REPUBLIC OF KENYA
MINISTRY OF FISHERIES DEVELOPMENT
DIRECTORATE OF AQUACULTURE DEVELOPMENT

5. FARMING OF TILAPIA IN PONDS

1. BIOLOGICAL CHARACTERISTICS OF TILAPIA:

I). Introduction

Tilapia is a general name of a group of cichlids endemic to Africa. All tilapia species are nest builders; fertilized eggs are guarded in the nest by a brood parent. The genera *Sarotherodon* and *Oreochromis* are mouth brooders; eggs are fertilized in the nest but parents incubate them in their mouths. For the *Oreochromis*, only females practice mouth brooding, while in *Sarotherodon*, either the male or both male and female mouth brood. The important aquaculture genera in Kenya are; *Oreochromis*, and *Tilapia*.

Tilapias are natives of Africa but have been introduced and produced widely around the world. They are primarily freshwater fishes. They are very tolerant of low water quality and can survive with low dissolved oxygen and even live and breed in saline water. They are hardy, grow well under crowded condition, resist diseases, have a higher fecundity than most fishes and reproduces freely in ponds. They grow well in culture systems, have well established markets around the world and are popular in various product forms.

Mbugua HM

Figure 1: Oreochromis niloticus (Nile tilapia)

Tilapia farming involves the culture of following species

(i) *Oreochromis niloticus*
(ii) *Oreochromis mossambicus*

(iii) *Oreochromis aureus*
(iv) *Oreochromis spilurus*
(v) *Oreochromis andersonii*
(vi) *Tilapia zillii.*
(vii) *Tilapia rendalli*

II). Feeding Habits

Tilapias are heterogeneous in their feeding. They are hardy, have rapid growth, and have ability to consume and efficiently assimilate a wide variety of foods. Various species are omnivorous; others feed on phytoplanktons while others are macrophyte feeders.

(i) *Omnivorous are; 0. mossambicus, O. niloticus, 0. spilurus, 0.andersonii and 0. aureus.*
(ii) *Phytoplankton feeders; O. leucostictus O. Macrochir O. esculentus O. alcalicus grahami and S. galilaeus*
(iii) *Macrophytes (feed on larger plants) feeders; T. rendallii and T. zillii.*

III). Maturation

In natural water bodies, tilapias mature in about two to three years. Under culture they tend to mature early. Sexual features distinguishing males from females are clear when fish mature (about 15 cm in *Tilapia zillii* and 10 cm in *Oreochromis niloticus*). Males have two orifices situated near the ventral (anal) fin, one is the urinogenital aperture and the other is the anus. The females have three orifices, the genital opening the anus and a urinary orifice (difficult to visualize with the naked eyes). Separation of males and females can be made easier by applying dye (India ink, indigo, etc.) to the papilla with a cotton swab to outline the male and female openings.

IV). Fecundity

Fecundity refers to the number of eggs produced by a fish in a spawn. This applies well for monocyclic species, that is, once a year breeders. Tilapias are polycyclic (many times breeders) and their ovary may contain eggs at different stages of maturity.

In substrate brooding tilapias, fecundity is much higher than mouth brooders. Other characteristics that differentiate substrate brooders (*Tilapia*) and mouth brooders (*Oreochromis*) are:

Table 1: Some characteristics that differentiating substrate brooders (*Tilapia*) and mouth brooders (*Oreochromis*)

Characters	***Tilapia***	***Oreochromis***

Fecundity	high	low
Egg diameter (mm)	1-1.5	up to 5.0
Yolk percentage	less than 25%	up to 45%
Yolk colour	pale yellow	orange
Size of fry at feeding	5-6 mm	9-10 mm
Courtship	prolonged (monogamous)	brief (polygamous)
Juvenile mortality	high	low
Longevity	up to 7 years	over 9 years

V). Environmental requirements

a) Optimal Temperature

Temperature affects fish distribution, survival and growth, rate of development, reproduction and even susceptibility to diseases. Various species and strains of tilapia differ in tolerance to low temperatures, but growth is generally limited at water temperatures below 16^{O}C and most become severely stressed at 13^{O}C. Death occur from 12^{O}C with few surviving temperatures below 10^{O}C. Most will not feed or grow at water temperatures below 15^{o}C and will not spawn below 20^{O}C. The normal water temperature should be between 20 to 30^{o}C. Metabolic rate rises at higher temperatures which lead to death.

b) Optimal Dissolved Oxygen (DO)

Tilapias are able to tolerate low levels of ambient oxygen. Usually, well fertilized ponds will have low levels of oxygen early in the morning. Night activities are dominated by respiration and decomposition which reduce DO. Larger fish are less tolerant than juveniles. This could be due to the difference in their metabolic demand. The optimal DO for tilapia culture is 4 mg/litre (50%) and should not go below 2.3 mg/litre

c) Salinity

All tilapia are tolerant to brackish water. The Nile tilapia is the least saline tolerant of the commercially important species, but grows well at salinities up to 15 ppt. The Blue tilapia grows well in brackish water up to 20 ppt salinity, and the Mozambique tilapia grows well at salinities near or at full strength seawater

d) pH

Tilapia can survive in pH ranging from 5 to 10 but do best in a pH range of 6 to 9.

e) Ammonia

Massive tilapia mortality will occur within a few days when the fish are suddenly exposed to water with unionized ammonia concentrations greater than 2 mg/L. Prolonged exposure (several weeks) to un-ionized ammonia concentration greater than 1 mg/L causes deaths, especially among fry and juveniles in water with low DO concentration.

f) Nitrite

Nitrite is toxic to many fish and chloride ions reduce the toxicity. Tilapias are more tolerant to nitrite than many cultured freshwater fish. In general, for freshwater culture the nitrite concentration should be kept below 27 mg/L.

*(For details see **Water Quality Management**)*

2. TILAPIA FARMING

Pond culture is the most popular method of growing tilapia in the world. They are grown in fertilized ponds where the fish utilize natural foods from ponds. Management practices of the systems ranges from extensive; using only organic or inorganic fertilizers, to intensive systems, using high-protein feed, aeration and water exchange. The major problem to overcome in this system is the prolific breeding of the fish that occur in ponds under mixed sex culture. This breeding if not controlled results to overcrowding in the ponds. The end result is stunted growth yielding small size fish (less than 100gms) which may not be of market value. In mixed-sex populations, juveniles can make up to 70 percent of the total harvest weight. Therefore strategies for producing tilapia in ponds should aim at controlling spawning and recruitment.

For easy management and economical operation in Kenya, grow out ponds should be about 1 to 2 meters deep and at least 300 sq meters for semi intensive production of tilapia. A harvesting sump in the pond behind the drainage outlet is needed to concentrate the fish in the final stage of drainage. The pond should drained completely and be allowed to dry to eradicate any fry or fingerlings that may interfere with the next production cycle. This will also kill some parasites, frogs' egg and other unwanted organisms that may be in the ponds.

I). Mixed-sex culture

In mixed-sex culture of tilapia, both males and female are cultured together but harvested before or soon after they reach sexual maturity. This minimizes chances of recruitment and overcrowding. The disadvantage in this is that fish is harvested at a smaller size due to the limited growth period.
In this culture practice, fish are usually stocked at low rates to reduce competition for food and promote rapid growth. One month-old, 1-gram fry are stocked at 1 to 2 per square meter into and grown for about 4 to 5 months. In

cold areas where the water temperatures are low and therefore slow growth, tilapia might not reach marketable sizes in that period.

Newly-hatched fry should be used all the time because older ones will reach sexual maturity at a smaller, unmarketable size. They could also be mature fish but stunted. Supplemental feeds with 25 to 32 percent protein are generally used. The average harvest weight is about 250 grams, and total production about 0.25 Kgs/sq m for a stocking rate of 1 fish/m^2. Higher stocking densities can be employed to achieve higher production but must be combined with very good management. Expected survival is about 80 percent.

Species such as *Tilapia zilli*, *T. hornorum*, or *T. mossambica* are not suitable for mixed-sex culture because they reach reproductive maturity at 2 to 3 months at an unmarketable size of about 30 grams. Those that are suitable for this culture are *O. nilotica* and *O. aurea* which reach reproductive maturity at 5 to 6 months

Two to three crops of fish can be produced annually in Kenya depending on the water temperatures.

II). Mono sex culture

To overcome the problem resulting from prolific breeding of tilapia, ponds are stocked with males only because the males grow almost twice as fast as females.

Male fingerlings can be obtained by three methods:

- Hybridization
- Sex-reversal and
- Manual sexing.

None of these methods is always 100 percent effective, and a combination of methods is recommended. Hybridization can used to produce better results of males only. The hybrids can then be subjected to hand sexing and/or sex-reversal treatment. Sex-reversal requires obtaining recently hatched fry and rearing them in tanks or hapas where they are subjected to hormone laced feed for about three weeks.

*(For details see **Hatchery Management and Tilapia Fingerling Production**)*


Figure 2: Breeding hapas in a fish pond (Mbugua HM)

Manual sexing (hand sexing) involves separating males from females by visual inspection of the external urinogenital openings. Reliability of manual sexing depends on the skill of the workers, the species to be sorted and fish sizes. Experienced workers can easily sex 20-gram fingerling *T. hornorum* and *T. mossambica*, 30-gram *T. nilotica*, and 50-gram *T. aurea*.

Tilapia males are preferred for culture because they grow faster than females. Females use considerable energy in reproduction and do not eat when they are incubating eggs. All-male culture permits the use of longer culture periods, higher stocking rates and fingerlings of any age. High stocking densities reduce individual growth rates, but yields per unit area are greater. If the growing season can be extended, it should be possible to produce fish of up to 500 grams. Expected survival for all-male culture is 90 percent or greater.

Females included in a male only culture, affects the maximum attainable size of the original stock in grow-out.

A stocking rate of 2fish/m^2 is commonly used in Kenya to achieve yields of 1kg/ m^2. At this stocking rate the daily weight gain will range from 1.5 to 2.0 grams. Culture periods of 6 months or more are needed to produce fish that weigh close to 500 grams. There are cases in Kenya where stocking densities of 6 juveniles/ m^2 is practiced with a production of up to 3kg/ m^2. Higher stocking densities will require water aeration and sub-optimal feeding rates may have to be used to maintain suitable water quality.

III). Polyculture

In Kenya tilapia are frequently cultured with other species, mainly catfish (*Clarias gariepinus*) to take advantage of many natural foods available in ponds and to produce a secondary crop, or to control tilapia breeding. Polyculture uses a combination of species that have different feeding niches to increase overall production without a corresponding increase in the quantity of supplemental feed. Polyculture can improve water quality by creating a better balance

among the microbial communities of the pond, resulting in enhanced production.

Other possible polyculture combinations that can be done in Kenya include:
Tilapia and prawns (*Macrobrachium rosenbergii*): In case, survival and growth of tilapia and prawns are independent. Feed is given to meet the requirements of the fish. Prawns, which are unable to compete for the feed, utilize wasted feed and natural foods that result from the breakdown of fish waste.
Tilapia and largemouth bass (*Micropterus salmoides*): The bass which is carnivorous control the breeding of tilapia in mixed sex culture. This allows the original stock to attain a larger market size. Predators must be stocked at a small size and percentage to prevent them from depleting the tilapia stock.

IV). Fertilization and manure application

Where the natural pond productivity is enhanced through water fertilization, reasonable production can be achieved without exogenous feeding. Although yields will be lower that those obtained with exogenous feeding, fertilization will reduce the quantity and expense of feeding. Application of an inorganic fertilizer high in phosphorus should be done prior to stocking fish to create an algal bloom. Tilapia productivity is stimulated mainly by an increase in phosphorus and to a lesser extent by an increase in nitrogen. The inorganic fertilizers used in Kenya are DAP and CAN.

Di Ammonium Phosphate (DAP), Mono Ammonium Phosphate (MAP) and Urea are the cheaper sources of nutrients.

- For Phosphorus; DAP or TSP
- For Nitrogen; UREA

a) Methods of applying chemical fertilizers

Dissolve the fertilizer in a bucket of water by stirring, and then sprinkle the solution at different points of the pond. If you throw the fertilizer in while dry, it will sink and some of the nutrients, especially phosphorus will be absorbed by the mud.

Application Rates for chemical fertilizers recommended in Kenya:

D.A.P.; 2g/m^2 every week i.e. 200g per 100m^2 per week

UREA; 3g/m^2/week i.e. 300g/100m^2/week

Fertilizer application for earthen ponds *(Ngugi C.N.)*

Animal manure is widely used in Kenya in fish production in earthen ponds in. The quality of manure as a fertilizer varies depending on the source animal and the quality of feed fed to the animal. Pig, chicken and duck manures increase fish production more than cow and sheep manure. Animals fed high quality feeds (grains) produce manure that is better as a fertilizer than those fed diets high in crude fibre. Fine manures provide more surface area for the growth of microorganisms and produce better results than large clumps of manure. Manure should be distributed evenly over the pond surface area. Accumulations of manure on the pond bottom produce low oxygen conditions (during decomposition) in the sediment resulting to reduced microbial activity and sometimes result in the sudden release of toxic chemicals into the water.

b) Methods and rates of applying manure

- Crib method: A compost crib constructed using wooden sticks at one or more sides of the pond. It helps fertilize the water gradually. The manure in the crib requires frequent turning to facilitate the release of nutrients.
- Bag method: A bag is filled with manure and tied to the corner of the pond. The bag is shaken weekly or daily to release nutrients.

Manure application rates depend on the size of the pond, which is expressed as surface area of the water in the pond. The recommended rate is 50g of dry matter per m^2 per week i.e. 5Kg/100m^2/week.

The maximum rate depends on the quality of the manure, the oxygen supply in the pond and water temperature. If early morning DO is less than 2 ppm, manuring should be reduced or stopped until DO increases. When water temperatures are less than 18° C, manure application should be discontinued. At low temperatures the rate of decomposition decreases and manure may accumulate on the pond bottom. A subsequent increase in temperature could then result in oxygen depletion.

c) Agricultural lime.

- Used to improve soil quality, which helps the organic and chemical fertilizers to work better. It also helps to clear up muddy water.
- In red soils; about 20kg per 100m2 can be applied. Black cotton soils may require a little more.

Some characteristics of organic and chemical fertilizers

Organic (farm manure)	**Chemical: -** DAP, Urea, MAP, TSP
Contains trace minerals and vitamins.	Contains only what the label says
Uses oxygen to decompose.	Does not use oxygen when dissolving
Is highly variable in composition depending on feeds given to the animals and bedding used	Varies little in composition from what is indicated on the label.
Can help reduce turbidity due to clay silt in the ponds	Does not reduce turbidity
Can help reduce seepage in ponds	Does not act on seepage
Some of the ingredients can be consumed directly by the fish	Not directly consumed by the fish

V). Integrated systems

Manure application can be made easy by placing animal production units adjacent to or over the fish ponds so that fresh manure can easily be delivered to the pond on a continuous basis. This also allows the feed wasted by the animals to fall into the fish pond and utilised by the fish. Effective and safe manure loading rates are maintained by having the correct number of animals per pond surface area.

a) Chicken/fish farming

Maximum tilapia yields are obtained from the manure output of 5,000 to 5,500 chickens/ha, which deliver 100 to 113 Kg (dry weight) of manure/ ha/day. Several crops of chickens can be produced in one fish production cycle.

Tilapia/Catfish farming integrated with poultry farming *(Mbugua HM)*

b) Duck/fish farming

Ducks are grown on ponds at a density of 750 to 1500/ha. The ducks are raised in confinement, fed intensively, and allowed a small portion of the pond where they forage for natural foods and deposit their manure. Ducks reach marketable size in 10 to 11 weeks and therefore staggering production cycles is needed to stabilize manure output.

c) Pig/fish farming

Approximately 60 to 70 pigs/ha are required to produce a suitable quantity of manure (90 to 100 pounds of dry matter/acre/day) for tilapia production. The pigs are usually grown from 44 to 220 pounds over a 6-month period. In cultures and religions where pigs are considered unclean, used of pig manure might reduce the marketability of the fish.

VI). Harvesting

Fish produced for consumption should be harvested when they reach market size. In Kenya, tilapia are ready for harvesting within six to nine months depending on the size at stocking, target harvest size, water temperature and level of management employed. The time of harvesting is determined through regular sampling which should be done monthly.
A day or two before harvesting, feeding and fertilizer application should be stopped. During harvesting:

- Fish should be checked for off flavors
- Fish should be harvested during cool weather
- Harvesting and transportation equipment should be set up well in advance to ensure reduced stress and minimal fish mortality.

Tilapias are best harvested by seining for partial harvesting and complete drainage for complete harvesting.

Harvesting an ornamental fishpond using a seine net *(Mbugua HM)*

Once harvested, fish should be handled with care and transported to the market while still fresh.

VII). Growth and yields

Under proper management and optimal conditions, 1-gram fish are cultured in nursery ponds to 20 to 40 grams in 5 to 8 weeks and then stocked into grow-out ponds. In mono-sex, males can reach 200+ grams in 4 to 5 months, 400 + grams in 5 to 6 months, and 500+ grams in 8 to 9 months.

Dress-out percentage on tilapia is low compared to species such as trout and catfish. Tilapias have a dress-out of 51 to 53 percent of live weight for whole-dressed fish (head-off) and 32 to 35 percent for fillets.

VIII). Diseases

Tilapias are more resistant to viral, bacterial and parasitic diseases than other commonly cultured fishes. Few diseases and mortalities have been reported in semi intensive tilapia farms in Kenya. This could due to low stocking densities in these systems. Lymphocystis, columnaris, whirling disease, and hemorrhagic septicemia may cause high mortality, but these problems occur most frequently at water temperatures below 11^0 C. The most important cause of mortalities is anoxia resulting from blooms of algae. Sudden lowering of temperatures to below the tolerance levels, which can happen during the rainy seasons, can lead to problems including mortalities.

For further information, see ***Fish disease, parasites and predators management and control***