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## TILAPIA, CARP, AND CATFISH

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### ABSTRACT

Research activities on tilapia focused on *Oreochromis niloticus* and red tilapia. Experiments include developing new experimental and statistical procedures for strain evaluation, development of a stable reference strain, development of a high-yield red tilapia strain through introgressive hybridization, comparison of fish growth in different environments relevant to aquaculture, development of an index for routine monitoring of salinity tolerance of existing tilapia strains/experimental stocks, evaluation of nutritional requirements of red tilapia, and determination of heavy metal contents of tilapia in Laguna de Bay, Luzon, Philippines.

Research on carp (*Aristichthys nobilis*) and catfish (*Clarias macrocephalus*) were focused on improvement of methods for induced spawning, development of seed production techniques, and nutritional requirement of bighead carp fry and broodstock.

### INTRODUCTION

Red tilapia and Nile tilapia (*Oreochromis niloticus*) have become popular species for aquaculture in Asia. These were identified as priority species for SEAFDEC research during the First Seminar on Aquaculture Development in Southeast Asia (ADSEA '87). The genetic improvement of these species is now a major concern of many universities and international and regional research institutions.

Successful attempts in induced spawning and year-round sexual maturation in floating net cages (Fermin 1990) have made bighead carp (*Aristichthys nobilis*) a popular aquaculture fish in the 90,000-hectare Laguna Lake in Luzon, Philippines. To date, there are 16 private carp hatcheries around Laguna Lake.

Breeding of the freshwater Asian catfish *Clarias macrocephalus* in captivity has been reported by Hara (1977), Carreon et al. (1976), and Ngamvongchon et al. (1988). However, catfish culture in the Philippines is still hampered by the lack of fingerlings.

This paper presents the results of studies on tilapia, carp, and catfish at SEAFDEC/AQD from 1988-1991.

## TILAPIA

Hatchery, nursery, and grow-out techniques for tilapia (*Oreochromis niloticus*) developed at the SEAFDEC Aquaculture Department (SEAFDEC/AQD) are reviewed in Fermin (1988) and Carlos and Santiago (1988). Bautista et al. (1988) reported that a male to female ratio of 1:4 is most efficient for all types of breeding facilities.

### Strain Comparison Procedures

An important objective of any fish breeding program is to develop genetically superior strains. Comparison experiments at SEAFDEC/AQD involve rigorous size grading (collimation), use of full-sib groups for comparison, and inclusion of internal reference fish in each replicate tank for statistical control.

*Size-grading or "Collimation"*. Test strains (Nile tilapia) and reference strain (red tilapia), of approximately the same age, were matched as closely as possible based on their lengths at the start of every experiment for accurate measurement of size-specific growth.

*Full-sib Groups*. Each full-sib family was matched with equal size and equal number of red tilapia.

*Internal Reference Strain*. The usual strain comparison study involves analysis of variance (ANOVA). The internal reference procedure uses an analysis of covariance (ANCOVA) in which growth of reference fish (red tilapia) is the concomitant variable to reduce error variance caused by environmental variation like population density and food supply (Basiao and Doyle 1990a).

The first attempt to use red tilapia as an internal control showed a significant statistical interaction between the internal control and the test strains (Basiao and Doyle 1990a). The statistical procedure of using an internal reference is feasible only if there is no biological interaction between the test and the reference fish (Doyle et al. 1990).

## Comparison in Diverse Environments

Strains were compared in high-input, well managed environments as well as low-input and marginal or artisanal conditions. Tilapia strains show significant genotype effect during a three-week temporary crowding period (Basiao and Doyle 1990b) and at the end of the final grow-out period in hapa cages in Laguna de Bay (Basiao, unpublished results).

No genetic variation in growth is found in Nile tilapia strains held in freshwater for two weeks, acclimated for four days in a salinity of 32 parts per thousand and reared in 32 parts per thousand seawater for two weeks (Basiao, unpublished results).

Genotype-environment interaction can be an important factor in selecting fish under various aquaculture conditions. Romana-Eguia and Doyle (1992) found indications of genotype-environment interaction among three Nile tilapia strains reared on low (rice bran) or high (commercial diet) quality feeds. These strains also differ in their growth response under a restricted or non-restricted feeding regime (Romana-Eguia, personal communication). However, ranking of the strains are similar in the two feeding regimes.

## Index for Monitoring Salinity Tolerance

Based on mean survival time (MST) and median survival time ( $ST_{50}$ ), freshwater-spawned and reared *O. mossambicus* and *O. mossambicus* x *O. niloticus* hybrids show higher salinity tolerance than *O. niloticus* (Villegas 1990a). Increased salinity tolerance with age or body size is also evident in the study.

Villegas (1990b) reported that the highest growth for *O. mossambicus* is at 15 and 32 parts per thousand while the optimum salinity range for growth of *O. niloticus* is 0-10 parts per thousand.

## Mercury Levels in *O. niloticus*

A few pollution studies at SEAFDEC/AQD have focused on mercury levels in sediment, water, and selected fishes from Laguna de Bay. The mercury content of tilapia samples (undetectable to 0.1 parts per million) is below the maximum permissible levels of 0.5 parts per million set by the World Health Organization (WHO) and United States Food and Drug Administration (USFDA). Mercury levels in sediments range from 27 to 117 parts per billion, while water samples show low (undetectable to 0.5670 parts per billion) mercury levels (Cuvin-Aralar 1990).

Another study has shown that tilapia fry (0.042-0.081 grams body weight and 12-15 millimeters total length) exhibit hyperactivity and erratic swimming after exposure to varying mercury concentrations (Cuvin-Aralar 1991). Scoliosis, a curvature in the mid-trunk region, is significantly correlated with increasing mercury concentration (0.03-0.06 parts per million).

## Nutrient Requirements

A study on the growth response of red tilapia fry to varying protein levels (25,30,35, and 40%) and protein to energy ratios (111,100, and 80 milligram per kilocalorie) shows that red tilapia fry attain highest weight gain at 40% protein diet with a protein to energy (P/E) ratio of 111 milligrams per kilocalorie (Santiago and Laron 1991). The study also shows that protein efficiency ratio decreases with increasing protein level.

A study on the amino acid requirements of Nile tilapia has shown that the essential amino acid requirement pattern is highly correlated with the essential amino acid composition of the muscle of the fish (Santiago and Lovell 1988).

*Leucaena leucocephala* and *Azolla pinnata* were tested as protein sources in formulated diets fed to Nile tilapia broodstock and fry. Santiago et al. (1988a) have shown that on the basis of fry production and growth, *Leucaena* leaf meal should not exceed 40% of the diet of Nile tilapia broodstock. Dried and finely ground *Azolla pinnata* was found to be a desirable component of feeds for Nile tilapia fry (Santiago et al. 1988b). Growth of fry increases as the level of the dietary *Azolla* meal increases.

## CARP

Experiments on bighead carp were conducted to refine the induced spawning techniques and determine the response to nutrient level and feeding regimes.

### Induced Spawning

Studies to further improve the techniques of induced spawning were undertaken (Fermin 1988). Bighead carp broodstock with mean body weight of 25-5.4 kilograms were induced to spawn with intraperitoneal injections of varying combined dosages of human chorionic gonadotropin (HCG) and luteinizing hormone-releasing hormone analogue (LHRHa) (Fermin and Reyes 1989). Fish were spawned successfully following a single or double injection of 1,800-2,000 international units HCG in combination with 10,15, or 20 micrograms LHRHa per kilogram body weight (Fermin and Reyes 1989).

In a related study, a combination of 75 micrograms LHRHa/kilogram body weight + 15 milligrams DOM (domperidone)/kg BW given at two injections is likewise effective in inducing bighead carp to spawn. However, injection protocols using LHRHa + DOM have lower combined cost than HCG + LHRHa (Fermin 1991).

Lake-reared bighead carp broodstock were induced to spawn using LHRHa, LHRHa + RES (reserpine), LHRHa + HCG, and HCG alone. LHRHa + HCG give the highest mean fertilization (90%) while the lowest (32%) is obtained with LHRHa only (Gonzal, personal communication). Induced spawning protocol using LHRHa + HCG gave the highest (79%) mean hatching

rate while HCG alone gave the lowest (28%). Incubations were done at 26.8 °C and water hardness of 300-500 milligrams/liter CaCO<sub>3</sub>.

### Nutrient Requirement and Feeding

A study of different feeding regimes has shown that bighead carp fry fed combination of *Brachionus* and artificial diet containing 41.5% crude protein and 11.9% crude fat have the highest growth, but survival rate is highest for fry fed *Brachionus* alone (Santiago and Reyes 1989). Fermin and Recometa (1988) also found that artificial diet in combination with *Brachionus* and *Moina* is best for growth of bighead carp fry. A feeding rate of 30% body weight is most suitable for bighead carp fry fed artificial diet (Carlos and Santiago 1988).

Santiago and Reyes (1991) found 30% dietary protein as optimum level for maximum growth of young bighead carp fed isocaloric diets of varying protein levels. The survival rates do-not differ significantly among treatments while feed conversion ratio and protein efficiency ratio do not clearly indicate the required protein level.

Bighead carp fry perform better on diets containing 3,130-3,470 kilocalorie metabolizable energy per kilogram and P/E ratios of 92 and 100 milligrams protein per kilocalorie (Trono-Legiralde 1990). The 37% protein diet with approximately 3,470 kcal metabolizable energy produces maximum growth. Of the levels tested, 4.26% dietary lipid and 42% carbohydrate are best for bighead carp fry.

A study of various feeding treatments (40% protein diet, 20% protein diet, and no artificial diet or control) revealed that artificial diet does not hasten the growth and maturation of 10.5 month old bighead carp stocked in floating cages in Laguna Lake (Santiago et al. 1991). This finding supports an earlier observation that bighead carp sexually mature year-round without supplemental feeding in floating net cages in Laguna de Bay (Fermin 1990). However, fish fed 40% protein diet have the highest mean total weight of eggs/female, total number of eggs/spawning, and number of eggs/kilogram body weight. The study shows that fry of the fed broodstock have higher survival rates than fry of the unfed broodstock when deprived of food for up to ten days.

Sexual maturation in two-year old bighead carp reared without supplemental feeding in 12.5 x 10 x 3 meters floating net cages in Laguna de Bay was observed year round (Fermin 1990). High maturation rates in both sexes are positively correlated with high inorganic turbidity in the lake.

## CATTISH

*Clarias macrocephalus* mature but do not spawn in captivity. There is a need to study induced oocyte maturation and ovulation to provide a steady supply of seed for the industry.

Captive catfish (39-167 grams body weight) can be induced to undergo oocyte maturation and ovulation at 15-16 hours after simultaneous injection of

0.01-0.10 micrograms LHRHa and 1 microgram pimozone (PIM)/gram body weight (Tan-Fermin, in press).

A study (Tan-Fermin 1991) on the suitability of different formalin-containing fixatives for *C. macrocephalus* eggs showed that one percent phosphate-buffered formalin is the most suitable fixative. The osmotic pressure of one percent buffered formalin is not significantly different from the catfish plasma.

### RESEARCH IN PROGRESS FOR 1991

Activities on tilapia include 1) developing the best practical procedure for the comparative evaluation of genetic strains of tilapia in small to medium-sized facilities, 2) comparison of fish growth in contrasting lake environments, 3) development of a stable reference strain and refinement of techniques for using internal reference fish, 4) development of an improved strain of red tilapia through introgressive hybridization, and 5) evaluation of heavy metal tolerance and uptake of different tilapia strains.

On-going activities on carp and catfish include broodstock and breeding management of bighead carp and improvement of induced breeding and seed production techniques for catfish.

### RECOMMENDATIONS

The need to develop strains in diverse environments is worth considering in selection programs. We must learn our lesson from the Green Revolution in field crop production where development of new varieties led to the increased use of fertilizers and pesticides. In most cases, this has become detrimental to the poorer sector of society and very costly to the environment. Strains or breeds that will perform well in artisanal conditions will not only benefit small-scale or artisanal fisherfolk but will also help preserve our environment.

Refinement of hatchery techniques for red tilapia and catfish is needed to increase production. Likewise, feed development for nursery and grow-out of red tilapia, catfish, and bighead carp also needs further studies. Broodstock and breeding management schemes of bighead carp have to be re-evaluated to verify reports of slow growth that is attributed to inbreeding.

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