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Sustainable Aquaculture for a Secure Future

Title: Atlas of Tilapia Histology

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Abstract: Tilapia is the common name applied to several closely related species of fish that have become the second most important group of farmed fish, after the carps. Global production of the tilapias is somewhat greater in volume than that of the salmonids, although probably lesser sales value, due to the higher prices for salmon products. However, the benefit of tilapia farming to household income may be greater as the vast majority of tilapia are reared by small farmers in relatively poor tropical countries for domestic consumption, local trade, and for international exports. Tilapia have become a major commodity in international trade. Production in China exceeded 900,000 metric tons in 2005 and in the United States, tilapia was the sixth most popular seafood item. Production and consumption continues to rise at an annual rate

of more than 10%.

Tilapia species are native to Africa and the Middle East, and refer to several genera and species of fish that were formally classified in the genus *Tilapia*, in the family Cichlidae. In the reclassification scheme developed by Trewavas (1983) the several hundred species of Tilapia were split into the genera; *Oreochromis*, *Sarotherodon* and some remained as *Tilapia*. The *Oreochromis* are maternal mouthbrooders, the *Sarotherodon* are paternal mouthbrooders and the *Tilapia* are substrate spawners. The species that are most commonly reared in aquaculture are in the genus *Oreochromis*. These include the Nile tilapia, *Oreochromis niloticus*, the blue tilapia, *O. aureus*, the Mozambique tilapia, *O. mossambicus*, and *O. urolepis hornorum*, sometimes called the Wami River tilapia. These species all readily hybridize in captivity. There are now many strains of the parent species along with many hybrid strains available to growers.

There are also several species in the genus *Tilapia* and the genus *Sarotherodon* that are of interest to aquaculture. Tilapia, like the other cichlids, are also of special interest to hobbyists and ecologists. Tilapia in Africa have been intensively studies for the species clusters have evolved in the Rift Lakes of East Africa. Some lakes contain over one hundred species in a single genus. Some of the tilapias native ranges extend up into Israel and Syria. One of the most common names for the fish is St. Peter's fish. This comes from the fact that two species of tilapia are native to lakes in Israel and are reputedly the fish that were caught by the Apostles and that Jesus used to feed the multitudes as recounted in the Bible.

From the 1930's to 1960's various tilapia populations were widely distributed around the world by missionaries, national governments, and international development agencies in efforts to improve the nutritional welfare of poor farmers in developing countries. In the 1960's and 1970's the fish were further distributed into additional watersheds in many countries for use as bio-control agents to reduce mosquito and aquatic weed populations in irrigation systems. By the late 1980's when commercial interests began to consider tilapia for aquaculture, one or more species had already become established in virtually every tropical country and may sub-tropical regions.

Domestication of the tilapias started in the 1950's and 1960's with groups working in several countries. In the 1980's and 1990's several sophisticated breeding programs were begun which vastly improved the growth rates, average size and profitability of commercial rearing of tilapia. These improved strains have now also been widely distributed. Tilapia have been important to aquaculture because of the ease with which they can be bred in captivity and the wide variety of water conditions in which fish can grow. The tilapia species grown in aquaculture evolved in ephemeral waters in Africa and the Middle East that are subject to wide swings of environmental conditions as the water evaporates away in the dry season and then greatly increases in volume and water quality in the wet season. As water evaporates, fish populations density increases, along with salinity and ammonia concentration, dissolved oxygen decreases, while pH and temperature go through diurnal swings. When the rains come and water quality and volume improves, the fish spawn. Thus, various strains can be grown in water varying in salinity from fresh water to full strength seawater (35 ppt). They will grow in water ranging

from acidic (pH of 5) to alkaline (pH of 9). Tilapia can survive low dissolved oxygen (<2 mg/l) and high ammonia levels (50 mg/l) for longer periods than most other fish. Consequently, they can be grown in densities greater than virtually any other kind of fish. These characteristics make them ideal for aquaculture.

Another characteristic that facilitates selective breeding and domestication is their reproductive behavior. The tilapias used in aquaculture are maternal mouthbrooders. A female lays her eggs in a simple nest prepared by the male, the male fertilizes the eggs and then the female picks the eggs up and incubates them in her mouth. Even after eggs hatch, fry will remain in the mother's mouth. Once the fry are free-swimming they will return to her mouth for protection. Females can produce several hundred to several thousand young per spawn. The high levels of parental care allows breeders to quickly raise thousands of young for directed selection or for stocking into production units. Another advantage is that the adults become sexually mature in less than six months, when they are still a fraction of their potential size. This is an additional advantage for selective breeding, allowing several generations to be produced in the time it takes other fish to reach maturity. The drawback to this high potential for reproduction is that tilapia introduced to new (exotic) locations can quickly spread and impact native fish populations. Likewise in production ponds without predators, tilapia can over-populate ending up with large number of small, stunted fish. This can present a serious problem for aquaculturalists who are attempting to rear a large size fish for market.

Eggs of tilapia are relatively large and fry are hardy and omnivorous. Fry readily feed on a variety of foods including periphyton and phytoplankton, zooplankton and powdered feed. This allows the culturist to further manipulate spawning by removing the young from the female and raising them independent of the mother. Removal of fry will encourage the female to begin eating again; she eats little while brooding, and will be ready to spawn again in several weeks. Sex of the fry can be manipulated in several ways. Undifferentiated sexual organs of juvenile tilapia can be induced to produce phenotypic all male or all female populations. Males grow more rapidly and crops of primarily males will avoid problems associated with unwanted spawning. There are several methods and reasons for this "sex-reversal". Untreated gonads are depicted in this volume for references purposes.

Another reason that tilapia are prized as aquaculture species is because they are herbivorous or omnivorous, depending on the species. In nature, tilapia receive all of their nutrition from algae, higher plants, detrital matter and/or small invertebrates. This makes it easy to grow the fish in ponds with minimal inputs of feed or fertilizer in extensive aquaculture. If semi-intensive systems are used to generate greater production from a facility, fertilizers can be used to produce algae and zooplankton. In intensive production, feeds containing primarily plant proteins can be fed. These inputs are considerably less expensive than the costly feeds containing high percentages of fish meal or other animal proteins that must be fed to carnivorous fish. Consuming herbivorous fish is a more ecologically efficient transfer of energy and protein to human consumers than using carnivorous fish that require fish or their animal proteins in their diets.

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These are just a few of the reasons that tilapia have become one of the most important domesticated fish around the world. The authors felt that it was important to provide a reference work that demonstrated the normal anatomy and histology. Trewavas (1983) provides excellent descriptions and line drawings of external anatomies of the tilapia species, including teeth, fin configurations, and gill rakers. However, internal anatomy is not included in that reference. *Oreochromis niloticus* was selected to depict the normal healthy condition as it accounts for more than 70% of global fish production and even higher when its hybrids are included. Although the fish is very hardy, the increased densities, polyculture and unusual environments in which the fish is reared, are exposing them to pathogens and stress conditions that lead to disease conditions. It is our hope that this reference will allow farmers and fish health professionals to make quicker and more accurate diagnoses. It should also be of interest to producers and breeders who need references to compare "normal" fish with newly bred strains and hybrids or fish reared in unusual environmental conditions.

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