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Review | Derleme

Biology, Induced Breeding and Culture Prospects of the Asian Striped Dwarf Catfish, *Mystus tengara*: A Review

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Abstract: The Asian striped dwarf catfish, *Mystus tengara* is a freshwater tropical fish, inhabits both stagnant and flowing waters. This species is widely distributed in India, Bangladesh, Sri Lanka, Pakistan, Afghanistan, Nepal and Bhutan. Because of excellent nutritional content and delicious flavour, it has a strong market demand, positioning it as a potential candidate species for the aquaculture diversification in freshwater. The native population of this species has recently diminished due to over-exploitation and several unintended ecological alterations. A thorough understanding about biological characteristics of a species is essential for farming it. Numerous scientific investigations have studied various aspects of the biology of *M. tengara*, but there is a lack of information regarding its breeding, seed production and culture practices. The present review is aimed to highlight a consolidated picture of the status of general and reproductive biology, captive seed production as well as culture potential of this valuable species. This study will explore the scope of future research for the advancement of commercial aquaculture and conservation of the *M. tengara*.

Keywords
- Aquaculture practices
- Induced breeding
- *Mystus tengara*
- Reproductive biology

1. INTRODUCTION

Mystus tengara (Hamilton, 1822) also known as the Asian striped dwarf catfish is a freshwater tropical species, member of the family Bagridae under the order Siluriformes, which may be found in both stagnant and flowing waters (Jayaram, 2006; Darshan et al., 2013; Gupta, 2015). This species is mainly distributed in India, Bangladesh, Sri Lanka, Pakistan, Afghanistan, Bhutan and Nepal, but has also been reported from Vietnam, Cambodia, Laos, Malaysia and Myanmar (Talwar & Jhingran, 1991; Froese & Pauly, 2017). *M. tengara* is nutritionally rich, containing approximately 9.83% protein, 3.47% lipid, 8.91% carbohydrate and 2.14% amino acids along with essential minerals (Silambumuthu et al., 2018). Owing to this nutritional profile and its good flavour, the species has strong market demand and is considered a promising candidate for aquaculture (Siddiqui et al., 2010; Ahmed et al., 2012). In addition to making its debut in markets for ornamental fish, this species is reportedly exported from India as an indigenous decorative fish with a moderate export price (Gupta & Banerjee, 2008; Gupta & Banerjee, 2012[a, b]; Jayalal & Ramachandran, 2012).

The order Siluriformes (catfishes) comprises a diverse group of freshwater fishes with several species of commercial importance in aquaculture and capture fisheries. Major farmed catfishes include *Pangasianodon hypophthalmus* (striped catfish) and various *Clarias* spp. (air-breathing catfishes), which together contribute millions of tonnes annually to global catfish production. In 2023, global catfish aquaculture production was estimated at around 7 million tonnes with *Pangasius* spp. contributing approximately 3.4 million tonnes, air-breathing catfishes around 1.8

million tonnes and bagrid catfishes nearly 0.7 million tonnes (Cai et al., 2023). Smaller silurid species, including *M. tengara* and similar indigenous catfishes represent a smaller and less documented fraction of global production, highlighting the need for diversification in aquaculture species.

According to reports, *M. tengara* has been assessed as Least Concern, since it does not face any significant threats (Ng, 2010). Despite not being endangered, the natural population of this species is declining as a result of overexploitation and other unintentional ecological changes that make its natural habitat unsuitable (Hossain et al., 2009). However, information about reproduction is frequently scarce, considering its commercial importance, which encourages biological study on the reproductive characteristics of this fish species. For fisheries management, it is essential to examine fish reproductive parameters in order to understand when and how long reproduction occurs (Bhattacharyya & Maitra 2006; Trindade-Santos & Freire, 2015; Freitas et al., 2016). Studies on the reproductive cycle are crucial for the optimization of appropriate broodstock m anagement techniques, profitable fish farming as well as conservation initiatives (Mijkherjee et al., 2002; Mylonas et al., 2010; Migaud et al., 2013). However, not much is known about its grow-out culture techniques as well as captive breeding and larval rearing, which are necessary to develop the sustainable aquaculture and captive seed production of this species (Gupta & Banerjee, 2013[a]; Gupta, 2015; Mitu, 2017). Availability of quality seed in adequate quantity is essential for the successful aquaculture of any species. In order to assess the breeding season, standardization of seed production and improve culture techniques, it is important to study the annual reproductive cycle of gonadal development. Any investigation of fish reproductive biology must include studies of the sex-ratio, length at first sexual maturity, gonadal maturation cycle and spawning periodicity, among other aspects (Rastogi & Saxena, 1968; Guraya et al., 1975; Khan et al., 1992; Mitu & Alam, 2014).

In order to highlight the lack of knowledge in the areas of captive spawning, seed rearing, nutritional requirements and culture practices of *M. tengara*, this review compiles all of the information currently available. It also suggests the suitability of this important food fish as an aquaculture candidate species and offers helpful directions for future research. This review will further help in bridging the information gap that researchers face when studying the sex ratio, sexual maturity, reproductive cycle, fecundity and the relationship between length and weight of *M. tengara*.

2. GENERAL BIOLOGY

2.1. Morphology

Mystus tengara (**Figure 1**) is morphologically adapted and exhibits several features that support its ecological role. The morphological characteristics of this species have been comprehensively described by several authors. The body is longer and compressed laterally, tapering towards the caudal end (Talwar & Jhingran, 1991). The head is broad and dorsoventrally flattened and the terminal mouth is equipped with villiform teeth on both jaws, suitable for bottom-feeding behavior (Jayaram, 2006). There are four barbel pairs: two mandibular barbel pairs along with one pair each of nasal and maxillary barbels. The maxillary barbels are elongated, often extending to the base of the pectoral fins (Jayaram, 2006). The dorsal fin has a strong serrated spine and 7 soft branched rays (Nair et al., 2022). Adipose fin lengthy with a deep incision at the posterior end and origin does not reach the base of the last dorsal fin ray (Darshan et al., 2013). A robust, sharply pointed pectoral fin with 7 to 8 rays supporting it (Nair et al., 2022). The pelvic fin has one weak spine with 5 soft rays and does not reach the anal-fin origin (Talwar & Jhingran, 1991). Anal fin with two or three weak spines contained with 10 to 12 soft rays (Jayaram, 2006). Caudal fin deeply forked with 7 rays on the upper lobe and 8 rays on the lower lobe, upper lobe longer (Darshan et al., 2013). The body is light brown to grey with a distinct dark lateral band running from the gill cover to the caudal peduncle (Ng, 2010). Fins are often dusky or semi-transparent (Talwar & Jhingran, 1991).

Compared to larger cultivated Siluriformes, such as *Pangasius* spp., which have a robust body form, *M. tengara* is much smaller and more slender (Silambumuthu et al., 2018). Although many *Clarias* spp. also possess four pairs of barbels similar to *M. tengara*, their overall body proportions, fin morphology and colour patterns differ (Jayaram, 2006). The deeply forked caudal fin and distinct dark lateral band are characteristic features that help distinguish *M.*

tengara from other commonly cultivated catfishes (Talwar & Jhingran, 1991; Ng, 2010). Within the genus *Mystus*, *M. tengara* can be further differentiated by its comparatively slender body, relatively longer maxillary barbels, strongly serrated dorsal spine and well-defined lateral band, whereas species like *M. cavasius* and *M. vittatus* are generally larger and more robust with less pronounced dorsal spines, more emarginate caudal fins and fainter lateral markings (Jayaram, 2006; Darshan et al., 2013). These morphological distinctions are important for accurate species identification and have practical relevance for aquaculture management.

Figure 1. The figure illustrates the key morphological features of *M. tengara*, including its laterally compressed elongated body, broad flattened head, four pairs of barbels and distinct dorsal and adipose fins. Notable diagnostic characters, such as the serrated dorsal spine, deeply forked caudal fin and dark lateral band along the body are clearly visible and help distinguish this species from other catfishes.

2.2. Habitat and niche

Mystus tengara is ecologically significant due to its adaptability to diverse freshwater environments and its role in aquatic food webs. The species occurs in a wide range of habitats, but shows a preference for slow-moving or stagnant waters (Ng, 2010). It is commonly found in canals, ponds, rivers, streams, beels (oxbow lakes), floodplains and rice fields, particularly in shallow, warm waters with muddy or sandy substrates (Talwar & Jhingran, 1991; Jayaram, 2006). Moderate aquatic vegetation and turbid conditions provide shelter and foraging opportunities. Its tolerance to fluctuations in temperature, dissolved oxygen and turbidity allows it to thrive in disturbed or seasonal water bodies (Ng, 2010). Ecologically, *M. tengara* occupies a benthopelagic niche, living and feeding mainly near the bottom, while also utilizing mid-water zones (Jayaram, 2006). It functions as a secondary consumer, helping regulate benthic invertebrate populations and contributing to nutrient cycling (Talwar & Jhingran, 1991).

Compared with other Siluriformes, *M. tengara* occupies a more specific ecological niche associated with shallow and slow-flowing or stagnant habitats. Related species, such as *M. cavasius* and *M. vittatus* are generally linked to larger river and backwater systems and attain greater body sizes, whereas *M. tengara* is more characteristic of floodplains and pond-like environments (Jayaram, 2006). Likewise, larger cultivated catfishes including pangasiids (*Pangasius* spp.) prefer deeper flowing rivers, while air-breathing *Clarias* spp. tolerate oxygen-poor swampy habitats (Gisbert et al., 2022). These differences highlight habitat and niche variation among silurid fishes and help explain their ecological roles and aquaculture suitability.

2.3. Growth pattern

At Baruipur, South 24 Paraganas, West Bengal, India, Gupta & Banerjee (2015) conducted a one-year study on the length-weight relationship (LWR) of *M. tengara* from an undisturbed wetland and observed the maximum adult total length in the range of 7.2 to 11.3 cm for male and 7.3 to 11.7 cm for female and the weight of the species were in the range of 3.43 to 13.63 g for male and 2.83 to 14.88 g for female. However, Kalita et al. (2017) investigated on this species obtained from Lechia-Pavomari beel (wetland), Dhemaji, Assam, India and recorded that the total length and body weight of *M. tengara* was found in range from 4.44 to 11.56 cm and 1.62 to 12.84 g, respectively. Hasan et al. (2020) collected 50 individuals of *M. tengara* from Bhairab river (Bagerhat), Shibsa river (Paikgacha), Khulna river (Shyamnagar) as well as Kholpetua river (Satkhira) in South-western Bangladesh and recorded minimum and maximum length of 9.1 and 15.5 cm, respectively, while minimum and maximum weight of 17 and 56 g, respectively. The weight and length range of *M. tengara* was from 2.12 to 22.44 g and 7.1 to 17.3 cm, respectively in two different habitats (rivers and ponds) of Paschim Medinipur and Jhargram, West Bengal, India (Jana et al., 2022). Kaushik et al. (2025) observed minimum and maximum length of 5.21 and 8.13 cm, respectively as well as minimum and maximum weight of 1.41 and 5.22 g, respectively of *M. tengara* in Jorasar river, Sonitpur, Assam, India. Talwar & Jhingran (1991) reported 18 cm as the maximum total length of *M. tengara* and maximum weight of 90 g was reported by Fakhruddin et al. (2022). Mitu et al. (2019) made a study in Ganges river of Rajshahi, North-western Bangladesh and observed that the relative weight of *M. tengara* was significantly higher in females than males and the LWR highlighted that females had positive allometric growth, while males had negative allometric growth.

In general, species within the order Siluriformes exhibit considerable variation in growth patterns. Many larger catfishes, such as *Pangasius* spp. typically show positive allometric growth, where body weight increases at a faster rate than length under favourable environmental and nutritional conditions (Kumar et al., 2020). In contrast, smaller indigenous silurid species may show negative, isometric or positive allometry depending on local environmental conditions, habitat type and resource availability, reflecting flexible growth dynamics across habitats (Jayaram, 2006). These variations in growth dynamics are influenced by factors like water temperature, food availability and habitat type, providing a useful context for interpreting the length-weight relationships reported for *M. tengara* across different regions.

2.4. Food and feeding habits

Mystus tengara is a carnivorous fish and mainly feeds on crustacean parts, copepods, rotifers, zoobenthos, fish parts and larvae (Gupta & Banerjee, 2014; Mondal et al., 2017; Roy et al., 2022; Majumder et al., 2024). However, Mitu & Alam (2016) as well as Rao (2017) described that the species is an omnivorous fish. Zooplankton are the basic dietary components, while rotifers are the favored food items of this fish species at different life stages (Gupta & Banerjee, 2014). Furthermore, Mitu & Alam (2016) have reported that insects are the most prevalent prey group and favourite food source, followed by diatoms and green algae. Crustaceans and insect parts followed by algae or plant materials, molluscs, protozoan, detritus and sand grains are the most abundant food item of *M. tengara* in Manair river, Karimnagar, Telengana, India as described by Rao (2017). The gut of *M. tengara* contained no identifiable phytoplankton or plant-derived substances in different natural water bodies of local river at Haraputa, Gossaigaon, Kokrajhar, Assam, India as observed by Roy et al. (2022). Majumder et al. (2024) recorded 30.28% of zooplankton followed by 24.28% of fish body parts, 20.21% of aquatic insects and 13.27% of phytoplankton in the gut content of *M. tengara*, which was collected from Gomati river and Rudrasagar lake, Tripura, India. However, the gut content analysis of *M. tengara* in Nagavali river, Andhra Pradesh, India contributed by 29.70% of zooplankton followed by 25.27% of phytoplankton, 23.48% of fish body parts and 14.22% of aquatic insects (Pratap et al. 2025). The variation in reported gut contents across different studies likely reflects habitat-specific prey availability and seasonal fluctuations rather than strict dietary specialization. *M. tengara* inhabits diverse freshwater environments where plankton density, benthic fauna and detrital inputs differ considerably. Under such conditions, ingestion of algae or detritus may occur incidentally during benthic foraging or serve as a supplementary resource when preferred animal prey is scarce.

Considering the consistent predominance of animal prey, the species may therefore be characterized as a carnivorous-insectivorous feeder with opportunistic trophic flexibility, an adaptive strategy in dynamic floodplain ecosystems.

Feeding intensity in *M. tengara* shows clear seasonal variation linked to the reproductive cycle. Gupta & Banerjee (2013[a]) reported peak feeding activity during the pre-spawning season, followed by a decline during the breeding period. The highest GaSI (gastro-somatic index) and RLG (relative length of gut) values in this species were observed in pre-monsoon and monsoon, respectively, while lowest in winter season (Deori et al., 2017). Seasonal changes in feeding intensity also appear closely linked to the reproductive cycle. Elevated feeding during the pre-spawning period likely corresponds to increased energetic demand associated with gonadal development, particularly vitellogenesis in females and spermatogenesis in males (Jana et al., 2024). In contrast, reduced feeding during the breeding season may result from enlargement of gonads limiting gut capacity, hormonal influences that suppress appetite during active reproductive phases and behavioral prioritization of courtship and spawning over foraging (Wang et al., 2023). Such seasonal modulation of feeding allows energy to be allocated efficiently toward reproduction rather than somatic growth.

3. REPRODUCTIVE BIOLOGY

3.1. Sexual dimorphism

The genital papilla, which is solely seen in male fish (**Figure 2**) and absent in females (**Figure 3**), serves as an external feature distinguishing male and female *M. tengara* (Gupta, 2015). During the spawning season, the genital papilla in males becomes extremely prominent. In contrast, females are generally larger than males and can be readily identified by their swollen abdomen during the breeding period (Gupta & Banerjee, 2013[a]). This pattern aligns with the broader trend in Siluriformes, where external sexual differences are typically subtle but become more apparent during reproductive maturity.

Figure 2. Male *M. tengara* with muscular genital papilla.

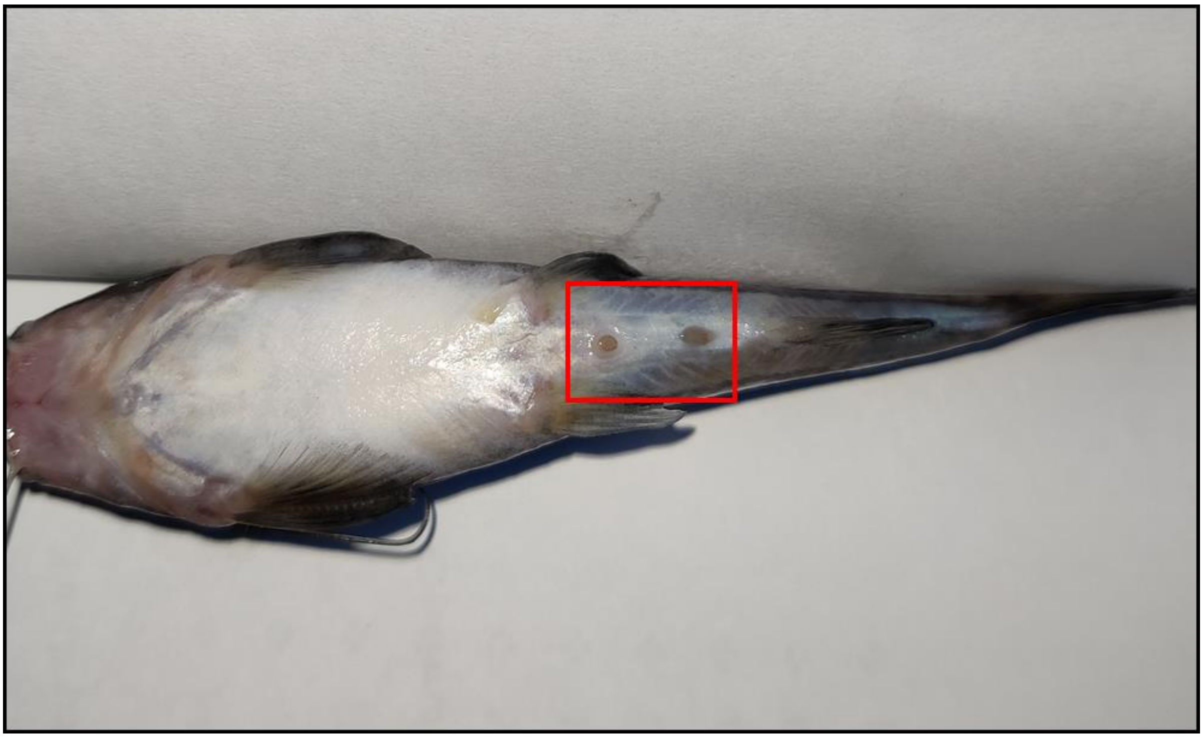

Figure 3. Female *M. tengara* with round genital opening.

3.2. Sex ratio

In the studied populations of *M. tengara*, females outnumber males, which may reflect an adaptive reproductive strategy where higher female abundance maximizes spawning output and ensures greater population recruitment. Gupta & Banerjee (2013[a]) reported a male-to-female ratio of 1:1.67 in a freshwater wetland near Baruipur, South 24 Paraganas, West Bengal, India, while Mitu et al. (2019) observed a ratio of 1:1.22 in the Ganges river of Rajshahi, North-western Bangladesh. These reported sex ratios are specific to the study areas mentioned and similar patterns have not been documented for other natural populations of *M. tengara*.

3.3. Size and age at maturity

The size at first sexual maturity (SFSM) of fish is used to determine the minimum harvest length that is acceptable for reproduction (Rahman, 2017). Therefore, SFSM is essential for evaluating fish reproductive parameters and usually help the experts to evaluate the onset and length of reproduction for the purpose of managing fisheries (Trindade-Santos & Freire, 2015; Freitas et al., 2016). To date, no research has been conducted on this matter for *M. tengara* in captivity except Gupta & Banerjee (2013[a]), who reported that males mature earlier than females with males attaining first maturity at a minimum length of 7.5 cm and females at 8.0 cm. These values are specific to the study population in West Bengal, India. Supporting evidence from other natural populations (three different Oxbow lake) in Bangladesh indicates broadly similar patterns with SFSM ranging from approximately 6.28 to 7.74 cm and age at first maturity around 1.17 to 1.19 years, suggesting that males generally mature slightly earlier than females, although values may vary with local environmental conditions (Islam et al., 2024).

3.4. Gonado-somatic index

The gonad maturation stage along with the degree of ripeness is indicated by the gonado-somatic index (GSI) (Suwa & Yamashita, 2007; Rizzo & Bazzoli, 2020). In *M. tengara*, female mean GSI values ranged from approximately 1% in December to a peak of about 18.2% in July, while male GSI values ranged from roughly 0.2% in December to around 3.5% in July (Gupta & Banerjee, 2013[a]). These data indicate that females maintain higher GSI than males throughout the maturation period. GSI begins to rise from January, increases gradually from April to June, peaks in July, declines from August and reaches its lowest value in December, reflecting the seasonal reproductive cycle of the species. Quantitative data from another natural population (Ganges river of Rajshahi) in Bangladesh show that female GSI ranged from 0.2% in January to a peak of 16.2% in June (Mitu, 2017). These findings further support the use of precise GSI measurements to assess gonadal development and reproductive timing in *M. tengara*.

3.5. Gonadal maturity stages

There is a differentiation on number of gonadal maturity phases of *M. tengara* as reported by several workers. Guraya et al. (1976) have reported that gonadal maturity and spawning initiation of *M. tengara* may be influenced by monsoon rain and long photoperiod. Rastogi & Saxena (1968) and Guraya et al. (1975) have reported seven developmental phases of gonad namely immature virgin, preparatory virgin, maturing virgin, pre-spawning virgin, spawning, depletion and recoupment phase in this species. However, Gupta & Banerjee (2013[a]) have summarizes five maturity phases of gonad namely immature, maturing, mature, ripe and spent. Later, Mitu & Alam (2014) have reported six maturity phases for this fish species namely immature, maturing, mature, ripe, spent and resting.

3.6. Fecundity

One of the most essential aspects of fish biology is fecundity, which is also a major factor in determining the commercial viability of fish stocks (Hughes & Stewart, 2006; Tracey et al., 2007; Kumar et al., 2019). Prior to spawning, the total number of mature eggs in the ovary that must be laid in a single reproductive event is referred to as fecundity and this number varies within species-specific ranges, serving as an auto-recruitment indicator (Alam & Pathak, 2010). According to Khan et al. (1992), *M. tengara* is a low-fecundity species with absolute fecundity ranging from 720 to 5223 eggs. Specific fecundity of *M. tengara* varies among natural populations. Gupta & Banerjee (2013[b]) reported 825 to 1938 eggs per cm of body length, while Mitu & Alam (2014) reported 1215 to 1678 eggs per cm of body length. The observed differences between absolute and specific fecundity are likely influenced by environmental conditions, geographical location, fish size and age as well as sampling methodology (Musa & Bhuiyan, 2007). Variations in water quality, food availability and habitat productivity among study sites can affect gonadal development and the number of mature eggs, resulting in lower specific fecundity values in some populations compared to absolute fecundity (Ogunola et al., 2018).

3.7. Spawning season

The "breeding" or "spawning" season of a species is the specific time and period when it typically breeds (Alam et al., 2012). Knowledge on spawning season is very essential for ensuring the sustainability of the fish population since it forbids capturing spawners during the reproductive time. Each species has a cyclical spawning season during which the organism develops to maturity and prepares to reproduce once more. According to Guraya et al. (1975), breeding season of *M. tengara* ranged from July to September. However, Rastogi & Saxena (1968) have reported that spawning season of this species varies from April to August or early September and June is the peak spawning month. Gupta & Banerjee (2013[a]) have documented the breeding season from May to September with July being the peak month for spawning. Moreover, Mitu & Alam (2014) as well as Mitu (2017) have stated that breeding season of *M. tengara* lasted from April to July with a peak in June.

3.8. Breeding periodicity

According to Prabhu (1956), the length of the breeding period in teleosts is extremely variable as some species spawn only once, others twice, while few may spawn multiple times within a year. Most studies on fish breeding periodicity focus on measures of ova diameter and intraovarian egg maturation (Vladykov, 1956; Sathyanesan, 1962; Yamamoto et al., 1964). Rastogi and Saxena (1968) reported that the ova diameter of *M. tengara* ranged from 0.04 to 0.72 mm with the highest average value (around 0.45 mm) recorded in June. Gupta and Banerjee (2013[a]) similarly documented peak ova diameters ranging from 0.45 to 0.60 mm in July. In contrast, Mitu (2017) observed a wider range of ova diameters (33 to 1629 μm) with the highest mean value (1062 μm) occurring in June. The distribution of ova diameter shows multiple peaks, indicating that *M. tengara* can breed more than once during a single spawning season, classifying it as a multiple spawner (Rastogi & Saxena, 1968; Guraya et al., 1975; Mitu & Alam, 2014; Mitu, 2017). The frequency of spawning in this species is influenced by environmental conditions, such as water temperature, food availability and habitat productivity. Higher temperatures and abundant food resources during pre-monsoon and monsoon periods likely stimulate gonadal maturation, resulting in peak spawning activity, whereas suboptimal conditions may delay or reduce spawning events (Bhat et al., 2025). This ecological flexibility allows *M. tengara* to reproduce multiple times within a breeding season, aligning with observations from natural populations.

4. INDUCED BREEDING AND LARVAL DEVELOPMENT

Culture practices of any given species need adequate quantity of quality seed, which is only possible by the artificial propagation of the species. Fishes have diverse mode of reproduction *vis-à-vis* breeding. The breeding season has been limited to a specific time of year and the majority of teleosts exhibit rhythmic reproductive activity. Thorough study of gonadal development and maturation of desired species is utmost necessary to produce required quantity of seed as it is among the most crucial prerequisites for aquaculture success (Pati et al., 2004; Routray et al., 2007; Bisht et al., 2013; Chakrabarti et al., 2017). The issues with obtaining fish seeds for a specific species have since been resolved by induced breeding or artificial propagation. The standardization of induced breeding technique along with improved larval rearing methods have enabled the large-scale production of high-quality seed in controlled environments, ensuring a reliable and timely supply of stocking material for aquaculture farms. This procedure involves injecting the ripe brood fish with synthetic hormones or other stimulating substances, which encourages the timely release of milt from males and eggs from females in captivity (Lam, 1982; Marimuthu et al., 2000; Aktar & Islam, 2015). However, the most difficult aspect of fish farming is larval rearing, since they have demanding for high nutrition, need live feeds and are extremely sensitive to water quality parameters (Morais & Conceição, 2009; Hamre et al., 2013).

In India, the first study on induced breeding and embryonic development of *M. tengara* was carried out by Talukdar et al. (2024). They collected mature broods (both male and female) from Kapla beel (Lat: 26°20′13.8″ N and Long: 91°13′26.9″E), Barpeta, Assam, India, acclimatized in a glass aquarium (250.5 L) and fed with live *Tubifex* and chopped earthworm twice daily at a rate of 2 to 3% of their body weight. Ripe male with an average length of 7.3±0.5 mm and weight of 12.08±1.14 g along with female having mature ovary with an average length of 8.2±0.61 mm and weight of 13.61± 0.74 g were chosen for induced breeding in the months of June and July with a sex ratio of 1:1. Captive breeding was conducted in FRP (fiber reinforced plastic) hatchery of diameter 148 cm, filled with water up to 10 cm. Selected fish were administered a single dose of intramuscular injection of synthetic hormone (Gonopro FH) at 0.5 mL/kg body weight for the males and at 1 mL/kg body weight for the females. Spawning occurred 7 to 8 h post-induction at a water temperature of 26 to 29 °C with an average fertilization rate of 80.66%. The fertilized eggs were spherical, transparent and highly adhesive with an average diameter of 0.5 mm. The hatching of the embryo occurred after 14 to 15 h post-fertilization. The newly hatched larvae measured with 1.62 mm in length, which were immobile, devoid of pigmentation, transparent and comma-shaped with a spherical yolk sac.

In Bangladesh, Fakhruddin et al. (2022) conducted an experiment at the Tebunia BRAC Fish Hatchery to determine the ideal range of water quality parameters for *M. tengara* induced breeding. They collected healthy and strong bagrid catfish (*M. tengara*) in the month of November from Chalan beel through liaison with many farmers and stocked for six months in a pond that was scientifically prepared. When the trial began in April, the fish was 1.5 years old. Brooders were fed a farm-formulated supplementary diet containing fish meal/highly digestible protein (28%), mustard oil cake (33%), brown rice bran (21%), wheat flour (13%) and molasses (5%) at a feeding rate of 1.5% body weight. Selected mature male and female broods were administered a synthetic inducing substance, i.e., salmon gonadotrophin releasing hormone (sGnRH). The weight ranges for males and females were 40 to 70 g and 50 to 90 g, respectively. Male fish received hormonal doses of 0.4 mg/kg body weight, whereas female fish received 0.8 mg/kg body weight. Following one hour after the induction of females, males were injected. The fish were then released at 1:1 (female and male) ratio into selected concrete tanks. All of the females in the tank ovulated the eggs within 10 to 14 h. To move the eggs into the hatching jar after fertilization, a hapa was made out of georgette cloth and placed in the bottom of a rectangular breeding tank. Water quality parameters like temperature, dissolved oxygen and pH were evaluated in brood rearing pond, overhead tank water as well as in hatching jar to know the optimum levels. The mean temperature, pH and dissolved oxygen varied from 29.75±1.22 to 33.94 ±0.18 °C, 7.10±0.14 to 7.40±0.28 and 4.40±0.57 to

5.35±1.06 mg/L, respectively in pond water, while 26.50±0.71 to 31.00±1.41 °C, 7.00±0.00 to 7.30±0.42 and 3.80±0.14 to 5.50±0.42 mg/L, respectively in overhead tank water. Finally, they found a significant positive correlation among temperature and dissolved oxygen with fertilization and hatching rate.

In another experiment, Fakhruddin et al. (2023) studied the ideal age based on sGnRH dosages for induced breeding of *M. tengara* at Arifa Fish Hatchery, Bogura, Bangladesh. To conduct the experiment, different age groups of fish were stocked (separated by inside netting) in a small brood-rearing pond (20 decimal area with a water depth of 1.5 meters) in February. In that pond, proper quantity of fertilizer, lime and other necessary treatments were given. Additional feed was provided to brood fish at a rate of 1.5% of their body weight. Between April to July, three distinct brood groups with a six-month age difference (1, 1.5 and 2-year-old) were selected in 1:1 (male and female) ratio for induced breeding trial. In each age group, three different doses (0.8, 1.0 and 1.2 mL/kg body weight) of Ovasis (sGnRH) were administered to females, while all males were injected with 0.5 mL/kg body weight. Female broods began releasing eggs 7 h after the treatment and it takes longer than 3 to 4 h for ovulation to finish. Finally, a dose of 1 mL/kg was shown to be optimal for 1-year-old females, whereas 0.8 mL/kg was appropriate for 1.5 and 2-year-old females based on the results of fertilization and hatching rates.

5. CULTURE PRACTICES

Freshwater is becoming more limited, highlighting the need to diversify indigenous fish species to foster aquaculture that balances productivity with ecological considerations. The selection of new candidate species for freshwater farming has implications not only for conservation, but also for the long-term viability of aquaculture (Sarkar et al., 2006). Among the potential candidates, catfish and air-breathing fishes have been proposed as valuable additions to the list of species suitable for freshwater farming. The availability of hatchery-reared individuals of these species could help reduce pressure on wild capture fisheries, thereby mitigating declines in natural populations. Despite this, relatively little effort has been devoted to the cultivation of indigenous species, particularly carnivorous fishes with high market demand. *M. tengara*, a species with strong consumer preference is currently harvested mainly through capture fisheries. Consequently, there is an urgent need to initiate its captive culture (Gupta & Banerjee, 2013[a]). To date, culture practices of *M. tengara* have been reported only by Mondal et al. (2017), who reared wild-collected juveniles (5.09 ± 0.48 cm, 1.38 ± 0.11 g) in traditional polyculture ponds at a density of 5000 per hectare along with mixed Indian major carp fingerlings (4.98 ± 0.61 cm, 1.09 ± 0.26 g) at 14000 per hectare. During the culture period, no commercial supplementary feed was provided. The fish were nourished using farmyard manure (200 kg/ha/month) and household food waste (11.37 kg/ha/day). After 12 months, *M. tengara* reached an average size of 13.92 ± 0.88 cm and a weight of 31.56 ± 2.08 g.

Successful aquaculture of any fish species requires a comprehensive understanding of its biology and husbandry, including life stages, reproductive biology, induced breeding, seed production, nursery rearing, nutritional requirements, farming technology and disease management. However, published information on these aspects is limited for *M. tengara*. A few studies have provided insights into reproductive biology (Gupta & Banerjee, 2013[a]; Mitu & Alam, 2014), feeding ecology (Gupta & Banerjee, 2014; Mitu & Alam, 2016), growth patterns (Mitu et al., 2019; Jana et al., 2022) and preliminary induced breeding (Fakhruddin et al., 2022; Talukdar et al., 2024), which collectively support the need for focused research on captive culture and sustainable aquaculture practices for this species.

6. CONCLUSION

The current review indicates that comprehensive details on the general biology and reproductive cycle of *M. tengara* are well documented. In contrast, there is limited information on induced breeding, seed rearing and grow-out culture of this valued fish as a result of which farmers do not take up this species for culture. We have gathered and reviewed every published document that is currently available about its biology or aquaculture and these will undoubtedly offer guidance for conducting further investigations on various aspects of *M. tengara* in order to advance the scientific aquaculture. Furthermore, it is urgent to conserve this species and evaluate its aquaculture potential. No major attempts have been done until now to establish a large-scale seed production unit of *M. tengara* to fulfill the seed requirement as well as aquaculture practice that meets the market demand, despite the ongoing efforts of researchers on induced breeding, larval rearing and scientific farming. Important research gaps for the development of aquaculture of this species also includes standardizing the optimal water quality parameters, nutritional requirements and appropriate supplemental feed for rearing and growing of the larvae. Future studies should focus on the feasibility of *M. tengara* farming in a variety of culture systems, including cages and tanks (re-circulating or flow-through systems) as well as the development of high-quality seed at different stages of life. In order to address the year-round seed requirements for cultivation of this species, research on domestication and captive maturity through environmental along with hormonal manipulation will be beneficial.

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The authors declare that they have no conflict of interest.

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