An insight to red tilapia breeding and culture: A farmer advisory

Somu Sunder Lingam, R., Stephen Sampath Kumar, J., Chidambaram, P., Aanand, S. Velmurugan, P. and Bhosle Rameshwar Venkatrao

Tamil Nadu Dr J. Jayalalithaa Fisheries University, Nagapattinam, Tamil Nadu, India - 611002

Fish, being a highly traded agricultural commodity, is an important source of nutrition as well as a livelihood for many rural people in developing nations (FAO, 2020). This affordable high quality protein food is either harvested from natural resources via capture fisheries or cultured using available natural resources via culture-based fisheries. However, the over exploitation of natural resources has led to declining returns from capture fisheries. To compensate, commercial aquaculture has emerged as an important food production sector at the global level. Initially, the availability of seed was the major limiting factor for growth of the industry. However, the success of induced breeding in the 1980's revolutionised aquaculture by making plenty of quality seed available for grow-out. In subsequent years, the heavy dependency on hatchery-produced seed and poor management of broodstock has resulted in a deterioration in seed quality, which has led to severe disease outbreaks and economic losses. Experts suggested diversification, through introduction new species or new varieties of strains in aquaculture to overcome this issue.

Tilapia, the most diversified cultivable fish species in the world, has reached new heights of production in recent times. The estimated production of tilapia in 2020 was around 6.8 mmt. At present, the tilapia industry is growing at a rate of 4% (Tveteras et al., 2019). However, disease outbreaks, especially *Streptococcus* infection, significantly threaten the tilapia industry. The industry has introduced various new strains, genetic improvements and better management practices to combat these emerging problems. Among the new strains, red tilapia – an alternative to Nile tilapia – is showing an impressive rate of success in due to its attractive colour, faster growth rate and good market demand. Supply of quality seed will play a major role in achieving the anticipated growth of this industry. Effective broodstock management and proper seed production is required to produce quality seed. To achieve this it is necessary to disseminate knowledge about red tilapia breeding and seed production to farmers.

Status of red tilapia

Tilapia is projected to overtake carp production by 2025. Among the different strains of tilapia developed, red tilapia was first developed in Taiwan, Province of China, during the late 1960's. Originally, red tilapia was a genetic mutant, which was produced by crossing female reddish-orange Mozambique tilapia with normal male Nile tilapia. Later, many countries such as USA and Israel developed their own red varieties using different strains, which changed the genetic makeup of original red strain. Subsequently, scientists have discovered that red tilapia has greater growth potential in salt water and produces fish with slightly higher EPA and DHA content.

After the introduction of red strains in farming, the production of red tilapia significantly increased from the 1980's onwards. In Malaysia, within three decades, red tilapia production exceeded the mossambicus tilapia production. In countries such as Colombia and Jamaica red tilapia replaced the culture of Nile tilapia. In India, states including Kerala, Andhra Pradesh, Tamil Nadu and Odisha have cultured red tilapia for the past 30 years for domestic consumption. Other countries including Thailand and Bangladesh also promoted red tilapia farming. Increased domestic consumption of red tilapia convinced Chinese farmers to popularise red tilapia farming. Presently, four red tilapia strains from Taiwan Province of China, Thailand, Malaysia and the Stirling strain, dominate the red tilapia industry.

Male (top) and female (bottom) red tilapia brooders.

Female (left) and male (right).

Breeding of red tilapia

Tilapia is a prolific breeder and breeds throughout the year. However, comparatively, small sized eggs and low fecundity occur in red tilapia during the summer months (April – May). In general, tilapia breeding is carried out using three methods:

- **Pond-based breeding:** In this method either earthen or lined ponds are used to breed the fish. Since the pond ecosystem provides a natural environment for pit construction – tek – frequency of breeding is high in pond-based systems. However, the collection of broodstock for egg or seed collection is a difficult task in pond-based breeding of tilapia.

- **Tank-based breeding:** In this method concrete cement tanks are used to breed the fish. Similar to pond systems, collection of brooders is a difficult task. However, tank systems are highly suitable for early larval rearing.

- **Hapa-based breeding:** In this method hapa are installed in the earthen ponds to keep the brooders separated for breeding and seed production purposes. Easy handling of brooders, egg and fry collection making this method a more suitable one for tilapia breeding (Bhujel, 1999).

Brooder hapa installation.

Red tilapia breeding using hapa system

The most common and widely practiced successful method of tilapia breeding. In hapa breeding, a set of predetermined numbers of male and female brooders of red tilapia are released and allowed to mate and produce fertilised eggs. However, successful breeding needs technical as well as field level knowledge about red tilapia breeding patterns.

Red tilapia brooders

In any captive breeding activity, the status of the broodstock plays a major role in deciding the success and quality of seeds produced. In hatcheries, healthy brooders are separately maintained using high quality diets. In general, males and females are stocked and reared in the same pond and segregated for breeding after attaining maturity.

Male	Female
Genital papilla is tapered (pointed) in shape	Genital papilla is round (button) in shape
Genital papilla has one opening (urinary pore)	Genital papilla has two openings (oviduct and urinary pore)
Smaller in size with flat belly	Bigger in size with bulging belly

Breeding hapa with red tilapia brooders.

Hapa installation

Hapa are rectangular or square net cages or impoundments, placed inside a pond to contain broodstock during breeding operations. There are different sized hapas available on the market. However, hapa made of polyethylene with total area of 30 m^2 (10 m × 3 m × 1 m) are mostly preferred for easy handling of tilapia broodstock. Hapa are installed and anchored using bamboo poles and ropes. To install one brooder hapa, four bamboo poles of 3.6 m height are required. Each bamboo is cut into two pieces (1.8 m height each, for a total of eight poles) and driven into the pond bottom approximately 30 cm deep. The first two poles are placed parallel to each other at a distance of 3 m. Then, from those two poles, at a 90° angle, two more poles are placed 10 metres apart to make a rectangular shape 10 m long and 3 m wide. After installing four poles, the hapa is tied 30cm above the bottom and 30 cm below the top of the bamboo. Then at approximately 3 m intervals, on both sides, place the remaining four poles. The water level inside the hapa is maintained at 90 cm depth.

Breeding

Once the hapa is installed, broodstock are released inside. Healthy brooders of >200 g size should be selected for breeding purpose. The fecundity of tilapia used to be high at younger age (smaller size), therefore, while selecting the brooders, fish that have crossed the reproductive age (>500 g) should be avoided. Handling difficulty during egg collection and lower breeding frequency are additional problems associated with the selection of older brooder fish.

The sex ratio maintained for red tilapia broodstock is 2:1 (female : male) and stocking density is 2 brooders/m^2. Therefore, a brooder hapa is stocked with 20 well matured males and 40 female red tilapia. However, one or two pairs may be additionally stocked to compensate for the loss of brooders due to natural mortality. Red tilapia, being a prolific variety, breeds once in a month, however, removal of eggs from the mouth reduces the inter-spawning interval and increase the spawning frequency. After the release of brooders in the hapa, they should not be disturbed for 10-15 days and the first egg collection can commence after this period. In breeding hapa, brooders are fed twice in a day (3% of body weight) with a high-quality diet. The fecundity of red tilapia is about 4,500-5,500 eggs/kg body weight.

Egg collection

Eggs can be collected from breeding hapa once in 7-10 days. Egg collection is comparatively easier in hapa breeding than the pond- or tank-based systems. To gather the brooders in one corner, a 3 m long bamboo pole is used. The pole is first placed below the bottom of the breeding hapa, which is then lifted above the water column from one corner. In the same

Female red tilapia incubating eggs in mouth.

position, the pole is dragged from one corner to the other which helps to congregate all the brooders. The pole is then placed over the breeding hapa in such a way that it should temporarily hold the brooders in the corner.

Female fish incubate the fertilised eggs in their mouth. Therefore, while hand picking the brooders during egg collection, their mouth should be closed, otherwise they may spit the eggs into the water. Females with eggs in their mouth should be transferred to an egg collection trough, where their mouth and opercula are opened to collect the eggs. After collection the female fish are released back into the hapa. The egg collection trough is maintained with minimum water (2-3 litres) to maintain the collected eggs in good condition. An average female yields about 1,500 of eggs per cycle. Collected eggs are moved to a jar hatchery. Brooder health condition is also checked during the egg collection process.

Colour of the eggs	Condition of the eggs
Slightly brownish	Good condition and ready to hatch
Yellow	Mostly immature eggs and takes more time for hatching
White	Unfertilised eggs

Tilapia glass jar hatchery

In the hatchery, collected eggs are first measured (by volume, in ml) and counted and loaded in the hatching jar. The jar is a vertical container made of glass or transparent FRP or PE. The jar should be transparent material to allow egg condition to be observed. Capacity of the jar is 5 litres (14.5 cm diameter) and it can be loaded with 250 ml of eggs (approximately 6,250 eggs). With the help of a vertical PVC pipe, water is released in the bottom of the jar to keep the eggs in suspension. Water flow is maintained at 3-5 l/min. The larvae is float to the surface once they hatch, due to the presence of an oil globule, and are collected in the hatchling collection tray. Water overflowing from the hatching jar is passed through a simple biofilter unit, a 200 litre FRP tank filled with charcoal and sand, and collected in a sump. A submersible pump (2 hp) placed in the sump, with a help of sensor, automatically pumps the water to the overhead tank. The treated water stored in the overhead tank is circulated again to the jar hatchery. In this way water flow is maintained in the hatchery to minimise the entry of pathogens and other foreign substances.

Generally, each hatching jar is operated for 48-72 hours after loading the eggs. After this period the unhatched and white coloured eggs are discarded. The fry are collected and kept in a separate tray for 24-48 hours with mild water flow, to complete absorption of the egg yolk. Once, the yolk sac is completely absorbed, the fry are shifted to an all male production nursery rearing unit.

Egg collection from brooders.

Red tilapia glass jar hatchery.

All male production

In general, all male tilapia seed are produced to avoid stunted growth due to prolific breeding behaviour and to obtain better production by the faster growing males in grow-out conditions. Androgenic hormone, 17α methyl testosterone (17α MT), is commonly mixed with the feed and fed to the early fries to convert them to males. Producing all male seed using hormone is the cheapest and easiest method, however, it has various environmental as well as potential human health issues. 1 kg of hormone incorporated feed is prepared by dissolving 70 mg of 17α MT in 125 ml ethanol. The dissolved content is sprayed over fry feed having a protein content of >34% and mixed well. Then the feed is dried for overnight and stored in good condition. Gloves should be worn while preparing the feed to avoid direct contact with 17α MT.

Yolk sac absorption tray.

The hormone-treated feed is fed to fry for 21-28 days. In general, either indoor or outdoor based cement tanks are used for all male production rather than the hapa-based system. The availability of natural feed in the hapa-based system leads to poor sex conversion. Generally, square cement tanks (2 m × 2 m × 1 m; 4,000 l capacity) or rectangular tanks are preferred for all male red tilapia production. Stocking density is maintained at 2 individuals/l. Fry are fed four times in a day at 10-12% body weight. Once in three days, 30% of the water needs to be exchanged to get better production. The development of algae along the walls of cement tanks should be avoided, because behavioural domination has been noticed among the red tilapia fries. The domination of shooter fry during feeding leads the weaker fry to graze the algae developed along the walls which again affects the effectiveness of sex conversion.

Fry rearing in nursery hapa

25-30 day old all male seed (approx. 1.5-2.0 cm) are stocked in hapa, installed at ponds. Generally, nursery hapa (8 m × 3 m × 1 m) with a closed top are used for nursery rearing to avoid the entry of fish eating birds. At one corner, a zip-like opening is provided to open the hapa for feeding. Each hapa

can be stocked with around 10,000 fry (400-425 fry/m^2). Fry are fed four times daily. Rearing is continued for 30-45 days, as per the size requirement. Once they reach 3-5 g the seeds are transferred to grow-out ponds.

Grow-out culture

Fingerlings (4-6 cm) are directly stocked in fertilised pond for grow out culture. Generally, rectangular ponds of 1,000 m^2 are preferable. Fingerlings are stocked at the rate 5 individuals/m^2 and fed twice a day. Water depth should be kept above 1 m and care taken to ensure the availability of natural food in the culture pond to maintain the colouration. Culture duration is 4-6 months and it varies based on the growth performance and market demand. Harvesting at a size of >300 g size fetches a good market rate (Rs. 120/Kg) in the local market. Mostly fish are supplied to the local market and very few commercial farmers are involved in exports.

Water quality

In any aquaculture activity water quality is one of the major factors that decide the successful production of fish. Therefore, knowledge about the physical, chemical and biological parameters of water are more important. However, red tilapia, being hardy varieties, tolerate a wide range of environmental variations. Red tilapia can tolerate and be grown in the following water quality conditions:

Water quality parameter	Range
Dissolved oxygen (mg/l)	3-5
Temperature (°C)	24-32
Salinity (ppt)	0-35
pH	6-9
Alkalinity (mg/l)	20-400
Hardness (mg/l)	20-500
Ammonia (mg/l)	0.01 – 0.1
Nitrite (mg/l)	0.01 – 0.1

Feed management

Feed plays a major in broodstock development because the quality of seed produced is directly proportional to the quality of broodstock. In the case of grow-out culture, most of the farmers are using locally available low cost ingredients such as rice bran, groundnut oil cake, and broken rice to feed the fish. Since, red tilapia is a voracious feeder, it is recommended to feed them three to four times a day. On the other hand, all male production unit must use pellets with >32% crude protein to avoid morphological deformities in the developing fry. The following feeding schedule can be practiced for red tilapia to obtain better production:

Stage of fish	Crude protein (%)	Feedings	Ration (% bw)
Brooder	28-32	2 / day	2-3 %
Fingerling	24-28	2 / day	3-5 %
Fry (nursery)	28-30	4 / day	8-10 %
Fry (all male production)	>32	4 / day	10-15 %

Challenges in red tilapia farming

- The non-availability of a sufficient quantity of quality seed limits commercial level farming of red tilapia in many parts of the world.
- The improper management of broodstock may lead to inbreeding which results in low quality seed production.
- Red tilapia is a hybrid variety, therefore, strict biosecurity measures must be implemented in farms to prevent the escapement of culture stocks to the wild which may lead to genetic pool contamination of wild or native stocks.
- Sex conversion and all male seed production using hormone incorporated feed may have impacts on natural ecosystems due to residual effects.

References

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