GIANT CLAM CONSERVATION IN THE PHILIPPINES

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Efforts to conserve giant clam resources in the Central Visayas by clam farming are assessed.

All seven species of clams belonging to the Family Tridacnidae have been reported from the Philippines (Rosewater, 1965, 1982). Recent surveys have shown that three species (The largest species, Tridacna gigas and T. derasa, and the china clam Hippopus porcellanus) exist in small numbers in the southern and southwestern parts of the country but are either extinct or nearly extinct in the Luzon area, the Central Visayas, and the Western Visayas (Alcala, 1986; Juinio et al., 1986). In order to conserve these species, two Philippine laboratories, the Marine Science Institute at the University of the Philippines and the Silliman University Marine Laboratory (SUML), have conducted research in giant clam mariculture since 1984, in collaboration with three other laboratories in Australia, Papua New Guinea, and Fiji. The program is supported by the Australian Center for International Agricultural Research. The captive breeding program hopes to restock protected reefs with juveniles spawned and reared in the laboratory, with the cooperation of artisanal and commercial fishermen. Clam farming thus serves as incentive for coral reef protection, which is also needed in the Philippines because of the widespread degradation of coral reefs.

The present paper describes the initial efforts at SUML to conserve giant clam resources through clam farming in protected reefs of the Central Visayas.

CLAM BREEDING AND REARING AT SUML

Five species of tridacnids have been induced to spawn with serotonin injections or addition of macerated gonads to the spawning tanks. The laboratory has several thousand juveniles of Tridacna maxima, T. squamosa, T. derasa, and Hippopus hippopus for farming purposes. About 2,200 juvenile clams have so far been distributed to 11 groups of fishermen on the islands of Negros, Apo, Balicasag, and Pamilacan. The fishermen-cooperators have grown these clams on protected reefs and have agreed to leave mature animals as breeding stock on the reefs at harvest times. About 50,000 juveniles belonging to five species will be distributed to more fishermen during the next few months.

COOPERATING AGENCIES

In its program of promoting clam farming, SUML has been collaborating with the University of the Philippines Marine Science Institute and has worked with the local fishermen's organizations, the Philippine Council for Agriculture and Resources Research and Development, and the Central Visayas Regional Project-1. The last named office is promoting the proper management of terrestrial and shallow-water marine resources in the central Philippines. The Laboratory hopes to also involve in the program the Bureau of Fisheries and Aquatic Resources, as well as private individuals.

TECHNOLOGY GENERATION

It is now thought that giant clams may be farmed commercially for both meat and shells. To this end SUML is attempting to develop a technology package for giant clam culture adapted to local conditions in fishing villages. But even before this package becomes available, SUML has been conducting training sessions on giant clam mariculture and conservation among fishermen at two villages in Negros Oriental, in cooperation with the Central Visayas Regional Project-1. The training sessions include techniques of clam spawning, larval rearing and ocean nursery. It is hoped that these sessions will increase the conservation-consciousness of the fishermen, resulting in reef protection and clam farming for economic benefit.

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A PRELIMINARY STUDY OF THE REPRODUCTIVE CYCLE OF Tridacna squamosa Lamarck (BIVALVIA:TRIDACNIDAE) AT CARBIN REEF, CENTRAL PHILIPPINES

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Results of gonad biopsy of T. squamosa gonads, conducted every 3 to 4 months from September 1985 to September 1986 at Carbin Reef, Negros Occidental, indicated seasonality in spawning. A probable peak of spawning coincided with the wet season and the period of high water temperature, June to September. The presence of clams with mature eggs throughout the sampling period indicates a potential for year-round spawning.

Giant clams are being subjected to increased fishing essure because of their food and shell (Jameson, 1976; Braley, 84). They are now the subject of mariculture efforts in a mber of laboratories in the Indo-Pacific region for the purpose preventing their extinction and augmenting existing stocks for od (Munro and Heslinga, 1981; Fitt et al.,1984; Heslinga et ., 1984). Knowledge of breeding seasons of giant clams must be tained to provide conservationists information they need to pport efficient population management as well as understand the productive success of these animals before the feasibility of a rge-scale mariculture of giant clams can be determined ameson, 1976;Braley, 1984). Tridacna squamosa, one of the tant species in the Philippines (Rosewater, 1965), is being udied for mariculture for food and its colored shell.

Tridacna squamosa, a medium-sized species with shells up to cm in length, is of commercial importance more for its shell an its meat. Known as "hagdanan" or "dagatan" in Cebuano and anlot" in Ilonggo, the colored variety of T. squamosa together th two other species, is the most marketable species of idacnid clams on the Philippine local market (Gomez, 1986). e possibility of culturing T.squamosa, and other species of ant clams, has been studied in a number of laboratories in the do-Pacific (Gwyther and Munro, 1981; Fitt et al.,1984; Heslinga al. , 1984). Spawning cycles based on spontaneous or induced awnings and presence of mature gametes have been observed in e Marshall Islands (Rosewater, 1965), in Fiji (LaBarbera, 75), Palau (Hardy and Hardy, 1969; Beckvar, 1981; Fitt and ench,1981; Heslinga et al.,1984), New Guinea (Gwyther and nro,1981), and Tonga (McKoy,1980).

This study on the reproductive cycle of T. squamosa aims to ntribute to present knowledge of the biology of giant clams; it hoped that the results of the study will have practical plications to giant clam farming. In this contribution, gonad conditions of T. squamosa using the gonad biopsy technique of Crawford et al. (1986) were examined by regular sampling of natural populations at Carbin Reef, located in the Visayan Sea, 10° 59´N and 123° 28´E, northern Negros Occidental.

MATERIALS AND METHODS

Gonad biopsy samples were collected randomly from clams in situ at Carbin Reef in September and December 1985, and in April, June, and September 1986 (roughly at 3-4 month intervals), with the aid of SCUBA. A human biopsy needle was inserted through the mantle, an inch below the exhalent siphon, into the gonad of the gaping clam. Smaller clams (less than 15 cm) required needle insertion of about half an inch or less to hit the gonad. A piece of coral rubble was usually placed in between valves to prevent them from closing, but it was also possible to slowly approach a gaping clam and insert the needle as quickly. Gonadal samples from each clam were placed separately in 10 ml labelled plastic vials filled with clean seawater, and covered. The cover was removed only when a small volume was drawn with the biopsy needle and placed inside the vial. The presence of sperm and eggs can be determined macroscopically. A cloudy sample with small, round, grainy particles indicated the presence of both sperm and eggs; a cloudy sample with no particles indicated the presence of only sperm, while a sample with only small round grainy particles indicated the presence of eggs. This visual procedure made recording easier and saved time. Microscopic examination soon after collection confirmed the presence of sperm and eggs as well as the size and maturity of the latter: spherical eggs with clear, well-differentiated, thin outer membranes indicated maturity; irregular shapes in various sizes indicated the opposite.

The water temperature at every sampling was determined using a field thermometer.

Egg-size was determined from 50 randomly-chosen eggs using a micrometer eyepiece calibrated to 13.2 millimicron per micrometer unit.

In order to assess the reproductive condition of each clam the following data were recorded:

1) egg density of mature eggs from a 10 ml sample,
2) egg size, less or greater than 92 um in diameter,
3) egg shape: proportion of distorted to spherical eggs,
4) presence or absence of a clear, well-differentiated membrane surrounding the egg,
5) presence or absence of sperm.

The stages of the gonad samples were determined following the four-stage classification of Braley (1984) (see below). A fifth category, "male," was added, when only sperm was present:

- Developing: eggs up to 92um, generally various sizes but usually tear drop shape in a progressive state,
- Ripe/Mature: eggs from 92 um, vitellogenesis complete (ova cytoplasm filled with yolk), dense eggs in the sample,
- Regressive: (post spawning) eggs any size but degenerate,
- Spent/Resting: lack of gonad in the sample; all "resting" samples were biopsied twice to be certain of the lack of eggs and sperm,
- Male: only sperm is present.

The size of eggs considered mature in this study followed LaBarbera (1976), who gave the size range for eggs which developed to metamorphosed larvae from 92.3 to 117.8 um. The number of clams falling in each category was as determined for each sampling month..

Results were subjected to a test of independence using the G-test (Sokal and Rohlf, 1969), to determine whether the frequency of each reproductive condition was the same in any month sampled.

RESULTS

Table 1 summarizes the number of clams biopsied during the ive sampling dates from September 1985 to September 1986, the umber and percentage of clams falling in the four reproductive tages, and data on temperature . The data on percentage of the our reproductive stages and the presence of sperm only are resented in bar graphs (Fig.1). Spawners of this species at arbin Reef peaked in December 1985 (17.6 %) and June 1986 (18). The lowest percentage of clams with ripe eggs occurred in pril 1986 (9.7 %), although ripe eggs were found on all the ates sampled. Developing eggs were present in a large percentage f all samples except in the September 1986 sample. Clams with perm only (which indicated the male phase of the individual, ith eggs in a resting condition) were also present in all the onths sampled. The total absence of gametes (indicating a robable spontaneous spawning before biopsy) occurred in most of he clams in the September 1986 sample, in some in the December 985 and June 1986 samples, but in none in the September 1985 and pril 1986 samples. No clam was found in the regressive condition uring the sampling period. The R x C test of independence using he G-test (Sokal and Rohlf, 1969) was significant at $p<0.005$, ejecting the null hypothesis that there is no difference in the

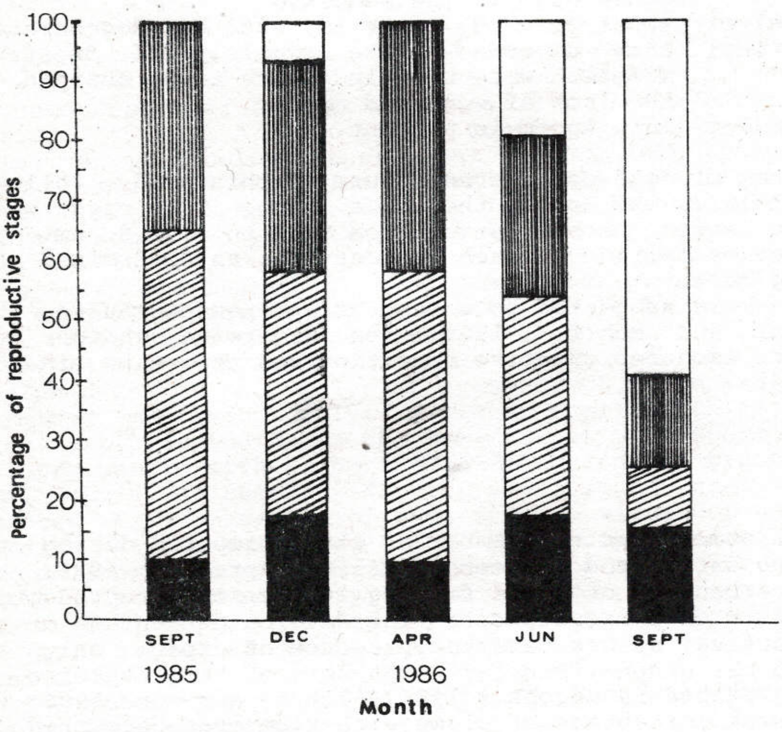

Fig.1. Percentage of various reproductive stages of gonads in *T. squamosa* in Carbin Reef, Sagay, Neg.Occ. from Sept. 1985 – Sept. 1986.

Legend: ■ – mature eggs; ■ – developing eggs; ▥ – sperm only; □ – spent; ▨ – regressive.

Table 1. Gonad condition of *T. squamosa* at Carbin Reef, Sagay, Negros Occidental, Philippines

Sampling Date	No. of Clams Biopsied at Random	Range of Water Temperature (Celsius)	Range of Clam Length (cm.)	Clams with Ripe Eggs		Clams with Developing Eggs		Clams with Sperm Only (immature or resting)		Clams with No Gametes (spent)	
				No.	%	No.	%	No.	%	No.	%
September 1985	20	29.5 - 31.0	11.0 - 24.9	2	10	11	55	7	35	0	0
December 1985	17	27.0 - 27.5	15.6 - 23.0	3	17.6	7	41.2	6	35.3	1	5.9
April 1986	31	27.5 - 28.5	15.4 - 23.9	3	9.7	15	48.4	13	41.9	0	0
June 1986	22	28.0 - 29.0	16.4 - 25.5	4	18.2	8	36.4	6	27.3	4	18.2
September 1986	20	30.0 - 32.0	11.0 - 27.6	3	15	2	10	3	15	12	60

frequency of each reproductive condition on any date sample (aseasonality).

DISCUSSION

Although the data were collected only every three to four months in one year they suggest a peak spawning from June to September, coinciding with the wet season and the period of higher water temperatures (Table 1). Spawning may have commenced in May, for which month I have no data. Our observation of natural spawning on the study reef in June and September provide additional evidence. However, the presence of clams with mature eggs throughout the sampling period indicates that the potential for year-round spawning exists.

There may be a minor spawning episode in December, as shown by a small proportion of clams with spent gonads. This seems to agree with the observations on gonads maturing every five to six months among broodstock clams (T. derasa) in Palau (Heslinga, pers. comm.). A similar span of time seems to be required for gonad maturity in a few individuals of H. hippopus in the laboratory (unpub. data).

In this study the spawning activity of T. squamosa from June through September and in December agrees with the findings of LaBarbera (1986), Gwyther and Munro (1981), and McKoy (1980) However, it is not known whether spawning had occurred in January, February, March, or November, as reported to have occurred in the Marshall Islands (Rosewater, 1965), Palau (Beckvar, 1981; Fitt and Trench, 1981; Heslinga et al., 1984), Tonga (McKoy, 1980), and in the Philippines (unpub. data). The same species may spawn during the same month of the year, regardless of geographical location, but further investigation is needed to establish this. (Jameson, 1976). It is interesting to note that T. squamosa spawned in the summer months (December-February) in Tonga (McKoy, 1980), whereas it spawned during the winter months (in July) in Fiji (LaBarbera, 1975). The speculated winter breeding of this species by Yamaguchi (1977) and Fitt and Trench (1981) disagrees with the summer spawning hypothesis of McKoy (1980). These discrepancies, according to McKoy (1980), may result from population differences (either induced or genetic) between Australian tridacnids and those of the more easterly Pacific Islands.

Results of hypodermic extraction of gonads from T. gigas and T. derasa on the Great Barrier Reef suggest a potential early to mid-austral summer spawning for the former and to a lesser degree for the latter, indicating the presence of seasonality for these species in Australia (Braley, 1984).

Although the factors influencing gonad maturity and the initiation of spawning in situ are not known, the abundance of food supply and other environmental factors could bring about avorable conditions. (Birkeland, 1982, cited in Braley, 1984). he ability to ovulate might be related to lunar or seasonal ycles, but this is not yet well understood (Munro and eslinga, 1982). A strong case can be made only for seasonality, or which temperature, phases of the moon (tides), and water otion have all been implicated, but which are supported by onflicting evidence (Rosewater, 1965; LaBarbera, 1975, Jameson, 976, Beckvar, 1981). It is believed that in nature, different ocal environmental cues, varying from place to place, may rigger gonad maturation and spawning (Fitt and Trench, 1981). irkeland (1982) suggested that if high rainfall affects hytoplankton bloom by increased availability of nutrients from errestrial runoff, then there would also tend to be a easonality in the spawning of tropical marine invertebrates as xhibited by their temperate counterparts.

Heslinga and his colleagues (1984) called for an assessment f the importance of spawning "seasonality" in tridacnids and its otential role in limiting hatchery production. They claimed that ost previous studies were too brief to substantiate claims of he supposed seasonal "peaks" in spawning intensity. Although ome of the conflicting data in tridacnid spawning behavior may eflect real latitudinal variation, it is still premature to onclude, as Yamaguchi (1977) did, that giant clams are haracterized by seasonal breeding peaks (Heslinga et al., 1984).

The short duration of the study did not allow the etermination of an annual, repetitive spawning cycle of this pecies as Jameson (1976) reported. Although spawning may be easonal for a given species, the actual time span of spawning ay vary from one year to another and may occur for only a brief eriod (Stephenson, 1934; Fitt and Trench, 1981). Until factors nfluencing gonad development are determined, successful nduction of normal spawning for experimental or maricultural ork will depend on the investigator being in the right place at he right time (Fitt and Trench, 1981).

CONCLUSION

Although there was probably a peak spawning period for T. squamosa, the presence of spawners throughout the sampling period ndicates that a potential for year-round spawning exists. This ooks promising for mariculture of this species, as availability f spawners would not limit hatchery production. Spawning nduction for mass production of juveniles may be done during the eak spawning period and larval rearing during the rest of the ear.

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