Biology of Mahanadi Mahseer, *Tor Mosal Mahanadicus* (David) Reared in Freshwater Pond Culture System

B.C. MOHAPATRA*, S.K. SAHOO, S. DAS GUPTA and S.D. GUPTA

ICAR- Central Institute of Freshwater Aquaculture, Kausalyaganga, Bhubaneswar-751002, Odisha, India.

**Abstract**
This paper is about the study on biology of Mahanadi Mahseer, *Tor mosal mahanadicus* (David) reared with Indian Major Carps (IMC) in Freshwater Pond Culture System conducted at ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar. The study focused on biological parameters, i.e., food and feeding habits; maturity; and length and weight relationship of Mahanadi mahseer, *Tor mosal mahanadicus*, a fish species under endangered group reared with IMCs such as *Catla catla* (Catla), *Labeo rohita* (Rohu) and *Cirrhinus mrigala* (Mrigal) in pond culture system. The fish was found to be omnivore and benthic feeder, and was acclimatized to pond culture condition and reared with supplementary feed such as rice bran and ground nut oil cake. In two years of pond rearing, male fish attained maturity and milting was recorded at an average size of 228 ± 11.36 mm length and 110 ± 6.61 g weight. Female fish attained early vitellogenic stage having primary vitellogenic oocytes in their ovaries at an average fish size of 287 ± 31.0 mm length and 224 ± 15.6 g weight. Length weight relationship of the fish in pond culture system reared from fry stage to adults was $W= 0.0001339 L^{2.4301}$ or log $W = -3.8733 + 2.4301 \log L$ and from fingerling stage to adults was $W= 0.0000633 L^{2.5920}$ or log $W = -4.1986 + 2.5920 \log L$.

**Introduction**
The mighty mahseers (*Tor* spp) are cold water fishes and acclaimed as famous sport and food fishes of India. It is known as tiger in rivers, because of the fight it musters to wriggle off the hook during catch. In the past, mahseer formed a substantial natural fishery in the major riverine and lacustrine ecosystems of India. For the fishermen, mahseer is of considerable importance due to its large size. As an edible fish, it is highly esteemed and fetches...
highest market price. In India there are available seven recorded species and two sub-species of genus *Tor*. Jhingran and Sehegal have attributed the occurrence and distribution of mahseer, more due to water temperature, rather than to the altitude. *Tor mosal mahanadicus* (David) is indigenous to the Mahanadi River system and is termed as Mahanadi mahseer. It is considered important as an aquaculture potential species.

Mahseers were considered as carnivorous and slow growing, and thus unsuitable for fish culture. However, a careful study of the feeding habits of the fish indicating that it is omnivorous has dispelled the notion that mahseers are carnivorous. Studies on the anatomical adaptations of the alimentary canal system also confirm that mahseers are omnivorous. The mahseers which belong to Cyprinidae are clad with largest shining scales in freshwater fishes, and are also referred to as large scaled carps in India. Though the conventional farming of this fish is not promising because of slow growth compared to Indian and Chinese carps, however, by formulating practical diets and appropriate technologies, there is scope to harness the potential of this group of fishes. Environmental stresses coupled with the increase in fishing activity, destruction of brood fishes and juveniles during monsoon, low fecundity and higher predation during its longer hatching and semi-quiscent periods have reduced the abundance and availability of natural stock of mahseers to very low level. The culture of mahseers has to be undertaken with a multifaceted approach considering their value in sport, food and conservation through scientific management.

David and Badapanda reported systematic observations on some aspects of biology and fishery of Mahanadi mahseer. The fish is omnivorous, but changes its feeding habits depending upon the availability of food in the habitat. Its pond rearing in Sonepur Fish Farm, Odisha for a period of 120 days is reported. No other reports are available on its rearing in pond system with other cultivable fish

### Table 1: Gut content analysis of adult Mahanadi mahseer collected from Satkosia Gorge, Angul District, Odisha

<table>
<thead>
<tr>
<th>Sample 1 (Gut content)</th>
<th>Sample 2 (Gut content)</th>
<th>Sample 3 (Gut content)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anabaena 140</td>
<td>Clostrium 260</td>
<td>Cosmarium 40</td>
</tr>
<tr>
<td>Oocystis 20</td>
<td>Senedesmus 600</td>
<td>Cyclotella 20</td>
</tr>
<tr>
<td>Senedesmus 20</td>
<td>Merismopedia 240</td>
<td>Oocystis 40</td>
</tr>
<tr>
<td>Cosmarium 20</td>
<td>Cosmarium 340</td>
<td>Pediastrum 40</td>
</tr>
<tr>
<td>Plant parts 40</td>
<td>Cyclotella 80</td>
<td>Dictyospherium 40</td>
</tr>
<tr>
<td>Egg parts 20</td>
<td>Nitzschia 220</td>
<td>Glenodiniun 500</td>
</tr>
<tr>
<td>-</td>
<td>Plant parts 380</td>
<td>Staurastrum 40</td>
</tr>
<tr>
<td>-</td>
<td>Oocystis 100</td>
<td>Arthodesmus 40</td>
</tr>
<tr>
<td>-</td>
<td>Pediastrum 40</td>
<td>-</td>
</tr>
<tr>
<td>-</td>
<td>Diploneis 120</td>
<td>-</td>
</tr>
<tr>
<td>-</td>
<td>Navicula 160</td>
<td>-</td>
</tr>
<tr>
<td>-</td>
<td>Dictyospherium 120</td>
<td>-</td>
</tr>
<tr>
<td>-</td>
<td>Glenodiniun 40</td>
<td>-</td>
</tr>
<tr>
<td>-</td>
<td>Staurastrum 80</td>
<td>-</td>
</tr>
<tr>
<td>-</td>
<td>Cymbella 60</td>
<td>-</td>
</tr>
<tr>
<td>-</td>
<td>Goniodoma 40</td>
<td>-</td>
</tr>
<tr>
<td>-</td>
<td>Crucigenia 60</td>
<td>-</td>
</tr>
<tr>
<td>-</td>
<td>Coelastrum 20</td>
<td>-</td>
</tr>
</tbody>
</table>
species and its maturity in confined culture system. No proper culture practices have been followed so far for the species, which needs greater attention\textsuperscript{16}. Dinesh et al., 2015\textsuperscript{12} had evaluated the potential of \textit{Tor khudree} to thrive in ponds of the plains under culture conditions along with cultivable carps like \textit{Catla catla}, \textit{Labeo rohita} and \textit{Cirrhinus mrigala} with seeds collected from the River Chalakudy, Kerala. An attempt was made under Network Project on “Germplasm Exploration, Cataloguing and Conservation of Fish and Shellfish Resource of India” funded and operated at ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar to rear this fish in pond culture condition along with the Indian major carps such as \textit{Catla catla} (Catla), \textit{Labeo rohita} (Rohu) and \textit{Cirrhinus mrigala} (Mrigal) to observe its performance, potential and biology.

This study was initiated at ICAR-CIFA as there was available no report on the captive performance of Mahanadi mahseer under long term pond rearing conditions. Hence, the present study was conducted with the major objective of “Captive breeding and culture of Mahanadi mahseer in pond rearing system” and to generate more information on the species for future use.

\textbf{Material And Methods} \\
\textbf{Collection Of Mahanadi Mahseer From Wild} \\
In first phase \textit{Tor mosal mahanadicus} advanced fry (average size 40 mm length and 1.01 g weight) were collected from Tel River, a tributary of Mahanadi at Sonepur, Odisha during March, 1999 and transported to the Farm facility at ICAR-CIFA, Bhubaneswar (approx. 278 km from the collection site) for rearing in pond culture condition along with the Indian Major Carps such as \textit{Catla catla} (Catla), \textit{Labeo rohita} (Rohu) and \textit{Cirrhinus mrigala} (Mrigal). This study continued up to July 2001. In second phase during 2007-2009, the pond culture experiment was repeated for conformity of the results of first phase. Mahseer fingerlings (average size 62 mm length and 2.6 g weight) were collected from Mahanadi River at Kamaladiha Village near Tikarpada, Anugul District, Odisha in June, 2007 by the help of local fishermen and transported to Farm facility at ICAR-CIFA, Bhubaneswar (approx. 160 km from the collection site) through water filled tanks for rearing in ponds. This experiment continued up to February, 2009 and results were submitted to ICAR-CIFA in 2010.

\begin{table}[h]
\centering
\caption{Gut content analysis of Mahanadi mahseer reared in pond condition at ICAR-CIFA, Bhubaneswar, Odisha} \\
\begin{tabular}{llll}
\hline
Juvenile mahseer & Plankton count (U/L) & Adult mahseer & Plankton count (U/L) \\
\hline
Botryococcus & 170 & Ankistrodesmus & 260 \\
Desmidium & 86 & Botryococcus & 600 \\
Cladophora & 123 & Fragilaria & 240 \\
Navicula & 146 & Anabaena & 90 \\
Mesotaenium & 65 & Protococcus & 340 \\
Synedra & 96 & Navicula & 370 \\
Closterium & 124 & Cladophora & 242 \\
Protococcus & 130 & Diatoms & 170 \\
Ankistrodesmus & 60 & Spirotaenia & 80 \\
Insect parts & 30 & Richterella & 120 \\
Sand and mud particles & 20 & Rivularia & 140 \\
- & - & Phormidium & 78 \\
- & - & Stephanodiscus & 135 \\
- & - & Insect parts & 20 \\
Sand and mud particles & 10 & \\
\hline
\end{tabular}
\end{table}
During September-November, 2008 in two collection trips juveniles and adult fishes were collected from Satkoshia Gorge, Tikarapada, Anugul District, Odisha, the deepest part of Mahanadi, which extends 14 miles in the river course for study of the fish biology, such as food and feeding habit, and length and weight relationship.

Rearing Of Collected Mahseer At Icar-Cifa Fish Farm
Pond size of 0.02 ha with water depth 1.5 m at ICAR-CIFA Farm facility was used for fish culture purpose. Collected Mahanadi mahseer seeds were reared along with Indian Major Carps such as Catla catla (Catla), Labeo rohita (Rohu) and Cirrhinus mrigala (Mrigal) in a ratio of 4:3:2:1 as polyculture system. Stocking density was 5000 nos/ha and supplementary feeding was applied @ 1-2% body weight daily. Ground nut oil cake and rice bran (ratio 1:1) (protein 26-28% and fibre 11%) were given as supplementary feed. Normal pond culture practice for IMC was followed for mahseer. Growth of the fish was monitored in the pond culture system. The physico-chemical parameters of pond water during culture were pH 6.8-8.5; dissolved oxygen 4.2-6.4 mg/l; total alkalinity 80-200 mg/l and total hardness 60-150 mg/l.

Study Of Food And Feeding Habit Of Mahseer
Mahseer fishes in juvenile and adult stages from pond culture system were dissected and guts were used for food and feeding habit study. This analysis was done separately for the adult fishes collected from Mahanadi River. In all the cases the gut contents were isolated and observed under microscope.

Length And Weight Relationship Of Mahseer
Length and weight relationship of Mahanadi mahseer from fry to adult in pond culture system in first phase was established with 45 fishes and in second phase from fingerling to adult with 39 fishes. The same was established for adult fishes (18 nos) collected from Mahanadi River separately. Length of the fish was measured with the help of a scale and weight in a weighing balance. The length and weight relationship was analyzed using the formula $W = aL^b$ or $\log W = \log a + b \log L$.

Where, $W =$ Weight of fish  
$L =$ Length of fish 
$a =$ Intercept or initial growth index  
b =$ Equilibrium constant

Observation Of Mahseer Maturity
Mahseer fishes from pond culture system were dissected, and ovary and testis were collected for

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Male</th>
<th>Female</th>
</tr>
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<tbody>
<tr>
<td>Length of fish (mm)</td>
<td>228 ± 11.36</td>
<td>287 ± 31.0</td>
</tr>
<tr>
<td>Weight of fish (g)</td>
<td>110 ± 6.61</td>
<td>224 ± 15.6</td>
</tr>
<tr>
<td>Length of coelomic cavity (mm)</td>
<td>99 ± 10.58</td>
<td>123.6 ± 8.38</td>
</tr>
<tr>
<td>% of cavity length to total length of fish</td>
<td>43.4</td>
<td>43.1</td>
</tr>
<tr>
<td>Length of ovary (a) Left (mm)</td>
<td>----</td>
<td>58 ± 4.94</td>
</tr>
<tr>
<td>(b) Right (mm)</td>
<td>----</td>
<td>61.6 ± 3.91</td>
</tr>
<tr>
<td>Length of testes (a) Left (mm)</td>
<td>70 ± 5.52</td>
<td>----</td>
</tr>
<tr>
<td>(b) Right (mm)</td>
<td>71 ± 8.27</td>
<td>----</td>
</tr>
<tr>
<td>GSI</td>
<td>2.24 ± 0.41</td>
<td>0.67 ± 0.05</td>
</tr>
<tr>
<td>Oocyte size (mm)</td>
<td>0.17 – 1.44</td>
<td>0.17 - 0.33</td>
</tr>
</tbody>
</table>

Primary oocytes : 0.17 - 0.33
Vitellogenic oocytes (2 types): 
0.42 - 0.59 and 0.84 – 1.44
study of maturity status. On maturity the length of gonads, gonado-somatic index (GSI), oocyte size, etc. were found out for fishes. Male fishes were induced with Ovaprim @ 0.2 ml/kg body weight and were stripped after six hours of injection. Spermatozoa count and its motility status were recorded.

Results And Discussion

Food And Feeding Habit Of Mahanadi Mahseer

The gut contents of three adult fishes collected from Satkoshia Gorge of Mahanadi River were analyzed (Table 1). Phytoplankton from the group Chlorophyceae was abundant in the gut content. Fragments of plant parts were available in it, but, Zooplankton were not observed. Along with these soil particles and broken molluscan shells were seen in it. This proves that the species is mostly a benthic feeder and omnivore. The plankton samples were mostly of phytoplankton ranging from 20-600U/I. Mahanadi mahseer accepted the supplementary feed (ground nut oil cake and rice bran) given in pond for Indian major carps. From the pond culture system three juveniles and three adult mahseers were sacrificed for gut content analysis. The average values are presented in Table 2. The fish was seen omnivorous and the gut content reflected the availability of food in the pond. Mahseer was also found to feed on green filamentous algae, insect larvae, small molluscs and periphyton. benthic animals (Arcella, Keratella, Chironomus) indicated that though mahseer can be considered as an omnivorous fish, it is largely herbivorous in habit. Badapanda and Mishra reared fry of Tor khudree at Sonepur, Odisha with GNOC and rice polish at a ratio of 1:1 and reported the fry were quite healthy. Nandeesha et al. reared Tor khudree fingerlings at Harangi Fish Farm, Karnataka for raising brood stock and sexual maturity with regular feeding with a formulated feed mixture at about 2% body weight. In the present study the Mahanadi mahseer was found to be omnivorous with major food items from phytoplankton group and in pond culture system well thrived with supplementary feed of GNOC and rice bran at a ratio of 1:1. The results are elaborative in nature in the present study and in general corroborate the findings of other workers of the country. The fishes were seen healthy during the entire culture period.

Length-Weight Analysis

Length weight relationship of the fish from pond culture system at ICAR-CIFA was established statistically. From fry stage to adults it was $W=0.0001339 \times L^{2.4301}$ or log $W = -3.8733 + 2.4301 \times \log L$ and from fingerling stage to adults was $W=0.0000633 \times L^{2.5920}$ or log $W = -4.1986 + 2.5920 \times \log L$. Length weight relationship of the adult fish from Mahanadi River system was found to be $W=0.0000001844 \times L^{3.6795}$ or log $W = -6.7342 + 3.6795 \times \log L$.

The length weight relationship in statistical analysis for Mahanadi mahseer has indicated a non-linear relationship. The logarithmic conversion of the data indicated the linear relationship. The “b” values for the fishes from the culture system were found to be 2.4301 and 2.5920. The same for the fishes from Mahanadi was calculated to be 3.6795. The “b” value usually lies between 2.5 and 4.0. If “b” values are computed less than 3, then the species become lighter for their length as they grow larger. In reverse way, if “b” values are more than 3, the species become heavier for their length in the process of growth. The length weight analysis can give some idea about the environment suitability for the fish. Based on “b” values we can conclude that the fish grew well in river than the pond culture system.

Growth Of Fish

In the present study, in pond culture system in the first phase, the fishes grew from fry stage to the size of 340 mm length and 305 g weight in case of male, and 370 mm length and 400 g weight in case of female in 28 months. In second phase experiment, fishes grew from fingerling stage to the size of 328 mm length and 295 g weight in case of male, and 352 mm length and 340 g in weight in case of female in 20 months. The Mahanadi mahseer could grow to a size of 170-200 mm in a rearing period of 120 days at Sonepur Fish Farm, whereas the Deccan mahseer reared in Odisha could attain up to 107 mm in 254 days. In the present study the fish growth was slower than the reports available from other places for the same and related species.

Observation Of Maturity In Mahanadi Mahseer

In pond culture system male attended maturity and milting at an average size of 228 mm length and 110
g weight. Three male and three female fishes were used for the maturity study. The maturity status of fish is presented in Table 3. Ovaprim (an inducing hormone for fish available in market) induced male yielded 0.25-0.3 ml milt/100 g body weight. Number of spermatozoa in milt varied between 3.0-5.5 x10⁶ per ml. In room temperature the sperm motility was about 80-100% till 4 hour. After activation of sperm it remained viable up to 30-40 seconds. Females were found having primary and vitellogenic oocytes in their ovary with average body size of 287 mm length and 224 g weight. In female fish the maturity was recorded up to third stage in pond culture system. It was observed that during peak breeding months, the male mahseer was bright coloured with thicker and protruded lips, thick dorsal spine, bright orange pectoral fins and bright orange to reddish anal fins; whereas the female mahseer was dull coloured with less protruded lips, thin and short dorsal spines, slightly pink pectoral fins and pinkish anal fin. The presence of few tubercles on the snout of male specimens is rarely developed.

The testes of mahseer have relatively higher growth rate than ovaries resulting in early maturity of males. In the lake, the size and age-at-first-maturity is lower for male (207 mm) than female (309 mm). Similar results were obtained for male and female in the present study. David reported in detail on the gonadal development of Mahanadi mahseer taking in to considerations the total length of the fish in different months of the year and concluded that the males and females above 370 mm and 480 mm attain maturity. Badapanda reported that the males above 260 mm and females above 240 mm attended maturity. In the present study the male fishes attained maturity from 217 g (average being 228 g). It was also observed two stages of oocytes in ovary of the fish. The different size groups of oocytes indicate that the species has an extended period of gonadal development and similar observation is also reported by David. Badapanda reported two sizes of mature and immature ova by dissecting the ovaries in early monsoon period. The results on gonadal status of fish are elaborative in nature in the present study and in general corroborate the findings of the other workers of the country.

**Conclusion**

Globally, steadily increasing demand for fish necessitates diversification of farmed fish species in order to obtain more economic gain from the systems. Tor spp seem good indigenous candidates for aquaculture. The present experimental trial evaluated the performance of Mahanadi mahseer under polyculture system along with Indian major carps in pond condition in terms of growth and reproductive maturity. The mahseer is found to be omnivorous and benthic feeder and exhibited slow growth in pond condition. Comparative slow growth may be attributed to lack of conducive environment due to higher temperature throughout the culture period as reported in other Tor spp. Confined environment may be responsible for slower growth of the species like Tor putitora. Male fish matured earlier than female in two years of pond culture experiment. Although males attained maturity under stagnant water, females could not attained late vitellogenic stages may be due to lack of conducive environmental factors require for stimulation of brain-pituitary-gonad axis. This is the most common reproductive dysfunction in captive fish, and may diminish after many generations of fish produced in culture conditions. However further studies have to be undertaken to develop the breeding and culture technologies of Mahanadi mahseer fish in captive conditions.

**Acknowledgement**

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