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Robert R. Stickney
Texas Sea Grant College Program
Bryan, Texas

ORNAMENTAL FISH CULTURE, MARINE

G. JOAN HOLT
University of Texas
Port Aransas, Texas

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See also ORNAMENTAL FISH CULTURE, MARINE

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G. JOAN HOLT
University of Texas
Port Aransas, Texas

OUTLINE

Breeding Marine Ornamental Fish
- Early Life History

Species Commonly Reared in Captivity
- Clownfish or Anemonefish (Pomacentridae)
- Gobies (Gobiidae)
- Dottybacks (Pseudochromidae)
- Seahorses (Syngnathidae)
- Drums (Sciaenidae)

Species with Potential for Captive Breeding
Bibliography

Keeping an aquarium is a hobby that engages an estimated 10–20 million enthusiasts, who own more than 90 million tropical fish (1). The retail value of the ornamental fish trade is approximately $1 billion (2). Although many of the freshwater ornamental fish sold to the public are farm raised, essentially all of the marine reef products (fish, invertebrates, live rock) are collected from the wild.

The Asia/Pacific region is the global center of marine diversity; it supports more species of coral and fish than does any other region on earth. This region is home to over 4,000 species of reef fish and more than one-third of the world's coral reefs. In this region, and throughout the tropics, natural populations of coral reef fish are increasingly threatened by development, dredging, coral collecting, and the live food-fish and aquarium-fish trade. Unfortunately, many of the common collection methods (dynamite, sodium cyanide) are destructive (3), and cause irreparable damage to coral reefs in addition to greatly reducing the area of natural habitat available for the settlement of new fish recruits.

Japan and the United States lead the market for aquarium fish; these two countries account for over half of the world's ornamental fish trade. The Philippines is a major exporter of marine aquarium products for the global aquarium trade, supplying an estimated 75–80% of the market (3). It is estimated that up to 90% of all aquarium fish imported by the United States from the Philippines have been collected by using cyanide (4). There are several cyanide fishing techniques, all of which damage corals. Cyanide is a broad-spectrum poison that acts on enzyme systems involved in respiratory metabolism **(3).** Exposing a fish to cyanide causes internal damage to its liver, intestine, and reproductive organs. Fish that survive exposure to cyanide, but are not taken by divers, can be expected to suffer impaired chances of survival, growth, and reproduction, and lowered disease resistance.

Less is known about the specific impacts of cyanide on reef invertebrates, but it seems likely that similar debilitating effects occur to them. In general, invertebrates seem to be more susceptible to cyanide than are fish. Loss of zooxanthellae (coral bleaching), inhibition of photosynthesis, and impaired respiration of coral in response to cyanide concentrations used in fishing have been documented in invertebrates (4).

BREEDING MARINE ORNAMENTAL FISH

The ability to meet demands for marine ornamentals by utilizing wild-caught fish is decreasing due to more stringent regulations on collections that deplete wild stocks and cause damage to fragile coral reef ecosystems. In the Philippines, one of the important suppliers of marine ornamental species to the United Kingdom, Europe, and the United States of America, destructive collecting techniques damage reef habitats. Furthermore, the marine environments in which these species exist under natural conditions are increasingly being threatened by various forms of human interference and natural disasters that result in extensive damage to coral reefs. Recently, some countries have taken steps to protect several species of marine fish and invertebrates.

Sri Lanka and other countries in the region are showing an increasing interest in the breeding of marine ornamental fish and invertebrates, both to reduce dependence on wild stocks and as a means of generating income for coastal communities. Increasing pressures on natural populations of coral reef organisms, and their expanding popularity in the aquarium trade, have spurred interest in the development of culture techniques for marine ornamentals. There is a strong call for tank-reared fish by both marine aquarium hobbyists and professional aquarists. Currently, few species of marine fishes are regularly reproduced in captivity and sold in the aquarium trade. The most commonly available are clownfish (Amphiprion spp. and Premnas biaculeatus), the neon goby (Gobiosoma oceanops) and relatives, and more recently the dottybacks (Pseudochromis spp. and Ogilbyina novaehollandiae) (5). Some other species have been bred and raised in captivity during the last 30 years (6), but not reliably or efficiently enough to sustain an industry. There are generally fewer problems in the spawning of tropical marine fish and invertebrates than in culturing the young. In fact, larval culture is the most difficult biological aspect of the culture of most marine species.

Why are some species raised successfully while most others are not? The easiest to raise, clownfish, have the advantage of being sequential hermaphrodites (they can change sex), which eliminates the problem of obtaining a spawning pair, and they produce demersal eggs for which the adults provide parental care (7). Although parental care ceases with the hatching of the eggs, the larvae are large enough at hatching to consume cultured rotifers (Brachionus plicatilis) (6).

Many of the more popular and costly marine aquarium fish, such as butterflyfish, angelfish, and wrasses, are more difficult to raise in captivity. They produce small free-floating eggs that are only about one-third the size of clownfish eggs, and the adults do not provide parental care. The newly hatched larvae are less than 2.5 mm (0.1 in.) long, and they have no eye or mouth development and very limited swimming ability. Traditional prey for the rearing of marine fish larvae (rotifers and Artemia spp. or brine shrimp) are not accepted, and may not be nutritionally adequate, for these marine ornamentals.

Early Life History

Survival through the early life stages has proved to be the major obstacle to large-scale production of a wide variety of marine ornamentals in captivity. Production of sufficient numbers of healthy juvenile fish for the market depends primarily on the refinement of larval rearing methods. Appropriate environmental conditions and proper prey for different stages during development are unknown and must be determined. Development of rearing systems for the tiny, delicate larvae is a challenge. Since they have rudimentary sensory and motor development, the larvae cannot swim and search large volumes of water to find food. This necessitates the feeding of dense blooms of live prey, and it often results in deteriorated water quality. Simple systems, such as the one described by Henny and coworkers (8) provide a confined volume for larvae and their prey, which facilitates high feeding density, and also allows for constant exchange of water. Water in the completely closed system is filtered, aerated, and heated, if necessary, in order to maintain adequate water quality (Fig. 1).

The next problem is that of finding appropriate prey. The first food for marine larvae is live plankton, generally zooplankton. Cultured rotifers are the most commonly-fed food in aquaculture, but many marine ornamentals do not grow and thrive on them. It may be because rotifers are too large, do not give appropriate behavioral signals, or are not nutritionally adequate. Natural plankton (including algae) would be the best choice, but they are not always accessible-and often when they are the species composition and nutrient quality vary over time. For reliable production, cultured prey must be available. Phytoplankton is relatively easy to culture but is not an adequate food by itself. Copepods are generally considered the best food overall for larval marine fish, however, culture success has been marginal at best. Gut analysis (9) showed tintinnids, dinoflagellates, protozoans, diatoms and copepods, in that order, as the most important prey for small (less than 3 mm or 0.12 in.) coral reef fish larvae. These findings suggest that the best first foods for rearing ornamentals are microzooplankton and large phytoplankton.

SPECIES COMMONLY REARED IN CAPTIVITY

Clownfish or Anemonefish (Pomacentridae)

Types of fish commonly raised in ornamental fish culture (10) are species that have three characteristics: they can change sex (sequential hermaphrodites), they have eggs that take several days to hatch, and they produce relatively large larvae (>2.5 mm or 1/10 in.) that have fast development. The clownfish is a good example. These fish can change sex from male to female (protandry). Generally two to four fish might occupy an anemone, including a large dominant female, a smaller male and one or two adolescents. If something happens to the female, the male, now dominant, will change into a female and one of the smaller individuals will become a male. Most commercial operations typically have only pair housed in the breeding tank. Clownfish spawn about twice a month by laying adhesive eggs onto a hard substrate. Eggs are tended

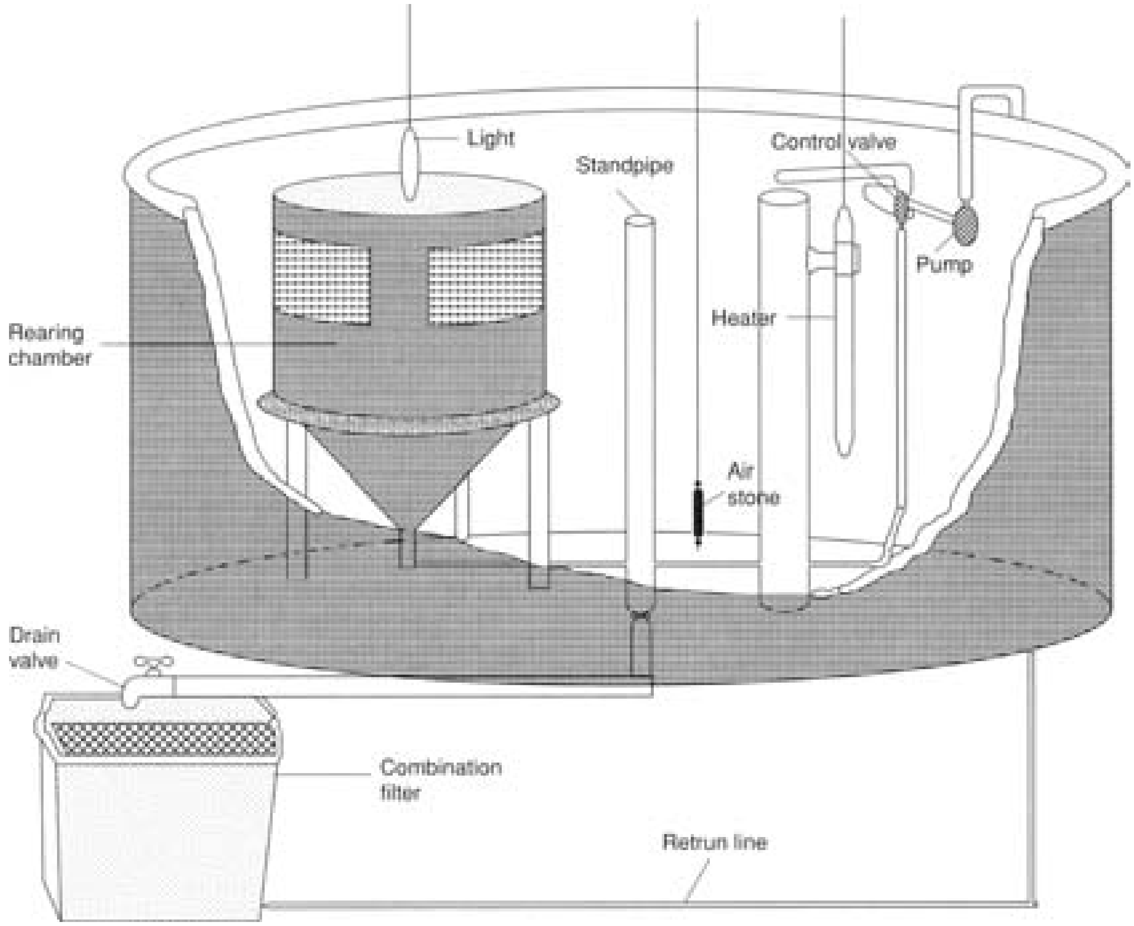

Figure 1. Rearing system for development of larvae of marine ornamentals. (From Hinney et al. 1995.)

by the male and hatch after a week. Newly hatched larvae feed on rotifers for several days, followed by brine shrimp. Within one to three weeks they metamorphose into juveniles. High survival of the young is possible with many of the 12-plus species that are regularly produced in captivity, and several commercial establishments produce and sell captive-bred clownfish. Joyce Wilkerson's new book Clownfish: A Guide (11) is an excellent source of information on the captive care and breeding of these fish.

Gobies (Gobiidae)

Gobies are typically small benthic fish that often act as cleaners, removing parasites from other fish. They are protogynous hermaphrodites, which means they can change sex from female to male but not the other direction. In captivity, gobies spawn regularly (every 2–3 weeks) and produce demersal adhesive eggs that are usually attached to the underside of a rock or to the roof of a small cavity. In most cases, spawning requires only the presence of a mated pair plus a suitable spawning site. The male guards and tends to the eggs for the 4–10 days between fertilization and hatching. Neon goby eggs are quite large; the larvae are 3–4 mm (0.1–0.2 in.) and are relatively advanced at hatch (12). Young can be raised on rotifers and wild zooplankton, and, later, brine shrimp nauplii. Metamorphosis to the juvenile stage takes about a month. Several species are regularly spawned in captivity. Commercially available gobies include the neon goby, the yellow-striped goby, the West Indian cleaner goby, the genie goby, and the masked goby (13).

Dottybacks (Pseudochromidae)

Dottybacks or fairy basslets are also protogynous hermaphrodites. They lay a gelatinous ball of eggs (about 2.5 cm or 1 in. in diameter), which is guarded by the male for a few days before the eggs hatch into 2–4 mm (0.1–0.2 in.) larvae. While the male is caring for the eggs, he chases away the female. When he wants to spawn, he aggressively invites the female to join him to spawn. The rotifer is readily accepted as first food by the larvae, and is replaced by brine shrimp nauplii after about two weeks. Metamorphosis occurs at about 30 days, followed closely by the development of full adult coloration. During the last three years, several species have been successfully reared (14) and are now offered for sale (13). M.A. Moe (15) has written a book that details the care and breeding of the orchid dottyback (Pseudochromis fridmani).

Seahorses (Syngnathidae)

Seahorses typically live in shallow areas and cling on to vegetation, rocks and other suitable substrates with their tails. Several species are monogamously pair-bonded and will not change spawning partners unless one of them

Table 1. Life History Characteristics of Popular Marine Aquarium Fishes that have been Spawned in Captivity

Mode of Reproduction	Egg Type	Number of Eggs	Egg Size mm (in.)	Incub Time in Days	Hatch Size mm (in.)	Larval Stage in Days	Reared in Captivity	Commercial	Species Reared
GONOCHORISIM (separate sexes)									
Syngnathidae—seahorses	Pouch brooder	50- 1500	?	20–28	6–13 (.2–.5)	?	Yes	No	Six species (17)
Apogonidae—cardinalfish (nocturnal)	Oral brooder	20+	1–2.5 (.04–.1)	21–24	3–6 (.12–.24)	21	Yes	No	Banggai Cardinalfish (20)
Sciaenidae—drums	Pelagic	2000–5000	.8–1.2 (.03–.05)	1	2.5 (.1)	20–30	Yes	No	Jackknife fish, cubbyu (18)
Ephippidae—spadefish, batfish	Pelagic	1000–5000	1 (.04)	1	2.5 (.1)	15	Yes	No	Spadefish (21)
Chaetodontidae—butterfly fish (coral polyp feeders)	Pelagic	3000–4000	.7–.9 (.03–.035)	1	1.4–2 (.06–.08)	40–60	No		
Opistognathidae—jawfish (live in burrows)	Oral brooder	1000	.85 (.03)	7–9	4 (.16)	21–28	Yes	Yes	Yellowhead jawfish (22)
Blenniidae—blennies (benthic)	Demersal (attached)	1000	.8 × 1 (.03 × .04)	4–10	4 (.16)	18–20	Yes	No	Black-lined blenny (23) marbled blenny (24),+ others (25,26)
Callionymidae—dragonets	Pelagic	?	.6–1 (.02–.04)	1	1–2 (.04–.08)	20–30	Yes	No	Mandarinfish (13)
SEQUENTIAL HEMAPHRODITISM (can change sex)									
PROTANDOUS (change from male to female)									
Pomacentridae (in part)—anemonefish or clownfish	Demersal (attached)	400–1500	1.5 (.06)	4–10	2.5–3 (.1-.12)	7–21	Yes	Yes	About 12 species of Amphiprion or clownfish (11 and references therein)
PROTOGYNOUS (change from female to male)									
Cirrhitidae—hawkfish	Pelagic	500	0.7 (.03)	1	1.5 (.06)	35–50	No		
Serranidae (in part)—swissguard basslet and reef basses	Pelagic	300	.6–.9 (.02–.035)	1	1.5–3 (.06–.12)	20	No		
Pseudochromidae—dottybacks or basslets	Demersal (egg mass)	500–2000	1–1.4 (.04-.055)	4–7	2–4 (.08-.15)	21–35	Yes	Yes	Dottybacks (13,14), royal gramma (27), blackcap basslet (28,29)
Plesiopsidae—comet or marine beta (secretive in caves/crevices)	Demersal (egg mass)	300–400	.95 (.04)	5–6	3–4 (.12-.16)	60	Yes	No	Marine beta (30–32)
Labridae—wrasses	Pelagic	500–7000	.5–1.2 (.02-.05)	1	1.5–2 (.06-.08)	30	Yes	No	Hogfish (33) spotfin hogfish to day 18 (32)
Pomacanthidae—angelfish	Pelagic	150–75,000	.6-.9 (-02-.035)	1	1.5–2.5 (.06-.1)	30	Yes	No	French, grey angelfish (34,35)
Pomacentridae (in part)—damselfish (intraspecific aggression)	Demersal (attached)	500–1000	.6-.9 (.02-.035)	3–5	2–4 (.08-.16)	30	Yes	No	Beaugregory (36), yellow-tailed damsel (37,38) threespot and white-tailed damsel (39)
Gobiidae (in part)—reef gobies	Demersal (adhesive)	100–1000	1–2 (.04-.08)	4–10	2–7 (.08-.28)	25–35	Yes	Yes	Green-banded, citron, neon goby+ (40,41)
SIMULTANEOUS HEMAPHRODITISM									
Serranidae (in part)—hamlets, sea basses	Pelagic	1500	.7–1 (.03–.04)	1	2.2 (.09)	20–30	No		

dies or is lost (16). Seahorses exhibit an unusual type of parental care in which the male becomes 'pregnant.' After a courtship that extends over several days, the female deposits her eggs in the pouch of the male, where they are fertilized. The male carries the eggs in his pouch for several weeks. By the time young seahorses are released from the pouch, they are approximately 10 mm (0.4 in.) in length, are well developed, and are able to feed on small plankton like rotifers and crustacean nauplii. Young seahorses can triple in size in 3 to 4 weeks, and they reproduce within a year. Seahorses have been successfully bred and reared in captivity by researchers and hobbyists alike. Information on captive spawning and rearing of seahorses may be found in an article by Amanda Vincent (17).

Drums (Sciaenidae)

An exception to the general characteristics for easy-to-rear ornamentals are the sciaenids or drums. The drums are gonochorists, i.e. an individual is either male or female for its entire life. These fish produce floating or pelagic eggs that hatch in less than 1 day into 2.5 mm (0.1 in.) long larvae. The larvae are able to feed on small rotifers at first feeding, but may do better with added wild zooplankton. Growth is fairly rapid; metamorphosis to the juvenile stage occurs at about three weeks. Several species, including the jackknife fish and highhat, have been spawned and reared in captivity (6,18,19) but none are yet produced in sufficient quantity for the tropical fish industry.

SPECIES WITH POTENTIAL FOR CAPTIVE BREEDING

Many of the marine ornamentals that have been spawned in captivity are listed in Table 1. Some are already commercially available, and others have the potential to be reared successfully in captivity. Based on previous successes, the most obvious species for future work might include fish that change sex, care for their embryos, produce large larvae (>2 mm or 0.1 in.) that can feed on rotifers or brine shrimp nauplii, and quickly develop into juveniles.

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See also ORNAMENTAL FISH CULTURE, FRESHWATER.

OSMOREGULATION IN BONY FISHES

JOSEPH J. CECH, JR.
University of California, Davis
Davis, California

OUTLINE

Osmoregulation and Ionic Regulation of Marine Fish
Osmoregulation and Ionic Regulation of Freshwater Fish