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Review Article

The Hatchery Management of Genetically Improved Farmed Tilapia (GIFT)

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Abstract

In order to meet future global food demand, aquaculture posses great potential and is considered as one of the most promising sectors to feed the growing population sustainably with lower carbon output. There are many candidate species which are suitable for aquaculture in tropical and sub-tropical region but one of the species which could help us achieving our sustainable goals such as zero hunger is Tilapia. Tilapia is the most nutrient-dense, and best-suited fish for culture. World Fish Centre (formerly as ICLAARM) came forward with the mono sex production of tilapia through selective breeding which is called as GIFT Tilapia. However, according to research on the state of cultured tilapias, the absence of a viable seed production plan may weaken efforts to assist farmers who are currently growing tilapias and endanger the successful adoption of improved technologies and strains. This article will discuss briefly the origin, biology, and potential of the species in context with global and Indian scenarios. In addition to this, the important aspect related to breeding is discussed based on the small experiment which could benefit the farmers and young professionals to understand the technical aspects of tilapia breeding and culture.

Keywords: Tilapia Seed Production; Breeding Methods; Hatchery Management; Feed Preparation

Introduction

Native to Africa, *Oreochromis niloticus,* also known as the Nile tilapia, is a popular tropical food fish. For Nile tilapia, a number of selective breeding projects have been established and are still in operation, including FaST (Bolivar 1998), GIFT (Genetically Improved Farmed Tilapia; Eknath., *et al*. 1993; Eknath and Acosta 1998), GET-EXCEL (Tayamen 2004), and GST (GenoMar Supreme Tilapia; Zimmermann and Natividad 2004). In Asia, where the fish are fed prepared feeds, these selective breeding procedures are typically carried out under more intense culture systems. Aquaculture, the sector of the food industry that is growing at the fastest rate, provides perhaps half of the world's fish supply. It is anticipated that aquaculture production would increase by 40% by 2030 to fulfil the rising demand for fish around the world. Tilapia, the second-most farmed fish in the world today, has had a tremendous impact on the development of aquaculture and will continue to do so in the future [7].

A new breed of tilapia called Genetically Improved Farmed Tilapia (GIFT) is providing households with a reliable source of food and nutrition while also providing small-scale farmers with a source of income. To be quick-growing and adaptable to a variety of conditions, the GIFT strain was developed as part of an innovative selective breeding process that began in 1988 [7].

Figure 1: Larvae of GIFT Tilapia.

History and biology of gif tilapia

From 1988 to 1997, five different research institutions worked together on the GIFT project, which was carried out in the Philippines [1,2]. The primary objective of this initiative was to "increase the quantity and quality of protein consumed by low income rural and urban populations in tropical developing nations, as well as in other parts of the world, resulting in an increase in the income of low income producers" [3].

The Philippines Bureau of Fisheries and Aquatic Resources (BFAR), the International Center for Living Aquatic Resources Management (ICLARM, now the World Fish Center), the Freshwater Aquaculture Center of Central Luzon State University (FAC-CLSU), the Marine Science Institute of the University of the Philippines (UPMSI), and the Institute of Aquaculture Research, Ltd., Norway, were the participating institutions. The Asian Development Bank, the United Nations Development Program, and ICLARM all contributed funding to this project [2].

The GIFT project had three specific objectives:

- To strengthen national institutions in aquaculture genetics research.
- To develop improved breeds of Nile tilapia (*Oreochromis niloticus*).
- To provide those fish breeds to national testing programmes, and to fish farmers, and to establish a mechanism for international exchange and evaluation of those improved breeds and research methods [3].

There are several reasons why the Nile tilapia was selected as the focal species. It is the ideal species for a breeding programme because of its quick generation time-roughly 8 months [4]. The significance of this species in aquaculture was likewise rising quickly [5,6]. In contrast to carnivorous species that mainly rely on fishmeal or other expensive animal protein, the omnivorous diet of the Nile tilapia makes it a great candidate for low-cost aquaculture [3].

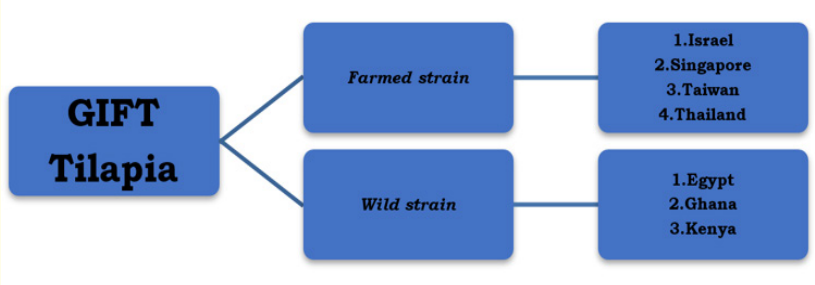


Figure a

Additionally, there were additional Nile tilapia resource stocks in a number of African and Middle Eastern nations.

In 1988, the "World Fish Centre" used selective breeding to create a fish in collaboration with the Philippines and Norway. In August 2011, India purchased 60 families of the GIFT base population (10th generation) from the World Fish Centre in Malaysia. In India, the Rajiv Gandhi Centre for Aquaculture (RGCA) in Vijayawada pioneered the manufacturing of GIFT seeds.

Why GIF tilapia is a suitable candidate species

Due of its distinct traits, tilapia becomes an excellent option for selective breeding to improve its genetic makeup. Being omnivorous, it may be raised in a variety of agricultural systems and just needs a small amount of fish meal in its diet. It can thrive in both freshwater and marine habitats and has a high natural tolerance to varying water quality. Since tilapia are resilient and have strong disease resistance, small-scale farmers can easily and affordably produce them for food, nutrition, and money [7].

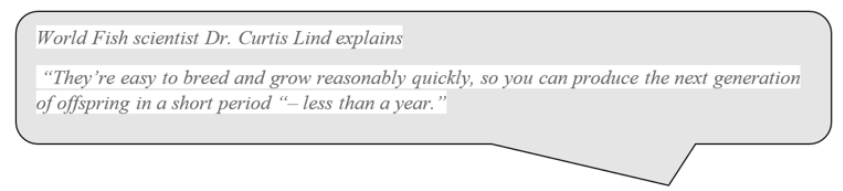


Figure b

Significance of GIFT strain of tilapia

- Sustainable farming
- Short Culture time
- Feed adaptability.
- High stocking density
- Highly Nutritious
- Hardy fish
- Faster growth rate
- Good market Demand

Steps to start farming

- Registration at the State Fisheries Department
- After approval - Selection of the site and Pond preparation
- Quality seed stocking with optimal density
- Ensure Biosecurity
- Don'ts - Farmers are not allowed to sell the seed or brooders.

Breeding scenario of GIFT strain of tilapia in India

Tilapia exports from India to other nations have previously been negligible, yet there is immense potential for this fish's export. Tropical regions are the best places to grow this fish because of the ideal temperatures for rapid growth. This fish can withstand temperatures between 82 and 86°F.

This fish reproduces a lot, and persistent efforts by a number of research organizations resulted in the development of monosex

Years that GIFT has been developed through selective breeding	No. of countries World Fish has distributed to GIFT to	No. of GIFT generations through selective breeding	No. of continents farming GIFT
28	16	20	5

Table a

all-male cultures. Currently, our nation is successfully producing and farming genetically modified farmed tilapia (GIFT). This species grows from 50-80 gm stocking to 600-900 gm size in within 6 months [8].

- The Rajiv Gandhi Centre for Aquaculture in Vijayawada provided criteria which are followed in order to implement the GIFT breeding method.
- Brooders must be purchased from RGCA Vijayawada.
- A single brooder is utilized for 40 cycles of reproduction in accordance with RGCA norms.

Breeding of GIFT tilapia

Tilapia are prolific breeders and have a year-round breeding cycle. GIFT tilapia have low fecundity and, in contrast, produce smaller-sized eggs throughout the summer (April-May).

Generally, three techniques are used to breed tilapia

- Pond-based breeding: In this technique, the fish are bred in lined or earthen ponds. Pond-based systems have a high breeding frequency because the pond habitat offers a natural setting for pit construction (tek). However, gathering brood stock for egg or seed harvest is a challenging task when growing tilapia in ponds.

- **Tank-based breeding:** This method involves breeding fish in concrete or cement tanks. The collection of brooders is a challenging task, much like pond systems. Tank systems, however, are ideal for early larval rearing.
- **Breeding using hapa:** In this technique, hapa are put in the clay ponds to keep the brooders apart for breeding and seed production. This approach is ideal for tilapia breeding due to the simplicity of handling brooders, eggs, and fry. (Bhujel, 1999).
- **Holding in Hapas:** Hapas are fixed net enclosures that are held in, resembling an inverted mosquito net. It is constructed from polyethylene netting with double-stitched nylon thread seams to prevent splitting. The typical dimension is 3*10*1m. Typically, the mesh size is 60 mm of blue material. Brooders were stocked in a 1:2 (male: female) ratio, with each brooder weighing between 120 and 300g [9].
- **Conditioning of brooders:** Brooders should be conditioned at least two weeks prior to stocking in breeding hapas. Tilapia brooders are fed a balanced diet (about 30% crude protein) at a feeding rate of 2 to 5% of their body weight during conditioning [9].
- **Evaluation of sexual maturity condition:** After conditioning, the female brooders should be checked for their readiness to spawn by visually examining their morphological characteristics. Female brooders are then categorized into one of the following maturity conditions:

Figure 2: Hapa breeding of GIFT Tilapia.

Category	Code	Morphological characteristics	Days until spawning
Ready to spawn	RS	Pink to red and protruding genital papilla, fully opened genital pore, and distended abdomen	3 to 7
Swollen	S	Pink to yellow genital papilla, slightly opened genital pore, and slightly distended abdomen	5 to 10
Not ready to spawn	NRS	White to clear and flat genital papilla, and normal abdomen	21 to 30
Has spawned	HS	Red genital papilla, and shrunken to compressed abdomen	15 to 30

Figure 3: Sexual maturity conditions of Female.

A mating strategy involving all selected brooders should be devised. Generally, each male breeder is mated at random to two female brooders.

- **Mouth clipping of males:** To avoid, or at least reduce, mortalities, the body weights of female and male brooders should be as close as possible to each other. Male brooders have their mouths clipped before breeding (to prevent fighting between two males competing for a female) and during mating. Mouth clippings of male GIFT Tilapia that are much larger than the female brooders to reduce their aggressive behavior.
- **Breeding process:** Females first release eggs, then males release semen eggs just 16 seconds later for fertilisation (external fertilization). Once after fertilisation is completed, maternal care has been done by the female brooder. The female keeps eggs in the buccal cavity
- **Egg collection process:** After being released into the hapa, brooders should be advised to maintain for 10 to 15 days before the first egg collection may start. In a breeding hapa, brooders receive a premium feed twice daily (3% of body weight). Once every 7-10 days, eggs from breeding hapa can be harvested. For upcoming cycles, eggs are collected on the 7^{th} day in summer and the 10^{th} day in winter.

Comparatively, collecting eggs in hapa breeding is simpler than in pond-or tank-based systems. Using a 3 m bamboo pole, the brooders are gathered in one corner. The pole is first positioned below the breeding hapa's base, and it is then raised from one corner over the water column. The pole is moved from one corner to the other while remaining in place, which is helpful, as shown in the figure 4.

All of the brooders will be gathered in one corner by two people holding the pole and dragging the hapas. By pressing the operculum, which opens the female's mouth, the eggs can be checked within. As soon as eggs are recognized in the mouth, they are collected in a container.

Figure 4: Dragging of brooders to one corner using pole.

Figure 5: Female tilapia with eggs in mouth.

After egg collection, it is carried inside to a facility where cleaning and disinfection procedures are performed. Eggs are cleaned of debris and other particles using fresh water two to three times, and then disinfected using 30 ppt salt for three to five seconds. This is done mostly to prevent fungal infections.

Figure 6: Disinfection of eggs.

Stocking of eggs in jar

Once all the processes are carried out, the eggs are stocked in jars in a range of 250ml per jar. Generally, per ml, 120 eggs are there. It takes around 7 days for the eggs to fully hatch. After that, it will be kept in an FRP tub for the following 7 days. Then it will be kept in outdoor hapa for the following 7 days.

Figure 7: Jar hatchery (7 days).

Hormonal feed preparation

Role of hormones in feed preparation

All male populations are produced for maturation and commercialization. tilapia populations that are "completely male" are produced for the production system Because of sexual dimorphism,

Figure 8: FRP Tank (7 days).

Figure 9: Outdoor Hapa (7 days).

Figure 10: Preparation of Feed.

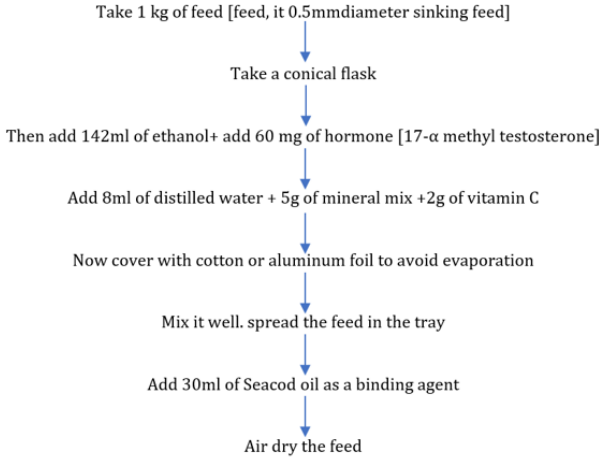
Figure 11: Hormonal Feed.

which refers to the fact that males are noticeably larger than females, monosex culture of male tilapia is frequently favoured to a mixed sex system (e.g., Ponzoni., *et al*. 2005; Nguyen., *et al*. 2007). In addition, due to congestion and feed competition in production ponds, this species' premature reproduction also contributes to the low growth performance of stocked fish. To produce monosex tilapia populations for the production system, a variety of techniques are available, including manual sexing, interspecific hybridization, androgenesis, triploidy, transgenesis, hormone sex reversal, and YY male technology (Beardmore., *et al*. 2001). The effectiveness of these technologies, however, varies with population, fry production seasons, and cultural conditions. All of the "all male" manufacturing techniques that are now in use have one or more drawbacks that either render them inefficient, unsustainable, or unacceptable.

For instance, customers' concerns about food safety have increased as a result of hormone-masculinizing tilapia. In the case of YY technology, it requires three generations of breeding to produce YY males. This indicates that if the source population is being selected, the YY men will be three generations behind in terms of genetic gain by the time they are available for use. Practically speaking, this might range from 20% to 45%, depending on the population's rate of development. Additionally, the use of YY technology depends on the involvement of a lab with reasonably sophisticated resources for producing YY males. It establishes a dependency between the laboratory, which supplies YY males, and the hatchery, which produces only male offspring for the production system. In general,

this is not a scenario to be encouraged, and in developing nations even less so (2011; Ponzoni., *et al*.). Therefore, we are attempting to prepare hormonal [17-methyl testosterone] feed in GIFT tilapia in order to maximize male production.

Procedure



Conclusion

Tilapia is considered as "Aquatic Chicken", according to FAO 2022, also it is the third most consumed fish around the world about 9% of total in 2020. Moreover, Tilapia has played a significant role in food security across many countries. Though World Fish Centre has completed 28 years of research, they are still working to improve the varieties and strains for better growth and disease resistance. Constant efforts are required to provide better quality of seed and knowledge to the farmers which will enable farmer to earn a higher return on their investment and better livelihood. We can also ensure the profitability as seen in some nations where, genetically modified tilapia has raised the country's tilapia production rate and reduced consumer prices. Hence, it can be concluded that the tilapia farming could be a game changer for the Indian farmers and aquaculture landscape.

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