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SPAWNING AND LARVAL DEVELOPMENT IN THE SNAIL *CERITHIUM CORALIUM* (PROSOBRANCHIA : CERITHIIDAE)

P. V. SREENIVASAN*
Centre of Advanced Study in Marine Biology, Parangipettai 608 502

ABSTRACT

The cerithiid snail *Cerithium coralium* (Kiener), spawns from February to September in Vellar Estuary. The snail spawned in the laboratory without any inducement. The ribbon-shaped spawn contains developing embryos enclosed in capsular wall. Maximum fecundity recorded was about 18,400 eggs in a single egg mass.

Early development involves formation of first polar lobe, polar body and second polar lobe in succession. Two-celled stage appears after two hours of spawning, and four celled stage after 4 hours. Trochophore stage is preceded by sterroblastula and gastrula stage. Veliger is formed within 24 hours, while hatching takes place after thirty six to fortytwo hours. Free veliger swims actively with the help of bilobed velar organs. Swim-crawl stage is attained by 12 days and larva settles as spat, when it is two and half whorled. The juveniles of five and seven whorled, lead benthic life with all adult characteristics. Intra-specific variations exist among the species of *Cerithium* in spawning periodicity, fecundity, size of the egg, development of embryo, hatching time and larval phase.

INTRODUCTION

FROM INDIA, ten species of the snails of the genus *Cerithium* (Family Cerithiidae) are known (Satyamurti, 1952). They are found in large concentrations in the shallow coastal waters, estuaries and backwaters. Many of them are intermediate hosts for digene worms and are of considerable importance in the human health programmes. Exhaustive accounts on the reproductive biology of different species of *Cerithium* are available in the works of Johansson (1953), Marcus and Marcus (1964), Raeihle (1968), Wolfson (1969), Houbrick (1970, 1971, 1973) and Cannon (1975) from other parts of the world. In spite of their wide distribution, not much is known about the reproductive strategies and development among the species of *Cerithium* from India, except for a brief description of eggs and early development of *Cerithium morus* (Natarajan, 1958) and *Clypeomorus* sp. (Manmadha Rao, 1977).

Cerithium coralium (Kiener) is found extensively in the subtidal area at the mouth of the Vellar Estuary. This species is found in close association with algal mats of *Chaetomorpha* sp. and reaches a population density of 1500/m². So far, nothing is known about its biology and other related aspects. Therefore, observations were made on the spawning, early development, pelagic larvae and juveniles and the results are presented in this account.

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* Present address : Madras Research Centre of CMFRI, 144 Marshalls Road, Egmore, Madras 600 008.

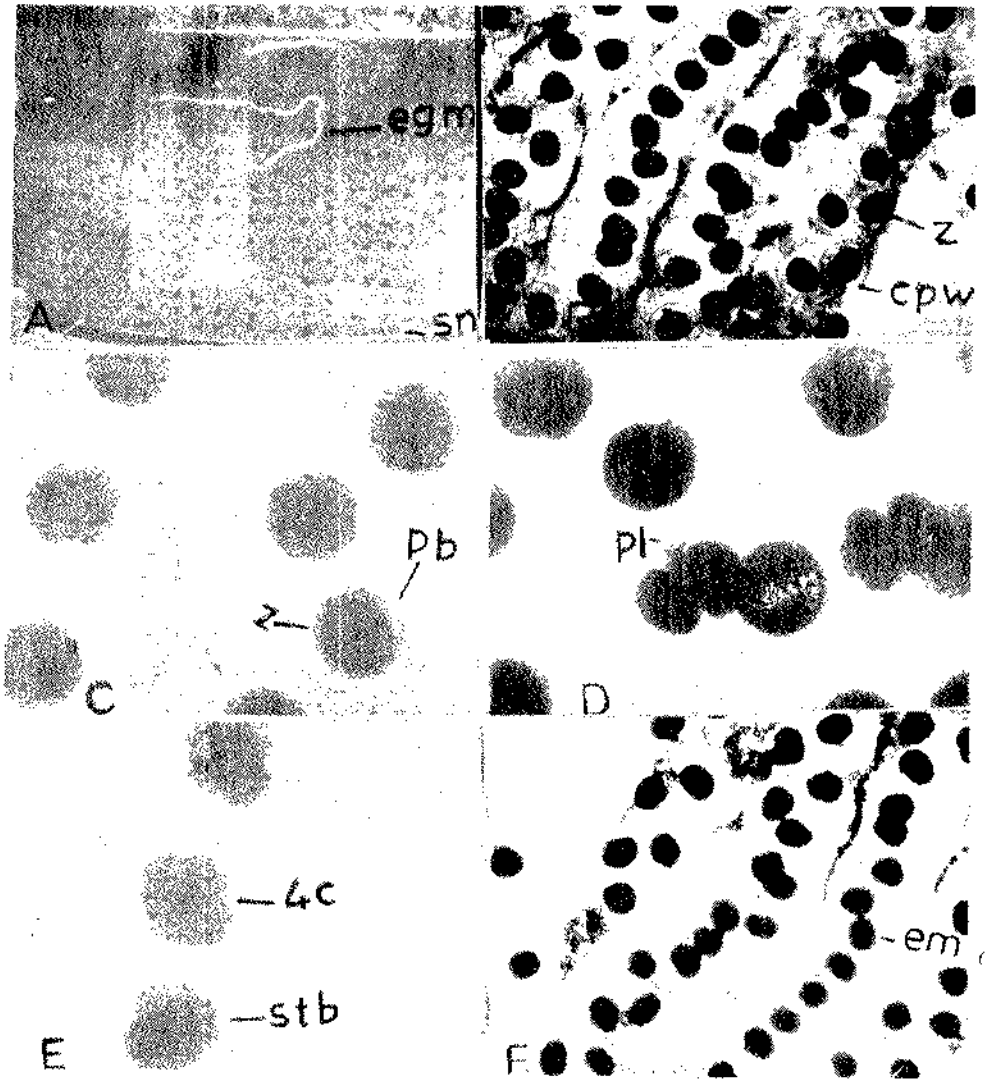

PLATE I. A. Egg mass on the side wall of the glass aquarium (The mother snail can also be seen). B. Egg mass with capsules. C. Single celled embryo with polar body. D. 2-celled stage with polar lobe. E. 4-celled and sterroblastula and F. Developing embryos. [acr : apical cilia, alf : albuminous fluid, apw : apical whorl, arc : archenteron, axr : axial rib, be : beak, bw: bodywhorl, ci : cilia, co : columella, cpw : capsular wall, dg: digestive gland, e : eye, egm: egg mass, em : embryo, f : foot, mc : mantle edge, mt : metatroch, op : operculum, pb : polar body, pl : polar lobe, prv : pre-veliger, sgr : spiral groove, sh : shell, sic : siphonal canal, sn : snail, st : statocyst, stb : sterro blastula, str : striations, te : tentacle, tr : trochophore stage, v : veliger, ve : velum, visc : visceral mass and z : zygote.

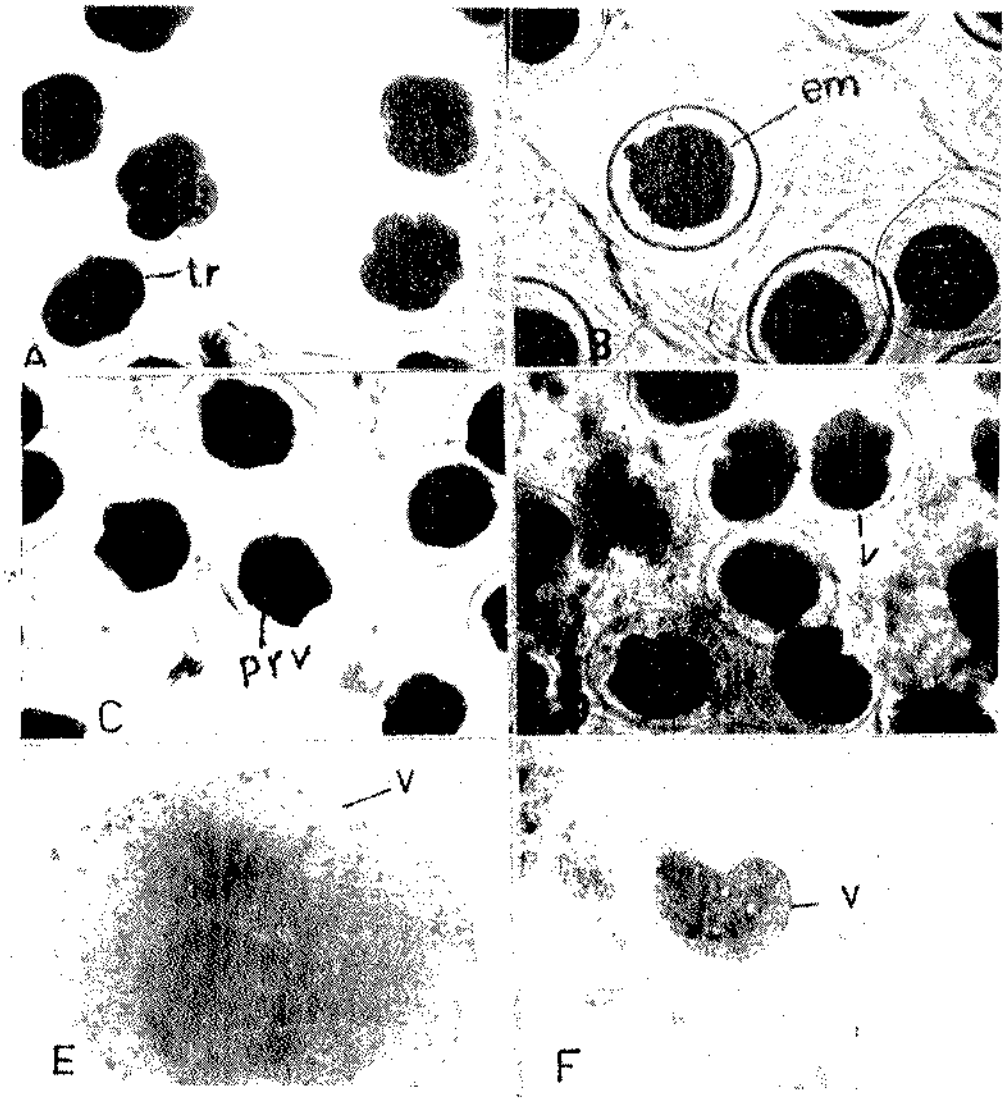

PLATE II — A. Trochophore stage, B. Advanced stage of development, C. Preveliger stage, D. Veliger within the egg capsule and E. Free veliger (D & E explain words, please see Plate I).

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Material and Methods

Cerithium coralium were brought from the Vellar Estuary (11°29′ N ; 79°46′ E), the natural habitat and kept in glass aquaria of 2 litre capacity, with 3/4 of it filled with filtered seawater. Fronds of *Chaetomorpha* sp. were provided in the aquaria, since the snail is found in association of the alga in the natural environment.

The snail spawned in the laboratory without any inducement. Ribbons of egg mass were carefully removed to 500 ml glass beakers, filled with filtered seawater and reared for further developmental stages. The salinity of the seawater ranged from 30.50 to 33.25‰ during the period of observations. Room temperature ranged from 30.5° to 32.5°C during day time and 24.3° to 25.0°C during night. Water was changed daily. While transferring the larvae, only active ones were transferred and weak and dying larvae were rejected. No feeding or aeration was resorted to during the present study.

Eggs and larvae were examined periodically, after narcotising them with 10% aquous Magnesium chloride solution. They were examined under light microscope and illustrations were drawn with camera lucida at table top magnification. Photomicrographs were taken.

Observations

Cerithium coralium is a hermophrodite however, there are no characters which can distinguish the sex externally. The testis is bright yellow in colour, while the ovary is creamy. The reproductive system is simple as in other cerithiids, described earlier (Houbrick, 1971 ; Cannon, 1975). The system includes the gonad, gonoduct and open pallial duct. The gonadial products are freely dispersed into the mantle cavity to be carried away by ciliary currents created by the ciliated cells in the gonoducts. Two types of sperms, eupyrene and apyrene were present. No spermatophere formation was observed during the present study.

Instances of parasitic castration by digene parasites were recorded frequently and nearly 10% of the population of the snail were found infected. Gonads of such snails resemble that of the testis in colour, but there are only different stages of developing worms are found in the gonad, in the place of spermatocytes.

Spawning

Cerithium coralium kept in the glass aquaria spawned on 10 occasions on 8th, 10th, 11th, 20th and 24th of March, 1st, 7th, 15th, 21st and 28th of April 1984. Similar spawnings were also recorded in May, June, July, August, September 1984 and again in February 1985. Only on two occasions, the spawning took place during day time, while the rest were in the night and early hours of the day time. On 17th March 1984, the spawning started at 0800 hrs and completed by 1330 hrs, when a female of 18.3 mm shell length laid an egg mass of 232 mm (Pl. I A). While laying the eggs, the female attached firmly to the sides of the aquarium and exuded strings of eggs with a lot of mucus. The movement of the snail was very slow. Short, jerky movements and turns of the foot were observed frequently as the eggs, embedded in a filament emerged. The filament moved very slowly from the right side of the mantle cavity near the exhalent siphon and proceeded down the right side of the foot. During deposition, the tip of the shell periodically moved forward pendulously, as the animal turned. The snail's radula continuously rasped the substrate, probably preparing the surface for attachment of the egg mass. Slight disturbances did not affect the snail, but on displace-

ment. the snail lost its spawning urge and moved away. Because of this nature, partial spawning was observed to be common and bits of the egg mass was found scattered all over the sides of the aquaria and on the algal filaments. The egg mass was found only near the water mark or slightly below, but never above the water level or in the bottom of the tank. In the field, bits of such egg mass were found on the algal filaments and on small boulders. resilent. Filaments were about 0.6 mm thick and 2.5 mm in length, and enclosed about forty egg capsules.

Individual egg capsules measuring 170-175 μ (Fig. 1 a), embeded within the gelatinous matrix of the filament, were arranged in pairs, each surrounded by a tough hyaline capsule. Within the hyaline capsule, the egg was surrounded and bathed by albuminous fluid, which was

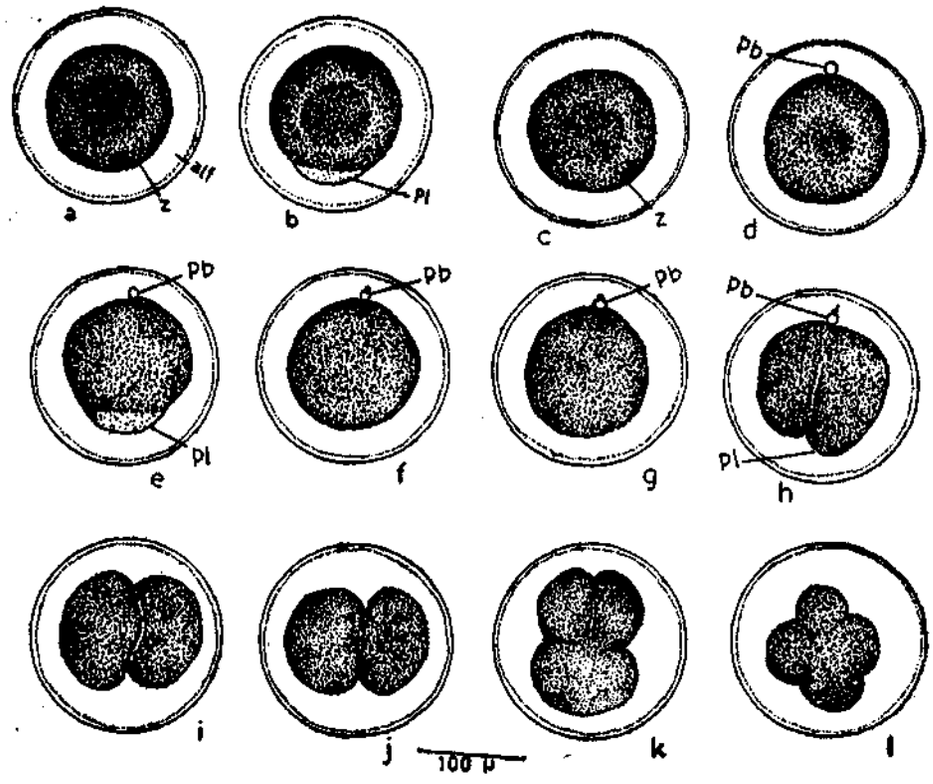

Fig. 1 a. Single egg capsule, b. Formation of first polar lobe, c. Withdrawal of polar lobe, d. Polar body formation, e. Second polar lobe formation, f. Withdrawal of second polar lobe, g. Cleavage in the polar body, h. Cleavage of egg and formation of third polar lobe. i. Cleavage of egg. j. 2-celled stage ; k and l. 4-celled stage (For explanations, please see Plate I).

The egg mass of *C. coralium* were deposited in a long, tightly coiled filaments (Pl. I B), arranged side by side. The filaments were composed of an external limiting membrane and an internal jelly, which was hard, but viscous near the capsular wall, but more clear near the egg. Within the egg capsule, zygote (or egg) measuring 110-115 μ in diameter were found. The egg was yellowish dark in colour and telolecithal. There were about 800 eggs

per cm of filament and the highest number of eggs recorded was 18,400 in the egg mass of 232 mm in length.

Early development

Soon after release, the egg was inactive for 15 minutes. Later, the first polar lobe formed slowly at the vegetal pole (Fig. 1 b) and gradually resorbed (Fig. 1 c). The egg appeared spherical again. After a brief pause, the first polar body formed at the animal pole (Fig. 1 d ; Pl. I C). The polar body was totally yolk-free and measured 10-15 μ. The second polar lobe appeared after 2 hrs (Fig. 1 e). Cleavage of the cells commenced with the formation of the third polar lobe (Fig. 1 f-h), leading to 2-celled stage (Fig. 1 i, j ; Pl. I D). Meantime, the polar body was resorbed. Four-celled stage was observed after 4 hrs of spawning. The cells were equal in size at this stage (Fig. 1 k, l ; Pl. I E). Eight-celled stage was observed after six hrs. Four micromeres and four macromeres were evident at this stage (Fig. 2 a, b). From this stage onwards, cleavage of individual cells were difficult to follow. Further divisions of the cells lead to the formation of sterroblastula, after eight hrs (Fig. 2 c-e). Development acquired momentum from this stage onwards, with cells formed by micromeres encircling macromeres, leading to gastrulation (Fig. 2 f, g ; Pl. I F), after nine hours. Trochophore stage was observed after twelve hrs (Fig. 2 h ; Pl. II A). Trochophore was oval with minute epitrochal cilia and a narrow band of metatrochal cilia. Embryo began to rotate with the help of cilia within the egg

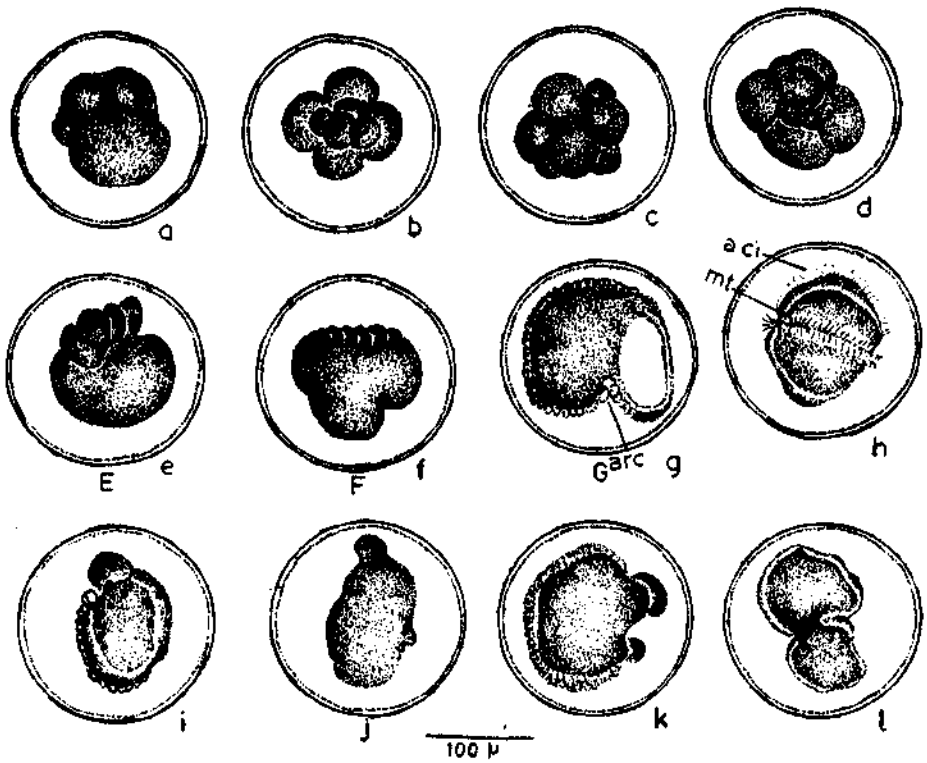

Fig. 2 a, b. 8-celled stage with macromeres and micromeres, c-e. Formation of sterroblastula, f. Sterroblastula, g. gastrula, h. Trochophore stage, i, j. Elongation of embryo, k. and l. Process of torsion (For explanations, please see Plate I).

capsule. Later, the embryo elongated (Fig. 2 i, j) and process of torsion made both the anterior and posterior ends to curve and join after fifteen hrs (Fig. 2 k, l ; 3 a-g). Preveliger with velar lobes formed after 20 hrs (Fig. 3 h ; Pl. II B, C). Fully developed veliger was observed after twenty-four hrs (Fig. 3 i ; Pl. II D, E).

was visible through the shell. The liver was coiled and full of reserve materials for the development of the embryo.

The veliger remained within the egg capsule for another twelve to eighteen hrs and finally hatched out from the capsule by thirty to forty-two hrs. Due to time gap in the release

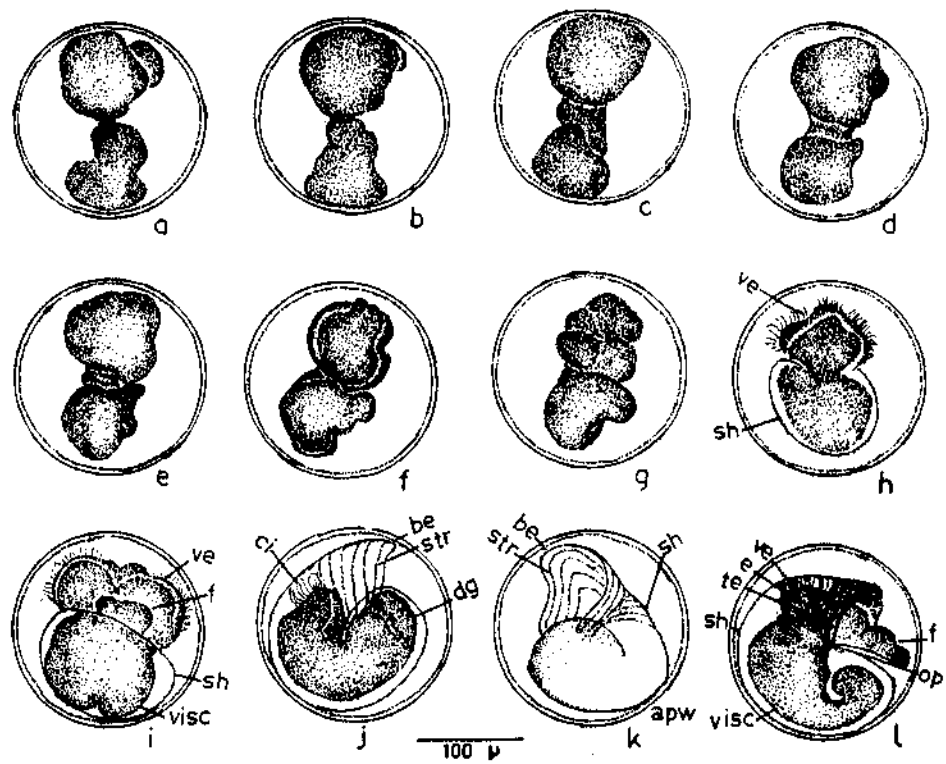

Fig. 3 a-g, Process of torsion, h, Pre-veliger stage, i, j, Fully formed veliger, k, Empty shell of veliger within the egg capsule and l, Veliger prior to hatching (For explanations, please see Plate I).

Veliger within the egg capsule measured 155-160 μ (Fig. 3 j-l). The shell is clearly evident with a prominent beak. The protoconch is pitted and the beak striated. Two velar lobes with two rows of cilia were visible. Foot prominent. Operculum was present and covered the aperture on withdrawal of the body into the shell. A prominent pair of eyes on the tentacles was found. The visceral mass contained the pulsating larval heart, which

of eggs from the mother, all the veligers in an egg mass could neither develop nor be released simultaneously, but only gradually. The emergence from the egg capsule appeared to be due to breaking of the capsular wall by ciliary beat of the veliger. The egg mass completely dissolved in sea water after sixty to seventy hrs, which also ensured the release of all the embryo from the egg capsule.

Planktotrophic larva

The veliger on hatching measured about 160 μ (Fig. 4 a). The larva was extremely active and swam upwards and downwards in a group. They exhibited positive phototaxis behaviour. The veliger poss ssed a strongly beaked shell with sculptures similar to the pre-hatched stage. The shell was highly transparent, exhibiting the interior organs. Velum, eyes, tentacles, mouth, foot and statocyst were present. The digestive gland was yellow with yolk granules.

stage was reached (Fig. 4 b). The beak became stronger with many lines of growth. There was no difference in any other morphology except in the reduction of yolk in the digestive gland. On sixth, seventh and eighth days, the larva measured 180-190 μ (Fig. 4 c). On nineth day, the larva attains 190-195 μ in size and two and half whorled. Morphological differences were found in the velar organs and reduced. Foot became elongated and contractile. The larva often settled on the bottom and swam again. Further changes

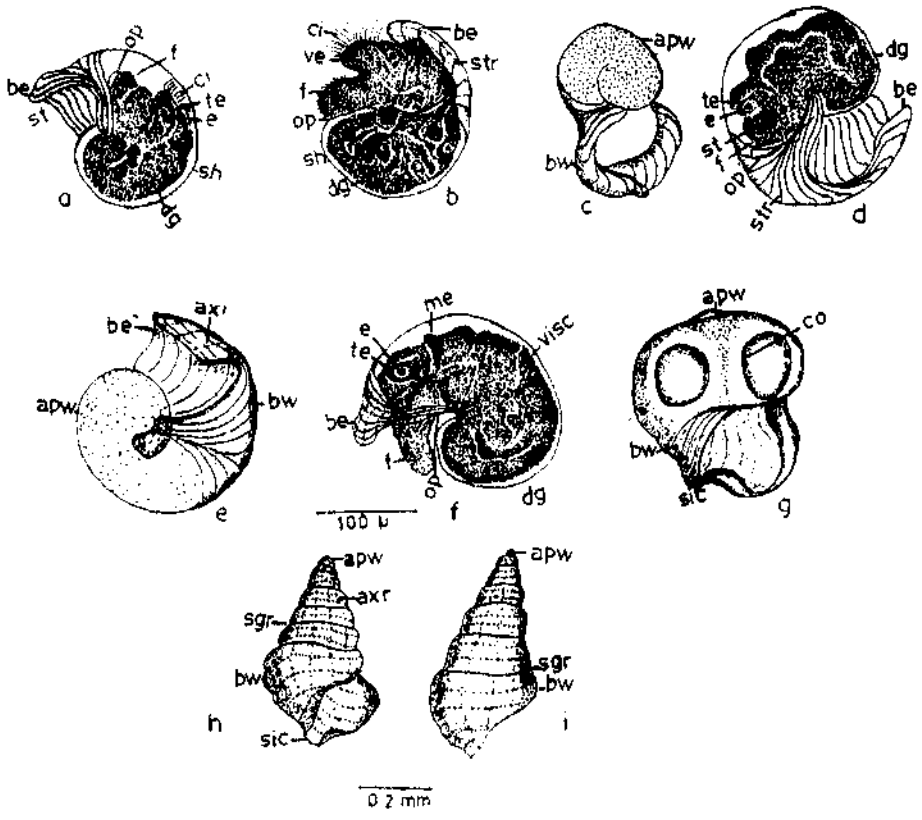

Fig. 4 a, Free veliger on hatching, b. 5-days old veliger, c. Empty shell of 7-days old veliger to show ornamentation, d,e. 10-days old veliger (swim-crawl stage), f,g. 12-days old veliger, h and i. Juvenile snail (oral and aboral views respectively) (For explanations, please see Plate I).

Growth of the veliger on subsequent days of hatching, was slow and steady. On second, third and fourth days, the veliger measured 165-175 μ (Pl. II F). On fifth day, two-whorled were noticed on tenth and eleventh days, when the larva started crawling with foot and also swam with the help of reduced velum (the swim-crawl stage). The larva measured 190-195 μ

at this stage (Fig. 4 d, e). On twelfth day, the velum was lost and the larva settled as spat (Fig. 4 f, g). Movement at this stage was very brisk. The spat was two and half whorled and measured 200-210 μ. The transparency of the shell became obscure, because of the deposition of calcareous materials. Protoconch was pitted. Columella was visible clearly through the bodywhorl. Further growth was not observed in the laboratory.

Juveniles

Juveniles of five and seven whorled, were collected from the field. The former measured 0.55 mm and the latter 0.70 mm (Fig. 4 h, i). They were pale white in colour. The shell sculptures with striations and axial ribs were clearly seen. Anterior siphonal canal was distinct and well developed. Movements of the juveniles were very brisk with the protractile foot. Black chromatophores were found all over the body, especially on the foot, head and mantle.

Discussion

In the reproductive strategy such as nature of spawning, formation of egg mass, intra-capsular development of the embryo, hatching and the larval phase, *C. coralium* shows close similarity to those of the earlier observations by Johansson (1953), Marcus and Marcus (1964), Raeihle (1968), Wolfson (1969), Houbrick (1970, 1971, 1973) and Cannon (1975). Houbrick (1973) in an exhaustive account on the reproductive biology of the species of *Cerithium*, showed that among the species of this genus, greater diversity exists in the spawning periodicity, fecundity, types of development, time required for developmental stages and nature of development. Periodicity of spawning is restricted for single month in some species like *C. guinaicum* to all through the year in *C. litteratum*. Fecundity varies from a mere 250 eggs in *C. lutosum* to about 90,000 in *C. guinaicum*. Direct development was observed in *C. muscarum* and *C. lutosum*, while indirect development with pelagic phase is present in other species. Incubation period ranges from three days to four weeks (in the case of *C. muscarum* and *C. lutosum*). Size of the egg ranges from 90 μ in *C. ebernum* to 250 μ in *C. muscarum* and that of the egg capsule from 130 to 500 μ. The size of the veliger also varies from 95 μ to 300 μ.

Natarajan (1958) reported for *C. morus* from Indian waters, an extended spawning period from July to January, indirect development and the sizes of zygote, egg capsule and veliger being 120 μ, 160 μ and 200 μ respectively. Incubation period recorded was 72 hours. In the case of *Clypeomorus* sp., Manmadha Rao (1977) recorded spawning all through the year, indirect development and a fecundity of 39,000 eggs in an egg mass. The sizes of the egg capsule ovum and the veliger being 70μ, 60μ and 57μ are much less than the former species. Incubation period in this species is about 80 hrs.

The present observations on *C. coralium* indicate a prolonged spawning period from February to September. Maximum fecundity recorded was 18,400. The average size of the egg capsule is 175 μ, while those of the zygote and the veliger are 115μ and 160μ respectively. Incubation period was only 36-42 hrs, which is much less than the earlier observations.

The above studies evidence that there are interspecific and intra-specific diversities among the different species of *Cerithium*, in spawning periodicity, fecundity, period of incubation, size of the egg and capsule and also that of veliger, as opined by Houbrick (1971).

The difference in the spawning periodicity of a species appears to be determined by the environmental conditions of the locality. Prolonged favourable conditions such as optimum temperature, salinity, availability, of planktonic food for the larvae, etc. tend to favour longer periods of spawning activity among molluscs

(Loosanoff and Davis, 1952 ; Allen, 1963 ; Webber and Giese, 1969 ; Vohra, 1970). Fecundity among the species of *Cerithium*, indicates that larger the size of the egg capsule and egg, lower the fecundity and smaller the egg capsule and egg, larger the number spawned. Number of eggs per spawn also vary with the size of the animal, its condition and also on the time of the year. Moreover, the snails that have direct development, tend to have low fecundity (Houbrick, 1971 ; Cannon, 1975).

Period of incubation of the embryo within the egg capsule depends on the reserve food material available in the capsule. Less the food, quicker the development and hatching is also earlier. This phenomenon appears to be the case with *C. coralium*, where the incubation period is much less than other species of *Cerithium*.

According to Houbrick (1971), all cerithiids invest their egg capsules within jelly filaments. According to Fretter and Graham (1964) and D'Asaro (1970), the jelly in the egg mass prevents the spawn from drying and protects the embryo from infestations. These observations are further evidenced by the present study.

Regarding the nature of development among cerithiids, Houbrick (1971) remarks that the first and most common method is the indirect development involving a planktonic veliger. This pattern involves many eggs, rapid cleavage and attainment of veliger stage, a short encapsulated period and emergence of planktonic veligers. And this is followed by a pelagic phase of varying length before settling occurs. In contrast, the direct development involves more jelly in the egg mass and tougher hyaline capsules, generally fewer eggs, a slower encapsulated development and hatching when the young ones are completely metamorphosed. Both the methods are adaptive ones, correlated with their ability to survive. However, the former method is undoubtedly an advantageous one in that it ensures wide dispersal over the environment and also enables free flow of genetic material among the population. The success of a species is largely dependent upon its ability to produce and maintain its larval stage. Successful colonisation of *C. coralium* in its natural habitat indicates that the reproductive strategy adopted by the species is most suitable.

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