STUDIES ON THE DEVELOPMENT OF TWO SPECIES OF STROMBIDAE FROM THE RED SEA

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SUMMARY

1.—*Strombus gibberulus* lays small faint yellow solitary eggs (90μ) arranged in a very thin long thread, which is also coiled ; entangled and coated with fine sand granules and is formed in triangular mass of about 3 to 5 cms. across. The first two cleavages are equal. Development proceeds rapidly and the free swimming veliger larva hatches out after 3 to 4 days of spawning It possesses a transparent bilobed velum (37μ x 52μ), a large triangular foot with its anterior constricted region carrying a tuft of small cilia and two rose spots on the sides of its metapodium, and a transparent larval shell of about one whorl (105 x 100μ).

2.—*Strombus fasciatus* deposited, in the laboratory, its coiled and entangled ribbon which was glued as no sand granules were provided. The yellow eggs (130μ) are arranged in rows of five eggs and a median one between the row. The larvae could not be obtained as all embryos died after three days of spawning.

INTRODUCTION AND HISTORICAL

There is a lack of knowledge of the development of Strombidae from the Red Sea. Only the egg-masses, development and metamorphosis of *Pterocera bryonia* (Gohar & Eisawy, 1967) and *Strombus* (*Monodactyles*) *tricornis* (Eisawy & Sorial, 1968) were previously described. In the present work the egg-masses and development of *Strombus* (*Conaruim*) *gibberulus* Linne and the egg-ribbon of *S.* (*Conarium*) *fasciatus* were observed. In the mean time this work is one of a series of studies on the developmental stages of some prosobranchs (Gohar & Eisawy, 1963 & 1967; Eisawy, 1970 & 1972) which are envolved in the temporary plankton of the Red Sea. Also the flesh of these two species is of economic value, being edible and is used as fish bait.

Studies on the breeding and larval development of other species of Strombidae appear to be limited to the following aurhors: Lamy (1928) and Risbec (1932) examined the spawn of *Pterocera* (=*Lambis*) lanbis Linne from New Caledonia. From the same locality Risbec (1932) studied the spawn which he thought to be that of *S. rugosus* Sowerby, as well as the spawn of *S. canarium* Linne (1945). From Florida the egg laying process of *S. pugilis alatus* Gmelin was noticed by Bower (1945), and description of the same species was made by Perry and Schwengel (1955). Ostergaard (1950) described the early embryological stages of *S.* (*Canarium*) *maculatus "Nuttall"* (Sowerby) from Hawaiian Island. Robertson (1959) studied the egg-masses and followed the development through the veliger stage of three species of conchs : *S. gigas* Linne, *S. castatus* Gmelin and *S. raninus* Gmelin from Bahamas. Randall (1964) described the reproductive habit of S. gigas, and D'Asaro (1965) gave an extensive account on the organogensis, development and metamorphosis of the same species.

The egg-masses of the present 2 species of Strombus are similar to those of other species of the family, consisting of eggs enveloped in a long twisted and entangled gelatinous string. The differences lie in the thickness and length of the ribbon, as well as the arrangement, number size and colouration of eggs.

According to Macdonald (1860), suggestion of Thorson (1940) and some of the above mentioned authors, the Strombidae are forms with free swimming pelagic larvae.

MATERIAL AND METHODS

The two species of *Strombus* were collected from the tidal zone, where they are living on coral reefs at Al-Gardaqua; Red Sea, and were kept separately in vivaria of the Marine Biological Station where they lived in a good condition for long time.

The egg-ribbon of both species were laid in the vivaria but only similar ones to those of *S. gibberulus* could be collected from the Sea. Parts of egg-ribbons, at various stages of development, were fixed in a properly expanded condition after narcotization in an isotonic solution of magneium chloride. The developmental stages were killed by addition concentrated formalin neutralized with borax, then fixed in 10% formaline in sea water and preserved in 70% alcohol.

Description and illustration of the egg-ribbons and developmental stages were performed on living material. Microscopic drawings of narcotized and fixed stages were carried out with the aid of a camera lucida.

1. Strombus (Canarium) gibberulus Linne.

A — *Habitat :*

S. gibberulus is abundant in the tidal zone, on dead fringing coral reefs near the Station, and round some islands of the area as Abu-Minkar, Gevatine and Shadwan Islands. It usually lives on beds of sea grass, at depths ranging between 6 inches and 3 feet. There is a tendency towards zoning, and sometimes groups of 50 to 200 animals are present in the area of one square mater. The habitat of this species is nearly similar to that of *S. tricornis* and other species of the family. The animal is very active and possesses a very strong foot with a serrated sharp claw-like operculum. It moves about by a series of jerking leaps and also can quick right itself if it is turned over on its back.

It is herbivorous, scraping the algae from the bottom or from the upper surface of shells or rocks.

The flesh of this animal is edible and is used as fish bait. The shell is also used for making handsome objects. The animals are also attacked by some predators as those mentioned in case of *S. tricornis*. In addition *Thais savignyi* was observed attacking 3 specimens in one hour. The empty shell is also used as a shelter by the hermit crabs.

B - Spawning and Egg - Ribbon :

The breeding season of *S. gibberulus* lasts from June till the end of August at a water temperature ranging between 26° and 30°C (in the laboratory mainly during August where average temperature is about 28°C). Similar eggmasses were also collected from the sea where they were laid at the tidal zone on fine sandy bottom or weakly attached to solid substratum. The animal usually prefers area with white fine sand granules contaminated with minute mud particles for spawning.

The egg-mass of this species (Fig.1) consists of a very thin long continuous thread which is coiled and entangled by the parent animal forming a triangular shape of about 3 to 5 cms.across. When freshly laid, the outer surface of the thread is sticky, gelatinous and is surrounded by a comparatively wide light mucoid substance. For that reason, a comparatively large quantity of fine sand granules adheres round the string giving it a rough cover which serves for the protection of eggs (Fig. 2). It was observed that the newly laid masses in-door aquarium which is free from sand grains, had no distinct thread but glued and confused in shape. Also their embryos died just after gastrulation while those obtained from the sea proceeded in development until hatching of the larvae. The string (Fig. 2) consists of cylindrical gelatinous tube in the middle of which are embedded the eggs which regularly arranged in a single row. The diameter of the tube is about 130 μ while that of the outer coat of sand grains is about 300 μ to 350 μ). The undeveloped egg (Fig. 2 & 3) is spherical in shape, faint yellow in colour and measures about 90 μ in diameter. It is surrounded with a narrow transparent case which is about 100 μ in diameter.

C — *Development* :

The development of *S. gibberulus* proceeds faster than that of *S. tricornis,* and lasts about 3 to 4 days from spawning till hatching of larvae, at an average water temperature of 28°C. This may be due to the very small eggs with little yolk and the comparatively high temperature during the breeding season.

The two polar bodies are extended just before the start of segmentation. The first cleavage occurs after one hour from spawning and gives rise to two nearly equal blastomeres (Fig. 4). The second cleavage is perpendicular to the first and results in the formation of four nearly equal cells in which "D" is slightly larger than the other three (Figs. 5 & 6).

The first quartette is attained by cutting off four small micromeres at the animal pole in a dextral position (Fig. 7). The second quartette is also attained by cutting off another four micromeres, sinsitrally arranged to the original four macromeres (Fig. 8).

The third dextral quartette gives rise to another four smaller micromeres & thus a stage of 12 cells is obtained (Fig. 9). The fourth quartette and the multiplication of the first three quartettes could not be exactly observed but generally they may be attained in the same manner as *S. tricornis.*

A blastula stage (Fig. 10), with a blastopore at the ventral side, is formed when the micromeres of the first three quartettes overgrow the macromeres which at the same time are invaginated.

The gastrula (Fig. 11), is formed after 18 hours from spawning when the micromeres arrange themselves in such a manner to form the ectoderm. The 4 macromeres will be the future endoderm of the embryo. It is nearly spherical in shape and measure about 93 μ in diameter.

Unfotunately further develoment could not be observed as the number of reared embryos were not enough to study organogensis in the developmental stages. Only study of the hatched larvae and their growth is achieved. This gap will be fulfilled later.

D - Hatching and Growth of Veliger

After three to four days of spawning, the larvae emerge out from the ribbon as typical small veligers. The newly hatched veliger larva of this species (Fig. 12 & 13) is a very active swimmer, positive phototactic and negative geutactic as it moves towards lighted area near the surface of the rearing basin. It possesses a transparent colourless bilobed velum which is provided with short cilia. The two velar lobes are oval in shape and nearly equal in size, and each is about 37 μ in length and 32 μ in the greatest breadth. A small ciliated mit-velar lobe is present behind and between the velar lobes. On its sides there are two small violet eye-spots (ocelli) which are situated at the bases of two small tentacles. The mantle fold is slightly thick, and at its right side open the anus. The foot is slightly large, capable of contraction and measures about 35 μ in length and 25 μ in breadth. It consists of a small cylindrical propodium and a flat triangular metapodium below which a small transparent operculum is present. The metapodium is constricted anteriorly with a tuft of small cilia, and is provided with two charatertic rose-coloured spots, one at each side of the anterior part. The two symmetrical otocysts are distinct at the base of the foot. The mouth is rounded, ciliated and situated between the velar lobes above the foot. The visceral mass is faint yellowish in colour and appears clearly through the transparent shell. It is differentiated into a small oesophagus which opens into a small stomach. The latter opens to the outside by the anus through a short intestine. There are two asymmetrical liver lobes occupying most of the shell. The heart which consists of a single small chamber could be easily distinguished as a contracting organ at the dorsal side of the larva. Its contraction and expansion would change the size about the double. There is a well-developed retractor muscle which is clearly visible extending from the shell to the anterior part of the visceral mass. The shell is transparent, about one complete whorl and measures about 105 μ in length and 100 μ in the greatest breadth.

The veliger grows greatly at the beeginning of its planktonic life. At the third day of swimming nearly all organs increase too much in size, especially the velum, the foot and the shell (Figs. 14 & 15). The velum is now measuring about 62 μ in length and 50 μ in the greatest breadth, and still acts as the effective swimming organ. Its cilia have been more elongated and are beating rhythmically keeping the larva upright with the apex of the shell against the bottom. The foot enlarges and is about 62 μ long and 42 μ in breadth with its characteristic features. The shell becomes larger and measures about 145 μ in length and 155 μ in greatest breadth. The new growth is transparent, colourless and is slightly more obvious at the dorsal side of the opening of the shell. All other organs such as tentacles, operculum and visceral mass increase also in size.

After five days of hatching, the larva grows gradually with the enlargement of all organs, sepecially the velum(Figs. 16&17). It is still positive phototactic, as it moves towards the more lighted area. The larvae attain their positive geutaxy gradually. The velum measures about 87 μ long and 62 μ in the greatest breadth, with longercilia and more elongated tendacles. The shell, which is now slightly more than one whorl, is about 150 μ long and 140 μ in the greatest breadth Also the new growth is transparent and is more distinct at the dorsal side of the opening that it appears as a blunt broad keel between the velar lobes. The foot is about 75 μ in length and 47 μ in breadth. with its two characteristic rosy spots and the anterior constriction more distinct. The visceral mass increase in size, especially the oesophagus, the stomach and the intestine, but the liver lobes do not fill the shell completely and accordingly the retractor muscle is more enlarged.

Unfortunately, it was impossible to follow the metamorphosis, as all larvae died after seven days of hatching when the shell is about 172 μ in length and 140 μ in the greatest breadth (Figs. 18 & 19). The new growth of the shell is also more distinct at the dorsal side of the opening. Before death of larvae, the velum was still large in size and did not show any tendency towards reduction.

It appears from the continuous enlargement of the velum and the gradual growth of both foot and shell that the larva will spend a longer period than these seven days in the planktonic life before metamorphosing to the young.

2. Strombus (Canarium) fasciatus Born

A — Habitat :

This small spotted stromb is also abundant in the tidal zone among dead coral reefs near the station, but it is less crowded than *S. gibberulus*. It lives in a similar habitat like that of the former species, but at deeper water which may reach down to two and half meters. It is also herbivorous, scraping the delicate algae from the bottom or rocks. Its movement is similar to that of the family, being in a series of jerking leeps.

The flesh of this species is used sometimes as fish bait. It possesses a very handsome shell which is used in curio objects by native inhabitants of the Red Sea. The animal is also attacked by other gastropod predators which are mentioned with the formei two specis of *Strombus*, and its shell is used as shelter by some hermit crabs.

B — Spawning and Egg-Ribbon :

Some specimens of this species were kept in the indoor vivaria. Only one egg-ribbon was laid during August at an average water temperature of 28°C. Similar egg-ribbon could not be obtained from the sa. It was not observed that this species migrates during the breeding season to the shallower water as in the form species; and thus spawning may occur at deeper water.

The single egg-ribbon obtained was reared, but unfortunately all embryos died within three to four days of spawning and thus the hatching larvae could not be obtained. The death of the embyos may be attributed to the fact that the ribbon was not covered with sand granules which serve for the protection of eggs as in other species.

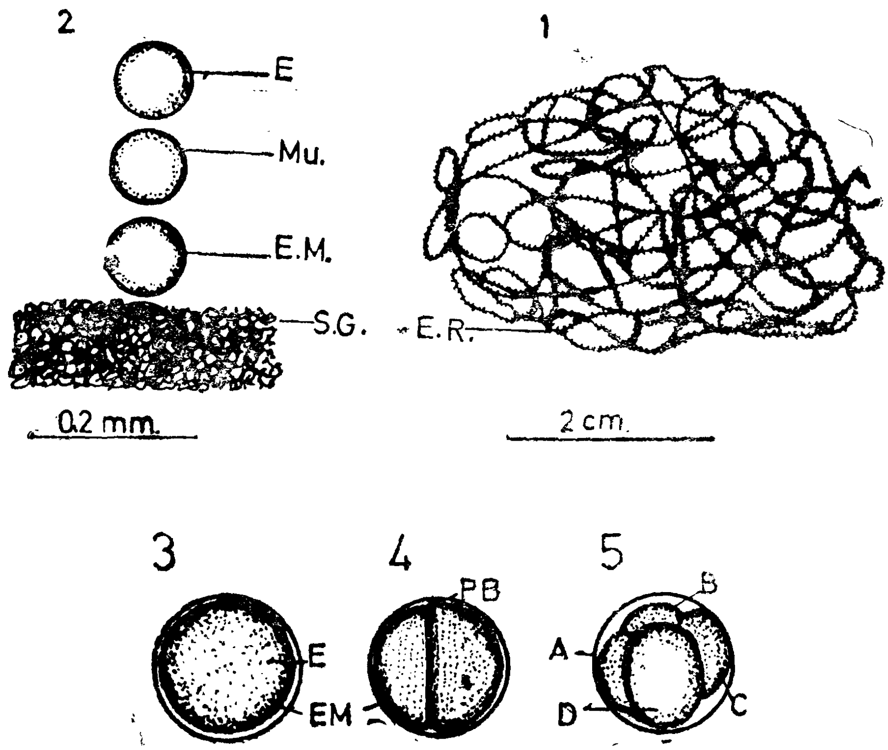
The egg-ribbon of *S. fasciatus* (Fig. 20) consists of a long glued string and when unrevelling it divides into small parts. It is similar to that of *S. gibberulus* in its entangling, coiling, colour and general shape, but the mass is slightly bigger and the string is somewhat thicker. It is formed of a long gelatinous thread which is arranged by the parent animal into a triangular mass of about three to five centimeters across. The string is roughly about 7 meters long with a diamter of about 750μ. It consists of a cylindrical gelatinous tube in the middle of which the eggs are embedded in a very light mucous substance. The eggs (Figs. 21 & 22) are nearly spiral in their arrangement and usually 5 eggs are located at the periphery of the tube and one median between each five.

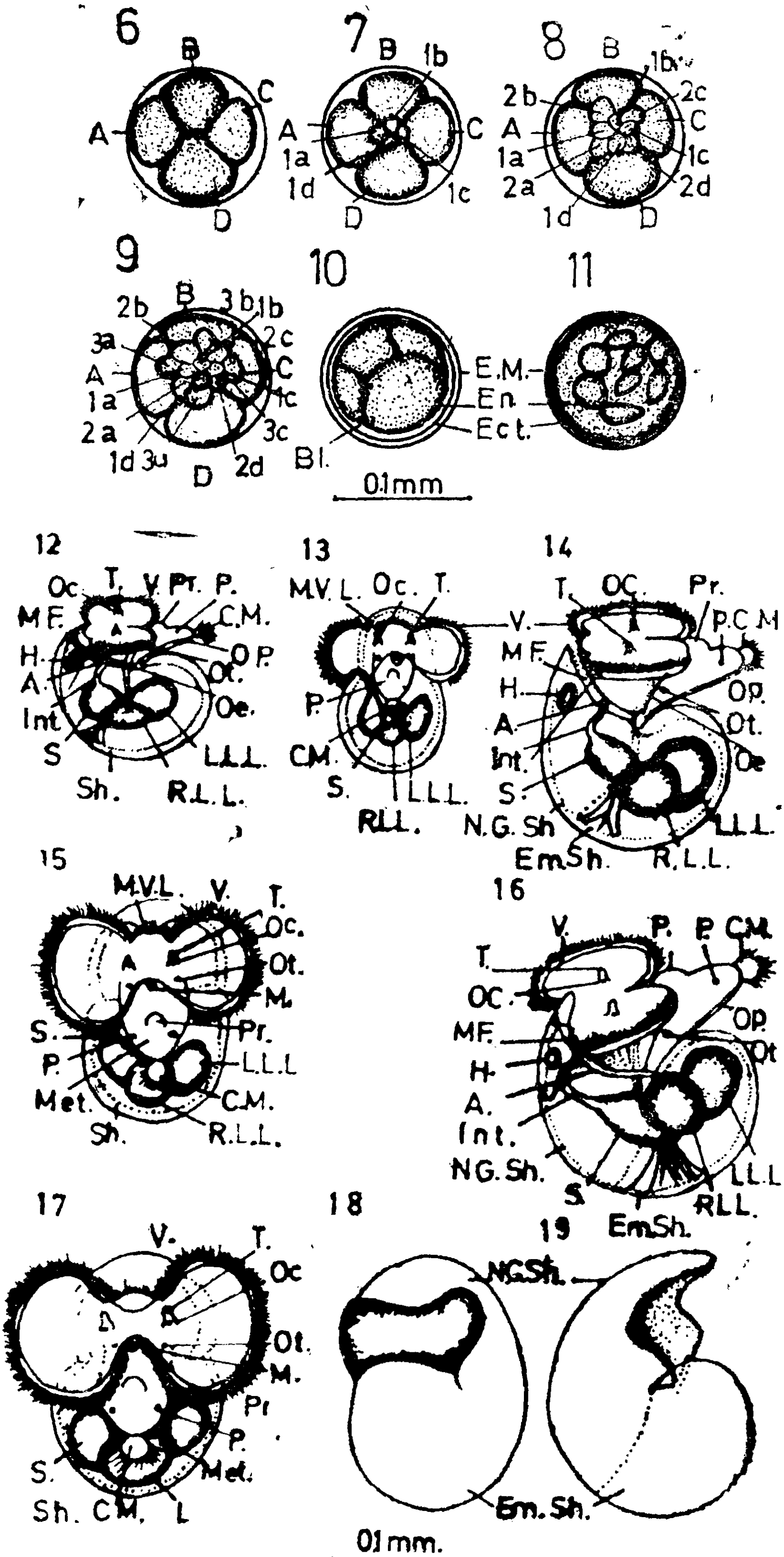
The undeveloped egg is spherical in shape, yellowish in colour and measures about 130 in diameter. It is surrounded by a very thin wide transparent case which measures about 250-300 μ in diamter. The eggs are also pripherally arranged inside their cases. Sometimes egg-cases, free from eggs are found and those may fill the spacd between the other cases.

In each centimeter of the ribbon, about 225 eggs are embedded, and thus the whole ribbon may be 157000 eggs.

List of abbreviations

A. = anus ; Bl. = Blastopore ; C.H. = Circular metapedium ; E. = Egg ; Ec. = Ectodem ; E. E. M. = Empty Egg membrane ; E.M. = Egg membrene ; Em. Sh. = Embryonic Shell ; En.= Endoderm ; E.R.= Egg ribbon ; H. = Heart ; Int. = Intestine ; L.L.L. = Left liver lobe ; M. = Mouth ; M. E. M. = Median Egg membrane ; M.F.=Mantle fold; Ma.=Macous; M.V.L.=Mit-lobe; N.G. Sh.=New Growth of Shell ; Oc.=Ocellus ; Op.=Opeculum ; Ot.=Otocyst ; P.=Pigment ; P.B.= Poler body ; P.E.M.= Peripheral egg membrane ; Pr.= propodium ; R.I .L= Right liver lobe ; S.=Stomach ; S.G.=Sand grains ; Sh. = Shell ; T. = Tentacle ; V. = Velum.

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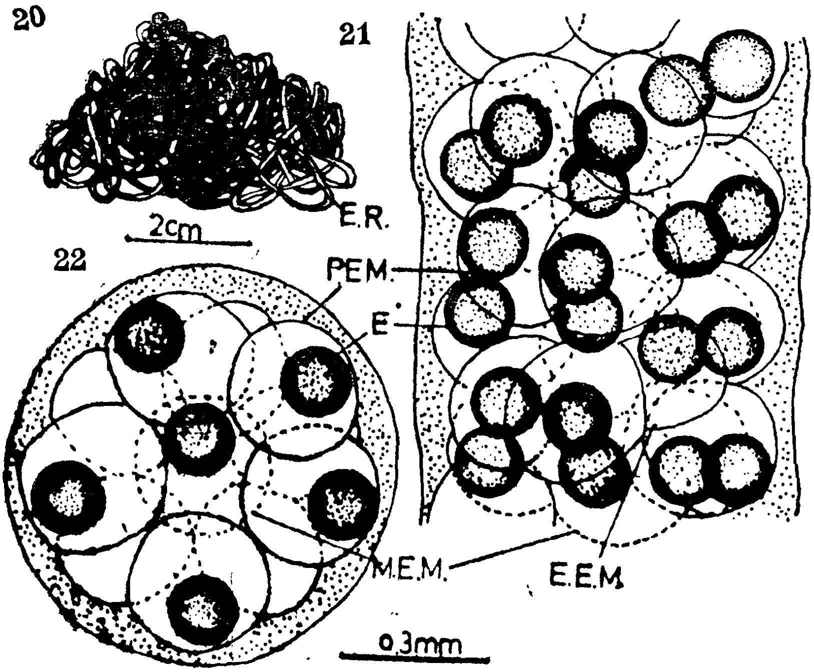

DISCUSSION

The egg-masses of *S. gibberulus* & *S. fasciatus* are similar to those of the other species of family Strombidae, being consisting of an elongated, twisted & entangled gelationoud cylindrical string, but differing in size, length colouration & arrangment of eggs. The following table shows comparative data on some of the previously studied species belonging to the two genera : Strombus and Pterocera.

It is clear from the above table that the egg mass and diameters of string and eggs are the largest in *S. tricornis* On the other hand, the diameter of the egg ribbon of *S. gibberulus* is the smallest. Robertson (1959) sated that the spiral arrangement of the three species (*S. raninus, S. costatus* and *S. gigas*) from Bahamas is a simple modification of the solitary type of *S. conarium* (Risbec 1932) and *S. maculatus* (Ostergaard 1950). He mentioned that the thread of eggs is coiled within the bounding membrane of the tube so that in turn of the coil there are 3 eggs in *S. raninus* 4-5eggs in *S. costatus* and 5-6 eggs *in S. gigas*. The same phenomenon can be applied for *P. lambis* and *P. bryonia* where coils consist of 2 eggs in the former (Risbec loc. cit.)and 3 eggs in the latter (Gohar and Eisawy 1967). In *S. gibberulus* the arrangement of eggs is solitary as those of the Indo-Pacific species, but in *S. tric-arnis* although the ribbon is thick it contains a single raw of eggs Actually the large gelations compartments obstacle the colling of eggs in the ribbon. In *S. fasciatus,* numerous eggs are present in the ribbon, but their arrangement differs from those of other species, as each row contains 5 eggs and between these fives theré is a median one filling the cavity between the rows.

Segmentation of eggs in the present three species of *Strombus* agrees with the general rule for all species of the family. The newly hatched veliger of *S. tricornis* differs from those of other species in the followings :

(1) It hatches out in the swim-crawl stage and thus it has a short planktonic life;

(2) It possesses 4-lobed velum with short cilia and irregular scattered yellow pigments;

(3) The shell which is semitransparent and unscalpured becomes opaque with the formation of transverse parallel small ridges in the advanced stage. The newly hatched larva of *S. gibberulus* is similar to veligers of *S. gigas* (D'Asaro 1969), *S. raninus* and *S. costatus* (Robertson loc. cit.) and *P. bryonia* (Gohar and Eisawy loc. cit.). The most distinct features of veligers of these species are : 1) the oval bilobed velum.

(2) The transparent unscaltptured shell ; 3) The tuft of cilia (sensory bristles) on the constricted posterior region of the foot ; 4) The presence of two characteristic pigmented spots on the two sides of the metapodium, these are orange in *P. bryonia,* orange red in Bahamas species and rose red in *S. gibberulus*. In *P. bryonia* and *S. gigas,* the velum undergoes several changes in its hape during development of the larva, becoming 4-lobed and then 6-lobed, while that of *S. gibberulus* does not show any change until death of the larva after 7 days. In *S. fasciatus* the egg ribbon was glued and development did not proceeded. This may be due to the absence of sand granules which serve as protection, and this agrees with what happened in *S. maculatus* (Ostergaard loc.)e ; whose spawn was laid in the laboratory where no sand granules were provided and embryos died after gastrulation.

On comparing the Red Sea species and the Bahamas species *S. gigas,* the following table could be obtained :

Species	Diameter of egg	Embryonic Period	Length of Shell of Veliger	Planktonic Period
S. gibberulus	90μ	3-4 days	105μ	long
S. gigas	110—120μ	4-5 days	148μ	more than 60 days
S. bryonia	216—250μ	5-7 days	270μ	18 days
S. tricornis	410—440μ	10-11 days	900μ	3-4 days

Although there is difference in the water temperatures during the breeding season of the four species, yet it can be roughly stated that the larger the egg, the longer the embryonic period, the larger the shall of the veliger, the shorter the planktonic life of the larve.

Species	Diam. of Egg mass	Length of ribbon	Diam. of ribbon	Gelat. Comp.	Arrang. of Eggs	Diam. of Egg	Egg memb.	Colour of Egg	Numer of Eggs
S. tricornis	12—15 cms.	3—4 ms.	2—2.5 mms.	present	solitary	410—440 µ	very wide	greenish	1800—2800
S. gibberulus	3%5 cms.	—	0.13 mm.	absent	solitary	90 µ	narrow	pale yellow	—
S. fasciatus	3—5 cms.	7 m.	0.75 mm.	absent	spiral 5 and one	130 µ	wide	yellow	about 157000
S. gigas	3.5×8 cms.	Up to 37.34 ms.	0.5—0.6 mms.	present	coiling 5 to 6	110—120 µ	narrow	—	average 480000
S. raninus	2.5×5.5 cms.	20 ms.	0.3 mms.	present	coiling 3 eggs	90—100 µ	narrow	—	400000—460000
S. costatus	4×8 cms.	13—15 ms.	0.6 mms.	present	coiling 4 to 5	150—160 µ	narrow	—	185000 210000

Sp									
S. regosus	—	—	1 mm.	absent	numerous	80	Wide	—	—
S. canarium	3 cms. (incomp.)	—	0.2 mm.	absent	solitary	100	moderate	pale yellow	—
S. maculatus	—	—	0.25 mm.	absent	solitary	100	narrow	pale yellow	—
P. lambus	10 cms.	—	1 mm.	absent	double	250	moderate	bricked	—
P. bryonia	7—8 cms.	2.7 ms.	1 mm.	present	spiral 3 eggs	216—256	narrow	white	18900—21750

S. = Strombus ; P. = Pterocera ; Arrang. = Arrangement; Gelat. comp. = Gelatinous components ; Diam. = Diameter ; mem. = membrane ; incomp. = incomplete.

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