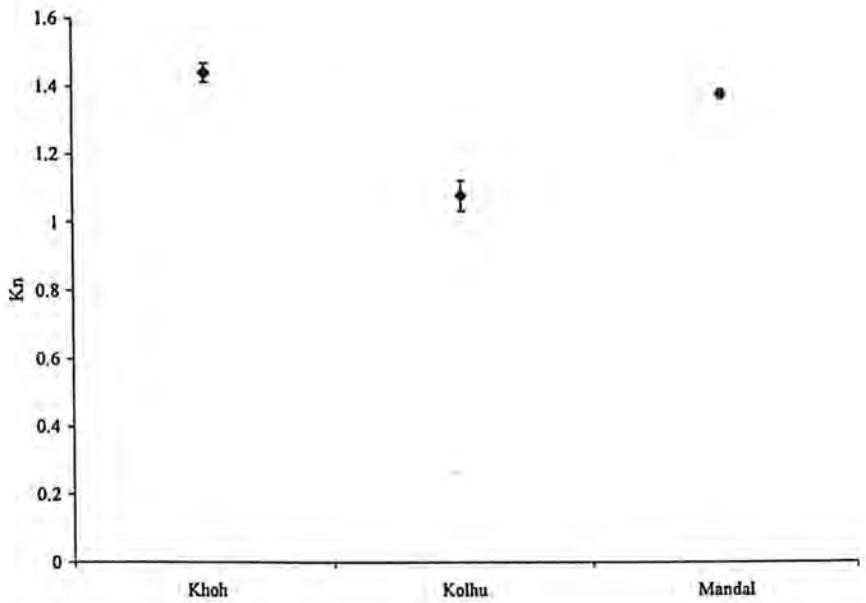

Figure 13. Condition factor (Kn) of Golden mahseer of 11-15 cm size class fishes in the all three rivers.

Note- One-way ANOVA showed there was significant difference among three rivers in body condition of fishes. Again differences between Khoh and Kolhu; Kolhu and Mandal. In this case, condition factor (Kn) drops down in Kolhu Tukey's test ($df = 2, 303$, $F = 20.910$, $p < 0.01$).

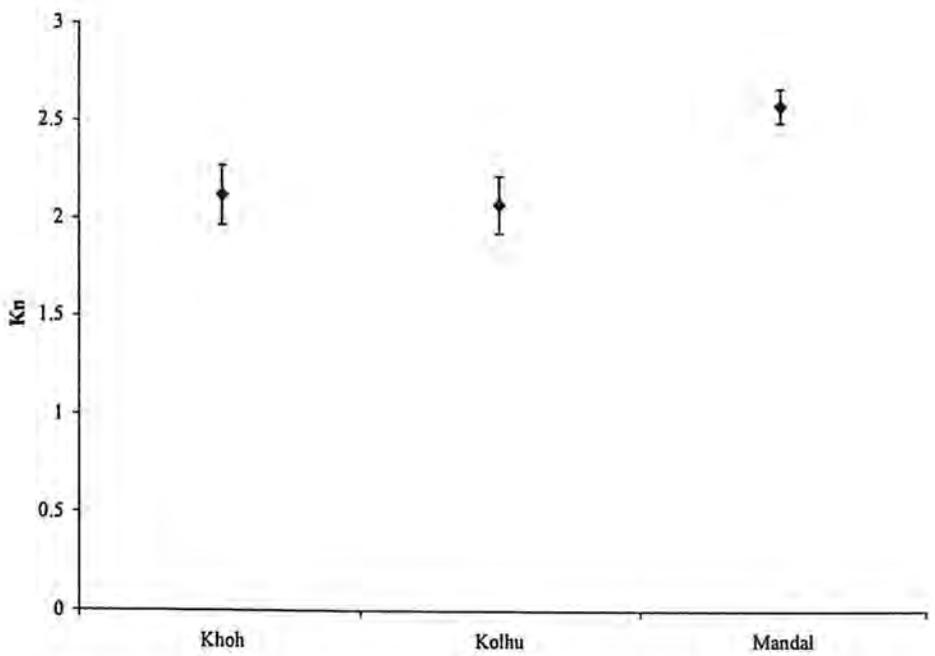

Figure 14. Condition factor (Kn) of Golden mahseer of 16-20 cm size class fishes in the all three rivers.

LSD shows significant differences between Khoh & Mandal and Kolhu and Mandal. Condition factor consistently better for Mandal River for this size classes. ($df = 2, 49$, $F = 4.700$, $p < 0.01$).

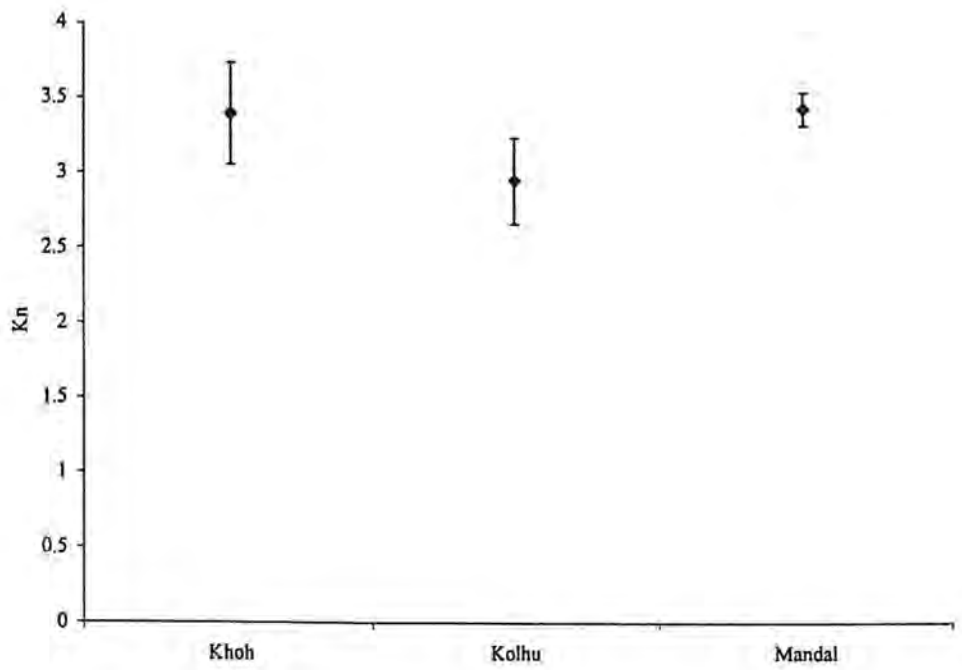

Figure 15. Condition factor (Kn) of Golden mahseer of 21-25 cm size class fishes in the all three rivers.

Population estimation using Capture-Mark-recapture method

An attempt was made to estimate the population size of all species which have occurred in the Mandal, Kolhu and Khoh rivers which forms the tributaries of Ramganga River. This was the first attempt in India for cold water fishes. Fishes belongs to Khoh and Kolhu Rivers were considered as closed population as these two rivers did not have any water connectivity between or with main Ramganga River during entire study period. However, Mandal had a permanent wsater link with the Ramganga River and hence fishes present here were considered as an open population. A total 12342 fishes were captured and released after clipping the caudal fin in all three rivers.

Even then the efforts were same in all three rivers and in all three sampling periods the total catch was drastically and constantly increased from first capture session to second recapture session. For example, the total number of fishes caught in first capture session were 1325 individuals but in the subsequent recapture sessions the total catch was 4366 and 6945 individuals. Since, there was a drastic differences in the total catch that too in closed populations I have decided to follow both Bailey's and Jolly-Seber method to estimate the population size of *Tor putitora*..

Population size of all fish species across rivers

First, I have used Bailey's method alone for calculating population size of all species using first-recapture data alone. All 1325 fish were marked and released in all three rivers during first capture session. In the first recapture session, 4366 fishes were captured, of these, 152 fishes were marked one (recaptures). Result shows that population size of all species in Mandal River was higher when compare to other rivers (Table 7). The population size of fishes in Khoh was smaller than other rivers (Table 7).

Table 7. Population size of fishes in all three rivers. Data pooled for all species.

Rivers	Mean	S.E.
Khoh	38386.8	17648.7
Kolhu	47251.2	7218.0
Mandal	119742.2	76341.2

It was observed that approximately 0.5 cm regeneration of caudal fin during interval of 30-32 days in the marked fish. All captured fish were examined on every occasion for the evidence of previous marking. It helps to identify the last time release. The 0.5 cm caudal fin regeneration was found of first time cut and 0.2 to 0.3 cm caudal fin cut was found as second time cut. Out of 2612 *Tor putitora* alone, 18 were caught twice and identified by caudal fin cut and caudal regeneration ranges from 0.2 to 0.5 cm. However, in case of *Garra gotyla*, and *Garra lamta* caudal fin was not increased over the study periods, except there was darkening in the lower caudal fin which was little difficult to second time to predict the time of release.

Populations size of *Tor putitora*

Both Bailey's and Jolly-Seber method were used to calculate the population size of *Tor putitora*. As per the Bailey's method, Mandal river had around 40510.1± 32259.1 golden mahseer (Table 8) but Jolly-Seber method estimates gives more or less similar values i.e. 40586.2 ± 34550.6 individuals (Table 9). There were drastic changes in the estimates between methods which would be discussed in the discussion section.

Table 8: Population size of *Tor putitora* among three rivers between three sampling periods (Bailey's method).

Rivers	Mean	S.E.
Khoh	2108.7	219.9
Kolhu	1991.8	749.9
Mandal	40510.9	32259.1

Table 9: Population size of *Tor putitora* among three rivers between three sampling periods (Jolly-Seber method).

River	Mean	S.E.
Mandal	40586.2	34550.6

CHAPETR- VII

Discussion and Conclusion

Status of fish in the Ramganga

Of the forty three species which have found in Mandal, Khoh and Kolhu rivers, *Barilius barila, Garra gotyla* and *Tor putitora* were commonly abundant in all the rivers. However, these three species were assessed as either vulnerable or endangered at global level (IUCN, 1997). The catch of these three species mainly comprised of juveniles and fingerlings. It shows that the tributaries of Ramganga River is one of the important breeding ground for these species and needs more conservation importance. If we protect these areas properly with regulated fishing (angling) then these small rivers will supply enormous number of offspring of these highly threatened species for ever.

Sadly, approximately 64% of fish species were assessed as very rare in the tributaries of the Ramganga. Since I don't know the food and feeding ecology of most of these species it would be difficult to give reason for their lower status. However, I could speculate that the degradation in the habitats especially changes in the substratum might be a reason for declining of these species in this region (Joshi, 1978). For example, water flow of Khoh River was interfered as a result of that algal growth on the surface of boulders was decreased. Many of these threatened species are feeds on algae (Joshi 1978).

It was found that, *Barilius barila, Barilius vagra, Barilius sharca, Garra gotyla gotyla, Labeo dero, Labeo dyochelius, Puntius vittatus, Schizothorax richardsonii,* were listed under *vulnerable* category (IUCN, 1997). *Botia lohachata, Nemacheilus. montanus, Tor putitora, Tor tor, Tor mosal* listed under as endangered category. Where as *Barilius barna, B. bendelisis,*

Glossogobius girius, Glyptothorax telchitta, G. pectinopterus Puntius ticto, Schizothorax progastus, and *Xenentodon cancila* were listed as Lower-risk threatened category. *Crossocheilus latius latius* comes under the Data Deficient (Table 1). These species were occurred in the study area. Therefore, it is important to enhance the conservation efforts to safeguard these species in Uttaranchal.

More number of species was recorded in Mandal but less number of species occurred in Khoh. It was found that fourteen species (Table 1 in Appendix –I) were common among all three rivers (Fig 2). The species richness per segment was more in the Mandal River followed by Khoh and Kolhu (Table 2). However, there was no significant difference found in the species richness between rivers. Number of individuals caught per segment (relative abundance) was significantly high in the Mandal River followed by Khoh and Kolhu (Table 3). Environmental parameters of these three rivers shows that all three rivers have similar water flow, water level and temperature but there was a significant differences in respect of substratum, turbidity and stream width (Table 2 & 3).

Some studies have tested species richness in local assemblages as a function of stream width (Matthews, 1998). Both width (r = 0.61) and stream depth (r = 0.60) both correlated with species abundance but more correlated with stream gradient (r = - 0.90). Similarly Paller, & White (1994) found that fish assemblages in South Carolina (USA) coastal streams strongly correlated with both stream width (r = 0.69) and depth (r = -0.78) as well as stream cross sectional area (r = 0.78). This appears to be the only case in which fish assemblages structure has been tested against cross sectional area of the stream (Matthews, 1998). Khoh river had a lot of boulders surfaced with algal growth which could be the major food for stream fishes

even then species richness and relative abundance of fish was lesser in Khoh than Mandal because the stream width of Mandal river was wider than other rivers.

The fish fauna of Khoh River was studied earlier by Joshi (1978) reported thirty-two fish species from the Khoh river basin. Now, 25 species have been reported from this river and it shows that remaining seven species extirpated from the Khoh River. There have been no studies on fishes in the Mandal and Kolhu River, so that, we could compare the present study. In the river Khoh, water was diverted for agriculture utilization, which could restrict the fishes remain present in the pools and there was no enough movement of fish as water flow was reduced drastically. That could be another reason for the declining of species in this river.

Length-weight relationship & condition factor

The L-W relationship of fishes has been widely studied topic but hill stream fishes of the Himalayas have not received greater attention so far. The biomass of fish population is often calculated from abundance by length and weight data using L-W relationship. It is one of the essential components of many investigations, including bioenergetic modeling studies, ecosystem or population models, and food web studies (Kimmerer *et al* 2005). Recently Lai & Helser (2004) reported that data on length and weight often ignores the inherent temporal and spatial grouping of the observations and thus bring change in the data hierarchy. To overcome this few studies on length and weight data revealed that the importance of collecting data continuously from the same area over the years to know the exact change in the study of biomass of the fish (Kimmerer *et al* (2005), Lai & Helser (2004).

The condition factor of golden mahseer (Kn) was better in the size classes having above 20-25 cm long body length in the study areas i.e. Kn>3 but the condition factor of young ones which

were shorter than 20 cm long was not good and Kn value was varied from 0.8 to 2.7 in this size classes. However, I have some reservation to mention that the condition factor of mahseer which has less than 20 cm body length was not good. Because at young stages, fish may not be fit in to the LeCren's Cubic Law due to physiological phenomenon.

An analysis on mark – recapture method

This was the first time in India, stream fishes were marked for estimating the population. Both Bailey's and Jolly-Seber method were used to calculate the population size of *Tor putitora*. As per the Bailey's method, Madal River had around 40510.1± 32259.1 golden mahseer but Jolly-Seber method estimates more or less similar values i.e. 40586.2 (S.E. 34550.6) individuals.

As per rule, the total catch must be more or less same in first capture and first recapture session then only one could estimate the population size using any methods such as Petersen, Bailey, Jolly-Seber etc (Lee, *et al,* 2003). However, the total catch of fishes in each session was drastically increased that too in ascending order during my sampling. As per rule I should not tried to calculate the population size using this data, however, I tried and got a result which might be an under estimate. I also learnt that more than four recapture sessions would require using the Jolly-Seber method for estimating the population size of stream fishes. Variations in the total catch could be due to efficiency of fishing which had increased gradually. It is strongly recommended that any study on the community or population of hill stream fishes should be carried out using electro-fishing method instead of using netting which might not be better sampling gear for stream fishes.

Conservation measures

Though, the Golden mahseer is globally threatened species, in Uttaranchal especially in the tributaries of Ramganga its population was better. Adult fish of mahseer get back to the main reservoir and reservoir often spawning. Study shows that the adult population of golden mahseer was declining very fast. However, juvenile's population was doing better. It has also revealed that the tributaries of Ramganga were mainly used as breeding ground and unfortunately due to various anthropogenic pressures the adult population adversely affected. Indiscriminate fishing and habitat destruction were the major damaging factor in this region. Angling may be allowed only in Khoh and Kolhu rivers that too with limitation in the number of fishing rods per year. Angling must be restricted between October and June. At least once in a life time fish must be allowed to breed accordingly the size of the fly (fishing rod) is also needs to be decided so that all the mahseer has an opportunity to breed. There should not be any angling below Domunda as two rivers Mandal & Ramganga enters in the National Park. One must also ensure that due to angling other wildlife should not be disturbed and revenue comes due to angling must be used for the conservation of rivers and betterment of local communities.

Conclusion

1. Globally threatened golden mahseer *Tor* putitora, *Garra lamta* and *Barilius barila* were common in the tributaries of Ramganga.
2. Tributaries of Ramganga i.e. Khoh, Kolhu and Mandal Rivers serve as an excellent breeding ground for golden mahseer as more juveniles were encountered in these rivers.
3. More number of fish species was occurred in the sixteen kilometers of Mandal River from Maida van to Domunda (in Kalaghar Tigre Reserve) which is less disturbed. There was no village besides to the river. Thus better population of fish.
4. Juveniles such as 6-10 cm body length size class were dominated in Khoh, Kolhu and Mandal rivers.
5. Condition factor of fish having more than 20 cm body length was better.
6. Variation in the total catch between capture and recapture sessions should not vary much which may give wrong population estimate.
7. The time interval between recapture sessions should kept minimum. It enables to minimize standard error of the calculated population size.
8. Electro-fishing method probably the best method for assessing the population as well as community structure of stream fishes.
9. Only angling may be allowed in Khoh and Kolhu River but not in Mandal. Any other fishing in these rivers need to prohibited immediately.
10. Upstream river stretch from Domunda to Jamun village in the Ramganga River may be allowed for angling tourism (catch and release) but one should ensure that there should not any disturbances to other wildlife.

CHAPETR- VIII

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APPENDIX - I

Species account of certain threatened fish of the Uttaranchal

Forty three species of fish representing six orders and nine families were collected (two species unidentified). A short account for some fishes is provided here which are enlisted as threatened under the IUCN & CAMP which were found in the Study Rivers. Information provided in this section is based on my observation on the species as well as from the literatures (Jayaram, 1981 & 1999, Talwar & Jingran, 1991).

1. *Barilius barila* (Hamilton-Buchanan)

Status: Common in study rivers (VU (B1, 2c), Fin Formula: D ii 7; iii 10-11; P i 12; V i 8

Common Name: Barred baril

Body shallow, depth is 4.6 to 4.8 times in standard length. Mouth moderate; jaw long, maxilla extends to below anterior-third of orbit; barbels two pairs, rostral pairs very short, the maxillary barbels extends up to anterior-third of orbit. Dorsal fin placed entirely in advance of anal fin. Pectoral fins about as long as head. Caudal fin forked, lower lobe slightly the longer. Scales moderate, with many radii; lateral lines with 43-46 scales; pre dorsal scales 22. Chest flattened, the scale in this region poorly developed. Characteristics muscular pads present in front of bases of pectoral fins- only evident in large, ripe males; epidermal surface of pad ridged transversely. Tubercles on snout and lower jaw poorly developed. Colour in life, dark olivaceous, otherwise silvery; 14- 15 (often less)vertical blue bands (more marked in young) which extends from back to lateral line; operculum golden. Fins are pinkish.

Distribution in the Study Rivers: This species was common in the study area in most of the segments. It was assessed as vulnerable at global level. This species occurred in all three rivers.

Geographical distribution: India: J &K, Delhi. U.P. M.P. Bihar, Assam, Manipur and Orissa; Nepal, Bangladesh and Burma.

2. *Barilius vagra* (Hamilton- Buchanan)

Status: Very rare (VU A1 a, 1c), Fin Formula: D ii, 8; a iii 10; Pi, 14, V 1, 8.

Body shallow, its length 4.5 to 4.6 times in standard length. Mouth moderate; jaws long, maxilla extends to below middle of orbit; barbels two pairs. Rostral barbels shorter than eye-diameter, the maxillary pair very short. Dorsal fin inserted almost anterior to anal fin, its last two fin rays over anal fin. Pectoral fin slightly shorter than head. Caudal fin forked, the lobes equal. Scales moderate with many radii; lateral line with 38-44 scales; pre dorsal scales 21-26. Tubercles small and poorly developed on snout and lower jaw. Colour Silvery with 10-14 bluish vertical bars (sometime indistinct) which usually remain much above lateral line. Fins bright pink or yellowish; dorsal and caudal fin grey edged.

Distribution in the Study Rivers: This species was very rare in the study area and also it is vulnerable at global level. It occurred in all three rivers but few individuals collected from Mandal and Khoh and more from Kolhu.

Geographical distribution: Afghanistan; Pakistan, Indus plain and adjoining hills; India; Himalayan and sub-Himalayan rivers; Nepal; Bangladesh; and Sri Lanka.

3. *Botia lohachata* (Chaudhuri)

Status: Very rare (EN B1, 2c), Fin Formula: D I 9-10; A I 5-6; P 14; V I 8

Body elongate and laterally compressed. Head moderate; length of snout less than remaining part of head. Eyes not wholly placed in posterior part of head; Eye diameters of about 4 times in head length, 2 times in snout length and about 1.5 times in inter-orbital width. Mouth small; barbel's four pairs (two pairs rostral; one pair each of maxillary and mandibular). Dorsal fin inserted midway between snout tip and caudal fin base. Caudal fin moderately forked. Scale minutes. Colour silvery grey or earthily brown (often with a dull golden gleam) with a series of Y shaped markings; arms of Y from each side meet on top of body so that a top view shows about four O-shaped markings; in large adults the regular Y-marks becomes obsolete and the fish then shows haphazard rod like markings. Fins hyaline to delicate grey; partly with dark blotches and bars.

Distribution in the Study Rivers: This species was very rare in the study area and also it was assessed as Endangered at global level. This species was found in Khoh and Kolhu but not in the Mandal River.

Geographical. Distribution: Pakistan: Indus river system; India: Ganga drainage; Bangladesh; and Nepal. Inhabits the plain and sub montane region.

4. *Garra gotyla gotyla* (Grey)

Status: Common (VU A1 ac), Fin Formula: D iii 7-8; A ii 5; P I 14; V i 8

Bodies elongate its depth 3.7 to 4.5 times in standard length. Head much depressed its length 3.5 to 4.2 in SL; interorbital region convex, its width 2.2 in Head length. Snout with a well developed median proboscis and a transverse lobe at a tip; free extremity of proboscis,

transverse lobe and lateral side of head in front of nostrils, covered with several large spiny tubercles. Mouth arched; mental disc well developed. Two pairs of barbels. Dorsal fin inserted nearer tip of the snout than to caudal fin base. Pectoral fin equal top or considerably shorter than HL. Scales moderate size; lateral line with 32-35 scales. Lateral transverse scale-rows 4 ½ / 3 ½; predorsal scales 9 or 10. Breast and belly scaled. Distance of vent from anal fin 4.1 to 7.2 times in inter-distance between pelvic fin origin and anal fin. Colour in life dark brown on back and light pink on flanks and belly; a dusky spot behind upper angle of gill opening; a row of dark spots along base of dorsal fin.

Distribution in the Study Rivers: This species was common in the study area but it was assessed as Vulnerable at global level. It was found in all three rivers in good number.

Geographical distribution: Pakistan, India: all along the Himalaya, Chota Nagpur plateau and Vindhya- Satpura mountains of the Indian Peninsula; Bangladesh and Upper Burma. It is found in the streams and lakes of the Himalayas and highly valued as a food.

Fish was found in shallow as well as deeper pools dominated with sands and gravels. It was found that this fish feeds on algal carpet present on the boulders and left with interesting biting marks in squared fashion. This is the reason it is named as Stone sucker. Fish was common throughout the Study Rivers.

5. *Labeo dero* (Hamilton)

Status: Very rare (VU A1 acd), Fin Formula: D ii-iii 9-12; A ii-iii 5; P I 16-17; V 17

Body elongate and its dorsal profile more convex than the ventral. Head rather small, its length 4.5 times in standard length. Snout very prominent over hanging mouth, without any lateral lobe but with a distinct groove across it and generally covered with pores. Eyes fairly small, not visible from underside of head, the diameter 4.5 to 5 times its head length. Mouth inferior, rather narrow; lips thick and continuous; lower lip closely papillated internally, joined to Isthmus by a narrow bridge. Barbel's one small maxillary pair. Dorsal fin inserted mid way between snout tip and origin of anal fin, its head more than depth of the body. Pectoral fins shorter than head. Caudal fin deeply forked. Scales moderate; lateral line with 40 to 44 scales; lateral transverse scales-rows 7 or 8 between lateral line and base of pelvic fin. Tubercles on snout often present few in number. Colour in life bluish or brownish black on back, bluish-silvery on flanks and belly; scales often tinged red; an obscure band along the flanks. Fins blackish with faint reddish hue; outer edge of dorsal fin rather dusky.

Distribution in the Study Rivers: This species was very rare in the study area but it was assessed as Vulnerable at global level. It was found in Khoh and Mandal rivers but was absent in the Kolhu river.

Geographical distribution: Pakistan; Sind hills; India: all along the Himalayas, Arunachal Pradesh; Nepal, Sri Lanka, Bangladesh, Burma and China. (Inhabits sides of torrential hill streams in shallow water).

6. *Nemacheilus montanus* (McClelland)

Status: Very rare (EN B1, 2c), Fin formula: D ii 7; A ii 6; P I 9; V I 6

Body elongate and uniform depth, its depth 6 to 8.7 times in standard length. Eye small, not visible from underside of the head. Nostril close to each other. Mouth semicircular; lips

moderately fleshy and deeply furrowed, lower lip interrupted in middle. Barbles well developed. Dorsal fin inserted slightly nearer to base of the caudal fin than to snout-tip. Caudal fin emarginated. Scales minute, non imbricate, and more conspicuous posteriorly; lateral lines complete. Colour in life 10-12 black vertical bands, boarder than interspaces, encircling body; bands anterior to dorsal fin break up into numerous narrow bands with growth. Dorsal fin with a black base and black blotch at base of its anterior few rays, and dark bar across its centre; caudal fin with a black band at its base and a bar across each lobe.

Distribution in the Study Rivers: This species was very rare in the study area but it was assessed as Endangered at global level. It was found only Mandal River.

Geographical distribution: India: Himachal Pradesh.

7. *Puntius vittatus* (Day)

Status: Very rare (VU A1, acd), Fin formula: D ii 8; A ii 5; P I 11; V i 8

Body elongate, its depth 2.5 to 2.8 times in SL. Mouth small and terminal; no barbels. Dorsal fin inserted nearer to base of the caudal fin than to tip of the snout; its last un-branched ray weak and entire. Scales moderate; lateral line incomplete, cases after three to six scales; scales in longitudinal series 2- to 22; pre dorsal scales 6 to 7. Colour in life yellowish-green, flanks greenish, belly silvery-white; each scale with a dark base and silvery edge; a round, gold bordered, dark blotch at base of caudal fin. Pectoral fins hyline; other fins pale yellow to brownish yellow; base of dorsal fin golden yellow; above it an oblique black, orange-edged band; minute dots on dorsal and anal fins.

Distribution in the Study Rivers: This species was very rare in the study area but it was assessed as Vulnerable at global level. It was found only in Khoh.

Geographical distribution: Pakistan, India: Goa, Karnataka, Kerala, Tamil Nadu, Kutch, Bihar, and Rajasthan; and Sri Lanka.

8. *Schizothorax richrdsonii* (Grey)

Status: Very rare (VU A1c, 2cd), Fin Formula: D iii 8; A iii 5; P I 15-16; V I 9

Body stream lined its depth 4.1 to 6.2 times in standard length. Head length 4 to 5 times in standard length. Eye diameter 4.1 to 5.4 times in head length. Mouth inferior, transverse and slightly arched; hard ochre-colored cartilaginous covering below lower jaw extends between corners of mouth, followed by a fleshy and flat lower lip which is covered with a set of raised papillae forming the sucker. Barbels two pairs (maxillary and rostral), usually shorter than eye diameter. Dorsal fin inserted almost midway between snout-tip and base of caudal fin; dorsal fin inserted almost inserted midway between snout tip and base of caudal fin; dorsal spine strong and serrated behind. Scales very small, 85 to 110 in lateral lines. Colour in life, steel-grey, becomes gradually lighter below; belly yellowish-white; body often with small grey spots. Dorsal and caudal fin grayish-white; pectoral, pelvic and anal fins ochre-yellowish.

Distribution in the Study Rivers: This species was very rare in the study area but it was assessed as Vulnerable at global level. This species was found in all rivers. Khoh River had god number of this fish. This is cold-water fish common in Khoh River but was not found in Kolhu and Mandal River. Fingerlings of this fish were very common in Khoh in the middle segment. Where as in Mandal at upstream area fingerlings were common at confluence of river Mandal and Kali River. The big sized fishes were found only in the Khoh River from the Durgadevi temple upto Amsod village.

Geographical distribution: India- along the Himalayas from Jammu Kashmir to Assam; Sikkim and Bhutan; Nepal; Pakistan; and Afghanistan.

Inhabits rivers, prefers to live among rocks.

8. *Tor putitora* (Hamilton)

Status: Common (EN B1, 2c), Fin formula: D iv; A ii 5; Pi 16-17; V i 8

Common name: Golden mahseer/ Himalayan mahseer

One of the largest and the most important game fish in India (Nautiyal, 1994). Fish of the torrential water of the Himalaya known as "Maha Sir" due to its massive head. It is also known as king of mountain streams. Head 4 to 4.5, depth 5.5 to 7 times in total length, eyes 3 to 5.3 times in head length; lips thick with a continuous labial grooves; adipose extension of lips is present; greater than body depth; two pairs of barbels, predator scales 9; dorsal fin originates midway between tip of snout and base of caudal, dorsal spine strong and smooth. Usually greenish above with lighter pinkish and salivary white below, a broad light grayish blue to purplish lateral line found generally in live specimens. Fins yellowish with fin base tinged with red maximum size of 280cm, 55kg of weight. Unfortunately, I could catch only small sized fishes not more than 28 cm long in the study area. However, in Mandal and Kolhu rivers the larger mahseer were seen but I could not catch it. In the Khoh river there was no evidences of presence of large sized mahaseer except near to Amsod where large sized mahseer fed by temple authorities.

Habitat ecology:

Mahseer live and grow to maturity in large river and migrates to head water creeks to spawn. They forage in groups over open gravel bed in afternoon and evening. Their preferred habitat are snow fed or rain fed running water, broken into pools and rapids, river bed mostly boulder strewn with gravel, pebble, and coarse sands, with plentiful insect live and breed in riverine habitat where summer and winter temperature neither very cold or warm 15^{0}C to 30 ^{0}C. Grow

well in highly mineralized water with high specific conductance and nearly neutral pH. They are long lived, slow growing, predatory, and feed on insects and fish fry of the other species. Their main enemies are otters and fishing eagles.

Reproduction

Mahseer which produces 45,800 to 75,500 eggs also it depends upon proportion of body length-weight. The young feed on diatoms, ciliates, rotifers, and crustaceans. The Mahseer is migratory in habit and their spawning migration is timed with season. They migrates form large river to spawn in creek from June to September, as soon as spawning is over they move downstream feeding areas of large rivers. In these months, water flow, temperature, pH dissolved oxygen are favorable for breeding. Migratory schools move from deeper water of lowland River to shallow water of upland spawning ground. The spawning pair selects slow moving water along river bank deposited at installment or in batches along gravel beds. They get soon attach to stones and pebbles until they hatch. A fertilized egg measures 2.18 to 2.87mm. Mahseer embryo hatches out in 49-75 hrs at 28 ^{0}C in sac fry to yolk sac persist up to 100 hrs. After 10-12 days, full fledged swims up to fry develop. Male fish matures when it reaches 2 years age and grow about 200mm total length and female matures at 300mm total length within or after 3 years.

Distribution in Study Rivers: This species was common in Mandal and Kolhu River but not common in Khoh River. However, this species was assessed as an endangered species at global level.

Geographical distribution: India, Bangladesh, Bhutan, Pakistan, Nepal.

APPENDIX-II

Table 1. Status of fish species in the tributaries of Ramganga River

Fish species	Khoh	Status	Kolhu	Status	Mandal	Status	Overall	CAMP
Aspidoparia morar	9	R	19	NC	29	C	NC	
Barilius barila	28	C	33	C	32	C	C	VU (B1, 2c)
Barilius barna	17	NC	20	NC	27	C	NC	LRnt
B. bendelisis	27	C	23	C	24	NC	NC	LRnt
Botia lohachata	3	VR	2	VR	0	VR	VR	EN (B1, 2c)
Barilius sharca	0	VR	3	VR	0	VR	VR	VU (A1a, 1c)
Barilius vagra	3	VR	15	R	2	VR	VR	VU
Catla catla	0	VR	1	VR	0	VR	VR	
Chagunius chagunio	1	VR	12	R	2	R	R	
Channa gachua	0	VR	0	VR	2	VR	VR	
Channa punctatus	0	VR	0	VR	2	VR	VR	

Crossochelius latius latius	0	VR	0	VR	1	VR	VR	DD
Garra gotyla gotyla	26	C	25	C	29	C	C	
Garra lamta	22	NC	15	R	27	C	NC	
Glossogobius girius	0	VR	1	VR	0	VR	VR	LRnt
Glyptothorax telchitta	9	R	0	VR	1	VR	VR	LRnt
G. pectinopterus	0	VR	0	VR	2	VR	VR	LRnt
Homaloptera rupecola	0	VR	0	VR	1	VR	VR	
Labeo dero	8	VR	0	VR	2	VR	VR	VU (A1acd)
Labeo dyochelius	4	VR	22	C	0	VR	VR	VU (Aacd)
Labeo calbasu	0	VR	0	VR	1	VR	VR	
Lepidocephalus guntea	6	VR	3	VR	19	NVC	VR	
Mastcembalus armatus	2	VR	2	VR	3	VR	VR	
Nemacheilus beavani	0	VR	1	VR	20	NVC	VR	
Nemacheilus botia	1	VR	0	VR	0	VR	VR	
N. garhwali	0	VR	0	VR	1	VR	VR	
N. montanus	0	VR	0	VR	1	VR	VR	EN (B1, 2c)

N. rubidipinnis	2	VR	13	R	9	VR	VR	
N. rupecola	0	VR	0	VR	2	VR	VR	
Puntius ticto	8	VR	15	R	25	C	NC	LRnt
Puntius sophore	0	VR	2	VR	2	VR	VR	
Puntius vittatus	1	VR	0	VR	0	VR	VR	VU
Raiamas bola	1	VR	11	R	0	VR	VR	
Schizothorax progastus	2	VR	0	VR	0	VR	VR	LRnt
S. richardsonii	19	NC	1	VR	4	VR	VR	VU (A1c, 2cd)
Small gouch like	0	VR	0	VR	13	VR	VR	
Tor chylinoides	9	R	0	VR	4	VR	VR	
Tor putitora	22	NC	29	C	30	C	C	EN (B1, 2c)
Tor tor	1	VR	3	VR	2	VR	VR	EN
Tor mosal	0	VR	1	VR	0	VR	VR	
Xenentodon cancila	0	VR	0	VR	1	VR	VR	LRnt
Golden colour	1	VR	0	VR	0	VR	VR	
Unknown sp1	1	VR	0	VR	0	VR	VR	

*number of segments from where fish caught,

C = Common,

NC = Not common,

VR= Very rare, R=Rare

Vu = Vulnerable,

EN = Endangered,

LRnt = Lower Risk Threatened,

DD =Data deficient.

APPENDIX-III

Family Order and Abundance of fishes from the tributaries of Ramganga River

Order	Family	Species	English Name	Total Abundance
Cypriniformes	Cyprinidae	*Aspidoparia morar*	*Aspidoparia*	358
Cypriniformes	Cyprinidae	*Barilius barila*	Barred baril	3861
Cypriniformes	Cyprinidae	*Barilius barna*	Barna baril	658
Cypriniformes	Cyprinidae	*B. bendelisis*	Hamilton's baril	1362
Cypriniformes	Cyprinidae	*Barilius vagra*	Varga baril	212
Cypriniformes	Cyprinidae	*Barilius sharca*	Shacra baril	21
Cypriniformes	Nemacheilinae	*Botia lohachata*	Loach	5
Cypriniformes	Cyprinidae	*Catla catla*	Catla	2
Perciformes	Channidae	*Channa gachua*	Snake head	2
Cypriniformes	Cyprinidae	*Chagunius chagunio*	Chaguni	33
Perciformes	Channidae	*C. punctatus*	Spotted snakehead	2
Cypriniformes	Cyprinidae	*Crossocheilus latius latius*	Gangetic latia	2

Cypriniformes	Cyprinidae	*Garra gotyla gotyla*	Gotyla	757
Cypriniformes	Cyprinidae	*Garra lamta*	Lamta garra	1162
Perciformes	Gobidae	*Glossogobius girius*	Tank goby	1
Siluriformes	Sisoridae	*G. pectinopterus*	Stonesucker	2
Siluriformes	Sisoridae	*Glyptothorax telchitta*	Stonesucker	14
Cypriniformes	Balitoridae	*Homaloptera rupecola*	River loach	4
Cypriniformes	Cyprinidae	*Labeo dero*	Kalabans	3
Cypriniformes	Cyprinidae	*Labeo calbasu*	Black rohu	2
Cypriniformes	Cyprinidae	*Labeo dyochelius*	Brahmaputra	101
Synbranchiformes	Mastacembelidae	*Mastcembalus armatus*	Spiny eel	10
Cypriniformes	Nemacheilinae	*Nemacheilus rubidipinnis*	Loach	11
Cypriniformes	Balitoridae	*Nemacheilus beavani*	Loach	49
Cypriniformes	Cobitidae	*Nemacheilus botia*	Loach	6
Cypriniformes	Nemacheilinae	*Nemacheilus garhwali*	Loach	2
Cypriniformes	Nemacheilinae	*Nemacheilus montanus*	Loach	79
Cypriniformes	Cobitidae	*Lepidocephalus guntea*	Guntea loach	47

Cypriniformes	Nemacheilinae	*Nemacheilus submontanus*	Loach	1
Cypriniformes	Balitoridae	*Nemacheilus rupecola*	Loach	1
Cypriniformes	Cyprinidae	*Puntius ticto*	Ticto barb	308
Cypriniformes	Cyprinidae	*Puntius sophore*	Spotfin swamp barb	16
Cypriniformes	Cyprinidae	*Puntius vittatus*	Kooli barb	1
Cypriniformes	Cyprinidae	*Raiamas bola*	Indian trout	34
Cypriniformes	Cyprinidae	*Schizothorax progastus*	Dinnawah snowtrout	1
Cypriniformes	Cyprinidae	*Schizothorax richardsonii*	Alwan snowtrout	796
Cypriniformes	Cyprinidae	*Tor chylinoides*	Dark mahseer	35
Cypriniformes	Cyprinidae	*Tor mosal*	Copper mahseer	8
Cypriniformes	Cyprinidae	*Tor putitora*	Golden mahseer	2630
Cypriniformes	Cyprinidae	*Tor tor*	Tor mahseer	4
Beloniformes	Belonidae	*Xenentodon cancila*	Freshwater garfish	2
Unknown	Unknown	Unknown	*Golden colour*	1
Unknown	Unknown	Unknown	*Small gouch like*	1

Figure 1

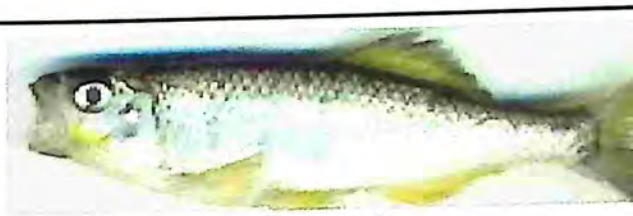


Figure 2

Figure 3

Figure 4

Figure 5

Figure 6

Figure 7

Figure 8

Figure 9

Figure 10

Figure 11

Figure12

Figure 13

Figure 14

Figure 15

Figure 16

Figure 17

Figure 18

Figure 19

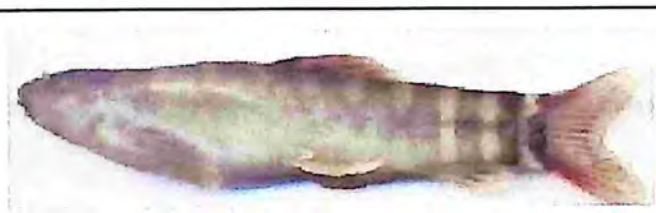


Figure 20

Figure 21

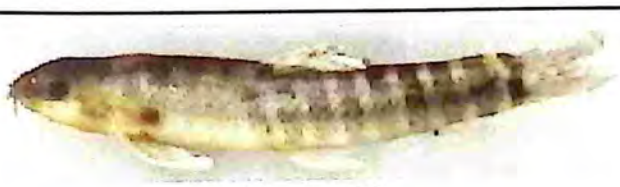


Figure 22

Figure 23

Figure 24

Figure 25

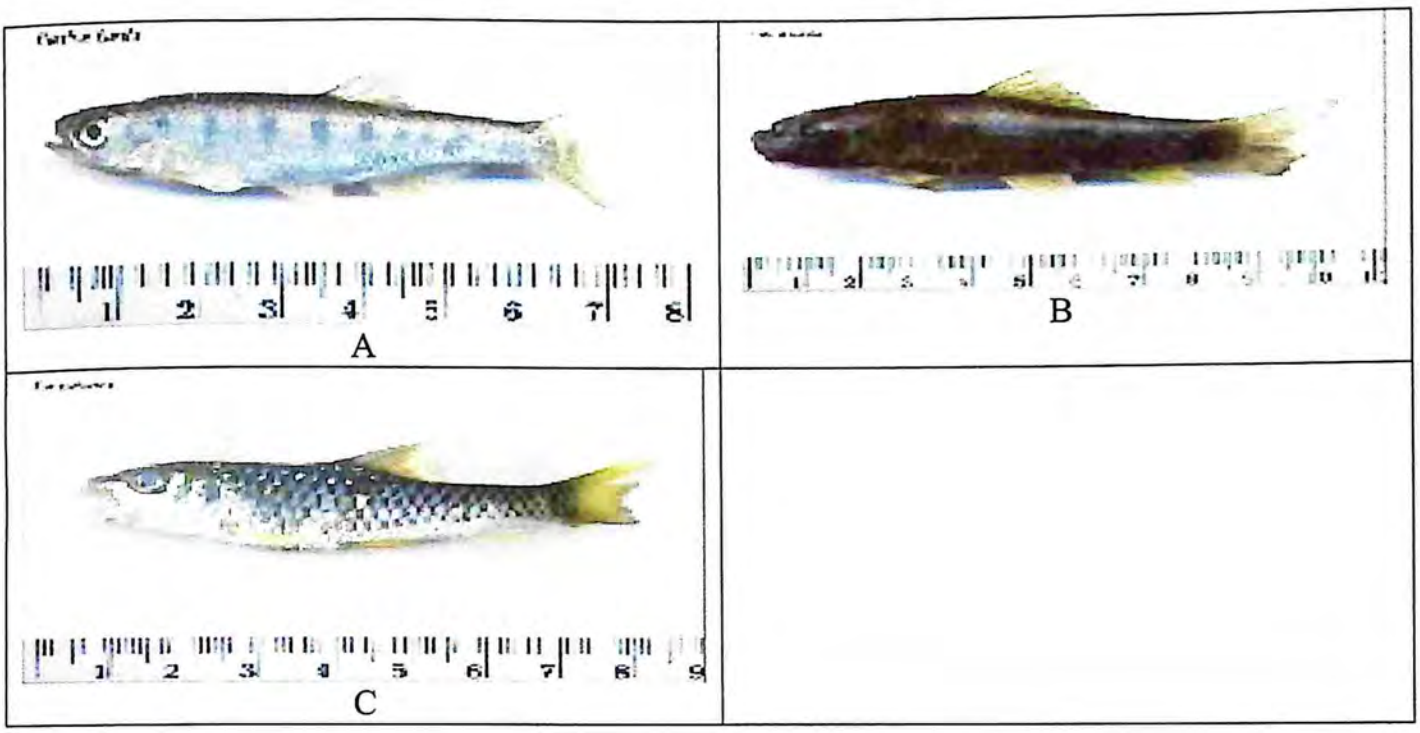
Figure 26

Figure 27

Figure 28

1. Figure 1 *Barilius barila* (Bared baril)
2. Figure 2 *Barilius barna* (Barna baril)
3. Figure 3 *Tor chylinoides* (Black mahseer)
4. Figure 4 *Labeo dero* (Kalabans)
5. Figure 5 *Barilius bendelisis* (Hamilton's barila)
6. Figure 6 *Tor putitora* (Golden mahseer)
7. Figure 7 *Puntius ticto* (Ticto barb)
8. Figure 8 *Garra gotyla gotyla* (Gotyla)
9. Figure 9 *Aspidoparia morar* (Aspidoparia)
10. Figure 10 *Chaginius chagunio* (Chaguni)
11. Figure 11 *Schizothorax progastus* (Snow trout)
12. Figure 12 *Channa punctatus* (Spotted snake head)
13. Figure 13 *Raimas bola* (Indian trout)
14. Figure 14 *Garra lamta* (Lamta garra)
15. Figure 15 *Unknown sp*
16. Figure 16 *Lepidocephalus guntea* (Guntea)
17. Figure 17 *Nemacheilus botia* (Loach)
18. Figure 18 *Glyptothorax pectinopterus* (Pattharchatta)
19. Figure 19 *Glossogobius girius* (Tank goby)
20. Figure 20 *Nemacheilus montanus* (Loach)
21. Figure 21 *Nemacheilus rubidipinnis* (Loach)
22. Figure 22 *Nemacheilus submontanus* (Loach)
23. Figure 23 *Botia lohachata* (Y loach)
24. Figure 24 *Xenentodon cancila* (Freshwater garfish)
25. Figure 25 *Homaloptera rupecola* (River loach)
26. Figure 26 *Mastacembalus armatus* (Spiny eel)
27. Figure 27 *Labeo dyocheilus* (Brahmaputra labeo)
28. Figure 28 *Schizothorax richardsonnii* (Alwan snow trout)

RECAPTURED FISH SPECIES



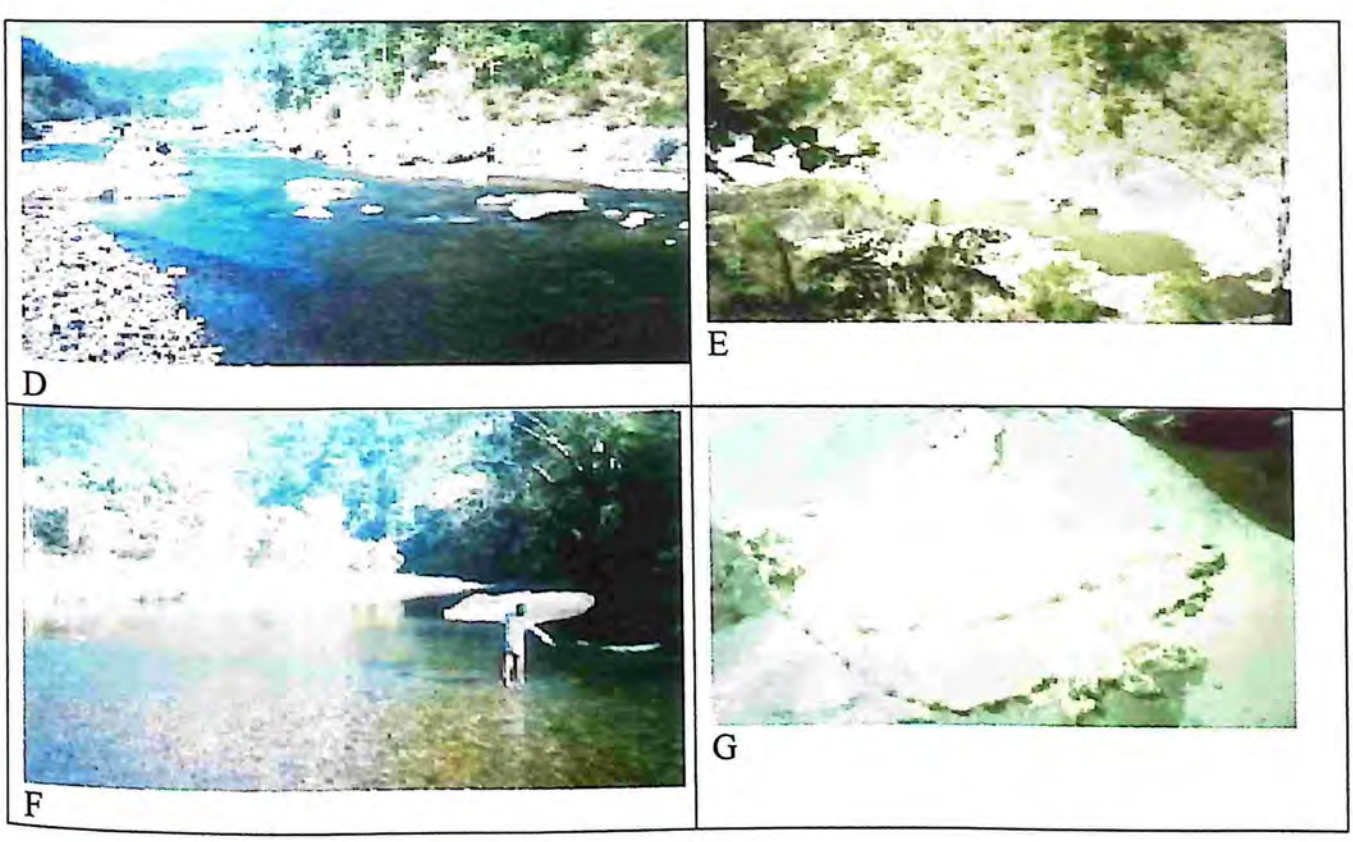
A

B

C

A - ***Barilius barila*** 0.5 cm caudal fin regenerated for 28-30 days.
B - ***Garra lamta*** darkening of caudal fin in one month
C - ***Tor putitora*** Fresh Recapture

SAMPLING METHHODOLOGY



D

E

F

G