PREDATOR CONTROL OF OVERPOPULATION IN CULTURED TILAPIAS AND THE ALTERNATIVE USES FOR STUNTED TILAPIAS IN NIGERIA

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Introduction

Aquaculture in Nigeria

The first attempt at fish farming was in 1951 at a small experimental station in Onikan (Lagos State) and various *Tilapia* species were used (Longhurst 1961). Modern pond culture started with a pilot fish farm (20 ha) in Panyam (Plateau State) for rearing the common/mirror carp, *Cyprinus carpio* (Olaniyan 1961; Ajayi 1971), following the disappointing results with tilapias. Although the first years of Panyam fish farm's existence were hardly satisfactory, the trials nevertheless generated sufficient interest that regional governments established more fish farms. Small-scale farms comprise a large proportion of aquaculture ventures ranging from homestead concrete ponds (25-40 m^2) operated by individual farmer or family to small earthen ponds (0.02-0.20 ha) operated as part-time or off-season occupation by communities, institutions, associations or cooperative societies (Anyanwu *et al*. 1989). The available water surface suitable for aquaculture was estimated as 483,406 ha (Ita *et al*. 1985). Both indigenous and introduced species are cultivated in ponds, reservoirs and cages. Tilapias, clariid catfishes and the common/mirror carp have always been the most widely cultured fish in Africa (Dada 1975; Sagua 1976; Satia 1990; Vanden Bossche & Bernacsek 1990) and are suited to low-technology farming systems in many other developing countries. This is because of their fast growth rate, efficient use of natural aquatic foods, propensity to consume a variety of supplementary feeds, omnivorous food habits, resistance to disease and handling, ease of reproduction in captivity, and tolerance to wide ranges of environmental conditions (Fagbenro 1987a).

One thing that is apparent from recent studies on tilapia that have relevance to aquaculture is that the most commonly studied species at present is *O. niloticus* (Linnaeus). It accounts for 64% of world production by weight, followed by *O. mossambicus* (10%), *O. aureus* (Steindachner) (3.6%) and *O. andersonii* (0.4%); while production by unspecified species is 2.7%. According to Adesulu (1997), the species and hybrids cultured in Nigeria are: *O. niloticus*; *O. aureus*; *S. galilaeus* (Artedi); *S. melanotheron* (Ruppell); *T. zillii* (Gervais); *T. guineensis* (Dumeril); *O. niloticus* x *O. aureus*. However, they are yet to reach their full aquaculture potential because of the problems of precocious maturity and uncontrolled reproduction, which often results in the overpopulation of production ponds with young (stunted) fish.

Tilapia - big fish, small fry

Natural reproduction of cultured tilapia species occurs in one of two ways: mouth brooders, for example *O. niloticus*, *O. mossambicus, O. aureus, S. galilaeus, S. melanotheron* or substrate brooders e.g. *T. zillii*, *T. guineensis*. The ease with which tilapias spawn and produce offspring makes them a good fish to culture. For example, the first selection criterion of species for culture is those species for which puberty begins after an acceptable and profitable marketable weight is reached. A species such as *O. mossambicus* is known to spawn at the age of three months when it only weighs 30g, even late-maturing species like *O. niloticus* and *O. aureus* begin spawning as early as 5-6 months after birth. However, this trait creates problems. Survival of young is high and grow-out ponds can become crowded. Fish become stunted as the supply of natural food organisms in the pond is depleted. Nearly 75% or more of the stock may be over 100 g in such cases. In order to produce large tilapia (over 150 g market price), special culture techniques may be required.

Tilapia population control

Population control in farmed tilapias has been reviewed by Mair & Little (1991). They mentioned that several effective methods have been used to control such undesirable tilapia population; including monosex culture (hybridization, manual sexing or grading), sex reversal by androgenic hormones, cage culture, tank culture, the use of predators, high density stocking (stock manipulation), sterilization (through the use of irradiation, chemosterilants and other reproduction inhibitors), intermittent/selective harvesting, the use of slow maturing tilapia species. The advantages and disadvantages of these control methods are known, of which very few have progressed from use in experimental studies or development trials to widespread adoption by farmers. Where a thorough assessment of user (farmer and consumer) perspectives are considered, the use of local predatory fish species to control such unwanted/undesirable tilapia recruitment in ponds is one of the most effective and practical methods, which Guerrero (1982) recommended for Africa.

Density control of tilapia populations by predators is not thoroughly researched in Nigeria as only few indigenous predators have been tested. These predators have some drawbacks (Table 1), for example *H. fasciatus* is also a prolific breeder and has a poor market value (due to small adult size). African clariid catfishes (*Clarias gariepinus, C. isheriensis*, *Heterobranchus bidorsalis*) do not have these limitations; hence the combined production of tilapia and clariid catfishes has attracted considerable attention, particularly in west Africa (Balarin & Hatton 1979) (Table 2). The hybrid clariid catfishes, *H. longifilis* x *C. gariepinus* and *H. bidorsalis* x *C. gariepinus*, and their reciprocal crosses grow faster than their parental species hence they are preferred for pond culture. Both hybrid catfishes are carnivorous with high propensity for piscivory, which suggests that they could be used to control tilapia recruitment in ponds, thereby producing market-size ("predator-proof") tilapias in ponds.

Choosing an efficient predator of a specific size with a recommended optimum predator-tilapia ratio represents a constraint to the success of this technique. Apart from the proper stocking densities and ratios, the effectiveness of combined culture of tilapias with predators is determined by many interrelated factors *viz*.:

Table 1. List of predatory fishes used to control tilapia reproduction in Nigeria

Predatory species and their qualities	References
*Clarias isheriensis (*syn. *C. agboinensis*) - prefers tilapia eggs to juvenile tilapia - poor market value due to small adult size - easily propagated in captivity using natural or hormone induced techniques	Fagbenro & Sydenham (1990)
African (sharptooth) mud catfish - *Clarias gariepinus (*syn. *C. lazera*) - omnivorous with high propensity for carnivory - becomes inefficient, competing for food with prey - fast growth - attains large adult size - easily propagated in captivity using natural or hormone induced techniques	Fagbenro (1987b) Sumonu-Ogunmodede (1998)
Heterobranchus bidorsalis - carnivorous with high propensity for piscivory - fast growth, attains large adult size - easily propagated in captivity using natural or hormone induced techniques	Fagbenro & Salami (1995) Ajayi (1998)
Heteroclarias (*H. bidorsalis/H. longifilis* x *Clarias gariepinus*) - carnivorous with high propensity for piscivory - fast growth, attains large adult size - easily propagated in captivity using natural or hormone induced techniques	Fagbenro (2000)
Snakehead - *Parachanna obscura* (syn. *Channa obscura, Ophiocephalus obscurus*) - voracious predator - difficulty in obtaining its seeds in natural waters - inability to reproduce in captivity - attains large size	Fagbenro (1989)
The jewel cichlid - *Hemichromis fasciatus* - voracious predator - a prolific breeder with short generation time (5-6 months) - poor market value due to small adult size	Fagbenro & Sydenham (1997)

a. **Availability of adequate good-quality supplementary feed for tilapias**

This improves the growth rate of tilapias, which then attain marketable size within a short period being desired as an economic benefit.

b. **Availability of predator fingerlings for stocking**

Because of the short rearing period and for other bio-technical reasons, the predators do not/are not allowed to reproduce in the ponds; therefore scarcity of initial stock of predators usually exists. This problem could be overcome either by using predators with high predation efficiency which will hence require fewer numbers that can be collected form the wild. It therefore means that tilapia rearing has to be synchronised with season when predator fingerlings/juveniles can be obtained.

c. **Dietary habits of predator**

Since tilapia recruits will serve as main food for the predators, it is expected that a piscivore is preferred to an omnivore, as the piscivore will exhibit higher predation efficiency.

d. **Appropriate time of introduction of predator**

Predators could be introduced as fingerlings or juveniles depending on which is available, but most importantly, the consideration should be the time of introduction. Predators should be introduced when their mouths are not wide enough to encompass the body circumference of original stock tilapias. In this case, time should be given such that original stock tilapias would have grown large enough to escape predation.

Table 2. Tilapia yields and tilapia A_T values from studies on mixed culture of tilapias with various clariid catfishes in Nigeria.

	Tilapia stocking Rate	Tilapia stocking Ratio	Adult tilapia yield (t/ha/yr)	Tilapia A_T value* (%)
T. guineensis & C. isheriensis [1]	10,000	2:1-10:1	4.3-4.6	86.2-96.2
T. guineensis & C. gariepinus [2]	6,000	6:1-12:1	3.1-4.0	71.5-93.5
O. niloticus & C. gariepinus [3]	10,000	10:1-20:1	1.7-2.5	-
O. niloticus & H. bidorsalis [4]	20,000	10:1-50:1	5.1-5.4	88.9-96.2
O. niloticus & H. bidorsalis [5]	10,000	12.5:1-50:1	2.4-4.0	54.5-72.2
O. niloticus & H. longifilis x C. gariepinus [6]	20,000	5:1-20:1	5.4-5.7	88.7-98.6
O. niloticus & H. bidorsalis x C. gariepinus [6]	20,000	5:1-20:1	5.2 – 5.6	87.3-98.1

* Tilapia A_T value = the percentage of market-size tilapia in the total tilapia population (Swingle 1950). [1]Fagbenro & Sydenham (1990) in Nigeria; [2]Fagbenro (1987b); [3]Sumonu-Ogunmodede (1998); [4]Fagbenro & Salami (1996); [5]Ajayi (1998); [6]Fagbenro (2000).

Tilapia: trash or treasure

Whereas Asian communities accept small sizes of fish, Africans have strong preference for large table fish (Balarin 1984). Under semi-intensive and extensive pond culture systems, tilapias show early maturation and prolific breeding, resulting in stunted growth; and because of their small sizes and bony feature, they have very low consumer appeal (Moses 1983). Because of the low consumer appeal of the smaller sizes, innovation could be directed towards presenting it in a more acceptable form designed to satisfy the growing demand for convenience foods and aquafeeds.

Use of stunted tilapia in fish silage production

According to Akande (1990) and Eyo (1993), low-value freshwater fishes such as tilapias could be economically utilised to produce acceptable high-protein fishery products for human consumption, and fish meal and silage for animal feeds from the processing wastes. Large quantities of cichlids are landed from freshwaters of Africa in short periods and often glut the market, consequently much remain unsold and spoil as a result of poor handling and processing (Shimang 1992). These surplus unmarketable tilapias could be economically recycled for animal feeding, through dry meal rendering or ensilation.

The two most important techniques (other than the direct production of rendered dry meals) used to preserve upgrade the nutritional value are: (a) ensiling through chemical acidification (acid-preserved silage) or microbial fermentation (fermented fish silage), and (b) protein hydrolysis using selected exogenous enzymes (protein hydrolysate). Both procedures rely on producing unfavourable conditions for putrefactive microrganisms, but conducive conditions for proteases (low pH required in the silage; high temperature required in the hydrolysate).

The preparation of acid or fermented silage using tilapias as substrates include trials made by Akande (1989), Dickson (1991), Fagbenro & Jauncey (1993, 1994a). Fermented silage was prepared from a mixture of minced tilapias (*Oreochromis* spp.), different carbohydrate sources (molasses, corn flour, tapioca flour) and *Lactobacillus plantarum* as inoculum, incubated anaerobically for 30 days at 5-35 ^{o}C. The pH and protein solubilization were temperature-dependent (Fagbenro & Jauncey 1993). The source of carbohydrate did not affect non-protein nitrogen (NPN) content or proximate composition of tilapia silage (Fagbenro & Jauncey 1994a). During storage at 30 ^{o}C for 180 days, NPN content increased and there was 8-11% loss of tryptophan (Fagbenro & Jauncey 1994b).

Use of tilapia silage in fish diets

Fish silage has been used as a feed supplement for various livestock and poultry animals and results have generally shown that it has good nutritional quality. The biological value of its protein was also comparable with that of fish meal protein. However, only recently has its potential in aquaculture diets been recognised, hence few studies have assessed their suitability. Generally, fish silage has been compared with fish meal and its suitability (or otherwise) assessed by fish growth responses, protein utilization and digestibility. Conflicting results have been reported on fish silage as fish meal replacer (either partially or totally) in fish diets.

a. Moist diets

Moist acid silage has been fed to carps, salmonids, eels, catfish, sea bass and tilapias with satisfactory results but few comparable results are available for fish fed fermented silage. Fagbenro & Jauncey (1994c, 1998) showed that *O. niloticus* and *Clarias gariepinus* fed with moist diets containing autolysed protein from fermented tilapia silage stored for 15 to 60 days showed good growth performance and protein utilization. There were no differences in body (carcass) composition and hepatosomatic index in *C. gariepinus* fed increasing dietary levels of autolysed protein from fermented fish silage and no morphological deformities were observed (Fagbenro & Jauncey 1994c).

b. Dry diets

Liquid fish silage is viscous, bulky and difficult to transport, stir or store, and can only be fed to pigs directly. There are no solids present to make into presscake; hence water removal by evaporation is necessary. Because of the low solids concentration, it is difficult to dry alone. Several methods of removing or reducing the water content of silages include spray drying, vacuum evaporation or drum drying. Alternatively, filler can be added and then dried together, after which the co-dried product can be used as protein supplement for poultry or fish. The nutrient content of the dried product is easily altered by the type and amount of filler material used, such as wheat offal, palm kernel cake, cassava flour, rice bran, maize flour, whey, potato flour, soybean-feather meal mixture, soybean meal, poultry by-product meal, meat and bone meal, feather meal (Akande 1990, Fagbenro & Jauncey 1995, Fagbenro *et al*. 1997), the choice of which is determined by cost and local availability. Ayinla & Akande (1988) reported that dietary inclusion of acidulated tilapia silage at 410 g/kg for *C. gariepinus* resulted in a better weight gain than diets containing 40 g/kg fish meal. Fermented tilapia silage co-dried with soybean meal replaced up to 75% of fish meal component in dry diets for *O. niloticus* and *C. gariepinus* (Fagbenro *et al*. 1994) while total replacement gave inferior growth responses, feed conversion and protein utilization, caused by reduced palatability of diets or reduced appetite. No differences occurred in the hepatosomatic indices of *O. niloticus* and *C. gariepinus* fed increasing dietary levels of co-dried fermented fish silage:soybean blend and no morphological deformities were observed (Fagbenro *et al*. 1994).

Use of stunted tilapia in fish meal production

Feeds account for over 50% of operational cost in intensive aquaculture and protein is the most expensive component of feeds. Fish meal (the conventional protein source) supports good fish growth because of its protein quality and palatability. Fish meal is often scarce and expensive especially good quality brands; hence cost of fish production and nutrition is often very high. As in most aquaculture ventures, reducing feed cost is a persistent concern as feed cost significantly impacts production cost. Fish meal, valued for its amino acid balance and unidentified growth factors, is widely used and plays a role in improving productivity and product quality of feeds. Fish meal provides the major protein source in most dry commercial aquaculture feeds and the periodic scarcity and high prices of herring and menhaden meals encourage the evaluation of alternative animal feed ingredients. Fish from stunted populations may be ideally suited for use in commercial fish diets. Waste materials remaining after larger fish are filleted might also have potential as a feed ingredient. Large quantities of stunted tilapias abound in Nigeria and they create disposal problems. Current disposal practices include burial, municipal garbage disposal and dumping in fields or streams. Recycling stunted tilapias into dry meals using low-level (artisanal) technologies will encourage and enhance aquaculture production.

Use of tilapia meal in fish diets

At present, the contribution of stunted tilapias to animal feeds is based on crushing sun-dried small tilapias, which are reduced to powder before being blended with various carbohydrates foods to form animal feeds. The processing is currently being undertaken more or less on cottage level as there are no licensed firms and the methods used inevitably vary from one producer to another. Under an artisanal fish meal production program, 50 kg. of tilapias are simmered in 20 litres of water in a half 200 litre drum for 20 minutes at 80 ^{o}C. This temperature had to be controlled to avoid overcooking. Excess water was discarded when the cooked fish was pressed manually in a gunny bag. The fish was then allowed to dry for three days in the open and ultimately reduced to powder in a hammer mill. The production of tilapia meal appears an attractive way of utilizing excess tilapia catches and stunted farmed tilapias for animal feed, and it would also reduce the foreign currency drain presently involved in importing fish meal. However, fish meal production should not overshadow the benefit of direct human consumption of fish in the fight against malnutrition.

Use of tilapia in salted dried minced fish cake production

Stunted tilapias could also be introduced into the human food chain. One of such ways is the conversion to mince and cakes. Fish mince is flesh separated in a communited form from skin, bones, scales and fins of fish. Production of mince from underutilized and unused species is not only an efficient way of recovering flesh for direct human food, but also a wide range of by-products such as pet foods and livestock meal can be made from bones as well as scales, liver, swim bladder, etc. The production of mince from tilapia could be a valuable source of utilizing it for the production of a versatile protein-rich product acceptable to the local consumers. Spiced minced fish or dried fish flakes is prepared by subjecting heavily spiced or curried fish to prolonged heating until the moisture content is greatly reduced and the fish fibre disintegrates. Preparation of this spice-minced fish is carried out in the home hence the amount and the types of ingredients used are left to the discretion of the individual household. It is prepared from a variety of marine fish and represents a traditional method of preservation. However, with the increasing price of marine fish, coupled with the problem of overfishing, pollution and seasonal fluctuation, freshwater fish is the next best alternative.

In the production of spiced minced fish cakes from stunted tilapias (Table 3), Akande (1990) concentrated efforts on producing an inexpensive cake that would be particularly appropriate for the growing fast-food trade as “raw and ready to fry” product. No loss in quality was reported when spiced minced tilapia cake was fried immediately after preparation and assessment of the product varied from good to excellent. An advantage of this product is the convenient preparation and lack of bones, which makes it readily consumed by children. It would be particularly appropriate for the institutional trade as raw, ready to fry product and for the housewife as a ready “heat-in-the-oven” product.

Similar works in Nigeria using stunted tilapias as substrates for salted minced fish cakes were conducted by Eyo (1996) and Aluko *et al*. (2000) as described in Figure 1. The cakes produced were stored at ambient temperature (25-32 ^{o}C) for up to two months during which the microbial count (total viable count, TVC) reduced from 4.4 x 10^3 to 1.5 x 10^2.

Table 3. Formula for spiced minced tilapia cake.

Ingredients	g/kg
Minced tilapia	878
Onion (fresh/chopped)	40
Concentrated tomato puree	40
Deodorised vegetable oil	20
Melon (ground)	10
Salt	7
Chilli pepper	4
Magi cubes	0.6
Thyme (dried leaves)	0.2
Curry powder	0.2

Tilapia
↓
Heading and gutting
↓
Washing
↓
Flesh-bone separation
↓
Mincing and addition of salt and spices (Table 8)
↓
Mixing
↓
Moulding into cakes
↓
Pre-heat treatment (70 ^{o}C for 2 hours)
↓
Oven-drying (40 ^{o}C for 50 hours)

Figure 1. Spice minced tilapia production (Akande 1990).

The drop in TVC was attributed to a lowering of water activity with increasing water loss. Although no attempts were made to identify the organisms in the total plate count, halotolerant organisms were responsible. The results of a taste panel confirmed the flavour as good, without a strong "fishy" taste. Odour, texture, saltiness and colour were satisfactory and no rancid taste was detected

Tilapia: husbandry vs. midwifery

Among the works in fish breeding research, the success of the works of Houssay (in 1930 and 1931) in breeding a catfish (*Cnesterodon decemmaculatus*) by inducing ovulation with intra-peritoneal injection of pituitary glands extracted from the hypophyses of *Prochilodus platensis* led fish breeding researchers worldwide along the avenues of hopeful contemplation and experimentation in fish breeding techniques. Today, scientists have succeeded in identifying and isolating the extrinsic and intrinsic factors that play vital roles in the development of sexual products and completion of reproductive cycle of fish (teleosts).

Use of tilapia pituitary in catfish breeding

The African catfishes, *Clarias gariepinus*, *C. anguillaris, Heterobranchus bidorsalis, H. longifilis* are cultured for reasons of their high growth rate, disease resistance and amenability to high density culture, related to their air-breathing habits (Huisman & Richter 1987, Haylor 1989, Haylor 1992, Fagbenro *et al*. 1993). *C. gariepinus* is circumtropical, constituting a major warmwater aquaculture species in Africa and has been introduced for cultivation in Europe and southern Asia while *Heterobranchus* spp. are endemic to Africa. Clariid catfishes do not breed in ponds, hence artificial propagation using exogenous hormones to induce oocyte maturation, ovulation and spawning is necessary. Various synthetic or purified hormones and steroids have induced ovulation in fishes (Huat 1980), but their use in many African countries (including Nigeria) is limited because they are expensive and are not locally available. To avoid these problems, and to encourage fish breeding programs, the use of crude piscine hypophyses was advocated by Britz (1991).

The reluctance of fish farmers to sacrifice precious catfish brooders as donors for hypophyses coupled with seasonality of maturation in clariid catfishes (Ayinla & Nwadukwe 1988, Haylor 1993, Haylor & Muir 1998), pose hindrances to homoplastic hypophysation in Nigeria. Although pituitary extracts from non-piscine sources such as African bullfrog (*Rana adspersa*), common toad (*Bufo regularis*) and domestic chicken (*Gallus domestica*) have also induced spawning in clariid catfishes in Nigeria, (Fagbenro *et al*. 1992, Nwadukwe 1993, Inyang & Hettiarachchi 1994, Salami *et al*. 1994), the standardization of methods dosages and concentration of hormones are often inadequate. It is generally more efficient to induce ovulation in fishes with a pituitary gland extract or a gonadotropin from a teleostean source because of the phylogenetic closeness between the donor and the recipient (Lam 1982).

Unlike catfishes, sexually-mature tilapias are available all-rear round and could be used as alternative sources of piscine hyposphyses for catfish breeding. Salami *et al*. (1997) investigated the effectiveness and dosage of acetone-dried pituitary extracts (ADTPE) from tilapias to induce oocyte maturation, ovulation and spawning in *C. gariepinus* and *H. bidorsalis*. Results showed that oocyte maturation and ovulation were induced in female *C. gariepinus* and *H. bidorsalis* by single intramuscular injection of 6-10 $mg.kg^{-1}$ ADTPE with optimum results obtained with 8 mg kg^{-1} acetone-dried tilapia pituitary extracts in both catfishes. At ambient temperature (27^{o}C), ovulation occurred within 14-18 hours post-injection resulting in 16-20% increase in egg diameter. Fertilization and hatching percentages increased with increasing hormone dosage. Survival of fry fed with mixed zooplankton diet was high (79-85%) after 30 days rearing.

This study conducted in Nigeria by Salami *et al*. (1997) demonstrated for the first time that optimal egg and larval quality in *C. gariepinus* and *H. bidorsalis* could also be achieved by using the tilapine pituitary hormone extracts to induce ovulation. The efficacy of ADTPE precludes the depletion of mature catfish (potential brooders) traditionally sacrificed for collection of hypophyses in fish hatcheries.

CULTURE TILAPIA FOR FOOD

Farm **tilapia** the modern way
It is real food in every way
When cultured the right way
Culture **tilapia** for food

Not exclusive in pens and cages,
But in tanks we also see,
In ponds as well we see
Culture **tilapia** for food

For **tilapia** farming to be sustained
Its seeds may be obtained
With cheaper feeds to maintain,
Culture **tilapia** for food

In villages, it is feasible
In towns, it is viable
In cities, it is sellable
Culture **tilapia** for food

Tilapia farming is practicable
With few tools available
It is food that is valuable
Culture **tilapia** for food

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