TILAPIA HATCHERY SYSTEMS

B.J. McAndrew
Institute of Aquaculture,
University of Stirling,
Stirling, Scotland

1. INTRODUCTION

It is ironic that possibly the major constraint hindering the rapid development of tilapia culture is the shortage of high quality seed for restocking. Yet one of the major problems encountered in pond culture is the excessive reproduction encountered in production or fattening ponds. In recent years the major advances in tilapia production have occurred where the fry and fingerling production have been separated from the ongrowing and fattening stages. This has allowed the use of a number of improved techniques to be developed. This has resulted in several orders of magnitude improvements in the numbers of fry being produced per female or per m^2 of hatchery. This article outlines the main types of hatchery systems used world wide and methods available for the production of higher quality and monosex fry populations for restocking.

2. EARTHEN PONDS

Fry production in earthen ponds is still probably the most widely used system for 'tilapia' fry production world wide. Variation in the production of fry from this type of system is highly variable and strongly dependent on the management practices. The poorest production is found in undrainable or undrained ponds in which there is no routine cropping system.

Successful pond hatchery units utilise completely drainable brood ponds, to facilitate pond maintenance and fish capture. They also assure high pond productivity and practise either a complete draining and capture, or capture routine at 18 day or monthly intervals (depending on size of fry required). Even the best managed pond hatcheries usually only average 10 fry/m^2/mt for first feeding fry

(Israel) or between 4-8 fingerlings/m^2/mt for 3-4 cm fingerlings (Coche 1982, Rothbard et al 1983). This usually means that pond based hatcheries need to be extensive to produce large numbers of seed.

The increased demand for high quality fish fingerling has promoted research into more effective tilapia fry production systems.

2.1 Hapas (net enclosures)

This form of fry production is now extensively practised in the Far East and particularly the Philippines. The system involves the use of fine nylon mesh enclosures or hapas (mosquito netting). These hapas are suspended above the lake or pond bottom on bamboo frames. The broodstock are kept inside the cages where they breed continuously. The fry produced are collected at regular intervals and are transferred to other cages or ponds for ongrowing. A variety of designs and sizes can be used. Any manageable size can be used, the net being suspended from a bamboo frame so the base is about 1m above the lake bottom. The frame is usually fitted with some form of catwalk to facilitate husbandry. Harvesting is simply carried out by crowding the fish into a corner of the net and separating the broodfish from fry, and netting all the fry or only those of a given size.

A double net enclosure in which the broodfish are restricted to a smaller large-mesh net inside the larger fine-mesh net almost doubles the efficiency of the system as the young fish can avoid being eaten. This also facilitates fry collection as the broodfish are easily handled.

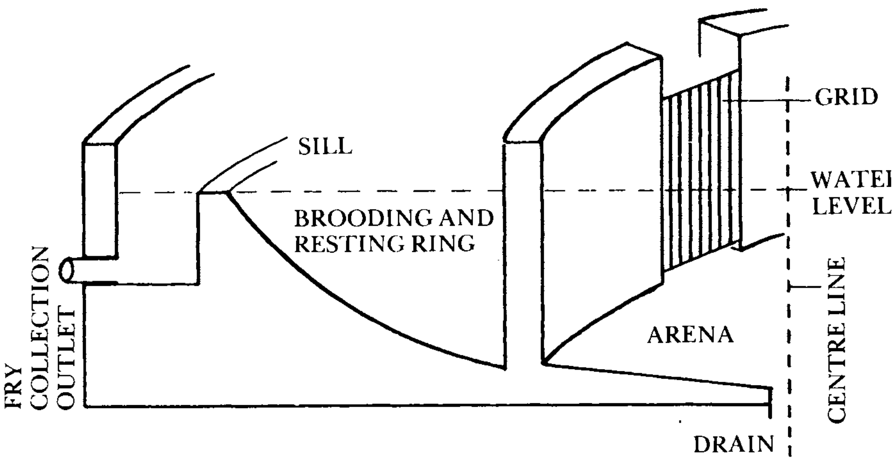
The broodfish will require some form of feeding in this system, so the nets are usually placed in highly productive lakes or ponds and some form of supplementary feeding supplied (rice bran, chicken feed, etc.)

Reported yields for fry from these systems are between 200 fry/m^2/mt (Guerrero and Garcia, 1982) and 880 fry/m^2/mt (Coche, 1982). The stocking density and sex ratio of the broodfish can play a major part in fry production and appears to be optional at 4-5 fish/m (100gm) and a sex ratio 1 ♂ : 3 ♀. Further intensification often results in an overall decrease in fry numbers. The hapa system of fry production is probably the easiest way of improving seed availability in a variety of culture environments such as reservoirs, lakes, large ponds and small village ponds. It offers a system which is manageable by one man, and would allow fry production to be separated from ongrowing in even a single pond. It is also adaptable to small-scale, owner-operated enterprises which would require a minimal outlay and could be easily expanded as demand increases.

3. TANKS

A number of tank systems have been developed in recent years to improve fry production in several countries. These range from plastic swimming pools (2m - 6m dia., 60cm deep), through concrete, fibreglass, asbestos, and steel tanks. These need to be fitted with a simple inflow and outflow device. The broodfish are stocked and either the total seed is collected at regular intervals (14-18 days) or fry are netted as they appear. The most efficient method is the collection of the total seed produced but this necessitates some form of incubation system to maintain eggs or larvae until first feeding. Simple fry collection is almost as efficient and production can be as high as 688 fry/m^2/mt (Snow et al 1983) and 1024 fry/m^2/mt (Coche 1982).

More complex tank designs which utilise the natural behaviour patterns of the broodfish fry to allow a more automated harvesting technique have been developed (Lovshin and A.B. Da Silva; Haller and Parker). Probably the best known of these is the Baobab arena system. This consists of a large circular concrete tank which has been divided into 3 separate rings (See diagram). The central ring is known as the arena and is isolated from the rest of the tank by a wall with



vertical grids which allows free passage to females but restricts the male to the central area. The next ring is designed to give the females an area to come into breeding condition, and is also supplied with 'hides' so that brooding females can remain undisturbed. The females can enter or leave the central arena at will through the grids provided. The bottom of this ring is sloped up to a shallow lip which is covered by a few mm of water and which then drops into the outside fry collection ring. This accommodates the brooding female's natural behaviour of releasing her fry into shallow water. The fry so released hopefully swim over the shallow lip into the outer collecting ring which can be drained on a regular basis, the fry being piped straight into suitable ongrowing ponds. This system has been used for a number of years and on average produces 100 fry/m^2/mt (J. Balarin pers. Com.).

4. TANKS/HAPAS

Probably the highest fry production levels recorded are for combined tank/hapa systems where large tanks are divided into separate net enclosures. This system allows a very accurate stock control since the broodstock are easily managed and can operate at an individual fish level. This method utilises the total seed collection method whereby individual females have their broods released manually and are then transferred into all-female tanks for reconditioning by intensive feeding. Rested females replace them in the hapas. Tagging of spawned females allows the rapid identification of infertile individuals and enables maximum utilisation of hatchery facilities. (2202 fry/m^2/mt, Hughes and Behrends, 1983; 3000 fry/m^2/mt, McAndrew, unpublished trial).

5. IMPROVEMENT OF FRY QUALITY

Once a regular hatchery practice has become established, improving fry quality for restocking becomes much easier. Often the easiest option to improve performance is the selection of a better tilapia species. It is now generally recognised that pure *O. niloticus* is the fastest growing 'tilapia' in freshwater. The switch from *O. mossambicus* to *O. niloticus* has been one of the major reasons for the impressive production levels now seen in countries such as Taiwan and the Philippines. This has been particularly so for the 'Red' tilapia strain of Taiwan which was initially a 'red' *O. mossambicus* strain which was subsequently hybridised with pure *O. niloticus* and in some cases with *O. niloticus* × *O. aureus* hybrids. The new hybrid has the 'red' colour of the *O. mossambicus* but improved growth rates from the *O. niloticus*.

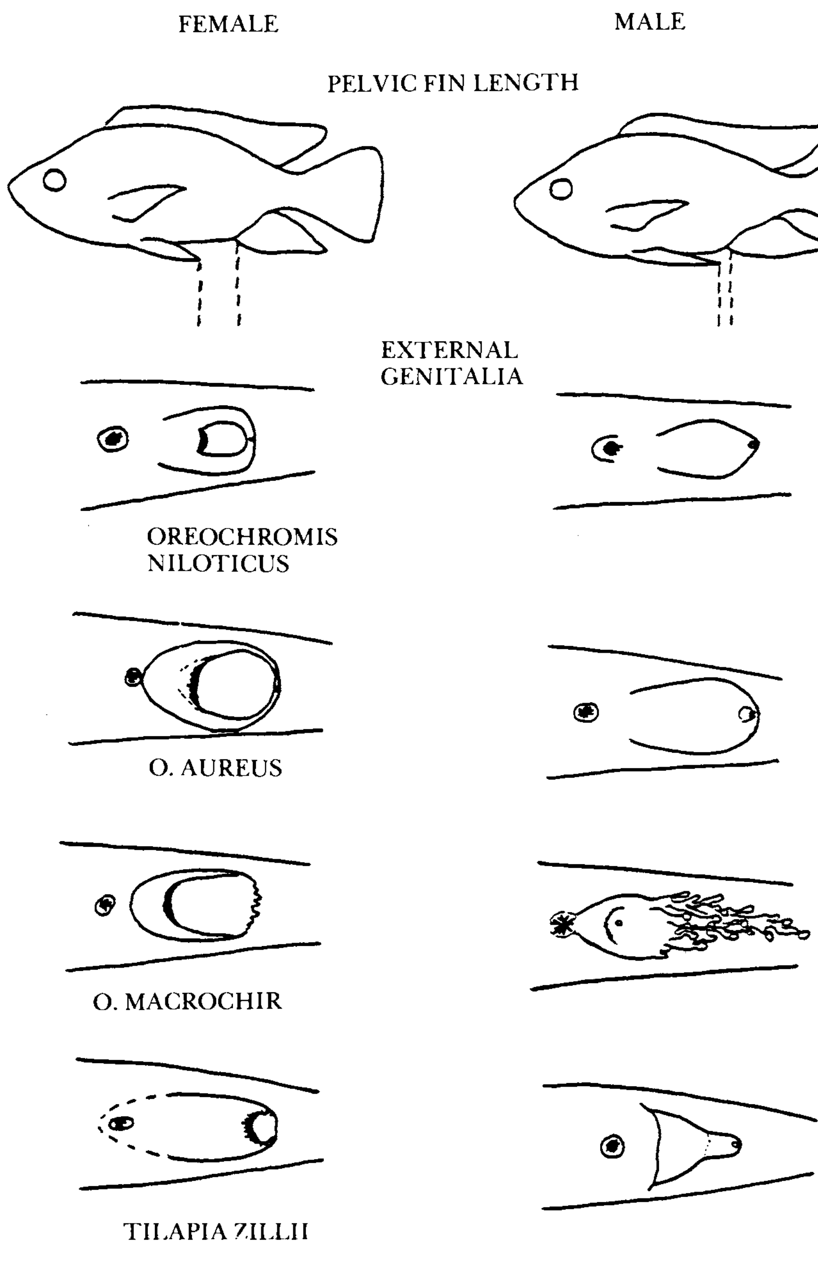
It is however pointless in trying to improve any species unless it can be maintained pure, and not lost by the infiltration of 'wild' species or uncontrolled inbreeding by poor stock management. Improved strains have been introduced into several countries and have lost their original performance particularly after the infiltration of *O. mossambicus* into the strain. The hatchery techniques described in the previous section should greatly reduce the risk of uncontrolled hybridisation, particularly if fish are maintained in some form of tank, and only fry from known pair matings are used for broodstock replacements. The major problems associated with tilapia can all be overcome by good management and husbandry rather than by the use of expensive 'hardware'.

6. MONOSEX FRY PRODUCTION

Hand sexing

This technique makes use of the clear dimorphism between the sexes in 'tilapia' species. Tilapia can be sexed by the differences in the urinogenital opening, fin morphology and adult colouration. Of these, the genitalia morphology is the most reliable and fin morphology can confirm the initial sexing. This process is much easier in large fish as the urinogenital openings are more obvious. However, skilled hatchery workers can achieve over 95% male populations on 5-7cm fish. Simple aids such as magnifying glasses and the use of coloured dyes (alcian blue, ink, malachite green) to accentuate the genitalia can significantly improve the efficiency of recognition. It is essential that hatchery workers are trained in the technique and understand the importance of obtaining all-male populations. Monitoring of the accuracy of the workers can be assessed by 'in house ' testing of production ponds at the hatchery or demonstration farm, or by extension workers counting the sexes in the harvests of farmers supplied by the hatchery.

With this method some form of fry ongrowing system is required to produce advanced fingerlings for hand sexing (approx 20 gms). Fish of this size are also more able to resist handling and stress and will have a better potential for growth particularly in low input, low-management village level ponds. Hand sexing is a relatively inefficient means of producing an all-male population in that almost half of the fish are not suitable for restocking and that they represent an investment in food, ponds, water and labour. The female fish which are not used for replacement broodstock may be sold on the local market if there is a small fish market, or the fish may be used to feed other livestock such as pigs or crocodiles, the waste from which may be used to fertilise the fingerling ponds. The female fish may also be dried and turned into fish meal and be mixed with other



Diagrams to show pelvic fin morphology and genitalial differences in four commercially important tilapia species.

components (rice bran) to make a good quality, supplementary feedstuff for fish or poultry.

Hand sexing can be taken at any stage in a pond production cycle especially where fry production has become excessive. The pond can be drained and netted, and the males can be kept and moved into another pond until they are of a marketable size. Once the trained staff have become proficient, success will be measured in the number of farmers requiring new fingerlings for restocking as they should have little or no fry to carry over into their next production cycle.

7. HORMONE SEX REVERSAL

This offers one of the most cost effective ways of producing 100% male populations for restocking. The system does not require a tank or hapa-based hatchery so that fry can be collected at the yolk sac of first feeding stages, and no later than one week after the fry are released from the female. The fry are treated by feeding a finely divided feed which has been impregnated with a suitable hormone. To guarantee success it is important that the fry are not allowed any natural feeding either by grazing algae or faecal material. This necessitates that the fry must be kept in some form of tank with good cleaning characteristics. The hormone feed can be locally produced from rice bran and fish meal (trash 'tilapia') and is ground into a very fine powder, 250 m. The feed is treated with one of the synthetic androgenic hormones Mα Methyltestosterone. The hormone must first be dissolved in alcohol (95%) and is then sprayed on or mixed with the dry food. The dosage is normally between 40 - 60ppm of hormone in the diet which is the equivalent of:

40 gms - 1 tonne feed
10 gms - 250 kg feed
1 gm - 25 kg feed

for 40ppm or:

60 gms - 1 tonne feed
15 gms - 250 kg feed
1.5 gms - 25 kg feed

for 60ppm feed.

The normal time for feeding this diet is for the first 30-40 days. If the young fish are all newly hatched and can be kept in clear water the lower dose for 30 days may be sufficient, whereas in non-ideal conditions the higher dose for a longer period may be required. If it is assumed that the FCR is 2:1 or even 3:1 then between 125,000 - 83,333 1gm fry could be produced from only 10gms of hormone would be around £10 and the necessary alcohol £5. As mentioned the feed could be made from local products or be dispensed from a central source. The inputs for such a hatchery set up should not be outside the resources of a government hatchery facility particularly if the tanks, brood, and sex reversals are installed with the other infrastructure.

There has been some disquiet about the use of hormones in food for human consumption. It has however been clearly shown in a number of surveys that at the levels used in such sex reversal procedures the hormone is quickly metabolised by the fish and that 99% of the hormone has disappeared within 48 hours of the last feed. It can be seen that as these fish will take up to 6 months before they are ready for marketing, little risk is involved if these procedures are undertaken correctly. Recent studies on hormone-treated fish also show an added advantage in that the hormone induces an anabolic effect in the fish which can enhance the growth rate by up to 10% over untreated siblings.

8. HYBRIDISATION

After Hickling's (1960) discovery that a cross between *O. mossambicus* × *O. hornorum* produced all-male hybrid fry there was great enthusiasm for this approach as the way of controlling excess breeding in ponds. However, presently there are not many countries in which this technique is widely used for monosex fry production. Over 25 different hybrid combinations have been attempted but only 6 of these are capable of consistently producing all-male broods. Little is known about the characteristics of these hybrids other than their sex-ratio. In general, hybrid performance can be predicted from the characteristics of the parental species. It appears from the literature that there is little evidence for hybrid vigour between any interspecific hybrids, but that different hybrids can exhibit a range of growth or other performance traits intermediate to the parental species. This is an important attribute in that different traits can be combined in a hybrid to give some advantage over either parent. e.g. *O. niloticus* × *O. aureus* combines the fast growth of *O. niloticus* with the hardiness of the slower growth *O. aureus*. The hybrid is intermediate in growth but displays the hardiness of *O. aureus*. This cross has also the added advantage of producing on average 80% male broods from mass spawnings (Majumdar & McAndrew 1983).

O. hornorum males are the only species which will consistently produce 100% male broods with different strains of *O. niloticus* and *O.*

mossambicus females, the *O. niloticus* × *O. hornorum* hybrid being much preferred because of its better growth performance. The number of hybrid crosses available for all-male hybrid brood production is very limited and success is heavily dependent on obtaining pure species and in being able to maintain their purity. This requires a relatively sophisticated hatchery and management system to ensure the long-term condition of the stocks. The added costs involved may well outweigh any advantages obtained from hybrids, particularly if this results in a dulling of performance when compared to a good single species such as *O. niloticus*.

REFERENCES

COCHE, A.G. 1982. Cage culture of tilapias, p.205-206. *In* R.S.V. Pullin and R.H. Lowe-McConnell (eds.). The biology and culture of tilapias. ICLARM Conference Proceedings 7, 432p. International Center for Living Aquatic Resources Management. Manilla, Philippines.

GUERRERO R.D. and A.M. GARCIA. 1983. Studies on the fry production of *Sarotherodon niloticus* in lake based hatcheries. P.388-393. Proceedings of the International Symposium on Tilapia in Aquaculture. May 8-13, 1983. Israel.

HALLER, R.D., and I.S.C. PARKER. 1981. New tilapia breeding system tested on Kenya farm. P.14. Fish Farming International 8 (1).

HICKLING, C.F. 1960. The Malacca Tilapia hybrids. P.1-10. Genetics, 57.

HUGHES, D.G. and L.L. BEHRENDS. 1983. Mass production of *Tilapia niloticus* seed in suspended net enclosures. P.394-413. Proceedings of the International Symposium on Tilapia in Aquaculture. May 8-13, 1983. Israel.

LOVSHIN, L.L. and A.B. Da SILVA. 1975. Culture of Monosex and hybrid tilapia. FAO/CIFA Tech. Paper 4 (Suppl. 1: 548-564). FAO, Rome.

MAJUMDA, K.C. and B.J. McANDREW. 1983. Sex ratios from inter-specific crosses within the tilapias. P.261-269. Proceedings of the International Symposium on Tilapia in Aquaculture. May 8-13, 1983. Israel.

ROTHBARD, S., E. SOLNIK, S. SHABBATH, R. AMADO, and I. GRABIE. 1983. The technology of mass production of hormonally sex-reversed all-male tilapia. P.425-434. Proceedings of the International Symposium on Tilapia in Aquaculture. May 8-13, 1983. Israel.

SNOW, J.R., J.M. BERRIOS-HEMANDEZ and H.Y. Ye. 1983. A modular system for producing tilapia seed using simple facilities. P.402-413. Proceedings of the International Symposium on Tilapia in Aquaculture. May 8-13, 1983. Israel.