shrimp culture could contribute to sustainable development in the Mekong Delta, specifically aiming at the smallholder. However, caution will be needed. The 'improved extensive' system has a production limit of about 300 kg/ha/crop. Uncontrolled expansion would have environmental consequences. For example, if many ponds were to be constructed in freshwater areas, their impacts on soils and freshwater aquifers could hamper other uses of land and water.

To secure the future of the 'improved extensive' shrimp/rice farming system and to avoid negative impacts, regulation and planning of coastal aquaculture development as components of an Integrated Coastal Area Management plan are urgently needed.

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Aquaculture of a High-Value Freshwater Fish in [Malaysia]: the Marble or Sand Goby (*Oxyeleotris marmoratus*, Bleeker)

S.H. CHEAH, S. SENOO, S.Y. LAM and K.J. ANG

Introduction

The marble goby (*Oxyeleotris marmoratus*, Bleeker) which is also known as the sand goby, is found in Cambodia, Fiji, Indonesia, Malaysia, the Philippines, Singapore, Thailand and Vietnam. It is cultured in ponds and former mining pools either in monoculture or in polyculture with tilapias. Cage culture in lakes and rivers has also been successful. Production statistics for the various countries are difficult to obtain but this excellent food fish commands a retail price of at least US$14/kg in some countries, such as in Malaysia and Singapore.

Breeding

Immature fish are difficult to sex but in the mature female, the urogenital papilla is barrel-shaped, tapers slightly towards the posterior end and extends almost to the anal fin; whereas in the male, the papilla is flattened, triangular in shape and tapers towards the posterior end. In gravid females, the papilla is reddish especially at the tip (Tan and Lam 1973).

The early development of the marble goby was described by Tan and Lam (1973). It was initially bred in Singapore (Tay et al. 1974). Mass seed production techniques have yet to be established and standardized. Natural breeding has been observed in fishponds but little has been published except for reports of Phinal (1980), and Tavarutmaneegul and Lin (1988). It spawns year-round with an annual average of 3.3-4.4 nests per female. The eggs are embedded in circular, jelly-like translucent masses with an average area of 250-350 cm^2 and average number of 24,000 eggs/nest (Tavarutmaneegul and Lin 1988).

In a spawning trial in Thailand, Tavarutmaneegul and Lin (1988) reported that 250-300 pairs of sexually mature males and females (300-500 g) were stocked in each of two 1,600-m^2 earthen ponds. The fish were fed daily with chopped raw fish. Twenty triangular egg collectors were placed at the bottom of each pond close to its edges. The egg collector was made by joining three pieces of asbestos tiles measuring 30 cm x 30 cm at the edges to form a triangle. The amount of eggs deposited ranged from 2,000 to 30,000 and the egg deposition density was about 80-90 eggs/cm^2 (Tavarutmaneegul and Lin 1988). Thirty cm lengths of 15-20 cm diameter sections of polyvinyl chloride (PVC) pipes cut into two can also be used as egg collectors. After about two weeks, the eggs are deposited on the inner surface of the egg collectors and occasionally on the outside of the pipes.

The first reported success at induced spawning of *O. marmoratus* in Malaysia was in 1989 (Lam et al. 1990; Cheah et al. 1991). In the first trial, twelve pairs of fish individually weighing approximately 250 g were divided into three groups and a double injection protocol was adopted. The females in groups A, B and C were injected with either 2 IU/g body weight of human chorionic gonadotropin (HCG), 4 mg/kg of acetone-dried common carp pituitary, or both, respectively. After 24 hours, a second injection that was double the dosage of the first injection was given to the three groups of females. The injection medium was 0.9% saline and the injection was administered intramuscularly between the lateral line and the dorsal fin, towards the caudal peduncle. Ovulation usually occurred between 2.4 and 3.8 days after the administration of the hormones. The ovulatory response for females in groups A, B and C were 4/4, 3/4 and 3/4, respectively, and only the eggs from A females (given HCG alone) hatched.

Further studies were then conducted using only HCG. In this second trial, a single injection protocol was adopted and seven females ranging in size from 190 g to 1,200 g were injected with 5 IU/g body weight of HCG. The ovulatory response in the second trial was 6/7 and the mean hatching rate was 31% (Cheah et al. 1991). In another study, the highest hatching rate attained was 56% and the eggs were stripped from females that were injected with 8 IU/g body weight of HCG (Cheah et al. 1992).

Recently, a multiple injection protocol has also been successfully tried where the females were injected with 3-5 IU/g body weight of HCG twice a day in the morning and afternoon for a period of three days (Senoo et al. 1992). During spawning, the eggs were deposited in a single layer on the top of the under surface of the egg collector and the individual eggs dangled from the egg collector by a bundle of adhesive filaments. After oviposition, the female leaves the egg collector while the male guards and tends the eggs (Senoo et al. 1993). Females that did not ovulate after three days were then returned to the broodstock tanks. Since the fish were allowed to lay their eggs naturally, high fertilization and hatching rates have been achieved.

Fish farmer harvesting a pond at Johore, West Malaysia and showing a 200-300-g marble goby. (PHOTOS BY S.H. CHEAH)

Hatchery and Nursery Techniques

After natural spawning, egg collectors are put into 40-l aquaria for incubation. With induced spawning, eggs are stripped into a dry bowl, previously coated with vaseline to prevent the eggs from clumping (Senoo et al. 1992). The eggs are then fertilized with sperm from testes removed from the males. The testes are macerated with a fine meshed cloth, and rinsed with distilled water or 0.9% saline into the bowl. The eggs are then transferred onto a 30 cm x 20-cm net (mesh size: 0.2-0.5 mm) making sure that the eggs form a single layer on the net. The net is then submerged in water for about 15 minutes and then turned over to enable the eggs to hang in the water column like a bunch of grapes. The eggs hatch after 2-4 days at 26-28°C and the larvae are about 3 mm long. A 30.2-cm, 467-g female can yield 25,000 newly hatched larvae (Brohmanonda and Thanakumcheep 1983). The larvae are kept in aquaria or incubation trays for three to five days until yolk-sac absorption is complete (Tavarutmaneegul and Lin 1988) and then transferred to concrete nursery tanks from 6 m^2 to 16 m^2.

Fry production can be done following either the single facility system or the multiple facility system (Cheah et al. 1993). In the somewhat traditional, single facility system, a nursery pond or tank is fertilized to enable a plankton bloom and then the fish larvae are released to graze on the plankton. In the more complicated multiple facility system, live food organisms such as rotifers, copepods and cladocerans are cultured in separate tanks or ponds and delivered to fish fry production tank or pond when required.

Nutrition

The postlarvae first consume microzooplankton such as ciliates and rotifers (Pasookdee and Sirikul 1983). Chicken egg slurry, prepared by mixing the yolk of hard boiled eggs with water, and rotifers such as *Brachionus calyciflorus* can be fed from day 7 to 20. Thereafter they consume macrozooplankton, such as *Moina* and *Artemia* nauplii, and from about 30-60 days, chironomid larvae (Tavarutmaneegul and Lin 1988). They continue their carnivorous diet by consuming small shrimps and fish thereafter.

After 30 days, postlarvae attain an average length of 1 cm and survival rates range from 7 to 55%. From 30 to 60 days, fry survival rates range from 75 to 100% and length at 60 days from 2.5 to 3.5

cm (Tavarutmaneegul and Lin 1988). Tay et al. (1974) recommended rearing fry in 90 cm x 44 cm, 35-cm deep tanks at a stocking density of 200 fry/tank and in natural light. The fish were fed daily with *Moina micrura* and *Daphnia longispinna* at 80% of their biomass.

Growout

Growout can be done in earthen ponds and cages. In a pond trial in Singapore, five hundred 67-day old fry with a mean weight of 0.57 g were stocked into a pond measuring 30.5 x 21.3 m with a 1.0 m depth of water. The pond was stocked with guppies a month prior to the stocking of marble goby fry, so that the guppies could reproduce and the goby fry could prey on their young. After five months of culture, *Oreochromis mossambicus* fingerlings measuring about 4 cm were released into the pond as forage fish, at monthly intervals for a period of seven months. Then, after 12 months of culture, the fish were fed trash fish until the end of the trial. The fish attained a mean weight of 175.1 g (range: 63.0 to 287.5 g) after a rearing period of 16 months. The poor growth and low survival rate were attributed to inadequate food especially in the early part of the study (Tay and Seow 1974).

Cage culture of marble goby in floating bamboo or wooden cages has been carried out in Thailand since the early 1970s (Suwansart 1979). Fish of about 100 g are stocked at a density of 100 fish/m^2 and fed a mixture of ground trash fish, rice bran, vitamin premix and salt. They are harvested and marketed after six to eight months at about 400 g (Tavarutmaneegul et al. 1984).

Many operators claim that this species grows rather slowly and unfortunately, there is a serious lack of information on its nutritional requirements. However, better quality diets would definitely improve growth rates. The other aspect to consider is the control of growth. Tan et al. (1990) successfully isolated and purified the marble goby growth hormone, and the amino acid sequence of the molecule has also been determined. In the same publication, it was reported that molecular cloning of the growth hormone gene was in progress. It is left to be seen if the availability of recombinant growth hormone and its gene will be able to produce faster growing fish.

Disease

Up until 1978, there was very little information on the diseases of the marble goby. Experimental cage culture at Universiti Pertanian Malaysia was disrupted by mass mortalities (Ang 1978). The fish were infested with protozoan parasites: *Trichodina sp.* and *Henneguya shaharini* sp. nov. (Shariff 1982). Cysts were found on the gill filaments. Boonyaratpalin (1981) described the clinical signs of parasitic infestations and microbial infections, and suggested practical measures for prophylaxis and chemotherapy.

Marble gobies grown in cages at the Nan river, Nakornsawan province, Thailand, carried four groups of ectoparasites: protozoa, trematodes, arthropods and fungi, with bacterial infections mostly caused by *Aeromonas hydrophila* (Supamataya 1984).

A sand goby virus (SGV) has been isolated from the ulcers on the skin and in the kidney and spleen of marble gobies in Thailand (Hedrick et al. 1986). This was a new aquatic birnavirus.

Future Directions

The production of marble goby is currently limited because most of the fry and fingerlings are collected from either tilapia-goby production ponds or from the wild. However, as induced breeding and larval rearing techniques become standardized, the problem of limited supply of seed can be overcome. The use of trash fish as feed during the growout phase will continue until suitably formulated feeds become available. There is thus an urgent need for research and development institutions to look into the nutritional requirements of this fish. It is also hoped that genetically improved faster growing varieties can be developed. Disease will become more important in the future as farmers try to increase stocking densities. Preventive strategies should always be adopted such as cleaning the pond bottom at the end of each production cycle to prevent the accumulation of feces and left-over feed. Sun drying and liming of the pond bottom with quicklime are also encouraged to disinfect the pond. Overfeeding is discouraged because excess feed fouls the water and can be a potential source for a disease outbreak. Access to large amounts of good quality water is advantageous.

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News Items

New Course Prospectus from the Institute of Aquaculture, University of Stirling

The Institute of Aquaculture of the University of Stirling, Stirling, UK, offers training at Ph.D., M.Sc., Postgraduate Diploma, B.Sc. with Honours, technical, non-graduating and short-course levels. The current research program of the Institute covers topics of fundamental and applied significance to the aquaculture industry worldwide including: environment, physiological ecology and feeding habits of cultured species, aquaculture production, applied fish physiology, aquaculture nutrition, reproduction biology and genetics, biotechnology, histopathology, nutritional pathology, parasitology, immunology, invertebrate culture and aquaculture engineering. Further information and a copy of the Institute's new course prospectus can be requested from the Academic Administrator, Mrs. J. Farrington, The Institute of Aquaculture, University of Stirling, Stirling, FK9 4LA, Scotland, U.K. Tel: (44) 0786-467874; Fax: (44) 0786-472133; UK E-mail LGR1@UK..AC.STIRL; Bitnet LGR1%UK.AC.STIRL@UK.AC.NSFRELAY.

Recent Publications on Grazing in Aquatic Environments

Many NTAS members have interests in research on herbivorous farmed fish. NTAS member Dr. Malcolm Beveridge sends a list of recent publications from the Institute of Aquaculture, University of Stirling (see preceding news item for contact numbers).

Beveridge, M.C.M., D.J. Baird, S.M. Rahmatullah, K.A. Beattie and G.A. Codd. 1993. Grazing rates on toxic and non-toxic cyanobacteria by *Hypophthalmichthys molitrix* and *Oreochromis niloticus*. J. Fish Biol. 43:901-907.

Beveridge, M.C.M., M.R.P. Briggs, A. Mowat, M.E. Northcott and L.G. Ross. 1988. The function of microbranchiospines in tilapias, p. 311-317. *In* R.S.V. Pullin, T. Bhukaswan, K. Tonguthai and J.L. Maclean, (eds.) The Second International Symposium on Tilapia in Aquaculture. ICLARM Conf. Proc. 15, 623 p.

Beveridge, M.C.M., M.R.P. Briggs, M.E. Northcott and L.G. Ross. 1988. The occurrence, structure and development of microbranchiospines among the tilapias (Cichlidae:Tilapiini). Can. J. Zool. 66(11): 2564-2572.

Beveridge, M.C.M., P.K. Sikdar, G.N. Frerichs and S. Millar. 1991. The ingestion of bacteria in suspension by the common carp *Cyprinus carpio* L. J. Fish Biol. 39(6):825-831.

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Dempster, P.W., M.C.M. Beveridge and D.J. Baird. 1993. Herbivory in the tilapia *Oreochromis niloticus* (L.): a comparison of feeding rates on phytoplankton and periphyton. J. Fish Biol. 43(3):385-392.

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Rahmatullah, S.M. and M.C.M. Beveridge. 1993. The ingestion of bacteria in suspension by fry of planktivorous Indian major carps (*Catla catla, Labeo rohita*) and Chinese carps (*Hypophthalmichthys molitrix, Aristichthys nobilis*). Hydrobiologia 264:79-84.

International Symposium on Socioeconomics of Aquaculture and the IAAEM Organized

The first International Symposium on Socioeconomics of Aquaculture was held in Keelung, Taiwan, 14-17 December