Status of sahar (*Tor putitora*) domestication and its development in the Himalayan Region of Nepal

Ash Kumar Rai

Golden mahseer.

Sahar (*Tor* spp.), a mahseer, is the second largest riverine fish species indigenous to Nepal, after the catfish *Bagarius yerrellii*. It is a well-known food and sport fish in the Himalayan waters, and an inhabitant of the fast flowing large rivers, lakes and reservoirs of Nepal. Sahar is omnivorous. It has high economic value, typically selling for NRs 250-350 per kg (US$ 3.50-4.90) which is 3-5 times higher than cultured carp fish. It can survive water temperatures ranging from 7-38°C. The species is migratory, over long distances, and also occurs in the South Asia region. Sahar is much sought after as a sport fish in India (Kulkarni 1970; Chaturvedi 1976).

The culture technology for sahar has not been commercialized as yet; however artificial propagation techniques have been developed successfully in Nepal following many years of research. Two species of sahar are available in Nepal of which *Tor putitora* is the most common whereas *Tor tor* is rare. The Trishuli River system and lakes of Pokhara valley are notable sources of *T. putitora* (Gurung and Pradhan 1994). Sahar growth is slower in first year and increases from second year onwards. Sahar is a partial breeder and breeds from March to November (Gurung et al. 2001). Brood fish should be maintained properly particularly for breeding purposes to get successful results.

Studies on management, propagation and conservation of sahar were initiated in different countries after the 1970s (Pathani 1981; Shrestha 1997). In the early sixties *Tor* spp. constituted one of the major species of commercial fisheries in the lakes of Pokhara valley (Shrestha and Gurung 1990) but now its catches are negligible (Swar and Gurung 1988; Wagle and Bista 1999).

The deteriorating environmental conditions of the water bodies as well as high fishing pressure using destructive gears such as electro-fishing, poisoning and dynamiting have contributed to this decline (Das and Joshi 1994; Shrestha 1994). Artificial propagation and culture technologies will help to conserve as well as maintain the declining population. They will also help to increase fish production, increase per capita animal fish protein consumption, provide more job opportunities and increase income of the people living in the rural areas as well as increase national fish production.

Distribution

Mahseer is a sport fish (McDonald 1948) that inhibits the mid hills and inner terai (Shrestha 1997), distributed in India, Bangladesh, Pakistan, Sri Lanka, Afghanistan, Burma and Nepal. *T. putitora* is distributed in most trans-Himalayan countries ranging from Afghanistan to Myanmar (McDonald 1948; Day 1958; Desai 1994). *T. putitora* and *T. tor* inhabit torrential waters and mid-hill lakes (Shrestha 1981; 1991) and can attain up to 45 kg in weight (Shrestha 1997) though fishers have recently caught *T. putitora* of 120 kg in the western Modi River. Shrestha (1995) has reported that *T. putitora* is found at an altitude 70-1891 metres.

Domestication

Development of seed production technology of sahar is essential to maintain and enhance its population abundance in natural water resources and to explore the possibility of high value commercial fish farming systems. Visualizing this objective wild brood fish of sahar were collected from the lakes (Phewa and Begnas) and rivers (Tadi River at Gadkhar and Devighat near Trisuli River) and have been reared in earthen ponds for domestication at the Pokhara and Trishuli Fisheries Research Stations, since 1989, with studies into its spawning behavior (FRC 2001). The brood fish were fed 2-3% body weight of a 35% crude protein content pellet made locally. Females spawned on and off in the past but not regularly each year. At the beginning breeding activity was carried out using mature wild brood fish in August-September. But at present the brood fish are domesticated and spawn regularly. The F2 generation is now being used as brood fish, which breed naturally in earthen ponds.

Growth of sahar

Growth of sahar in captivity is less than in nature (Shrestha 1997). Sahar of 1.3 g size reached 29 g within 7 months at 12-21°C in earthen pond at Godawari at an altitude 1800 m (Rai et al. 2001) whilst 0.5 g size reached 90-160 g within 12 months in earthen pond at above 18.5°C at Tarahara at an altitude of 74 m. Transparency in the ponds was maintained around 30cm Secchi depth through fertilization. Supplementary feed was provided at the rate of 2-3% body weight of fish per

day. The dissolved oxygen remained above 7.7 mg/l and pH between 8.0-8.4. The growth of sahar increased substantially from May onwards when water temperature reached above 18.5°C at Tarahara but above 22°C its growth was at Godawari, where water temperature ranged from 12-21°C (Rai et al. 2001). Hatchlings of 18 mg average weight reared in fiberglass pools from September 1992 to July 1993 reached an average of 1541 mg within 10 months and the growth was higher during June and July. The growth rate data of sahar increased with water temperature indicating that it is preferable for sahar to grow in warmer place than in colder place (FRC 1993) and southern terai region of Nepal shows potential to commercially grow sahar in the future.

Feeding habits and supplementary feed for sahar

Gut analysis of sahar showed that it feeds on small fish, insects, molluscs, insect larvae and vegetable matter. Sahar has variously been described as subsisting on vegetable matter (Dubey 1985), a herbi-omnivore (Kausal et al. 1980), carnivorous (Malhotra 1982), intermediate (McDonald 1948), and omnivore that feeds on insects, molluscs, micro-vegetation and algae (Negi 1994). Shrestha (1997) reported that adult sahar feed on gastropods, plant debris and algae whereas fingerlings feed mainly on algae. A study conducted on diet development for sahar showed promising results when fed a mixture of plant and animal protein sources (Bista and Yamada 1996). This study carried out for 210 days based on diets of 30% and 40% protein content; to about 6 g size growth was significantly higher ($P<0.05$) until 90 days when fed with 30% protein content diet, but after 90 days the larger fish growth was reversed and was significantly higher ($P<0.05$) on the 40% protein diet (Table 1). The diets contained 38% protein showed higher growth than the diets of 42% protein (Table 2). However 35% protein content diet showed comparable growth. Also fish growth gave best results when feed contained methionine, and mixing with methionine also allowed feed to be made containing a higher proportion of plant proteins, with equivalent results to using a higher proportion of animal protein in the feed (Bista and Yamada 1996). Samoon (1994) and Juyal (1994) also studied on food conversion efficiency by feeding with commercial fishmeal and supplementary feeding.

Table 1. Feed composition with different protein content diets fed to Sahar.

Ingredients	Crude protein (%)	
	30	40
Soybean	50	30
Shrimp	12	50
Wheat	16	8
Corn	10	5
Oil cake	10	5
Mineral mix.	1	1
Vitamin mix.	1	1
Total	100	100

Source: FRC, Pokhara

Spawning behavior of sahar

Characteristics of brood fish during spawning period: Sahar mainly breeds during the monsoon season. Mature males developed fine tubercles at the end of the snout, on the head, opercula and pelvic fins but not in females (Shrestha 1990; FRC 1993). During the spawning period the male brood fish started to chase females making a loop in the spawning areas, where gravel had been made available.

Spawning: Many authors have reported on the breeding activities of *Tor* spp. (Tripathi 1978; Masuda and Bastola 1984; Shrestha 1994; Kulkarni 1980; Joshi 1994; Chaturavedi 1976; Desai 1993; Gurung et al. 2001). Sahar *T. putitora* spawn is a partial spawner and spawns during March/April in the first cycle and again in August/October as a second cycle of spawning (FRC 1993; 2000). Shrestha et al. (1990) and FRC (1996; 1997) have reported of successfully inducing sahar to spawn using hormone during July to October. *T. putitora* is reported lay eggs in sheltered rock pools three times a year from January to September in Punjab (McDonald 1948). In Nepal, the first breeding attempt was carried out in the 1960s in FRC, Pokhara by stripping matured wild sahar but the regular attempt of its spawning has been underway since 1982. Later on Shrestha et al. (1990), Morimoto et al. (1995), and Baidhya et al. (2000) have reported the successful spawning of *T. putitora* using different methods. In the beginning mature wild brood fish were collected from the lakes Phewa and Begnas and spawned during August to October while fish from the Trisuli and Tadi rivers spawned during upward migration in March to May, the first spawning period (FRC 2001). Eggs were fertilized using milt taken from males in the field and brought into the station for incubation. Later brood fish were raised in earthen ponds where they were fed with artificial feed and used for hormone-induced spawning (LRH-A, pituitary gland and ovaprime). Shrestha et al. (1990) reported the successful spawning of hormone induced sahar reared in captivity with supplementary feeding. Sahar raised fed with artificial feed in cages and spawned artificially by stripping eggs at water temperatures between 25-28°C after injection of pituitary hormone extracted from common carp (Table 3).

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Table 2. Feed composition fed to Sahar and compared their growth rates.

Ingredients	Crude protein (CP) composition (%)		
	35	38	42
Fish meal		55	27.5
Shrimp meal	20	10	10
Wheat flour	12	15	10
Corn flour	10	5	13.5
Soybean cake	35	6	30
Cod liver oil		5	5
Rice bran	12		
Oil cake	9		
Vitamin mix	1	2	2
Mineral mix	1	2	2
Total	100	100	100

Source: FRC Pokhara

Status of sahar domestication

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Breeding was carried out continuously but achieved success partially at FRC Trisuli (FRC 1996; 1998/'99). However since 2000, F2 sahar have been spawning naturally without use of hormonal injections and without post-spawning mortality. Male sahar mature after 2 years and release milt year round but females reach maturity after 3-5 years cultured in earthen ponds feeding with 30-40% protein content diet. Based on few years data compilation on breeding activities of *T. putitora*, it can spawn up to nine months per year from March to November without using hormonal injection at preferable water temperature between 19.5-33.0°C (Gurung et al. 2001), whereas Chaturavedi (1976) has reported that a water temperature between 21.5-23.5°C is preferable with more than 9.5 mg/l of dissolved oxygen for sahar spawning. McDonald (1948) reported that mahseer spawn three times in a season, Desai (1994) noted mahseer breed from July to March and Pathani (1983) reported sahar spawn at least four times based on four types developmental stages of eggs. Mahseer is a partial spawning and release low number of eggs during single spawning event explained by many authors (Joshi 1994; Shrestha 1997; Shrestha et al. 1990), however it needs to examined more frequently to avoid over maturation of eggs. Shrestha et al. (1990) also stripped sahar three times but the third time obtained very few eggs and a very low fertilization rate, suggesting that the first spawning is best and the number of eggs and fertilization rate declines thereafter (Table 3).

Fertilization and incubation: The stripped eggs are fertilized using milt taken from the male immediately by dry method. The fertilized eggs washed in 1% salt solution for disinfection and then washed 3-4 times with fresh water. The fertilized swollen eggs, after hardening, ARE poured on screen-trays (33 cm × 33 cm size) for incubation and loaded trays are tied tightly in a stack and placed in a glass-fiber Atkin's incubation apparatus for incubation, supplying spring water regularly at the rate of 1.5-2 l/minute. The water temperature and dissolved oxygen recorded were 20-22°C and 4-5 mg/l, respectively and hatch within 90-125 hours (Table 4). The hatching time is dependent on the water temperature (Shrestha et al. 1990; FRC 1998/'99; Baidhya et al. 2000; FRC 2001). It takes about 48-72 hours to hatch at 26.5-31.0°C (FRC 1994; 1995). F2 generation sahar broods are successfully bred from March to November at water temperature ranging from 19.0-30.0°C (Gurung et al. 2001). However, frequent brood fish checking is necessary preferably biweekly to avoid over-ripening.

Nursing and rearing: The yolk sac is absorbed within 3-4 days after hatching and then the larvae need natural food or special artificial feed. Rotifer is an excellent natural food for many marine and fresh water fish larvae (Fontain and Revera 1980).

Importance and prospect of sahar culture industry: Sahar is very important native riverine sport fish. The development of its breeding technology leads a very positive development with the mass production of fingerlings, which can be stocked in the natural water bodies to maintain or increase its population as well as to support aquaculture industry. Sahar is very popular and has a very high demand and sells for a higher price than other cultured carp species. The study has shown that sahar culture is suitable in warmer areas particularly in southern part of Nepal, though the mid-hill region is suitable a breeding area and for egg development with its cool temperatures.

Trans-Himalayan cold water fish hatchery: Among the trans-Himalayan fish, sahar (*Tor* spp.), Katle (*Neolissocheilus hexagonolepis*) and asla (*Schizothorax* spp. and *Schizothoraichthys* spp.) are very important and economically high value fish, which are under study at FRCs, Trishuli and Pokhara. These economically high value fish species have high demand in the whole South Asia region. Successful spawning of these species in captive condition has been achieved although it needs further more detail studies to standardize the technique. There are other economically high value indigenous fish species, which also deserve study and to develop technology for culture practices. In order to carry out studies and develop technology, facilities and human resources and the required infrastructure development are essential. The basic facilities for trans-Himalayan fish spawning have

Table 3. Sahar (*Tor putitora*) fed with artificial feed and spawned using pituitary gland.

Brood fish				Pituitary gland injection time		
Male (kg)	Female (kg)	Feed fed for brood fish		1600 hrs	2200 hrs	1000 hrs
		Ingredients	Composition (%)			
0.8	1.8	Rice bran	40			
0.6	2.0	Wheat flour	20			
		Corn flour	20			
		Oil cake	20			
Female (kg)						
1.8				1.08 mg (10%)	8.64 mg (80%)	1.08 mg (10%)
2.0				1.20 mg (10%)	9.60 mg (80%)	1.20 mg (10%)
Male (kg)						
0.8					4.80 mg (100%)	
0.60					3.40 mg (100%)	
Date	Time	Stripping	Released eggs (no.)	Fertilized (no.)	Survival (%)	
2/8/1988	17:00	1st	4,500	4,479	99.5	
3/8/1988	10:30	2nd	2,000	1,945	97.3	
3/8/1988	16:00	3rd	100	30	30	

Source: Shrestha et al. 1990

Table 4. Breeding record of Sahar (*Tor putitora*).

Description	2000		2001	
	21 April	22 April	12 March	3 April
Water temp. (°C)	22.0	22.0	20	21
No. of Female	3	2	1	1
Average female weight (kg)	7.5	6.6	3.4	2.2
Average. total length (cm)	80.0	75.0	74	69
No. of male	3	1	2	2
Average male weight (kg)	7.5	6.0	4.0	5.5
Time of stripping	10:00	16:00	10:30	10:45
Total weight of eggs (g)	950	550	62	82
Total no. of eggs	88350	50600	3348	13202
Egg size (mm)	2.7	2.4	2.9	2.0
Dissolved oxygen (mg/L)	4 -5	4 -5	4-5	4-5
Fertility (%)	93-96	90-95	85	80
Incubation period (hours)	90-115	90-110	120-125	120-125
Total no. of hatchlings	57143	36836	2,500	8,800
Mean hatchibility (%)	>90	>80	73.9	66.6
Size of hatchlings (mm)	7.0 -8.0	7.0 -8.0	7-8	7-8

been well developed at the Pokhara and Trishuli Fisheries Research Centres and the fish hatchery at Kaligandaki, which serve the lakes/reservoirs in Pokhara and for rivers in Trisuli and Kaligadaki, respectively.

Among the trans-Himalayan fish species, sahar, katle and asla have been domesticated and are maintained with parental stock up to the F2 generation, which are very convenient for breeding. Therefore FRC Pokhara has the potential to be developed as a Trans-Himalayan Cold Water Fish Hatchery Centre in for the South-Asian region. The center will aim to study of trans-Himalayan cold water fish species on a regional basis with the coordination and exchange and maximum involvement of different specialists in different subjects of the region and to develop a complete technology package to enhance the culture industry in suitable places, particularly in mid-hill region, and to provide job opportunities as well as to increase the economic status in that region. The program will support and conserve the diminishing stocks of economically high value trans-Himalayan fish species.

Conclusion

Sahar is a very important sport and high value riverine native fish species, which is highly preferred in the market. To increase its yield and conserve the declining population in natural environment, breeding techniques should be standardized for mass seed production as well as should develop proper artificial feed for different stages. Breeding studies have been carried out regularly for a decade but there is still need to standardize the technique for mass seed production due to its complex or partial spawning pattern.

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