

Delivered Dr C.V. Kulkarni lecture on 'The Deccan mahseer – biology, breeding and conservation' at Seminar on 'Aquaculture and Mahseer Biodiversity Conservation' at CIFE, Mumbai, on 11.8.2011. The Seminar was held to commemorate Centenary Birth Celebrations of Dr C.V. Kulkarni.

The Deccan mahseer – Biology, Breeding, Culture and Conservation

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INTRODUCTION

India is blessed with some of the world's best game fishes like mahseers. Mahseers are regarded as a sacred fish (God's fish) by the Hindus. They had attracted the attention of the best anglers and naturalists from several parts of the world. The mahseers are known as an excellent sport fish/game fish that provide unparalleled recreation to anglers better than trout and salmon (the well known sport fish in northern America and Europe) and also help promote eco-tourism. The mahseers are considered 'The tiger or the king of freshwaters/rivers'. Early anglers in India considered mahseers better than hunting for the tiger. Jim Carbett called it 'a sport fit for kings'. Of the seven important species of mahseer belonging to the genus *Tor* in India, *Tor khudree* is the most important species available in streams and rivers that originate in the Western Ghats of the Peninsular India and is known to grow to 120-150 cm (40-50 kg). Over the years, the natural stocks of *T. khudree* have depleted due to anthropogenic activities. They too are a good food fish. Their presence indicate the health of rivers (mahseers inhabit only the upper stretches which are cool, clear, clean and well-oxygenated).

To conserve mahseer and develop sport fishing in India, the Government of India has been promoting the establishment of hatcheries. Investigations carried out by Tata Power Companies Limited (TPCL) at Lonavla, Maharashtra State, revealed the possibility of artificial propagation of mahseer (Kulkarni, 1971). This has helped establish mahseer hatchery in different States.

BIOLOGY

Species of mahseers

Of the 45 species of mahseer belonging to the genus *Tor*, Tor mahseer (*Tor tor*) (Near threatened), golden mahseer (*T. putitora*) (EN), Deccan mahseer (*T. khudree*)(EN-2011; IUCN Red List), Humpback mahseer (*T. mussullah*), mosal mahseer (*T. mosal*), *T. neilli*, *T. progenius*, *T. remadevi*, *T. kulkarni*, chocolate mahseer (*Neolissocheilus hexagonolepis*) and *N. wynadensis* have received greater attention.

Distribution of *T. khudree* (Deccan mahseer)

T. khudree is distributed in the major rivers and reservoirs of Central and Peninsular India (Madhya Pradesh, Maharashtra, Karnataka, Tamil Nadu and Kerala) as well as Sri Lanka (Fig. 1). The Deccan mahseer inhabit fast-flowing waters with a temperature range of 10-20°C (optimum), but *T. khudree* can thrive and

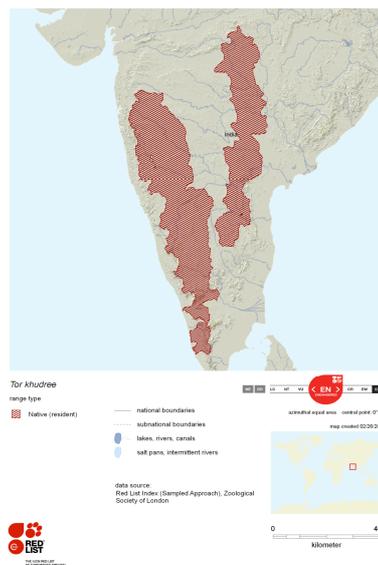


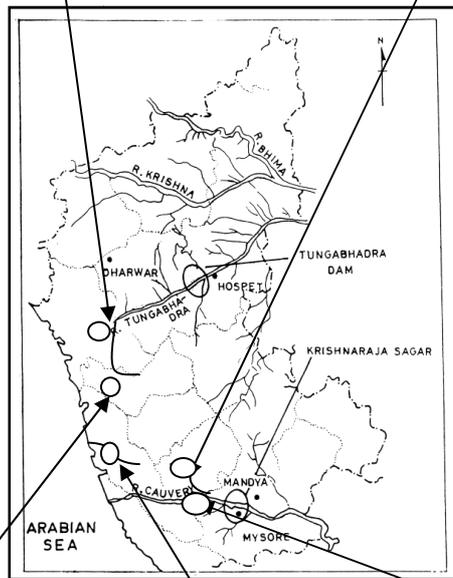
Figure 1 : Map showing the distribution of Deccan mahseers in India



Hariharapura (Tunga river)



Harangi (Harangi river)



Sringeri (Tunga river)



Sishila (Nethravathi river)



Ramanathapura (Cauvery river)

Figure 2 : Map showing the distribution of Deccan mahseers in Karnataka

and grow well in the plains and coastal regions at temperature ranging between 20 and 32°C. Both *T. khudree* and *T. mussullah* inhabit the Cauvery and its tributaries; reach 120-150 cm and 45-60 kg, with the former being more common than the latter. *T. khudree* is also known to occur in Tungabhadra, Kali, Sharavathi, Aghanashini, Varahi, Bedthi, Nethravathi, Seetha and Kumaradhara rivers, in Karnataka. The Cauvery is the home of hefty large mahseers.



Figure 3 : Deccan mahseer, *Tor khudree*



Figure 4 : Humpback mahseer, *Tor mussullah*

Identification of Deccan mahseers

1. **Deccan mahseer, *Tor khudree* (Sykes)** : The head length is almost equal to the depth of the body, 24-27 scales along the lateral line. Fins are bluish-grey. Maximum length : 144.7 cm (Fig. 3).

2. **Humpback or high-backed mahseer, *Tor mussullah* (Sykes)** : The head length is much shorter than the depth of the body (a short hump present on the back), 26-27 scales along the lateral line. Fins are reddish-grey. Maximum length : 150 cm (Fig. 4).

Although Menon (1992), based on detailed investigations concluded that *T. khudree* is same as *T. mussullah*, Jayaram (1997), after critically analyzing the systematic status of both *T. khudree* and *T. mussullah*, clearly stated that both are distinct species.

Maximum size recorded

Currently two species of mahseer, i.e. *T. khudree* and *T. mussullah* are found in Kodagu District of Karnataka. Recently a specimen of *T. mussullah* with a weight of 130 lb and a length of 4 ft , 7” was recorded at Dubare (on the Cauvery), which the International Game Fish Association (IGFA) has officially accepted as a new world record (the fish was caught by Mr Sudip Ghatak and certified by Mr Shyam Aiyappa).

BIOLOGY

Food and feeding : Mahseers are omnivorous, feeding not only on algae, small crustaceans, insects, aquatic weeds and their seeds, but also fruits that fall from trees overhead. They also accept artificial pelleted feed very well. Rice grains, puffed rice, groundnut, etc. offered by devotees at temple pools are also accepted as feed. Their voracious feeding habit attracts a large number of tourists at temple pools.

Breeding season and location : Although the exact location of the breeding grounds of Deccan mahseers is not known, they are reported to breed in flowing waters with pebbly bottom of the upper stretches, during monsoon months. In the Cauvery, they are known to spawn during July-October. *T. khudree* has been found to spawn in the river Harangi, just below the Harangi reservoir, during September (Kangku and Basavaraja, 2007). Fishermen catch brooders during their upstream migration using a special-type of bag net which is operated across the waterfall. The mahseers are batch spawners, releasing eggs in batches over a prolonged period. They do not spawn naturally in captive ponds and tanks. However, they spawn naturally in running waters with a specific combination of temperature, pH, velocity, turbidity and rains which collectively induce the fish to spawn (Dobriyal et al., 2000).

Reproductive traits

Age at 1st maturity : Male : 2+ yrs (captive : 1½ yrs., weight : 25-40 g)

Female : 3+ yrs., 282 - 900g (captive)

Fecundity : 7,500 – 17,500 per female

Fry availability : Crevices of stones and boulders found on river bed

Egg size : 2.8-3.2 mm; yolky eggs with little perivitelline space; colour : bright orange

BREEDING OF *T. KHUDREE*

A breakthrough in the artificial fertilization of *T. khudree* eggs was achieved in 1971 by Dr C. V. Kulkarni who helped establish the first mahseer hatchery in India at TPCL (Kulkarni, 1971). This paved the way for large-scale fry production and hence he is known as “The Father of Breeding of Mahseers” . Tripathi (1978), Joshi (1984) and Joshi et al. (2002) successfully hand-stripped domesticated or wild brood fish, without injecting hormones, while Nandeeshha et al. (1993), Keshavanath et al. (2006) and Kangku and Basavaraja (2010) hand-stripped and fertilized eggs of pond-reared *T. khudree* following injection of synthetic hormones or pituitary extract. Apart from hybridization of *T. khudree* and *T. tor*, the successful transportation of fertilized eggs of mahseer by air in moist cotton wool, without water was accomplished (Kulkarni, 1984).

Nandeeshha et al. (1993) were the first to achieve success in stripping and fertilizing eggs of pond-raised *T. khudree*. The TPCO has supplied nearly 0.8 million mahseer fingerlings (as on 1994) to different States of India and also to other countries where the fry are reared to fingerling stage and then stocked in natural water bodies to enhance mahseer stocks (Ogale, 2000). In addition, approximately 0.2 million mahseer fingerlings are released annually in the reservoirs owned by TPCO and the mahseer population therein has increased substantially (Kulkarni and Ogale, 1995). The second mahseer hatchery was established at Harangi Fish Farm in Kodagu District of Karnataka, southern India, with a capacity of 1.0 million fry per year, in 1992. So far the hatchery has been able to produce only a few thousand fry of *T. khudree* and the same has been released in selected stretches of the river Cauvery (Nandeeshha et al., 1993; Ogale, 2002).

Breeding of pond-raised *T. khudree* in Karnataka

Brood-stock management : For inducing spawning in pond-reared *T. khudree*, maturing adults (3-5 years) are separated sex-wise in May and stocked in 400m² rectangular ponds with a soil base of about 20 cm. Extruded floating feed or a feed comprising of groundnut oil cake (25%), fish meal (25%), rice bran

(25%) and rice flour (25%) is fed to brood fish at 2-3% body weight daily to enhance maturity. The ponds are manured once a month with cow dung (2000-3000 kg/ha) and partial water exchange is done every 15 days. The fish is periodically checked for somatic and gonadal growth. The spawning season for *T. khudree* is September - October.

Injection of brooders: Commercially available synthetic hormones, viz. ovaprim (Syndel Laboratories Canada; sGnRH-a + domperidone) and ova tide (Hemmo Pharma, Mumbai; mLHRH-a + domperidone) are effective in inducing spawning in the Deccan mahseer. The sex is identified based on the morphological characters wherein the ripe female has a soft and swollen abdomen, while the male readily oozes out milt with gentle pressure on abdomen. Only single dose of the hormone administered intramuscularly to both male (0.2-0.3 ml/kg body weight) and female (0.6 ml/kg body weight) is sufficient. The brooders are anaesthetized with quinaldine at 10 ppm for 1-2 minutes. The injected females and males are held separately in nylon hapas with flowing water. The females are periodically checked for their readiness for stripping.

Stripping and fertilization: The injected females are examined every 6-12 hours following injection and the stripping operations are undertaken after the females ovulate. This process is repeated several times till all the ovulated eggs are removed. Males are also stripped in the same manner such that milt of one or two males is sufficient to fertilize each batch of eggs. The motility of spermatozoa is checked prior to fertilization.

Egg incubation and hatching: The eggs are incubated either in rectangular wooden hatching trays (150 cm x 20 cm x 10 cm) with wire mesh at the bottom, with running water or in conico-cylindrical fiberglass tanks (80 l) with aeration (vortex blower). The hatching period varied from 70 to 112 hours depending on temperature. After the yolk-sac absorption, the fry is fed with egg yolk or sieved plankton.



Mahseer brooder being injected

Eggs being stripped

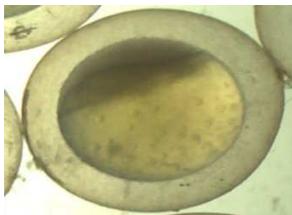
Fry rearing : Fry rearing is carried out in earthen ponds after ensuring sufficient plankton. The stocking density of fry is 0.1 million/hectare. The fry are fed with a feed consisting of fishmeal (25%), ground nut oil cake (25%), ragi flour (25%) and chicken egg yolk (25%).

Egg and embryonic development

Egg and embryonic stage

Hours after fertilization

	<u>At 20-22°C</u>	<u>At 26-28°C</u>
1. Blastodisc formation	2	-
2. Morula stage	5	4-5
3. Blastula stage	13	10
4. Gastrula stage	18	-
5. Yolk-plug stage	27	22
6. Embryo indication	37	-
7. Pea-shaped embryo	48	-
8. Twitching movement	55	33-34
9. Moderate twitching	63	55
10. Vigorous twitching	70	62
11. Hatching started	80	63
12. Hatching completed	112	70



Blastula (6 haf)



Advanced embryo just before hatching (41 haf)



Newly hatched yolk-sac fry

Mahseer hatcheries

The hatchery production of Deccan mahseer (*T. khudree*) is carried out in the State of Maharashtra at TPCL, Lonavla; at Harangi Fish Farm in Kodagu District of Karnataka (with a capacity of 1.0 million seed per year), at Malampuzha in Kerala and at Salaiyar Dam in Coimbatore District of Tamil Nadu.

CULTURE

Culture of *T. khudree* in cages (HDPE) at Walwan Lake, Lonavla was undertaken wherein they attained 174-359g after 370 days with survival rates of 35-57%. It showed an impressive growth of 600-900 g after 1 year in village ponds near Lonavla. Hatchery produced fingerlings reached 96 against 49.16 g of wild fingerlings with survival rates of 98 and 95%, respectively, after 120 days culture (Basavaraja et al., 2002).

With mahseer fry production technology standardized, efforts are now being made to develop grow-out techniques for them. One major problem is their relatively slow growth rate (Sehgal, 1999). Bista *et al.* (2002) observed low water temperatures to be the reason for the slow growth of fingerlings of *T. putitora* wherein they recorded weights of 19-23g in 210 days and 44g in 6 months. In Nepal, pond-reared *T. putitora* is known to grow from 0.5g to 90-160g in 12 months. In India, the pond-reared mahseer attained 175g in 12 months (Ogale, 2002), while in Malaysia cage reared *T. tambroides* was found to reach mean weights of 142-179g (maximum 270g) in 60 weeks (Ingram *et al.*, 2006).

In view of the growing interest in the commercial culture of mahseers in the Asian regions, studies on nutritional aspects of *T. khudree* and other mahseer species have been carried out by many workers (Bazaz and Keshavanath, 1993; Shrestha, 1997; Islam, 2002). Bazaz and Keshavanath (1993) reported weight gains of 19.37-25.65g when *T. khudree* was fed with four different feeds containing 37.12-39.8% protein. Raina *et al.* (1999) grew *T. putitora* in manured ponds for one year with artificial feed and obtained a survival rate of 55%. Islam and Tanaka (2004) concluded that *T. putitora* is a highly promising indigenous species for commercial aquaculture and the fish performs well if proper dietary conditions are met. Kohli *et al.* (2006) reported survival rates of 89.7, 88.9 and 46.3%, at 100, 50 and 25 fry/m³, respectively, in cages fixed in open waters.

CONSERVATION

The Western Ghats is an important biodiversity hot spot in the world, covering Kerala, Tamil Nadu and Karnataka (in particular), with several endemic fish species. Even though the *Tor* species once contributed significantly to natural stocks, their populations have dwindled to such an extent that they have been categorized as critically endangered species. Because of the decline in their fishery, all the seven species of mahseer have been listed as endangered by the Zoological Survey of India. The mahseer fishery of the river Cauvery has declined considerably over the years and the individual weight of fish caught has also decreased as a result of environmental degradation. Man-made environmental changes like construction of dams and weirs, pollution (chiefly industrial and agricultural) of rivers, destructive fishing methods like dynamiting, electrocution, poisoning, catching of brooders during their breeding migration, habitat change leading to oxygen depletion during summer, etc. are the major causes of such a decline. Several *in situ* and *ex situ* conservation strategies have been suggested to revive their stocks. The natural stocks of mahseers, in general and Deccan mahseer, in particular, have declined over the years. The main causes are : anthropogenic activities. Hence, there is a need to conserve and propagate them.

Types of conservation

There are two types of conservation. They are: *In situ* conservation and *Ex situ* conservation.

***In situ* conservation** : It involves protecting them in their natural habitat, e.g. Sanctuaries, Temple pools, etc. In view of the a decline in the natural stocks of mahseers in certain locations of Karnataka, several stretches of streams and rivers have been declared as sanctuaries, including temple pools. The Bhimeswari Camp on the river Cauvery in Karnataka continues to attract domestic as well as foreign anglers. Similarly, the Dubare sanctuary in Kodagu District attracts a lot of anglers and nature lovers. The anglers obtain licenses for angling from the Wildlife Association of South India (WASI), which manages the mahseer sanctuary, catch mahseer with hook and rod and record their weight, length, photograph/video record the majestic mahseers, before releasing them back into the river. Other mahseer sanctuaries at the temple pools of Ramanathapura, Sringeri, Thodikana. Thingale, Shishila, etc. are attracting a number of tourists and conservationists. The deep pools around Galibore, Bhimeswari and Doddamakkali have depths of 5-15 m, widths of 250 to 300 m and lengths up to 300-400 m even in summer offer excellent refuge even for larger mahseers of 30-40 kg. Certain areas are declared as sanctuary and poaching is almost negligible due to strict vigilance. Ironically, a few poachers in the stretch have been given an alternate vocation of performing the duty of a patrolling the stretch. In certain rivers stretches where temple pools are located, the devotees, temple trusts and people themselves are involved in protecting the fish from poachers as the mahseers are considered *Devarameenu* (God's fish).



Temple pool (*Pushkarni*) is one important way of *in situ* conservation of mahseers in Karnataka

***Ex situ* conservation**

Ex situ conservation involves protecting the natural stocks outside their natural habitat, e.g. producing seed in hatcheries and ranching in streams and rivers, gamete preservation, etc. The Department of Fisheries, Government of Karnataka, launched a programme in 1987 on 'Rehabilitation and development of mahseer fishery in the rivers and reservoirs of Western Ghats. A mahseer hatchery was established to produce 0.5 million fry for ranching in the State. Subsequently, hatchery produced *T. khudree* fingerlings in selected natural water bodies for conservation and promoting sport fishing.



Mahseer hatchery established at Harangi, Kodagu District



Ranching hatchery-produced fingerlings in natural water bodies is also another way of conservation of threatened species

Rajeev et al. (2011) reported that the exploitation rate was higher than the expected optimal level at all, but one fishing site, revealing that *T. khudree* populations are overfished in the Western Ghat study region. Further, a comparison of the exploitation rate at various fishing sites revealed no significant differences between commercial and subsistence harvest, as well as inside and outside protected areas. In spite of its endangered status, *T. khudree* receives no protection even in Biodiversity Hotspots like the Western Ghats, and its fishery is under threat of an imminent collapse (Rajeev et al., (2011).

Cryopreservation of *T. khudree* spermatozoa

A simple and practical protocol for the cryopreservation of *T. khudree* spermatozoa has been developed (Basavaraja and Hegde, 2004; Basavaraja et al., 2002;2006). When spermatozoa were preserved for more than 2 years (780 days) in LN₂, the motility percentage (40.0-42.5%), fertilization rate (98.01-98.13), hatch rate (37.26-42.01%) and fry survival (41.48-44.51%) were comparable with that of fresh spermatozoa. Growth and survival of fingerlings produced from 70-day-old cryopreserved and fresh spermatozoa were monitored over a period of one year. The fish attained a size of 38.24 g (15.28 cm) and 39.15 g (15.32 cm) in experimental and control groups. The spermatozoa cryopreserved up to 2 years have shown up to 50% motility.



Frozen spermatozoa samples being stored in LN₂

Species characterization

There is a lot of taxonomic overlapping among the different species of mahseers and the same is being investigated into by several scientists. The species characterization using DNA markers is being carried out in India and Malaysia. The genetic relatedness between five species of mahseers (*Tor tor*, *T. putitora*, *T. khudree*, *T. mosal mahanadicus* and *Neolissocheilus hexagonolepis*), examined by RAPD analysis, revealed that *T. khudree* is a distinct species (Vindhya et al., 2007).

Eco-tourism

The concept of eco-tourism in India is fast picking up. It implies travelling to undisturbed and uncontaminated natural areas with specific objective of studying, admiring and enjoying the scenery and the wild life. In Karnataka also, this is being blended with mahseer fishing in the hilly areas to attract local as well as foreign anglers and tourists. Eco-tourism generates a lot of revenue, creates much needed awareness of the importance of conservation and helps provide incentives to local people. WASI and Coorg Wildlife Society are actively involved in promoting eco-tourism and conservation of mahseers.

Strategies for the conservation of Deccan mahseers

- There is a need for regulatory measures to control exploitation of mahseers in their natural habitats other than the sanctuaries/temple pools.
- In order to create awareness on the importance of mahseers and angling
- Care should be taken to ensure the availability of sufficient water and also oxygen in temple pools during the summer months.
- Prevention of pollution in rivers.
- Banning of destructive fishing methods like dynamiting, electrocution, poisoning, etc.
- Delegate powers to local police to take stringent action in this regard.
- Ranching of selected stretches of rivers with hatchery produced fingerlings.
- Up gradation of the mahseer hatchery at Harangi to commercial scale production of fry.
- Control of poaching of mahseers, particularly the brooders.
- Set up a separate regulatory authority to prevent pollution of water bodies.
- Provide 'watch and ward' and boat to Temple authorities/Maths involved in their conservation.

Conclusion

The foregoing account reveals that the Deccan mahseers, in Karnataka in particular, are increasingly becoming threatened due to anthropogenic activities. Establishing hatchery, ranching hatchery-produced seed in natural water bodies and *in situ* conservation strategies have been found to help revive the mahseer stocks, to some extent, in Karnataka. To arrest the further decline in their stocks and to conserve the remaining fauna (whatever little is left) and rehabilitate them, more concerted efforts are needed by the government, NGOs, local communities, etc. If not, the precious germplasm may be lost forever from our waters.

REFERENCES

- Basavaraja, N., Hegde, S.N., 2004. Cryopreservation of the endangered mahseer (*Tor khudree*) spermatozoa: I. Effect of extender composition, cryoprotectants, dilution ratio and storage period on post-thaw viability. *Cryobiol.*, 49 : 149-156.
- Basavaraja, N., Hegde, S.N., Akash, N., 2002. The fertility of cryopreserved Deccan mahseer, *Tor khudree* spermatozoa. *Asian Fish. Sci.*, 15 :193-202.
- Basavaraja, N., Hegde, S.N., Palaksha, K. J., 2006. Cryopreservation of the endangered mahseer (*Tor khudree*) spermatozoa : Effect of Me₂SO, freezing, activating media and cryostorage on post-thaw spermatozoa motility and fertility. *Cell Pres. Technol.*, 4(1) : 31-47.
- Bazaz, M.M., Keshavanath, P., 1993. Effect of feeding different levels of sardine oil on growth, muscle composition and digestive enzyme activities of mahseer, *Tor khudree*. *Aquaculture*, 115: 111-119.
- Bista, J.D., B. R. Pradhan, B.R., Shrestha, R.K., Gurung, T.B., 2002. Nutrition, feed and feeding of golden mahseer (*Tor putitora*) for domestication and production in Nepal. *FAO Fish. Tech. Pap.*, 431: 107-117.
- Dobriyal, A.K., Kumar, N., Bahuguna, A.K. and Singh, H.R., 2000. Breeding ecology of some cold water minor carps from Garhwal Himalayas. In : Coldwater Fish and Fisheries: 177-186 (eds. H.R. Singh and W.S. Lakra). Narendra Publishing House, New Delhi. 337 p.
- Ingram, B., Sungan. S., Gooley, G., Sim, S. Y., Tinggi, D., De Silva, S. S., 2005. Induced breeding, larval development and rearing of two indigenous Malaysian mahseer, *Tor tambroides* and *T. douronensis*. *Aquacult. Res.*, 36 : 1001-1014.
- Islam, M.S., 2002. Evaluation of supplementary feeds for semi intensive pond culture of mahseer, *Tor putitora* Hamilton. *Aquaculture*, 212: 263-276.
- Islam, M.S., Tanaka, M., 2004. Optimization of dietary protein requirement for pond-reared mahseer *Tor putitora* Hamilton (Cypriniformes: Cyprinidae). *Aquacult.Res.*, 35: 1270- 1276.

- Jayaram, K.C., 1997. Nomenclature and systematic status of *Barbus mussullah* (Sykes, 1839). *J. Bombay Nat. Hist. Soc.*, 94(1): 48-55.
- Joshi, C. B., 1984. Artificial breeding of golden mahseer. *J. Inland. Fish. Soc. India*, 13(1) : 74-76.
- Joshi, P. L., Gurung, T. B., Basnet, S. R., Nepal, A. P., 2002. Domestication of wild golden mahseer (*Tor putitora*) and hatchery operation. *FAO Fish. Tech. Pap.*, 431 : 173-178.
- Kangku, O.N.S. and Basavaraja, N. 2007. Deccan mahseer (*Tor khudree*) – On the location of the wild brooders and fry, a breakthrough in the hatchery production of its seed. *Fishing Chimes*, 26(10): 32-36.
- Kangku Oliver N. Sangma, Basavaraja, N., 2010. Induced breeding, embryology and rearing of fry of Deccan mahseer, *Tor khudree* (Sykes). *J. Aquacult. Trop.*, 25(1) : 13-24.
- Keshavanath, P., Gangadhar, B., Basavaraja, N., Nandeesh, M.C., 2006. Artificial induction of ovulation in pond-raised mahseer, *Tor khudree* using carp pituitary and ovaprim. *Asian Fish. Sci.*, 19: 411-422.
- Kohli, M.P.S., Langer, R.K., Ogale, S.N., Dube, K., Prakas, C., 2006. Cage culture of Deccan mahseer *Tor khudree* in Walwan reservoir, Maharashtra, India. In: *International Symposium on Mahseer (Mahseer 2006)*. Malaysian Fisheries Society, Kuala Lumpur, Malaysia (abstract).
- Kulkarni, C.V., 1971. Spawning habits, eggs and early development of Deccan Mahseer *Tor khudree* (Sykes). *J. Bombay Nat. Hist. Soc.*, 67 (3): 510-521.
- Kulkarni, C.V., 1984. Air transport of Mahseer (Pisces) eggs in moist cotton wool. *Aquaculture*, 16: 367-
- Kulkarni, C.V., Ogale, S.N., 1995. Conservation of mighty Mahseer. The Tata Power Company Ltd., Bombay House, Bombay: 39 p.
- Menon, A.G.K., 1992. Taxonomy of mahseer fishes of the genus *Tor* with description of a new species from the Deccan. *J. Bombay Nat. Hist. Soc.*, 89 (2): 210-228.

- Nandeesh, M. C., Bhadraswamy, G., Patil, J.G., Varghese, T.J., Sarma, K., Keshavanath, P., 1993. Preliminary results on induced spawning of pond-raised mahseer, *Tor khudree*. *J. Aqua.Trop.*, **8**: 55-60.
- Nandeesh, M. C., Rao, K. G., Jayanna, R., Parker, N. C., Varghese, T. J., Keshavanath, P., Shetty, H. P.C., 1990. Induced spawning of Indian major carps through single application of ovaprim-C. In: R. Hirano and I. Hanyu (eds). The Second Asian Fisheries Forum Proceedings, Asian Fisheries Society, Manila, Philippines. p. 581-585.
- Ogale, S N., Kulkarni, C.V., 1987. Breeding of pond raised hybrids of Mahseer fish *Tor khudree* (Sykes) and *Tor tor* (Ham.). *J. Bombay Nat. Hist. Soc.* 84(2): 332-335.
- Ogale, S. N., 2000. Mahseer hatchery: planning and management. *Fishing Chimes* 19(10& 11) : 69-77.
- Ogale, S.N., 2002. Mahseer breeding and conservation and possibilities of commercial culture. The Indian Experience. *FAO Fish. Tech. Pap.*, 431 : 193-212.
- Ogale, S N., Kulkarni, C.V., 1987. Breeding of pond raised hybrids of Mahseer fish *Tor khudree* (Sykes) and *Tor tor* (Ham.). *J. Bombay Nat. Hist. Soc.*, 84(2): 332-335.
- Raina, H.S., S. Sunder, S., Joshi, C.B., Mohan, M., 1999. Himalayan Mahseer. Bulletin-1, National Research Centre on Coldwater Fisheries, Bhimtal, Uttar Pradesh, India. 29 p.
- Rajeev R., Ali, A., Neelesh, D., Alison, R., 2011. Is the Deccan mahseer, *Tor khudree* (Sykes, 1839) (Pisces: Cyprinidae) fishery in the Western Ghats Hotspot sustainable? A participatory approach to stock assessment. *Fish. Res.*, 110 : 29-38.
- Sehgal, K. L., 1999. Coldwater fish and fisheries of the Indian Himalayas : culture. *FAO Fish. Tech. Pap.*, 385 : 89-102.
- Shrestha, T.K. 1997. Prospects of propagating the Mahseer in PhewaLake of the Pokhara Valley. *The Mahseer*, 70-71.
- Tripathi, Y.R., 1978. Artificial breeding of *Tor putitora* (Ham.) . *J. Inland Fish. Soc. India*, 9 : 161.

Vindya, M., Praveen, K., Kuldeep, K.L., Peyush, P., Rajeev, K.S., Anindya, S.B., Lakra, W.S., 2007.
Molecular discrimination of five mahseer species from Indian peninsula using RAPD analysis.
Acta Zoologica Sinica, 53 (4) : 725-732.