Proc. Indian Acad. Sci. (Anim. Sci.), Vol. 93, No. 2, March 1984, pp. 97–106.

Natural history of the Garhwal himalayan mahseer *Tor putitora* (Hamilton) II. Breeding biology

PRAKASH NAUTIYAL

Fishery Biology Research Laboratory, Department of Zoology, Garhwal University, Srinagar 246 174, India

MS received 18 July 1983; revised 14 December 1983

Abstract. The fish matured only after attaining an average length of 700 to 770 mm. The period between July to September was established to be its spawning season. Observations on the Gonado–Somatic Index (GSI) and relative condition factor confirmed this observation. The variation in the sex-ratio during the spawning season was considered to be a remarkable adaptation towards low fecundity. The paper also comments on the problems of the Garhwal Himalayan mahseer and precautionary methods awaiting implementation in this region.

Keywords. Breeding; maturity size; spawning season; sex-ratio; *Tor putitora*.

1. Introduction

Mahseers are well-known for the sport provided by them, of which *Tor putitora* is found exclusively in the Himalayan region (Menon 1974). Earlier, the authors have commented on the problems encountered by the Garhwal Himalayan mahseer and have suggested ways of tackling them (Nautiyal and Lal 1982). The fact that the Superintendent of Dehradun reported on the state of fish (Mahseer) conservancy during 1871 in following terms (Atkinson 1973): "Breeding fishes are destroyed in great numbers and the small fry are also largely captured. The former are taken on the commencement of rains in every conceivable manner . . . ," implied that the mahseers were not cared for by the locals. Atkinson (1973) in his monumental work on the British Garhwal has commented that there was no reason to believe that what was written in 1871 may not be true of 1881 and of-course of 1980–82. It is a matter of coincidence that similar reports are still appearing.

Since its major population is exploited during the breeding season the author considered studies pertaining to breeding and related aspects like size at first maturity spawning season, frequency, fecundity and sex-ratio to be essential in solving the problems of the Garhwal Himalayan mahseer. In fact, the only studies conducted so far on this mahseer pertain to its spawning season and early larval stages (Thomas 1897; Khan 1939; Ahmad 1948; Qasim and Qayyum 1961; Bhatnagar 1964; Sehgal *et al* 1971; Desai 1972) and fecundity (Chaturvedi 1976; Kulkarni 1978; Pathani 1981; Nautiyal and Lal (in press). It is for the first time that the size at first maturity and sex-ratio of this fish are being discussed. As far as rehabilitation measures are concerned, attempts have been made in the past to induce breed mahseers in captivity and Tripathi (1978) along with Pathani and Das (1979) have successfully administered pituitary hormone injections to mahseers.

2. Materials and methods

Monthly samples of the Garhwal Himalayan mahseer were procured regularly for a span of two years from the Alaknanda (snow-fed) and the Nayar (spring-fed), two important tributaries of the Ganga. The sampling spots i.e. Srinagar for the Alaknanda was situated at latitude 30° 11′; longitude 78° 44′ and Banghat for the Nayar at 30° 58′ and 78° 46′ respectively.

2.1 *Size at first maturity*

Percentage distribution of the various maturity stages in each 200 mm size-group and percentage occurrence of the mature fish during the spawning season were calculated and the average length recorded. The relative condition factor (K_n) was also calculated for different size groups so as to arrive at consensus pertaining to the size at first maturity.

2.2 *Spawning season and frequency*

They were established by the following methods:

(i) Percentage occurrence of the mature fishes during different months. (ii) The presence of the eggs or larval stages at particular time of the year. (iii) The Gonado–Somatic Index (GSI). (iv) The seasonal cycle in K_n along with monthly variations in the K_n values.

2.3 *Sex-ratio*

The sex-ratio was calculated for different size-groups, months, maturity stages, and spawning seasons. The variation was recorded and its significance of difference tested by Chi-square method (χ^2).

3. Results

3.1 *Size at first maturity*

It is evident from figure 1a that in maturing individuals the IIIrd stage of maturity-'Ripening' appears for the first time in the 471–600 mm size-group. Since the percentage of mature individuals in this group was observed to be very low (17%) as compared to 33% in the 671–870 range, the average length i.e. 770·5 mm of the latter was considered to be the size at first maturity.

On the other hand, based on the classification of mature individuals, the average length at first sexual maturity at 50% level was estimated to be 700 mm (figure 1b).

The K_n values determined for different length-groups of *Tor putitora* (figure 2) exhibited a peculiar pattern of fluctuation. The point of inflexion in K_n at 401–520 mm range, (K_n) value being 1·02, was observed to record a very constant increase till it achieved another peak in the range of 881–1000 mm, K_n value being 1·185. It implied that some fishes start maturing by the time they attain a length of 520 mm and most of them mature till they attain a length of 880 mm. The average of 520–880 mm size-group i.e. 700 mm was thus determined to be the average length at first maturity, but

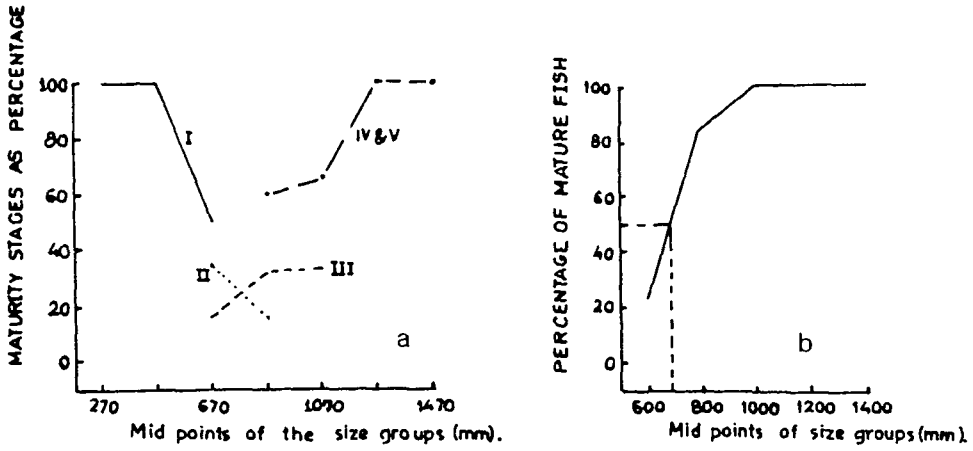

Figure 1. Percentage occurrence of **a**. various maturity stages in different size groups of *Tor putitora*. **b**. mature fish in various size groups of *Tor putitora*.

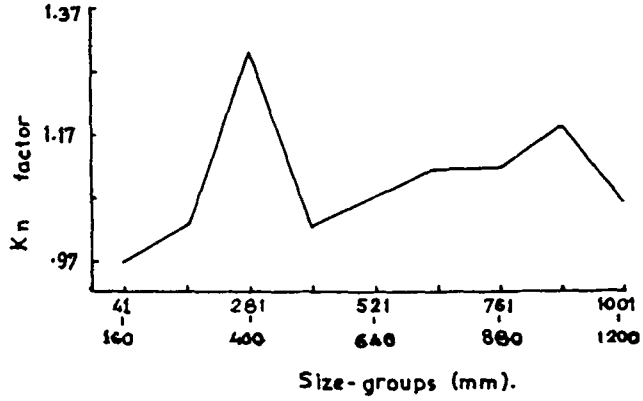

Figure 2. Average K_n values at different lengths.

700–770·5 mm range can be considered to be one within which all the individuals attain first maturity.

3.2 *Spawning season and frequency*

The immature fishes were present almost throughout the year while II, III, IV and V stages, only during July, August and September which obviously is its spawning period (figure 4).

All the attempts to collect fertilized eggs proved futile but the fingerlings were observed in the mainstream as well as in the deep pools (figure 5), on the river banks, during July–October/November, obviously implying the monsoon to be the spawning season.

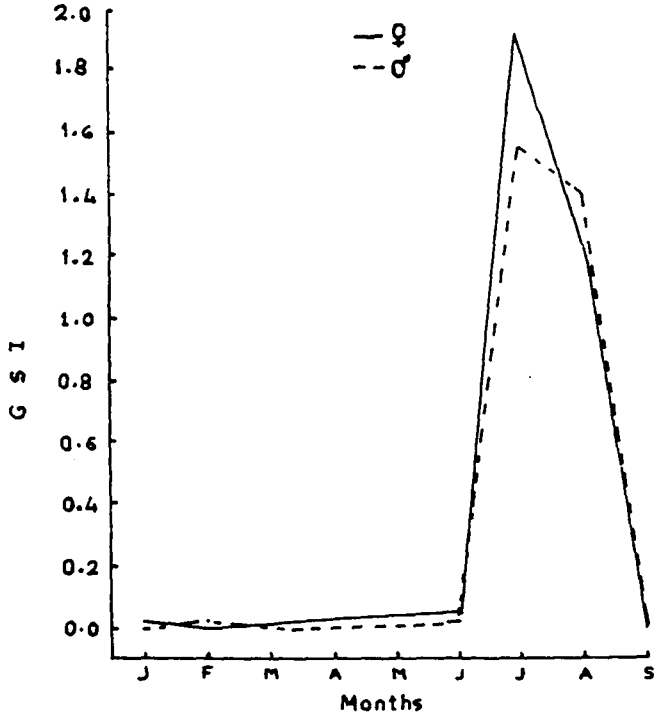

Figure 3. Seasonal variation in gonadosomatic index.

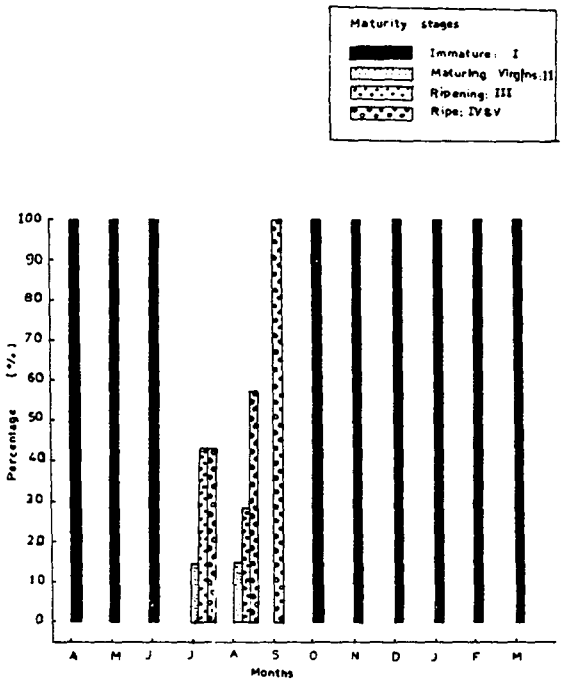

Figure 4. Percentage occurrence of various maturity stages during different months.

Table 1. Monthly variations in K_n.

Months	K_n	
	Males	Females
January	1·2985	1·2182
February	1·280	1·3136
March	1·1394	1·1401
April	1·2287	1·3171
May	1·7388	1·7492
June	1·4914	0·9832
July	1·9546+	1·5998
August	1·8519	1·9384+
September	1·069	1·4019

+ Peak.

The GSI was recorded to be high during July and August (figure 3) and so were the K_n values during these months (table 1).

3.3 *Sex ratio*

It is quite evident from the tables 2a–d that significant alternation in sex-ratio occurs both in the Alaknanda and Nayar mahseer. It is noteworthy that this variation of 1:7 occurs during the spawning season only, as far as the Nayar is concerned. Mahseer is available in the Alaknanda only for 3–4 months during which the variation in the sex-ratio was estimated to be significant.

4. Discussion

Based on the above observations the females of the Garhwal Himalayan mahseer matured sexually only after attaining an average length of 700 mm. The presence of brooders, larval stages, gonado-somatic index, the relative condition factor along with its seasonal cycle (separate contribution) enabled the author to conclude that the spawning season of the Garhwal Himalayan mahseer commences during July and extends up to September. Evidently, the fish is a '*annual breeder*' in Garhwal hillstreams as compared to, twice in Himachal waters (Sehgal *et al* 1971), thrice in Punjab waters (Khan 1939) and throughout the year in Bhakra reservoir (Bhatnagar 1964). Thomas (1897) too reported it to be a prolonged breeder. Karamchandani *et al* (1967), and Desai (1973) have reported that the Narmada *Tor* exhibits protracted spawning in three to four bursts but as it appears from the ova-diameter frequency (separate contribution) the putitor mahseer may spawn in two to three bursts, during the spawning season within an interval of two to three weeks.

According to MacDonald (1948) and David (1953) mahseer ascends the rivers during monsoon implying that changes in the abiotic factors influence the breeding activity of

Table 2a. Sex-ratio in different size-groups of *Tor putitora*, collected from the rivers Nayar and Alaknanda.

Length groups	Examined number of the specimens				Ratio of Males:Females		Chi-square $(\chi)^2$		Remarks			
	% of males		% of females						Nayar		Alaknanda	
	Nayar	Alaknanda	Nayar	Alaknanda	Nayar	Alaknanda	Nayar	Alaknanda	5%	1%	5%	1%
71–170	49·60	44·45	50·40	55·55	1:1·02	1:1·66	0·07	0·5	NS	NS	NS	NS
171–270	51·73	80·00	48·27	20·00	1:0·93	1:0·25	0·03	3·6	NS	NS	NS	NS
271–370	50·00	10·00	50·00	90·00	1:1·00	1:8·00	0·00	5·44	NS	NS	NS	NS
371–470	—	33·33	—	66·67	—	1:1·60	—	1·33	—	—	NS	NS
471–570	14·00	—	86·00	100·00	1:6·00	—	3·57	—	NS	NS	—	—
571–670	—	66·67	100·00	33·33	—	1:0·00	—	0·10	—	—	NS	NS
671–770	50·00	—	50·00	100·00	1:1·00	—	0·00	—	NS	NS	—	—
771–870	20·00	—	80·00	100·00	1:4·00	—	1·80	—	NS	NS	—	—
871–970	—	—	100·00	—	—	—	—	—	—	—	—	—
971–1070	—	—	100·00	100·00	—	—	—	—	—	—	—	—
1071–1170	—	—	100·00	100·00	—	—	—	—	—	—	—	—
1171–1270	—	—	—	—	—	—	—	—	—	—	—	—
1271–1370	—	—	—	—	—	—	—	—	—	—	—	—
1371–1470	—	—	100·00	—	—	—	—	—	—	—	—	—
71–1470	45·29	35·29	54·71	64·71	1:1·21	1:1·83	1·51	4·41	NS	NS	S	NS

NS = Non-significant; S = Significant at 5% and 1% levels.

Table 2b. Monthly variations in sex-ratio of Nayar and Alaknanda mahseer *Tor putitora*.

Year and months (1980–81)	Examined number of specimens				Ratio of		Chi-square $(\chi)^2$		Remarks			
	Males (%)		Females (%)						Nayar		Alaknanda	
	Nayar	Alaknanda	Nayar	Alaknanda	Males Nayar	Females Alaknanda	Nayar	Alaknanda	5%	1%	5%	1%
1980 April	—	28·60	—	71·40	—	1:2·5	—	2·57	—	—	NS	NS
May	80·00	22·22	20·00	77·78	1:0·25	1:3·5	3·60	2·77	NS	NS	NS	NS
June	66·60	50·00	33·33	50·00	1:0·05	1:1·00	0·33	—	NS	NS	NS	NS
July	—	56·30	100·00	43·75	—	1:0·77	1·00	0·25	NS	NS	NS	NS
August	13·80	—	86·20	—	1:6·25	—	15·20	—	S*	S*	—	—
September	40·00	—	60·00	—	1:1·50	—	0·20	—	NS	NS	—	—
1981 January	66·60	—	33·33	—	1:0·50	—	0·33	—	NS	NS	—	—
February	59·10	—	40·90	—	1:0·69	—	2·71	—	NS	NS	—	—
March	62·50	—	37·50	100·00	1:0·60	—	0·50	—	NS	NS	—	—
April	75·00	28·57	25·00	71·43	1:0·33	1:2·50	2·00	1·285	NS	NS	NS	NS
May	63·40	—	36·36	100·00	1:0·57	—	0·81	—	NS	NS	—	—
June	—	100·00	—	—	—	—	—	—	—	—	—	—
Total	52·20	35·29	47·85	64·71	1:0·91	1:1·83	0·30	4·41	NS	NS	S*	NS

Tables 2c and d. Sex-ratio during the spawning season and in the different maturity stages of *Tor putitora*.

2*c*												
1981	July	12·50	—	87·50	—	1:7·00	—	4·50	—	S*	NS	—	—
	August	12·50	—	87·50	—	1:7·00	—	4·50	—	S*	NS	—	—
	September	—	—	100·00	—	—	—	—	—	—	—	—	—
	July–Sept.	11·76	—	88·24	—	1:7·50	—	9·94	—	S*	S	—	—
1980	April to												
1981	September	45·29	—	54·71	—	1:1·21	—	1·51	—	NS	NS	—	—
2*d*													
	Immature	49·00	36·36	50·98	63·64	1:1·04	1:1·75	0·06	2·81	NS	NS	NS	NS
	Maturing	—	33·33	100·00	66·67	—	1:2·00	—	1·29	NS	NS	NS	NS
	Ripening	20·00	—	80·00	100·00	1:4·00	—	1·80	—	NS	NS	NS	NS
	Ripe	11·10	—	88·89	—	1:8·00	—	5·44	—	S*	NS	—	—
	Immature Ripe	45·29	35·29	54·71	64·71	1:1·21	1:1·83	1·51	4·41	NS	NS	S*	NS

the fish. Alikunhi and Rao (1951) considered flooding of rivers during monsoon to initiate some freshwater fishes to spawn. David (1953) maintains that lowering of the temperature range during cold months (22–28°C) highly influenced breeding of the Mahanadi mahseer while Desai (1973) considers the range of 19·9–28·4°C to be optimum for Narmada mahseer *Tor tor*. The author also observed the temperature range during the spawning season, especially at the Nayar where the Garhwal Himalayan mahseer was observed to spawn, and found the range of 21–25°C to be optimum. The flooding of summer haunts during monsoon along with the optimum temperature and high values of dissolved oxygen (8·81–11·0 ppm) provide a congenial atmosphere for the fish to lay its spawn. The change in water temperature is obviously the inducing factor.

The spawning grounds were observed to be a proportionate mixture of gravel, sandstones, implying the fish to be a '*lithophil*' (Nikolskii 1963). It has been observed to breed in knee deep waters in a tributary of the river Baner (Sehgal *et al* 1971), an environment which is readily available in the Nayar valley.

Studies on the sex-ratio have their own significance for they are helpful in detecting differential fishing, if any, in different periods of the year in the various size-groups and thus the abundance of the sex at a particular time or throughout the year (Chacko and Ganapati 1949). The most interesting aspect was the significant variation in sex-ratio (1:7), with females predominating during the breeding season, as also reported in the coregonials (Azbelev and Lagunov 1958) and the Godavari *Hilsa* (Chacko and Ganapati 1949). According to Koblitskaya (1961) such changes in the sex-ratio during the spawning season are of adaptive significance from the viewpoint of low fecundity. The Garhwal Himalayan mahseer too exhibits low fecundity (Nautiyal and Lal (in press)) for it possesses only 6,000 eggs per kg body weight as compared to 2,61,000 eggs per kg body weight of *Catla catla* and the significant variations in the sex-ratio of the Alaknanda mahseer, just prior to the spawning season and the Nayar mahseer during the spawning season lends support to Koblitskaya's (1961) observation.

Having considered all the facts it is apparent that the fish is naturally handicapped by delayed maturity for many of them are brought to market before they can lay their spawn and this alongwith unscientific fishing during the breeding season will lead to its anticipated gradual depletion. It would be appropriate at this juncture to quote Atkinson . . . . . "I would, therefore, strongly urge the prohibition of poaching and introduction of a close season for the carp tribe: in fact the introduction of Ross' Dun rules by legislative enactment."

Acknowledgements

The author is highly indebted to Dr H R Singh, Garhwal University, for laboratory facilities and encouragement. Thanks are also due to Dr M S Lal for his guidance and for critically going through the MS.

References

Ahmed N 1948 On the spawning habits and early development of the copper mahseer *Barbus* (*Lissocheilus*) *hexagonolepis* McClelland; *Proc. Natl. Inst. Sci.* **14** 21–28

Alikunhi K H and Rao S N 1951 On the bionomics, development and growth of a cauvery carp *Labeo kontius*, Jerdon; *Rec. Indian Mus.* **49** 157–174

Atkinson E J 1973 *The Himalayan Gazetter* II(1) (Delhi: Cosmo Publications)

Azbelev V V and Lagunov I I 1958 Sex-ratio in *Salmo salar*; *Zool. Zharn.* **37** No. 10

Bhatnagar G K 1964 Spawning and fecundity of Bhakra reservoir fishes; *Indian J. Fish.* **11** 485–502

Chacko P I and Ganapati S V 1949 On the bionomics of *Hilsa ilisha* (Ham.) in Godavari river; *Madras Univ. J.* **18** 16–22

Chaturvedi S K 1976 Spawning biology of *tor* mahseer *Tor tor* (Ham.), *J. Bombay Nat. Hist. Soc.* **73** 63–73

David A 1953 Notes on the bionomics and some early stages of the Mahanadi mahseer; *J. Asiat. Soc. Calcutta* **19** 197–209

Desai V R 1972 Notes on the early larval stages of *Tor putitora* (Ham.); *J. Zool. Soc. India* **24** 47–51

Desai V R 1973 Studies on the fishery and biology of *Tor tor* from river Narmada; *Proc. Indian Nat. Sci. Acad.* **39** 228–248

Karamchandani S J, Desai V R, Pisolkar M D and Bhatnagar G K 1967 Biological investigation of the fish and fisheries of Narmada river (1958–1966); *Bull. Cent. Indl. Fish. Res. Inst.* **10** 1–39

Khan H 1939 Study of the sex organs of mahseer (*Barbus tor*); *J. Bombay Nat. Hist. Soc.* **40** 653–656

Koblistkaya A F 1961 New data on the Biology of *Pomatoshistus caucasicus* Kaw. of the outer delta of the Volta; *Vopr. Ikthiol.* **1**

Kulkarni C V 1978 The present status of mahseer (fish) and artificial propagation of *Tor khudree* (Sykes); *J. Bombay Nat. Hist. Soc.* **75** 651–660

MacDonald A Sr J 1948 Circumventing the mahseer and other sporting fish in India and Burma (Bombay); *J. Bombay Nat. Hist. Soc.* 306

Menon A G K 1974 A check-list of fishes of the Himalayan and the Indo-Gangetic plains; *Indian Fish. Ecol. India.* Spl. Publ., 1

Monastryskii G N 1940 Methods of evaluating the roach stocks of the North Caspian; *Trudy*, VNIRO 11

Nautiyal P and Lal M S 1982 Recent records of the Garhwal mahseer *Tor putitora* with a note on its present status; *J. Bombay Nat. Hist. Soc.* **79** 693–695

Nautiyal P and Lal M S 1982 Fecundity of the Garhwal Himalayan mahseer *Tor putitora* (Ham.), *J. Bombay Nat. Hist. Soc.* (in press)

Nikolskii G V 1963 *The Ecology of Fishes*; (London: Academic Press) pp. 352

Pathani S S 1981 Fecundity of mahseer *Tor putitora* (Ham.); *Proc. Indian Acad. Sci.* (*Anim. Sci.*) **90** 253–260

Pathani S S and Das S M 1979 On induced spawning of mahseer *Tor putitora* (Hamilton) by mammalian and fish pituitary hormone injection; *Sci. and Cult.* **45** 209–210

Qasim S Z and Qayyum A 1961 Spawning frequencies and breeding seasons of some freshwater fishes with special reference to those occurring in the plains of Northern India; *Indian J. Fish.* **8** 24–43

Sehgal K L, Shukla J P and Shah K L 1971 Observations on fisheries of Kangra valley and adjacent areas with special reference to mahseer and other fishes; *J. Inl. Fish. Soc.* **3** 63–71

Thomas H S 1897 *The Rod in India*, London

Tripathi Y R 1978 Artificial breeding of *Tor putitora*; *J. Inl. Fish. Soc. India* **9** 161