

An overview of the biological diversity and culture of tilapias (Teleostei, Cichlidae)

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■ Introduction

Tilapias are African fishes currently used in warm water aquaculture throughout the world. The idea of introducing and developing tilapia culture in Africa arose around the forties, especially in the Belgian Congo (now the Democratic Republic of Congo) because of the difficulties in food supply caused by the Second World War. The first attempts were held at the Kipopo Station of the National Institute for Agronomic Studies of the Belgian Congo (DE BONT, 1950). Since then, and after numerous experiments with many different species (for a review see TEUGELS and THYS VAN DEN AUDENAERDE, 1991 ; TREWAVAS and TEUGELS, 1991a ; TREWAVAS and TEUGELS, 1991b), African tilapia culture has is presently mostly focused on one species, *Oreochromis niloticus* or the Nile tilapia. This herbivorous microphagous species is well suited to the low-technology culture systems used in developing countries (PULLIN, 1988).

Tilapia are ranked fourth in world fishculture, behind carps (Cyprinidae), salmonids and milk fish (*Chanos chanos*, Chanidae) (LAZARD and LEGENDRE, 1994). The estimated production is 500 000 metric tons (GARIBALDI, 1996). Tilapia culture has progressed considerably during the last ten years in certain countries, especially China, Thailand and the Philippines (PULLIN, 1988). In fact, the Philippines imported the first *Oreochromis niloticus* breeders in 1975, and now produce 70 000 metric tons per year (LAZARD *et al.* 1991). However, the culture of these fishes in their native continent has not been developed well, as is the case for African fishculture in general. Africa has produced 56 344 metric tons of cultured fish, in the global total of 11.1 million metric tons (GARIBALDI, 1996). Most of this African production consist of tilapias.

■ Biological Diversity and Systematic Considerations of Tilapias

Tilapias belong to the Cichlidae which, in number of species, is the third largest family of fishes out of a total of 482 families, after the Cyprinidae and the Gobiidae (NELSON, 1994). The Cichlidae, like the other two families cited, has more than 400 species (NELSON, 1994). According to TEUGELS et THYS VAN DEN AUDENAERDE (1992), the Cichlidae, belonging to the sub-order Labroidei and the order Perciformes, is particularly characterized by a single nostril on each side of the head. The body, of variable form but never very elongated, is rather compact and covered with cycloid or ctenoid scales. All fins are present. The inferior pharyngeal bones are fused, forming a bony, toothed triangle. The Cichlidae, freshwater or sometimes brackish water fishes, are found in Central and South America (one species ranges as far north as northern Texas). They are also found in the West Indies, and in the coastal zone in Madagascar, Sri Lanka, Israel, Syria, and of course, in Africa (NELSON, 1994 ; TEUGELS and THYS VAN DEN AUDERNAERDE,

1992). According to the most recent list, the Cichlidae family has 143 genera on the African continent (DAGET *et al.*, 1991).

Until recently the tilapias formed a single taxonomic unit, a generic rank, in the Cichlidae : *Tilapia* (*sensu lato*). Based on ethological characteristics, later supported by morphological and osteological criteria, TREWAVAS (1983) classified the tilapias in four genera belonging to the sub-family Tilapiinae. These are : *Tilapia* Smith, 1840 *sensu stricto*, *Sarotherodon* Rüppell, 1882 and *Oreochromis* Günther, 1889 and *Danakilia* Thys van den Audenaerde, 1969. The first three are of interest to aquaculture. They are briefly discussed below.

Genus *Tilapia* Smith, 1840

The genus *Tilapia* *s.s.* only contains the species that fix their eggs on a substrate, contrary to the other genera which perform oral incubation. Besides this ethological characteristic, the *Tilapia* species differ from other tilapias by the inferior pharyngeal bone which is as long as it is wide with the anterior point shorter than the toothed section ; the posterior pharyngeal teeth are bicuspid or tricuspid (sometimes quadricuspid). There are a maximum of 17 gill rakers on the lower part of the first branchial arch *versus* 28 in the other genera. Thirty-eight species are currently recognized (TEUGELS et THYS VAN DEN AUDENAERDE, 1991 ; STIASSNY *et al.*, 1992). Several of these have been tested in aquaculture (see TEUGELS and THYS VAN DEN AUDENAERDE, 1991 for a bibliographic review), but introduction trials have mostly been based on three species : *Tilapia rendalli* (Boulenger, 1896) and *T. zillii* (Gervais, 1848) in freshwater and *T. guineensis* (Bleeker, 1862) in brackish water.

The results obtained were not very satisfactory, in part due to their mode of reproduction. A brief description of the three species is given below. The characteristics used are from THYS VAN DEN AUDENAERDE (1970) and from TEUGELS and THYS VAN DEN AUDENAERDE (1992).

Tilapia rendalli is a deep bodied fish with convex dorsal and ventral surfaces (body depth considerably greater than that of

T. zillii). The caudal fin is clearly truncated (the end seems to have been cut). The eggs are yellow. Adults are colored olive green, darker on the back ; the chest and belly are a dirty white marked with black and cherry-red spots which extend to the cheeks and the lower flanks ; the lower part of the caudal fin is reddish (yellow), the upper part is greenish or marked ; dark vertical bars may appear on the flanks. In young fish (about 5 cm), the pelvic fins are orange in *T. rendalli* and without color in *T. zillii*. The natural distribution of *T. rendalli* includes the Shaba, the Upper Kasai and the Lualaba system in Congo, Lakes Tanganyika and Malawi, the Zambesi, the coastal region from the Zambesi delta to Natal, the Okavango and the Cunene. The estimated production of this species in 1994 was 868 metric tons, of which 803 metric tons were produced in Africa (GARIBALDI, 1996).

Tilapia zillii (Figure 1) is usually marked with two horizontal dark bands (when stressed), one on the lateral line, the other near the back ; these are crossed by vertical bars and spots appear at the intersections ; the caudal fin is covered with a grayish network with pale interstices ; the dorsal formula is XIV-XVI.10-14, mean XV.12 ; sub-truncated rounded caudal fin ; the eggs are green.

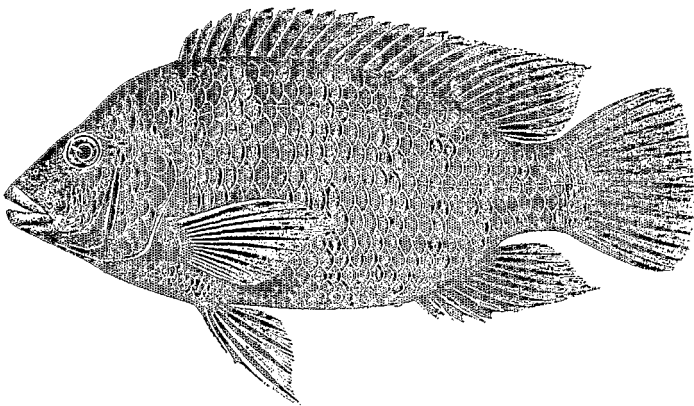


Figure 1
Tilapia zillii (from BOULENGER, 1901).

The natural distribution of *Tilapia zillii* covers southern Morocco, the Sahara, the Nilo-Sudanian basins (Senegal, Niger, including the Benue, Volta, Chad, Nile), the Sassandra, Bandama and Comoe basins in Côte d'Ivoire, part of the Congo basin (Ubangi, Uele, Ituri), and Lakes Albert and Turkana. Eighteen metric tons of *T. zillii* were produced in 1994 on the African continent.

Tilapia guineensis generally has a strongly sloped head profile ; the dorsal profile is convex and the ventral profile is horizontal. The dorsal formula is XVI-XVI. 12-13. Bright and highly visible colors, with mixes of deep blue green, copper green, deep black and zones of bright cherry red on the lower parts of the head and body ; these colors change considerably according to the physiological state and the sexual maturity of the individual. The natural distribution of *Tilapia guineensis* covers the coastal zones (fresh and brackish waters) from the Senegal River to the mouth of the Cuanza in Angola. No data were found on the production of this species.

Genus *Oreochromis* Günther, 1889

The genus *Oreochromis* contains the species where oral incubation is exclusively practiced by the females. Added to this is the reduced size of the belly scales compared to the size of the scales on the flanks ; the genital papilla is well developed in both sexes ; the inferior pharyngeal bone is longer than or as long as it is wide ; its toothed part is as long as or a little longer than its anterior part ; the posterior pharyngeal teeth are bicuspid, or with a reduced inferior cusp or without clear cusp (TEUGELS and THYS VAN DEN AUDENAERDE, 1992).

Thirty-three species of *Oreochromis* exist in Africa. Several of these have been tested in aquaculture (see TREWAVAS and TEUGELS, 1991a, for the bibliographic review). Note that *O. niloticus* is the most polymorphic species and the species most used in aquaculture. It is distinguished from the other taxa in the same genus by a caudal fin with regular black vertical bands all along its length. The species contains 8 subspecies, of which three, according to PULLIN (1988), have been cultured (*O. niloticus niloticus*, *O. n. eduardianus* and *O. n. vulcanis*). *O. niloticus* (Figure 2) is found naturally in the

coastal basins of Israel, the Nilo-Sudanian basins and in numerous East African lakes. Its global production is estimated at 426 773 metric tons of which 27 162 are produced on the African continent(GARIBALDI, 1996).

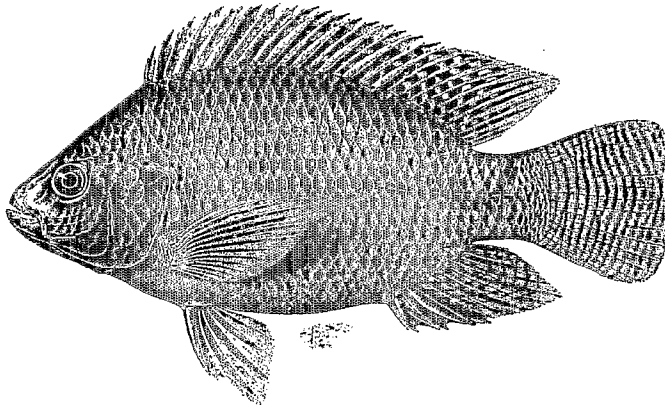


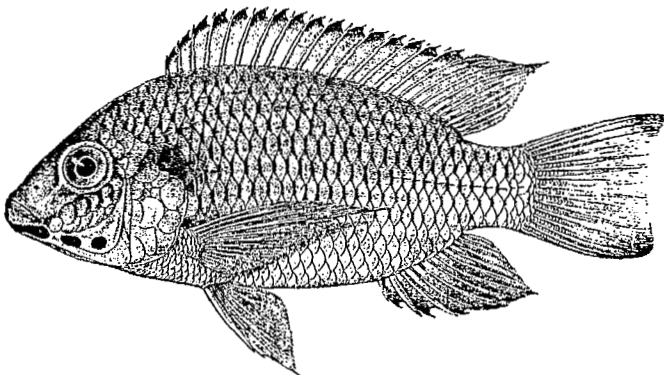
Figure 2
Oreochromis niloticus (from BOULENGER, 1907).

GARIBALDI (1996) cites six other species used in aquaculture : *Oreochromis mossambicus* (51 870 metric tons of which 55 in Africa), *O. aureus* (11 871 metric tons of which 74 in Africa), *O. andersonii* (2 200 metric tons produced in Africa), *O. macrochir* (350 metric tons produced in Africa), *O. spilurus* and *O. urolepis* (no production data).

Genus Sarotherodon Rüppell, 1852

The genus *Sarotherodon* contains the species where both males and females practice oral incubation. Beside this ethological characteristic, they are distinguished by belly scales which are of

almost the same size as those of the flanks ; the genital papilla of the male is smaller ; the inferior pharyngeal bone is longer than or as long as it is wide and its toothed part is shorter than the anterior part ; the posterior pharyngeal teeth are bicuspid or with a reduced inferior cusp or without clear cusp. Ten species belong to this genus. Two of these have been used in numerous aquacultural studies : *S. galilaeus* and *S. melanotheron* (Figure 3). The bibliographic review is given by TREWAVAS and TEUGELS (1991b). They are distinguished from each other by the number of gill rakers on the inferior part of the first branchial arch : (18) 19-27 for *S. galilaeus*, 12-19 (20) for *S. melanotheron*. They are also the most polymorphic with 5 subspecies each. The natural distribution of *S. galilaeus* extends from Jordan to the Congo basin. *Sarotherodon melanotheron* is a brackish water species, found from the mouth of the Senegal to the mouth of the Congo.



■ Figure 3
Sarotherodon melanotheron (from BOULENGER, 1915).

In total, 82 species of tilapia are present on the African continent. They are split among the genera *Sarotherodon* (12.2%), *Oreochromis* (40.2%), *Danakilia* (1.2%) and *Tilapia* (46.3%). When referring to the mode of reproduction of these fishes, we see that 54% of the tilapia species practice oral incubation against 46%

substrate spawners. A review of the geographical distribution of different tilapia species (DAGET *et al.*, 1991) shows clearly that the species with the greatest natural distribution are the ones that are currently used in aquaculture. In fact, a wide distribution confers to a species, without any doubt, a greater capacity to adapt to various types of environmental conditions. These adaptations, expressed in an aquaculture situation in terms of zootechnical performance, are an additional advantage.

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