STUDIES ON SOME ASPECTS OF BIOLOGY AND FISHERY OF THE COCKLE, *ANADARA GRANOSA* (LINNAEUS), FROM KAKINADA BAY[1]

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ABSTRACT

Age and growth of *A. granosa* has been studied by an examination of the size-frequencies of random samples for the period from April 1965 to September 1966. The cockles measure 31·5 mm. in length at the end of the first year and 49·5 mm. at the end of the second year of life. No growth rings were noticed to be of use in age determination. The commercial catches chiefly consisted of '0' and 1+ age groups in the year April 1965 to March 1966. The cockles reach sexual maturity when they measure 21 mm. and about 7 months old. They appear to breed throughout the year. There is a peak spawning activity in January-April period. The length-weight relationship has been studied.

Brief accounts are given regarding the location of the fishing villages, fishing season, fishing methods, extraction of lime, its marketing and utility. An estimate of the lime sold in the market by weight and value from Yetimoga village for one year is made. The factors that are in operation to check depletion of the cockle beds are discussed.

INTRODUCTION

THE culture of *Anadara* spp. is practised in China and Japan (Cahn, 1951). It has considerable economic importance in the Philippines, Thailand, Malaysia, and Borneo (Pathansali and Soong, 1958). At Kakinada Bay (Fig. 1) *Anadara granosa* is regularly fished along with species of *Placuna, Meretrix, Paphia, Oliva, Umbonium, Murex, Cerithium,* etc., for burning into lime. An organised lime burning industry exists in several villages, situated along the western and southern side of Kakinada Bay. The commercially exploited area in the Bay is about 100 square Km. and is characterised mostly by soft muddy bottom, with a good amount of silt deposition due to the flow of water through irrigation canals and small rivers like the Koringa river and the Gaderu river. Among the molluscs fished in the bay, *A. granosa* ranks first in price, for its lime is said to be of a very high quality. A number of fishermen depend on this fishery for additional income to the usual earnings. In view of the considerable economic importance of *A. granosa*, the present study was taken up and an attempt has been made in the following account to furnish particulars of the fishery along with information on some aspects of biology of the species.

MATERIAL AND METHODS

The biological studies were based on random samples, taken for a period of 18 months from April, 1965 to September, 1966, from Kakinada Bay. Collections were made once every month, except for December, 1965 and June, 1966, when no samples were obtained. During low tide a plank-built boat was engaged with one diver. The large specimens were hand-picked, while the smaller ones were obtained by sieving the bottom with a sieve having 2 mm. mesh size. Each random

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sample usually consisted of more than 150 cockles. In the laboratory, length of the cockles was measured in the greatest antero-posterior direction correct to 0·1 mm. with vernier calipers. Age and growth have been studied by analysis of length-frequency distribution. The data were arranged in size groups with class intervals of 3 mm. and their percentages calculated. A total of 3,250 cockles were measured for this purpose. For one year, from April, 1965, to March, 1966, a *Kuncham* (about 5 litres) of the cockles landed by fishermen were regularly obtained every month and their length was measured for age composition of the commercial catch. These sample values were not raised to represent the size composition of the entire commercial catch; only the sample

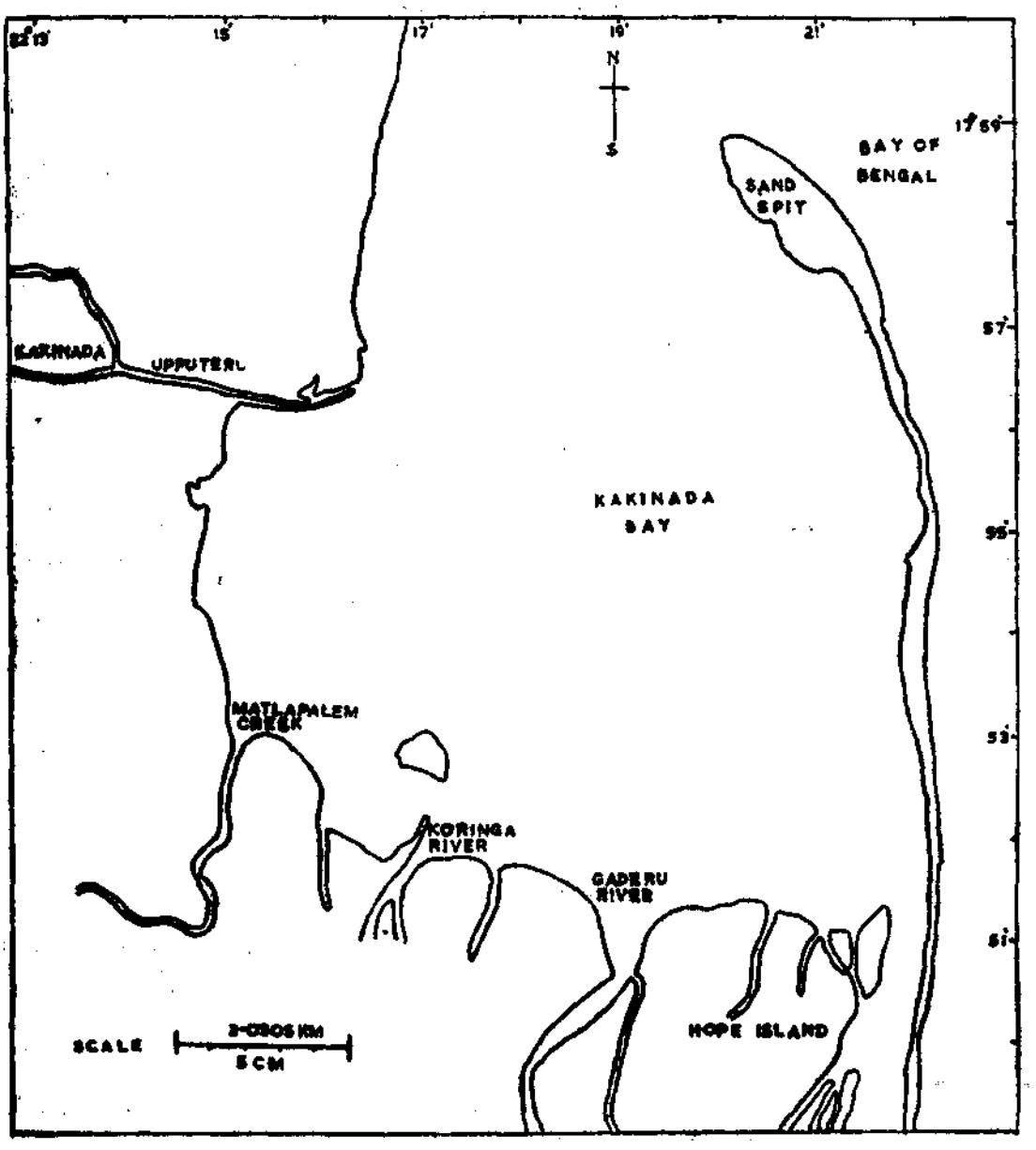


FIG. 1. Map showing the vicinity of Kakinada Bay.

values were pooled for each quarter and for the whole year. The length-weight relationship was studied by using specimens collected in April, May and June, 1965, and preserved in 5% formalin. The excess moisture was removed by filter-paper, and weights were recorded to the nearest milligram. For maturity studies the gonads were examined microscopically. A survey of some fishing villages around Kakinada Bay was undertaken to collect information about the economic importance of the fishery, fishing methods, season, and the method of lime preparation.

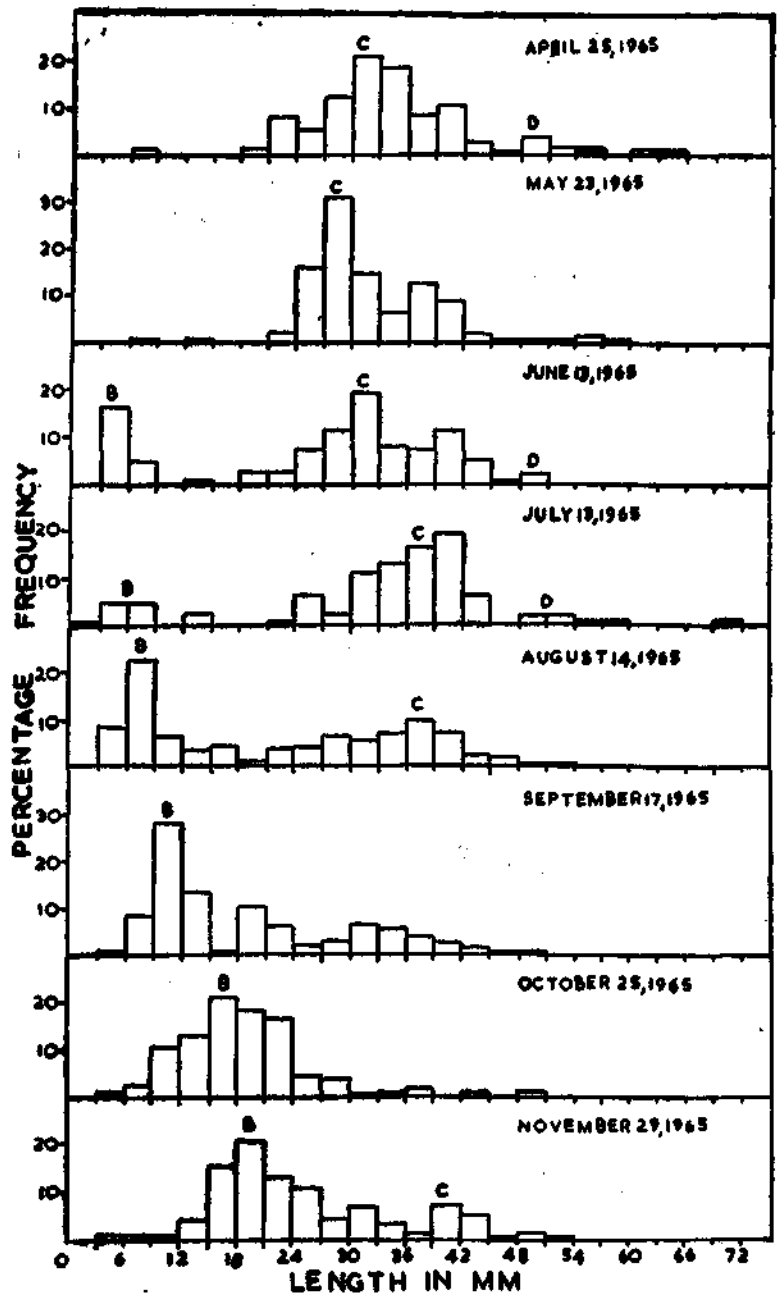


FIG. 2. Length-frequency distribution of *Anadara granosa*.

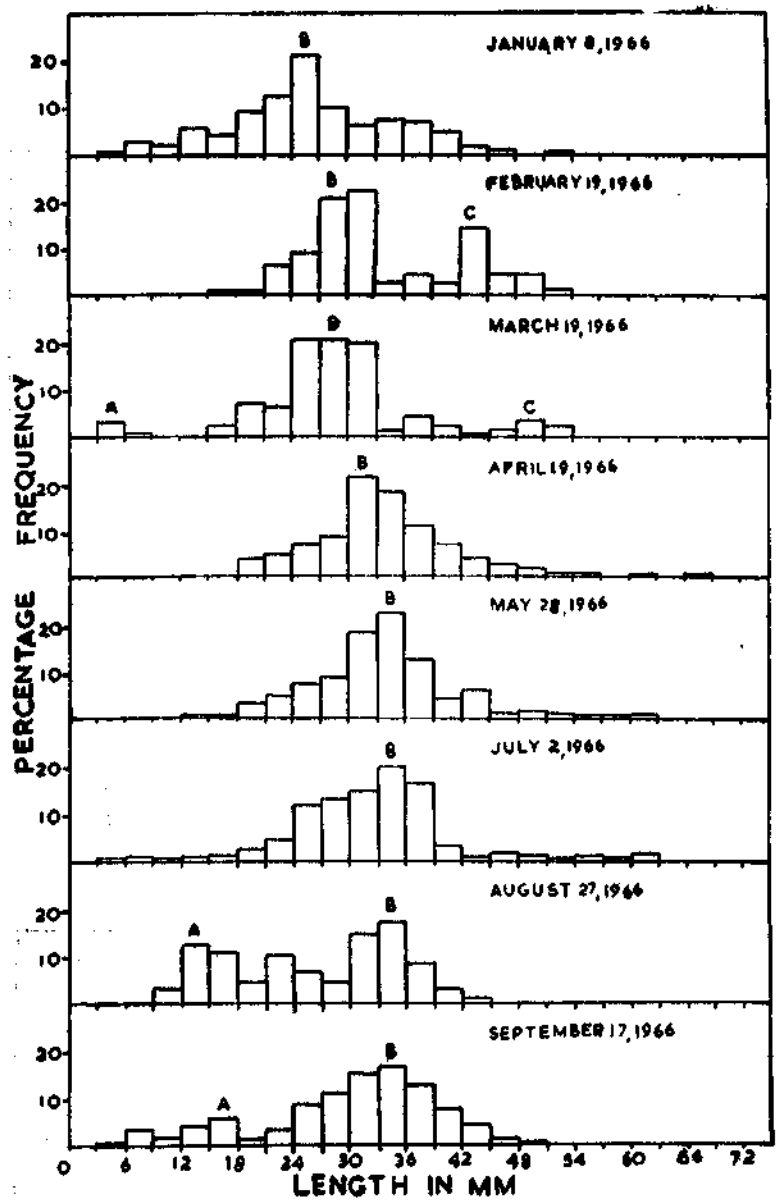


FIG. 3. Length-frequency distribution of *Anadara granosa* (*continued*).

AGE AND GROWTH

The length-frequency distribution based on random samples collected is shown in Figs. 2 and 3. In June, 1965, 3 modes, namely, B, C, and D were present at 4·5, 31·5, and 49·5 mm. respectively. Mode B moved to 31·5 mm. by April, 1966, *i.e.*, it grew to the size of C in about one year's time. Hence the time interval between B and C can be regarded as one year. In April, 1965, mode C was at 31·5 mm, and D at 49·5 mm, and in March, 1966, C moved to 49·5 mm. In other

words it occupied the position of D in one year's time. Consequently the difference in age between C and D may be considered as one year.

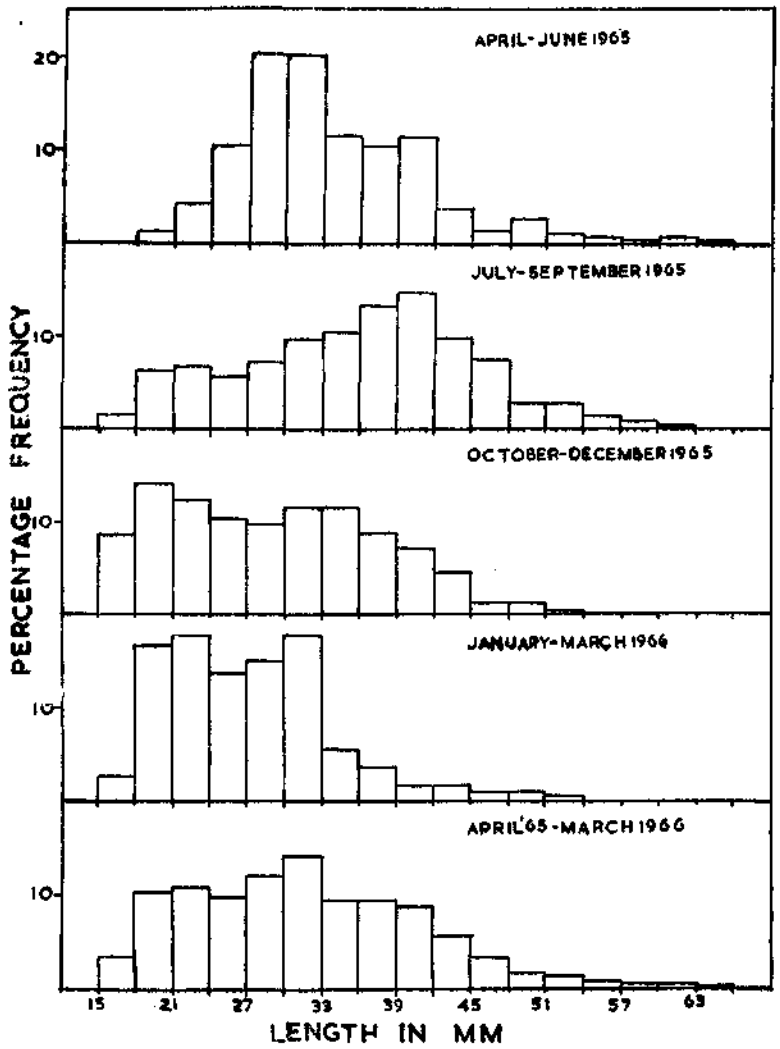


FIG. 4. Size-frequency distribution of commercial catch of *Anadara granosa*.

Reference to Fig. 2 shows that B, which was 4·5 mm. in June, 1965, moved to 7·5 mm. by August, 1965, thereby showing a size increment of 3 mm. in 2 months time. Assuming the same growth rate prior to June, 1965, B would have stood at 1·5 mm. or more likely less, in April, 1965, forming the 1965 year class. From the above it can be reasonably concluded that the cockles indicated by B at 31·5 mm. in April, 1966, have just completed one year of life. Mode B remained stationary at 34·5 mm. for 5 months from May to September, 1966. Whether this is due to cessation of growth or due to the mixing of smaller size groups is not clear.

It has already been shown that B, C, and D have a time interval of one year each. Since B represents the 1965 year class, it would follow that C and D represent the 1964 and 1963 year classes respectively. C and D stood at 31·5 mm. and 49·5 mm. in April, 1965, and as 31·5 mm. is the

length attained at the end of the first year of life, it would lead to the conclusion that the cockles measure 49·5 mm. at the end of the second year of life.

In March, 1966, mode A was present at 4·5 mm. which shifted to 16·5 mm. by September, 1966. By allowing a growth rate of 3 mm. in 2 months, as was done for B in the early part of life, A would have measured 1·5 mm. or less in January, 1966, and represents the 1966 year class. In April and May, 1966, considerable number of empty shells measuring 4 mm. to 11 mm., with both the valves open and attached, were collected. Judged from the freshness of the colour, these shells belonged to the 1966 year class. There was no indication of any external damage and the cause of the motality is not known.

Cockles measuring 30 to 70 mm. in length were studied in detail and growth rings were not observed to be of any utility in age determination (Plate I, Fig. 1).

Age Composition of the Commercial Catch

The size frequency distribution of the commercial catch for one year from April, 1965 to March, 1966, on a quarterly basis, and also for the whole year, is indicated in Fig. 4. It will be seen that the commercial catch consisted of cockles belonging mainly to '0' and 1+ age groups. The '0' age group is exploited in large numbers from October to June while 1+ age group formed the majority of the catch in July–September. For the whole year '0' age group formed 59·6%, 1+ age group 37·9%, and the rest 2·5%. The smallest cockle obtained from the commercial catches measured 16·2 mm. and the largest 65·4 mm.

Size and Age at Sexual Maturity and Spawning Period

A few individuals measuring around 18 mm. showed mature gonads and a majority of cockles from 21 mm. onwards revealed ripe reproductive elements in both the sexes. As the cockles grow to 21 mm. length in about 7 months time, it is concluded that *A. granosa* reaches sexual maturity when it is about 7 months old.

Between 15 and 20 adult cockles were examined microscopically for their gonadal condition from monthly samples. In this study maturing, ripe, and spent individuals were encountered throughout the period of investigation. From this, it would appear that *A. granosa* spawns throughout the year. A perusal of the length-frequency data (Figs. 2 and 3) reveals that 4·5 mm. modal group was present in varying numbers from June, 1965, to March, 1966, for a period of 10 months excepting February, 1966 (December 1965 no collection). This fact indicates that spawning is very much prolonged and lends support to the duration of spawning period arrived at by gonadal study.

Reference to Figs. 2 and 3 also shows that the modes A and B are well demarcated as isolated or nearly isolated groups. Hence there is every reason to believe that, in spite of breeding activity throughout the year, a definite peak occurs in the spawning. Such peak spawning appears to have occurred in January, 1966, and April, 1965, as was shown in size-frequency analysis for the modes A and B respectively.

Length-Weight Relationship

A preliminary plot of the logarithmic values of length and the corresponding weight showed that the same regression line would not fit the data for the entire length range examined. There appeared to be a break in the relationship at a length of about 20 mm. Two regression lines were therefore fitted by the method of least squares, one to the length range 3 to 19 mm. and the other

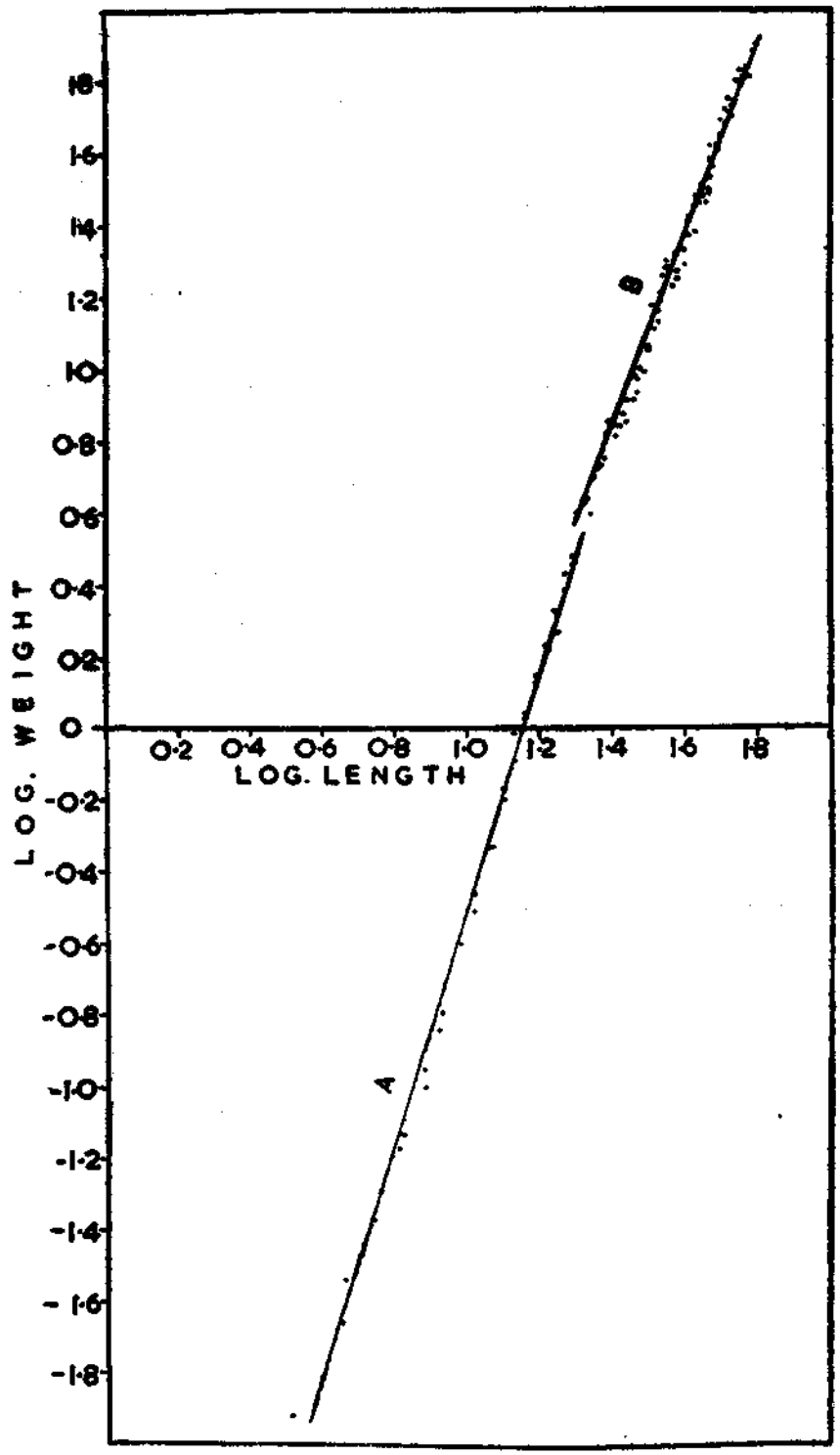


FIG. 5. Logarithmic relation of length and weight of *Anadara granosa*. Length range 3 to 19 mm. is represented by the regression line A and 20 to 63 mm. by B.

to the length range 20 to 63 mm. The number of specimens in the former group was 34 and in the latter group 78. The relationship obtained was

3 to 19 mm. length group: $Y = -3{\cdot}7130 + 3{\cdot}2096\ X$
20 to 63 mm. length group: $Y = -2{\cdot}8732 + 2{\cdot}6459\ X$

where Y = log weight and X = log length.

The difference between the two regression coefficients was tested by the method of analysis of covariance. The relevant data are given in Table I.

TABLE I

Analysis of Covariance of the length-weight relationship of A. granosa *from Kakinada Bay*

Length range	N	N − 1	$\Sigma(x-\bar{x})(y-\bar{y})$	$\Sigma(x-\bar{x})^2$	$\Sigma(y-\bar{y})^2$	$b\,\Sigma(x-\bar{x})(y-\bar{y})$	$\Sigma(y-Y)^2$	N − 2
3 to 19 mm. ..	34	33	5·2961	1·6501	17·0651	16·9984	0·0667	32
20 to 63 mm. ..	78	77	3·6767	1·3896	10·6734	9·7282	0·9452	76
TOTAL ..	112	110	8·9728	3·0397	27·7385	26·7266	1·0119	108

N = Number of observations. $\Sigma(y-Y)^2$ = Sum of squares due to deviation from regression.

Test of heterogeneity of regressions within the samples

Source of variation	Degrees of freedom	Sum of squares	Mean squares
Deviation from average total regression ..	109	1·2517	—
Deviations from individual regressions within samples ..	108	1·0119	0·009369
Difference ..	1	0·2398	0·2398

F = 25·595. $F_{1\%} = 6{\cdot}89$.

The F test showed that the difference between the two regression coefficients is significant at 1% level. The two regression lines marked as A for the length 3 to 19 mm. and as B for the length range 20 to 63 mm. are shown in Fig. 5.

It will be seen from the figure and text that the smaller cockles upto 19 mm. length increase in weight in relation to length at a higher rate than the larger ones.

FISHERY

Fishing villages.—Among the fishing villages, where the cockle fishery is practised, mention may be made of Yetimoga, Gadimoga, Bhairavipalem, Balusutippa, and Masanitippa. In Yerragaruvu village, where a lucrative lime burning industry exists, no fishing is done, but the fishermen regularly buy the cockles from nearby villages.

Fishing season.—The cockles are fished thoughout the year with maximum catches in January due to heavy demand for lime in this month.

Fishing method.—Plank-built boats, with 5 to 8 divers on each boat, depending on the size of the boat, go to the bay about 3 hours after the high-tide. Each diver carries with him a bamboo basket and a rope about 8 metres long. After anchoring the boat at the collection spot, the diver ties one end of the rope to the basket and the other end to his waist. The cockles, along with other molluscs, are hand-picked and transferred to the basket. The rope helps him to keep track of the basket as he often comes to surface for breathing. After the basket is full, the catch is transferred to the boat and the operation is repeated for four to five hours by which time the water begins to swell due to the approaching high-tide. Generally fishing is confined to less than four metres depth during low-tides at daytime. The catch is auctioned and each fisherman gets Rs. 2 to 5 as his share for the day's fishing.

Method of lime extraction.—The cockles are burnt into lime in an oven, locally known as *batty* (Plate I, Fig. 2). The *batties* are hollow and cylindrical; small ones have 110 cm. diameter, height 75 cm. and the wall 15 cm. thick with 9 ventilation holes at the base; big ovens have 155 cm. diameter, 85 cm. height, the wall at base 18 cm. thick and has 14 ventilation holes. There are also *batties* of intermediate sizes.

The *batty* is constructed on levelled ground, elevated 2 to 3 metres. Bamboo pieces of the required height are fixed in a circle and woven horizontally 15 to 20 cm. from the ground to top with thin bamboo sticks. A thick layer of mud is plastered both inside and outside of this bamboo structure, after making the required number of ventilation holes at the base. Care is taken to see that mud plastering is sufficiently thick inside the bamboo structure so as to avoid contact with fire. The *batty* is allowed to dry for 4 to 5 days before it is operated.

The cockles, with meat intact, are dried for about 4 days before they are transferred to the *batty*. By this method the valves open and the moisture is evaporated from the meat. However, when there is heavy demand for lime, the cockles are burnt within hours of landing, in which case the time taken for burning would be longer, requiring more coal. Also, the quality of the lime is said to be poor. Different species of molluscs are burnt separately to ensure uniform burning into lime.

Inside the *batty* pieces of broken tiles and earthen pots are kept to allow free passage of air. Upon this a layer of dried coconut or palm fibre is placed. Over this, layers of coal and cockles are filled alternately up to the top of the *batty*. Again coconut fibre is placed on this and in turn covered superficially with little mud so that the top fibre layer is not blown by the wind. Now the *batty* is lit at the bottom through the ventilation holes and the latter are closed with mud excepting those 3 or 4 facing the wind. If the direction of the wind changes, those facing the wind are opened and the remaining ones closed.

During rainy season an umbrella made of palm leaves is suspended above the top of the *batty* from bamboo poles erected for the purpose. The elevated platform on which the *batty* is constructed prevents the flow of ground water into the *batty* and at the same time ensures a rich supply of air.

After the *batty* is lit, it is allowed to burn for five to six hours by which time the fire goes out. The lime is collected after eight to ten hours. The burning operation usually begins at 12 noon, the fire goes out by 5 P.M., and the lime is taken out at 4 A.M. next morning for marketing. At present there are 23 *batties* at Kakinada.

Marketing and economics of the fishery.—The cockles burnt into lime maintain their shape (Plate I, Fig. 3) and are sold in the market by a local measure known as *kuncham*, which is equivalent to about five litres. A *kuncham* of burnt cockles weighs approximately 2 kg. and fetches 25 to 35 paise. 'Pongal', which comes in January every year, is an important festival in Andhra Pradesh when lime-washing of the houses is customary. In this month the cost of a *kuncham* of burnt cockles goes up to 50–60 paise due to the prevailing demand.

Based on the information furnished by merchants, an approximate estimate was made of the lime sold in the year 1966. The figures given pertain to the lime prepared out of cockles from Yetimoga fishing village only. About 160 tons of lime was sold valued at Rs. 32,000 and January alone accounted for 70 tons priced at Rs. 18,000. From the figures it would appear that the fishing intensity is dependent upon the local demand and prevailing prices of lime.

Utility.—The cockle meat is said to be good for pregnant women and except for this occasional medicinal use it is not eaten locally. As already stated the cockles are burnt into lime with meats intact.

Discussion

The growth of *A. granosa* from a commercial bed at Penang Island, Malaysia, was studied by Pathansali (1964). From his figures it would appear that the length of one-year-old cockle is 27·5 mm., two-year-old 37·5 mm, and three-year-old 43·3 mm. The present study from Kakinada shows that one-year-old measures 31·5 mm. which compares favourably with Pathansali's estimate. But the size of two-year-olds at 49·5 mm. in the present investigation is very much higher than that estimated by Pathansali. It may be mentioned here that Pathansali himself stated that his estimate of the growth of cockles above 25·4 mm. in length is not reliable due to commercial exploitation on the culture bed. It is also possible that the disparity observed in the growth may be due to differences in the environmental conditions.

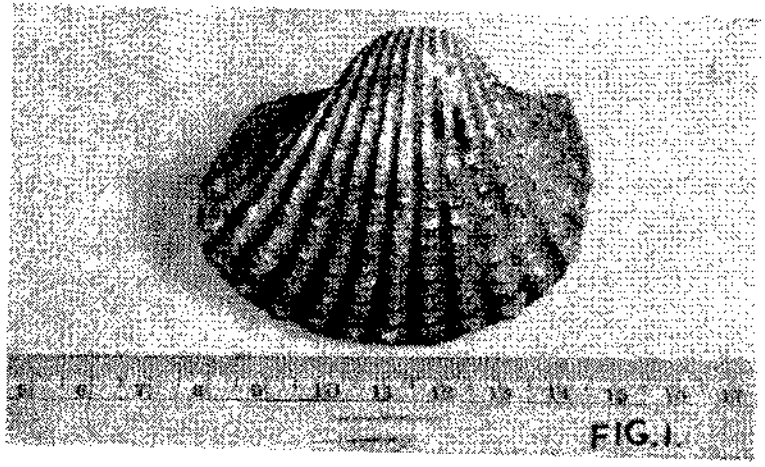
Pathansali (*op. cit.*) found that *A. granosa* reaches sexual maturity between 18–20 mm. length when the cockles are about 6 months old. These findings closely correspond to what is observed at Kakinada.

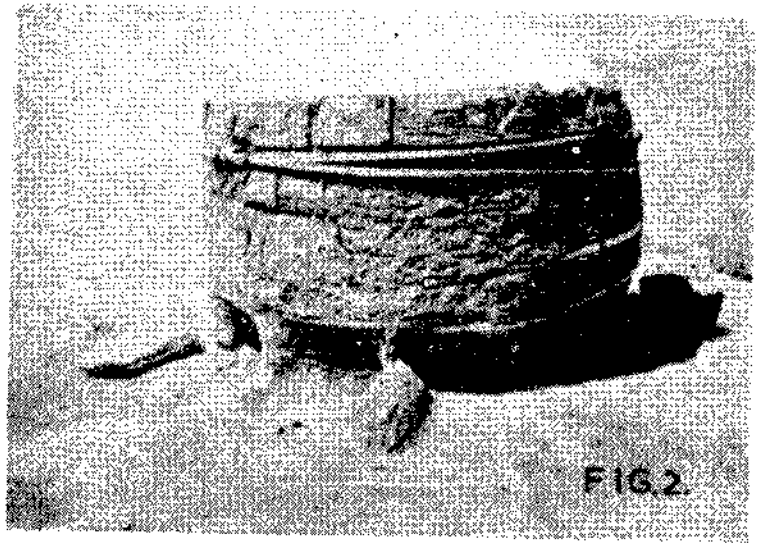
On the spawning of *A. granosa* from Malaysia, Pathansali (1964) wrote "....the major breeding season is spread over a period of time, and some breeding takes places throughout the year." He collected larvae throughout the year for three years and by gonadal study observed that peak breeding took place in late August–September in 1958 and in late September–early October in 1959. In the present study the author found that *A. granosa* spawns throughout the year with peak spawning in April, 1965, and in January, 1966. The results obtained at Kakinada regarding the duration of the spawning period and the occurrence of a definite peak in the breeding activity are in agreement with Pathansali's findings. While off Penang Island *A. granosa* has major breeding period in August–October, at Kakinada the peak spawning seems to take place some time in January–April period.

Among the bivalves which showed prolonged spawning period, investigated from India, mention may be made of *Crassostrea madrasensis*, which under marine conditions breeds throughout the year with two peaks, once in about November–December and again about May (Rao, 1951). *Meretrix casta* from Adayar estuary appears to breed throughout the year with peak spawning activity in certain months only (Abraham, 1953). In *Solen kempi*, Rao *et al.* (1962) noted that spawning is prolonged, commencing in October–November and extending until the end of March, with vigorous spawning activity at the beginning of the spawning period. It would appear, that in those species which have a prolonged spawning period in a given environment, there exists a definite peak or peaks in the breeding activity, restricted to certain months only.

It has been stated in the length-weight relationship study that the smaller cockles up to about 19 mm. length increase in weight in relation to length at a higher rate than the larger ones. This change in weight is quite likely due to the onset of sexual maturity at 21 mm. length.

A. granosa is cultured for its food value in some 3,500 acres in Malysia. Its meat is equal to other shellfish in food value and compares well with beef (Pathansali and Soong, 1958). The meat





FIGS. 1–3. Fig. 1. Photograph of *Anadara granosa*. Fig. 2. A *batty* in operation. Fig. 3. Marketing of the cockle lime. The local measure, *kunchum* is also shown.

of the above species is not eaten at Kakinada, except for medicinal use, although a number of species of bivalves are used for culinary purpose both along the east and west coasts of India. This is because of traditional dislike; moreover, the red colour of the cockle meat does not find favour with the people.

In the present condition of the cockle fishery, three factors strongly operate to check depletion. Firstly, there are many areas in Kakinada Bay where the depth is more than 4 metres, which are not exploited, thus leaving large-sized individuals to replenish the stock. Secondly, the prolonged spawning habit of *A. granosa* should help considerably in providing recruits to the fishery for a major part of the year. Lastly, except for January every year, there is not much inducement for fishermen to catch cockles in large quantities due to low market value of lime. However, once the meat finds utility it can be reasonably expected that the picture will change.

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