

Reproductive Cycle of the Cockle *Anadara antiquata* L. in Calatagan, Batangas, Philippines¹

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ABSTRACT

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The annual gonad condition of *Anadara antiquata* was determined histologically in biweekly samples collected over a two-year period from Calatagan, Batangas, Philippines. Examination of gonad sections showed that gametogenic activity and spawning occur continuously throughout the year, with peak spawning from July to September. Fluctuations of the gonad index suggest that the duration of the gametogenic cycle is 1-2 months.

ADDITIONAL INDEX WORDS: *A. antiquata*, cockle, gametogenic cycle, gonad, histological analysis

INTRODUCTION

The cockle *Anadara antiquata* L. is an important fishery item in many shoreline towns in the Philippines. In Calatagan, Batangas (longitude 120° 37' 13" E, latitude 13° 48' 53" N), it is the only edible bivalve mollusc that is commercially harvested from wild populations.

A. antiquata belongs to the family Arcidae, subfamily Anadarinae which is recognized for its farming potential. Among the members of this family which are the subject of extensive culture operations are *Anadara granosa* in West Malaysia (BROOM, 1983), *A. subcrenata* in Korea and *A. unflata* which is transported from the Philippines to aquaculture farms in Japan (DZYUBA and MASLENNIKOVA, 1982).

With the increasing demand for cheap protein sources, research agencies have started investigating the production potential of local bivalve species by conducting detailed studies on their basic reproductive biology. This paper provides information on the reproductive cycle of *A. antiquata* which may contribute significantly towards the development

of a technically feasible and economically viable culture program.

MATERIALS AND METHODS

All cockles used for this study were obtained around Maahas Island in Calatagan, Batangas. The sampling area is a vast seagrass bed of sandy-muddy sediments mixed with coral rubble. The average depth during low tide is about 0.5 m. The cockles, which burrow in the sediments, are found at a depth of approximately 2-6 cm.

From October 1978 to September 1980, twenty cockles with a size range between 38.5 to 50.7 mm were sampled randomly every two weeks. The cockles were opened at the hinge and preserved in 10% formalin-seawater. Two subsamples of gonad tissue were taken from each cockle for histological analysis. Standard histological techniques were employed. Paraffin tissues were sectioned at 7 micrometers, stained with Delafield's hematoxylin and counterstained with eosin.

Temperature and salinity were recorded, generally at mid-day, during the collection period. The readings were plotted for each sampling date and their influences in regulating the reproductive activity of the animal were discussed.

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Assessment of Gonad Condition

Sections of the gonad tissues were assigned to a stage of gonad development according to the criteria used by ROPES and STICKNEY (1965) for the soft-shelled clam, *Mya arenaria*. In brief, the following are the stages and their criteria:

(1). Inactive Stage — Gonad follicles are small, with few recognizable sex cells.

(2). Active Stage — This stage is characterized by the rapid proliferation of gametes; gonad follicles contain spermatogenic and oogenic cells in different stages of development.

(3). Ripe Stage — In females, the follicles contain a large number of mature oocytes which appear to be free in the lumen; in males, the follicles are filled with spermatozoa. The antecedents of the spermatozoa form a thin layer at the periphery of the follicle. All cockles in this stage are physiologically prepared to spawn.

(4). Partially Spawning Stage — Obvious gaps in the lumina indicate that some gametes have been shed. Follicles still contain few ripe gametes. In both sexes, gametogenic activity may start at this stage thus making a quick transition to the active stage.

(5). Spent Stage — Follicles contain few or no residual spermatozoa or mature oocytes within the lumina. In males, a thin layer of spermatogenic cells at the follicle wall indicate the onset of new development.

The data obtained from histological analysis were presented in frequency distribution histograms and expressed as percentage of individuals in each stage of gonad development per collection.

Gonad Index Determination

The gonad index, which provides an estimate of the reproductive activity among individuals in a population, was determined. The calculation was patterned after the scheme adopted by KENNEDY (1977) from WILSON and SEED for mussels. In computing for the gonad index, the five gametogenic stages were assigned numerical scores as follows: inactive = 1, active = 2, ripe = 3, partially spawned = 2, and spent = 1. The number of cockles classified in each stage was then multiplied by the corresponding numerical value and the products averaged. Values close to 1 indicate the presence of inactive and/or spent individuals. Values close to 2 imply that spawning and development are continuously occurring whereas those approaching 3 denote the

presence of ripe individuals. In general, an increase in the value of the gonad index implies gonad development, while a decrease implies spawning.

RESULTS

A. antiquata is dioecious. Sexes can be differentiated on the basis of color. The male gonad is usually cream in color, while the female is orange. The gonad, in both sexes of *A. antiquata*, envelopes the visceral mass. It consists of a system of branched tubules wherein the developing gametes are formed.

Of the 1,040 cockles examined, there were more males than females. In general, however, the sex ratio did not differ significantly from 1:1. No hermaphrodites were found in any of the gonad sections examined.

Annual Gonad Condition

Figure 1, expressed as percentage of individuals in each stage of gonad development over time, shows that *A. antiquata* breeds throughout the year, with one or two periods of peak spawning. In Year 1 of the study period (October 1978 to September 1979), heavy spawning occurred practically throughout the year, with spawning peaks from March to April and from June to September. Prior to the spawning peaks, there was an observed increase in gametogenic activity, although gametogenesis was most intense from May to early June when more cockles with ripe gonads were observed.

In Year 2 (October 1979 to September 1980), intense spawning was apparent only from July to September. Isolated peaks outside the major breeding period were noted from late November to December and from late April to early May. From January to March, gametogenesis was rapid as indicated by the increase in number of ripe cockles. From late May to June, there was another increase in gametogenic activity.

The inactive stage occurred only during the months of November, December, and January in Year 1 and in January in Year 2. Individuals in the spent stage were likewise few and observed intermittently throughout the study period.

Gonad Index

Figure 2 shows the reproductive condition of *A. antiquata* expressed in terms of the gonad index. The values of the gonad index remained at 2.0 and above through most of the sampling period indicating

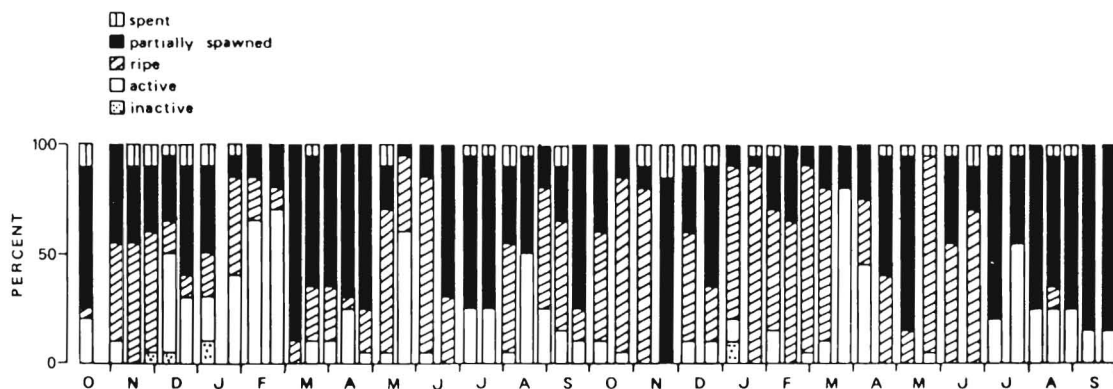


Figure 1. Percentage distribution of gonadal stages for *A. antiquata*. Spaces between bars reflects date of sampling.

continuous gonadal activity and spawning. The months when inactive and spent individuals were encountered brought the value of the gonad index below 2.0. The tendency of the gonad index to drop below 2.0 was observed more often in females than in males.

The gonad index curves for both sexes showed a 1-2 month period between successive upward pulses, with females exhibiting longer intervals between peaks. This trend was constant throughout the two-year sampling period.

Environmental Factors

Figure 3 shows the surface temperature and salinity readings at the study area recorded at mid-day of each date of collection. In year 1, tempera-

ture ranged from 26 to 33°C. Lowest mean quarterly value was 27.7° from October to December, 1978 and the highest was 30.5° from July to September, 1979. In Year 2, temperature was from 26.5 to 32.5°C. The lowest mean quarterly value was registered at 28.0°C during the first quarter of 1980 and the highest mean quarterly value of 30.5° was again recorded during the third quarter of 1980.

For salinity, the range was 27 to 36 ppt for Year 1, and 30 to 36 ppt for Year 2. The lowest mean quarterly values were recorded during the third quarter of each year, coinciding with the onset of the rainy season. In Year 1, the lowest quarterly value was 29.4 ppt, while in Year 2 it was 32.2 ppt. Highest mean quarterly values, on the other hand, were recorded from January to March in Year 1 (32.2 ppt) and January to June in Year 2 (34.4 ppt).

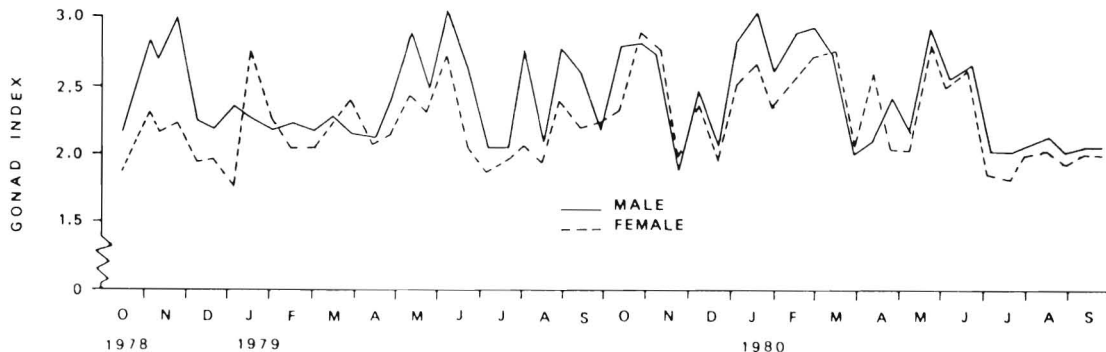


Figure 2. Gonad index of *A. antiquata*.

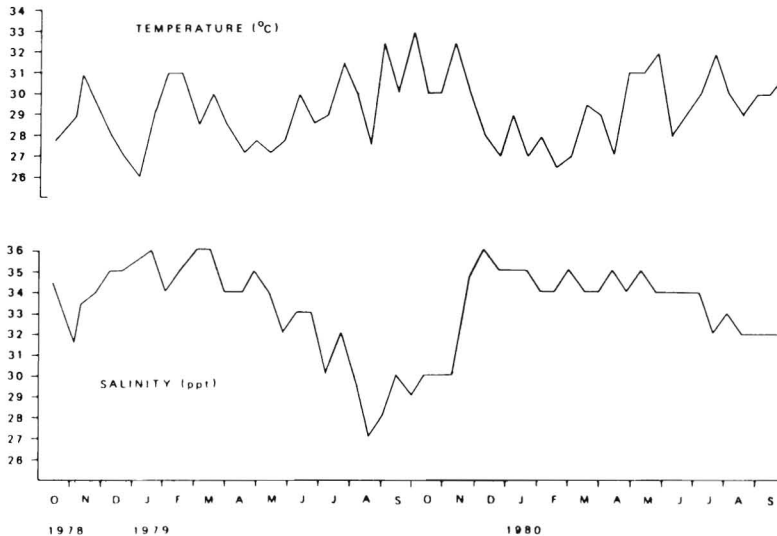


Figure 3. Temperature and salinity readings for each date of collection at Maahas, Calatagan, Batangas.

DISCUSSION

Annual Gonad Condition

The results of the gonad examination show that gametogenic activity and spawning in *A. antiquata* occurs continuously throughout the year, a condition which is typical in many tropical bivalve molluscs. Some local bivalves found in a similar condition include the brown mussels *Modiolus philippinarum* (WALTER and DELA CRUZ, 1980) and *M. metcalfei* (LOPEZ and GOMEZ, 1982b) and the mangrove oysters *Crassostrea echinata* and *C. lugubrius* (LOPEZ and GOMEZ, 1982a).

Although spawning is year-round in *A. antiquata*, variation in the number of individuals spawning at a given time occurred during the two-year study period. While temperature and salinity are considered as important factors affecting the regulation of the gonadal cycle in many bivalve species (GIESE, 1959; KINNE, 1970; GIESE and PEARSE, 1974), these two parameters do not seem to directly control the reproductive activities of *A. antiquata*.

There are indications that high temperature brings about an increase in spawning activity in *A. antiquata*. Spawning was most active during the third quarter of the year when the highest mean quarterly value of temperature was obtained. That the major spawning season coincided with the period when temperature was relatively high supports pre-

vious observations by STEPHENSON (1934) that the majority of tropical species spawn exclusively or most intensely during the warmer months. This trend, however, did not support the occurrence of other minor spawning peaks observed outside the major breeding season, suggesting that factors other than optimal temperature influence spawning in *A. antiquata*.

Prolonged changes in salinity as a result of heavy fresh-water discharge or monsoon rains could affect the reproductive activity of the animals (KINNE, 1964). The gametogenic cycle of the cockle *Anadara granosa* in the West Coast of Malaya was observed by PATHANSALI (1964) to display a definite seasonality which appears to be closely related to variation in salinity. He noted that breeding takes place mainly during the earlier half of the Northeast Monsoon when low salinity conditions are sustained over a long period of time.

The recorded salinity around Maahas Island (Figure 3) showed that low salinity conditions were maintained for a time during the third quarter of 1979, coinciding with the spawning peak for that year. Spawning peaks other than that observed during the third quarter of 1979 could not, however, be attributed to change in salinity since fluctuations during other times of the study period were less pronounced and of short duration.

The spawning peaks observed outside the major

breeding season which occur when temperature and salinity are presumably less favorable appear to be a function of the rate at which the gametes attain a morphologically ripe state, that is, spawning may be spontaneous after the individuals reach a critical state of maturity.

Gonad Index

The gonad index fluctuations during the first year of the study period characterize gonad development and spawning as the dominant reproductive events, while in the second year the trend indicates longer periods of ripening. Values of the female gonad index were generally lower than those of the males since they have a greater tendency to spawn-out completely and undergo an inactive phase. Males, on the other hand, have higher gonad index values because aside from appearing to have a faster rate of gametogenic activity, thereby producing more ripe individuals at a given time, they also have the tendency to develop a new set of sex cells for a succeeding gametogenic cycle while spawning at the same time. This redevelopment phenomenon appears to be the reason why the inactive stage is practically nonexistent in the male gonad cycle.

The gonad index indicates more or less synchronous gonad development and spawning in both sexes of *A. antiquata*. the period between succeeding peaks in the gonad index curve occur every 1 to 2 months, suggesting that the duration of the gametogenic cycle is within this range.

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