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Culture of Hybrid Tilapia: A Reference Profile [1]

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Species account

Taxonomy and distribution

Tilapia is a generic term used to designate a group of commercially important food fish belonging to the family Cichlidae; the expression is derived from the African native Bechuana word "thiape," meaning fish. Cichlids are classified in the large order Perciformes, and inhabit the fresh and brackish waters of Africa, the Middle East, coastal India, Central and South America. True tilapias, however, are native only to Africa and the Middle East. Although exotic to the United States, populations of tilapia are now established in Arizona, California, Hawaii, Florida, Nevada, North Carolina, and Texas.

Cichlids are well known as colorful aquarium fish, and for their ability to adapt to new environments. Cichlids also display highly organized breeding activities. Because of their complex evolutionary biology, cichlid classification and naming is one of confusion and constant modification. Consequently, the tilapias have recently been classified into three genera. A distinguishing characteristic between the genera is the type of care the parents provide to their young. In the species of the genera *Sarotherodon* and *Oreochromis* the parents will incubate and protect the young in their mouths (mouth brooding); in particular the Oreochromis species are distinguished by maternal mouth-brooding where parental care of the young is performed primarily by the female. In contrast, incubation of eggs in a lake or pond bottom built-in "nest" is exhibited by those species belonging to the genus *Tilapia*.

For simplicity purposes, all three genera and hybrids in this text will be referred to as *tilapia*. Important commercial species include: the Mozambique or Java tilapia (*Oreochromis mossambicus*, also known as *Tilapia mossambica*), blue tilapia (*O. aureus*, a.k.a. *Tilapia aurea*), Nile tilapia (*O. niloticus*, a.k.a. *Tilapia nilotica*), Zanzibar or Wami tilapia (*O. hornorum*, a.k.a. *Tilapia urolepis*), and the redbelly tilapia (*O. zilli*, a.k.a. *Tilapia zilli*).

Culture

History

Tilapia have been raised as food for human consumption for a long time; tilapia farming is believed to have originated some 2,500 years ago.

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Tilapia have also been transplanted to many countries outside their native range and are now farmed worldwide. In the United States, commercial culture of tilapia is concentrated in Arizona, California, and Florida. It is not clear, however, what species of tilapia are under cultivation. A collection of hybrid stocks currently constitute the bulk of the commercial production. The hybrids under cultivation are female mouth-brooders and believed to have originated from genetic crosses of predominantly blue tilapia (*O. aureus*) and ancillary *O. niloticus*, *O. mossambicus*, and *O. hornorum* species. Some evidence of genes from *T. rendalli* and *S. melanotheron* are also apparent. Two popular hybrids are the Florida red, a species cross between *O. aureus* and *O. mossambicus*, and the hybrid between the *O. aureus* and *O. niloticus* tilapias. The aurea strain is principally used because of its tolerance to cold water temperatures.

Life history characteristics

Tilapia are known for their ability to sexually mature at a small size, around 8-10 cm (3-4 in.) in body length, and a young age (sometimes when 2-3 months old). Adult fish are known to live six to eight years, but some fish eleven to twelve years of age have been reported. In temperate regions, the spawning season of tilapia usually begins during the spring months when water temperatures rise, and spawning continues throughout the year as long as water temperatures are above 22°C (72°F).

As mentioned above, tilapia have an elaborate breeding behavior and are substrate nest builders. In most cases, males establish and aggressively defend territories. Nests are built in the form of shallow pits in the pond bottom, and are used for courting and spawning. After the female releases her eggs and fertilization takes place, most parent tilapia will pick up the eggs from the nest, incubate, and protect their young in their mouths (mouth brooders). A few species will leave the eggs on the spawning substrate and incubate the embryos by fanning water through them with their fins.

Depending on age, body size, and mode of egg incubation, female tilapia have a large variation in the number of eggs they produced. Blue female tilapia are reported to lay around 9-10 eggs per gram of body weight (around 4,500 eggs/pound). The eggs of hybrid tilapia are yellow-brown in color, egg shaped, and will sink to the bottom when spawned. The eggs vary in size from an average of 2 to 4 mm (0.08-0.16 in.) in diameter, depending on the species and number of spawns. After fertilization, eggs hatch in 2 to 4 days, depending on water temperature. Newly-hatched embryos absorb their yolks in 3 to 4 days. The free-swimming young are then protected by their parents for several days. In mouth-brooding tilapias, incubation, hatching, and care of the young may last a period of about three weeks. After yolk absorption, young tilapias actively feed on a varied diet, such as plankton and detritus.

Production systems

In the United States, tilapia are considered important for their food value. These fish have also been popularized for their use in waste-water treatment schemes and aquatic-weed control programs.

Because of the diversity of culture systems it is impractical to describe all the different operations used for raising tilapia commercially. Life stages and culture technology for commercial production of hybrid tilapia in the United States are described in Figure 1. Domestic production of hybrid tilapia consists mainly of all-male populations, which are raised primarily as a high-quality fish for human food. Culture is carried out in indoor tanks, water recirculating systems, outdoor raceways, ponds, and floating cages. In several states, primarily Florida and California, tilapia are also fished commercially. "Extensive" pond culture methods for tilapia, traditional in many countries throughout the world, are not commonly used in the United States. For example, culture of tilapia in wastewater fed ponds, a viable and less expensive production system, is not considered acceptable for ecological or sanitary reasons.

Tilapia growth rates are influenced by a variety of factors; water temperature, sex, supplemental feeding, and stocking density noticeably affect their growth rate. Tilapia are susceptible to cold water temperatures, and will not over-winter in most temperate climates. Most hybrid tilapia will stop eating at water temperatures below 16°C (61°F),

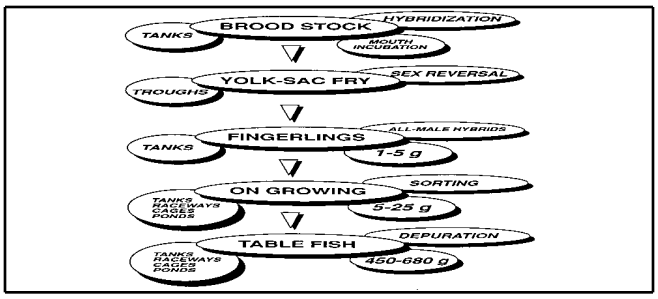

Figure 1 .

and will begin to die at around 13°C (55°F). Water temperatures between 25-32°C (77-90°F) are preferred for raising hybrid tilapia in intensive culture.

In populations of tilapia, males grow faster and more uniform in size than females. A predominantly male population also tends to reduce reproduction, overpopulation and stunting of fish in production ponds. For these reasons, a common culture practice is to raise an all-male population. A monosex population can be achieved in several ways. Customarily, fish are visually sexed at a young age (20-30 g) and females discarded from the grow-out system. Another common method for obtaining an all-male population is achieving sex reversal by oral administration of androgenic hormones (e.g. a mixture of 60 mg of methyl testosterone per kilogram of food will treat approximately 5,000 newly hatched fry, fed 2-4 times per day for 3-4 weeks). Use of hormones in sex reversal of fish is currently under evaluation by the U.S. Food and Drug Administration. Faster growth rates and monosex populations are also obtained by crossing different species. For example, crosses between *O. niloticus* and *O. aureus* produce a high percentage of males. A recently developed technique for obtaining a monosex male population is by producing "supermales" (see Tave 1990). Supermales are produced by hormonal sex reversal and artificial chromosomal manipulations.

Little data are available on the efficiency of hybrid tilapia to convert feed into meat. With the use of high-quality formulated diets, the feed conversion should range between 0.33 to 0.67 g of fish weight gain per gram of practical diet consumed (e.g 1.5-3 pounds of feed/1 pound of fish). Young hybrid tilapia are easily weaned and grow fast to market size when fed formulated diets. Fast growth rates are common when fish are fed foodstuffs containing levels of 35-50% protein for fish < 1 g (0.04 oz); 30-40% for 1-5 g (0.04-0.18 oz) fish and 25-30% for 5-25 g (0.18-0.88 oz) animals. For larger fish, recommended dietary levels vary from 25% protein for fish raised in ponds, 28-32% when reared in cages, to 35-40% when fish are grown in tanks. Tilapia growth rates also increase with multiple daily feedings (3-8 times a day depending on fish size). Feed allowance for young fish (<25 g) is usually 6-15% of their body weight per day, and older fish (>25 g), 1-3% of their body weight.

Recommended stocking densities for table-size tilapia production are extremely variable, and vary according to fish size and system of production. In fed and aerated production ponds, young (50 g) hybrid tilapia are usually stocked at 9,500 to 19,500 fish per hectare (4,000 to 8,000 fishlacre). In tanks or raceways, tilapia of 25-50 g (0.88-1.77 oz) in body size are stocked at densities between 140 and 248 fish/m^3 (4-7 fish/ft^3) of container space. In final grow-out production cages, stocking densities for 60-100 g hybrid tilapia range from 250 to 400 fish per cubic meter (7-11 fish/ft^3) of cage. When cages are placed in ponds, the pond stocking density cannot exceed those numbers (e.g. fish/acre) which would be achieved by growing the fish free-swimming in the pond.

The estimated time to raise hybrid tilapia from egg to food-size fish is highly variable, but is usually in a range between 6 and 12 months. The time required is primarily dependant on water temperature, fish density, and quality of diet.

Product forms

Hybrid tilapia are commonly sold as red or golden tilapia. Live tilapia are marketed in the 450 to 680 grams (1-1.5 pound) range, and yield between 30 to 39 percent whole fish to boneless fillets. Fish are most often traded as whole (dressed and undressed), fresh and frozen. Nutritive value of hybrid tilapia is considered around: 96 kcal/100 grams of raw meat, 19.2% protein and 2.3% fat by weight.

A serious problem when marketing tilapia is "offflavor;" the flesh of fish having a musty/muddy odor and flavor. Holding the fish in clean and continually flowing water for 7 to 10 days will usually reduce the problem.

Future outlook

In the United States, production and sale of tilapia have severe legal restrictions and are prohibited in many states. Those persons interested in raising or selling tilapias should contact the appropriate agency in their state.

To the author's knowledge, only a handful of tilapia operations in the United States have been considered successful aquaculture business ventures. High costs of production, environmental constraints (e.g. low water temperatures), lack of consumer product demand, and competition from high quality, low cost imported fish are major constraints for development of the tilapia aquaculture industry.

Promising species for commercial grow-out include the *O. niloticus* and *O. aureus* species, and their corresponding hybrids. Cage culture in large, man-made bodies of water or heated effluents, and harvesting from established exotic populations appear as promising and immediate competitive alternatives for economic solvency of tilapia enterprises.

Sources of information and selected references

A wealth of information has accumulated on the biology and culture of tilapia. Most of the information that exists in the literature, however, emphasizes husbandry methods in extensive pond culture conditions. In the United States, little has been published on commercially raising hybrid tilapia to market size. Listed below are some essential sources for information and general references on culturing tilapia. Numerous leaflets, pamphlets, and guides for raising tilapia have also been produced by cooperative extension offices across the country.

A special permit is required for the possession of tilapia in the state of Florida. Please contact the Florida Game and Fresh Water Fish Commission and your county extension agent if you are interested in farming tilapias.

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Fisheries and Aquatic Sciences Department. University of Florida, 7922 NW 7lst St., Gainesville, Florida 32606. Telephone: (352) 392-9617.

Florida Game and Fresh Water Fish Commission. Aquaculture Project, 3900 Drane Field Rd., Lakeland, Florida 33803. Telephone: (813) 644-9269 or (800) 282-8002.

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Production considerations

Tilapia are well known for their broad tolerance to environmental conditions. However, little information is available on the culture of hybrid tilapia for commercial purposes in the United States. For these reasons, biological and environmental optimum parameters for production of hybrid tilapia are difficult to ascertain. The values presented below indicate expected life cycle attributes and water quality averages or ranges for maximum survival, growth, and reproduction of hybrid tilapias under culture conditions. Figures are to be used only as guidelines and based on personal experience of the author, as well as scattered information in the aquaculture literature.

Life history characteristics

- Age at sexual maturity (months): 5-6
- Size at sexual maturity (grams): 28-350
- Stocking ratio for spawning: 2-5 females to 1 male Annual spawns: 7-10 broods
- Spawning success e.g. spawns/week:20-30%
- Eggs/gram of fish:1-4
- Survival of egg to fry (< 5 g): 70-90%
- Survival of fry to fingerling (5 to 30 grams): 60-90%
- Survival of fingerling to market (30 to 680 grams): 70-98%

Environmental requirements

- Water Temperatures for
  - Optimum growth: 28-32°C
  - Optimum spawning and embryo development:25-30°C
- Dissolved Oxygen (DO): above 3.0 mg/l
- Carbon Dioxide: below 15 mg/l
- Salinity: 0-28 ppt
- Turbidity:25-100 mg/l
- pH: 6.0-8.5
- Alkalinity: 50-700 mg/l
- Total Ammonia Nitrogen (TAN): 0.5-1 mg/l

Useful Unit Conversions

Temperature Relations:

°F = (°C x 1.8) + 32

°C = (°F - 32) ÷ 1.8

Metric Conversions:

meters (m) x 39.37 = inches (in.)

centimeters (cm) x 0.394 = inches (in.)

millimeters (mm) x 0.039 = inches (in.)

hectare (ha) x 2.471 = acres (A)

liters (l) x 0.264 = gallons (gal)

cubic meters (m) x 35.31 = cubic feet (ft)

gram (g) x 0.0022 = pounds (lb)

gram (g) x 0.0353 = ounces (oz)

kilogram (kg) x 2.205 = pounds (lb)

grams per liter x 1.0 = parts per thou.