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Larval development and juvenile growth of the sea cucumber *Stichopus* sp. (Curry fish)

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ABSTRACT

The global populations of Curry fish have been severely depleted over the past decade. This study describes spawning, fertilization, larval rearing, and juvenile growth in a commercially important *Stichopus* species. Data pooled from monthly trials conducted over 2 years indicate that, under optimal conditions, juveniles can be grown to a size of ca. 20 cm in length in 7 months. The survival rates are typically between 30 and 50%. Pilot research indicates that the growth of young sea cucumbers in abandoned abalone tanks has potential. Overall, this study demonstrates that Curry fish can be reared in captivity, thus providing an alternative to fisheries, or a way to maintain sustainable harvests and eventually contribute to the restoration of the natural populations.

1. Introduction

Sea cucumbers (Echinodermata: Holothuroidea), a diverse group of marine invertebrates, known as 'beche-de-mer' or 'trepang', are generally consumed in Asia, where they are regarded as traditional medicine, delicacies and aphrodisiacs. Sea cucumbers present a high nutritional value due to their high protein, low fat content, aminoacid profile and are a rich source of trace elements (Chen, 2003).

Curry fish is a yellow/brown sea cucumber, covered with small dark spots. It is a medium to large-sized species (300–700 mm), stout, thick and firm, with low papillae, and a moderately smooth tegument. Curry fish has a wide Indo–West Pacific distribution (Rowe and Gates, 1995), can be found on tropical reefs, and is considered edible with medicinal properties (Liao, 1997).

The fast pace of development of sea cucumber fisheries to supply the growing international demand for beche-de-mer is placing most fisheries and many sea cucumber species at risk including Curry fish, which was highly abundant and is nowadays rare or locally extinct (FAO, 2008; Otero-Villanueva and Ut, 2007).

In China, the soaring price of *Apostichopus japonicus* has stimulated the development of aquaculture including sea ranching activities. Presently, China is successfully producing an estimated 10,000 t, dry weight, of *A. japonicus* from aquaculture, mainly to supply local demand. Chen (2004) noted that recovery plans for *A. japonicus* are in place together with the establishment of many conservation zones. Recently in Malaysia, great progress of research on aquaculture for *Stichopus horrens* has been achieved (Zaidnuddin, 2009). The reproductive biology of *Stichopus variegates* (presently revised to *Stichopus herrmanni*, Rowe and Gates, 1995) has been reported by Conand (1993). Tehranifard et al. (2006) reported the reproductive cycle of *S. herrmanni* from Iran. However, no published work is available on the larval development, juvenile growth and artificial propagation of Curry fish in China.

This study presents data on the development of embryos, larvae and juveniles of Curry fish *Stichopus* sp. over a 16-month period at Weizhou Island, China. The results contribute to maintenance of sustainable use and will contribute to the restoration of natural populations.

2. Materials and methods

2.1. Collection and maintenance of animals

In total 648 adult sea cucumbers (mean wet weight > 500 g) were collected from nearby coastal areas of Weizhou Island (21°03′N,

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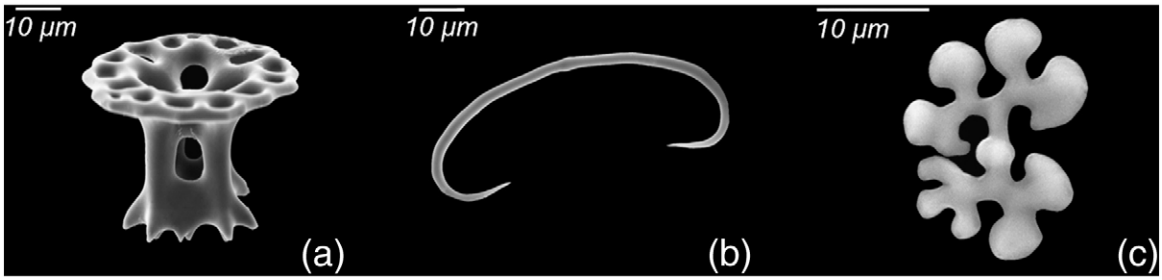

Fig. 1. Dorsal ossicles of *Stichopus* sp.. a: Tables. b: C-shape rod. c: Rosette.

109°07′E) and maintained at the Weizhou Aquaculture Farm to serve as broodstock from April 2006 to October 2007. The adults were conditioned in the tanks for a few days prior to spawning.

2.2. Species identification

Ossicles were prepared by scanning electronic microscopy (SEM). The dorsal body walls of ten sea cucumbers were obtained by dissection, and fixed in 95% ethanol at −20 °C in the farm. In the laboratory, the body walls were treated with 10% sodium hypochlorite solution for 1–2 min to obtain ossicles, and carefully rinsed with distilled water at least three times following procedures by Massin et al. (2000). The specimens were critical-point dried and coated with gold–palladium in a sputter coater (Hitachi, E-1010) and ossicles were observed using 20 kv accelerating voltage and 1000–3000 magnifications under a Hitachi S-3400N SEM. Species identifications were based on the taxonomic descriptions of dermal ossicles by Liao (1997) and Massin (1999).

2.3. Spawning and fertilization

On arrival (1800–2000 h) at the farm, the specimens were placed in aerated 2000-L tanks and monitored overnight for spawning activity. Spawning of sea cucumber was conducted by open-air drying followed flow-through filtered seawater stimulation. Males and females were isolated in plastic buckets. As soon as they showed signs of imminent spawning (spawning behavior, such as sway), they were isolated. Each female was then placed separately in a 300-L spawning tank and maintained until release of eggs. The female was removed, and the spermatozoa solution obtained from isolated spawning males, was added to the eggs. The best fertilization rates and lowest occurrence of polyspermy were obtained with a concentration of 5–10 spermatozoa per egg. After fertilization, the eggs were rinsed to remove excess sperm. 10 mL water was randomly collected after gentle stirring, and the number of eggs was counted, egg counts were performed at least three times and the amount was calculated. Individual female *Stichopus* sp. spawned a mean of 3.48×10^6 eggs (s.e. $=1.4\times10^5$, $n=5$ females). Then the eggs were transferred to hatchery tanks at a density of 0.5 eggs mL^{-1}.

2.4. Embryo and larval culture

Several air stones positioned at the bottom of each culture tank provided sufficient aeration and ensured gentle water circulation. The larvae were reared at ambient seawater temperature (27–31 °C). In the wild, Curry fish lives under substrate with low light levels. Therefore, the photoperiod was designed as 0 h light:24 h dark in this experiment. When the auricularia had a functional gut, the larvae were fed every day using a wet mix of commercial marine yeast (*Rhodotorula*) and microalgae (dominated by *Rhodomonas* and *Dunaliella*) at a frequency and concentration dictated by the daily observation of the digestive tract contents (the number of cells in the stomach).

The water in each tank was changed every day by draining the tanks through a 53-μm sieve. After the first water change, the early auricularia larvae were stocked at a density of 0.2 larvae mL^{-1}.

Seven days after fertilization, 100 sets of plastic settlement sieves were conditioned in an outdoor tank supplied with filtered running seawater to promote growth of a diatom film. Each set of substrates consisted of six sieves measuring 300×240 mm, stacked

Table 1
Number of spawning observations.

Year	Month	Date	Lunar phase	n[a]	Male[b]	Female[b]
2006	May	26-05-2006	Last	148	13	0
		27-05-2006	New	148	38	3
		28-05-2006	New	148	36	8
		29-05-2006	New	148	16	2
	June	10-06-2006	Full	342	0	0
		25-06-2006	Last	342	4	3
		26-06-2006	New	342	73	21
		27-06-2006	New	342	68	25
		28-06-2006	New	342	12	3
	July	10-07-2006	Full	418	0	0
		24-07-2006	Last	418	6	2
		25-07-2006	New	418	73	28
		26-07-2006	New	418	66	29
		27-07-2006	New	418	15	4
	August	08-08-2006	Full	518	0	0
		23-08-2006	Last	518	10	3
		24-08-2006	New	518	49	21
		25-08-2006	New	518	39	18
		26-08-2006	New	518	12	2
	September	07-09-2006	Full	518	0	0
		21-09-2006	Last	518	8	1
		22-09-2006	New	518	24	9
		23-09-2006	New	518	20	9
		24-09-2006	New	518	12	0
2007	June	14-06-2007	Last	540	12	4
		15-06-2007	New	540	79	39
		16-06-2007	New	540	76	38
		17-06-2007	New	540	29	4
		28-06-2007	Full	578	0	0
	July	13-07-2007	Last	578	14	3
		14-07-2007	New	578	85	32
		15-07-2007	New	578	88	41
		16-07-2007	New	578	23	3
		28-07-2007	Full	613	0	0
	August	12-08-2007	Last	613	16	4
		13-08-2007	New	613	79	33
		14-08-2007	New	613	73	35
		15-08-2007	New	613	10	2
		27-08-2007	Full	648	0	0
	September	10-09-2007	Last	648	20	3
		11-09-2007	New	648	37	11
		12-09-2007	New	648	29	8
		13-09-2007	New	648	16	0

[a] Number of *Stichopus* sp. collected during each field trip.
[b] Number of spawning individuals.