Breeding technology for Nile tilapia in Aquaculture hatcheries

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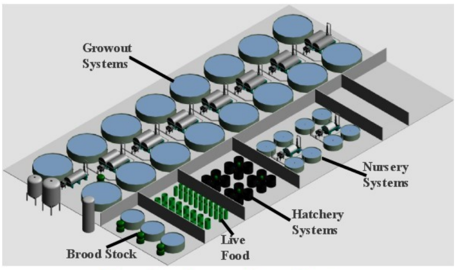
The Nile tilapia (*Oreochromis niloticus*) is famous in aquaculture and this fish is cultured as a food source in over seventy countries. Nile tilapia is considered the best species among all the tilapia species for Aquaculture production. There are several different strains used in Aquaculture. The *Chitralada* or *Thai* strain, originally Egyptian strain, is considered one of the purest ones. It has a high growth rate and reproductive ability. *GIFT* (genetically improved farm tilapias) strain developed by ICLARM (World Fish Center) is regarded as a good strain for its fast growth and high fillet yields. Other strains include Ivory Coast, Ghanian, Stirling, Vietnamese and other various local strains found in Asia. It is suggested for those who want to start a large hatchery; start with new and the best original genetic stocks available from a registered and reliable commercial tilapia hatchery. Total number of broodstock required can be calculated based on the production target assuming an average of 250 to 500 eggs that can be collected from a female per month under natural conditions, depending on her size. The eggs have about 30 % overall survival until being ready to be sold as fingerlings to customers.

Reproduction methodology:
Nile tilapia can live longer than 10 years in nature. Food availability and water temperature appear to be the limiting factors to growth. Optimal growth is achieved at 28-36°C and declines with decreasing temperatures. In aquaculture ponds, *O. niloticus* can reach sexual maturity at the age of 5-6 months (20-30 cm or 150-250 grams). Under aquaculture conditions, tilapia generally mature at smaller sizes than in natural environments.

Males initiated breeding with the creation of a spawning nest, which is fiercely guarded. When the water temperature increases above 24°C a female will lay her eggs into the nest. These are then fertilized by the males before the female collects them in her mouth (known as mouth brooding). The eggs, which will then hatch, are incubated and brooded in this manner until the yolk sac is fully absorbed. Two weeks later the female will start to spit the fry out. Tilapia are characterized by low fecundity and relatively large egg size. The number of eggs a female will produce is dependent on body size. This can range from 100 eggs (produced by a 100 g fish) to 1500 eggs (spawned by a 1 kg fish). In most tilapias, fecundity varies considerably among fish of the same species, and even among females of similar sizes, especially in large fish classes. Fertilized eggs are yellow, have an elongated or ovoid shape and measures between 1.3 and 1.8 mm in diameter. The eggs are sticky and can thus adhere to the substratum and will not be subject to continual disturbance by water currents. The eggs hatch after about 10 days and the young fry remain in the female's mouth for a further two days. After their storage yolk has been used, fry begin making feeding sorties but always remain as a compact shoal and never stray more than about 25 cm away from the female. The females will not eat while the juveniles are in her mouth and she will not spawn while brooding. Males on the other hand fertilize the eggs of multiple females continuously given optimal environmental conditions.

Tilapia can be bred in ditches, rice fields, ponds, hapas, net pens, cages or tanks depending upon the available facilities and the scale of operation.

Hatchery design:
Hatchery tanks constructed from fiberglass, plastic, glass, concrete, or wood (fitted with a plastic liner) that range from 4 to 100 m^2 and up to 1.5 m deep are used for tilapia seed production. As with hapas, tilapia seed that ranges from fertilized eggs to swim-up fry can be produced in tanks. Broodfish stocking rates can vary from 3 to 10 fish per square meter, and broodfish sex ratios vary from one female to one male up to ten females to one male. However, the most common sex ratios used are one to four female broodfish per male. Stocking density for broodstock can vary depending on the type of production facilities used for the hatchery. Normal stocking density of broodfish is 2 fish m^2 (1:1) in ponds, 6 fish m^2 (3:3) in hapas and 10 fish m^2 (5:5) in tanks. The normal Recirculation Aquaculture System components are included in the design of a typical tilapia RAS hatchery. A heat pump can be included in the RAS system in sub-optimal climatic areas to keep the water warm enough for breeding purposes. Maintenance of good water quality is critical to successful hatchery operations.



Complete Aquaculture Systems





Broodstock selection and conditioning:
As broodstock fish are the key element of the hatchery, their quality and management affect the quality and quantity of seed production, which are ultimately the major indicators of success or failure of the hatchery. When obtaining breeding stock, the farmer must ensure that the brooders are from good genetic material. Geographical varieties and consistently inbred strains all show different characteristics and many are inherently poor growers. Thus, genetic selection of stock is vital. Always select fast growing stock varieties that are well-proportioned, deep anterior body-breast area (behind the head) for optimum fillet yields.

Interspawning interval:
The removal of eggs and sac-fry from mouth-brooding females shortens the interspawning interval and increases the spawning frequency. The removal of eggs and sac-fry at 5 to 10 day intervals significantly increases seed production compared with natural egg incubation and compared with egg and sac-fry removal at 2 to 4 day intervals. The inter-spawning interval is also shortened through the exchange of broodfish. For example, each time eggs and sac-fry are collected from mouth-brooding females, either only the spent females or all females are exchanged for broodfish that have been conditioned for 10 days. During conditioning, only female broodstock are stocked, at high density, and they are fed with a high-quality formulated feed for 5 to 10 days. Broodfish exchange and conditioning also increases spawning synchronicity, possibly through disruption of established social hierarchies and maintenance of elevated concentrations of the gonadal steroids 17ß-estradiol and testosterone. Daily Nile tilapia seed production for a 10-day harvest interval increases from 31 seeds per kilogram female weight where only swim-up fry are removed to 106 seeds per kilogram female weight where seeds are removed and spawned females are exchanged, to 274 seeds per kilogram female weight where seeds are removed and all females are exchanged. Seed harvested at 10 day intervals from all treatments included swim-up fry and fertilized eggs. Conditioning females for 7 days and exchanging females every 7 days may be more economical than a 10 day conditioning period and 5 day harvest interval.

Incubation:
Eggs harvested from broodfish in hapas or tanks must be incubated in hatchery facilities. Tilapia eggs are negatively buoyant and, in the absence of a current to suspend them in the water column, they sink quickly and clump together. A variety of incubation systems have been used successfully for tilapia eggs. When up-welling Zuger-type

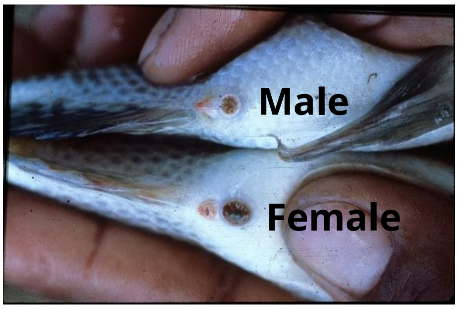
hatching jars have been used for tilapia eggs, incubation success has been variable because of incubation-induced mechanical injury to eggs and subsequent secondary infection. Down-welling round-bottom incubators result in 17 to 22 % greater hatchability and an improved overall survival (85 %) from egg to 10-day-old swim-up fry compared with overall survival (60 %) for conical up-welling incubators. Egg loading rates range from 650 to 1 350 eggs per liter in small incubators, and up to 4 000 eggs per liter in large incubators. Water flow rates are 1 L/min in small incubators and 1 L/s per 10 000 eggs in large incubators. Sac-fry harvested from broodfish also must be held in the hatchery until yolk sac absorption is complete. When the fry reached a total length in size of 6 to 7 mm (1 to 2 grams) they can be moved to the nursery tanks.

Sex control:

Tilapia males grow approximately 40 % faster compared to sexually matured females and all male populations are usually used for grow out purposes on commercial farms. Sex reversal has become a widely used method of producing all-male tilapia populations. Various hormones have been used by fish culturists to produce sex-reversed tilapia, with some form of methyl or ethyl testosterone being the most common. The standard technique is to dissolve the hormone (commonly used hormones have been synthesized and are readily available) in alcohol. The alcohol is then poured over prepared feed and allowed to evaporate, resulting in the feed being coated with small amounts of the hormone. [Methyl testosterone works well with 30 to 60 mg/kg of feed (30 to 60 ppm).] Immersion in hormone solutions has also been used for sex reversal. First-feeding fry are provided with the treated feed, usually for about three weeks. If the process is done properly, 95 to 100 % male populations can be produced. The most recent development involves the production of YY males—that is, males with two Y chromosomes (diploid males are normally XY). The process involves exposing normal male tilapia fry to estrogens (female hormones) to produce females that are XY instead of XX. When feminized males are bred with normal XY males, the offspring produced will have the following genotypes: 1 XX female: 2 XY males: 1 YY male. Mating YY males with normal XY females will result in all-XY male offspring. Producing YY males requires extreme care in identification of the genotype of each fish produced from the pairing of feminized males with normal males.

Fry nursery rearing:

Tilapia swim-up fry must be reared to 1 to 2 grams average weight before being stocked into nursery ponds. Generally, fry rearing occurs simultaneously with sex reversal. As



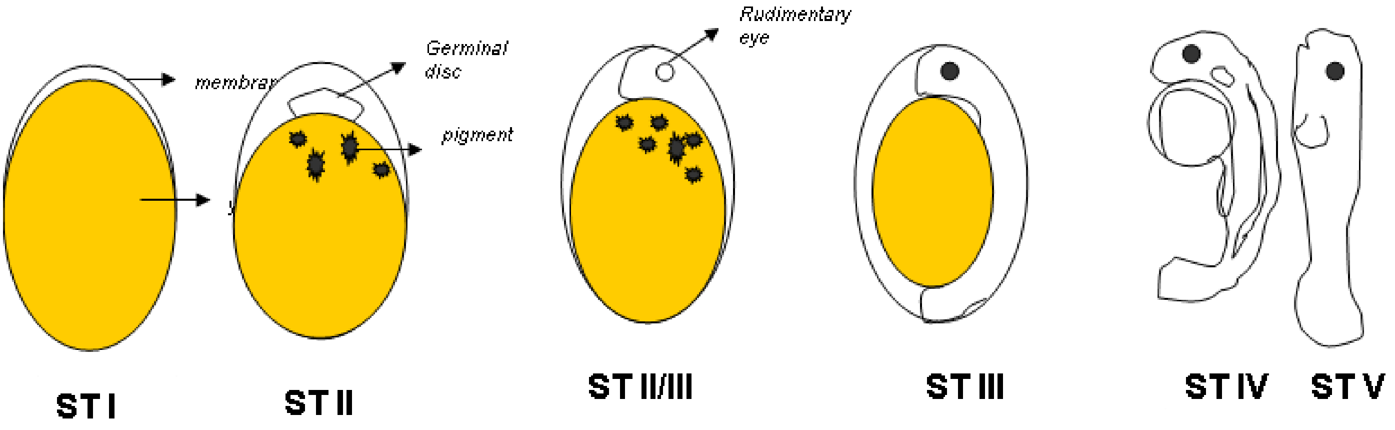


Figure 1. Different developmental stages and descriptions of Nile tilapia eggs in the hatchery facilities of Aquaculture and Aquatic Resources Management (AARM) Field of Study of the Asian Institute of Technology. Numbers were assigned arbitrarily. *Note:* ***Drawings were based on eggs observed in the stereoscope.***

Stage No.	Description	Incubation system	Stocking density (gram)	Water rate (pressure)
I	Light to dark yellow in colour. Less than 24 hours after fertilisation.	Jar	300 - 400	High
II	Presence of pigment and germinal disc. If the colour is golden yellow, it is more efficient to incubate the eggs in the incubating trays.	Jar	300 - 400	High
II/III	Rudimentary eyes are visible and heartbeat can be also observed. The eggs should be further hatched in incubating trays.	Tray	80 - 100	High
III	Pre-hatch stage. Head, eyes and tail are visible. Fry is moving by the later development of ST III.	Tray	80	High
IV	Hatchlings.	Tray	80	Medium
V	Swim up fry ready for stocking in sex reversal treatment hapas.	Tray	80 - 100	Low

Table 1. Summary table on the different stages of Nile tilapia eggs, incubation systems, stocking density in each type of incubation system and water flow rate for the different stages of eggs. Information in this table were based on the evaluation carried out at the AARM/AIT hatchery during the month of January with the temperature of 28 °C in jar and 27.5 °C in trays.

with reproduction, tilapia fry can be reared in hapas (2 to 5 m^2 surface area) suspended in fertile earthen ponds, hapas suspended in concrete tanks, stocked free in tanks (5 to 25 m^2 surface area), or stocked free in earthen ponds. Stocking rates vary from 2 000 to 16 000 fry per square meter in hapas suspended in either ponds or tanks, from 150 to 750 fry per square meter free in tanks, from 75 to 260 fry per cubic meter free in ponds, from 6 000 to 12 000 fry per cubic meter in recirculating tank systems, and from 8 000 to 18 000 fry per square meter in tanks with continuous water exchange. The fry-rearing phase generally lasts 28 to 30 days. Fry growth is a function of water temperature, stocking rate, feeding rate, and quality of feed.

Conclusion:

Closed recirculating systems can in theory produce tilapia at an estimated cost of R 40 to R 50/kg and have the potential for profitable operation by supplying ethnic live fish markets, fresh tilapia niche markets for the LSM 8-10 market groups and value added products for the high income professional consumer, but these are rather limited and easily saturated. The future of tilapia aquaculture in temperate, developed locations lies in marketing campaigns to portray fresh, locally produced tilapia as a high quality product worthy of premium prices.

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Sources:

Some of the photos are "Google images"