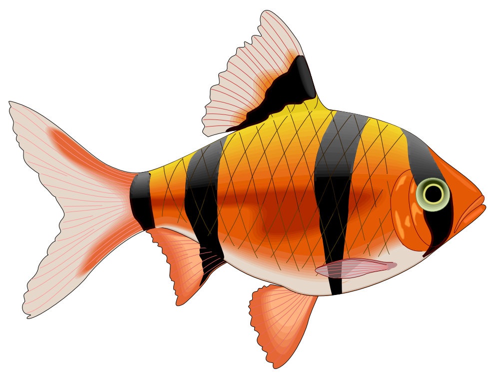
A Manual for Commercial Production of the Tiger Barb, *Capoeta tetrazona*, A Temporary Paired Tank Spawner



By
Clyde S. Tamaru, Ph. D.
Brian Cole, M. S.
Richard Bailey, B. A.
Christopher Brown, Ph. D.

Center for Tropical and Subtropical Aquaculture
Publication Number 129

Table of Contents

Acknowledgements

This manual is a combined effort of three institutions, the **Center for Tropical and Subtropical Aquaculture (CTSA)**, which is one of five Regional Aquaculture Centers funded by the United States Department of Agriculture Cooperative State Research, Education and Extension Service, the University of Hawaii Sea Grant Extension Service (SGES) and the Hawaii State Aquaculture Development Program (ADP), Department of Land and Natural Resources, State of Hawaii.

Financial support for this project was provided by the Center for Tropical and Subtropical Aquaculture through grants from the U.S. Department of Agriculture Cooperative State Research, Education and Extension Service (USDA grant numbers 93-38500-8583 and 94-38500-0065).

Production of the manual was also funded in part by a grant from the National Oceanic and Atmospheric Administration, project #A/AS-1, which is sponsored by the University of Hawaii Sea Grant College Program, School of Ocean Earth Science and Technology (SOEST), under Institutional Grant No. NA36RGO507 from NOAA Office of Sea Grant, Department of Commerce, UNIHI-SEAGRANT-TR-96-01.

Support for the production of the manual was also provided by the Hawaii State Aquaculture Development Program, Department of Land and Natural Resources, State of Hawaii, as part of its Aquaculture Extension Project with University of Hawaii Sea Grant Extension, Service Contract Nos. 9325 and 9638.

The views expressed herein are those of the authors and do not necessarily reflect the views of the Center for Tropical and Subtropical Aquaculture, USDA or any of its sub-agencies.

Special thanks are extended to Christine Carlstrom-Trick for her editorial comments.

This manual was first published in 1997. In 1998, Patti Killelea-Almonte prepared this document in Adobe Acrobat format and in HyperText Markup Language for distribution on the Worldwide Web. The layout was modified slightly from the original version, although the content remains the same.

Introduction

In keeping with the overall goal of supporting the development of an ornamental fish industry in Hawaii, the Center for Tropical and Subtropical Aquaculture, Sea Grant Extension Service, and the Aquaculture Development Program pooled their resources to produce a series of "How To" manuals covering the commercial production of a variety of ornamental fish species. This manual on the commercial production of the tiger barb, *Capoeta tetrazona*, is the second in the series.

The information presented here and in future volumes is intended to assist aquafarmers in overcoming some of the technical constraints of operating a business for the production of ornamental fish in Hawaii. Unless stated otherwise, the methods described have been field-tested in Hawaii. The reader should be aware that the methods described are not the only methods to produce the target ornamental fish species. One characteristic of Hawaii is the diversity of habitats and microclimates throughout the island state. While a particular method presented may be suitable for one area, modifications may be necessary to achieve similar production results from one location to another. The authors encourage farmers to apply their individual experience and expertise in order to interpret and adapt the material presented.

Likewise, although this manual is directed to the culture of *C. tetrazona*, the methods described are also applicable to other members of the barb family, which have similar reproductive strategies.

In the context of these "How To" manuals on the commercial production of ornamental fish, some terminology will be used to generally group fish into certain production modes based on their reproductive life history. The four major modes of reproduction in ornamental fish production are described as follows:

- **Pond spawners** are fish that will naturally spawn and produce fry in large tanks or outdoor ponds in captivity. Pond spawners can be subdivided into two simple groups, the livebearers and substrate spawners. Examples of fish that fit into this reproduction mode are swordtails, and rosy barbs, respectively.

- **Permanent-paired spawners** are fish that bond or mate for life and are usually kept together in glass aquariums or large tanks. These fish will produce eggs on a substrate, which can either be removed for incubation or allowed to remain with the parent broodstock to be raised. Examples of fish that fit into this reproduction mode are the angelfish or discus fish species.

- **Hormone-induced spawners** are fish that will not reproduce in captivity without hormonal intervention. These fish require an injection of a specific hormone to induce final oocyte maturation and ovulation. Eggs are obtained by either allowing the fish to naturally spawn or by hand stripping eggs and sperm and artificially fertilizing and incubating them. Examples of fish that fit into this reproduction mode are tin foil barbs, and Labeo sharks.

- **Temporary-paired spawners** are fish that bond only for a short period to spawn. Often these are schooling fish, and they may never spawn together again. In commercial production, these fish are placed together for only a short period of time in a hatchery tank or aquarium. Tiger barbs and other related barb species (see Table 1) fall into this category and are the subject of this manual.

Table 1. Barb species related to *Capoeta tetrazona* that can be produced in a similar manner.

Species	Common Name	Species	Common Name
Puntius stoliczkanus	tic tac toe barb	*conchonius*	rosy barb
hexazona	six banded barb	*cumingii*	cuming's barb
pentazona	five banded barb	*nigrofasciatus*	black ruby barb
everetti	clown barb	*ticto*	tic tac toe barb

Introduction to the Tiger Barb

The barbs are a subfamily (Cyprininae) of freshwater fishes native to Southeast Asia. Their large scales, bright colors, schooling behavior, and ease of maintenance and breeding have made them popular in the aquarium trade. Well over 70 barb species are currently commercially important. Color patterns of the tiger barbs fill the spectrum from black to red, and green to gold, with fry displaying color at an early age. Barbs that have been hybridized to emphasize bright color combinations have grown in popularity and production over the last 20 years. Market values range from the bread-and-butter prices (or $0.10 to $0.30 farm-gate to wholesale value) to the more unusual species that may command a few dollars each in the specialty markets. Of the total number of ornamental fish species imported into the United States during 1992 (1,539 species), only 20 species account for more than 60% of the total number of individuals being imported. The tiger barb ranks tenth in number of individuals and accounts for 1.3% of the total (Chapman et al. 1994). Table 2 summarizes the top 20 species and the percentage of the total number of ornamental fish imported into the United States in 1992.

Two basic types of reproductive behavior exist in the barb family: non-territorial spawners and male-territorial spawners, to which the tiger barb belongs (Kortmulder 1972). Although this manual focuses on the commercial production of tiger barbs, *C. tetrazona*, the commercial production methods described are also applicable to other barbs and other species with a similar biology.

Table 2. Summary of top 20 freshwater ornamental fishes imported into the US in 1992. (Data summarized from Chapman et al. 1994).

Common Name	Scientific Name	Percentage of Total Fish Imported	Millions of Individuals Imported
Guppy	*Poecilia reticulata*	25.8%	51.9
Neon tetra	*Paracheirodon innesi*	11.3%	22.7
Platy	*Xiphophorus maculatus*	5.4%	10.9
Siamese fighting fish	*Betta splendens*	2.7%	5.4
Goldfish	*Carrasius auratus*	2.4%	4.8
Chinese algae-eater	*Gyrinocheilus aymonieri*	2.4%	4.8
Shortfinned molly	*Poecilia sphenops*	2.0%	4.0
Cardinal tetra	*Paracheirodon axelrodi*	1.5%	3.0
Glassfish	*Chanda lala*	1.5%	3.0
Tiger barb	*Capoeta tetrazona*	1.3%	2.6
Red oscar	*Astronutus ocellatus*	1.2%	2.4
Yucatan molly	*Poecilia velifera*	1.1%	2.2
Redtail black shark	*Labeo biocolor*	1.0%	2.0
Coolie loach	*Acanthopthalmus kuhlii*	1.0%	2.0
Sucker catfish	*Hypostomus plecostomus*	0.9%	1.8
Harlequin rasbora	*Rasbora heteromorpha*	0.9%	1.8
Angelfish	*Pterophyllum scalare*	0.8%	1.6
White cloud	*Tanichthys albonubes*	0.5%	1.0
Green corydoras	*Corydoras aeneus*	0.2%	0.4
Leopard corydoras	*Corydoras julii*	0.1%	0.2
Total		**64.0%**	**128.6**

Taxonomy

The scientific name of the tiger barb is *Capoeta tetrazona*. However, there has been debate over the years as to the appropriate genus and species for this fish. In 1855, the German ichthyologist Bleeker described this fish as *Barbus tetrazona*. In 1857, Bleeker described another species under the same scientific name. Then in 1860, Bleeker used *C. sumatraus* to describe the original species. In the late 1930s, this mistake was discovered, and the tiger barb nomenclature was changed back to *B. tetrazona* (Alfred 1963). More recently Dr. L. P. Schultz has reclassified the barbs according to the number of barbers each species possesses (Axlerod and Sweeney, 1992).

However, as stated by Zakaria-ismail (1993), "from my ongoing osteological studies that have been classified under *Puntius*, the genus Barbodes cannot be properly defined." Today we are left with three generic classifications, *Barbodes*, *Capoeta* and *Puntius*, all of which appear in the literature when referring to tiger barbs and other barb species. The current taxonomic status of the tiger barb, presented in Figure 1, hints that the taxonomy of the species is far from being settled. To commercial breeders, however, this fish will most likely always be referred to as the tiger barb.

ORDER	Cypriniformes
SUBORDER	Caracoidei
FAMILY	Cyprinidae
SUBFAMILY	Cyprininae
GENUS	*Capoeta* (*Barbodes*, *Puntius*)
SPECIES	*tetrazona*

Figure 1. Current taxonomic status of the tiger barb.

Distribution

The natural geographic range of *C. tetrazona* reportedly extends throughout Sumatra, Borneo, Thailand, and Malaysia, (Figure 2) with unsubstantiated sightings reported in Cambodia (Desilva and Kortmulder, 1977; Furtado and Mori, 1982; Mohsin and Ambak, 1982). It has been reported that *B. tetrazona* was found in clear or turbid shallow waters of moderately flowing streams. However, a 1980s collection from swamp lakes that are subject to great changes in water level suggests a wide tolerance to water quality fluctuations. Distribution in Malaysia indicates that tiger barbs prefer hard waters with a calcium carbonate ($CaCo_3$) concentration greater than 40 parts per million (ppm) according to Kortmulder (1982). Although there are no official reports of introductions, the fish is also found in many other parts of Asia, and with little reliable collection data over long periods of time, definite conclusions about its natural geographic range versus established introductions are difficult. In North America, there have been no reported established populations, which is logical considering many tropical species are intolerant of habitats with seasonal low temperatures.

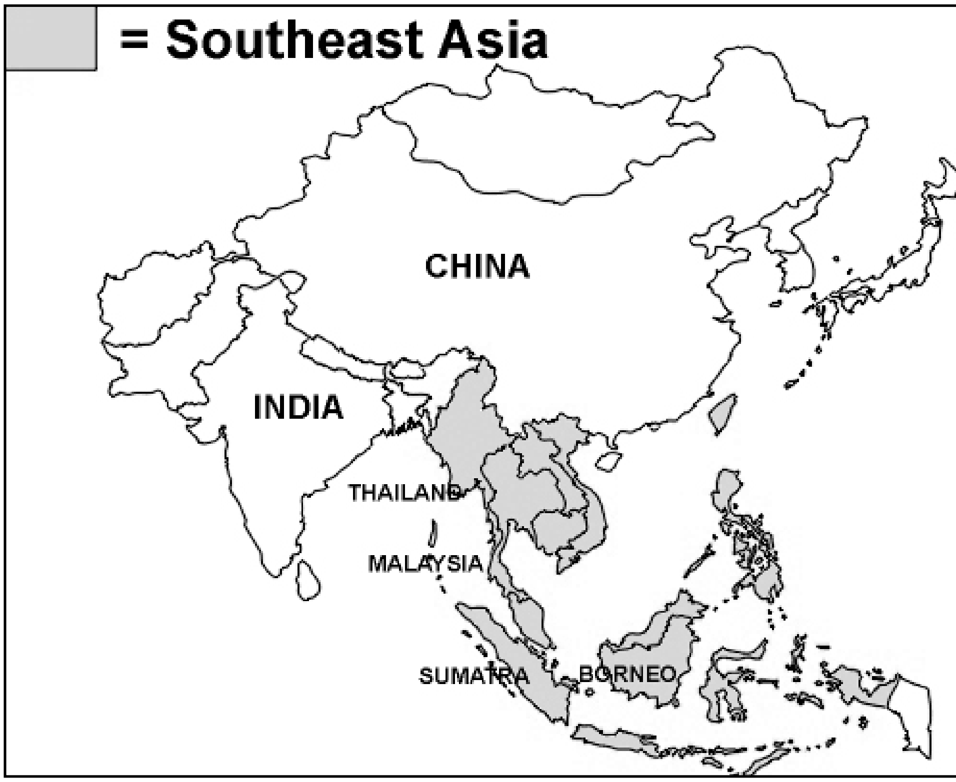


Figure 2. Natural geographic range of the tiger barb in Sumatra, Borneo, Malaysia, Thailand, and possibly Cambodia.

Morphology

Many species of barbs have similar color patterns, particularly the black band markings, which vary widely in size and shape. Although there are distinct phenotypes of the tiger barb, the homologies in the black markings can be categorized by their position and classified type as characterized by Taki *et. al.* (1977). Several phenotypes exist that differ in vertical striping pattern. One variety, *Barbodes tetrazona partipentazona*, has attained subspecies status based on the presence of an incomplete trunk band and five rather than four vertical bands, according to Frankel (1985).

Five barb types can be categorized based upon the pattern of body markings as presented in Table 3. Although classifying the barbs according to these color patterns can help distinguish species, it may not be suitable to classify the different body patterns for the commercially raised hybrids.

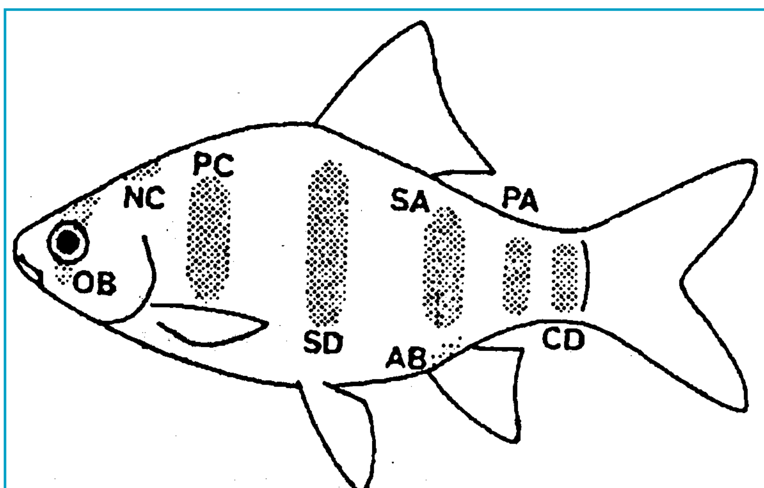


Figure 3. Location of black body marks (modified from Taki et al. 1977).
Abbreviation key:
AB = anal-basal marking;
CD = caudal marking;
NC = nuchal marking;
OB = orbital marking;
PA = post-anal marking;
PC = pectoral marking;
SA = supra-anal marking;
SD = subdorsal marking.

Inter- and intra-specific hybridization is done to achieve different colors and patterns to satisfy market demand for new tiger barb varieties. Gold and albino tiger barbs are examples of commercially produced hybrid fish. Common hybrid species, which are commercially produced, are listed in Table 4.

Table 3. Common black bar markings and patterns of related barb species. (Modified from Taki et al. 1977)

Body Type	Body Markings or Patterns
Type A	Body plain or having a caudal spot that tends to fade with age.
Type B	Bars in orbital, supra-anal and caudal fin positions.
Type C	Bars, spots, or blotches in the pectoral, subdorsal, supra-anal and caudal positions; an orbital marking may or may not be present.
Type D	Pectoral, subdorsal, supra-anal, anal-basal, post-anal, and caudal spots or blotches that may be indistinct, absent or connected to each other in any combination.
Type E	Bars or round blotches in the nuchal, subdorsal, supra-anal and caudal positions.

Table 4. Common barb hybrids representing different color patterns (Modified from Kortmulder 1972).

Parent Species	Common Name	X	Parent Species	Common Name
conchonius	rosy barb	x	*stoliczkanus*	tic tac toe
cumingii	cuming's barb	x	*stolickanus*	tic tac toe
stoliczkanus	tic tac toe	x	*cumingi*	cuming's barb
nigrofasciatus	black ruby	x	*stoliczkanus*	tic tac toe
stoliczkanus	tic tac toe	x	*nigrofasciatus*	black ruby
cumingi	cuming's barb	x	*nigrofasciatus*	black ruby
nigrofasciatus	black ruby	x	*conchonius*	rosy barb
tetrazona	tiger barb	x	*nigrofasciatus*	black ruby
conchonius	rosy barb	x	*tetrazona*	tiger barb
stoliczkanus	tic tac toe	x	*tetrazona*	tiger barb

Note: According to common scientific nomenclature, the female parent is given first.

The hybrids mentioned in Table 4 are produced to obtain enhanced golden shades and color. The red and green colors still present in F_1 hybrid offspring can be further developed through continued breeding. However, fading or enhancing of certain color characteristics through hybridization greatly impedes sorting young fish by sex for future broodstock, since tiger barbs are not sexually dimorphic. The only possible exception to this would be selecting for broodstock fish at a smaller size that have desirable color and pattern at that market size even though the color and/or pattern may still change with age. Examples of body markings changing with age and body length are presented in Figure 4. From top to bottom, the tiger barbs in Figure 4 are 3 days, 5 days, 7 to 8 days, 15 to 20 days and 25 days post-hatching, respectively.

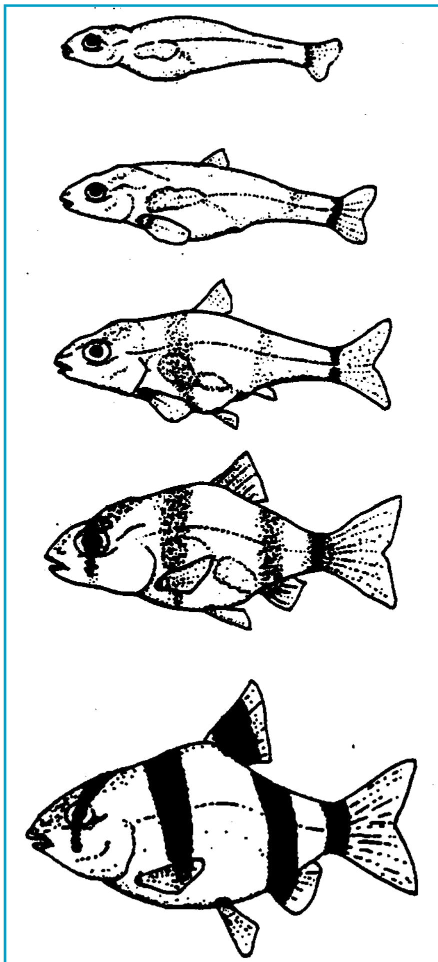


Figure 4. Change in morphology of tiger barbs during development.
Top to bottom:
5.3 millimeters,
6.0 millimeters,
7.3 millimeters,
10.1 millimeters
and
25.0 millimeters.
(Illustrations by Rich Bailey).

Water Quality

Tiger barbs thrive in water with hardness of 100 to 250 parts per million $CaCo_3$ and a pH of 6.5 to 7.5 (Baensch and Riehl 1993; Scheurmann 1990). The optimal temperature range for growth of tiger barbs is 22°C to 25°C (72°F to 78°F). Breeding takes place when temperatures consistently range between 23°C to 28°C (75°F to 82°F) with 25°C (78°F) being ideal. Tiger barbs are fairly hardy and capable of withstanding temperatures as low as 18°C (65°F) and as high as 32°C (90°F).

The length versus weight relationship of *C. tetrazona* was determined from samples of tiger barbs reared at Windward Community College (WCC) at Kaneohe, Hawaii, and is summarized in Figure 5. The statistical model:

LNWT=(O.126*TL)-4.268

where *LNWT = natural log of body weight in grams* and *TL = total body length in millimeters* was found to provide the best fit of the data, $R^2 = 0.95, P<0.001$. The relationship can be used to estimate body weight when only total body length is available.

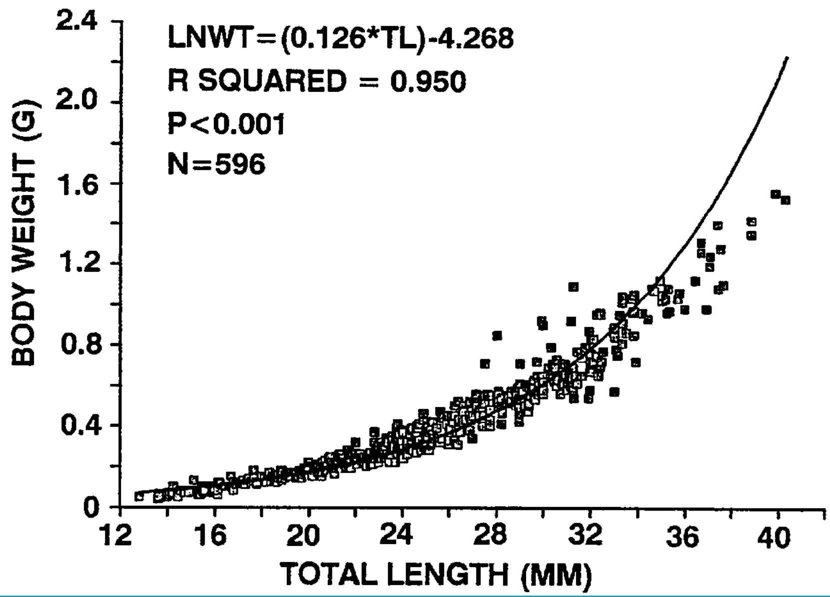


Figure 5. Length versus weight relationship of tiger barbs.

Reproduction

C. tetrazona usually attains sexual maturity at a body length of 20 to 30 millimeters (0.8 to 1.2 inches) in total length or at approximately six to seven weeks of age. Although tiger barbs are not sexually dimorphic, males display a bright red coloration on the fin rays and snout, while females tend to be more round in the abdominal region and slightly less colorful (Figure 6). Tiger barbs can obtain a maximum length of 5 centimeters (2.0 inches) and a body depth of 2 centimeters (0.8 inches) as reported by Kortmulder (1972). All related barbs mate in a sex ratio of 1 male to 1 female with the male displaying aggressive behavior while the female is submissive. Submerged aquatic plants or roots are often chosen by the female as the substrate on which to deposit the eggs. During the actual spawning event, the male clasps the female with its fins during which eggs and sperm are released over the substrate. This behavior may last for several hours or until all the eggs are released. Several hundred eggs may be laid in one spawning event. A summary of the common reproductive behavior for most of the barbs was described by Bakker *et. al.* (1982) as follows:

- promiscuous mating
- no parental care
- selective depositing of eggs by the female
- external fertilization during mating clasp (1 male:l female)
- females receptive during mating sessions lasting hours

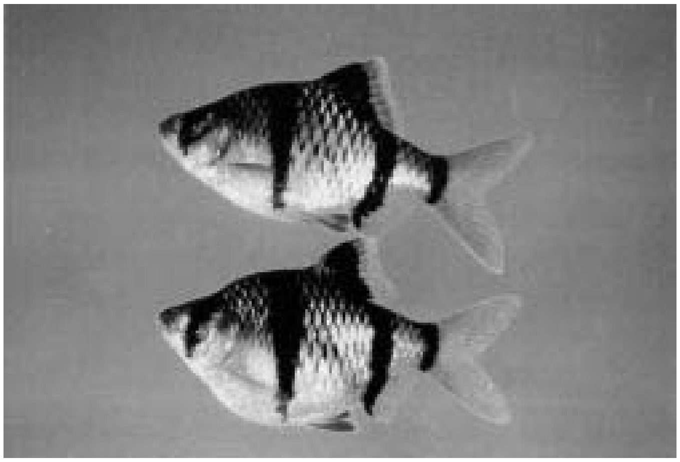


Figure 6. Photograph of an adult male tiger barb (top) and adult female tiger barb (bottom).

* repeated mating clasps with or without a change in partner or location
* male plays the active role in courtship
* male more active in antagonistic behavior and competition.

There is nevertheless a wide variation in mating behavior between species and subspecies.

Fecundity

An average of 300 eggs can be expected from each female per spawn in a mature broodstock population, although the total number of eggs released will increase with the maturity and size of the fish. Spawned eggs are adhesive, negatively buoyant in freshwater and average 1.18 ± 0.05 mm in diameter. Figure 7 shows the pooled size frequency distribution of eggs spawned from five mating pairs. Some variation in average egg size was detected among the five spawnings, but the size variation may not have any biological significance.

Tiger barbs have been documented to spawn as many as 500 eggs per female (Scheurmann 1990; Axelrod 1992), and production records at the WCC aquaculture site show similar results. It has been reported that the tiger barb is a serial spawner (i.e., spawning more than once during the spawning season) and with proper conditioning females can spawn at approximately two-week intervals (Munro *et. al.* 1990).

Growth

An experiment carried out at the National University of Singapore, in which female barbs were held under a natural photo-period of 12 hours light and 12 hours dark at temperatures of 26°C to 28°C, reported ovulation over a two-day period. Overripe eggs, which are opaque and white, were extruded from the ovaries up to four days after ovulation, with post-ovulatory follicles persisting for two days at most. Yellow atretic eggs appeared two days after ovulation and have been reported to persist for up to 14 days (Munro *et. al.* 1990).

To obtain a growth profile of tiger barbs (Figure 8), a rearing trial was conducted at WCC from October 1 through December 26, 1995. Tiger barb larvae were obtained (as described in a later section) and stocked into a 40-liter (10-gallon) tank and later stocked into a 9,500-liter (2,500-gallon) tank kept outdoors and covered with clear plastic sheets. Samples of fish were obtained at

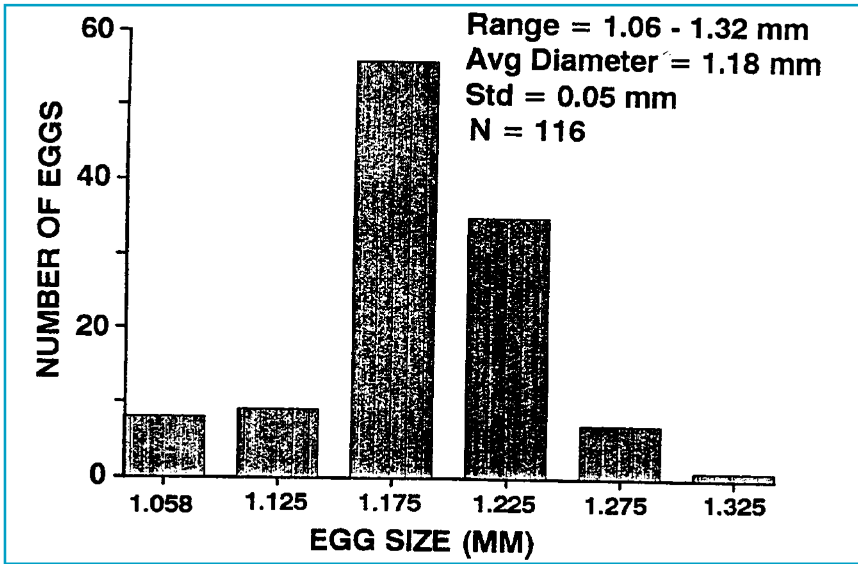


Figure 7. Size frequency distribution of spawned tiger barb eggs.

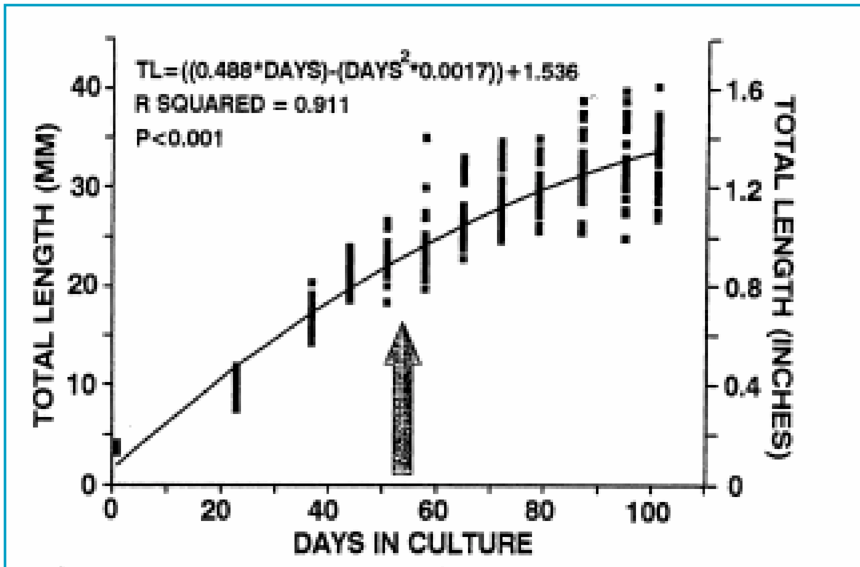


Figure 8. Growth of tiger barbs reared at 27°C. Arrow indicates size/age at first maturity.

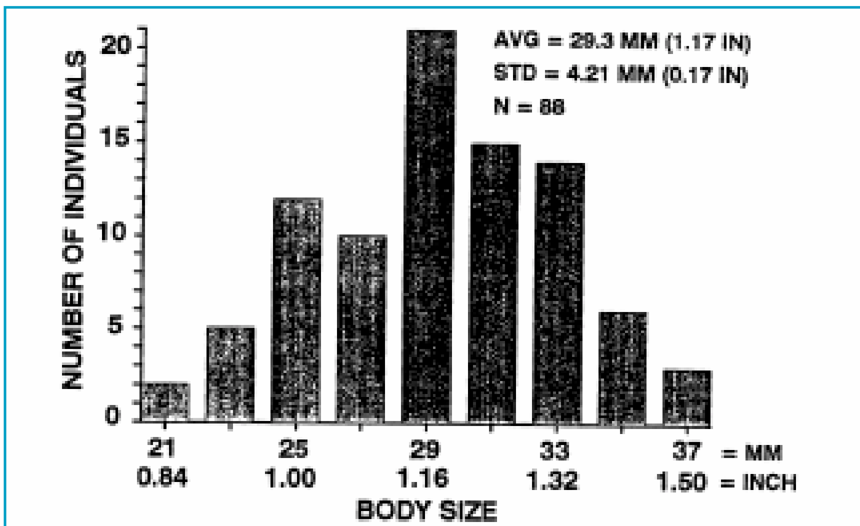


Figure 9. Size frequency distribution of tiger barbs after 101 days in culture.

weekly intervals, and the length of the rearing trial was 101 days. Average water temperature during the trial was recorded at 27°±0.7°C. The data were subjected to regression analysis and the statistical model:

$$\mathbf{TL = ((0.488 * Days) - (0.0017 * Days^2)) + 1.536}$$

where *TL = total body length in mm* and *Days = number of days in culture*, was found to provide the best fit of the data *($R^2 = 0.91\ 1$, $P<0.001$)*. As mentioned previously, the size at first maturity ranges from 20mm to 30 mm (0.8-1.2 in) and is indicated as the arrow in Figure 8. The calculated age at first maturity using 20 mm (0.8 in) as the size at first maturity was 51 days. The size frequency distribution of the tiger barbs at the end of the rearing trial is summarized in Figure 9. A pooled sample of barbs (n = 88) was distributed using 3-mm size classes, and the observed average body length was 29.3 ± 4.2 mm (1.2 ± 0.2 in).

Commercial Production

Broodstock Conditioning

Tiger barbs that are going to be used as broodstock (e.g., 20 to 30 millimeters or 0.8 to 1.2 inches body length) are first collected from a production pond or tank and sorted with size graders. The fish are then separated by sex using a glass-top sorting table. Sexually mature females are identified by a full round abdominal region, and sexually mature males are identified by bright red colors on the fin rays. Fish that have undesirable color, poorly defined bar or black band patterns, or deformities are discarded. The selected broodstock are then placed by sex into separate conditioning tanks. The conditioning tanks can be circular, square, or rectangular, but the rectangular tanks are more efficient for removing and selecting broodstock. Injuries as a result of handling can be minimized with the use of the proper size of dip net in relation to the size of the tank. A stocking density of 1 fish to 4 liters (approximately 1 fish per gallon) is recommended. The conditioning tank should be provided aeration and water exchange at a rate of 20% per day. Separation of the sexes elicits a synchronization of spawning that results in a large number of fry at the same time. The separated fish are conditioned by a diet of frozen blood and/or tubifex worms, *Artemia*, a high quality flake or a prepared paste (see Appendix 1) at least two or three times per day to satiation for a period of two weeks.

Conditioning the sexes in separate tanks is an important step in the production process. Lack of proper conditioning will result in greatly reduced numbers of successful synchronized spawnings. It cannot be overemphasized that during conditioning of the broodstock good water quality should be maintained as the conditioning diets can lead to fouling of the water. In addition, subtle changes in water quality can reportedly influence spawning of tiger barbs. Spawning experiments where water from tanks in which males were kept during the conditioning process resulted in an overall reduction in the incidence of ovulation of females relative to controls in the spawning tanks (Munro et al. 1990). Other studies have reported that a decrease in salinity of 10 to 20% may induce or force synchronized ovulation (Munro et al. 1990; Axelrod 1992). Successful synchronized spawnings have taken place at the WCC aquaculture facility by simply moving broodstock from the conditioning tanks to those with fresh clean water.

Spawning

Tiger barbs and related species are generally easy to breed, requiring only minor but important manipulations in broodstock conditioning, water quality, and spawning substrate. Commercial breeding hatcheries of tiger barbs are designed to maintain light levels either indirect or very subdued and walking traffic to a minimum. The hatcheries often hold several hundred spawning tanks that are utilized at a single time to produce large numbers of fish of similar size per trial (Figure 10). The process for spawning the tiger barbs after conditioning is as follows:

Step 1. Stocking the spawning tank
Single pairs of broodstock fish are placed into 40-liter (10-gallon) glass aquaria with little or no aeration. A stiff bottle brush (Figure 11) that is used as a spawning substrate is placed in each spawning tank in the late afternoon of the same day that spawning pairs are introduced to the tanks. Other spawning substrate materials, such as rayon knitted yarn are also used by commercial producers (Figure 12). The stiff spawning brush functions as the substrate on which the sticky eggs are laid, prevents the broodstock from eating the spawned eggs, and is easily cleaned between spawnings.

Step 2. The following morning:
The morning after stocking, check each aquarium for eggs and be careful to note which pairs of fish might currently be spawning so that you do not disturb them. If a flashlight is shined up from the underside of the tank, spawned eggs can be seen as small translucent yellowish spheres averaging 1.18 ± 0.05 mm in diameter adhering to the stiff brush.

Step 3. After spawning:
Egg-filled brushes are removed from the spawning tanks and placed in other tanks for incubation and larval rearing. The broodstock are returned to the conditioning tanks for further conditioning or holding. Fish that are exhibiting spawning behavior and others that have not yet spawned are allowed to remain in their spawning tanks for an additional day.

Paired fish are allowed only two days to spawn, after which they are removed from the spawning tanks. The hatchery is then cleaned and prepared to receive another batch of conditioned broodstock. After the egg-filled brushes and broodstock have been removed, the spawning tanks may be immediately restocked for another spawning run. If conditioned broodstock are available, a simple hatchery of 40 to 50 10-gallon tanks can produce roughly 10,000 tiger barb larvae per week.

Larval Rearing

Larval culture is characterized by the introduction of various feed types during the development of the larvae. Feeds customarily used can vary in size, quality, and quantity during the course of the rearing process. A schematic of the feeding regimen used for rearing the tiger barb larvae is presented in Figure 13.

The procedure for rearing tiger barb larvae is as follows:

Step 1. Preparation of the incubation and rearing tank:
The size of the incubation and larval rearing tank is determined by the potential number of

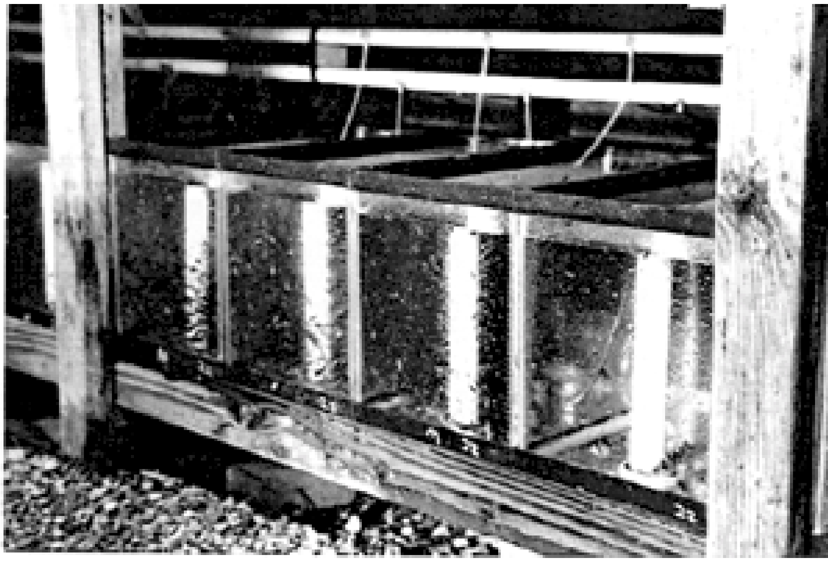


Figure 10. Spawning tanks used for commercial production of tiger barbs.

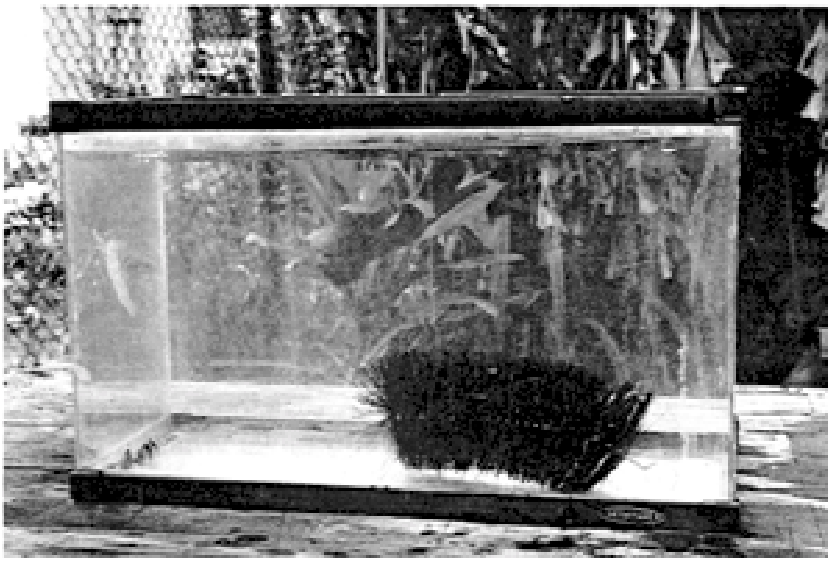


Figure 11. Spawning tank with bottle brush used as a substrate.

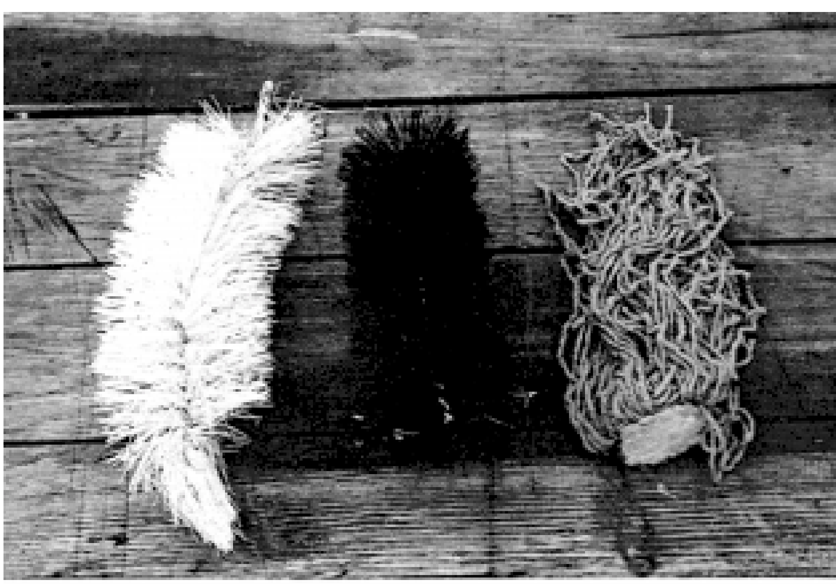


Figure 12. Various types of brushes used as spawning substrates in commercial tiger barb production.

fry, and the volume of brushes it can hold underwater. A rule of thumb for stocking is to use approximately twenty brushes containing spawned eggs to each 120-liter (30-gallon) horizontal glass aquarium. The larval-rearing tank is prepared by first treating with methylene blue or other antifungal agent according to instructions specific for disinfecting eggs. Constant aeration and a water flow rate sufficient to prevent the water from becoming cloudy should be provided. The level of aeration and rate of water exchange should be gentle, yet still high enough to maintain good water quality during the entire larval rearing cycle.

Step 2. Hatching:

Spawning brushes containing the sticky eggs from the spawning tanks are placed into the tanks prepared to hold the hatched larvae. The eggs should hatch in three days if a temperature of 25°C to 27°C (78°F to 80°F) is maintained. The newly hatched fry are non-swimming for two days and obtain nutrition from the yolk sac, so the fry do not require feeding at this time. Three days after hatching the yolk sac is usually absorbed and disappears.

Step 3. First feeding:

When fry are approximately 4.0 mm (0.16 in) in body length at three or four days after hatching and/or free swimming, feed should be introduced. It should be noted that the hatching of larvae may vary, resulting in the presence of larvae at different stages of development. Initial feeding must begin when the first larvae with a fully absorbed yolk sac are observed. Newly hatched brine shrimp, *Artemia* sp., approximately 500 m (0.02 inches) in size is introduced as the first feed and used exclusively for the next two days. The method for preparation of brine shrimp eggs for hatching is presented in Appendix 2. The fry should be fed to satiation three or four times per day. Satiation is determined by the observation of reduced feeding in the fry and a gut area that has become round and orange in color (indicating brine shrimp in the stomach). Care should be taken not to overfeed and to maintain good water quality in the larval-rearing tank at all times.

Step 4. Feeding protocol:

Overfeeding with brine shrimp and/or high protein larval feeds can quickly pollute the

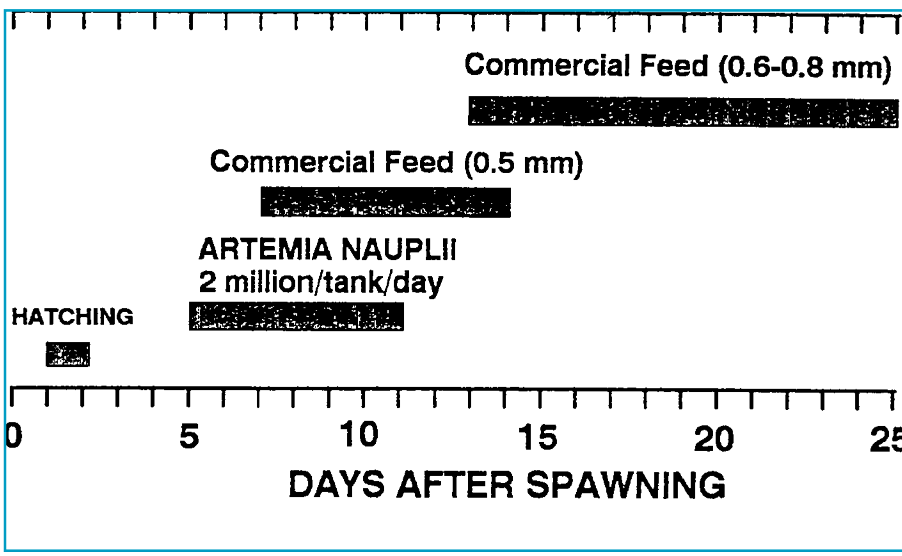


Figure 13. Schematic diagram of the feeding regimen used for the larval culture of tiger barbs.

water. Adjust the feeding rate according to the amount of debris on the tank bottom and observe water quality. Feeding more often with smaller rations can lessen the risk of elevated ammonia levels that can easily kill fry. After feeding brine shrimp exclusively for two days, prepared commercial fry feed should be introduced. Fish should be slowly weaned onto new feeds by alternating small amounts of prepared feeds with brine shrimp nauplii over the course of a day. When weaning fish to a new feed, daily introduce 10% of the new food while reducing the same percentage of the first feed until 100% of the new food is accepted. Fish are sometimes reluctant to accept new feeds but slowly weaning off one and onto a new feed can reduce the amount of wasted feed in a tank. It is important to remember that excess feed can rapidly lower water quality. The feed weaning process can be completed in three to five days. A number "00" size (0- to 5-mm diameter particle size) or "swim-up" feed having the consistency of fine powder is often used when weaning fry to commercially available feeds. Once the fry have been successfully weaned to a commercial fry diet for two days and are approximately 5.0 mm (0.2 inches) in length, they can be transferred to prepared outdoor nursery tank(s) or directly stocked into a growout pond or tank.

Step 5. Harvesting and moving fry:
Once fry have been actively feeding for two to three days, they can be stocked into a growout pond or tank. Growout ponds or tanks should be prepared (See Next Section) and stocked no later than 1 0 days after being filled with water to avoid problems that would develop with aquatic weeds and/or establishment of predatory aquatic insects. Fry transfer should take place during the morning and care must be taken to avoid extreme differences in temperature, pH and light intensity. Fry can be removed from the rearing tank by siphoning with tygon tubing that has at least a 3/8-inch inside diameter. Fry are siphoned into a bucket that has a 100 m screened section that has been cut into the wall of the bucket about three to four inches from the top of the bucket. This allows the fry to be collected into a reservoir of water in the bucket and excess water to drain out without harming the collected fry. The bucket containing the fry can then be taken to the pond or tank where they can be acclimated before stocking.

Preparing Outdoor Ponds and Tanks for Stocking of Fry

Outdoor nursery or growout ponds or tanks must be properly prepared prior to stocking with hatchery fry. A high number of fry are usually lost shortly after stocking from the hatchery due to improper preparation or lost during harvests due to less than optimal harvesting conditions.

Pond, Tank Preparation, and Aquatic Weed Control

Step la. Pond preparation:
Earthen ponds for growout of tiger barbs should first be sun-dried until the bottom cracks. This process allows for the decomposition of organic matter that has built up in a pond during the last production cycle.

Step 1b. Tank preparation:
Growout tanks can be of various shapes and sizes and constructed out of various materials (e.g., high-density polyethylene, canvas-lined plywood). The size of the growout tank

should match the egg production capability as stocking densities are based upon the working volume of the tank. Stocking densities of 1 to 5 fry per liter (4 to 20 fry per gallon) are recommended, although higher stocking densities have also been reported. All growout tanks should be equipped with continuous aeration and water supply. A recommended rate of water exchange for a 12- to 15-foot-diameter tank is 1/4 to 1/3 gallon per minute. It is best to clean the tank and allow it to sun-dry for at least two or three days prior to filling and stocking.

Step 2. Weed control:
Emerging weeds should be removed either by hand or by an approved herbicide. In the event that herbicides are used, an agricultural extension agent should first be consulted for assistance in obtaining the proper permits and methods for application. Herbicides such as Casaron, which is a broadcast herbicide that is effective on rooted aquatic and terrestrial plants, Diquat, which is particularly effective on a wide range of aquatic plants, or Sonar, which is effective on rooted aquatic and semi-aquatic plants, can be used.
NOTE: When using any herbicide, follow the label directions for proper application.
When treating ponds currently in production that are heavily infested with aquatic weeds, extreme care must be taken to minimize possible low dissolved oxygen levels that can result from decomposing plant matter. Under such conditions, it is recommended that only one half of the pond be treated at a time. Additionally, ponds should only be treated during sunny, mild temperature, and breezy weather conditions that allow for optimal oxygenation of the pond water while the organic matter is decomposing. If aeration equipment is available, 24-hour aeration can eliminate a low oxygen level problem while treating aquatic weeds with herbicides.

Step 3a. Pond fertilization:
After elimination of the vegetation, the pond should be filled as soon as possible and fertilized to obtain an algal bloom or “green water.” A liquid fertilizer with a N-P-K (nitrogen-phosphorus-potassium) ratio of 1-3-0 is recommended. This is generally mixed as a 10-30-0 or a 12-36-0 ratio and can be purchased from local distributors (see Appendix 3). The fertilizer is applied at a rate of 1 milliliter per 5 square feet of surface area or 3 to 5 gallons per acre of pond water. Inoculating the pond with green water from another pond or tank will speed up the establishment of an algal bloom. Once the bloom has been established (which usually takes only two or three days) the fish can be stocked into the pond. If delays in stocking the pond are encountered, the water should be checked for the presence of aquatic insects.

Step 3b. Tank fertilization:
In tanks, fertilizer is applied at a rate of 1 milliliter per 50 liters (13 gallons) of water. Inoculating the tank with green water from another pond or tank will speed up the time to establish an algal bloom. Once the bloom has been established (which usually takes only two or three days), the fish can be stocked into the tank. If delays in stocking the tank are encountered, the water should be checked for the presence of aquatic insects.

Step 4. Controlling aquatic insects:
Aquatic insects (e.g., dragonfly nymphs, water boatmen, and backswimmers) can pose a serious predation threat to larval fish if not controlled. Stocking a pond or tank soon after the algal bloom has stabilized allows the fish fry to grow to a size where larval insects

pose less of a predator problem. To further reduce the insect problem, netting with 1/4-inch or smaller mesh placed securely over the pond or tank restricts adult flying insects from depositing eggs and reproducing. The pond or tank should be checked periodically for insect infestation. If infestation is detected, quick measures must be taken to reduce fry losses. Applying boiled linseed oil at a rate of 1 to 2 milliliters per 5 square feet of surface area can eliminate most aquatic insects. The linseed oil will cover the surface of the water and essentially suffocate the air breathing aquatic insects. The linseed oil will slowly dissipate as it evaporates from the water surface over the next few days. For assistance, notify the University of Hawaii Sea Grant Extension Service (SGES) aquaculture extension agents.

Tank, Pond, and Cage Growout System Comparison

Pond Culture

Traditionally most growout of ornamental fish takes place in earthen ponds because of reduced construction costs and because the bottom soils support a healthy natural food chain (phytoplankton and zooplankton) from which the fish to feed on. However, earthen ponds tend to have emerging aquatic weed problems and because of their size preventing bird and insect predation with netting may be more difficult. Additionally, they often require more than one person to harvest and bottom debris must be removed prior to transfer of fish.

Tank Culture

Large circular tank culture eliminates aquatic weeds, frog/toad infestations, can be harvested by one person, can be easily covered with netting to reduce insect problems, and allows for more effective measures in treating for pathogens. The phytoplankton and zooplankton population densities in “green water” tank culture of systems, in comparison to an earthen pond culture are not very significant. However, tank culture requires more supplemental feeding than earthen pond culture systems. The additional amount of feeds used in tank culture does not add significantly to the overall production costs of a tank growout operation versus an earthen pond growout operation.

Cage Culture

Cage culture in large ponds falls somewhere between tank and pond growout culture in terms of ease and productivity. Cage operations in large ponds can benefit from the natural productivity of the food chain, while still being manageable by one person when harvested. Having a number of cages per pond allows for multiple species production in and out of the cages as well as for stocking fish at various sizes or ages. However, cages do foul and periodically require cleaning or replacement of the netting material. For established farms with large production ponds for other species, cage culture of ornamentals serves as an alternative and cost-effective way to diversify production.

Commercial Grow-out Stocking Densities

Tiger barbs are well adapted to high-density culture. Stocking densities as high as 10,000 fry per cubic meter in systems designed for high-density culture have been achieved (personal communication, Dallas Weaver, 1995). It has been reported that stocking densities of 400 to 450 individuals per square meter or greater results in reduced growth rates (Tay and Tan 1976). Extrapolating from stocking densities used by Tay and Tan (1976), tiger barb production can exceed 500,000 fish per acre per year.

Feeds and Feeding

The nutritional composition of feed plays a significant role in growth, coloration, and overall health of ornamental fish. When culturing fish at high densities it is important to feed a diet of the proper proportion of protein, lipid, carbohydrate, vitamins and minerals. This is especially true for tank culture systems. Although tiger barbs are considered omnivorous, gut analysis of wild-caught fish indicate that they prefer a more vegetative diet. One study done in Malaysia found fish with 15 different types of phytoplankton, one source of higher plant tissue, four different types of zooplankton and both aquatic and terrestrial insects in the guts (Shiraishi et al. 1972). Stomach analyses of other barb species have shown similar results (Kortmulder 1982). A good growout feed for tiger barbs should be at least 28% to 32% total protein by weight, and the source should be high in essential amino acids and highly unsaturated fatty acids (HUFA). As a rule of thumb, larval fish require high levels of total protein in their diets (30 to 45%). As the fish grows, less total protein is needed (e.g., minimal level of 28 percent to 32 percent). The quality of the available protein is an important factor when choosing the proper feed. Not much information is available on the nutritional requirements of tiger barbs; however, general nutritional requirements of tropical warmwater fish do not seem to vary greatly between species (National Research Council 1983). As more information on the nutritional requirements of aquarium fishes becomes available, manufacturers will incorporate refinements into commercial feeds. Feeds that can be used for growout of tiger barbs are listed in Table 5.

Table 5. Commercially available feeds suitable for high-density tiger barb growout.

Feed	Feed Type
Rangen Trout	Swim-up #1 and #2
Purina Trout	00, 01 and 02
Moore Clarke Salmon	Nutrafry, #O, #1 and #2

Although the feeds listed are suitable for production of ornamental species, it should be noted that they contain higher protein levels than required. Fish in earthen ponds are fed once a day *ad libitum* with a commercial diet containing a minimum of 28 percent to 32 percent protein. Many of the pigments required by tiger barbs for good coloration are obtained from naturally occurring phytoplankton (green water) and zooplankton feed sources. However, tiger barbs reared in high-density tank culture systems should be fed a complete diet that includes a color enhancing agent, such as astaxanthin, at least two times per day to supplement natural feeds that might be limited in this type of culture system. It usually takes at least one month for the fish to show color changes resulting from pigmented feeds.

The tiger barb, like many cultured fish, has a digestive tract that is very inefficient in digesting feed. Dividing the total daily amount of feed to be delivered into three or more portions throughout the day will eliminate an excess of uneaten feed and reduce the organic fouling and oxygen demand on the system, while promoting faster growth. Automatic feeders work well in culturing tiger barbs, whereby they are filled in the morning with the appropriate amount of feed needed for the day. Tiger barbs exhibit a diurnal pattern in their activity. They cease being active between 22:00 and 04:00 hours and have a peak in activity between 14:00 and 18:00 hours (Shiraishi *et. al.* 1972). Pond reared fish receiving a single feeding should be fed between 14:00 and 18:00 hours, and high density tank culture systems utilizing automatic feeders should be turned off between 20:00 and 06:00 hours.

Water temperature and quality directly influence the desire of fish to feed. When temperatures drop below 20°C, tiger barbs will consume less feed. During cold weather conditions, it is best to feed late in the afternoon when the water temperatures have had a chance to elevate from solar radiation. Periodically checking the feeding response and the amount of feed remaining on the bottom of the tank or pond will help to determine the proper amount to feed. Feed should be completely consumed within 15 minutes after delivery. If all the feed has been consumed in that time period, present a little more to determine the satiation point of the fish. There is no documentation on the feed conversion ratio (FCR) or the percentage of body weight per day requirements of tiger barbs or for many other ornamental aquarium fish. By comparing data for fish that have a similar size and biological characteristics, tiger barbs should be fed approximately 10% of their body weight per day.

Water Quality

Tiger barbs can tolerate extreme variations in water chemistry and thrive in water with a hardness from 100 to 250 ppm of $CaCo_3$, (moderately hard) and a pH of 6.5 to 7.5 (Baensch and Riehl 1982; Scheurmann 1990). No data is available regarding tolerances of tiger barbs to various salinities and is an area of future investigation. Water quality parameters for optimal growth, survival and reproduction are summarized in Table 6.

Table 6. Optimal water quality parameters for commercial production of tiger barbs.

Water Quality Parameters	**Ranges**
Temperature	22°C to 28°C or 72°F to 82°F
Hardness	100 TO 250 milligrams per liter $CaCo_1$
pH	6.5 to 7.5
Total ammonia ($NH_3 + NH_4$)	< 1.0 milligrams per liter
Dissolved oxygen	2.0 milligrams per liter
Phytoplankton	Secchi reading of 30 to 40 cm

Harvesting Tiger Barbs

Step 1 - Preparation for harvesting from a pond:
Prior to any harvesting, a pond should be inspected for aquatic weed infestation and the appropriate herbicides applied, if necessary, with the proper lead time. Tank culture systems avoid problems with emerging aquatic plants and lessens the degree of management and harvesting problems.

Step 2. Disease inspection:
One week before harvest, the fish should be sampled and examined for disease and proper treatment applied if necessary. Treatment of disease will be covered in the disease section. Fish should then be sampled again prior to harvest to guarantee that the fish are in good health. Following these procedures insures a smooth harvest and minimizes mortalities.

Step 3. Holding Tank:
As soon as possible after harvesting by any of the described methods, the fish should be placed in a 300- to 500-gallon holding tank equipped with running fresh water and aeration. Preparation of the holding tank must be completed prior to harvesting to avoid delays between the time of capture and stocking in the holding tank(s). Special attention should be given to screening the drain to prevent fish from escaping. The size of the screening is also important to consider because large amounts of debris will be added to the tank with the incoming fish, and this can clog the screen covering the drain and result in a holding tank that is overflowing. After placing the fish inside the holding tank(s), any debris that has come in from the harvest should be removed and dead or injured fish discarded. Salt is added to the water to bring the salinity up to 9 ppt (9 kilograms per cubic meter or 20 lbs per 250 gallons), which is an isotonic solution, to help reduce handling stress by stimulating fish to naturally produce a slime coat. Harvested fish can be maintained in the holding tank for an extended (one to two weeks) period of time before fish are selected and marketed. A maintenance diet is provided to the fish in the holding tanks.

Step 4a. Harvesting by trap:
Tiger barbs can be harvested using a variety of traps (Figure 14) or seined. When trapping barbs, place the trap 12 to 18 inches below the surface and bait the trap with either a paste or large pelleted feed. Traps should be checked periodically to avoid overcrowding. Transfer the collected fish into the holding tank. Debris that is collected with the harvested fish should be removed along with any dead fish. The fish are examined the day before sorting to insure good health. If bacterial or other pathogens are present, the holding tank should be treated prior to further handling.

Step 4b. Harvesting with a seine:
Tiger barbs can also be harvested with a seine net made of knotless nylon Ace or Delta weave with a mesh size of 1/8 inch. Seine nets should have a length 2.5 times the width of the pond being harvested and a width twice the depth of pond being seined. Seines used for harvesting ornamental fish should also be equipped with twice as many floats and bottom lead weights as standard seines. When ordering seines of this type, the buyer must specify double floats and double leads. It is essential that all debris and filamentous algae be removed from the pond prior to seining. This usually requires manually removing the

unwanted material. After removal of the aquatic vegetation and debris, the seine is pulled through the pond. particular attention should be given during the last stages when bringing in the seine near the pond bank to insure that the fish are not overcrowded. This is generally done by stretching and opening the seine to form a “hammock” or “purse.” The fish will then swim out of any trash and mud that may have been brought in with the seine; they then can be removed from the seine with dip nets, leaving the debris behind. If all fish are to be collected and placed in a holding tank, the fish caught in the seine should be placed in buckets containing fresh water and transported immediately to the holding tank. Several passes through the pond can be made until the numbers of fish decline noticeably. At that time, the pond depth can be lowered by at least one half, and the process repeated. Lastly, the pond should be drained and all remaining fish collected and placed in the holding tank. If the process is not conducted carefully, excessive injuries and stress to the harvested fish will result in mortalities.

Step 5. Sorting:

Tiger barbs are often sold prior to reaching sexual maturity, so sorting by sex is not necessary. Because tiger barbs are not sexually dimorphic (i.e., having different color patterns between sexes), they are graded for size using a bar grader (Figure 15). Fish are netted from the holding tank and placed into a bar grader. The smaller fish will swim through the grader bars, while the larger ones are retained in the box. By changing the widths (grader sizes),any size fish can be sorted by increments as small as a quarter of an inch. Several test runs with fish might be required to determine the size grader needed. Market size tiger barbs are usually sorted using grader sizes ranging from No. 8 to No. 14. During the grading process, any off-color fish are removed with hand nets and discarded. The fish are then sorted into bag lot numbers and placed in holding tanks, where the guts are allowed to purge over a 48-hour period, followed by bagging and boxing for shipping.

Step 6. Bagging and boxing for shipping:

Tiger barbs can be packed at 30 to 40 fish per liter (120 to 160 fish per gallon) with enough oxygen to withstand 48 hour of transport. Depending on the distance the fish need to travel, over-packing can reduce the shipping freight cost to the customer. However, only established packing densities that have been proven successful should be used; do not assume that just any shipping density will work. Fish should be counted in bag lot numbers

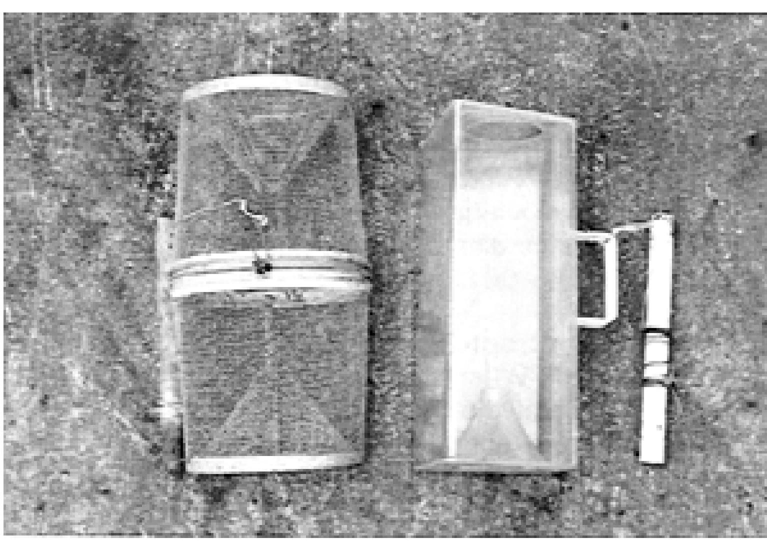


Figure 14. Photo of two types of traps used to collect tiger barbs.

and placed in containers equipped with flow-through water. These containers should be made of a durable material that will not break or be damaged by handling (plastic containers work well). The containers should be equipped with a standpipe to control the water level, which when removed will allow the water to drain to a box lot quantity. Although there are several sizes of shipping boxes and bags, a standard full bag measures 37.5 centimeters wide, 37.5 centimeters long, and 55 centimeters deep. The extra depth allows for proper sealing of the bag for shipment. The bag is filled with approximately 8 liters (approximately 2 gallons) of water for shipment. This keeps the total weight of the packed box just below 9 kilograms (20 lbs.). Following this procedure enables the packer to gently lift and pour the container of fish and water into a bag without netting or handling the fish again. Having the fish counted in box lot sizes will minimize the time needed to bag the fish. The bag is purged of air by squeezing the bag to the water level and then inflating with oxygen. To seal the bag, twist the bag top tightly and wrap with a rubber band or use a banding machine. The bags are then placed in a Styrofoam box, which in turn is held in a cardboard box if the fish are to be shipped as individual boxes. The lids of the cardboard box are taped shut for air cargo shipping. Larger orders can be consolidated into LD-3 containers in which the cardboard boxes will not be needed. Consolidating orders and cooperative marketing with other farmers can open new market outlets because of increased numbers and possible varieties of fish and decrease the shipping costs to prospective buyers.

Disease

Disease Prevention, Treatment, and Management

The three most common disease problems encountered by commercial fish farmers are caused by Protozoa (*Trichodina*), Monogenea (*Dactylogyrus* and *Gyrodactylidae*) and Fungi (*Saprolegnia*). *Trichodina* is a round-saucer or domed-shaped protozoan with cilia. When seen through a microscope, they are constantly in motion, moving quite distinctly and rapidly. They most commonly attach to the gills and soft tissue, such as fin rays. Heavy infestations can cause respiratory prob-

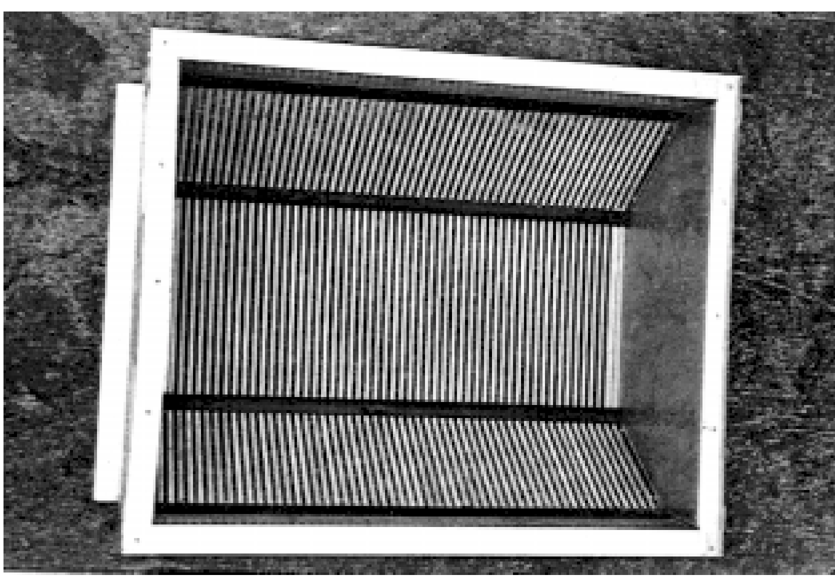


Figure 15. Photo of bar grader used to sort tiger barbs by size.

lems by causing the gill tissue to produce excess mucus. Several control methods can reduce and/ or eliminate this parasite from the culture system. The most common procedure is a bath of formalin at 25 ppm for 24 hours. Once diagnosed and treated, the fish should be checked daily to monitor the effectiveness of the treatment. Several treatments may be necessary.

Monogenea (*Dactylogyrus* and *Gryclactylidae*) are also commonly found on the gill and soft ray tissue of the infected fish. Transmission is usually by direct contact. After the eggs hatch, free-swimming larvae seek a host and attach themselves using a series of hooks and sucking valves at the base. They appear worm-like under the microscope. Infected fish usually exhibit what is commonly called flashing, in which the fish rub on a hard substrate or shake in attempts to remove the parasite. There are two common treatment methods. The first is a formalin bath at a concentration of 250 ppm for one hour. This is the preferred method when handling large numbers of fish because no handling is required and the tank is simply flushed after the specified time period. The second method is a sodium chloride (non-iodized salt) dip at a concentration of 25,000 to 35,000 ppm (25 grams per liter to 35 grams per liter). Duration of the dip is determined by the tolerance of the individual species to high salinity and the effectiveness of the treatment. It is recommended that preliminary tests be run on small samples of fish to determine the proper length of time and concentration.

The fungi *Saprolegnia* commonly occurs as an opportunistic infection as a result of injuries incurred in handling the fish. It usually appears as a white or light gray patch on the surface of the fish. Its appearance under the microscope is best described as having a cotton strand appearance. *Saprolegnia* can be problematic to treat because as of this writing some of the most effective compounds have been regulated out of use. However, some of the newer copper and iodine compounds work well. One of the tried-and-true methods is a formalin bath at a concentration 250 ppm for one hour per day for five consecutive days.

Formalin Preparation

Formalin can be employed as one means of combating all the disease mentioned. Formalin, a clear aqueous solution of formaldehyde containing a small amount of methanol, is commonly used as a general fixative for preserving tissues. Concentrated formalin normally contains 37% to 40% formaldehyde.

Note: Use extreme caution when using concentrated Formalin.

For use as a disinfectant and/or for treatment of parasites, concentrated formalin is usually diluted to very low concentrations (10 to 300 parts per million). The equation normally used to determine the amount of formalin to be used for treating a disease outbreak does not employ the percent active ingredient because by convention 30 percent to 37 percent formalin is considered to be a 100 percent active solution. An example of the calculation to determine the amount of formalin to be used to make a 100 ppm solution in a 100-liter (26-gallon) tank is as follows:

Note: 1 ppm = 1 milliliter per 1,000 liters
Concentrated formalin = (100 liters x (1 milliliter per 1,000 liters) x (100 ppm)

From the above calculation, 10 milliliters of concentrated formalin must be added to the 100-liter (26-gallon) container to obtain a final concentration of 100 ppm. Pour the concentrated formalin into the tank and be sure to distribute it evenly.

For smaller water volumes, a stock solution of 10 percent formalin (90 milliliters concentrated formalin + 910 milliliters of water) is first made. By adding 1 milliliter of the 10 percent formalin stock solution to 1 gallon (3.8 liters) of water, a 25-parts-per-million formalin solution is obtained. Adjust the amount of stock solution to the number of gallons of water to result in the desired concentration (e.g., 2 milliliters per gallon = 50 parts per million; 4 milliliters per gallon = 100 parts per million; and so forth). Multiply by the number of gallons of water to be treated to obtain the proper amount of stock formalin solution needed (e.g., 4 milliliters per gallon = 100 parts per million; for a 10-gallon tank, 4 x 10 = 40 milliliters of 10 percent formalin stock solution is needed to result in 10 gallons of 100-parts-per-million formalin).

Recommendation: Some test trials with healthy fish should be attempted prior to any disease outbreak to become familiar with the calculations described above. If there are any concerns, please contact the Sea Grant Aquaculture Extension Agents.

Economics

Factors Affecting Price of Tiger Barbs

Factors that affect the market for tiger barbs can be understood by examining price sheets from various distributors. For the purposes of this manual, the pricing of tiger barbs and some of the related barbs from one trans-shipper of ornamental fishes out of Singapore (Sunny Aquarium Company) was reviewed. From the most recent price sheets, it can be seen that tiger barb prices, like those of all ornamental fishes, are quite variable for different body sizes and color varieties (Figure 16). The tiger barb ranges in price from less than $0.10 per fish to $0.33 per fish when the body length is 25 millimeters and 50 millimeters (1.0 and 2.0 inches), respectively. Likewise, at each marketable body size, the price of an individual barb depends on the variety, e.g., regular tiger barb, albino tiger barb, or green tiger barb. The green tiger barb is approximately three times the price of the common tiger barb at all of the body sizes. It should be emphasized that the prices represent what is solicited from the distributor, and the actual farm-gate price can only be estimated as these values are confidential. A rule of thumb that can be used to estimate farm-gate price is to subtract 20 percent to 30 percent of the list price.

From this pricing scenario, it can be concluded that the tiger barb is a “low value” species and consistent production of large quantities (10,000 to 20,000 per month) is necessary to turn a profit as well as to compete in the market. As mentioned previously, more than 2.5 million individual *C. tetrazona*, were imported into the United States in 1992. To estimate the future demand for this species, price sheets from the last 15 years were examined and the continued increase in price over time indicates a consistent and continued market demand. The data are summarized for both the tiger barb and albino tiger barb in Figure 17.

Another factor affecting farm-gate prices is whether one sells directly to a retailer (highest price), to a wholesaler (moderate price) or through a transshipper (lowest price). Farmers should investigate market outlets thoroughly to obtain the highest possible price for each item produced. It is also recommended that a farmer have at least three to five different market outlets and provide the one offering the highest market price with the largest percentage of fish produced.

Start-up Costs

The production of ornamental fish has been one of the more profitable types of aquaculture outside of Hawaii (e.g., in Florida, Singapore, Taiwan, and Japan). Recently the CTSA-funded project titled *Ornamental Aquaculture Technology Transfer* produced an in-depth study titled "Report on the Economics of Ornamental Fish Culture in Hawaii," which examined the economics of owning and operating an ornamental culture endeavor. The report, available through CTSA or SGES, emphasizes that doing business in Hawaii with the high cost of living, of rent, of water, and of labor presents several challenges to aquafarmers, in addition to the fact that Hawaii is not a major transshipping destination. Hawaii does, however, offer several natural advantages, such as climate, proximity to the US mainland and no federal import duties (e.g., US Customs Fee, US Fish and Wildlife Inspectors Fee, airline fuel surcharge, dock or port fee), all of which can compensate for some of the disadvantages.

The report modeled three different farm sizes (small = Farm A, medium = Farm B and large = Farm C) with three different levels of production and ornamental species mix. Farm A represents a live-bearer production module, which is elaborated on by Tamaru et al. (in press). Farm B consists of 50 12-foot-diameter tanks and includes a 1,200-gallon hatchery. Farm C consists of 200 12-foot-diameter tanks and a 2,500-gallon hatchery. Using two different pricing scenarios,

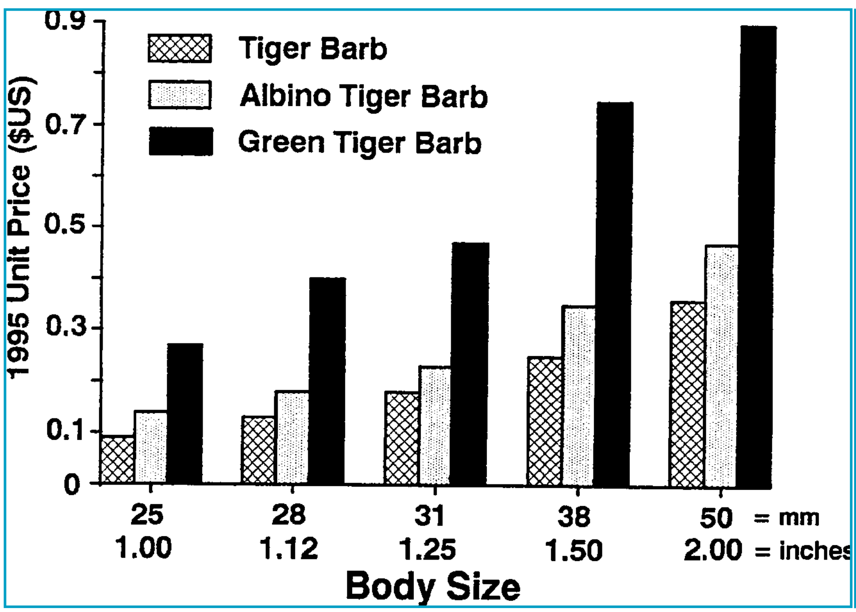


Figure 16. Comparison of prices of three types of tiger barbs at different body sizes. (Values obtained from Sunny Aquarium Company 1995).

"all three farms in the study proved to be profitable to own and operate" (Teichman et. al., 1994), and showed that Hawaii farmers could compete with a landed cost in Seattle from suppliers of fish from Asia and still turn a profit. Hawaii farmers have a substantial advantage over competitive suppliers of fish from Asia because Hawaii-raised fish require less time in transit, so farmers can emphasize product quality (e.g., lower percentages of dead on arrivals, high health) as a primary marketing strategy. They need not rely solely on price competition to sell their products.

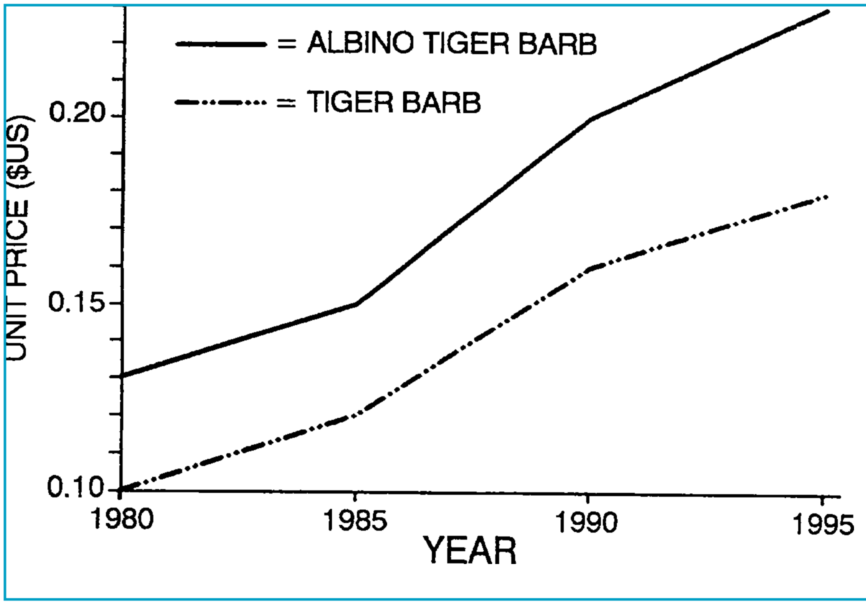


Figure 17. Comparison of prices for 31-millimeter (1.25-inch) tiger barbs and albino tiger barbs over a 15-year period. (Values obtained from Sunny Aquarium Company, Hawaii).

For the purposes of this manual, the production costs of tiger barbs in multi-species Farms B and C are considered. A breakdown of the equipment, supplies and start-up costs for a single species (tiger barb) hatchery is presented in Table 7. The equipment and supply list covers what is considered necessary to build a hatchery for the production of tiger barbs and also includes shipping of the cultured product. Based on 1993 pricing of materials, the total cost is estimated at $10,353. Using the average number of eggs produced per female (300 eggs per spawn) and multiplying by the number of spawning tanks (n = 25) approximately 7,500 eggs can be produced per synchronized spawning event. If this activity is carried out at two-week intervals, the monthly egg production of the facility can be estimated to be approximately 15,000 eggs per month. It should be noted that the start-up costs do not include labor, power, water, lease fees, or insurance costs as these will vary from farm to farm.

Enterprise Budget

In practice, any given species raised on a farm is referred to as an enterprise. This enterprise will consume and/or share a given amount of farm resources. In order to estimate the net profits obtained from the production of tiger barbs, the variable and fixed costs associated with carrying out this specific activity need to be identified. Once the associated costs are determined, profit margins can be calculated (see Table 8).

Some assumptions that must be made to understand the enterprise budget as presented are:

1. the farm including the hatchery is already established and producing fish in addition to tiger barbs;
2. a production of 12,500 fry with 80 percent survival to market;
3. purchase of 150 broodstock @ 0.27 each with one year production;
4. purchase of two 12-foot-diameter tanks @ $450 each with five-year life;
5. purchase of two 300-gallon brood conditioning tanks @ $100 each with five-year life;
6. purchase of 25 10-gallon aquariums @ $8 each with five-year life;

7. the marketing of medium size (1.125-inch to 1.25-inch body length) tiger barbs at $0.24 per fish;
8. shipping at densities of 250 fish per box;
9. marketing of 10,000 tiger barbs on a monthly basis.

It must be understood that the information presented represents tiger barb production as only one facet of a multi-species ornamental fish farm and that the production of ornamental fishes is already established. The reader should also note that during a given month, only 40 hours of labor are necessary to carry out the production of tiger barbs. Likewise, tiger barbs are produced at set intervals to result in 10,000 marketable, medium-size fish per month. As stated previously, the tiger barb reaches a marketable, medium size approximately three months after hatching.

The total variable costs of production are estimated at $568.00. The fixed costs are estimated at $56 to $63 based upon estimates given in the "Report on the Economics of Ornamental Fish Culture in Hawaii", (Teichman et al., 1994). This results in an estimated $624.63 total monthly production cost. Using the market value of medium-size tiger barbs ($0.24 per fish, Sunny Aquarium Company 1995) the value of 10,000 tiger barbs is $2,400. The net profit of the tiger barb enterprise is approximately $1,800 per month. It should again be emphasized that these prices are based upon only one distributor and may vary from dealer to dealer. In addition, as mentioned previously, the actual farm-gate price can only be estimated as these values are confidential. However, with a 30 percent mark-up, the estimated farm-gate value would be approximately $1,050. From the information presented, there are several strategies that one must consider in order to maximize profits. These include marketing smaller fish at higher volumes, marketing larger fish, or producing another variety that commands a higher price. Using the enterprise budget allows the reader to examine the pros and cons and to plan a particular strategy appropriate for his/her situation.

Table 7. Equipment and supplies for tiger barb hatchery

Category	**Quantity**	**1995 Price in US$**
Equipment		
12-foot-diameter tank	2	$900
ground liner	1 roll	$90
regenerative blower	1	$398
airstones (small)	25	$20
airstones (large)	2	$15
air tubing	1 roll	$27
0_2 bottle rental	1	$50
0_2 regulator	1	$70
PVC pipe and fittings	assorted	$200
bird netting	1 roll	$10
bar grader	2	$300
thermometer	2	$50
field microscope	1	$20
conditioning tanks (300-gallon)	2	$300
aquariums (10-gallon)	25	$200
pawning brushes	25	$92
lumber (hatchery)	assorted	$2,619
used pickup truck	1	$4,000
Supplies		
chlorine	5 gallons	$100
broodstock	150	$41
feed (*Artemia*, broodstock, growout)	-	$85
rubber bands	1 bag	$10
transport bags	4	$16
transport boxes (inner)	40	$140
transport boxes (outer)	40	$100
water test kit	1	$300
misc. chemicals	-	$100
dip nets	-	$100
Total	-	**$10,353**

Table 8. Enterprise budget for commercial production of tiger barbs.

Category	**Description**	**1995 Price in US$**
Variable Costs		
Chemicals	Salt	$10.00
Feed	*Artemia*, Prepared Feed	$50.00
Repairs	-	$20.00
Transportation	100 miles @ $0.28 per mile	$28.00
Phone/Fax	-	$50.00
Labor	40 hours @ $10 per hour	$400.00
Miscellaneous		$10.00
Total Variable Costs		*$568.00*
Fixed Costs		
Lease	1/20 acre @ $200 per acre	$10.00
Water	1 gallon per minute @ $0.60 per 1,000 gallons	$25.92
Depreciation (Broodstock)	-	$3.38
Depreciation (Tanks)	-	$17.33
Total Fixed Costs		*$56.63*
Total Fixed and Variable Costs		$624.68
Income		$2,400.00
Net Profit		***$1,775.37***

Literature Cited

Alfred, E.R. 1963. Some colorful fishes of the genus *Puntius*, Hamilton (30):135-142.

Axelrod, H.R. and M.E. Sweeney. 1992. The Fascination of Breeding Aquarium Fish. T.F.H Publications, Inc. Ltd. Neptune City, N.J.

Baensch, H.A. and R. Riehl. 1993. Aquarium Atlas Vol; 1-2. Mergus-Veriag GmbH Hans A.

Chapman, F. A., S. Fitz-Coy, E. Thunberg, J.T. Rodrick, C.M. Adams and M. Andre. 1994. An analysis of the United States of America International Trade in Ornamental Fish. CTSA Project Final Report, University of Florida, Department of Fisheries and Aquatic Sciences, Food and Resource Economics Department. 55 pp.

Desilva, S.S. and K. Kortmulder. 1977. Some aspects of the biology of three species of *Puntius* (*Barbus*) (*Pisces Cyprinidae*), endemic to Sri Lanka. Netherlands J. of Zoo. 27(2):182-194.

Frankel, J.S. 1985. Inheritance of trunk striping in the Sumatran Tiger Barb, *Barbus tetrazona*. J. of Heredity. 76;478-479.

Furtado, J.1. and S. Mori. 1982. The Ecology of a tropical freshwater swamp, the Tasek Bera, Malaysia. Dr. W. Junk Publishers, Hague, Netherlands.

Kortmulder, K. 1972. A comparative study in colour patterns and behavior in seven Asiatic Barbus species (Cyprinidae, Ostariophysi, Osteichthyes) Behavior, International Journal of comparative ethnology. 14: 1-60.

Kortmulder, K. 1982. Etho-ecology of seventeen Barbus species (Pisces; Cyprinidae) Netherlands J. of Zoology. 32 (2): 144-168.

Mohsin, A.K.M. and Ambak, M.A. 1982. Cyprinoid fishes of the Subfamily Cypriniod in Selangor. Malay. Nat. J. 35: 29-55.

Munro, A.D., C. Li-Lian, and K. Nqankee. 1990. Preliminary observations on environmental control of ovulation and spawning in a small tropical Cyprinid (*Barbus tetrazona*). Proc. of the Second Asian Fish. Forum, Tokyo, Japan pp. 17-22.

National Research Council. 1983. Nutrient Requirements of Warmwater Fishes and Shellfishes. National Academy of Sciences, Washington, D.C. 102 pp.

Scheurmann, 1. 1990. Aquarium Fish Breeding. Baron’s Educational Series Inc. Hauppauge, N.Y.

Shiraishi, Y., N. Mizuno, M. Nagai, M. Yoshimi, and K. Nishiyama. 1972. Studies on the diel activity and feeding habit of fishes at Lake Bera, Malaysia. Japanese J. of Ichthyology. 19(4)295-305.

Sorgeloos, P., P. H. Leger, W. Tackaert, and D. Verischele. 1986. Manual for the culture and use of brine shrimp *Artemia* in aquaculture. *Artemia* Reference Center, State University of Ghent, Belgium. 319 pp.

Sunny Aquarium Company. 1995. Various price lists. Waimanalo, Hawaii USA.

Tamaru, C.S., B. Cole, R. Bailey, and C. Brown. (in press). A manual for commercial production of the swordtail, *Xiphophorus belleri*. Center for Tropical and Subtropical Aquaculture, Waimanalo, Hawaii USA.

Tay, S. H. and C. S. Tan. 1976. The cultivation of *Gymnocorymbus teinetzi*, *Hyphessobrycon Callistus serpae* and *Puntius tetrazona* in cage-nets in a pond. Sinapore J. Prim. Ind. 4(21): 37-51.

Taki, Y., A. Katsuyama, and T. Vrushido. 1977. Comparative morphology and interspecific relationships of the Cyprinid genus *Puntius*. Japanese J. of Ichthyology. 25(l);1-7.

Teichman, J., C. Brown, B. Cole, R. Bailey, and J. Brock. 1994. Report on the economics of ornamental fish culture in Hawaii. Center for Tropical and Subtropical Aquaculture. Waimanalo, Hawaii USA. 14 pp.

Zakaria-ismail, M. 1993. The fish fauna of the Sungai Teris and Sungai Rengit, Krau Game Reserve, Pahang, Malaysia. Malayan Nature J. 46(l);201-228.

Appendix 1. Preparation of conditioning pastes.

Formula 1 for paste to condition tiger barb broodstock.

Ingredient	Amount
ground beef heart	3 lbs
ground beef liver	3 lbs
raw eggs	4
spinach	6 oz.
peas	6 oz.
carrots	6 oz.
oat bran	4 oz.
multivitamins	24 drops
gelatin (unflavored)	4 packets

Formula 2 for paste to condition tiger barb broodstock.

Ingredient	Amount
ground beef heart	5 lbs
ground beef liver	5 lbs.
high protein baby food (cereal)	2 lbs.
raw wheat germ	2 lbs.
dried split peas	10 oz.
spinach	20 oz.
raw eggs	4
whole shrimp	8 oz.
brewers yeast	4 oz.

Preparation:

Step 1: Trim all the excess fat and any connective tissue or tendon (stringy material) from the beef heart and liver.

Step 2: Use a food processor or blender to grind or mash the meat into very small pieces.

Step 3: Mix the remaining ingredients (except for the gelatin in Formula 1) in a blender or food processor.

Step 4a: In Formula 1, the gelatin acts as a binder that holds the mixture in a paste. Mix the gelatin in a pot with as little hot water as necessary to fully dissolve the gelatin. Allow the mixture to cool slightly but remain fluid, then mix it with the other ingredients. Pour the mixture into “zip-lock” bags and press them into flat sheets. The paste should be refrigerated until used or frozen if it will be stored for long periods.

Step 4b: Formula 2 requires the mixture to be cooked using a double boiler until the mixture becomes slightly grainy. The mix is then placed into "ziplock" bags and pressed into sheets for storage. The mix should be refrigerated until used or frozen for long-term storage.

Variations of these formulas can be tailored to suit nutritional needs of specific fish and according to available ingredients. The one common ingredient is high quality protein. Other ingredients, such as spirulina, can be added at 0.5 percent to 1.0 percent by weight. For fish that are more herbivorous, the fish meal or red meat components can be reduced and vegetable protein such as soybean meal can be substituted. Before making a paste formula, it would be wise to consult the literature to determine the natural diet of the fish.

Appendix 2. Hatching of Brine Shrimp (*Artemia*) and Preparation for Feeding

Much of the expense of tiger barb fry production involves purchasing *Artemia* cysts and subsequent efficiency in hatching the cysts for use in feeding. The cost has escalated in recent years; the price for a 1-lb. can of *Artemia* cysts was $35 to $45 in 1995. Fish fed *Artemia* exhibit significantly higher survival rates and elevated weight gains compared to fish given other feed sources. In addition, fish that do not readily take prepared feeds almost always will accept *Artemia*. Several considerations must be taken into account to optimize use of *Artemia* nauplii as a larval feed. These are discussed in the following sections.

Artemia Supplies and Strains

Artemia from various parts of the world differ in size and nutritional qualities. The two most commonly available *Artemia* strains are the strain from Great Salt Lake in Utah strain, which have 486 mm size instar 1 nauplii (first hatch stage), and the San Francisco Bay Brand, which have slightly smaller, 428 mm nauplii (Sorgeloos et al. 1987). *Artemia* also have varying hatch grades; those with higher hatching percentage grades command a higher price. Commercial supplies of cysts have fallen in recent times due to harsh winters that have affected the environmental conditions of cysts, considerably increasing price and availability. When choosing a source of *Artemia*, the following should be considered:

1. cyst hatching rates;
2. nauplii size at hatch (instar I)
3. nutritional value
4. packaging method

Tiger barbs do well on any strain of *Artemia*, so cost may be the only factor when choosing an *Artemia* source.

Hatching Container

Hatching containers can be purchased from a supplier or constructed from materials such as inverted 5-gallon drinking water containers fitted with a rubber stopper and plastic valve. The design of the hatching container is important. It should have a conical shape, smooth inside surface, translucent and easily drained bottom, and a dark, opaque top. Newly hatched nauplii are attracted to light (positively phototactic) so using hatching containers with translucent bottoms aids in harvesting. Examples of hatching containers being used at the WCC facility are presented in Figure 18.

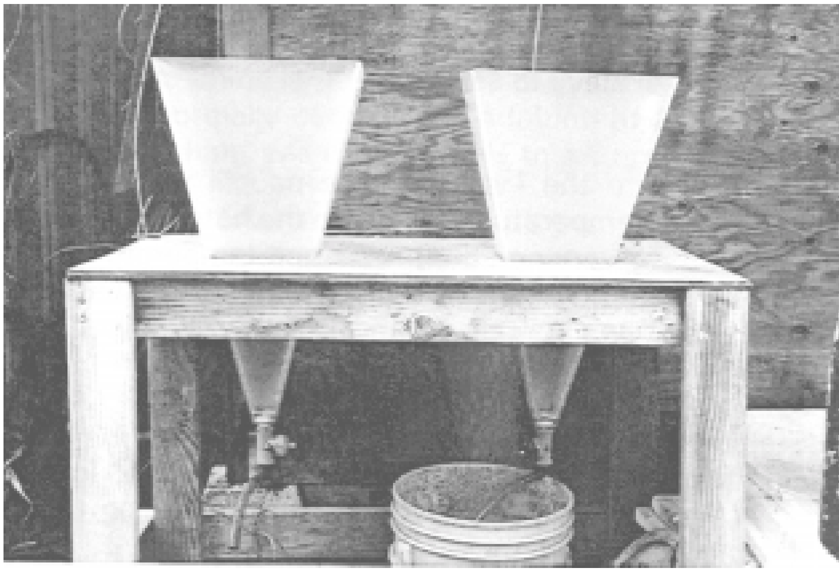


Figure 18. Photo of* Artemia *hatching containers.

Cleanliness and Sterilization

The primary reason for poor hatching of *Artemia* nauplii is lack of cleanliness. Slime or detritus on the hatching container walls and airline tubing contributes to significant bacterial interference. Thoroughly cleaning the parts that are in contact with water during hatching can improve the consistency and hatching percentage of cysts. To disinfect the hatching containers, first fill with tap water and add either powdered or liquid bleach and aerate for 20 to 30 minutes. If powdered bleach (calcium hypochlorite) is used, add approximately 300 milligrams per 24 liters (0.01 oz per 6 gallons), or use liquid laundry bleach (5.25 percent active and unscented) at 3.5 milliliters per liter. Be sure to rinse the container thoroughly with tap water prior to use.

Light

Place a light source, such as a 60-watt bulb, above the container during the first few hours of rehydration (i.e., when cysts are first placed from the can into water). Cysts are dehydrated before packing to maintain them in a dormant state and suspend bacterial growth. Cysts begin to rehydrate when placed in water, at which time light is needed to stimulate the cysts' hatching mechanism. The light can be lit over the container during the entire hatching period. After hatching is completed (14 to 18 hours), the light over the hatching container is placed underneath the translucent bottom of the hatching container for harvesting.

Temperature

Generally, *Artemia* will hatch into the instar I stage nauplii within 14 to 18 hours at temperatures 25°C to 30°C. Lower temperatures lengthen the hatching time. However, different sources of *Artemia* have varying hatch rates and temperature optima. It is important to know when first hatch occurs so the *Artemia* can be harvested at the smallest size possible for easy consumption by the fish larvae. The instar I stage nauplii have a higher nutritional value in comparison to later developmental stages; *Artemia* nauplii can metamorphose into the next developmental stage (instar I) within several hours. Therefore, timing of the harvest is important to maximize nutritional value. It is recommended that a constant temperature be maintained in the hatching containers by the use of heaters to result in a consistent hatching time that best coincides with larval feeding schedules.

Salinity

The water used for hatching should contain 35 grams rock salt per liter (approximately 0.3 pounds per gallon) of tap water, or seawater at 35 ppt salinity can be used. Do not use iodized salt during the hatching process. Although cysts can be hatched at a lower salinity, maintaining the pH is more difficult which in turn results in a lower hatching percentage.

Cyst Density and Preparation

Hatching cysts at densities greater than 2 grams per liter of salt water can cause the pH to decrease, adversely affecting the hatching percentage. Use no more than 2 grams cysts per liter of salt water. When hatching significant quantities of cysts, bacteria can interfere and lower hatching percentages. Bacteria grow on the cysts, decaying their outer shells, and can lower pH and dissolved oxygen. Disinfecting cysts prior to hatching will lessen the amount of initial bacteria that cover the cysts. This can be done by placing the cysts in a chlorinated freshwater solution for 15 to 20 minutes prior to placing them in salt water. The chlorine solution can be made by adding 3 grams of 70% active calcium hypochlorite or 40 milligrams of 5.25 percent active sodium hypochlorite or household bleach (unscented) to 10 liters of tap water. This is suitable to disinfect 500 grams of cysts. After 20 minutes of disinfecting the cysts, rinse with tap water and place them into the saline hatching solution for incubation.

pH

A pH above 8.0 should be maintained during hatching of cysts. As mentioned previously, when hatching large quantities of cysts (e.g., 2 grams cysts per liter), the pH of the hatching medium normally decreases. The addition of 2 grams sodium bicarbonate per liter of salt water used for hatching will raise the pH to an optimal level for maximal cyst hatching percentages.

Cyst Storage

The hatching percentage of cysts will start to decline within a few months after the nitrogen-filled container has been opened if it is stored at room temperature. Once a can of *Artemia* cysts has been opened, it should be covered with the plastic lid provided and stored in a refrigerator at 5°C to 10°C.

Harvesting and Preparation for Feeding

Once *Artemia* cysts have hatched into the first nauplii stage (instar I), they should be harvested. Remember that not all cysts hatch at the same time. To assure harvest of the highest number of nauplii at the right time, several test runs should be performed and analyzed by recording temperature and time of hatching. To harvest *Artemia* nauplii, remove the light source above the hatching container and illuminate the translucent area near the bottom of the hatching container, which will attract the nauplii to the light source and drain valve. Turn off the aeration for approximately 10 minutes. At this time, unhatched cysts and cyst shells will float to the surface and the hatched nauplii will swim toward the light source.

> **NOTE: Do not let the nauplii accumulate on the bottom of the hatching container for more than 10 minutes.**

Open the bottom drain valve to pour off any settled debris and discard it; close the valve once the fluid becomes orange-brown in color. Place a container to receive the newly hatched brine shrimp under the hatching container and open the valve slowly. Once the fluid exiting the hatching container becomes clear, close the valve. The orange-color *Artemia* nauplii are then poured into a brine shrimp net or screen with 125-millimeter to 150-millimeter nylon mesh. Thoroughly rinse the nauplii with tap water to remove bacteria and hatching metabolites, and place the collected nauplii into a container filled with fresh salt water, and aerate. Repeat the entire procedure if a lot of nauplii remain in the hatching container. The *Artemia*nauplii are now ready to be fed to the fish fry.

Storage of Newly Hatched *Artemia*

Unused harvested, washed nauplii can be placed back into a container of fresh saltwater with aeration and kept for future feedings. *Artemia* nauplii metamorphose very rapidly, so refrigerating the aerated container will delay metamorphosis and help keep the nauplii in the instar I stage and maintain the nutritional value of the nauplii.

Appendix 3. List of suppliers and organizations.

Listing in this appendix does not constitute an endorsement of products or services but instead recommends products or services that the listed manufactures, suppliers or organizations may provide. For a more comprehensive listing, consult your local extension agent or buyers guide directory editions of one of the industry related publications.

General Aquaculture Products

Aquacenter Inc

Seven Oaks Rd., Leland, MS 38756
Phone: (800) 748-8921 Fax: (601) 378-2862
Aeration equipment, water pumps, PVC fittings, filters, nets, water quality test kits, tanks

Aquaculture Supply

33418 Old Saint Joe Rd., Dade City, FL 33525
Phone: (904) 567-8540 Fax: (904) 567-3742
Aeration equipment, water pumps, laboratory equipment, biological filtration, algal nutrients, inoculant, rotifer starter kits

Aquanetics Systems, Inc.

5252 Lovelock St., San Diego, CA 92110
Phone: (619) 291-8444 Fax: (619) 291-8335
Aeration equipment, water pumps, sterilization equipment, chillers, heaters, PVC fittings, recirculation systems and components

Aquatic Eco-Systems, Inc.

2056 Apopka Blvd., Apopka , FL 32703
Phone: (407) 886-3939 Fax: (407) 886-6787
Aeration equipment, water pumps, monitors, and controls, recirculation systems, laboratory equipment, nets, tanks and liners

AREA

P.O. Box 13303, Homestead, FL 33090
Phone: (305) 248-4205 Fax: (305) 248-1756
Aeration equipment, valves and test equipment, filtration, disinfection equipment

Grainger

4397 Lawehana St., Honolulu, HI 96818-3138
Phone: (808) 423-0028 Fax: (808) 423-0031
Pumps, filters, hoses, electrical supplies

Southern Aquaculture Supply Inc.
P.O. Box 326, 565 St. Mary St.
Lake Village, AR 71653
Phone: (501) 265-3584 Fax: (501) 265-4146
Pumps, filters, hoses, electrical supplies

Chemical Products

Argent Chemical Laboratories
8702 152nd Ave. N.E., Redmond , WA 98052
Phone: (206) 885-3777 Fax: (206) 885-2112
Therapeutics, chemicals, formalin, quinaldine, MS-222, specialty feeds, laboratory equipment, reference books and manuals

Brewer Environmental Industries, Inc.
311 Pacific St., Honolulu, HI 96718
Phone: (808) 532-7400
Herbicides, insecticides, fertilizer, agricultural products

Chemaqua
P.O. Box 2457, Oxnard, CA 93033
Phone: (805) 486-5319 Fax: (805) 486-2491
Therapeutics, water conditioning products

Crescent Research Chemicals
4331 E. Western Star Blvd., Phoenix, AZ 85044
Phone: (602) 893-9234 Fax: (602) 244-0522
Therapeutics, bacterial cultures, water conditioning products, hormones (i.e., CPH, HCG, LHRH-A) test kits, meters

Fritz Chemical Company
Aquaculture Division
P.O. Drawer 17040, Dallas, TX 75217
Phone: (800) 527-1323
Therapeutics, water conditioning products, commercial slime

Hawaiian Fertilizer Sales, Inc.
91-155 C Leowaena St., Waipahu, Hi 96797
Phone: (808) 677-8779
Fertilizer, herbicides, agriculture products

Netting Products

Memphis Net and Twine Co. Inc.
2481 Matthews Ave.
P.O. Box 8331, Memphis, TN 38108
Phone: (800) 238-6380 Fax: (901) 458-1601
Seines, dip nets, gill nets, floats, lead weights, aprons, knives, rope, baskets, commercial fishing supplies, bird netting

Nylon Net Co.
615 East Bodley
P.O. Box 592, Memphis, TN 38101
Phone: (901) 774-1500 Fax: (901) 775-5374
Seines, dip nets, gill nets, floats, lead weights, aprons, knives, rope, baskets, commercial fishing supplies, bird netting

Tenax Corporation
4800 E. Monument St., Baltimore, MD 21205-3042
Phone: (410) 522-7000 Fax: (410) 522-7015
Plastic netting, tank liners

Florida Fish Coop.
10503 Cone Grove Rd., Riverview, FL 33569
Phone: (813) 677-7136
Clear plastic fish traps

Water Quality Kits

Hawaii Chemical & Scientific.
2363 North King St., Honolulu, Hawaii 96819
Phone: (808) 841-6245
Chemical reagents, test kits, laboratory supplies

Hach Company.
P.O. Box 389, Loveland , CO 80539-0389
Phone: (303) 669-3050 Fax: (800) 227-4224
Laboratory equipment, chemical reagents, test kits, meters

LaMotte Company
P.O. Box 329 Rt. 213 N Chestertown , MD 21620
Phone: (800) 344-3100 Fax: (410) 778-6394
Laboratory equipment, chemical reagents, test kits, meters

Tanks and Liners

Integrated Construction Technologies.
150 Poopoo Pl., Kailua Kona, HI 96734
Phone: (808) 261-1863 Fax: (808) 262-3828
Concrete holding tanks

Lim Foo W and Sons.
11 30 Wilder Ave., Suite 102, Honolulu, HI 96822
Phone: (808) 521-5468
Fiberglass tanks

Lomart Tanks Liners and Filters.
114- Kekaha Place Honolulu, HI 96825
Phone: (808) 395-5786 Fax: (808) 395-7175
Prefabricated tanks and PVC liners

Pacific Lining Systems.
74-5606-F Pawi Pl., Kailua-Kona, HI 96740
Phone: (808)326-2433 Fax: (808) 329-9170
High Density Polyethylene (HDPE) custom fabricated tanks

Plas-Tech, Inc.
Sand Island Access Road
Honolulu, HI 96819
Phone: (808) 847-2339 Fax: (808) 845-4337
Fiberglass tanks

Rainwater Resources.
P.O. Box 62015, Honolulu, HI 96822
Phone: (808) 947-3626
Steel circular tanks

Aquatic Culture & Design.
P.O. Box 911, Kapaau, HI 96755
Phone: (808) 889-5225 Fax: (808) 889-0200
Permalon tank/pond liners

Fish Graders

Commerce Welding and Manufacturing Co.
2200 Evanston, Dallas, TX 75208
Phone: (214) 748-8824 Fax: (214) 761-9283
Aluminum interchangeable bar graders

Magic Valley Heli-Arc and Mfg.
198 Freightway St.
P.O. Box 511, Twin Falls, ID 83301
Phone: (208) 733-0503 Fax: (208) 733-0544
Aluminum adjustable bar graders

Feeds

Feed and Farm, Inc.
91-319 Ofai St., Kapolei, HI 96707
Phone: (808) 682-0318 Fax: (808) 682-0639

Fritz Industries, Inc.
P.O. Box Drawer 17040, Dallas TX 75217-0040
Phone: (214) 285-5471 Fax: (214) 289-8756

Land-O-Lakes, Inc.
Campbell Industrial Park
91-254 Ofai Street, Kapolei, HI 96707
Phone: (808) 682-2022

Ralston Purina International
Checkerboard Square - 11 T, St. Louis, MO 63164
Phone: (314) 982-2402 Fax: (314) 982-1613

Rangen Inc.
115 13th Ave., Buhl, ID 83316-0706
Phone: (208) 543-6421 Fax: (208) 543-4698

Waimanalo Feed Supply
41-1521 Lukanela
Waimanalo, HI 96795
Phone: (808) 259-5344 Fax: (808) 259-8034

Feed Additives

Dawes Laboratories
4801 W. Peterson, Chicago, IL 60646
Phone: (312) 286-2100
Nutrients, trace elements, vitamin premixes

Hoffmann-LaRoche Inc.
45 Eisenhower Dr., Paramus, NJ 07652-1429
Phone: (201) 909-5593 Fax: (201) 909-8416
Nutrients, trace elements, vitamin premixes, color enhancing additives

Red Star Specialty Products
Division of Universal Foods Corp.
433 E. Michigan St., Milwaukee, WI 53202
Phone: (414) 347-3968
Nutrients, trace elements, vitamin premixes, color enhancing additives

Shipping Materials

Diverse Sales and Distribution
935 Dillingham Blvd., Honolulu, Hi 96817
Phone: (808) 848-4852
Plastic transport bags

Koolau Distributors Inc.
1344 Mookaula, Honolulu, Hi 96817
Phone: (808) 848-1626
Plastic transport bags

Allied Products Ltd.
91-110 Kaomi Loop Rd., Kapolei, HI 96707
Phone: (808) 682-2038
Styrofoam boxes and styrofoam sheet material, corrugated outer boxes

Unisource

91-210 Hanua, Wahiawa, Hi 96786
Phone: 808 673-1300
Corrugated foam core boxes

Broodstock

Worldwide Aquatics

41-653 Poalima St., Waimanalo, HI 96795
Phone: (808) 259-7773 Fax: (808) 259-5029

Ty's Tropicals

99670 Kaulainahee Pl., Aiea, Hi 96701
Phone: (808) 488-0716 Fax: (808) 487-7104

Florida Fish Coop.

10503 Cone Grove Rd., Riverview, FL 33569
Phone: (813)-677-7136

Other listings available from Pet Business Magazine Directory Issue and Aquaculture Magazine Buyers Guide.

Fish Wholesalers/Distributors — Hawaii (1996)

Worldwide Aquatics

41-653 Poalima Street, Waimanalo, Hi 96795
Phone: (808) 259-9098 Fax: (808) 259-5029

Hanohano Enterprises

53-594 Kam Hwy., Punaluu, Hi 96717-9650
Phone: (808) 293-7773 Fax: (808) 293-1962

Ty's Tropicals

99-670 Kaulainahee Pl., Aiea, Hi 96701
Phone: (808) 488-0716 Fax: (808) 487-7104

Kaneohe's Pets Are Us

P.O. Box 914, Kaneohe, HI 96744
Phone: (808) 236-2717 Fax: (808) 236-7158

Saltwater Fish Hawaii

45-512 Luluku Road, Kaneohe, Hi 96744
Phone: (808) 247-6963 Fax: (808) 235-4634

Wayne's Ocean World

99-899 Iwaena, Unit #103, Aiea, HI 96701
Phone: (808) 484-1144 Fax: (808) 484-1145

Superior Tropica Farms

85-748 Waianae Valley Rd., Waianae, HI 96792
Phone: (808) 696-4955

Pisces Pacifica

P.O. Box 1583, Kaneohe, Hi 96792
Phone: (808) 239-8044 Fax: (808) 239-5014

Tropical Fish Breeders of Hawaii

3577 Pinao St. #13, Honolulu, Hi 96822
Phone: (808) 988-1600

National Wholesalers/Distributors are available from the Pet Business Magazine Directory Issue or Aquaculture Magazine's Buyers Guide:

Pets Business Magazine

5400 N.W. 84th Ave., Miami, FL 33166
Phone: (305) 592-9890 Fax: (305) 592-9726

Aquaculture Magazine Buyer's Guide

P.O. Box 2329, Ashville, NC 28802
Phone: (704) 254-7334