Mugil cephalus Linnaeus, 1758

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IDENTIFICATION

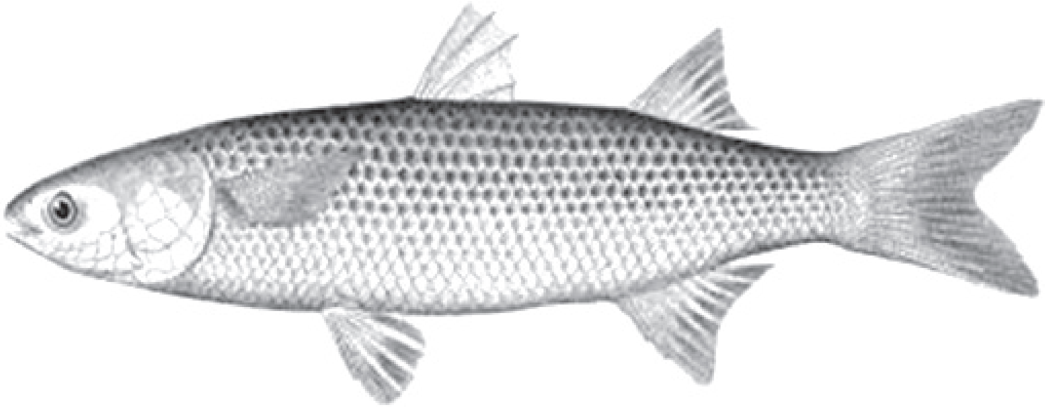
Order	:	**Perciformes**
Family	:	**Mugilidae**
Common/FAO Name (English)	:	**Flathead grey mullet**

Local names: Boi, Gandhiya, Bhomat (**Gujarati**); Boi, Boita, Bol, Mangan, Pilas, Pilsa, Sheroto (**Marathi**); Gobri, Wekhanu (**Konkani**); Mala (**Kannada**); Thirutha, Thirutha kanambu (**Malayalam**); Madavai, Kasmin, Manla (**Tamil**); Kathiparega, Meyman (**Telugu**)

MORPHOLOGICAL DESCRIPTION

Body is cylindrical, robust, with broad head. The width of head is more than width of the mouth cleft; adipose eyelid is highly developed, more than that of other mugilid species, covering most of the pupil; upper lip is thin, no papillae, labial teeth of upper jaw small, straight, and dense, in several rows; mouth cleft ends below posterior nostril. Two dorsal fins; the first one has 4 spines; the second has 8-9 soft rays. Anal fin has 8 soft fin rays. Pectoral fins short (when folded forward does not reach eye). It must be noted that dorsal and anal fin spine and ray count cannot be used as a distinguishing feature for *M. cephalus* since this overlaps with a number of other mugilids.

Source of image : CMFRI, Kochi



Pectoral fins are with 16-19 rays; pectoral axillary about one-third length of fin. Scales in lateral series is 36-45. Colour back blue/green, flanks and belly pale or silvery; scales on back and flanks usually streaked to form longitudinal stripes; dark pectoral axillary blotch. *Mugil cephalus* has been reported to be part of a species complex which involves 14 other mugilid species. Nearly 30 species of *Mugil* have been synonymised with *M. cephalus* indicating the level of taxonomic confusion that exists regarding this species.

PROFILE

GEOGRAPHICAL DISTRIBUTION

Flathead grey mullets are distributed in Indian Ocean, Atlantic Ocean, Pacific Ocean and Mediterranean Sea. They are cosmopolitan in nature i.e. found in coastal waters of the tropical, subtropical and temperate zones of all seas. It is distributed from California, USA to Chile in Eastern Pacific; from Japan to Australia in Western Pacific; from India to South Africa in Western Indian Ocean; from Nova Scotia, Canada to Brazil in Western Atlantic; Cape Cod to southern Gulf of Mexico; Bay of Biscay to South Africa, including the Mediterranean Sea and Black Sea in Eastern Atlantic.

HABITAT AND BIOLOGY

Mugil cephalus is a coastal species that often enters estuaries and rivers. Usually it forms schools over sandy or muddy bottom, between 0 and 10 m, in highly salty to fresh waters that are warm or temperate from 8 to 24 °C. The grey mullet is catadromous and it can tolerate a wide range of water salinity. Adult mullet tolerate zero salinity to 75 g/l, while juveniles reach high salinity tolerance at lengths of 4-7 cm. Adults form spawning aggregations and migrate offshore to spawn. The larvae move inshore for cover from predators as well as for access to rich feeding grounds. After reaching 5 cm in length, juvenile mullets move into slightly deeper waters.

It is a diurnal feeder, feeding on zooplankton, dead plant matter and detritus. This species also grazes on epiphytes and epifauna from seagrasses and surface scum containing microalgae at the air-water interface. Larvae feed primarily on copepods, mosquito larvae, and plant debris when they are below 3.5 cm in length. The amount of sand and detritus in the stomach contents increases with length, indicating that more food is ingested from the bottom substrate as the fish grows. Reproduction takes place in the sea, at various times of the year depending on the location. They do not have an obligatory freshwater phase in its life cycle. The fish sexually matures at the age of 3-4 years. Females spawn 0.8 to 2.6 million eggs. The maximum length reported is 120 cm SL and maximum weight 12 kg.

PRODUCTION SYSTEMS

Mugil cephalus has been farmed intensively in different parts of the world since centuries. It has been farmed in Italy, Egypt, erstwhile Soviet Union, Israel, Taiwan, Hong Kong, Japan, Philippines, Indonesia, China and India. Intensive research efforts have gone into it's induced breeding and larval rearing. Several studies on induced breeding and larval rearing of this species has been published in the 1980s and 1990s from USA, Israel, Philippines, etc. Taiwan was the first country to complete the reproductive cycle of *M. cephalus* fully in captivity.

BREEDING IN CAPTIVE CONDITIONS

Mugil cephalus does not spawn naturally in captive conditions; it needs to be induced to spawn in captivity. However it does mature in captivity. Broodstock needs to be maintained at salinities of 32-35 g/l for good spawning. Successful broodstock maintenance has been reported from fish maintained in freshwater ponds, seawater ponds and rubber-lined dirt ponds filled with re-circulating seawater from countries other than India. In India, the Central Institute of Brackishwater Aquaculture (CIBA), Chennai successfully domesticated broodstock of *M. cephalus* in 100 t re-enforced concrete tank (RCC) with seawater circulation. Approximately 75-80 % of the water was exchanged daily. Tanks were cleaned on alternate days. Fish were fed pelleted maturation feed at 3 % of body weight daily. A high lipid feed was given during recouping period and low lipid during gonad maturation period. Period of maturation showed concurrence with exposure to shortened photoperiod and lower water temperatures. Spawning occurs only through stripping or hormonal induction (purified salmon gonadotropin, human chorionic gonadotropin, 17α methyltestosterone, etc.) of the fish. At CIBA, female fish were injected with a priming dose of hCG @ 6000-10000 IU/kg body weight followed 24 h later by a resolving dose of Ovaprim @ 3-5 ml/kg body weight. Male fish were not given any hormones. At CIBA the fishes were stripped. However other workers have reported natural spawning behaviour following hormonal induction.During spawning, male fish starts getting active as the hydration of the female fish progresses. When the female releases the first set of eggs, the male is stimulated to release sperm. Once this happens, the female gives out eggs in large numbers continuously for some time.

Fertilized eggs remain floating in the water with hatching being influenced by water temperature. At CIBA hatching occurred in 30-32 h at a water temperature of 26-28 °C and salinity of 26 g/l. However the range of hatching reported globally ranges from 59-64 h at temperatures of 20-24.5 °C and salinity of 24.39-35.29 g/l to 34-38 h at temperatures of 23-24.5 °C and salinity of 30.1-33.8 g/l.

LARVAL REARING

Larvae start external feeding 3-5 dph and are liable to show adverse growth if not fed by 84 h post-hatch. The general larval rearing protocol is to rear the larvae along with rotifers as their exclusive feed, along with phytoplankton in the larval tank. Complete larval rearing is reported to take 42-55 days. Studies have shown that adding *Nannochloropsis oculata* along with rotifers in the larval tank ensures higher survival of larvae up to 15 dph. Feeding the larvae with enriched *Artemia nauplii* from 15-35 dph also ensures higher survival rates. The optimal stocking density suggested for successful larval rearing is 10-20 larvae/l of water along with 5-10 rotifers/ml and $5\text{-}7 \times 10^5$ cells/ml of phytoplankton. It has also been reported that there are two critical periods during larval rearing when high mortality occurs 2^{nd}-3^{rd} day and 8^{th}-11^{th} days of rearing. These two periods are associated with an increase in specific gravity of larvae and consequent sinking of larvae to bottom of the tank. Larvae have been reported to grow from 2.63 mm to 17.69 mm by 42 days.

NURSERY REARING

The nursery rearing has been reported to be carried out in earthen ponds, where they depend mainly on natural food available in the pond. The pond was prepared by adding animal manure at the rate of 2.5 to 5.0 t/ha before filling the pond with water. Fry were stocked at the rate of 125 nos./m^2 fifteen days after filling the pond with water. Artificial pellets were given as supplemental feed. Even rice and wheat bran were used as an additional source of food. Chicken manure and chemical fertilizers (usually phosphate and nitrates) were added as and when required to maintain secchi disc readings of 20-30 cm. The fry were cultured in nursery ponds for 4-6 months, depending upon the size of fingerlings required for stocking in grow out system. Generally nursery rearing is carried out to produce 10 g mullet seeds. The optimum required protein level for mullet nursery rearing is 25 %.

The nursery rearing of mullet were also carried out in hapas fixed in pond. The fry of size 1.6 to 2.4 cm was stocked in hapas @ 400 nos./m^3 for initial 30 days then reduced to 200 nos./m^3 for next 60 days or until the fish attained a size of 10-15 cm. The fish were fed thrice a day with wet wheat flour and flattened rice.

GROW-OUT

It has been farmed in ponds and enclosures in many countries of the world. Culture of this species is prevalent in Italy, Egypt, Taiwan, Japan, Korea, Hawaii, Russia, Israel, Philippines, Hong Kong, etc. This species has been cultured along with carps in Israel and Hong Kong and with milkfish in Philippines. It can be cultured in freshwater, brackishwater and marine water. In India too this species has been farmed in Bengal, Madras and Kerala. Both pond culture as well as cage culture has been carried out successfully in India.

For pond culture, the ponds were prepared by drying, ploughing and manuring by adding animal manure at the rate of 2.5 to 5.0 t/ha before filling water in the pond. Water level was kept at a depth of 25-30 cm for 1-2 weeks for phytoplankton development. Then water level was increased to 1.5 to 1.75 m and fingerlings were stocked in the pond. Chicken manure and chemical fertilizers (usually phosphate and nitrates) were added as and when required to maintain secchi disc readings of 20-30 cm. Fish of 10-15 cm size were stocked @ 6175-7410 nos./ha in the pond. Rice and wheat bran were used as supplemental feeds. The culture period of mullet was 7-8 months. The production from such system was 4.3-5.6 t/ha/crop. In semi-intensive polyculture system, where mullet was stocked with carp and tilapia, @ 2,470-3,705 nos./ha together with 1,850-2,470 nos./ha of 100 g common carp juveniles and 61,750-74,100 nos./ha 10-15 g Nile tilapia fingerlings the yield was 20-30 t/ha/crop, of which 2-3 t were mullet.

Mullet can also be cultured in cages installed in backwater systems. The stocking density used for cage culture was 27 nos./m^3 of 10-15 g size. The fish grew to a size of 380-550 g after 195 days of culture. They were fed on artificial pellets.

FOOD AND FEEDING

Larvae are planktivorous, feeding particularly on calanoid and cyclopoid copepods. However when the larvae reach 10-20 mm SL size they start feeding on small invertebrates and benthos. Larger fish tend to feed on detritus and benthic microalgae particularly diatoms, along with other small invertebrates and meiofauna.

GROWTH RATE

The growth rate of the fish is highly influenced by temperature and salinity, hence there are varied reports of growth rates for this species. The growth rate in juveniles was reported as 17 mm per month during spring and summer which decreased to 5 mm per month during winter in a study along the Atlantic coast of USA. The fish is reported to grow faster in tropical waters reaching 14-18 cm SL in the first year, but attaining only 13-16 cm SL in temperate waters. Studies from Australia indicate that the species reaches 46 cm, 51 cm and 54 cm by the age of 5, 6 and 7 years. In culture systems, this species grows to a size of 0.75-1 kg after 7-8 months of culture period from 10-15 g size. They can grow to a size of 1.5-1.75 kg after two on growing seasons.

DISEASES AND CONTROL MEASURES

The disease reported in *Mugil cephalus* and their control measures are given below:

Disease	Agent	Syndrome	Measures
Viral Disease			
Iridoviral disease	*Iridovirus*	Systemic disease; congested fins; increased mucus production; highest mortality at lower temperatures (<24 °C)	Vaccination; environmental improvement
Bacterial Disease			
Red pest of eels, red sore, red boil, saltwater furunculosis	*Vibrio anguillarum*	Systemic infection; acute haemorrhagic and septicaemic disease with mass mortality; anorexia; darkening; abdominal distension, dermal haemorrhages; skin ulcers; occurrence of exophthalmos	Vaccination; environmental improvement
Streptococcosis	*Streptococcus faecalis*	Haemorrhagic areas on body surface	Antibacterial drugs in feed;environmental improvement
Bacterial fin rot	*Flexibactercolum naris*	Breakdown of tissues between fin rays (fin rot)	environmental improvement
Motile aeromonas septicaemia	*Aeromonas hydrophyla ; A. caviae* and *A. sobria*	Systemic infection;acute haemorrhagic and septicaemic disease; haemorrhagic spots on skin and base of fins; ulcers and skin necrosis; exophthalmia and dropsy	Environmental improvement; antibacterial drugs in feed
Parasitic Disease			
Gill myxobolosis	*Myxobolus goensis*	Gill infestation	Environmental improvement
Sea lice	*Caligus* spp.	Infestation occurs commonly in the skin	Medicated bath; environmental improvement
Epizootic ulcerative syndrome (EUS); Red spot disease	*Aphanomyces invadans*	Skin ulcers	Environmental improvement

PRODUCTION, MARKET AND TRADE

PRODUCTION

The global aquaculture production ranged from 1,040 t in 1950 to 12,360 t in 2014. The global capture production ranged from 18,100 t in 1950 to 1,30,139 t in 2012.

MARKET AND TRADE

Flathead grey mullet has a good market in many countries of the world namely Egypt, Taiwan, India, Israel, etc. It is marketed fresh, frozen, salted and dried and its eggs are considered a delicacy. In India the species has a good demand in the domestic market fetching up to ₹ 300/kg.

CHALLENGES TO MARICULTURE

Even though seed production in captivity has been achieved for *M. cephalus*, culture of the species in many parts of the world still depend on wild collected fry. This will eventually lead to pressure on wild populations. Hence to carry out sustainable aquaculture, scaling up of seed production is critical. In India, large scale hatchery production of seeds of *M. cephalus* is yet to become a reality. Studies indicate that *M. cephalus* consists of a cluster of ecologically specialized mugilids, perhaps even a species complex, which do not have uniform life-history traits. This can probably be a reason for the failure in large scale captive breeding of the species, especially when spawners are collected from different habitats.

FUTURE PROSPECTS

Since *Mugil cephalus* is a high valued fish in India, there is good scope for scaling up of seed production technology in the country. This also requires a thorough understanding of the species/ stock status of *M. cephalus* in Indian waters. Moreover there exists good potential for this species to be cultured in cages in estuarine and lagoon systems of the country.

SUGGESTED READING

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