NURSERY AND GROW-OUT OPERATION FOR TILAPIA AND CARP

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ABSTRACT

Most researches conducted at the Binangonan Freshwater Station of the SEAFDEC Aquaculture Department were directed toward enhancing growth and survival of the young tilapia and carp in the nursery as well as increasing yields in grow-out cages, pens, and ponds. Studies included the culture and evaluation of phytoplankton and zooplankton as feeds of the tilapia and carp fry to fingerlings; determination of protein and amino acid requirements of young Nile tilapia; development of practical dry diets; evaluation of feeding regimes, feeding rates, and feeding frequencies ; and the use of fertilizers in nursery ponds.

For the grow-out aspect, one of the earliest studies demonstrated the profitability of the monoculture of tilapia in cages which triggered the initial proliferation of tilapia cage culture by the private sector in areas near the Station. Subsequently, supplemental feeds were developed and evaluated; non-conventional feedstuffs were tested as feeds or feed components; and the growth rates of Nile tilapia fingerlings in cages at varying stocking densities were evaluated at three distinct rearing periods covering one year.

Prior to the successful mass production of bighead carp fingerlings at the Station, studies on polyculture of tilapia, milk fish, and different species of carp were conducted in cages and pens with remarkable results. This led to the technology-verification projects on polyculture at various areas in Laguna Lake. With the availability of freshwater fishponds for research purposes, studies on polyculture in ponds were also conducted.

INTRODUCTION

The Indo-Pacific Region produced as of 1983 about 83% of the world aquaculture production of 10.5 billion mt (FAO 1985). The largest contribution came from China (56%), India and Japan (11% each). Korea (6.1%), Philippines (4.2%), and Indonesia (1.9%) have also contributed significantly.

On the basis of production, the Chinese carps are the most important food fishes in Asia followed by the Indian carps, tilapias, milkfish, catfishes, and gouramis (Guerrero 1986 and 1987). In terms of distribution, tilapia ranks first followed by common carp *(Cyprinus carpio,* bighead carp *(Aristichthys nobilis),* and silver carp *(Hypophthalmichthys molitrix)* consecutively. The estimated tilapia and carp production in Southeast Asia from 1976 to 1984 showed an increasing trend (BFAR 1980 and 1984) which may also reflect the increasing demand for fingerlings of both groups.

Tilapia culture in the Philippines started when *Tilapia mossambica (Oreochromis mossambicus)* from Thailand was introduced in the country in 1950. However, it was the impressive performance in terms of growth and consumer acceptance of the Nile tilapia *(O. niloticus),* introduced in 1972, which led to the development of tilapia farming in the country. Culture of Nile tilapia in cages in the Philippines was first done in 1974 (Delmendo and Baguilat 1974). Although Indian carps and some species of Chinese carps became available in 1966 through the Bureau of Fisheries and Aquatic Resources (BFAR) (Reyes 1972, Chaudhuri 1979), only the Chinese carps are being commercially produced to date.

The SEAFDEC Aquaculture Department, through the Binangonan Freshwater Station (BFS) which was established in 1976, developed various techniques for tilapia culture which were readily accepted by the fish farmers in the vicinity and eventually in other areas. In 1983, the Aquaculture Department also succeeded in the large-scale production of bighead carp fingerlings.

This paper presents studies conducted at the BFS concerning tilapia and carp nursery and grow-out operations.

REARING FACILITIES

Nurseries

The tilapia and carp fry are reared in tanks, cages, or ponds. For experiments, size of rearing facilities is influenced by construction cost and availability of experimental fish for a given number of treatments. Net cages of various meshes (fine-meshed net, 0.30 cm or A-net, and 0.40 cm or B-net) are used in the lake. The dimensions are 1 × 1 × 1 m, 1 × 1 × 1.5 m, 3 × 1.5 × 1 m. Cages are usually covered with the same netting material used for the other sides. Oval fiberglass tanks (1.3-ton capacity) coated with white epoxy paint and concrete tanks (1 × 2 × 1 m) are used for land-based studies. In 1985, nursery ponds (5 × 10 m) were available for fry to fingerling production.

Grow-Out Facilities

For rearing tilapia fingerlings to marketable size under experimental conditions, cages (1 × 1 × 1 m, 2.5 × 2.5 × 2.5 m, and 5 × 10 × 1.5 m) and fishpens (40 × 20 m) have been used.

The grow-out facilities for carp consisted of pens (10 × 50 m) and cages measuring 5 × 10 × 1.5 m and 5 × 20 × 1.5 m. Nets for the cages or pens have mesh sizes of 0.40 cm (B-net), 0.50 cm (CC-net # 22), 0.70 cm (CC-net # 17), and 1.5 cm (CC-net # 8).

Grow-out as well as nursery cages recommended for commercial operations are usually larger and their actual size is determined primarily by the ease of management and the financial capability of the fish farmer.

REARING METHODS

Nursery

A study showed that sustained supply of phytoplankton as feed for Nile tilapia fry produced higher growth and survival compared to rice bran alone (Pantastico et al 1982). Growth of fry was also enhanced when phytoplankton concentration in the rearing medium was increased from low to moderate (90-120 × 10^3 cells/ml) and high (150-175 × 10^3 cells/ml). The acceptability of five species of fresh water algae was tested and it was found that *Navicula notha* (a diatom) and *Chroococcus dispersus* (a unicellular cyanophyte) as feeds resulted in highest growth and survival of the tilapia (Pantastico et al 1985). *Oscillatoria quadripunctulata,* a filamentous cyanophyte, has limited acceptability to tilapia fry probably because of its larger size compared to *Chroococcus.* In terms of assimilation of ^{14}C-labelled algae, the highest assimilation rates were obtained in fry fed with *Navicula* and *Chroococcus,* whereas only negligible amounts of *Chlorella, Euglena,* and *Oscillatoria* were assimilated by the fry. Another study showed the poor performance of Nile tilapia fry fed with *Chlorella* but it also demonstrated the suitability of *Moina macrocopa* (a cladoceran) as feed for the fry (Baldia 1984). Thus, although phytoplankton in general enhances the growth of young Nile tilapia, some algal species have higher nutritional value.

Cannibalism among the different sizes of tilapia fry and fingerlings has been recognized as a factor that decreases recovery of fish in nurseries. It was observed that cannibalism became more intense as the difference in sizes of fish increased (Pantastico et al 1987). However, feeding with phytoplankton, particularly the blue-geen alga, *Spirulina,* proved effective in reducing cannibalism.

Because tilapias readily take artificial feeds from the first feeding up to adult stage, studies on certain aspects of feeding Nile tilapia with prepared feeds have been undertaken. The protein requirement of Nile tilapia fry was determined under laboratory conditions to be 35% of the diet (Santiago et al 1982). This supplements what was earlier known about the protein requirements of older Nile tilapia and the juveniles of other mouth-brooding tilapia. Subsequently, it was shown that the optimum daily feeding rate for Nile tilapia fry stocked at 5 fry/1 was 30-45% of the fish biomass when a formulated dry diet was the only feed for the fry (Santiago et al 1987a). Moreover, survival rate was higher when the fry were fed with dry pellet crumbles rather than an unpelleted diet of the same formulation.

In the formulation of practical fish diets the quality of protein as reflected by its essential amino acid components is as important as the quantity of protein required by the fish. Recently, the essential amino acid requirements of the Nile tilapia fry were quantified (Santiago 1985). As in other fishes studied so far, the essential amino acid requirement pattern for the Nile tilapia was highly correlated with the essential amino acid pattern of the muscle of the fish.

Stocking rate of 5 fry/1 is used under laboratory conditions. Water in the rearing containers is partially replaced daily to maintain good water quality. Natural food is given *ad libitum* while artificial feeds are given three times a day. In nursery cages, stocking rate of 300 to 500 fry/m^2 is recommended (Bautista 1987). The fry are initially placed in fine-meshed net cages, then transferred to A-net and B-net cages as the fish grow. Supplemental feeds are given when supply of natural food is low.

Silver carp and bighead carp fry are usually stocked in tanks at 500/m^3 with the water replaced daily. The combination of an artificial diet having a crude protein level of 40% and the zooplankton, *Brachionus* and *Moina* given *ad libitum,* was found best for the carp fry (Fermin 1985, Anon. 1985). With an artificial diet alone given 1-3 times/day (Table 1), the suitable daily feeding rate is 30% of the fish body weight (Carlos 1985). On the other hand, the cyanophyte, *Spirulina platensis,* seemed to be the most promising natural food for very young silver carp (Pantastico et al 1986a). Based on assimilation rates of ^{14}C-labelled live food organisms, acceptability of specific phytoplankton to bighead carp fry occurred at a later stage (Baldia et al 1985).

Table 1. Percent composition of formulated feeds for carp larvae/fry

Ingredients	g/100 diet
Fishmeal	56.6
Soybean meal	11.4
Shrimp meal	9.0
Rice bran	10.7
Oil	5.0
Starch	3.0
Vitamin-mineral premix	4.3
Estimated crude protein	40.0

The initial stocking rate in fine-meshed nursery cages (hapas) is 1500-3000 carp fry/m^2. It is reduced to 750-1500/m^2 in A-net cages after two weeks, then to 400-800/m^2 in B-net cages (Fermin pers. comm. 1987). In ponds, the normal stocking rate is 35 fry/m^2. Pond water is fertilized to enhance natural food production by using chicken manure at 60 kg/ha/2 weeks, or an inorganic fertilizer, ammophous

(16-20-0), at 20 kg/ha/2 weeks and *Sesbania* at 60 kg/ha/2 weeks (Anon. 1985).

Studies on tilapia culture were both monoculture and polyculture while carp researches were mainly polyculture with tilapia, milkfish, and sea bass.

The first tilapia species used for cage culture was *O. mossambicus.* The fish, 10 g each, were stocked in B-net cages at 75 pieces/m^2 and were given the combination of rice bran, fish meal and ipil-ipil *(Leucaena leucocephala)* leaf meal (60:20:20), or the combination of rice bran and chopped snails (70:30) as supplemental feed. Results showed that fish given supplemental feeds had much higher growth compared to the controls (Pantastico et al 1979). The feasibility of using ipil-ipil leaf meal as a low-cost feed ingredient was also demonstrated. Subsequently, *O. niloticus* fingerlings, stocked at a density of 150/m^2, were given supplemental feeds consisting of ipil-ipil leaf meal and rice bran in varying proportions: I – 33.3% ipil-ipil: 66.7% rice bran; II – 66.7% ipil-ipil: 33.3% rice bran; III – 100% ipil-ipil; and IV – 100% rice bran. Fish given ipil-ipil leaf meal at varying dietary levels grew faster compared to those given rice bran alone (Pantastico et al 1980). Fresh *Azolla pinnata,* a tiny aquatic fern, was also an effective supplemental feed for tilapia fingerlings in cages, particularly when the primary productivity of the Lake was low (Anon. 1980, Pantastico et al 1986b) while dried and finely ground *A. pinnata* was desirable component of feeds for Nile tilapia fry (Santiago et al 1987b). Within a range of protein required by Nile tilapia fingerlings, practical diets with higher protein content did not necessarily produce better growth than those with lower protein level (Santiago et al 1986). Furthermore, diets with fish meal (18%) resulted in higher weight increases compared to those containing 0 or 5% fish meal.

The growth of Nile tilapia in cages is greatly influenced by the seasonality of natural food and water temperature. Tilapia fingerlings reared in cages in Laguna Lake at different months of the year showed marked differences in growth and survival (Basiao and San Antonio 1987). Fish reared in April-July had much higher growth than those reared in August-December or December-April. Without supplemental feeding, fish stocked at 50 and 100 fingerlings/m^2 in April-July attained a marketable size of over 100 g during harvest. At 150 and 200 fingerlings/m^2 growth was much lower. Information from this study has guided fish farmers as to the time of stocking and the stocking rates of young Nile tilapia in cages in the Lake.

In 1984, an experiment on pen culture of Nile tilapia compared the growth rates of fish at different stocking densities ($5/m^2$, $10/m^2$, and $15/m^2$) (Anon. 1984). Results showed an inverse relationship between stocking rate and mean weight of tilapia. At $5/m^2$, mean body weight after 4 months was 161.35 g. Net yield was only 0.188 kg/m^2 based on a recovery rate of 23%. Better harvesting technique for tilapias in pens has to be developed.

As part of the limnological project at BFS, fish growth was monitored in March-August 1984 (Anon. 1984). Hapa net cages (1 × 1 × 1 m) were installed in the West Cove of Laguna Lake and stocked with 10 fish/cage. After five months, tilapia *(O. niloticus)* attained a mean weight of 145 g. Net yield was 1.4 kg/m^2.

In collaboration with two private fish cage operators in Bo. Kalinawan, Binangonan, Rizal, two stations were established in 1985 at the West Bay of Laguna Lake. Station 1 was inshore and Station 2 was offshore. Tilapia fingerlings with mean initial weight of 0.55 g were stocked in B-net cages (50 m^2) at $16/m^2$. After six months (May to October) without feeding, mean weight of 43.4 g was attained by the tilapia reared in cages in Station 2 compared to only 28.5 g by those in cages in Station 1.

Polyculture of carps with other fish species was done in 1980 using a stocking rate of 6.6 pieces/m^2 at three varying stocking ratios (Castro et al 1980a, Castro et al 1980b). All species reached marketable size after 3 to 4 months. Final mean weights of milkfish and silver carps as the major species were highest at a stocking density of $4.5/m^2$, followed by $3/m^2$, and $5/m^2$. Fastest growth rate was exhibited by bighead carp, followed by silver carp, milkfish, tilapia, and common carp. With milkfish as the primary species, highest average net production of 558.16 kg/500 m^2 was obtained at a ratio of 4.5 milkfish:0.5 tilapia:0.1 bighead:0.5 common carp/m^2. With silver carp, the highest average net production obtained was 1218.85 kg/pen at a ratio of 5 silver:l tilapia:0.1 bighead:0.5 common carp/m^2. The two studies demonstrated locally that polyculture of fish species with complementary feeding habits is an effective means of increasing fish yield per unit area of cage or pen.

Another polyculture was undertaken in 1984, this time in seven areas representing the four distinct areas of Laguna Lake:Central Bay, West Bay, East Bay, and South Bay (Anon. 1984, Lijauco and Paraan 1984). Tilapia were grown with silver, bighead, and common carps at

$13/m^2$ and at a stocking ratio of 10 tilapia:2 common carp:0.5 bighead: 0.5 silver. Mean final weight of tilapia in the various bays was 63-181 g after six months of culture. There was not much difference in the mean final weight of common carp but the mean weight of bighead carp ranged from 699-1600 g while that of silver carp was 325-525 g. Tilapia from the southwestern part of the West Bay had the highest mean final weight of 181 g. Growth of tilapia as well as that of bighead, silver, and common carps in the South, East, and Central Bays was high.

Two technology verification projects were pursued in 1985 to determine the areas in Laguna Lake suitable for polyculture. Tilapia and bighead carps were stocked in CC-net cages (50 m^2) at 10 tilapia: 6 bighead carp/m^2 in the first project (Anon. 1985). The mean final weight of tilapia after 180 days (May to October) was 38.8 g and 41.4 g for the West Bay (inshore) and West Bay (offshore), respectively, from an initial weight of 0.55 g. Mean weight of tilapia from the South Bay (177.5 g) was much higher. The same trend was observed on the growth of bighead carp. Higher mean weight of 770 g was obtained in the South Bay compared to 187 g and 422 g for the West Bay (inshore) and West Bay (offshore), respectively. The second project was conducted simultaneously with the first and fish farmer cooperatives around Laguna Lake were involved in the implementation (Tabbu et al 1986). Bigger CC-net cages were used (200 m^2 and 100 m^2). These were stocked with 10 tilapia, 1.2 bighead carp and 0.6 common carp/m^2. Compared with the first project, higher mean weights of tilapia were obtained: 66 g at West Bay, 108.3 g at South Bay, and 102 g at East Bay Mean weights of bighead carp were: 1540 g (southwestern part of West Bay), 1170 g (South Bay), and 1290 g (East Bay). From the two polyculture studies in 1985, highest fish yield was obtained in the South Bay, followed by East Bay, and the southwestern part of West Bay. Moreover, bigger cages allowed higher fish growth.

Additional researches were subsequently conducted in ponds. Tilapia was cultured singly or in combination with bighead carp and sea bass in cages installed in ponds. Results showed highest yield from tilapia-carp-sea bass combination and tilapia-carp combination after six months (Anon. 1986, Tabbu 1986). On the other hand, the effect of different inorganic and organic fertilizers and their combinations on fish yield was evaluated. A stocking density of $4.6/m^2$ and a ratio of 2.5 tilapia and 2.1 bighead carp were used. Among the fertilizers used, chicken dung alone or phosphorous (0-18-0) alone gave the highest yields (Anon. 1986, Acosta 1986).

DISEASES AND PARASITES

The Fish Health Laboratory at BFS has reported occurrence of parasite infestation and diseases in tilapias and carp (Palisoc 1985). Samples came from land-based hatcheries or nurseries as well as from pens, cages, and open waters. Recommended treatments for affected fish are presented in Table 2. It is impractical to treat infected or diseased fish in cages or pens in large bodies of water. However, valuable fishes such as carp and tilapia broodstock may be harvested and transferred to land-based facilities for treatment.

Table 2. Parasites and disease organisms of tilapia and carp and their treatment

Fish species	Infective organism	Treatment	Dosage	Duration
T. nilotica	*Pseudomonas*	Oxytetracycline	7.5 g/100 kg of fish/day	7-12 days
	Trichodina	Salt bath	1000-2000 ppm	indefinite
	Dactylogyrus	Salt bath	1000-2000 ppm	indefinite
Bighead Carp	*Trichodina*	Formalin	150 ppm	1 hour
	Pseudomonas	Oxytetracycline	7.5 g/100 kg of fish/day	7-12 days
Silver Carp	*Aeromonas*	Oxytetracycline	7.5 g/100 kg of fish/day	7-12 days
	Citrobacter	Oxytetracycline	7.5 g/100 kg of fish/day	7-12 days
	Micrococcus	Oxytetracycline	7.5 g/100 kg of fish/day	7-12 days
	Lernaea	Salt bath	1000-2000 ppm	indefinite
		Formalin	15-25 ppm	indefinite

PRODUCTION CONSTRAINTS

The main problem of tilapia and carp production is the insufficient supply of high quality fingerlings, particularly when these are needed for stocking. Although many hatcheries exist, it is difficult to obtain at one time the desired number and size of fish. For cage culture of both species, poaching is a serious problem. Also, typhoons cause destruction of cage and pen installations, loss of fish to open waters, and fish mortality. Lack of technical knowhow by some fish farmers also affect fish production.

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