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LARVAL REARING, SPAT PRODUCTION AND JUVENILE GROWTH OF THE BLOOD CLAM *ANADARA GRANOSA*

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ABSTRACT

The blood clam *Anadara granosa* spawned in the Shellfish Hatchery Laboratory, Tuticorin on two occasions. The fertilised eggs measured 50-60μ in diameter, morula larvae developed in 3-4 hrs and the trochophore stage was reached in 5 hrs. The straight hinge stage was attained in 20-26 hrs after fertilization and these larvae measured 83μ length and 65.5μ height. Advanced umbo stage was reached on day 12 (size 155.3 × 140.5μ) and on day 16, majority of the larvae were in pediveliger stage with an average size of 182.7 × 162.9μ. Settlement began on day 16 and majority of the larvae were set on day 18. The growth of the spat in the hatchery is described by the exponential equation $L = 0.0002739\ D^{2.2623}$ where L is length in mm and D, days. On day 59, the spat attained an average size of 2.42 × 1.70 mm. A total of 8090 spat were produced. During the nursery rearing in the field, the seed clam attained 20 mm average length in the following 5 months. In India, *A. granosa* seed were produced for the first time. The significance of this study for the mass production of the blood clam seed in the hatchery and its relevance to undertake blood clam culture are highlighted.

INTRODUCTION

AMONG the clams belonging to the family Arcidae, the blood clam *Anadara granosa* (Linnaeus) is widely distributed and is cultured for its food value in China, Japan, Malaysia, Taiwan and Thailand (Broom, 1985 ; Chen, 1976 ; Nie, 1982). In India, it forms a fishery of considerable magnitude only in the Kakinada Bay (Narasimham *et al.*, 1984). The results given in this paper form a part of the programme undertaken to develop appropriate technology for the hatchery production of the seed of commercially important Indian clams. From India, the present study is the first to repor upon the production of the seed of *A. granosa* in a hatchery.

From Malaysia, Wong *et al.* (1986) gave an account on induced spawning, larval development and juvenile growth of this species.

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MATERIAL AND METHODS

The work was carried out at the Shellfish Hatchery Laboratory of the Tuticorin Research

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Centre. Twenty-five specimens of *A. granosa* (Pl. I A), ranging in length from 39 to 74 mm were collected from the Tuticorin Bay and transferred to 100 1 FRP tank containing seawater. The clams were kept in the conditioning room (water temperature 24-26°C) and fed intensively with the Haptophycean flagellate *Isochrysis galbana*, cultured in the laboratory as outlined by Nayar *et al.* (1984). After 15 days, they were transferred to 100 1 perspex tank and the water temperature was raised to 32°C by thermostat controlled heating element. Whenever there was no spawning the clams were transferred back to the conditioning room and the experiment repeated after 10-15 days. Two spawnings occurred, one on 4-2-1988 and the other on 26-2-1988 and both were in the conditioning room. The fertilized eggs were washed in 40μ and 100μ sieves to remove excess sperms, debris, etc. and released in 1 tonne FRP rearing tank. Sand filtered sea-water was supplied to the rearing tank through a hose, the delivery end of which was plugged with surgical cotton. The water was changed completely on alternate days and half the volume of water replaced on the days preceeding complete water change. Gentle aeration was provided in the rearing tank. Periodically 20 larvae/spat were measured for length in antero-posterior axis and for height in dorso-ventral axis. The average of these measurements were given for different growth stages. *Isochrysis galbana* was given as food once a day after determining the cell concentrations with heamocytometer.

The hatchery produced seed were reared in the Tuticorin Bay from day 60 onwards in 40×40×10 cm cages made of 6 mm iron rod and covered with an inner 0.6 mm and outer 20 mm mesh synthetic webbing. These cages were hung from a rack in 1 m depth. Each cage contained 100 clam seed.

Although both the seed clams and adults of *A. granosa* are known to thrive well in soft sediment, comprising particles predominantly of <125μ size (Narasimham *et al.*, 1984) in the present study, no sediment was provided in the rearing experiments either in the hatchery or in the field.

During the two larval/spat rearing experiments, the water temperature in the hatchery ranged from 27° to 32°C and salinity from 31.8‰ to 33.6‰. In the Tuticorin Bay, where the juveniles were reared in cages, the water temperature ranged from 24.5 to 29.2°C and salinity from 33.6 to 35.5‰.

The results obtained in the two rearing experiments are comparable and those of the first experiment are described. Though spawning was profuse in the second experiment, due to space constraint in the laboratory, 6,000 larvae alone were used in rearing and the rest of the larvae were released in the Tuticorin Bay.

Results

Early development and larval rearing

The eggs were spherical, light pink red in colour and measured 50-60.7 μ with an average of 51.9μ. Fertilization occurred within minutes and soon after the eggs became opaque (Pl. I B). Cell division (Pl. I C, D) was observed within 10 minutes. After passing through the blastula and gastrula stages, the morula larvae (Pl. I E) developed in 3-4 hrs, trochophore stage (Pl. I F) in 5 hrs and the D-shaped larvae (Pl. II A) in 20-26 hrs after fertilization. On day 1, the minimum size of the straight hinge larvae was 80μ in length × 65μ in height, maximum size 90 × 70μ with an average of 83 × 65.5 μ. Beginning on day 1, *I. galbana* was given as food at 5,000 cells/larva/day. On day 5, the straight hinge larvae attained an average size of 111.2×98.8 μ. Early umbo stage was observed on day 7 and the larvae measured 131.6 × 106.3 μ. At this stage, the feed was increased to 7,000 cells/larva/day. Advanced umbo stage was reached

on day 12 when the larvae measured 155.3 × 140.5μ (Pl. II B). On day 14, some of the larvae developed foot and on day 16, majority developed foot, marking the advent of pediveliger stage (Pl. II C); at this stage the average size of the larvae was 182.7 × 162.9μ with a minimum size 169.5 × 156.9μ and maximum of 207.5 × 172μ. The hinge of 12-16 days old larvae showed 14-16 teeth, arranged in a linear series, leaving a gap in the middle. Also the prodissoconch of these larvae showed 8 - 10, more or less evenly spaced concentric growth lines. The rate of feed was increased to 10,000 cells/larva/day from day 14. Settlement of the larvae was first observed on day 16 and majority were set on day 18. The relationship between the length and height of the larvae is described by the equation :

$$H = -8.9333 + 0.9351\,L$$

Where H and L represent height and length in μ respectively (Fig. 1). The coefficient of correlation between the parameters studied is 0.9901.

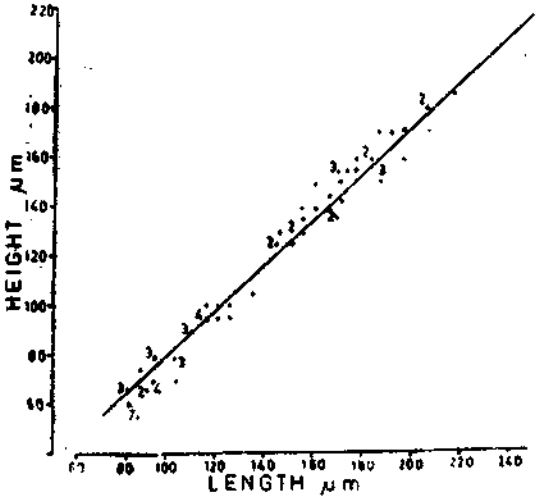

FIG. 1. The relationship between length and height in the larvae of *A. granosa*.

Spat rearing

On day 20, the post set clam measured 259.1 × 232.8 μ and the algal cell ration was increased to 12,000 cells/larva/day. On day 22, the shell of the spat measuring 283μ in length showed 18 ribs, a characteristic feature of adult *A. granosa* (Pl. II D). On day 25, the average size was 350.1 × 316.6μ and on day 31, it was 653.7 × 524 μ ; at this stage spiny periostracum was observed on the shell of the spat (Pl. II E). The food was increased to 15,000 cells/spat/day on day 25 and it was further increased to 20,000 cells/spat/day on day 40. The spat attained an average size of 1.114 × 0.953 mm on day 40 ; 1.87 × 1.48 mm on day 48 and on day 54, wide disparity in the growth of the spat was observed (Fig. 2). The minimum size of spat was 1.127 × 0.966 mm, maximum size 4.508 × 2.672 mm with an average of 2.35 × 1.67 mm. Food was increased to 25,000 cells/spat/day from day 48 to day 59. On this day, the spat attained an average size of 2.42 × 1.70 mm. In the hatchery, the growth of the post set clams was curvilinear and the following exponential equation describes their growth :

$$L = 0.0002739\ D^{2.3033}$$

Where L is length in mm and D is the number of days after spawning (Fig. 2). The r value obtained is 0.9944 which indicates high degree of correlation.

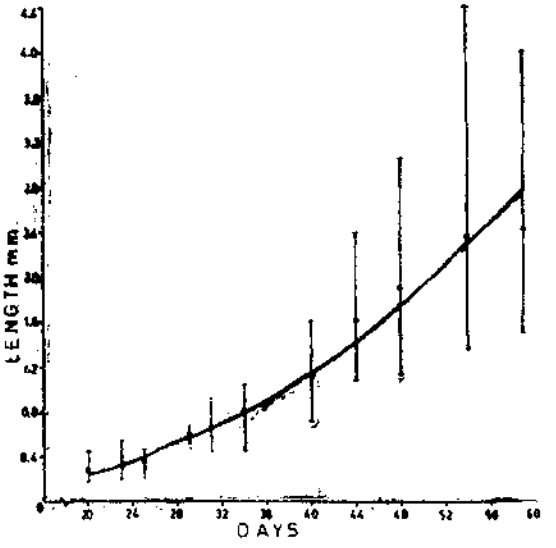

FIG. 2. Growth of the spat of *A. granosa* in the hatchery. Vertical line represents the length range and the solid circle, the mean length. The curve obtained by fitting the growth equation is also shown in the figure.

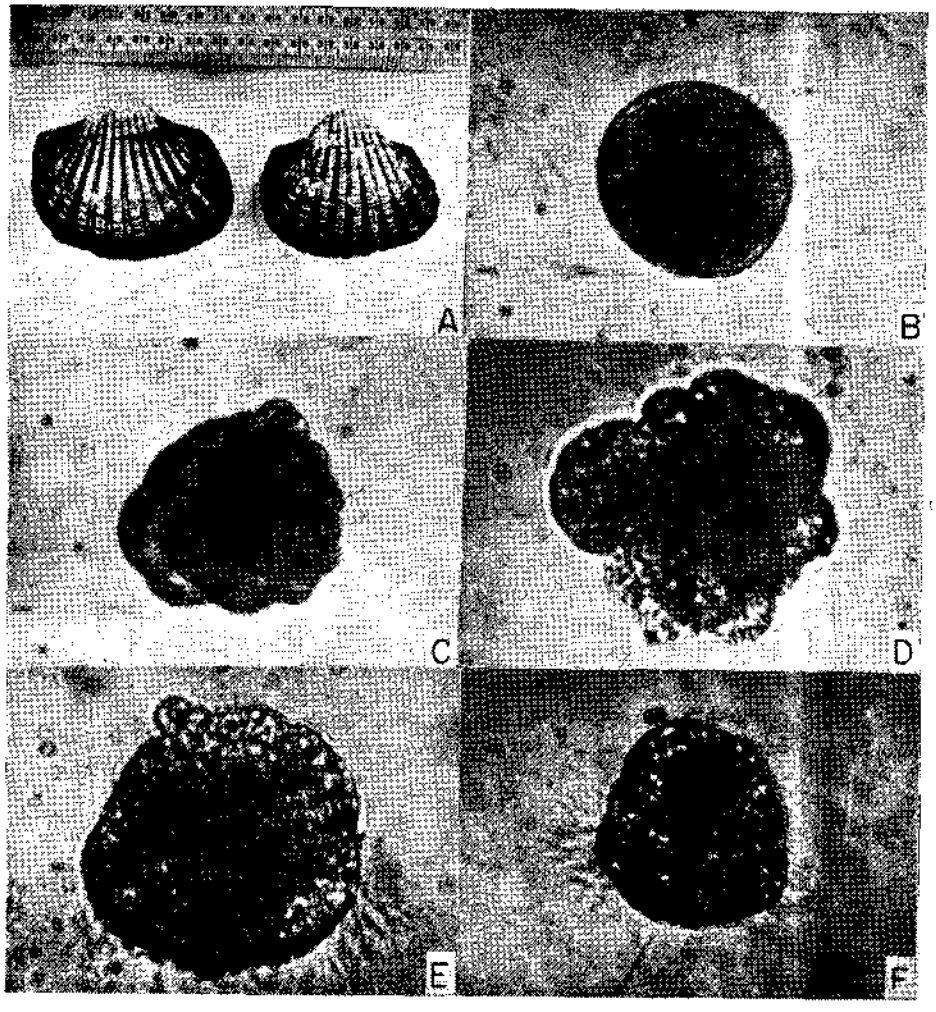

PLATE I. Adult clams and early developmental stages of *A. granosa*: A. Adult specimens, B. Fertilized egg (60μ), C, D. Cleavage stages, E. Morula stage and F. Trochophore larvae.

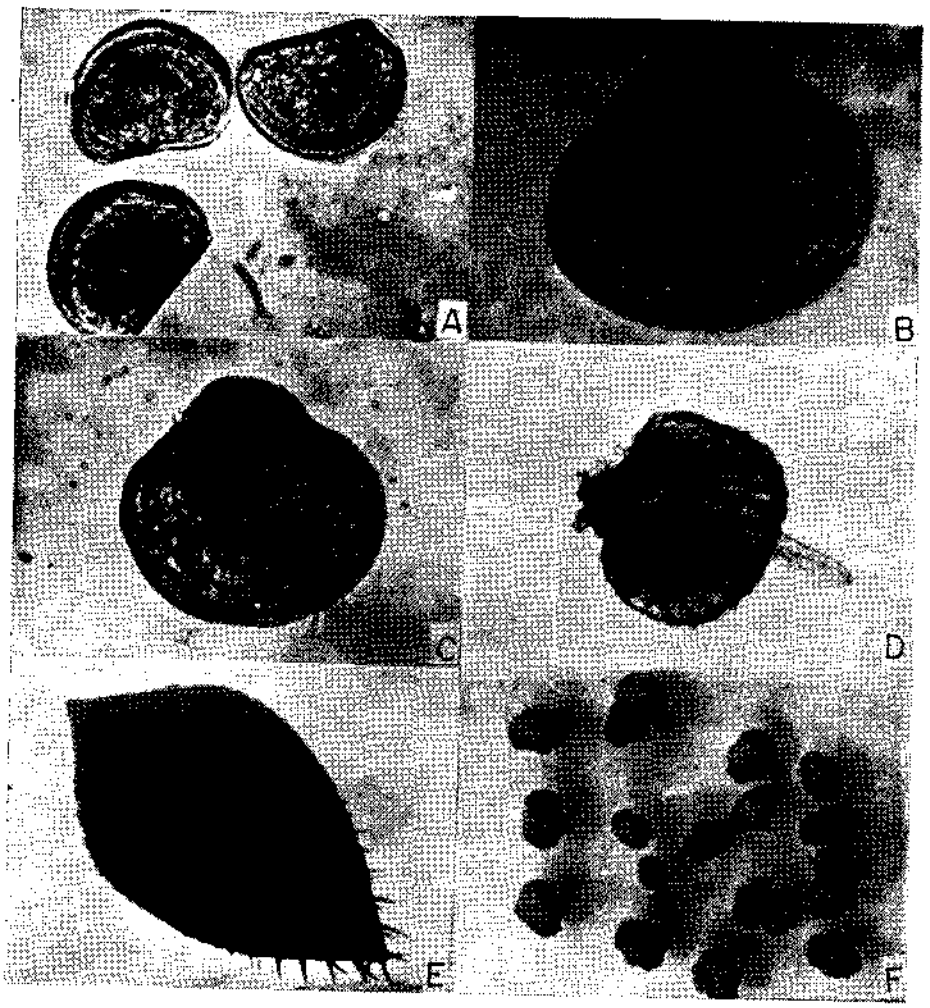

PLATE II. Larval stages and seeds of *A. granosa*: A. Straight hinge stage – Length 90 μ × height 70 μ, B. Umbo stage – 155.3 × 140.5 μ, C. Pediveliger stage – 182.7 × 162.9 μ, D. Post set clam measuring 350 μ in length showing ribes, E. Spat measuring 660 μ showing spiny periostracum and F. clam seed measuring 1.8 to 3.5 mm.

On day 1, the larval density in the first spawning was 312 larvae/l and in the second 600 larvae/l. Till the termination of the experiment in the hatchery, the same quantity of water was used in both the rearing studies.

Spat production

In the first rearing experiment, from out of 1,56,000 straight hinge larvae on day 1, the spat produced on day 59 was 7,576 which gave a survival rate of 4.86%. In the second rearing experiment, a total 6,000 day 1 larvae resulted in the production of 514 spat on day 60 which gave a survival rate of 8.57%.

Juvenile rearing

The hatchery produced blood clam seed (average length 2.42μ) were reared in the Tuticorin Bay from day 60 onwards in cages suspended from a rack. The average lengths attained were 6.47, 10.45, 14.50, 17.60 and 20.0 mm in 1-5 months respectively (Fig. 3). The survival rate during this 5 months juvenile rearing was quite high at 93%.

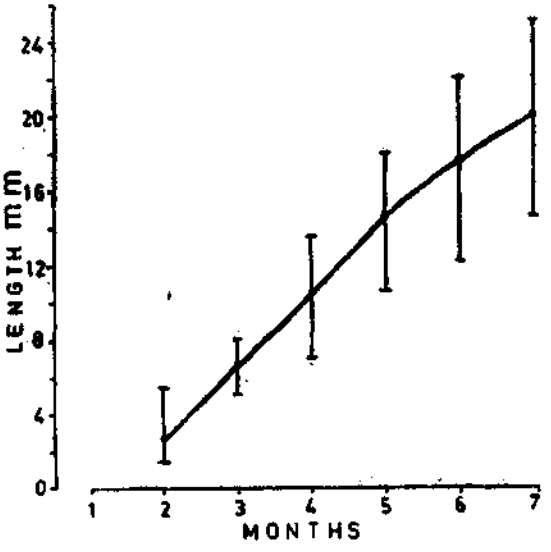

FIG. 3. Growth of the juveniles of *A. granosa* in the Tuticorin Bay. Vertical line represents the length range and the monthly mean lengths are connected by a curve drawn by eye.

DISCUSSION

In view of their importance in aquaculture, several species of blood clams were studied for induced spawning and larval development; in some cases spat production was achieved (Broom, 1985). Induced spawning in bivalves by thermal stimulation is well established. By this method, spawning was induced and in some instances, larval development studied in *Anadara broughtonii* (Kanno and Kikuchi, 1962; Kanno, 1963; Imai and Nishikawa, 1969; Yoo, 1969; Kim and Koo, 1973) in *A. subcrenata* (Ting *et al.*, 1972) and in *A. transversa* (Loosanoff and Davis,1963). From Malaysia, Wong *et al.* (1986) observed that *A. granosa* spawned on several occasions when exposed for the second time from 17±1°C to 34±1°C. However, in the present study, on both the occasions, spawning occurred in ripe *A. granosa* when the temperature was brought down from 32°C to 24°C.

Wong *et al.* (1986) conducted the rearing experiments of *A. granosa* at a temperature of 26-30°C and salinity of 32‰. Their study showed that the fertilized eggs of *A. granosa* measure 50-60μ, trochophore larvae 55-65μ and the straight hinge larvae which developed in 20-24 hrs, measure 70-90μ in length. The umbo stage was developed on day 12 and there was settlement between 21 to 23 days after fertilization. These results are comparable to those obtained in the present study except that the larval development was faster in this study. The most distinctive character in the larvae of *Anadara* spp. is the presence of a series of hinge teeth. While Wong *et al.* (1986) made no mention, Pathansali (1963) described the presence of 16 comb like teeth on the larval hinge of *A. granosa*, collected from plankton. In the present study also 14-16 teeth were observed in 12 and 16 day old larvae. In *A. broughtonii*, Tanaka (1971) found 3-7 teeth. Pathansali (1963) also reported on the presence of 10 concentric

lines on the larval shell of *A. granosa*. In this study also 8-10 concentric growth lines were observed on the shell of 12 and 16 days old larvae. In the prodissoconch of *A. broughtonii* and *A. subcrenata* also concentric growth lines were present (Tanaka, 1971). Similar growth lines were observed by the authors in two species of venerid clams reared recently and this character does not appear to have any diagnostic value.

According to Wong *et al.* (1986), in Malaysia, the spat of *A. granosa* attained 1.1 to 1.2 mm length in 2 months from spawning under laboratory conditions and in an upwelling system maintained in the laboratory, these spat attained average shell length of 18 and 19.7 mm after another 7½ months rearing. Thus from spawning, the clam seed attained <20 mm length in 9½ months. In the present study, the growth of *A. granosa* was faster, both in the hatchery and in the field since the spat reached 2.42 mm average length in the hatchery in 2 months from spawning and in the field they attained 20 mm average length in the following 5 months. Thus the overall growth in 7 months from spawning was 20 mm. The faster growth in this study may be due to favourable experimental/field conditions under which *A. granosa* was reared or it may be a genetic character of the population occurring in the Tuticorin Bay or both. It is of interest to note that *A. granosa* also grew faster under field culture in India (Narasimham, 1985) when compared to its growth in the culture fields in Malaysia (Broom, 1985).

Simple techniques for the culture of the blood clam were developed by Narasimham (1980) and a production of shell on weight of about 40 t/ha/5-7 months were obtained under field conditions in the Kakinada Bay (Silas *et al.*, 1982). For the transfer of clam culture technology to the farmers, the seed availability in nature proved to be a major constraint. In this context, the present study is significant as it developed the basic technology required for the hatchery production of the seed of *A. granosa*. Some of the techniques followed here, no doubt, need improvements so as to optimise the seed production both in terms of survival and growth. Towards this end further work is in progress.

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