REPRODUCTIVE CYCLE OF COCKLE, *ANADARA INDICA* (GMELIN) IN JAKARTA BAY

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ABSTRACT

Cockles were collected from May 1993 through April 1994, to determine the annual reproductive cycle. Monthly histological observation of the gonads, showed that the cockle spawned throughout the year. Active and spawned gonads were found every month and the latter had high percentages. A low percentage (0.3 %) of ripe gonads was only found in November. The ratio of males to females in the adult population was 1:2. The occurrence of hermaphrodites is discussed.

INTRODUCTION

Cockle, *Anadara indica* has economic importance. This cockle inhabits estuarine areas with muddy bottoms. The genus *Anadara* is abundant in Asia: China, Japan, Thailand, Singapore, Philippines, Malaysia and Indonesia. However, little is known about cockle biology in general. Pathansali & Soong (1958), Pathansali (1963, 1964), and Broom (1982) provide information on some aspects of cockle culture, the effect of salinity changes on the activity, the biology, and the growth of *A. granosa* in Malaysian waters. Since *A. indica* is less popular than *A. granosa*, practically nothing is known about the biology of this cockle which lives in the same habitat as *A. granosa*. The objective of this paper is to determine the reproductive cycle of *A. indica* in Jakarta Bay. For proper management of this cockle detailed knowledge of its reproductive cycle is essential.

MATERIALS AND METHODS

Samples of *A. indica* were collected monthly from Cikamal estuary, Jakarta Bay, from March 1993 through April 1994 (Fig.1). Twenty eight to thirty specimens (length 33 to 48 mm) were fixed in Bouin's fixative, dehydrated in ethyl alcohol, cleared in chloroform and embedded in paraffin. Tissues were sectioned (5 μm), and stained with hematoxylineosin. Based on examinations of gonadal slide preparations the reproductive cycle was arbitrarily divided into 5 stages, according to Ropes & Stickney (1965):

Inactive stage: Gonia lacking, and follicle consisted of solidly packed follicular tissue. The sex was undiscernible histologically.

Active stage: the active or developing stage characterized by an increase in the number of oocytes in female, and spermatocytes in male. The degree of development was determined by increasing numbers of oocytes or spermatocytes, spermatids and the enlargement of the follicles. In the later stages of development, many ripe or free oocytes were found in females. Towards the centre of the lumen of the follicles of male gonads, spermatids differentiated into spermatozoa arranged in dense radiating bands.

Ripe stage: this stage was characterized by large numbers of detached or free oocytes or dense, radiating mature spermatozoa.

Spawned stage: this stage consisted of two substages: partially spawned and spent stages. In partially spawned stage, the lumen of follicles showed varying degree of emptiness. The cockles are considered to have partially shed their gametes. This stage was accompanied by the redeveloping gametogenic cells, thus making a quick transition to the active stage. The follicles are empty in the spent stage, except for few unspawned oocytes in stages of cytolysis or residual spermatozoa.

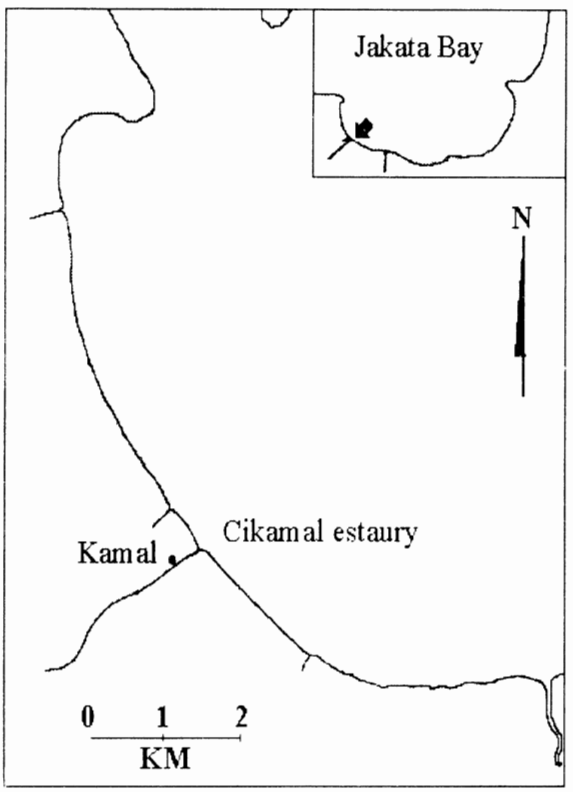

Figure 1. Map of the study site.

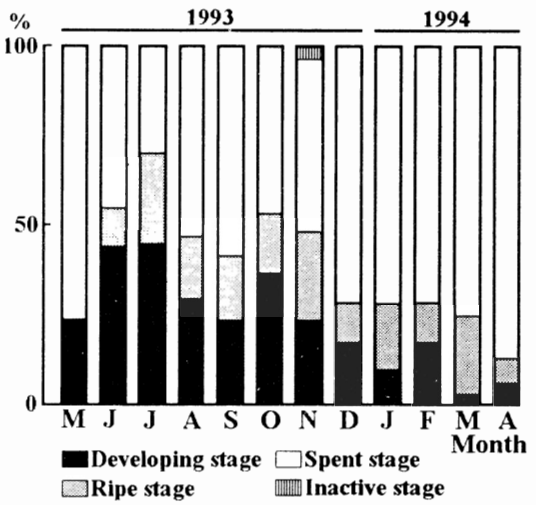

Figure 2. Frequency of monthly gonad stages of the cockle, *Anadara indica* in Jakarta Bay.

RESULTS

Reproductive cycle

The reproductive cycle of cockle, *A. indica* is shown in Fig. 2. The inactive stage was found only in November (0.3 %). Developing stages occurred every month with a peak between June and July 1993. From December until April, the occurence of developing stages were low. Ripe stages were found almost every month except in May, with low percentages (6.9 - 24.1 %). Spawned stages occurred every month with high percentages (30.0 - 86.2 %). Peak spawning activity was attained from December until April.

Sex ratio

Among 347 individuals of the adult population (33.0-48.0 mm) of *A. indica*, 115 males, 229 females and two hermaphrodites were found (Table 1). The ratio of males to females was 1:2.

Table 1. Sex ratio of the adult population of cockle, *Anadara indica* in Jakarta Bay, May 1993 - April 1994. I = number of individuals.

Month	Female		Male		Herma-phrodite		Inactive gonad		Total
	I	%	I	%	I	%	I	%	
May1993	16	55.2	11	37 9	2				29
June	23	79.3	6	20.7					29
July	18	62.1	11	37.9					29
August	16	53.3	14	46.7					30
September	23	79.3	6	20.7					29
October	21	70.0	9	30.0					30
November	18	62.1	10	34.5			1		29
December	8	64.3	10	35.7					28
January1994	24	82.8	5	17.2					29
February	14	50.0	14	50.0					28
March	22	78.6	6	21.4					28
April	16	55.2	13	44.8					29
Total	229	65.99	115	33.14	2	0.57	1	0.30	347

DISCUSSION

The histograms (Fig. 2) show clearly that spawning of *A. indica* in Jakarta Bay occurs continously throughout the year. Tranter (1958a) found that the pearl oysters have a less restricted breeding season in lower latitudes, and the major spawnings occur outside the warmer months, for example *Pinctada margaritifera* in Torres Strait and *Pinctada fucata* in Ceylon. *Marcia hiantina* and *Anomalodiscus squamoses* spawn continously throughout the year in the Philippines (Toral-Borza & Gomes 1986). *Anadara antiquata* which inhabits coral islands in Jakarta Bay, Indonesia, spawns throughout the year (Kastoro 1978). Orton (1920) stated that in the those parts of the sea where temperature conditions are nearly constant, and where biological condition do not vary much, animals will breed continously. However, gametogenesis in some tropical species appear to be restricted to certain months. The timing, duration and the number of gametogenic cycles vary in populations of a species within different parts of the geographic range (Sastry 1979).

High percentage of spawned stages and low percentage of inactive stage of the cockle *A. indica* in the Cikamal estuary of Jakarta Bay indicate that the gonad development is very fast. Giese (1959), and Giese & Pearse (1974) reviewed the influence of exogenous and endogenous factors on the annual reproductive cycle of marine invertebrates including pelecypoda. Recent studies indicate that a reproductive cycle response is produced through an interaction of environmental factors, especially temperature, with the organism. Gonad development is an energy demanding process. The mobilization of nutrient from the ingested food is essential for gamete development. Loosanoff (1937), and Ansell (1961) found that the recovery period is very brief, and gametogenesis begins immediately after spawning in *Mercenaria mercenaria* and *Venus striatula*. In these species, the initiation of gonad development coincides with the increase in phytoplankton after a winter delay. Gonad growth and gametogenesis are dependent upon direct intake of food during the period of gonad development (Sastry 1966, 1968).

The rapidity of the recovery period of the gonads of *A. indica* in Jakarta Bay may be due to the availability of food. Blooming of phytoplankton always occurs in the estuaries of Jakarta Bay, *e.g.*, *Skeletonema* (Diatomae) during periods with low salinity (Praseno 1980). Compared to the fast recovery of *A. indica*, the *A. antiquata* which inhabits coral islands of Jakarta Bay, had slow gonad development. These coral islands are located far from the estuaries and the concentration of phytoplankton is lower than in the estuaries. Inactive stages of *A. antiquata* gonads were observed during 5 months in the year (Kastoro 1978).

Studies of the sexuality of the family Arcidae are few in tropical waters. Pathansali & Soong (1958) found that *Anadara granosa* is unisexual or dioecious. They also reported that both sexes are equal in numbers and no sex changes were observed. Separate sexes are also found in *A. trapezia* (Sullivan 1960). Yoloye (1974) reported that *A. senilis* (African bloody cockle) is a protandric hermaphrodite in which the females outnumber the males at a ratio of 76 to 24. No hermaphroditic gonads were found in the larger individuals indicating that a second sex reversal does not occur. A similar relationship was found in *A. antiquata* characterized by many females compared to males, and a small number of hermaphroditic individuals (1.2 %), changing from males to females (Kastoro 1978).

The present study shows that the females of *A. indica* are twice as common as males in Jakarta Bay. The small proportion which is hermaphroditic, changing from male to female, may indicate that *A. indica* is a protandric hermaphrodite, similar to *A. senilis*. However, more studies of its sexuality are needed to prove this condition.

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