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Grouper and snapper aquaculture in Taiwan

by Mike Rimmer

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A previous article outlined the status of marine finfish aquaculture in Taiwan (see Austasia Aquaculture *11(5)). Some of the highest value finfish species being cultured, or developed for culture, in Taiwan are groupers (Family Serranidae) and snappers (Family Lutjanidae). Groupers and snappers are in demand not only in Taiwan but also in other parts of Asia, for example, in the live markets of Hong Kong and southern China, where they bring up to $A 87/kg (Dragon Search, 1996). This article deals with the technical aspects of production of groupers and snappers in Taiwan.*

Broodstock

A particular feature of marine finfish aquaculture in Taiwan is that broodstock of most, if not all, species cultured are maintained in outdoor ponds. These ponds are up to 0.3 ha in area and 2–4 m deep. Stocking density is usually around 300 fish in a single 0.2–0.3 ha pond, which for king grouper (*Epinephelus lanceolatus*) represents a biomass of up to 10 tonnes (t) in a 0.3 ha pond. Some other fish species—e.g. milkfish—may be held at lower density (100 fish per pond) due to their greater space requirement. Broodstock ponds have one or two paddlewheels to aerate and circulate the water, but only low rates of water exchange. The fish are fed every three days with trash fish, and every two or three weeks with squid stuffed with a vitamin supplement.

Generally, the fish breed naturally in the ponds. At the height of the breeding season up to 20 kg of eggs (c. 30 million eggs) are produced per day by the 300 broodfish in a single 0.2 ha grouper broodstock pond. Eggs are sold by weight. Hormone induction appears to be rarely carried out, although I did observe king grouper and sea bass (*Lates calcarifer*) on two farms being injected with HGG as they were transferred between ponds. According to the farmers, hormonal induction is usually carried out to encourage the fish to breed earlier in the season than would occur without this intervention. Fingerlings produced early in the season, when demand is great and supply is small, attract higher prices than those supplied later in the season, so there is an economic rationale for inducing broodstock to spawn early. Researchers from the Taiwan Fisheries Research Institute (TFRI) have developed techniques for cryo-preservation of grouper sperm, and this technique has reportedly been used in at least one Taiwanese hatchery (Chao et al., 1992), but it appears not to be in widespread use.

Larviculture

Larviculture is undertaken using either the 'indoor method' or 'outdoor method'—i.e. in concrete tanks indoors or in outside ponds. The compara-

tive advantages and disadvantages of each technique are listed in Table 1. To a large extent, the use of a particular method depends on the location of the hatchery; the indoor method is more common around the Pingtung district in southern Taiwan, while the outdoor method is common in the Tainan district in southwestern Taiwan. The larval-rearing technique used also varies with the species cultured. Groupers are reared using both indoor and outdoor methods, as is red sea bream (*Pagrus major*), but red snapper (*Lutjanus argentimaculatus*) is reared using only the outdoor method.

Indoor method

The indoor method is basically traditional Asian intensive larval rearing, undertaken in large fibreglass or concrete tanks up to about 100 m^3. The rearing tanks are circular or rectangular in shape, flat-bottomed and with a white or light-coloured interior. Larviculture is undertaken using either greenwater or clearwater techniques. The algal density used for greenwater culture ranges from 50 000 to 500 000 cells/ml. Variables such as algal density are measured only in research hatcheries; commercial hatcheries just add algal cells until the desired shade of green is reached.

The eggs are generally added directly to the larval-rearing tanks. Occasionally they are placed in hatching tanks, and then the newly hatched larvae are transferred to the rearing tanks; this process enables larval density to be estimated more accurately. Grouper larvae are fed oyster trochophores from first feed (usually D4) for two days. Rotifers are also added to the rearing tanks, generally commencing from first feed. Recent research at TML indicates that a combination of oyster trochophores and small rotifers (either SS-strain, sieved S-strain, or neonates) is the best initial feed (Su et al., 1996). Rotifer densities are maintained at about 2–3/ml until the grouper larvae are large enough to eat brine shrimp or adult copepods, which is when the dorsal and pectoral spines reach the end of the caudal fin. Generally, grouper larvae are able to feed on adult copepods from D16 (water temperature >26°C) or D22 (<26°C).

Table 1: **Comparison between the indoor and outdoor larval-rearing systems (from Liao, 1995)**

	Indoor	Outdoor
Tank or pond depth	1.0–2.0 m	1.0–1.5 m
Water volume	< 100 t	> 100 t
Survival rate (early stage)	High	Unstable
Feed supply and water control (late stage)	Poor	Easy
Larval growth	Slow	Fast
Seed quality	Poor	Good
Production cost	High	Low
Filamentous algal growth	Impossible	Possible

Outdoor method

The outdoor method of larval rearing is undertaken in concrete or earthen ponds ranging in size from 200 m^2 to 0.5 ha, and, less commonly, to 1 ha. The ponds are filled only 1–2 days before being stocked with eggs. The inlet is screened with a fine mesh 'sock' filter to exclude potential predators and nuisance species. Stocking density for grouper ranges from about 1 kg of eggs (i.e. circa 1.5 million eggs) in 0.1 ha to 2 kg (c. 3 million eggs) in 0.2–0.5 ha larval-rearing ponds. For red snapper eggs, stocking densities are 2–3 kg (c. 3–4.5 million eggs) for ponds up to 1 ha.

One or two enclosures formed by a tarpaulin set around a floating support structure are set up in the pond, usually with shadecloth overhead to reduce light intensity and mild aeration to ensure adequate dissolved oxygen and mixing of the water within the enclosure. The enclosures range in size from 5 m^3 in small concrete ponds to 8–10 m^3 in earthen ponds 0.2–0.5 ha in area. The enclosures are pumped full of pond water and fertilised grouper or snapper eggs are added to the enclosures. Oyster trochophores are added to the enclosures from first feed (usually D4) for two days, then the larvae are released into the pond. The enclosures allow smaller quantities of oyster trochophores to be fed while retaining relatively high prey densities. They also allow farmers to visually estimate larval survival after the first few days of culture, which is the period when most mortality occurs. If survival is very low, the farmer may choose to restock the enclosure with another batch of larvae, rather than release the survivors into the pond.

Rotifers (and, incidentally, other zooplankters) are cultured in small concrete or earthen ponds,

usually about 0.05–0.1 ha. The rotifers are cultured using trash fish placed in fertiliser bags and left to decompose in a corner of the pond, or by the addition of organic wastes. A paddlewheel aerator is placed in the pond to assist with aeration and to generate a current in the pond. Zooplankton is harvested using a fine (c. 85 mm) mesh net that is set downstream from the paddlewheel aerator for 1–2 hours. The collected zooplankton is added to the larval-rearing pond. Farmers attempt to maintain rotifer density at about 3–4/ml, but like other aspects of pond management, rotifer density is not measured, but is maintained 'by eye'. Later in the larval-rearing cycle, adult copepods are harvested from the zooplankton production ponds using the same technique, although with a larger mesh (c. 210 mm) mesh net. Some farms pump water from rotifer production ponds into the larval-rearing pond, and may also pump zooplankton-rich water from growout ponds into larval-rearing ponds.

The larvae are reared in ponds until they reach 2.5–3 cm total length (TL), when they are harvested. In the case of grouper and snapper, this takes about four weeks. Pond temperatures need to be above 20°C to ensure any larval survival for grouper; if they drop below 18°C, the grouper larvae will die. For this reason, some farms will not buy grouper larvae until April, even though eggs are available from early March. In addition, farmers feel that the quality of eggs produced early in the season is inferior to those produced later.

Survival of groupers and snappers using both indoor and outdoor larval rearing methods is highly erratic, but generally low. One farmer using the outdoor method told me that he would be very happy to harvest 100 000 fingerlings from his 0.1 ha larval-rearing pond, which would correspond to 7 per cent survival. Researchers at TFRI's Tungkang Marine Laboratory (TML) report that a major constraint to grouper aquaculture is the irregular nature of larval survival. The major problem, according to TML researchers, is high mortality at first feed, although there is often low-level mortality throughout the larval-rearing process.

Nursery

Grouper

Two pond-culture systems are used for the nursery phase of grouper farming: the small pond and large pond systems. The small pond system uses ponds about 100 m^2 in size, within which are placed small cages (1.2 m x 0.8 m x 0.8 m). Maximum stocking density per cage is 2000 fingerlings at 6 cm TL. The large pond system is usually used during winter, since handling juveniles at low water temperatures will cause disease and mortality. Imported grouper fingerlings are cheaper in autumn and winter ($US 0.2–0.4/fish for fingerlings 2–2.5 cm TL) than in spring ($US 2–3/fish), so farmers may purchase fingerlings and stock them in large ponds over winter. Before the ponds are stocked with fish, small shrimp (*Palaemon* spp.) are stocked to provide prey for the juvenile groupers. Chopped small trash shrimps and fish are also supplied as supplementary feed. However, results of this type of culture are reported to be inconsistent. Grouper fingerlings are fed a range of different feed types, including adult brine shrimp, small shrimp (*Acetes chinesis*), small gobies (*Gobiidae),* and mosquito fish (*Gambusia* spp.) (see Liao et al. 1995).

Grouper fingerlings are fed four to six times a day at the beginning of stocking, but feeding is gradually reduced to twice a day when they reach about 6 cm. Groupers are fed to satiation to reduce cannibalism. Food conversion ratios (FCRs) for *Epinephelus marabaricus* range from 2.2:1 to 3.6:1 for wet nursery feeds and 0.8:1 for eel (dry) feed, for a fish body weight of 3.4–14 g. Growth to 6 cm takes about one to one-and-a-half months during summer (26°C), and three months during winter (20–24°C). Continuous grading at five-day to seven-day intervals is necessary during the nursery stage to reduce cannibalism (Liao et al., 1995).

Red snapper

The main diet for red snapper in the nursery phase is the shrimp *Acetes chinensis* and chopped trash fish. Red snapper fingerlings produced during summer are usually sold directly to growout farmers, but fry produced in autumn are usually stocked in nursery ponds for over-wintering and sold the following spring for higher prices. Prices for red snapper fingerlings are low: $US 0.04–0.08/fish at 2.5–3 cm TL, and most fry are exported (Liao et al., 1995)

Growout

Grouper

Grouper are farmed in cages and in ponds. Growth rates for *E. coioides* are better for cage culture: 8–10 months from 6 cm TL to market size of 400–800 g in cages, versus 10–14 months in ponds. King grouper (*E. lanceolatus*) are prized because of their rapid growth. According to Mr Tai (Long Diann Trading Company Ltd, Pingtung), from 75 mm fingerling (c. three months old) they reach 2.4 kg in 12 months and 15 kg in two years. King grouper are also being cultured in Thailand, which reports similar growth rates of 2–3 kg in 12 months (R. Yashiro, pers. comm.).

Although trash fish has traditionally been the preferred feed for grouper growout, more farmers are

now utilising pellet feeds (mainly moist pellet feeds). About 70 per cent of Taiwanese grouper farmers now use artificial feeds. Fish are initially fed twice a day, but this is reduced to once a day when they reach 200 g. In winter, fish are fed every other day before sunset; in other seasons, they are fed every morning. FCRs for grouper range from 4:1 to 5:1 for trash fish, and 1.2:1 to 1.4:1 for moist pellets. Grouper in ponds are stocked at 2–7 fish/m^2 and typical production rates are 10–30 t/ha/crop (Liao et al., 1995).

Red snapper

Red snapper are stocked at 3–5 fish/m^2, and take about 12–18 months to reach the preferred market size of 400–1000 g. Typical production rates are 15–20 t/ha/crop. Red snapper are fed moist pellet feed, dry floating pellet, or trash fish. FCRs range from 2.2:1 to 2.5:1 for moist pellet and from 7:1 to 9:1 for trash fish. Red snapper are graded one month after stocking, when the fingerlings have reached 9–12 cm TL (Liao et al., 1995).

Red snapper are tolerant of low oxygen conditions, with a lethal oxygen concentration of 1.2 mg/l for fingerlings 4.7–5.2 g at 30°C and 25 ppt. The body colour of red snapper darkens when the fish are fed artificial feeds and cultured at low salinity (3–10 ppt). Dark-bodied fish bring lower market prices. Body colour can be improved by supplementing the feed with shrimp heads, xanthophyll or astaxanthin for two-to-three weeks before harvesting (Liao et al., 1995).

Disease

Grouper

Grouper diseases in the nursery include swim bladder inflation syndrome, white spot (*Cryptocaryon irritans*), and whirling disease (possibly viral nervous necrosis or VNN). Swim bladder inflation syndrome mainly occurs during metamorphosis and may be due to a deficiency of highly unsaturated fatty acids (HUFAs) in the diet. An unknown factor causes high mortality of fish 3–4 cm TL; symptoms include darkened body colour, loss of appetite, reduced activity, and aberrant behaviour such as facing the pond wall and sitting on the substrate while maintaining swimming motions (Liao et al., 1995).

The predominant disease of grouper in growout is white spot (*Cryptocaryon tritans*), which causes high mortalities in autumn. In the early stages of infection the fish can be treated with 30 ppm formalin and 0.35 ppm copper sulfate. Infected fish may be moved to another pond. The fish leech *Piscicola* sp. is also a problem in grouper growout. Although this parasite does not cause mortality, infected fish lose their appetite and their market value is diminished due to their appearance. Taiwanese farmers state that fish leech infestations can be reduced or avoided by stocking shrimp in the grouper ponds (Liao et al., 1995).

Red snapper

Mortalities in the nursery and growout phases may be caused by *Amyloodinium ocellatum* and *Trichodina* sp. Dense diatom or dinoflagelate blooms can cause bubble disease, impede gill function and may lead to high mortality (Liao et al., 1995).

Constraints

The two major constraints to the development of grouper culture in Taiwan appear to be consistent production of fingerlings and an apparent increase in disease-related mortality. Larviculture of grouper has always been unreliable, with highly variable but generally low survival. Taiwanese farmers have overcome the problem of low survival to some extent by adopting cheap fingerling production methods and stocking extremely high numbers of eggs. According to TML researchers, the unreliable nature of fingerling production is at least partly related to survival in the first few days after the commencement of exogenous feeding, although mortality continues throughout much of the larval rearing systems.

Reports from farmers suggest that grouper fingerling survival is generally decreasing, and that they are seeing problems that they did not experience a few years ago. TML staff are also concerned about the apparent increase in disease incidence, particularly syndromes apparently related to viral nervous necrosis (VNN). A huge, uncontrolled trade in broodstock, larvae, fingerlings, and market-sized fish in Asia effectively and rapidly spreads any new diseases throughout the region.

If, indeed, the future of grouper aquaculture in Asia is now threatened by the widespread occurrence of VNN, there are implications for Australia. Relatively little is known of VNN and its relationship to other viral diseases of finfish, such as barramundi picorna-like virus (BPLV). It is possible that Australia, being relatively isolated from the trade in live fish in Asia, is free of VNN. If so, we should endeavour to maintain this disease-free status as we have successfully done with salmonids.

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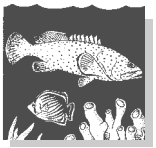

Culture of coral reef fishes

by Suresh Job, Michael Arvedlund & Michael Marnane

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Over the past couple of years, a number of different coral reef fish species have been successfully spawned and reared at James Cook University, with relatively high rates of survival. A list of these species is shown in Table 1 (see next page). Some of the species listed have been spawned, but the larvae have not yet been reared.

Breeding set-up

The University's Research Aquarium Facility comprises two recirculating seawater systems. The main system has a holding tank of 150 000 litres (l) and a smaller system of 50 000 l. Together, these systems service a total of 40 satellite tanks of 1000 l and approximately 80 smaller tanks in covered areas, and five temperature controlled laboratories. High quality water is maintained using algal scrubbers, biological trickle filter towers, protein skimmers and high-pressure sand filters. A heater/chiller unit ensures that critical outside areas and the five laboratories receive temperature controlled water (26°C – 28°C), allowing the coral reef fish breeding programme to continue throughout most of the year.

In all the breeding tanks, good water movement is maintained using submersible pumps to ensure high levels of oxygenation. With the exception of the anemonefish (Family Pomacentridae) species, all the breeding fish are maintained outdoors with a 50 per cent shade cloth roof over them. Outdoors, the fish spawn consistently for about 10 months of the year. The anemonefish are maintained in pairs in indoor tanks and breed consistently throughout the year. The temperature in all the breeding tanks is maintained between 26°C and 28°C, with the exception of those containing *Premnas biaculeatus*, which is most successfully bred at a water temperature of 28°C – 30°C.

The most important considerations when trying to breed reef fishes are to provide an appropriate environment and to feed broodstock adequate levels of nutritious food. The tank sizes recommended in Table 2 (see page 45) are a rough guide to the sizes required for breeding. Breeding fish are territorial and extremely aggressive toward members of their own sex. The underlying rule is that group spawners require enough space so that smaller individuals can form territories of their own and avoid aggression from their tank mates. Pair spawners can usually be bred in much smaller tanks. As far as food goes, our preference is to mix high cholesterol foods such as shrimp (which apparently improves egg quality) with vitamin-enriched flake foods.