

BROODSTOCK MANAGEMENT AND SEED PRODUCTION OF TILAPIA AND CARP

Armando C. Fermin
Aquaculture Department
Southeast Asian Fisheries Development Center
Tigbauan, Iloilo, Philippines

ABSTRACT

Bighead (*Aristichthys nobilis*) and silver (*Hypophthalmichthys molitrix*) carps were reared in ponds, pens and floating cages in Laguna Lake until maturity. Spontaneous gonadal maturation and rematuration of carp broodstock occurred within 2-2.5 years with average weight of 3-4 kg. Under lake conditions, broodstock were not given supplemental feeds. Induced spawning of gravid females was done by intraperitoneal injections using HCG combined with either common carp pituitary homogenates or LHRH-A. Stripping and dry-fertilization of eggs were done 6-8 hr after the final injection. Eggs were incubated in water containing 300-500 ppm Total Hardness. Fertilization and hatching rates were 23-88% and 7-36%, respectively. Post-larval carps were reared in tanks and fine-meshed nylon net cages installed in manured ponds. Tank-reared post-larvae were fed with *Brachionus plicatilis* and subsequently with *Moina macrocopa* in combination with powered formulated feeds containing 40% crude protein. Fry were harvested and stocked in nursery cages after 30-45 days of rearing in tanks.

Four-month old 50-100 g tilapia (*Oreochromis niloticus*) stocked in hapa net cages, tanks or ponds were used for breeding. Egg and fry production was significantly high at 4 females/m² stocking density. Different sex ratios, however, did not affect fry production. Spawning frequency and total growth of broodstock was highest in fry fed formulated diets containing 50% crude protein. Harvesting of fry was done every 15 days during summer months and every 21 days during cold months. Fry were reared in tanks and hapa cages and fed diets containing 35% crude protein. Supplemental feeding in the lake was suspended when productivity reached 3 gC/m² /day.

TILAPIA

Introduction

Tilapia culture in the Philippines started in the 1950's with the introduction of *Tilapia mossambica* (also known as *Oreochromis mossambicus*) from Thailand (Guerrero 1986). The fish, due to its prolific nature, did not gain much popularity because the ponds where the fishes were stocked became overpopulated with small fishes.

In the early 1970's, there was a renewed interest in the growing of tilapia. *Tilapia nilotica* (also known as *Oreochromis niloticus*) was introduced from Thailand and Israel in 1972 (Guerrero 1985). The culture of Nile tilapia was readily accepted by farmers because of its fast growth and lighter color compared to the Mossambique tilapia. Government as well as private institutions has taken much interest in *O. niloticus* culture.

Since 1977, the Binangonan Freshwater Station (BFS) of the Southeast Asian Fisheries Development Center (SEAFDEC) has undertaken researches on tilapia farming in Laguna Lake. Studies were done on stocking density (Basiao 1986), supplemental feeding (Santiago et al 1982), natural feeding (Pantastico et al 1985), broodstock development and production of high-quality fry and fingerlings (Bautista 1986), among others.

Today, tilapia ranks second to milkfish in economic importance. The annual production of tilapia from inland waters, i.e., fresh and brackishwater ponds, lakes and reservoirs, was estimated at 50 200 mt (Guerrero 1985). In 1984, about 13 111 mt of tilapia were produced from 15 311.46 ha of fishponds in 12 regions of the country.

Broodstock Development and Management

Rearing facilities. Among the various rearing facilities used for breeding tilapia, the three most commonly used are: hapa net cages installed in the lake, concrete tanks, and earthen ponds. Hapa net cages with mesh of 0.5 mm are 3 × 3 × 2 m. The cages in the lake are suspended from either fixed bamboo posts or floating bamboo modules arranged in series. The cages are submerged at a depth of at least 1.0-1.5 m, leaving an allowance of 0.5-1.0 m of the net above the water surface. The cages may or may not be covered.

Concrete tanks are constructed in series, each measuring $4 \times 5 \times 1$ m. The series of tanks is not less than 20 tanks to minimize water temperature fluctuations. Each compartment is designed with a catch basin occupying about 15-20% of the floor area with depth of about 10-12 cm. This serves to collect both the breeders and fry during harvest. Water is drained through a removable PVC (polyvinylchloride) stand pipe (about 7 cm dia) which also maintains the water level at 50-75 cm.

Earthen ponds with rectangular shape have an area of 100-320 m² (10×10 m or 16×20 m) per compartment. Each compartment is provided with water inlet and outlet, both of which are protected with a net barricade. Water level in the pond is maintained at a depth of at least 70 cm.

Rearing methods. Four-month old tilapia with weights ranging from 50-100 g are used for breeding. The stocking density varies according to rearing facility used.

In hapas, the breeders are stocked at 5 females/m². In concrete tanks, a density of 4 females/m² is used without aeration and 6 females/m² with aeration. A lower density of 2 females/m² is used in earthen ponds. The sex ratio for all types of breeding facility is 1:4 or 1:7 male to female (Bautista 1987).

A study was conducted on the effects of the different stocking densities and sex ratios on egg and fry production of *Tilapia nilotica* bred in hapa cages and in concrete tanks (Bautista 1987). Results showed that both lake-based hatchery using hapas and land-based using concrete tanks, the highest average production of egg and fry were obtained at the lowest stocking density of 4/m². The most efficient sex ratio for both hatcheries was 1:4, male to female, although it was not significantly different from the other ratios used, i.e., 1:7 and 1:10 (Fermin et al 1986). The frequency of spawning per female was highest at 1:4 sex ratio; however, there were no significant differences among the three ratios.

In a related experiment, the effect of varying dietary crude protein of *T. nilotica* breeders were determined. Results showed that spawning frequency and total growth (body weight plus total weight of eggs collected) had a tendency to increase as the dietary crude protein level increased to 50% (Santiago et al 1983)

Size differences among fish are not so great as to minimize aggression especially by the males (Basiao 1981). The premaxilla of the male breeder is removed by clipping with scissors to prevent injury or death of females during courtship (Santiago et al 1983).

The broodstock are fed daily with formulated dry pellets with 50% dietary crude protein (Santiago et al 1983). The feed is given twice daily at 3.0% of the biomass, once in the morning and once in the afternoon.

Capture, handling, and transport. Tilapia broodstock are selected from different grow-out systems like pens, cages, and ponds at BFS and from other government and private institutions. Broodstock from fishpens and earthen ponds are collected by seining. Harvested fish are held in a more convenient container like small cage or tank with aeration for the selection process. From the cage or tank, fish are directly transferred to the transport containers, i.e., plastic bag and *bayong* (buri bag).

Sex is determined during the selection process, by examining the genital papillae located near the anus. Males have pointed papillae with one opening, the urogenital, while females have rounder papillae with two openings, the urogenital and the ovipository. In general, males are larger than females of the same age (Basiao 1981).

At least one day before transport, the broodstock are temporarily held in tanks with aeration for conditioning.

Fish are transported in oxygenated doubled plastic bags placed in *bayongs*. The density of fish varies according to size, from 8-12 breeders (about 100 g each per bag) filled with 10-15 l of water. The breeders are transported early in the morning or late in the afternoon when ambient temperature is low. A few ice cubes are placed in one or both sides of the outer bag to keep ambient temperature to about 24-26°C.

Diseases and parasites. Newly transported breeders are prone to disease and parasite infestation due to stress. Fish are subjected to disinfection in salt baths, at 1 000-2 000 ppm prior to stocking in the hatchery (Palisoc 1986).

Lernea infestation has occasionally been observed in tilapia broodstock. Infected fish is treated with 0.25 ppm Dipterex.

Constraints to broodstock production. The continued deterioration of tilapia stocks through inbreeding could result in the production of poor quality fry and fingerlings. This leads to slow growth and body deformities of the progenies and adversely affects succeeding generations.

Tilapia broodstock in the lake are constantly subject to environmental hazards especially during typhoons. Unfavorable weather conditions may cause severe damage or complete loss of stocks.

Seed Production

Rearing facilities. Lake and land-based facilities are used for rearing newly harvested tilapia fry. Lake-based nursery consists of floating hapa cages measuring $3 \times 3 \times 1.5$ m with cover. Covered cages may be suspended in fixed bamboo posts or in floating bamboo modules, arranged in series at 1-1.5 m intervals. The set-up is protected from strong waves and water hyacinths during typhoons by a peripheral bamboo barricade constructed at least 10 m away from the set-up.

Land-based nursery is made of concrete or wooden tanks. Nursery tanks are either square or rectangular ranging from $4 \times 4 \times 1.5$ m — $3 \times 8 \times 1.5$ m and arranged in series. Each compartment is provided with inlet and outlet for easy draining of water during cleaning and harvesting. About 120 l glass aquaria are used to incubate eggs and rear yolk-sac fry until yolk has been resorbed. Aquaria are provided with moderate aeration to keep eggs in suspension throughout the incubation period.

Rearing methods. Newly harvested fry from breeding cages are stocked in hapas at 300-500/m². While in hapas, the fry are given supplemental feeds such as hard-boiled egg yolk, blended trash shrimps, formulated feeds or commercial livestock starter feed (Table 1).

Supplemental feeding of fry is suspended when primary and secondary productivity in the lake is at least 3 g C/m²/day.

In tanks, fry are stocked at 1000/m². At least 1/3 of the total water volume is changed daily. Fry are fed with formulated dry diets containing at least 35% crude protein (Table 2) (Santiago et al 1982). Feed is given twice daily at 15% biomass. The feed is a mixture of all the ingredients including vitamins and minerals. Oil and gelatinized

Table 1. Types of feed given to tilapia fry reared in hapas in Laguna Lake (Bautista 1986)

Feed Type	Form of Feed	Feeding Rate	Frequency	Feeding Period
Chicken egg yolk	mashed, moist	1 pc/20 000 fry	2×/day	Days 1-3
Trash shrimp	blended, wet	25 g/10 000 fry	2×/day	Days 4-7
Formulated feed 35% CP	meal form	10-15% of fish biomass	2×/day	Days 4-7
Broiler starter mash	finely ground	50 g/10 000 fry	2×/day	Day 7 onwards

Table 2. Percentage composition of formulated feeds for tilapia fry (Santiago et al 1982)

Ingredient	%
Fish meal	30.17
Soybean oil meal	25.95
Ipil-ipil leaf meal	8.10
Copra meal	11.48
Rice bran	12.24
Dextrin	2.73
Cod liver oil	1.00
Vegetable oil	1.00
Starch	3.00
Vitamin premix ^a	0.69
Mineral premix ^a	3.60
Butylated hydroxytoluene	0.04
Est. crude protein (%)	35.00
Anal. crude protein (as fed) (%)	36.00
Est. digestible energy (Kcal/100 g)	250.00

^aFor complete and practical diets (Nat. Res. Council 1977)

Based on values for channel catfish: protein, 3.5 Kcal/g; fat, 8.1 Kcal/g; NFE, 2.5 Kcal/g (Nat. Res. Council 1977, Wilson 1977)

starch are added last. The mixture is then extruded through 2 mm dies of a heavy-duty meat grinder. The resulting pellets are oven-dried at 70°C until moisture content is about 10% or less. The dry pellets are crumbled and sieved. Feed particles that pass through the No. 60 mesh sieve are fed to fry for the first two weeks. During the 3rd and 4th week, fry are given feeds that pass through No. 45 mesh sieve. Larger crumbles are fed subsequently. Stocks of prepared feeds are kept in a refrigerator.

The rearing tanks are maintained by siphoning uneaten feeds and feces. Water is changed every 10 days by draining at least 1/3 of the total water volume. Growth of phytoplankton in tanks, especially the blue-green algae and diatoms, is encouraged. In some cases, uni-algal cultures of the desired species are used to inoculate the rearing tanks on a regular basis. These serve as food for the growing fry aside from maintaining good water quality in tanks. The blue-green algae *Chlorococcus dispersus* and the diatom *Navicula notha* enhanced growth and survival of tilapia fry (Pantastico et al 1985).

Diseases and parasites. *Tilapia nilotica* fry infected with *Trichodina* and *Dactylogyrus* are treated with salt bath at the concentration of 1 000-2 000 ppm. *Pseudomonas* has also been found in tilapia fry reared in nursery tanks. Aside from salt bath, fry are fed oxytetracycline-treated artificial feeds at 7.5 g/100 kg fish body weight per day for 7-12 consecutive days.

Harvest and transport. Fry are harvested after 21-30 days of rearing in hapa cages in the lake or 30-45 days in tanks. Fry are sorted according to the mesh size of the cage to which they were to be transferred, i.e., A-net (2 mm sq mesh), B-net (4 mm diagonal mesh) or C-C net (20 mm diagonal mesh). Fingerlings measuring about 2-2.5 cm total length are stocked at 200-250/m² using A-net or B-net cage in the lake for further rearing. In a related experiment by Tabbu et al (1986), tilapia recovery was highest in breeding hapas than in the ponds. Fry were collected from the ponds either by seining or by means of fine mesh scoop nets. Low fry recovery in ponds was attributed to cannibalism and other factors such as asynchrony of spawning cycles and variable fecundity.

Fingerlings are transported in doubled plastic bags filled with oxygen at a fry density of 500-1 000/bag in 10-15 l of water.

Production constraints. In general, tilapias are prolific breeders so that the production of fry is not much of a problem. However, some unfavorable environmental parameters in the lake like low water temperature during cold months, scarcity of natural food, and adverse conditions during typhoons could lower their reproductive capacity. Likewise, growth and survival of tilapia fry are affected by these parameters.

CARP

Introduction

Carp culture in the Philippines began in 1966 when fingerlings of Chinese carp, i.e., bighead, silver and grass carps, and the common carp were grown in ponds at the Tanay Experimental Station of the Bureau of Fisheries and Aquatic Resources (Chaudhuri 1979). Subsequently, mass seed production of these species was conducted. In 1969, the first successful induced spawning of bighead and silver carps by hormones was achieved (Reyes as cited in Chaudhuri 1979). Despite these pioneering efforts, the carp culture technology did not flourish due primarily to the limited production of fry and fingerlings.

In the mid-1970's, two enterprising fish culturists ventured into hatchery and grow-out culture of Chinese carps. They developed carp broodstock from the fingerlings obtained from Taiwan (Santos, pers. comm.). However, fry and fingerling production was limited to their own requirements for grow-out.

The potential of bighead and silver carps for cage culture in the lake was further recognized when several studies were undertaken by SEAFDEC AQD in 1980. From the fingerlings of Chinese carp obtained from a private hatchery in Bulacan, broodstock was developed and subsequently induced to spawn for seed production. Studies on broodstock development resulted in the successful gonadal maturation and rematuration of bighead and silver carps in floating cages in the lake all year round (SEAFDEC Asian Aquaculture 1984). The first record of induced spawning of lake-reared carps was achieved at SEAFDEC AQD in 1983. The fingerlings produced were made available to the fishpen and cage operators in Laguna Lake. The following year, more than 100 000 bighead carp fingerlings were made available to several fishpen and cage operators in the lake. The number of fishpen operators has increased to 14 in 1985-1986, operating an aggregate area of 1 862 ha for bighead carp grow-out (Almazora 1987). At the

minimum stocking density of 10 000/ha, a total of 18.6 million carp fingerlings are needed for cropping every 6-8 months.

At present, there are about 16 private carp hatcheries around Laguna Lake, ready to supply fingerlings. These hatcheries operate at varying production rates ranging from 0.1 to 1.5 million fingerlings/6-month operation (Almazora 1987). Carp fingerlings (about 4-6 cm length) are sold at the current price of P2-2.50 each.

Broodstock Development and Management

Rearing facilities. Fishpens, cages, and earthen ponds are used to rear bighead and silver carp broodstock. Broodstock pens are $10 \times 50 \times 2.5$ m, each lined with size 20 mm mesh nylon netting. The net is buried at least 0.5-1.0 m deep and held in place with bamboo stakes. It is extended to about a meter above the water surface.

Cages are $4 \times 4 \times 3$ m or $5 \times 10 \times 3$ m covered, and with mesh size of 4-20 mm. The cages arranged in series are suspended in stationary or floating bamboo modules. It is protected from strong waves and heavy growth of water hyacinths during typhoons by a peripheral bamboo and net barricade.

Earthen ponds have each a total area of 500 m^2 ($20 \times 25 \times 1.0$ m) with mean water depth of 0.75 m. Each compartment has individual inlet and outlet gates for easy draining and refilling.

Rearing methods. One-year old bighead and silver carps are stocked and maintained at densities of 100-200/500 m^2 fishpen or at 10-20/ m^2 in floating cage. The two species are reared separately. In ponds, bighead and silver carps are reared in polyculture in compartments at 25 pcs/500 m^2 . A female to male ratio of at least 1:1 to 1:2 is maintained in all rearing facilities.

In the lake, carp broodstock are not given supplemental feeds. Bighead carps feed on zooplankton while silver carp thrives mainly on phytoplankton, both of which grow abundantly in the lake (Carlos et al 1986). Preliminary experiments on the supplemental feeding of carp broodstock in floating cages in the lake were done (Castro et al 1984). The experiments aimed primarily at enhancing the gonadal maturation and subsequently the spawning capacity of the fish. The fish were fed daily, once in the morning and once in the afternoon, at 3% biomass with the dry pellet that contained about 35% crude protein. Initial

data, however, showed no significant results. Further investigations are still needed.

Broodstock ponds are prepared by draining, sun-drying, and fertilizing with chicken manure prior to stocking of fish. Chicken manure is applied initially at the rate of 2-3 t/ha and subsequently at 1-1.5 t/ha/7-10 days. The breeders are given supplemental feeds twice daily at 3.0% biomass. Pond water is partially flushed and replenished at least twice a week.

Gonadal development. Carp broodstock are sampled monthly to assess gonadal development and growth. During sampling, fish are held in a large rectangular styrofoam box (0.5 × 1.0 × 0.7) m) filled with lake water and aerated.

Fish are anesthetized with 2-phenoxyethanol at the rate of 30-40 ml/100 l of water. At least 6-8 breeders weighing 3-4 kg each are held in the box at a time during sampling. Broodstock are measured individually for total length, weight, and body girth. Each fish is coded by marking the surface of the head with a lead pencil. The mark could last more than a month and is renewed every sampling time.

Sex of breeders is determined by means of their pectoral fins. A mature male broodstock has rough pectoral pins due to the presence of "ctenoid teeth structures" which appear prominently along the first ray. A male broodstock is selected for induced spawning when it readily gives off milky white milt when press gently along the abdominal portion. A female breeder has smooth pectoral fins. When fully mature, its belly is distended with pinkish genital papilla. Gonadal maturity is assessed by cannulation. Stage IV mature eggs are yellowish in color, easily dispersed in freshwater, and are 1.0-1.4 mm dia. The nuclei of mature eggs are polarized when placed in a petri dish containing FAA solution (9.05% formaldehyde, 4.55% acetic acid, and 86.4% ethyl alcohol) (Fermin 1986a). The fish is then selected for induced spawning.

Gonadal maturation and spawning. Under Laguna Lake conditions, bighead and silver carps attain sexual maturity in 2-2.5 years, each ranging 3-4 kg. They undergo spontaneous gonadal maturation and rematuration throughout the year without hormonal inducement (Fermin 1986b). Carp broodstock maturation rates peak in summer (March-May) when natural food in the lake are most abundant. This gradually declines to its lowest approaching the cold months (December-January) (Fig. 1).

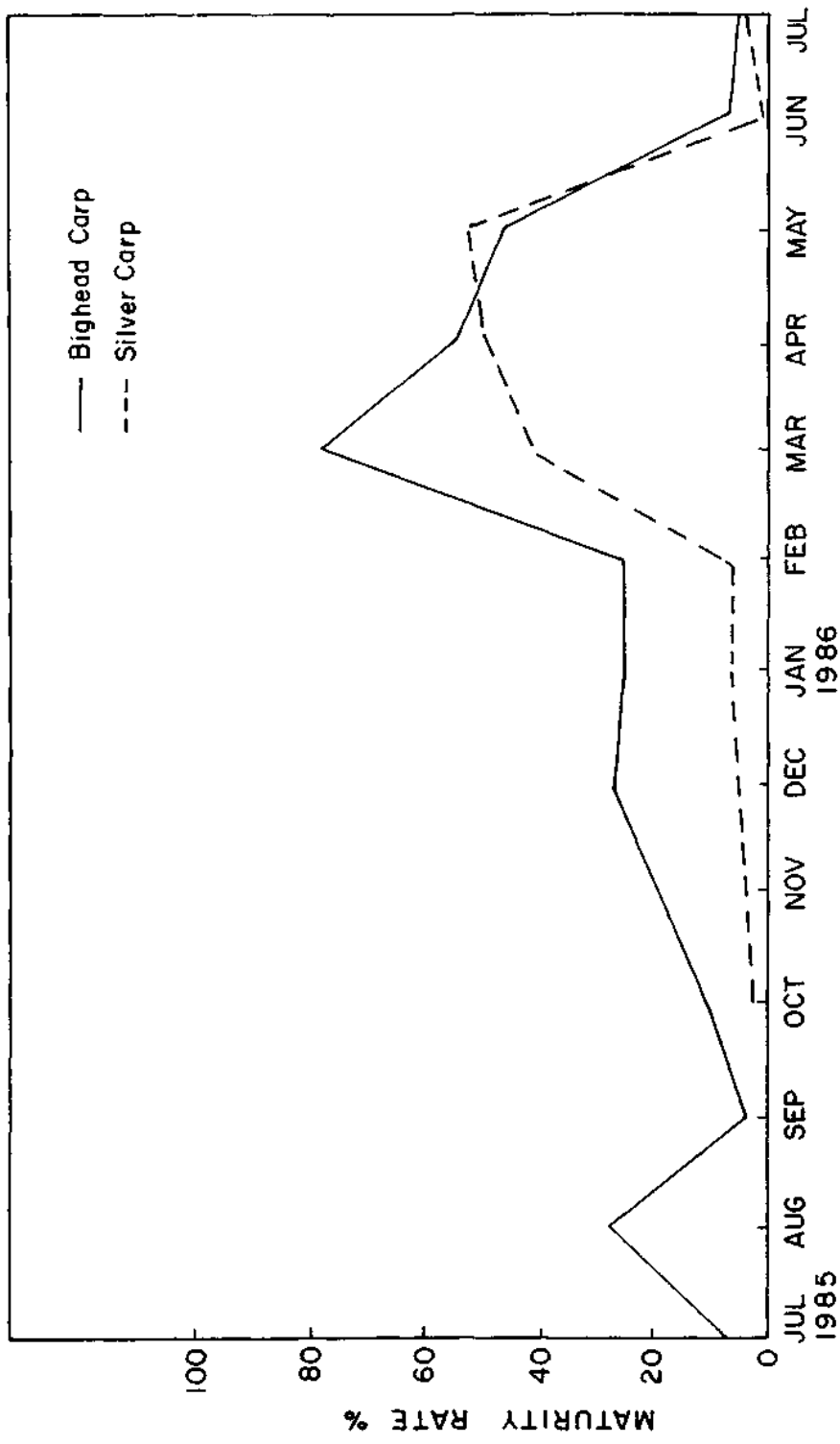


Fig. 1. Percentage maturity rate of bighead and silver carp broodstock reared in floating cages in Laguna Lake from July 1985 to July 1986 (Fermin et al 1986)

Gravid females with mature Stage IV eggs are selected for induced spawning. The fish are conditioned in a circular pool (5 m dia and 1.3 m depth) made of G.I. sheets and lined with plastic canvas. The tank is provided with water jet effecting a continuous circular flow of water. Two to three males are used for every female. The fish are held in the tank for 18-24 hr prior to hormone injection. The hormones used for carp spawning are: Human Chorionic Gonadotropin (HCG), leuteinizing hormone-releasing hormone analogue (LHRH-a) and common carp pituitary gland (PG). The females are injected with an initial dose of HCG at 10% of the total dosage of 2 000 IU/kg body weight. During the second injection, about 6-8 hr later, the remaining 90% of HCG is injected in combination with either 20 µg of LHRH-a or 3-4 pcs of common carp PG homogenized in 1-2 ml of distilled water. At this point, males are also injected with 1 000 IU of HCG/kg body weight. The hormones are given by intraperitoneal injections behind the pectoral fin.

During the latency period, about 6-8 hours after injecting the final doses, the fish display aggressive movements causing intermittent rippling on the water surface. The female is then taken out of the tank and stripped of its eggs which are collected in an enameled basin. A 3-kg breeder can spawn about 15 000-200 000 eggs. Simultaneously, 2 or 3 males are stripped of their milt directly into the eggs which are stirred with feather. Fertilization rates vary from 23-88% (Table 3). Eggs are incubated in well water with total hardness of 300-500 ppm (Gonzal et al 1987) (Fig. 2 and Table 4). Lake or underground water with total hardness of about 75-150 ppm may cause premature bursting of carp eggs within 5-8 hours of incubation. The normal incubation period for carp eggs ranges from 13-18 hr at water temperature of 28-30°C. Hatching rates vary from 7-36%. Under favorable conditions, a spent female may remature in 2-3 months in Laguna Lake.

Diseases and parasites. Injuries by handling and crowding during the process of induced spawning sometimes lead to some bacterial and fungal infections of the breeders. Broodstock are subject to indefinite salt bath at a concentration of 1 000-2 000 ppm after spawning and before putting back in cages (Palisoc 1986). *Aeromonas hydrophila* and *Citrobacter micrococcus* have been found in silver carp broodstock used in induced spawning. The fish were injected with oxytetracycline at 7.5 g/100 kg fish body weight/day for 7-12 consecutive days. Parasite infestation has not been observed in carp broodstock reared in the lake.

Table 3. Induced spawning of bighead and silver carps broodstock reared in floating cages, Laguna Lake, 1985 and 1986 (Fermin et al 1986)

Date	Species	No. of Females	Average Weight, kg	No. of Males	Total Amount of Spawmed Eggs	Fertilization Rate, %	Hatching Rate, %	Larval Production	Remarks
1985									
Aug. 14	Silver Bighead	1	2.8	3	95,000	45	12	5,000	— delayed spawning
		2	3.5	3	115,000	74	23	20,000	— incomplete spawning
Aug. 22	Bighead	2	4.0	5	250,000	23	9	6,000	— delayed spawning
Sept. 11	Silver	3	3.1	5	330,000	35	15	18,000	— poor milt discharge by males
Sept 24	Bighead	3	3.1	7	350,000	45	26	40,000	— partially spawned
Oct. 12	Bighead	1	5.2	4	450,000	50	18	41,900	— prolonged incubation
	Silver	1	3.5	2	150,000	60	31	28,000	temp. 26°C
Oct. 16	Bighead	3	4.3	6	800,000	72	7	23,150	
Nov. 12	Bighead	2	3.5	6	450,000	70	26	86,500	— delayed spawning
Dec. 9	Bighead	3	2.0	7	450,000	65	24	68,900	
Dec. 19	Bighead	3	3.7	8	900,000	88	36	288,800	
1986									
Mar. 17	Bighead	4	2.7	8	550,000	75	32	132,000	
Mar. 24	Bighead	4	4.0	7	480,000	83	26	104,000	
June 26	Silver	3	4.5	7	125,000	42	28	14,800	— partially spawned
July 1	Silver	3	3.3	5	460,000	46	8	16,900	— delayed and partially spawning
July 21	Bighead	1	2.8	4	83,000	50	24	9,900	

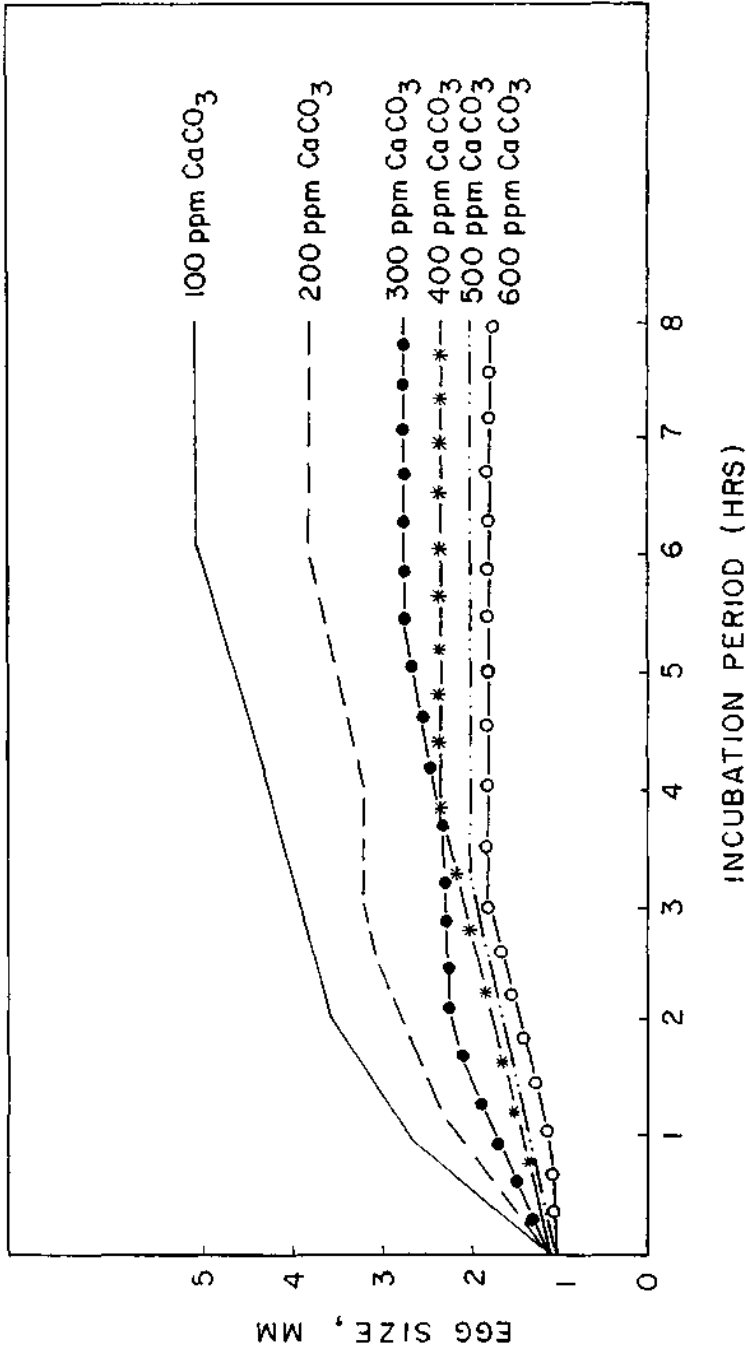


Fig. 2. Enlargement of silver carp eggs exposed to different levels of water hardness (CaCO₃) (Gonzal et al 1987)

Table 4. Mean egg diameter, hatching rate and larval production of silver carp spawn after 7-hr, incubation at varying levels of water hardness (Gonzal et al 1987)

Total Hardness	Mean Egg Diameter (mm)	Hatching Rate (%)	Larval Production (%)
100	5.0	3.67 ^b	7.95 ^c
200	3.8	4.50 ^b	29.45 ^{cb}
300	2.7	22.50 ^a	40.20 ^b
400	2.3	27.50 ^a	67.50 ^a
500	2.0	28.83 ^a	71.80 ^a
600	1.9	3.67 ^b	40.20 ^b

¹Means with the same superscript are not significantly different (P > 0.10)

Production constraints. The production of carp broodstock is adversely affected by poor weather conditions in the lake. During typhoons, broodstock cages and pens are prone to destruction by strong waves resulting in complete loss of fish. Poaching is another perennial problem being experienced by hatchery operators. Bighead carp broodstock are easy prey to poachers because of their sedentary nature.

Seed Production

Rearing facilities. Carp fry are reared in indoor tanks made of fiber glass, marine plywood, cement, or plastic canvas. Fiberglass tanks are oval-shaped with total capacity of about 1.3 t each. Water can be kept at a depth of 0.5-0.6 m. Marine plywood and cement tanks are rectangular measuring 1.2 × 2.4 × 0.6 m and 2.0 × 2.8 × 0.7 m, respectively. Plastic canvas tanks are circular with a diameter of 3 m and water depth of about 0.3 m. Mean water depth of rearing tanks is 0.5 m.

Carp fry are also reared in fine-mesh net-cages installed in earthen ponds. Net-cages of about 80 µ mesh size measure 1 × 3 × 1.5 m or 2 × 5 × 1.5 m. The cages are tied to bamboo or ipil-ipil (*Leucaena leucocephala*) posts spaced about 1 m apart. The cages are arranged in

series in the middle of the pond. The pond has an inlet and outlet which permits periodic flushing of water.

Rearing methods. Three to four day old bighead or silver carp fry are stocked in the nursery tanks at 10/1 of filtered lake water or unchlorinated tap water. Each tank is moderately aerated.

During the first 2 weeks of rearing, fry are fed daily in *ad libitum* with small-sized zooplankton like *Brachionus plicatilis* in combination with artificial feeds. *Brachionus*, a marine rotifer, are mass produced in artificial sea water with 10-15 ppt salinity in 120 l capacity glass aquaria or in 240 l capacity galvanized iron tanks. The zooplankton are fed daily with freshwater *Chlorella* plus bread yeast (Acosta et al 1986). Harvesting is done starting on the 3rd day of culture up to the 7th day, after which the culture is renewed. *Brachionus* is washed with sufficient freshwater before feeding to fry. Fry can be fed artificial feeds with 40% crude protein (Table 5), (Fermin 1985).

Table 5. Composition of artificial feed used for rearing carp fry (Fermin 1985)

Ingredient	%
Fish meal	40.60
Soybean meal	36.13
Rice bran	15.00
Vitamin-mineral premix	5.00
Cod-liver oil	3.27
Estimated crude protein %	40.066
Analyzed crude protein %	40.21
Estimated digestible energy	270.503

In the next 3-6 weeks the fish are gradually shifted to larger zooplankton such as nauplii and small adults of *Moina macrocopa*. Mixed sizes are given in the latter part of the rearing period. Artificial feed is given in addition to *Moina*.

Moina, a cladoceran, is mass-produced outdoors in circular cement tanks about 1.3 t capacity, using fermented leaves and stalks or water hyacinths (*Eichhornia crassipes*) mixed with filtered lake water at 50:50 ratio (Baldia 1986). Peak production of *Moina* is attained at

the 9th day; then it gradually declines. Cultures are renewed every 10th day.

Throughout fry rearing, phytoplankton in the form of "green-water" is added daily to the culture tanks after each water change. Phytoplankton improves the water quality in the rearing tanks and enhances fry survival (Fermin 1985). They have the ability to assimilate nitrogenous end-products of fish wastes and excess feeds.

Fry are stocked in nursery cages installed in the ponds, at the rate of 1 000-1 500/m². They are given artificial feed *ad libitum* to supplement the natural food in the pond. Ponds are fertilized every 2 weeks with chicken manure at 0.1-0.2 kg/m². The manure is placed in sacks and hanged at different sites within the pond. Water depth in the pond is maintained at 0.5-0.75 m throughout the rearing period. Carp fry are cultured for 21-30 days in cages after which they are released directly in the pond.

Diseases and parasites. Carp fry reared in indoor tanks are vulnerable to disease and parasite infestation particularly under conditions of crowding, handling stress, and poor water quality. Bighead carp fry in tanks were found to be infected with *Pseudomonas*. The fry were treated with indefinite bath of formalin at concentration 15-25 ppm (Palisoc 1986). Preventive measures like daily change of water, and removal of excess feed and other wastes are generally practised.

Harvesting and transport. Fry are harvested after 30-45 days of rearing in tanks or 25-30 days in cages in the pond. They have a total body length of about 1.5-2.5 cm.

Harvesting is done by slowly draining the water in the tanks leaving at least 1/3 of the total volume. The fry are either scooped out or completely drained into the collecting basins half-filled with water and lined with soft, fine-meshed net.

During transport, fry are kept in 10-15 l of water in oxygenated doubled plastic bags (60 × 90 × .003 cm) packed in buri bags (*bayong*). Density of fry ranged from 70-100/l. Bags are inflated with oxygen and secured by tying each layer with rubber bands. A few pieces of ice cubes are put on opposite sides of each bag to cool water to about 24-26°C. Transport of fry is done preferably in the morning or late in the afternoon when ambient temperature is low.

Production constraints. The insufficient supply of natural food organism could adversely affect growth and survival of fry reared in indoor tanks. The adverse conditions in the lake especially during the rainy months can cause heavy mortality of fry. Fry reared in ponds have better growth rate. However, recovery during harvest is very low.

REFERENCES

- Acosta BO, Laron MA. 1986. Evaluation of *Brachionus* cultured in different media as food for Chinese carp fry and fingerling. 7p. Submitted for the SEAFDEC AQD Annual report, 1986.
- Almazora RR. 1987. A project feasibility study for a carp hatchery and grow-out financing scheme. Makati, Metro Manila: Asian Institute of Management. Thesis. 136p.
- Anon. 1984. Artificial propagation of Chinese carp in Laguna de Bay. *SEAFDEC Asian Aquacult.* 6(12): 1-2.
- Baldia SF, Pantastico JB. 1983. Feeding of live food organisms for fingerling production of carps. 8p. Submitted for the SEAFDEC AQD Annual Report, 1983.
- . 1984. Culture and utilization of *Moina macrocopa* (Straus) as feed of tilapia (*Oreochromis niloticus*) fry. Diliman, Q.C.: University of the Philippines System. Thesis. 106 p.
- , Pantastico JB, Baldia JP. 1985. Acceptability of selected zooplankton and phytoplankton for growing larvae/fry of bighead carp (*Aristichthys nobilis*). 11 p. Paper presented at the Asian Symposium on freshwater culture; 1985 October 10-15; Beijing, China.
- . 1986. Mass production and improvement of food value of selected zooplankton for larval rearing of finfishes I. Production schemes for freshwater zooplankton. 9p. Submitted for the SEAFDEC AQD Annual Report, 1986.
- Basiao Z. 1981. Tilapia broodstock development and seed production. 8p. Lecture presented during the International training on tilapia cage culture in Freshwater; 1981 October 19-November 6; Binangonan Research Station, Binangonan, Rizal.
- , San Antonio A. 1986. Growth and survival of Nile tilapia fingerling in net cages without supplemental feed in Laguna Lake, Philippines. Maclean JL, Dizon LB, Hosillos LV, eds. The First Asian Fisheries Forum; proceedings of the First Asian Fisheries Forum; 1986 May 26-31; Manila, Philippines. Manila: Asian Fisheries Society: 533-538.
- Bautista AM. 1986. Tilapia hatchery and nursery systems: operation and management. Guerrero RD III, De Guzman DL, Lantican CM, eds. Tilapia farming: proceedings of the first national symposium and workshop on tilapia farming; 1986 November 24-26; PCARRD, Los Banos, Laguna. Los Banos, Laguna: PCARRD: 8-13. PCARRD book ser., no. 48.
- Bautista AM, San Antonio AI, Basiao Z. 1987. Egg and fry production of *Tilapia nilotica* at different sex ratios and stocking densities. Binangonan, Rizal: Binangonan Freshwater Station, SEAFDEC Aquaculture Department 25p. (Unpublished material)
- Carlos M, Duran E, Gonzales D, Arcilla R, Aralar E. 1986. Ecological studies for the management of Laguna Lake. 13p. Submitted for SEAFDEC AQD Annual Report, 1986.

- Castro SC, Lacierda RB, Fermin AC. 1984. Development of techniques for carp broodstock maturation in lakes and ponds. Submitted for the SEAFDEC AQD. Binangonan Research Station Annual Report, 1984.
- Chaudhuri H. 1979. Status and problems of carp hatchery and management. 13p. Paper presented at the Symposium-workshop on fish hatchery-nursery development and management; 1979 September 27-29; PCARR, Los Banos, Laguna.
- Fermin AC. 1985. Growth and survival of bighead carp (*Aristichthys nobilis*) fry fed different types of feed and their combinations. Munoz, Nueva Ecija: Central Luzon State University. Thesis. 49p.
- , Lacierda RB, Reyes DM, Laron MA. 1986. Development of techniques for carp broodstock maturation in lakes and ponds. 13p. Submitted for the SEAFDEC AQD Annual Report, 1985.
- . 1986a. Principles of induced spawning. 13p. Lecture paper presented during the International training on freshwater aquaculture; 1986 September 15-October 17; SEAFDEC Binangonan Freshwater Station; Binangonan, Rizal, Philippines.
- . 1986b. Carp hatchery and nursery operation and management. 17p. Lecture paper presented during the International training on freshwater aquaculture; 1986 September 15-October 17; SEAFDEC Binangonan Freshwater Station; Binangonan, Rizal, Philippines.
- . 1986c. Carp broodstock culture and management. 10 p. Lecture paper presented during the International training on freshwater aquaculture; 1986 September 15-October 17; SEAFDEC Binangonan Freshwater Station; Binangonan, Rizal, Philippines.
- Gonzal A, Aralar E, Pavico J. 1987. The effect of varying levels of water hardness on the hatching and viability of carp eggs. *Aquaculture* (In press)
- Guerrero RD III. 1985. Overview of freshwater aquaculture in the Philippines and Southeast Asia. 18p. Paper presented during the Seminar on agribusiness opportunities in freshwater aquaculture; 1985 January 15-17; Manila.
- Guerrero RD III. 1987. Commercial production of tilapia in freshwater ponds and cages in the Philippines. Guerrero RD III, De Guzman DL, Lantican CM, eds. Tilapia farming; proceedings of the first national symposium and workshop on tilapia farming; 1986 January 14-16; PCARRD, Los Banos, Laguna. Los Banos, Laguna: PCARRD: 14-20. PCARRD book ser., no. 48.
- Palisoc F. 1985. Diagnosis of fish parasites and diseases. Submitted for the SEAFDEC AQD Annual Report, 1985.
- Pantastico JB, Baldia JP, Baldia SF, Reyes DM Jr, Tabbu N, Gonzal A. 1984. Growth and survival of carp fry at varying densities in freshwater ponds. 10 p. Submitted for the SEAFDEC AQD Annual Report, 1984.
- , Baldia J, Baldia S. 1985. Growth and survival of carp fry reared to fingerling stage at varying stocking densities and types of fertilizers. 14p. Submitted for the SEAFDEC AQD Annual Report, 1985.
- , Baldia, JP, Reyes DM Jr. 1985. Acceptability of five species of freshwater algae to Tilapia (*Oreochromis niloticus*) fry. Cho CV, Cowey CB, Watanabe T, eds. Finfish nutrition in Asia: methodological approaches to research and development (includes proceedings of the Asian finfish nutrition workshop; 1983 August 23-26; Singapore) Ottawa: IDRC: 135-144.
- PCARRD. 1985. The Philippines recommends for tilapia. Los Banos, Laguna: PCARRD. 57p. Technical bulletin ser., no. 15-A.

- Santiago CB, Banes-Aldaba MB, Laron MA. 1982. Dietary crude protein requirement of *Tilapia nilotica* fry. *Kalikasan; Philipp. J. Biol* 11(2-3):255-265.
- , Aldaba MB, Laron MA. 1983. Effect of varying dietary crude protein levels on spawning frequency and growth of *Sarotherodon niloticus* breeders. *Fish. Res. J. Philipp.* 8(2):9-18.
- Tabbu NS, Lacierda RB, Equia R. 1986. Harvesting techniques for Nile tilapia fingerlings. *Fish. Res. J. Philipp.* 12(2):39-42.