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THE AFFINITIES OF THE PELAGIC TUNICATES.

No. 1. ON A NEW PYROSOMA.

(*Dipleurosoma elliptica.*)

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Part I.—INTRODUCTORY.

I am indebted to Dr. Caswell Grave for the opportunity to study the Pyrosoma that is here described. The specimens were collected in the Gulf Stream off Beaufort, North Carolina, by the United States Commission of Fish and Fisheries, and were brought to the marine laboratory of the Commission at Beaufort. They were intrusted to me for study by Doctor Grave, the director of the laboratory. The illustrations that accompany the memoir were drawn by Mr. Carl Kellner.

While all the species of Pyrosoma that have been described are circular in cross section, the cross section of the one that is to be described is a flattened ellipse, so that the colony has two broad sides (fig. 4) and two narrow edges (fig. 5).

Except for this flattening, it does not differ in any essential way from other Pyrosomas, which are tubular colonial ascidians that float or swim in the water of the ocean, usually at considerable depth below the surface, but often at or very near it. As their name expresses, they are among the most brilliantly luminous of marine animals, glowing with an intense white light that is notable even under the noonday sun of the tropical ocean. The light, which is under the control of the organism, is emitted by a pair of luminous organs (fig. 2 and fig. 8, *h*), on each side of the pharynx, near the mouth, and in the coelomic cavity.

The basis or foundation of the colony, that binds the ascidians together into an organized whole, is a hollow tube of cellulose (figs. 2 and 4) closed at one end, A, and opened at the other, B. The open end carries a muscular diaphragm, by which the aperture may be reduced or enlarged.

The ascidian units, or ascidiozooids, many hundreds or thousands in number, are so placed that their mouths *d*, are on the outer service of the tube, while their cloacal apertures, *c*, open into the cavity of the tube, or common cloaca (fig. 3, CC), which again opens to the external water through the terminal opening which may be reduced in size, or, perhaps, completely closed by the muscular diaphragm.

The members of the community breathe and obtain their food, like other ascidians, by drawing water through the mouth (fig. 8, *d*) into the pharynx or gill-chamber (fig. 8, *e*) by the vibration of the cilia around the gill slits. The waste water is discharged from the body through the cloacal aperture, and, as the cloaca of each ascidiozooid opens into the common cloaca, this becomes filled with water, which, overflowing through the open end, tends to drive the colony through the water in the opposite direction. This current is modified and controlled by the diaphragm, and by the movements of the ascidiozooids, so that the progress through the water is not slow and continuous, but rapid and intermittent. A muscle, shown near the cloacal aperture in figure 8, extends from each ascidiozooid to those adjacent to it and binds all the units of the colony together, so that they are able to make concerted movements, and thus to control the expulsion of the locomotor current.

The structure and the development of Pyrosoma have been well described by many naturalists, and a good account of the more essential features is to be found in the text-books. Those who wish for a more complete account should consult the memoirs of Herdman (Report on the Tunicata collected during the voyage of H. M. S. "Challenger," XXVI-XXVIII), of Salensky (Beiträge zur Embryonalentwicklung der Pyrosomen. Zool. Jahrb. IV and V), and of Seeliger (Zur Entwicklungsgeschichte der Pyrosomen. Jenaische Zeitschr. für Wiss. Naturw. XXIII., and Die Pyrosomen., Leipzig, 1895).

The subject of this memoir is a new form of Pyrosoma, which seems to me to be generically different from all that have been described; but, as its differences from the forms that are known do not involve its fundamental structure, I have little to add to the published accounts, although a brief sketch of the origin of the colony will be the most satisfactory way to explain the meaning of the terms that are to be used in describing the species.

The egg of Pyrosoma gives rise to an embryo which, while it acquires some indications of ascidian structure, remains rudimentary and quickly degenerates. It is commonly called by the name Cyathozooid, given to it by Huxley. It is shown, in an advanced stage of degeneration, at *cy* in figure 1. Before it begins to degenerate, it gives rise to a tubular outgrowth, which becomes divided, by constrictions, into four segments, each of which ultimately becomes an ascidian. The four segments are in a row at first but as they grow and develop into ascidians they twist so as to form a zone or girdle around the rudimentary Cyathozooid, as is shown in figure 1. These four primary ascidiozooids are the foundation of a new colonial Pyrosoma. As figure 1 shows, they are inclosed in a common mantle of cellulose, and are arranged in a circlet around a common cloaca into which the cloaca of each opens, while the mouths are on the outer surface. The surface that is below in figure 1 is the closed end of the colonial tube, while the opening is above in the figure, in the center of the rosette of eight tubular processes that are shown in the figure. In all ordinary Pyrosomas, the circlet that is formed by the four primary ascidiozooids is a circle, but in the species that is the subject of this paper it is an ellipse; the ascidiozooid marked *pa* 1 and its fellow lying in the long axis of the ellipse, and the one marked *pa* 2 and its fellow in the short axis. They are also shown, at a later stage, at *pa* 1 and *pa* 2, in figure 2.

The four primary ascidiozooids soon begin to multiply by budding, and thus to lay the foundation for a new colony, which may ultimately consist of thousands of ascidiozooids, all produced, either immediately or indirectly, as buds, by the four primary ascidiozooids. As each ascidiozooid that arises as a bud soon begins to produce buds in its turn, only a few of those that enter into the structure of an adult colony arise immediately from the primary ascidiozooids.

Few young colonies, large enough to have all the characteristics of the full-grown colony, and yet small enough and transparent enough to be studied with a microscope, have been found, and none have been adequately figured.

Among Doctor Grave's specimens is one, about half an inch long, which he had stained and mounted in balsam. It is shown in figure 2, with one of its flat sides toward the observer. As it is small enough to be studied as a transparent object under the microscope, and is yet, in all essential particulars, a fully developed Pyrosoma, it presents a more complete picture of the organization of the colony than any drawing that has been published. The colony is represented with its closed end below, and the open end with its diaphragm above. It consists of seventy ascidiozooids, arranged in seven rows or verticils, and of numerous buds. There are four ascidiozooids—the primary ascidiozooids—in the first row, eight in the second, ten in the third, twelve in the fourth, twelve in the fifth, fourteen in the sixth, and ten in the seventh. The ascidiozooids in the first row are the largest, and there is a gradual decrease in size to the last row, in which they are no larger than the buds, *j*, that are carried by those in the first and second rows. All are placed with their dorsal surfaces and brains toward the open end of the colony, and their ventral surfaces and endostyles toward the closed end. The new buds arise at the aboral end of the endostyle, on the ventral surface, as shown at *j* in figure 8, and in figure 2.

As the smallest and youngest ascidiozooids are nearest the open end, while they arise on the surface of the zooid that is nearest the closed end, it is clear, from the figure, that a migration must take place from the region where new buds arise to the region where they complete their growth and development, and that this migration must, in some cases, be from one end of the colony to the other. Each young ascidiozooid has two tubular processes, like those that are shown in figure 1, on the region of the body that is nearest the open end of the colony. These processes lengthen until they reach and enter into the diaphragm, where they are shown in figure 2. With a microscope they may be traced inward among the zooids and buds, although the components of the colony are so crowded, and the tubes so delicate, that I have not been able to follow any of them to the end, except the ones that end in the zooids in the row nearest the opening. The number of tubes in the diaphragm, at the stage shown in figure 2, is nearly equal to the number of zooids, but somewhat less, so that some of them must fail to reach the diaphragm, or else degenerate and disappear after they have reached it. The walls of the tubes are muscular, and they are, no doubt, concerned in the opening of the diaphragm, and in the migration of the zooids, although it is not probable that they bring about the migration by direct muscular contraction, since the distance that the zooids move seems to be too great to be brought about in this way. It is more probable that the tubes become shortened by some structural change, which, aided, it may be, by their muscular contractions, draws the new ascidiozooid into the region of the colony where there is most room for it. In young colonies there is most room at the open or growing end, and the colony grows by the addition of new whorls of zooids at this end, and the zooids are arranged in verticils. As the colony grows, new zooids become fitted into the spaces between the old ones, and the verticillated arrangement which is so notable in the young colony is no longer recognizable (fig. 4).

PART II.—DESCRIPTIVE.

DIPLEUROSOMA, genus nov.

DIAGNOSIS OF THE GENUS.

Colony bilaterally symmetrical with reference to one of the planes that pass through the principal axis. In cross section the colony is elliptical, with the common cloaca, or central chamber, reduced to a narrow slit in the long axis of the ellipse.

DIPLEUROSOMA ELLIPTICA, nov. sp.

Figures 4, 5, 6, 7, and 8.

DESCRIPTION OF THE SPECIES.

Distribution.—Found in the Gulf Stream off Beaufort, North Carolina. It is, no doubt, widely distributed in the waters of the Gulf Stream.

Length of colony.—Twenty-two centimeters.

Greatest diameter of colony.—Fifty-seven millimeters.

Least diameter of colony.—Twelve millimeters.

Ratio between the long axis and the short axis of the elliptical cross section.—About one to four.

Distribution of the ascidiozooids.—Regularly verticillated in small colonies, irregular in large ones.

Outer surface of mantle.—Smooth in young colonies, thickly set in large ones, with tubercles that are very variable, usually conical and symmetrical but often with a tongue-like projection on the dorsal side.

Oral tube.—Conical, axial, nearly as wide as long.

Mouth.—In long axis and usually horizontal or at right angles to the long axis. In young colonies, and in many of the zooids of large colonies, it is at the bottom of a shallow conical pit. In most of the ascidiozooids in large colonies it is at the end of a conical process; in a few, on the ventral surface and near the tip of a tongue-shaped process.

Branchial chamber.—Not narrowed at inner end.

Gill slits.—Thirty-seven or more.

Longitudinal folds of branchial chamber.—Eighteen or more.

Endostyle.—Nearly straight.

Testis.—In a pouch that protrudes beyond the general outline, with from seven to nine lobes.

Cloacal muscle.—Long.

Dorsal tentacles of pharynx.—About seven, variable and irregular.

Oral processes.—The writers on Pyrosoma attribute great taxonomic importance to the absence or presence or shape of the oral processes on the outer surface of the colony, since these structures are conspicuous when present and easy to sketch and to describe.

In many species they are, no doubt, characteristic, affording a ready means of identification, but in others they are too irregular and variable to have any systematic value.

In the species that is here described the outer surface of the test is smooth in young colonies, and the mouths are at the bottoms of conical pits, figure 2, as they are in some of the zooids of old colonies. Most of the zooids of older colonies have processes that are conical and symmetrical, and the mouths are terminal, figure 8. There is nothing distinctive in the length of the processes, for some are short and some long. While they are usually conical and symmetrical with reference to the long axis of the ascidiozooid, they are sometimes elongated on the side that is dorsal to the mouth, which is thus oblique and on the ventral side of the process at some distance from its tip.

Dipleural symmetry.—The dipleural symmetry that characterizes this species is recognizable in the embryo, becoming more marked with the growth of the colony.

The embryonic colony of four primary ascidiozooids, figure 1, is nearly circular, although the two ascidiozooids, *pa* 1, that are to occupy the sides of the colony, are easy to distinguish from the two, *pa* 2, that are to lie on the edges.

The young colony, with seventy ascidiozooids shown in side view in figure 2 and in transverse section in figure 3, exhibits marked dipleuralism.

There are seven ascidiozooids on each edge, or fourteen in all, and twenty-seven on each side, or fifty-four in all, and the four primary ascidiozooids, *pa* 1 and *pa* 2, are readily distinguishable. The diagrammatic section, figure 3, is through the verticil that is fourth from the closed end in figure 2. As the diagram shows, there is one zooid on each edge at this level, and there are five on each side, or twelve in all, and the thickness of the colony is about equal to one-half its breadth, so that the ratio of thickness to breadth is one-half.

In the adult colony, shown in side view in figure 4, in end view in figure 6, in edge view in figure 5, and in section in figure 7, there are about sixty zooids in each cross section, and the thickness of the colony is to its breadth about one to four.

Verticillation.—In the full-grown colony there is no visible trace of an arrangement of the zooids in rings, although this arrangement is regular and conspicuous in the young colony shown in figure 2.

In this there are seven rings, with four zooids in the first, eight in the second, ten in the third, twelve in the fourth, twelve in the fifth, fourteen in the sixth, and ten in the seventh, or seventy in all. The regular verticillation is obliterated, in older colonies, by the interpolation of new buds between the rings.

EXPLANATION OF THE PLATES.

REFERENCE LETTERS.

A. The closed end of the colony.
as. An ascidiozooid.
B. The open end of the colony.
c. The cloaca of the ascidiozooid.
CC. The common cloaca of the colony.
d. The mouth.
f. The mantle of cellulose.
g. The endostyle.
h. The luminous organ.
i. The testis.
j. A bud.
k. The stomach.
l. The intestine.
n. First oral muscle.
o. Second oral muscle.
p. The œsophagus.
PA. 1. The primary ascidiozooid on the edge of the colony.
PA. 2. The primary ascidiozooid on the side of the colony.

FIGURES.

FIG. 1.—The cyathozooid and the four primary ascidiozooids of *Dipleurosoma elliptica*.
FIG. 2.—A young colony of *Dipleurosoma elliptica*, with seven verticils of ascidiozooids.
FIG. 3.—Transverse section of the colony shown in figure 2.
FIG. 4.—Side view of a fully grown colony of *Dipleurosoma elliptica*.
FIG. 5.—Edge view of same.
FIG. 6.—The open end of same.
FIG. 7.—Transverse section of same.
FIG. 8.—A single ascidiozooid from a fully grown colony of same.