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Short communication

## Population structure of Himalayan mahseer, a large cyprinid fish in the regulated foothill section of the river Ganga

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### Abstract

Studies were conducted to assess the population structure of Himalayan mahseer *Tor putitora* in the foothill section of the Ganga where the river has been extensively regulated through the construction of two barrages and an array of canals for hydropower generation, irrigation and recreation. The age composition of samples, measuring 14.4–98 cm in length varied from 1+ to 9+ and 1+ to 8+ during 1993–1994 and 1994–1995, respectively. The age classes 2 to 4+ accounted for 70–73% of fish, while age classes 5 to 9+ accounted for 27–30%. The 2+ class (33.1%) was largest in 1993–1994 while the 3+ class (32.3%) was largest in 1994–1995. Of all the age-classes, the percentage of 2+ males was high (40.6%) as compared with 2+ females (25%). No males were recorded in age groups beyond 5+. Approximately 95% of fish were immature. It is believed that this skewed age distribution is due to habitat modification resulting from impoundment and perhaps also overfishing. © 2000 Elsevier Science B.V. All rights reserved.

**Keywords:** Himalayan mahseer; *Tor putitora*; Population structure; Regulated river; The Ganga

### 1. Introduction

Age and growth rates are two attributes of prime importance in assessing fish population and their response to various types of management measures. The age structure, like other parameters of the population may alter in response to environmental fluctuations. The data on age structure can also be used to draw inferences on health of the population, mortality and survival rate (Nikolsky, 1976; Bagenal, 1978; Rounsefell and Everhart, 1985).

The mahseers *Tor* spp. are large, riverine cyprinids occurring in southern Asia. Himalayan (golden) mahseer *Tor putitora* may exceed 3 m in length and are one of the largest freshwater fishes. In the Himalayan stretch of the Ganga, the author [PN] had recorded in 1980–1981, a fish measuring 137.7 cm in length and 22 kg in weight (Nautiyal and Lal, 1981). Between 1993–1995 the largest fish measured 129 cm and weighed 18 kg. During 1995–1996 the largest size was recorded to be 113 cm only. Mahseer are locally important food fish, and increasingly are an important game fish, sought by tourist anglers. However, mahseer populations are increasingly under threat from the effects of river impoundment, overfishing and pollu-

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tion (Nautiyal, 1994, 1996). Few studies exist on the age structure of Himalayan mahseer populations. In Garhwal region Nautiyal (1990), provided information about age composition and growth rate of the Nayar and Alaknanda mahseer stock, which constituted only a section of the population. The present study was conducted to determine the age structure of the mahseer population downstream of the regulated foothill section of the river Ganga downstream of the Bhimgoda barrage at Hardwar; to highlight the abundance of different age groups, and to provide an insight as to present status of the population.

## 2. Materials and methods

### 2.1. Location of sampling stations

The Ganga originates as the Alaknanda and the Bhagirathi from the Bhagirathi khark (Gangotri glacier) in the northwestern Himalaya. These two parent tributaries meet at Devprayag to be known as the Ganga from there on. The lesser Himalayan tributaries like the Nayar and the Saung form a confluence with the Ganga downstream of Devprayag (Fig. 1). The Ganga is regulated for the first time in the foothill stretch between Rishikesh and Hardwar and for the second time in its journey from source to foothills. In the hilly tract its upstream tributary the Bhagirathi is regulated at Maneri for power generation (Nautiyal et al., 1988). The stretch of the Ganga between Rishikesh and Hardwar is situated between 29°56' and 30°7' North latitude and 78°10'–18' East longitude having an elevation of 289–325 m above sea level. The regulation is achieved by two barrages, one at Veerbhadra near Rishikesh and the other at Bhimgoda near Hardwar (Fig. 1).

The Nayar is located upstream of the Veerbhadra barrage, and the Saung below it. The regulation is largely for power generation, irrigation and recreational purposes. The Bhimgoda barrage is used to regulate flow of the Ganga in the upper Ganga canal. This is achieved through the use of one unregulated and two regulated canals located laterally (along the right bank). While the latter two canals are just adjacent to the barrage, the former is significantly upstream.

### 2.2. Fish samples

Fish samples were obtained regularly between 9:00 and 13:00 hours at monthly intervals for two years between September 1993 and August 1995 from Ajeetpur, a major fish landing centre in the foothill section of the Ganga (Fig. 1). Since a major part of the discharge is diverted for irrigation into the upper Ganga canal very little flow is available in the river at the sampling location. Consequently, the river lacks its characteristic torrential flow, and current velocity is reduced. Annually, the current velocity regime varied from 0.2 to 1.0 m s<sup>-1</sup>. The river channel is quite wide (ca. 500 m). During the low flow (October–February) when fishing activity is at its peak, the flow is restricted to a small part of the channel and gets divided into many streams so the river is shallow (<1 m) except for the pools which are up to <5 m deep. Owing to their large size the mahseer are restricted to such pools. Water temperature varied from 11°C to 24°C.

Fish were caught using gill and cast nets. The size of gill net varied from 40 × 7 to 60 × 10 m (L × W). The mesh size was 10 and 7 cm, respectively. Fish samples were taken randomly from the fish contractor at Ajeetpur or alternatively from the Raiwala fish market. Fish were preserved in 10% formalin after opening the abdomen. Care was taken to include fishes of all sizes. Sex was determined after examining the gonads under microscope.

Age composition was determined from key scales, obtained from the base of dorsal fins from fish measuring 14.5 to 98 cm, using a Carl Zeiss Jena Documenter. The annulus formation was determined according to the criterion suggested by Bagenal (1978) and adopted by Nautiyal (1990); widely spaced ridges follow a zone of closely spaced ridges. The annulus is usually considered to be at the outer border of the closely spaced ridges. The number of annuli for each of 223 scales was recorded. Age classes were determined on the basis of annuli and designated as 1+, 2+, 3+ and so on. A percentage frequency table was prepared on the basis of fish size at an interval of 3.0 cm to record the size of the fish at different age classes, and to compute age composition in different sex and years.

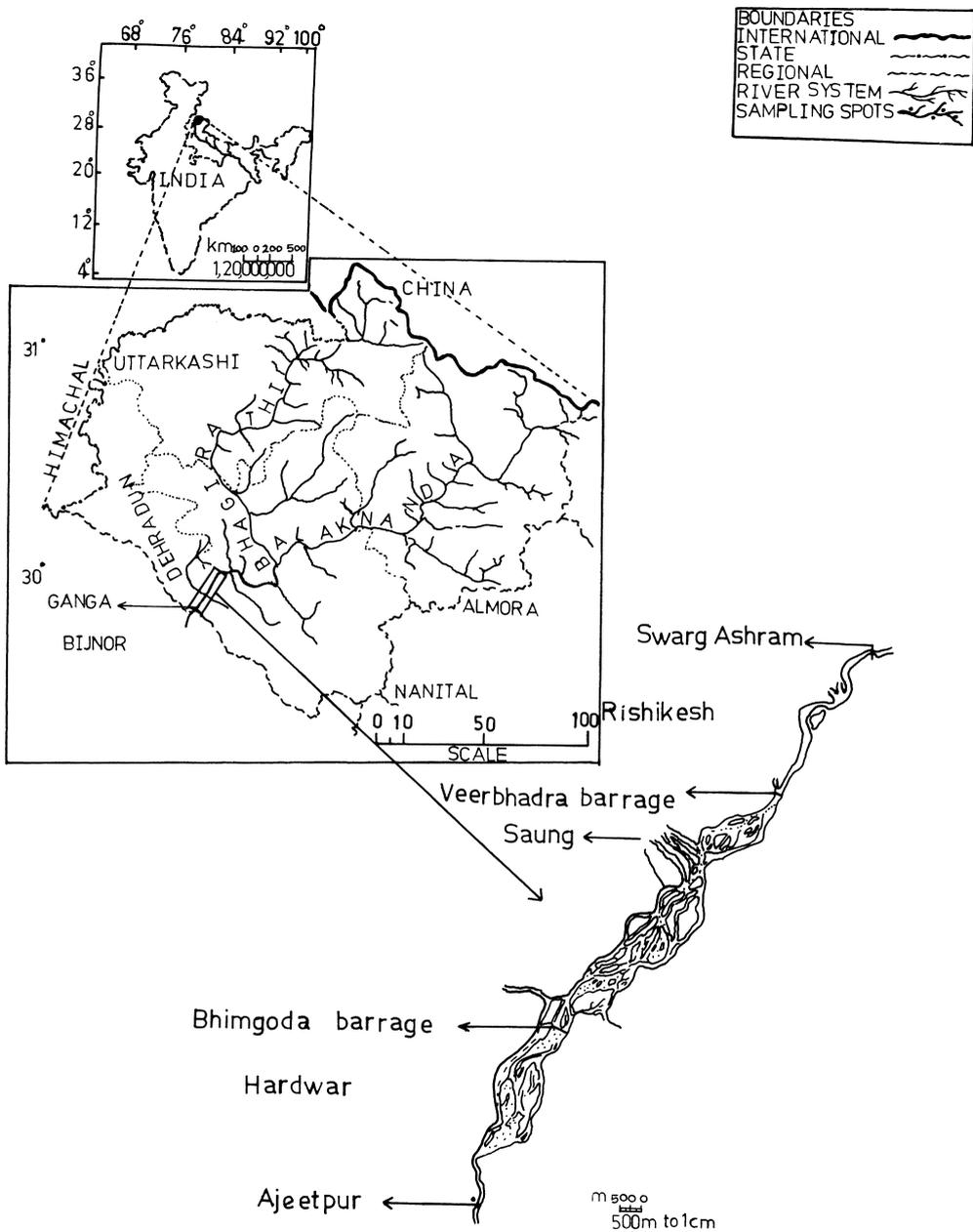


Fig. 1. Map showing the important tributaries of the Ganga river system [Alaknanda, Bhagirathi, Nayar and Saung], and the location of barrages in the foothill section of the Ganga.

### 3. Results

In the Himalayan mahseer samples individuals collected during 1993–1994, were 1+ to 9+ age

classes, measuring from 14.5–98 cm. The yearly data for 1994–1995 showed ages of 8+ age classes in the fishes measuring 18.5–77.5 cm in length. There were five age classes for males and nine for females. The

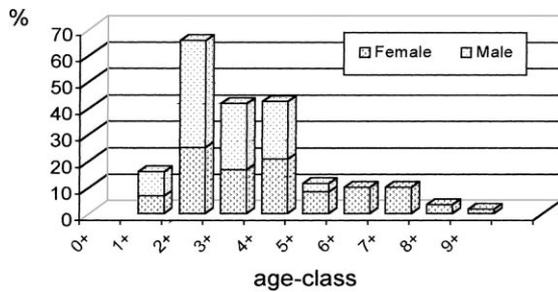


Fig. 2. Size-related variation in the age structure of *Tor putitora*.

age groups 2+ to 4+ accounted for 73% of total samples. The 2+ age group accounted for 33.1% of fish, 3+ for 20.1% of fish and 4+ for 20.2% of fish. All other age groups accounted for less than 10% of the total stock (Fig. 2). Of the various age classes, the 2+ age class accounted for 40.6% of males, and 25.0% of females. The 3+ and 4+ respectively, constituted 25% and 21.8%, of males as compared with 16.6% and 21.6%, of females (Table 1).

In the Himalayan mahseer stock comprising age 1 to 9+, the age classes 2 to 4+ constituted a large percentage (73% in 1993–1994 and 70% in 1994–1995) of the Ganga stock. Among these age classes, the 2+ and 3+ constituted 66.01% and 44.8% in the respective years. In this stock very little percentage of 1+ individuals was found in 1993–1994 (8.07%) and 1994–1995 (4.04%) year samples. The frequency percentage of fish continuously decreased in the 4 to 8+ age groups, being 19.3%, 10.3%, 4.4%, 3.5% and 1.3%, respectively. In the males 2+ and 3+ age classes accounted for 40.6 and 25%, respectively. In the females the 2+ and 3+ age classes accounted for 25.6 and 16.6%, respectively. Consequently, the Ganga stock of golden mahseer consisted largely of

immature individuals (<6+), since they mature (especially females) at >60–70 cm.

#### 4. Discussion

In the regulated section of the river at Hardwar the stock of Himalayan mahseer downstream of the Bhimgoda barrage consisted of 1 to 9+ age groups only. A recent study, however, shows that the fishes in 9+ (up to 17+) form a part of the stock upstream of the Veerbhadra barrage in the Ganga River system. They were found to occur seasonally in the Nayar and Alaknanda owing to their migratory habits (Nautiyal, 1994, and technical report to Ministry of Environment and Forests India). The presence of older fish above this barrage can be attributed to the prohibition of fishing around the religious town of Rishikesh and because the steep banks make the area inaccessible for poaching. The older groups probably remain unexploited. The older age groups form a small part of the catch during the period July–September when they ascend the Nayar to spawn (Nautiyal, 1994). Like Rishikesh, fishing is prohibited in Hardwar, a temple town with immense religious importance. Further, the stretch between Veerbhadra and Bhimgoda barrage is protected under Rajaji National Park. Despite these measures this stretch does not harbour a good size because the regulated stretch carries a meager discharge much less than the section upstream of Veerbhadra barrage. Extensive regulation has fragmented the mahseer habitat, which may account for the absence of age groups beyond 9+ below the impounded waters at Hardwar. Between October and February all gates of the barrage are closed. Little water is allowed to pass out from the last gate of the Bhimgoda barrage. Thus, the river channel in the

Table 1  
Age composition of *Tor putitora* for different sexes, years and pooled samples

Percentage composition by age groups									
	1+	2+	3+	4+	5+	6+	7+	8+	9+
Pooled	6.27	27.9	26.01	19.2	10.3	4.4	3.58	1.35	0.4
1993–1994	8.07	33.07	20.09	20.07	5.65	4.83	4.83	1.61	0.8
1994–1995	4.04	20.2	32.3	18.1	16.6	5.05	2.02	1.01	–
Male	9.3	40.6	25	21.8	3.1				
Female	6.6	25	16.6	20.6	8.3	10	10	3.3	1.6

immediate vicinity of the barrages is unsuitable for the large mahseer. Mahseer can be seen only in the deeper pools about a kilometre or further below the barrage.

The barrages lack any kind of fish ladder or a pass, which would allow free movement of the fishes after monsoon i.e. between November and February. In this period the discharge of the river declines and all of it is harnessed for power generation. With the rise in atmospheric temperatures from March to mid-July the fresh snow begins to melt and the discharge of the river increases marginally. In this period also the gates remain closed. The barrage gates are usually opened to regulate the extra discharge during peak floods in August. This is the only opportunity for free mixing of the population. Juvenile, adolescent and mature Himalayan mahseer commence upstream migration during late February or early March coinciding with the onset of snowmelt. They usually remain in the glacier-fed upstream tributaries of the Ganga e.g., the Alaknanda and Bhagirathi for 4–5 months, i.e., March–June. Mature adults ascend the Nayar during July and breeds there till the end of September. Upstream migration is thus a pre-requisite to breeding. For fish to breed they must cross this barrage in February/March. However, throughout this duration [from March to June] the fish below the barrage cannot ascend, as gates remain closed. Since the gates open in August, which is peak-breeding period (Nautiyal, 1984, 1996) little time remains to undertake arduous upstream migration. While this explains the absence of age groups beyond 9+ in the regulated section, other factors may also contribute to this situation. The low water levels allow easy fishing, thereby enhancing the fishing pressure which may force the larger mahseer to seek refuge in the deeper pools where it is difficult to land them by the use of gill nets alone. Possibly the stock below the barrage has been heavily fished or overexploited, so that very few individuals of large size may exist. The barrages have rendered the habitat immediately below them unsuitable for the larger fish.

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