steps necessary to ensure a transformation to a sustainable, cyanide-free live reef fish trade.

Indeed, without a great deal of work such as that being carried out under the DFRI, there will be no Indo-Pacific reef fish on the market able to be certified as cyanide-free and otherwise sustainably caught and handled.

Documentation and evaluation

Finally, IMA and WRI believe it is important that experiences from the field, both good and bad, need to be widely shared and evaluated. To that end, the DFRI places strong emphasis on documenting its work and resulting data and lessons learned into high quality, readable publications and other media for wide dissemination to policymakers, fisheries and marine conservation managers, donor agencies, NGOs, and the general public.

Conclusions and a request for feedback and partnership

WRI and IMA are well aware that this ambitious initiative is well beyond the scope of our two organisations working on our own. As a result, the DFRI will only work in countries and communities where there is strong support from local government units, fisheries agencies, local and national NGOs, and the communities where field activities are carried out. And we are already working with, or in the process of developing relationships with, a range of international institutions, including the World Bank, Asian Development Bank, U.S. Agency for International Development, The Nature Conservancy, the World Wide Fund for Nature (WWF), and Conservation International.

While we are convinced that the DFRI's approach is essentially sound, doubtless there are many improvements and refinements that could be made. We therefore urge readers to send us comments and recommendations and, above all, we invite collaboration with any and all organisations that share our commitment to conserving the reefs of the Indo-Pacific into the next millennium.

Contacts

Vaughan R. Pratt, President
International Marinelife Alliance
#17 San Jose Street, Kapitolyo
Pasig City, Metro Manila, Philippines
E-mail: imaphil@mnl.sequel.net
Tel: +632 631 4993
Fax: +632 637 7174
http://www.imamarinelife.org/

Charles V. Barber, Senior Associate
World Resources Institute
14 Cabbage Street, Valle Verde 5
Pasig City, Metro Manila, Philippines
E-mail: cbarber@mnl.sequel.net
Tel: +632 631 0421
Fax: +632 631 0406
http://www.wri.org/wri

Notes on reproduction in the estuarine stonefish *Synanceia horrida*

D.G. Fewings[1] *& L.C. Squire*[1]

The estuarine stonefish, *Synanceia horrida* is a benthic ambush predator with a distribution ranging from India to Australia and north to China (Randall, Allen & Steene, 1990). The species typically inhabits coastal foreshores, in waters that are subject to salinity fluctuations and often carry a high sediment load (Grant, 1987). These conditions provide a muddy substrate, which the estuarine stonefish use to camouflage themselves from predators and potential prey by burying themselves in the silt or sand, with only their mouth slit protruding (Grant, 1987). We observe that these fish can be tracked from one sunken ambush site to another by following impressions left in the mud by the fish hopping across the bottom on its pectoral fins

Stonefish are an important fisheries resource in the live fish trade. After capture, the fish are maintained alive, then transported, usually by air, to Hong Kong where they are considered a delicacy. (Fifteen-inch Stonefish, *Synanceia veruccosa*, averaging about 38 cm in length, were selling live for $US 34.10 per kg live weight in the Hong Kong market in February 1999 (Y. Sadovy, pers. comm.)).

To date, stonefish have been collected from several sources, including the Philippines, Indonesia and Papua New Guinea. Stonefish stocks have been recorded as fished out of prime areas in Papua New Guinea, where previously large numbers were collected for anti-venom production (Brown

1. P.O. Box 5N. Cairns Post Office, Cairns 4870, Australia

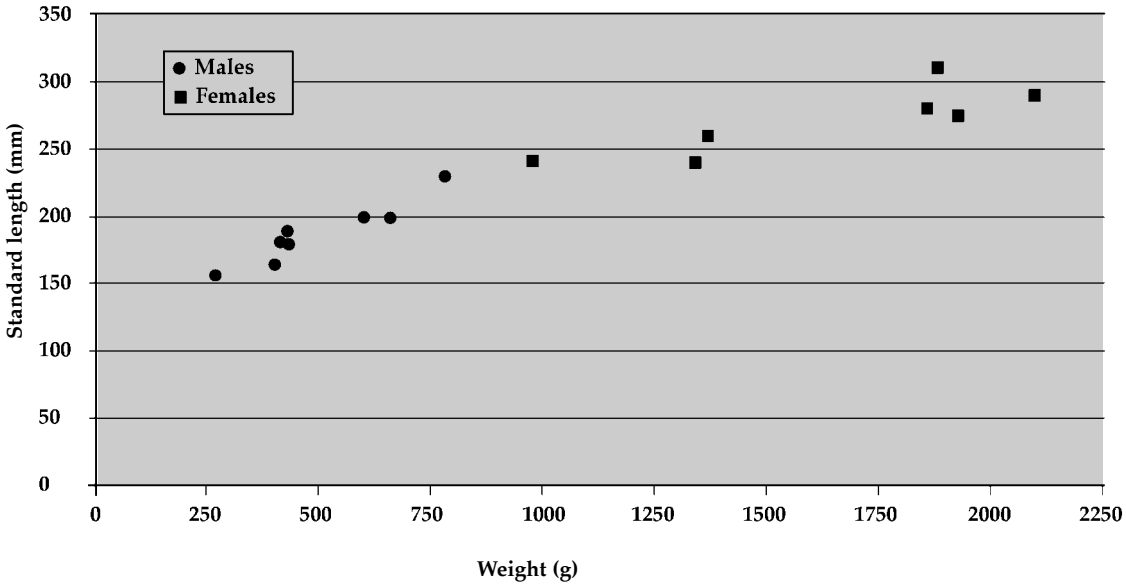

Figure 1: **Size distribution of estuarine stonefish (*Synanceia horrida*) specimens**

& Fielder, 1991). The loss of stonefish in this area was perhaps the first documented depletion resulting from overfishing of any marine fish in Papua New Guinea and emphasises the importance of stonefish to the live fish trade.

The demand for stonefish suggests that an investigation into the potential use of *S. horrida* for future aquaculture ventures may be warranted. It would therefore be valuable to have a detailed knowledge of the stonefish reproductive cycle. This paper reports on the authors' observations of a spawning aggregation of *S. horrida* in Queensland, Australia, and the subsequent egg release by females of specimens in captivity.

The spawning aggregation, observed on 21 October 1997, was located at the end lead markers for the dredged channel leading into a harbour, on the east coast of north Queensland, Australia. The layout of this site consists of three pylons spaced 8 metres apart at the bottom, in the shape of an equilateral triangle. The minimum depth of the site is 8.5 metres. The tidal range for the month varied from mean sea level of 0.88 metres at low tide, to a mean sea level of 2.34 metres at high tide. The surrounding substrate consists of a soft, silty, mud layer on a hard-packed mud bottom. There is an accumulation of rubbish around the pylons in the form of ladders and old batteries from the lead marker lights.

S. horrida specimens were being targeted at the time for public aquarium displays. At this site they are normally found as solitary individuals, either sitting up off the bottom, camouflaged on the marker pylons, or completely buried in the mud, with only their eyes and mouth slit protruding. On the documented occasion, however, between 25 and 30 *S. horrida* specimens were seen concentrated in an area of bottom of about 16 m^2**.** All but one were sitting up on top of the substrate where the fish were much more conspicuous that the few which had been seen at the site previously.

Sixteen stonefish were collected. Sexual dimorphism was apparent, with a distinct size difference between male and female fish (Fig. 1). All small specimens collected were males, with females having standard lengths of up to 80mm greater than the largest male. Females were noticeably broader in proportion to their lengths, had swollen abdomens and a mean weight of about 50 per cent greater than that of the male specimens (Fig. 1).

The *S. horrida* specimens were collected at high tide, at about 2 pm, and placed in a holding facility during the late afternoon. The four largest fish, all females, were placed in a glass fish tank measuring 900 mm x 450 mm x 450 mm. The remaining fish were divided between two identical tanks. One male and one female died during the acclimatisation period. This might have been the result of an inability to cope with capture stress when in such an advanced reproductive state.

Overnight the four female *S. horrida* released their eggs, producing a layer of eggs, 60 mm thick in a gelatinous mass on the bottom of the tank. We do not know if the nature or buoyancy of the eggs

would have changed with fertilisation. The unfertilised eggs had a mean diameter of 1.55 mm ± 0.02. The eggs in the dead female fish were hydrated and the dead male was running ripe with free flowing milt being released during its handling.

For aquaculture it is preferable to have closed the reproductive cycle of a species rather than rely on wild-caught specimens for grow out or broodstock (McCormack, 1989). Accomplishing this requires understanding the natural breeding conditions of the animal in question and replicating them as closely as is practical. Our observations may thus be useful to anyone planning a stonefish breeding programme.

S. horrida has several characteristics that suggest that it may be suitable for farming. With a diameter of 1.55 mm, its eggs are relatively large for marine fish. Larvae that hatch from large eggs tend to be well developed, to be strong swimmers and to feed usually within 24 hours. Such larvae are generally easier to feed and grow out than marine fish which have less well-developed larvae at hatching.

The cost of transporting a product to its destined market can be an important factor when deciding the viability of an aquaculture operation. *S. horrida* specimens require only small volumes of water. Ratios of 1:1 water to product weight have been demonstrated as sufficient for at least 24 hours—enough time to pack and airfreight the fish from northern Australia to Hong Kong. This factor greatly reduces the shipment costs of the fish and enhances its viability as a live food commodity. As their common name suggests adult estuarine stonefish also tolerate a large range of salinities (personal observations).

Larvae of *S. horrida* were not observed during this study and no assumption can be made as to whether they are pelagic or demersal. Species from the related family, Scorpaenidae, produce a floating, gelatinous egg mass, while species from other related families exhibit both demersal and pelagic spawning (Thresher, 1984).

In many Asian areas, shrimp farms have failed due to disease outbreaks and poor water quality. Shrimp culture ponds often experience considerable salinity fluctuation and develop sludge layers on the bottom (McCormack, 1989). Fish candidates are being investigated to use in these vacated ponds. However, many species require higher water quality than these ponds provide. The estuarine stonefish typically inhabits areas with similar characteristics, however, and might prove suitable for farming there.

Acknowledgments

We thank Liz Cox of the Queensland Department of Primary Industries in Cairns, for measuring the *S. horrida* eggs. We also thank Lyle Squire Jnr. and Cadel Squire for the collection and observations of the stonefish specimens.

References

BROWN , I.W. & D.R. FIELDER (1991). The Coconut Crab: Aspects of *Birgus latro* biology and ecology in Vanuatu. A.C.I.A.R. Monograph No. 8, Canberra 1991.

GRANT, E. (1987). Grant's Fishes of Australia. E.M. Grant Pty Ltd., Redcliffe.

MCCORMACK, G.B. (1989). An overview of aquaculture. Invertebrates. **In:** Aquaculture Proceedings 117. Post Graduate Committee in Veterinary Science. University of Sydney. 19–85.

RANDALL, J.E., G.R. ALLEN & R.C. STEENE. (1990). Fishes of the Great Barrier Reef and Coral Sea. Crawford House Press, Bathurst.

THRESHER, R.E. (1984). Reproduction in Reef Fishes. T.H.F. Publications Inc. Ltd., Neptune City, New Jersey.