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Pond Culture of Tilapia

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In the U.S., the most appropriate species of tilapia for culture are the mouthbrooders: *Tilapia nilotica, T. aurea, T. mossambica, T. hornorum*, and the substrate spawners: *T. rendalli and T. zillii.* Various hybrids between mouthbrooding species may also be important; e.g., most of the reddish-orange tilapias are hybrids. In general, mouthbrooders have been used more in food fish production, whereas substrate spawners have been used mostly for weed control.

Species selection

Potential tilapia culturists in the U.S. should first determine which species, if any, can be legally cultured in their state. Assuming there are no restrictions, selection of a species will depend mostly on growth rate and cold tolerance. Rankings for growth rate in ponds are *T. nilotica* > *T. aurea* > *T. rendalli* > T. *mossambica* ≥ *T. hornorum.* Most of the hybrids tested grow as fast as their parent species. Cold tolerance may become an increasingly important criterion for selecting a species in more northerly latitudes. *Tilapia aurea* is generally recognized as being the most cold tolerant.

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Pond culture is the most popular method of growing tilapia. One advantage is that the fish are able to utilize natural foods. Management of tilapia ponds ranges from extensive systems, using only organic or inorganic fertilizers, to intensive systems, using high-protein feed, aeration and water exchange. The major drawback of pond culture is the high level of uncontrolled reproduction that may occur in growout ponds. Tilapia recruitment, the production of fry and fingerlings, may be so great that offspring compete for food with the adults. The original stock becomes stunted, yielding only a small percentage of marketable fish weighing 1 pound (454 grams) or more. In mixed-sex populations, the weight of recruits may constitute up to 70 percent of the total harvest weight. Two major strategies for producing tilapia in ponds, mixed-sex culture and male monosex culture, revolve around controlling spawning and recruitment.

There is no restriction on pond size, but for ease of management and economical operation, shallow (3 to 6 feet), small (1 to 10 acres) ponds with drains are recommended. Draining is necessary to harvest all of the fish. A harvesting sump is needed to concentrate the fish in the final stage of drainage. The pond bottom should be dried to eradicate any fry or fingerlings that may interfere with the next production cycle.

Geographic range for culturing tilapia in ponds is dependent upon temperature. The preferred temperature range for optimum tilapia growth is 82° to 86° F. Growth diminishes significantly at temperatures below 68° F and death will occur below 50° F. At temperatures below 54° F, tilapia lose their resistance to disease and are subject to infections by bacteria, fungi and parasites.

In temperate regions, tilapia must be overwintered in heated water. In the continental United States, the southernmost parts of Texas and Florida are the only areas where tilapia survive outdoors year-round with the exception of geothermally-heated waters, most notably in Idaho. In the southern region, tilapia can be held in ponds for 5 to 12 montns a year depending on location.

Mixed-sex culture

Mixed-sex populations of fry are cultured together and harvested before or soon after they reach sexual maturity, thereby eliminating or minimizing recruitment and overcrowding. A restricted culture period limits the size of fish that can be harvested.

In mixed-sex culture, tilapia are usually stocked at low rates to reduce competition for food and promote rapid growth. One month-old, 1-gram fry are stocked at 2,000 to 6,000 per acre into growout ponds for a 4- to 5-month culture period. Newly-hatched fry should be used because older, stunted fish, such as those held over winter, will reach sexual maturity at a smaller, unmarketable size. Supplemental feeds with 25 to 32 percent protein are generally used. At harvest, average weight is approximately 0.5 pound (220 grams), and total production is near 1,400 pounds/acre for a stocking rate of 4,000/acre. Expected survival is roughly 70 percent.

Species such as *Tilapia zillii, T. hornorum*, or *T. mossambica* are not suitable for mixed-sex culture because they reproduce at an age of 2 to 3 months and at an unmarketable size of 30 grams or less. Tilapia suitable for mixed-sex culture are *T. aurea, T. nilotica* and their hybrids, all of which reproduce at an age of 5 to 6 months.

Two to three crops of fish can be produced annually in the tropics compared to only one crop in temperate regions. In temperate regions, mixed-sex culture is referred to as young-of-the-year culture because fry produced in the spring are grown to marketable size by autumn. Early spawning is needed to maximize the growout period. The growout season is shortened by about 2 months to account for spawning and rearing of 1-gram fry for stocking growout ponds.

Male fingerling rearing

With male monosex culture, fry are usually reared to fingerling size in a nursery phase, and then male fingerlings are separated from females for final growout. All-male fingerlings can be obtained by three methods: hybridization, sex-reversal and manual sexing. None of these methods is consistently 100 percent effective, and thus a combination of methods is suggested. Hybridization may be used to produce a high percentage of male fish. The hybrids may then be manually sexed or subjected to a sex-reversal treatment. All three methods are sometimes used. Hybridization and sex-reversal reduce the number of female fingerlings that must be discarded during manual sexing. This saves time, space and feed. Problems nevertheless still exist with hybridization and sex-reversal. Producing sufficient numbers of hybrid fry may be difficult because of spawning incompatibilities between the parent species. Sex-reversal is more technically complicated and requires obtaining recently hatched fry and rearing them in tanks with high quality water. Both hybridization and sex-reversal may produce less than 100 percent males.

Manual sexing is commonly used by producers. Manual sexing (hand sexing) is the process of separating males from females by visual inspection of the external urogenital pores, often with the aid of dye applied to the papillae. Secondary sex characteristics may also be used to help distinguish sex. Reliability of sexing depends on the skill of the workers, the species to be sorted and its size. Experienced workers can reliably sex 15-gram fingerling *T. hornorum* and *T. mossambica*, 30-gram *T. nilotica*, and 50-gram *T. aurea*.

In the tropics, fingerlings may be produced year-round. In temperate regions, fingerlings are produced during summer and stored in overwintering facilities for the next growing season. If manual sexing is used, it is done prior to overwintering. The best fingerling size for overwintering depends on the number of fingerlings that will be needed and the available storage capacity. Fry of 1 gram or less are stocked in nursery ponds and fed high-quality feeds. Ponds stocked at 20,000 fry/acre will produce 100-gram fingerlings in 18 weeks, while 40,000 fry/acre will produce 50-gram fingerlings in 12 weeks, and 72,000 fry/acre will produce 27-gram fingerlings in 9 weeks. Fingerlings that weigh less than 20 grams should not be overwintered because their survival rate will be low.

Overwintering facilities consist of geothermal springs, greenhouses and heated buildings. Fingerlings can be held in cages located in geothermal springs or in small ponds or tanks through which warm spring water is diverted. In greenhouses and heated buildings, recirculating systems are used to hold large quantities of fingerlings. Fingerlings can be overwintered in long, narrow ponds that are covered with clear plastic if the winter is mild.

Male monosex culture

Males are used for monosex culture because male tilapia grow faster than females. Females use considerable energy in egg production and do not eat when they are incubating eggs. Male monosex 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 weighing one pound (454 grams) or more. Expected survival for all-male culture is 90 percent or greater. A disadvantage of male monosex culture is that female fingerlings are discarded.

The percentage of females mistakenly included in a population of mostly male tilapia affects the maximum attainable size of the original stock in growout. For example, manually sexed *T. nilotica* fingerlings (90 percent males) stocked at 3,848/acre will cease growing after 5 months when they average about 0.8 pounds (365 grams) because of competition from recruits. If larger fish are desired, females should comprise 4 percent or less of the original stock and predator fish should be included.

The stocking rate for male monosex culture varies from 4,000 to 20,000/acre or more. At proper feeding rates, densities around 4,000/acre allow the fish to grow rapidly without the need for supplemental aeration. About 6 months are required to produce 500-gram fish from 50-gram fingerlings, with a growth rate of 2.5 grams/day. Total production approaches 2.2 tons/acre.

A stocking rate of 8,000/acre is frequently used to achieve yields as high as 4.4 tons/acre. At this stocking rate the daily weight gain will range from 1.5 to 2.0 grams. Culture periods of 200 days or more are needed to produce large fish that weigh close to 500 grams. To produce a 500-gram fish in temperate regions, overwintered fingerlings should weigh roughly 70 to 100 grams and be started as early as possible in the growing season. A stocking rate of 8,000/acre does require nighttime emergency aeration when the standing crop is high.

Stocking rates of 12,000 to 20,000/acre have been used in 1.2 to 2.5-acre ponds, but this requires the continuous use of two to four, one-horse power paddlewheel aerators per pond. Yields for a single crop range from 6 to 10 tons/acre.

With optimal temperatures, feeding rates depend on fish size and density. Optimal daily feeding rates for fish of 30, 50, 100, 175 and 450 grams are 3.5, 3.0, 2.5, 2.0 and 1.5 percent of body weight, respectively. If densities are high, sub-optimal feeding rates may have to be used to maintain suitable water quality, thereby increasing culture duration.

Polyculture

Tilapia are frequently cultured with other species to take advantage of many natural foods available in ponds and to produce a secondary crop, or to control tilapia recruitment. 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. The disadvantage of polyculture is the special equipment (sorting devices, conveyors, etc.) and extra labor needed to sort the different species at harvest. The role of natural pond foods is less important in the intensive culture of all male populations and may not justify the expense of sorting the various species at harvest.

Tilapia can be cultured with channel catfish (*Ictalurus punctatus*) with only a minor reduction in catfish yields. Male tilapia stocked at a rate of 800/acre yield nearly 770 pounds/acre when channel catfish are stocked at 3,000/acre. At this stocking rate, net production of catfish declines by roughly 170 pounds/acre, but for every reduction of 1 pound in catfish production, 4.5 pounds of tilapia are produced. Catfish production does not decline when cultured in combination with tilapia, silver carp (*Hypophthalmichthys molitrix*) and grass carp (*Ctenopharyngodon idellus*) at densities of 800, 1,000 and 20/acre, respectively. With no additional feed, total net production can reach nearly 4,120 pounds/acre compared to 2,370 pounds/acre for catfish cultured alone. The incidence of off-flavor catfish may be less in catfish/tilapia polyculture than catfish monoculture.

Another promising polyculture system consists of tilapia and prawns (*Macrobrachium rosenbergii*). In polyculture, 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. Stocking rates for 1 to 2 gram prawns vary from 4,000 to 36,000/acre, but a rate of 8,000/ acre is often used to obtain a high percentage of market-size prawns (<25 grams) and a yield of about 445 pounds/acre. Tilapia can be stocked in the range of 2,000 to 4,000/acre.

Another type of poylculture involves the use of a predatory fish, such as largemouth bass (*Micropterus salmoides*), to reduce tilapia recruitment. Stocking predators with mixed-sex tilapia populations controls recruitment and allows the original stock to attain a larger market size. Predators must be stocked at a small size to prevent them from eating the original stock. Predators may be stocked when tilapia begin breeding.

The number of predators required to control tilapia recruitment in culture ponds depends primarily on the maximum attainable size of the predator species, the ability of the predator to reproduce, and the number of mature female tilapia. In general, as predators grow they eat larger sized tilapia recruits. Eventually this may result in an increasing biomass of small tilapia that are not consumed. However, this problem should not develop in ponds that are completely harvested one or more times a year.

More predators are required to control recruitment when there are larger numbers of mature female tilapia. For tilapia populations ranging from 2,000 to 4,000/acre and containing 50 percent females, the recommended predator/prey ratio is one largemouth bass to 15 tilapia. With 10 percent females, the recommended ratio is one largemouth bass to 65 tilapia.

Use of predators has been effective on an experimental scale, but they have not been used widely in commercial operations because of the difficulty in finding reliable sources of fingerlings. Some of the best predators, such as guapote tigre (*Cichlasoma managuense*) and peacock bass (*Cichla ocellaris*), are exotic species and may be illegal to use.

Fertilization and manuring

The most appropriate mouthbrooding tilapia for culture can feed low on the food chain, on a diet of plankton and detritus. If the natural productivity of a pond is increased through fertilization or manuring, significant production of tilapia can be obtained without supplemental feeds. Although yields are not as high as those obtained with feed, fertilizers and animal manures can be used to reduce the quantity and expense of supplemental feeds. An increase in natural food has a much greater effect on tilapia production at densities less than 4,000/acre.

Inorganic fertilizers are used less often because of their expense, but a single large application of an inorganic fertilizer high in phosphorus is frequently made 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. Phosphorus is effectively increased through the application of liquid polyphosphate (13-38-0) at a rate of 20 pounds/acre (2.4 gallons/acre).

Manuring, which is widely used for food fish production overseas, has not been practiced in the U.S. because of public perception. Manuring may have application in the production of tilapia as a source of fish meal for animal feeds. The quality of manure as a fertilizer depends on several factors. 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 fiber. Fresh manure is better than dry manure. Finely-divided 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. Large accumulations of manure on the pond bottom produce low oxygen conditions in the sediment that reduce microbial activity and sometimes result in the sudden release of toxic chemicals into the water column.

To maximize fish production, manure should be added daily to the pond in amounts that do not reduce dissolved oxygen (DO) to harmful levels as it decays. The maximum application rate varies from 90 to 180 pounds/acre/ day for dry manure. 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. If it is not possible to measure DO, the maximum rate should be limited to 90 pounds/acre/day to ensure a margin of safety. When water temperatures are less than 64° F, manuring 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 an oxygen depletion.

The rate of manuring should be increased gradually as the fish grow. The recommended manuring rate as dry matter is 2 to 4 percent of the standing fish biomass per day.

Yields of male monosex populations in manured ponds have been modest, but production costs are very low if the manure is free. For example, all-male hybrids (*T. nilotica* × *T. hornorum*, 29 grams) stocked at 4,000/acre will produce a net yield of 1,470 pounds/acre of 200-gram fish in 103 days when given fresh cattle manure at an average rate (dry weight) of 46 pounds/acre/day. In comparison, fish receiving a commercial high-protein feed will give a net yield of 2,370 pounds/acre. Feeding costs per pound of production are two to twenty times higher for fish fed the commercial diet compared to fish receiving manure.

Integrated systems

Collection, transport, storage and distribution of manure involve considerable expense and are major obstacles to manured systems. These problems can be overcome by locating the animal production unit adjacent to or over the fish pond so that fresh manure can easily be delivered to the pond on a continuous basis. Effective and safe manure loading rates are maintained by having the correct number of animals per pond surface area.

Chicken/fish farming

Maximum tilapia yields are obtained from the manure output of 2,000 to 2,200 chickens/acre, which deliver 90 to 100 pounds (dry weight) of manure/acre/day. Broiler flocks should be composed of three size groups to stabilize manure output. Several crops of chickens can be produced during a fish production cycle.

Pig/fish farming

Approximately 24 to 28 pigs/acre 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.

Duck/fish farming

Ducks are grown on ponds at a density of 300 to 600/acre. The ducks are generally raised in confinement, fed intensively, and allowed access to only a portion of the pond where they forage for natural foods and deposit their manure. Ducks that are raised on ponds remain healthier than land-raised ducks. Also by raising ducks on ponds, feed wasted by the ducks is consumed directly by the fish. Since ducks reach marketable size in 10 to 11 weeks, staggered production cycles are needed to stabilize manure output.

Harvesting

Tilapia are best harvested by seining and draining the pond. A complete harvest is not possible by seining alone. Tilapia are adept at escaping a seine by jumping over or burrowing under it. Only 25 to 40 percent of a *T. nilotica* population can be captured per seine haul in small ponds. Other tilapia species, such as *T. aurea*, are even more difficult to capture. A 1-inch mesh seine (with bag) of proper length and width is suitable for harvest.

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