SPAWNING, LARVAL DEVELOPMENT AND GROWTH OF TRIDACNA MAXIMA (RÖDING)(BIVALVIA:TRIDACNIDAE)

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Adult T. maxima were successfully induced to spawn in the laboratory using macerated gonad in December 1984 and January 1985. Spontaneous spawnings occurred in February and October 1985. Spawning can be induced in the morning as well as in the afternoon. Larvae were reared to the juvenile stage in larval rearing tanks and larval development monitored. A stereotyped development pattern was displayed. Less than 1% of juveniles survived from eggs. Four-month-old juveniles placed in raceways provided with a continuous flow of unfiltered sea water attained a mean shell length of 38.35 mm after eight months, with an average monthly growth of 4.1mm ± 0.8.

Giant clams (F. Tridacnidae) are highly specialized bivalves habiting shallow waters in the Indo-Pacific region. The largest valves in the world, they have been known to be overharvested their shell and meat (especially adductor muscle) (Hester Jones, 1974; Bryan and McConnel, 1976; Hirschberger, 1980). ttle is known of the biology and ecology of giant clams earson, 1977); but, due to the rapid decline in their popula- , a number of studies have focused on their reproductive logy (e.g. Stephenson, 1934; Wada, 1954; Braley, 1984, 1985) mariculture potential (e.g. Yamaguchi, 1977; Munro and linga, 1982; Heslinga et al., 1984).

There are, however, only a few studies focusing on Tridacna ma (Röding). Spawning induction using macerated gonad has discussed extensively by Wada (1954). LaBarbera (1975) and son (1976) reared larvae of T. maxima, and both studies orted the mechanism and rate of development from larval to larval stages. The effect of food supply on larval growth and strate preference of larvae were discussed extensively by her and Munro (1981).

Studies on the spawning, larval rearing and growth of ral species of giant clams are presently being conducted at Silliman University Marine Laboratory under the Australian er for Agricultural Research (ACIAR) Giant Clam Project. essful spawning induction and larval rearing were conducted T. maxima. The aim of this paper is to present data on

spawning, larval development and growth of T. maxima u laboratory conditions.

MATERIALS AND METHODS

Spawning.

Wild stocks of T. maxima were collected from reefs various localities in the Visayas, central Philippines, transported to the laboratory in buckets filled with sea wat Individuals were placed in outdoor cement tanks (2m x 3m x 0. supplied with flowing sea water eight hours a day. Salinity the stocking tanks ranged from 30 to 32.5 ppt and temperature to 33 °C.

Spawning inductions were conducted in the larval rear tanks (1m x 2m x 0.5m), filled with 400 liters of filtered water. Two larval tanks were used when inducing more than f clams at one time. Spawning was induced using macerated go following the method of Wada (1954). Material used for induct was prepared by slicing gonads from sacrificed adult T. max into pieces, weighing each piece and packing them in plas bags for storage in the freezer. Fresh macerated gonad was u during the first spawning induction. For the succeed experiments, however, a desired amount of frozen gonad was tha out immediately prior to induction. The gonad material was mi and pounded in a mortar with a small amount of filtered water. The macerated material was then filtered using an 80 mesh filter cloth to remove excess tissues and prevent bacter fouling in the larval tanks.

The clams to be used for spawning were chosen at random f the stocking tanks for any particular experiment. Adher epibiota on the shells was removed using a nylon brush. Cl were taken out of the water and left an hour to induce str and facilitate spawning induction. Clams were then transferred larval tanks and induced to spawn by pouring macerated go material near their inhalent siphons. One to three hours af spawning, adult clams were removed from the larval tanks, was and returned to the stocking tanks.

In cases of spontaneous spawning (non-induced) in stocking tanks, gametes were scooped with a fine mesh net buckets and transferred to the larval rearing tanks.

The spawning history of each clam was recorded, includ time of induction, sex of gametes and number of releases, duration of spawning.

Larval rearing.

After the removal of adult clams, filtered sea water added to the larval tanks to a total volume of 800 liters. Lar

were monitored by taking water samples from the surface for the first three days and from the bottom on succeeding days. Larval development was examined under a compound microscope. Volumetric counts were also monitored for each larval stage.

Unfiltered sea water was pumped into the tanks for at least five hours a day, seven days after fertilization, until the larvae became macroscopic. After three to four months, the juveniles were scraped from the bottom of the tanks by hand or using a knife. These juveniles were then transferred to raceways containing pieces of coral, which served as a substratum. Flow of unfiltered sea water was maintained for eight hours a day.

Growth.

Growth of the juveniles reared in the laboratory from April to October 1985 was monitored. All juveniles were counted and the shell length of 50 animals was measured using a small plastic vernier caliper every one to two months. Water temperature and salinity were monitored twice a day, in the morning and afternoon. Water temperature ranged from 23 to 30 °C, salinity from 25 to 35 ppt.

RESULTS AND DISCUSSION

Spawning.

For this study, successful spawning was defined as the release of sperm and eggs by one or more clams. T. maxima, held in stocking tanks for one to three months, were successfully induced to spawn sperm and eggs by adding macerated gonad to the water. Table 1 shows the summary of spawning inductions from November 1984 to October 1985. Water temperature in the spawning tanks ranged from 26 to 29°C, and salinity was between 27 and 33 ppt. Two of five spawning inductions were successful. Spontaneous spawnings also occurred on two occasions, 28 February, 1985 and 8 October, 1985.

The two spontaneous spawnings were observed to occur at the first quarter and a day after the new moon. Of the induced spawnings during which fertilized eggs developed successfully, one occurred two days after the last quarter and the other, at the first quarter. The lunar phases in which successful spawning induction of T. maxima occurred appeared to correspond with those of T. gigas at Palau (Heslinga et al., 1985), but further investigation of spawning time is required.

Successful spawning of T. maxima in the laboratory was induced in the morning as well as in the afternoon (Table 1). Spawning probably does not occur at night; in this study, it was observed that the valves of clams were either half-way or fully closed at night. Giant clams typically close their valves and

remain quiescent until dawn (Gwyther and Munro, 1981; Heslinga al., 1984).

The probable causes of spontaneous spawning in the laborato could not be determined. Other studies have shown that sponta eous spawning is stimulated by high temperature (Stephenso 1934) and by water movement (Jameson, 1976).

Table 1. Data on spawning inductions of T. maxima.

	DATE				
	12/18/84	01/30/85	03/14/85	04/29/85	07/31/
No. of clams used	ND	I 6 * II 6	5	I 6 * II 6	4
Size range (cm)	13-23	I 14-22 II 13-22	18-22	I 11-22 II 13-22	15-20
No. of clams spawned	ND	I 2 II 2	2	none	none
Amount of gonad used (gm)	ND	I 7 II 3	150	30	40
Time induced	1055 h	1421 h	1600 h	1050 h	1000
Time from induction to spawning	ND	I 4min. II 3min.	6-14min.	-	-
Duration of spawning	ND	I 42min. II 19min -2hrs & 19min	2 min.	-	-

ND - Not Determined
* - Two larval tanks used: 6 clams each

Preliminary results of this study have similarities with t observations of Jameson (1976) on the gonad condition of a pop lation of T. maxima on Guam. Our clams released their gametes the months of December, January and February, but only sperm March. Spawnings were not observed between April and July. It w only in October when the clams again released their gamete

The number of eggs released was determined only once. volumetric count, approximately 7,690,000 eggs were releas during the first successful spawning.

ilization and early development.

In this study, normal fertilization and early development of maxima eggs in the laboratory appear to be influenced by the ity of the sea water, maturity of clams and extent of poly-my. Large numbers of ciliates in the sea water were observed penetrate the eggs, causing the latter to break up. Immature were oval-, sickle- and rod-shaped, and were not fertilized viable sperm. Ripe eggs tended to be spherical in shape and more opaque than unripe eggs. The abundance of sperm in the often resulted in polyspermy, which in turn caused the non-opment of the eggs. Mature eggs surrounded by several sperm observed to remain undeveloped for two days. Cases of poly-my were also encountered by LaBarbera (1975) and Jameson), indicating poorly developed barriers to polyspermy in acnids (LaBarbera, 1975). In addition, overabundance of sperm the water contributed to bacterial fouling.

al development.

T. maxima larvae obtained from the successful spawning ctions on 18 December 1984 and 30 January 1985 were also ssfully reared through the juvenile stage in the laboratory. early life chronology and larval descriptions of T. maxima closely with the reports of LaBarbera (1975), Jameson) and Gwyther and Munro (1981). Fertilization of eggs rred immediately after spawning, and the blastula stage was ed after four hours. After 24 hours, trochophores hatched swam. Straight-hinge, D-shaped veligers with ciliated velum stomach were observed on the second day. On the fourth day, eginnings of foot formation occurred, indicating the start pediveliger stage. Settlement occurred on day eight, and veligers were seen crawling on the bottom on day nine. ing and opening of valves, elongation of foot and presence of were observed in few crawling pediveligers, indicating the letion of metamorphosis. On day 15, more than 50% became niles. A pair of gills and brown spots (which indicate the nce of zooxanthellae) on the anterior portion of the valves observed on day 21.

The rate of development of the laboratory-reared T. maxima this study differed from that of those observed in Fiji arbera, 1975), Guam (Jameson, 1976) and Papua New Guinea her and Munro, 1981). This variability is probably due to erences in culture conditions, such as temperature and ng techniques (Heslinga, pers. comm., 1985).

life and juvenile survival.

Estimates of larval and juvenile survival (Table 2) showed greatest mortality occurred in the pediveliger and juvenile s. Only 5.5% of fertilized eggs developed into veligers;

33.3% of veligers arrived at the pediveliger stage. About 0.9 of pediveligers metamorphosed into juveniles; only 0.02% fertilized eggs developed into juveniles. Beckvar (1981) al encountered mortality greater than 99% from egg to juvenile st in laboratory-reared T. gigas in Palau.

Several factors have been identified to cause low survi in the pelagic developmental stages. These include polyspern self-fertilization and unavailability of suitable substrate f settlement (Gwyther and Munro, 1981). However, successful re ing of pediveligers of T. derasa and T. squamosa without speci substrate has been recorded (Beckvar, 1981; Heslinga et a 1985).

Table 2. Survival rate (%) of T. maxima in the laboratory from December 1984 to April 1985.

STAGE	Approximate count	% Survival based from number of fertilized eggs	% survival fr previous sta
fertilized eggs	7,680,000	-	-
trochophore	not determined	-	-
veliger	420,000	5.5	-
pediveliger	140,000	1.8	33.3 (from veli
juvenile	1,396	.02	0.99 (from ped veliger)

Clumping of juveniles on coral rubble and in the corners raceways was often observed, and many empty shells were found these clumps. Juveniles 5 mm and less were observed to be sens tive to overcrowding, and easily died. It is not known crowding is related to the observed mortality.

Growth.

The monthly mean shell length of T. maxima under laborat conditions from April (four months old) to December (one y old) 1985 is presented in Table 3. The results show that a m length of 38.35 mm is attained in one year, which agrees with t data of Munro and Heslinga (1982). Growth of four-month-old

3. Data on growth of T. maxima (four-month-old) from April to December 1985 (n = 50),

MEAN SHELL LENGTH (mm) ± S. D. (range)						GROWTH RATE
MAY	JUNE	JULY	SEPT.	NOV.	DEC.	(mm)/month
8.2±7 (1.8-15)	11±9 (12-20)	17.3±5.2 (7.4-28.9)	19.86±5.3 (8-27)	26.89±6.81 (15-45.5)	38.35±6.07 (26.3-49.7)	4.1±0.8

maxima in raceways after eight months showed that the clams grew an average of 4.1 mm per month. Intensive cultivation of T. maxima for large-scale commercial mariculture for food may not be profitable as an industry. Yamaguchi, (1977) expressed a similar view. Cultivation of this slow-growing species as an aquarium pet may be feasible, as demand is slowly growing in some parts of America (Heslinga, pers.comm., 1985).

SUMMARY AND CONCLUSIONS

Induced spawning using macerated gonad was found to be effective in inducing adult T. maxima to spawn successfully in December 1984 and January 1985. This method is not only efficient, but is also the easiest method (Jameson, 1976). Spontaneous spawnings were observed twice, in February and October 1985. Successful spawnings have been induced in the morning and in the afternoon. The quality of seawater, maturity of the eggs and polyspermy appear to be major factors influencing normal fertilization and development of eggs. Improved rearing techniques, a better quality of water and more broodstock are needed in the laboratory for increased larval and juvenile survival in the culture system.

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