ASCIDIANS OF THE BERMUDAS

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The ascidians of the Bermuda islands have already been described by Van Name (1902) and a revision published by the same author in 1921 under the title "The Ascidian Fauna of the West Indies." In view of this the present paper is confined to a brief account of the fauna as a whole, a description of several new species, and a few notes upon certain other forms.

The ascidians of the Bermudas are almost identical, species for species, with those of the West Indies and Gulf of Mexico, and there is little doubt that, together with the bulk of the Bermuda fauna, they have been carried there from those regions by the west Atlantic drift.

Like ascidians throughout the world, their habitat is determined as a compromise between two factors, their ability to withstand wave-action and exposure, and their need for a good flow of well oxygenated water. They may accordingly be divided into three groups, those to be found only under stones, those attached to the upper surfaces of stones, or to various corals and sea-fans, and those found beyond the outer reefs.

Apart from such classification of habitat further description such as specified localities is practically unnecessary. Species found under stones in one locality are likely to be found in similar positions throughout the islands. The same holds true for forms that are attached to exposed surfaces.

The material upon which this paper is based was obtained through the facilities of the Bermuda Biological Station, St. Georges, and also through the assistance of Louis Mowbray, Esq., of the Government Aquarium.

Fauna List

Aplidium (*Amaroucium*) *bermudae* (Van Name)..........on corals
Aplidium (*Amaroucium*) *exile* (Van Name)..............under stones
Trididemnum savignii (Herdman)........................on algae, under stones
Trididemnum orbiculatum (Van Name)..................under stones
Didemnum candidum Savigny..........................under stones, on corals
Didemnum (*Polysyncraton*) *amethysteum* (Van Name)......under stones
Leptoclinum macdonaldi (Herdman)......................on corals, etc.
Lissoclinum fragile (Van Name).........................under stones
Polycitor (*Eudistoma*) *olivaceus* (Van Name).............on stones, corals, etc.

Polycitor (*Eudistoma*) *convexus* (Van Name)	on corals, etc.
Polycitor (*Eudistoma*) *clarus* (Van Name)	on stones, corals, etc.
Polycitor (*Eudistoma*) *capsulatum* (Van Name)	on corals, etc.
Clavelina picta (Verrill)	on sea-fans, wrecks, etc.
Clavelina oblonga Herdman	under stones, on corals
Cystodytes dellechiaiae (Della Valle)	on corals, stones, etc.
Distaplia (*Holozoa*) *bermudensis* (Van Name)	under stones, on corals
Perophora viridis Verrill	under stones
Perophora bermudensis n.sp.	under stones
Ecteinascidia turbinata Herdman	on stones, corals, wrecks
Ecteinascidia conklini n.sp.	under stones
Ecteinascidia conklini var. *minuta*	under stones
Ascidia nigra Savigny	on stones, etc.
Ascidia curvata Traustedt	under stones
Botryllus schlosseri (Pallas)	under stones
Botrylloides niger (Herdman)	on and under stones
Symplegma viride Herdman	under stones
Polyandrocarpa (*Eusynstyela*) *tincta* (Van Name)	under stones
Polycarpa obtecta Traustedt	on stones, corals, reefs
Styela partita (Stimpson)	on stones, corals, reefs
Pyura vittata (Stimpson)	on stones
Microcosmus exasperatus Heller	under stones, on reefs

The Bermuda fauna is exceptionally rich in members of the family Perophoridæ. Two well-known forms, *Ecteinascidia turbinata* and *Perophora viridis*, are common. Their close relationship, however, is emphasized by the discovery of transitional types. These new forms may frequently be found growing under the same boulder as those two species.

Inasmuch as the existing descriptions of *Ecteinascidia turbinata* are of immature zoöids, a somewhat detailed account is made here of this species; such an account also forms a basis for comparison of the other forms.

Ecteinascidia turbinata Herdman.

This species was originally described by Herdman from material collected at Bermuda by the Challenger expedition. Large orange colonies develop attached to the upper surfaces of rocks where currents are relatively strong.

The essential organization of the zoöid is shown in Fig. 1. The structures shown here for the first time are the heart, and the gonads with their ducts. The heart is of the same relative size and length, and is in the same relative position as in species of Ascidia or Phallusia. The gonads develop in the intestinal loop on the left side, as in Perophora, the ovary being surrounded by a ring of testicular lobes. The vas deferens during its distal course follows the intestine and they open together some distance short of the atrial siphon. The oviduct, on the other hand, is relatively short and wide. It passes

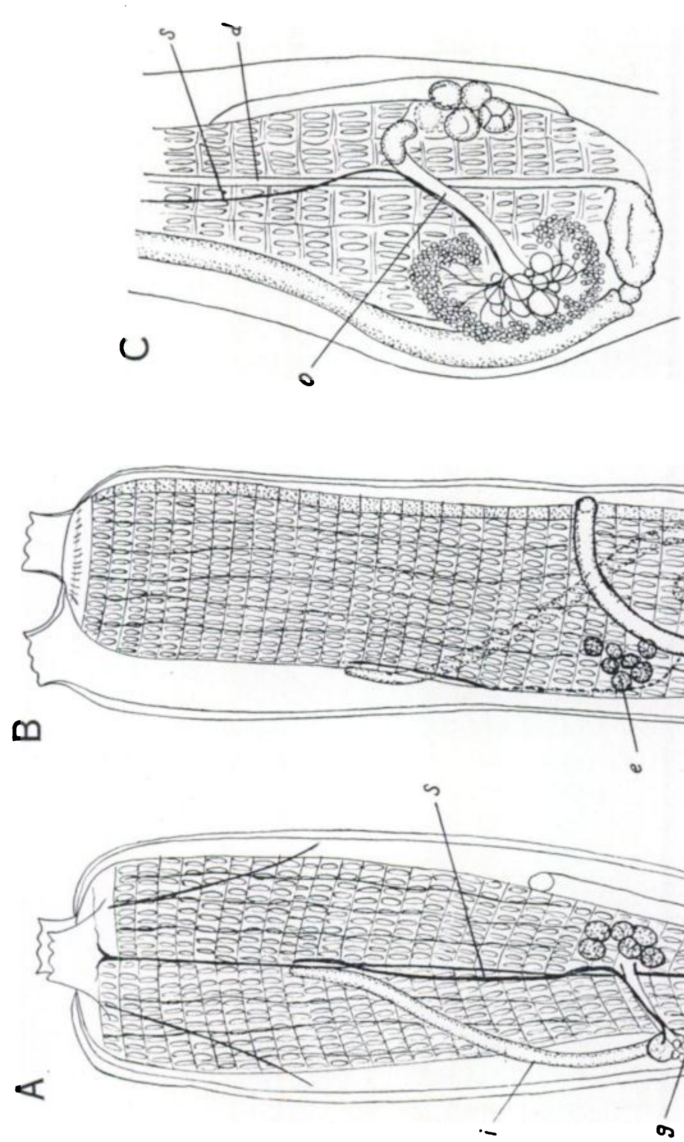

FIG. 1. *Ecteinascidia turbinata* Herdman. Mature blastozoöids, A, from dorsal, B, from right side; C, from dorsal and left aspect. *d*, dorsal lamina; *e*, embryos; *g*, gonads; *h*, heart; *i*, intestine; *o*, oviduct with egg emerging from it into right atrial cavity to join developing embryos; *s*, sperm-duct; *st*, stomach.

from the ovary to the dorsal lamina, opening beyond it into the atrial cavity of the right side. A single egg at a time is forced up the duct. During this brief passage it becomes greatly elongated through compression, rapidly regaining its spherical shape as it emerges.

The above features are generic, the characters of specific importance being as follows,—the tendency to grow on the exposed surfaces of rocks, the red or orange colour, the proximity of the atrial to the branchial siphon, the possession by the adult zoöid of about thirty rows of stigmata, and the formation of tadpole larvæ with twelve rows of stigmata. The breeding season extends from about June first to August or September.

Ecteinascidia conklini n. sp.

This species was at first mistaken for young colonies of *E. turbinata*. The generic features are identical with those of *E. turbinata*. The specific differences are the following: it is found only on the under side of rocks, the colour is green or yellow-green with but a thin red ring around the siphons, sometimes absent; the atrial siphon is long and placed some considerable distance from the branchial siphon; the rows of stigmata in the zoöids average about twenty in number, while smaller tadpoles are formed with but six rows of stigmata; the eggs are smaller, and the breeding season commences about one month later than that of *E. turbinata*, under identical conditions.

Ecteinascidia conklini var. *minuta* n. sp.

This form was found with mixed colonies of *E. conklini typica* and *Perophora viridis*. It differs from the type species in a few minor features only, which nevertheless seem worthy of recording.

It is smaller; the number of rows of stigmata in the zoöid rarely exceeds fifteen; the atrial siphon is short and close to the branchial siphon while both bear prominent ridges, and the eggs and larvæ are smaller although the tadpole possesses six rows of stigmata as in the other. The breeding season as far as is known coincides with that of *E. conklini typica*.

Probably the most definite feature distinguishing both *E. conklini typica* and *minuta* from *E. turbinata* is the curvature of the intestine in the former, tending to form a secondary loop. The intestine of *E. turbinata* is but very slightly curved in comparison.

Perophora bermudensis n. sp.

This species forms mixed colonies with the common *Perophora viridis*, both growing in great profusion on the under surface of stones where there is a good circulation of water.

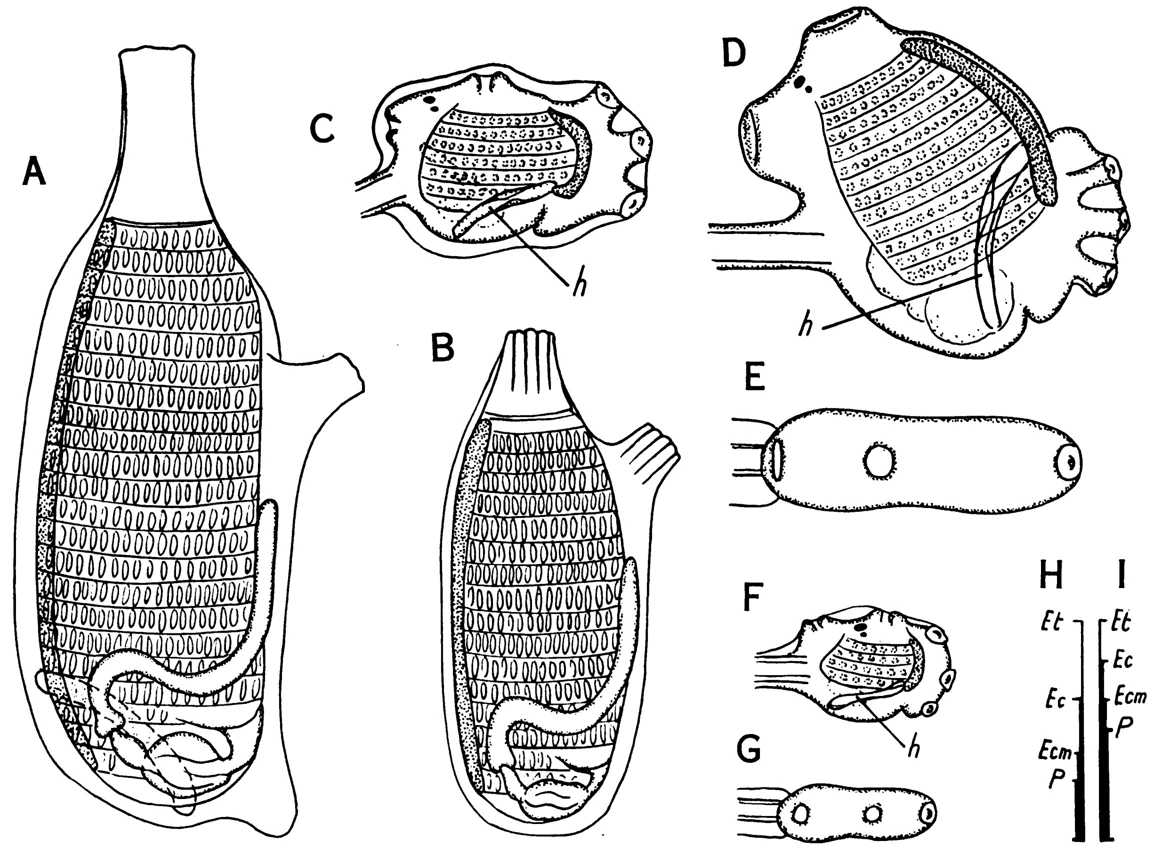

FIG. 2. A, blastozoöid of *Ecteinascidia conklini* n. sp., from right side. B, blastozoöid of *E. conklini* var. *minuta*, from right side. C, tadpole of *E. conklini* (that of *E. conklini minuta* is identical except for being smaller). D, tadpole of *E. turbinata* from side, E from top. F, tadpole of *Perophora viridis* from side, G from top. H, relative sizes of mature zoöids of the three species of Ecteinascidia and of Perophora. I, relative sizes of the eggs of the same forms.

The zoöids are drawn all to one and the same scale, while the tadpoles are also drawn to one scale.

h, heart.

Perophora viridis has a greenish tinge, as its name implies, and both oozoöid and blastozoöid have four rows of stigmata. *Perophora listeri* is similar in that the greenish colour is quite absent, but it forms by no means such dense colonies. *Perophora annectens* differs from both these species in that it has but three rows of stigmata.

Perophora bermudensis possesses blastozoöids with five rows of stigmata (although the oözoid has but four) and is accordingly unique. It may be readily distinguished from *P. viridis* with which it is usually entangled, by the absence of any green colour and the somewhat larger size of the zoöids.

Its structure is shown in Fig. 3, and it is seen that not only are there five rows of stigmata but that about a third of the stigmata of

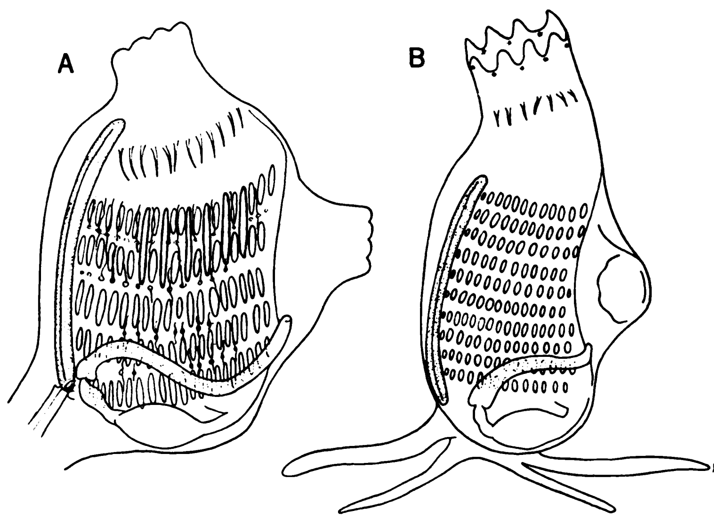

FIG. 3. A, blastozoöid of *Perophora bermudensis* n.sp. B, oozoöid of *Ecteinascidia conklini* or else a blastozoöid of *Perophoropsis herdmani* Lahille.

the first and second rows are common to both. This condition prevails in the smallest and youngest blastozoöids in which stigmata are discernible.

Perophoropsis herdmani Lahille.

This form was described by Lahille in 1890 from Banyuls and has not been rediscovered. It differs from species of *Perophora* in that there are at least ten rows of stigmata. It is a genus therefore intermediate between *Perophora* and *Ecteinascidia*.

At Bermuda, mixed with colonies of *Perophora viridis*, *P. bermudensis*, and *Ecteinascidia conklini*, were found individuals corresponding in structure to *Perophoropsis;* these are shown in Fig. 4.

There is, however, another possibility. It was determined in the case of *Ecteinascidia turbinata*, *E. conklini*, *Perophora bermudensis*, *Clavelina lepadiformis*, *Botryllus gigas*, and *Botrylloides leachii*, that in developing blastozoöids the number of rows of stigmata, while yet non-functional although perforate, equals or may slightly exceed the number of stigmata rows in the zoöid from which they arose. In no case was it less than that number. This statement is probably true for ascidians as a whole and will form the subject of further investigation.

This phenomenon accordingly rules out the possibility that the Perophoropsis-like forms were young blastozoöids of *Ecteinascidia;* while the fact that the oozoöid of *E. turbinata* possesses from the start twelve rows of stigmata makes it impossible that they are young oozoöids of that species. With *E. conklini* the case is different. The oozoöid first becomes active with but six rows of stigmata, and accordingly it is possible that the forms in question are slightly-grown individuals of this type, especially as they were solitary and without budding stolons, although occurring not far from one another. Another feature which supports such a contention is that the individual stigmata are but half the length of those of *Ecteinascidia* or *Perophora* species. Whether they are blastozoöids or oozoöids, they are probably but half-grown.

Provisionally, therefore, these perophorids will be assumed to be young oozoöids of *Ecteinascidia conklini* rather than the *Perophoropsis* of Lahille. If this is the case, then it should be noted that additional rows of stigmata appear in the oozoöid when the stigmata of the original six rows are merely a fourth of full adult size, and cannot be distinguished from those first six rows.

Genus *Clavelina*.

There is some confusion as to the number of species of *Clavelina* to be found in the Bermuda and West Indian region.

From material taken on the Challenger expedition at Bermuda Herdman described a form that he named *Clavelina oblonga*. In 1900 Verrill, in his general account of the fauna of the Bermudas, described an ascidian under the name *Diazona picta*. In the account of the Bermuda ascidians published by Van Name in 1902 this last was changed to *Rhodozona picta* on the ground that it differed materially from the type of *Diazona* and was intermediate in character between *Diazona* and *Clavelina*. In his later account (1921) of the ascidian fauna of the West Indies Van Name includes both these forms under *Clavelina oblonga*, the *Diazona picta* of Verrill being considered to be large colonies and Herdman's *Clavelina oblonga* young colonies of one and the same species. This he describes as a form in which the zoöids of a young colony are almost completely separated from one another but which in older colonies become enclosed for their greater part in a common gelatinous test.

Such a conclusion is believed to be the result of two factors, the study mainly of preserved material, and of material collected not later than May, that is, of material somewhat immature. Preservation destroys pigmentation and in these two forms results in a tremendous shrinkage of the thoracic part of the zoöids.

These forms are believed to be both clavelinids but also to be quite distinct species. On this assumption then the one should be known as *Clavelina oblonga* Herdman and the other as *Clavelina picta* (Verrill). It is hoped that the following descriptions will show this to be the case.

Clavelina oblonga Herdman.	**Clavelina picta (Verrill).**
Habitat.	*Habitat.*
Attached to the under-surface of stones near low-water level, very rarely in more exposed positions.	Attached to sea-fans, corals, submerged wrecks, etc., from low-water level to a few fathoms; never found under stones; a good flow of water seems to be necessary.
Breeding season.	*Breeding season.*
End of April until August.	End of June until August or September.
Form of colony.	*Form of colony.*
Number of zoöids rarely exceeds 40, usually much less. They are attached to a basal stolon, but otherwise are separated from one another. Budding occurs throughout breeding season so that zoöids of all sizes are to be found.	Colonies usually possess more than 40 zoöids and may have as many as 1000. The zoöids are embedded in a common test, which is usually divided into corms. During the summer the thorax of each zoöid extends beyond the common test, at other times it is usually completely embedded. Budding does not occur during the breeding season or the months preceding it and so the size of the zoöids is very uniform in any one colony.
Pigmentation.	*Pigmentation.*
Test crystal-clear. Branchial sac with flecks of white pigment near its anterior end. Abdominal region yellowish. In living state whole colony perfectly transparent.	Test unpigmented but slightly opaque. Endostyle, dorsal lamina, and peripharyngeal bands densely coloured with purple or carmine cells. They also extend throughout the abdomen and then accumulate in the ends of the test vessels. They appear in the late embryo in such places and the oozoöid is as highly coloured as the blastozoöids.
Egg and tadpole size.	*Egg and tadpole size.*
0.31 mm. diameter (egg). 2.25 mm. total length (tadpole).	0.49 mm. diameter (egg). 3.30 mm. total length (tadpole).
Post-larval development.	*Post-larval development.*
Tadpole and young oozoöid have from the first, two rows of definitive stigmata.	Tadpole and young oozoöid have from the first, four rows of definitive stigmata. All other species of *Clavelina* have but two.

Clavelina oblonga usually occurs in groups of two or three during May and increases in number throughout the breeding season until about forty zoöids of various size may be found in one colony. This was found to be the case in both 1930 and 1931, and the implication is that the oozoöid forms a few winter statoblasts which regenerate and give rise to the type of colony just described during the following spring, while such a colony dies off at the end of the summer, failing to form a second generation of statoblasts. That is, the life-cycle is completed within 18 months; otherwise, large colonies should be found similar to those of *Clavelina lepadiformis*, which is not the case.

That *Clavelina picta* was originally taken to be a diazonid is due

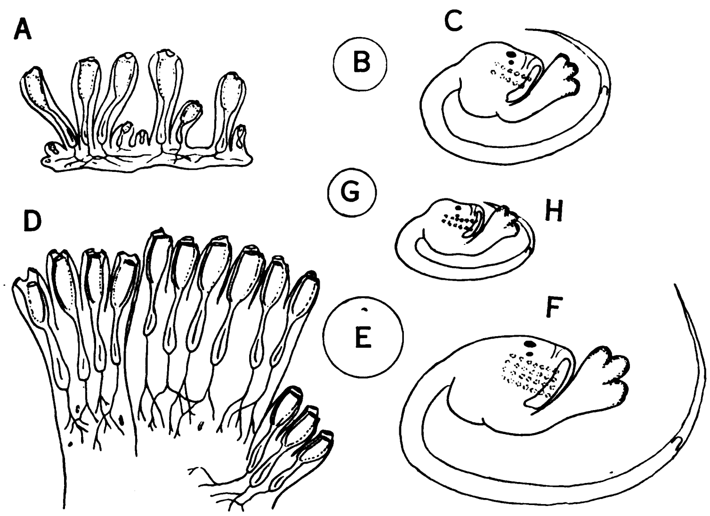

FIG. 4. A, colony of *Clavelina oblonga* Herdman. B, C, egg and tadpole of same. D, part of a colony of *Clavelina picta* (Verrill). E, F, egg and tadpole of same. G, H, egg and tadpole of *Clavelina lepadiformis*.
The eggs and tadpoles are drawn to the same scale.

to a superficial similarity in type of budding. In *Diazona violacea* budding by abdominal strobilation occurs after the breeding season has ended, and only then. So that every autumn each zoöid forms eight or ten compact bodies which regenerate slowly through the winter and spring to become sexually mature in the late summer; the process is then repeated. Therefore the zoöids are uniform in size and remain embedded in the common test, although the anterior part of the thorax of each extends separately during the late summer.

In *Clavelina picta* winter statoblasts are formed after the breeding season and apparently at no other time. The oozoöid probably forms about ten such bodies. These regenerate, grow and become sexually mature during the winter and spring. They carry on these processes close together within the test of the oozoöid, and so remain within a common test. During the late summer these processes are repeated, resulting in the formation during the following year of a colony composed of about ten corms, each containing ten or more zoöids. This may be repeated a third year to form massive colonies. During maturity the anterior parts of the zoöids extend from the common test just as in *Diazona*, and as in *Diazona* they contract and degenerate after the breeding season while the thoracic extensions of the test are sloughed off. Thus, apart from the difference in budding, strobilation of the abdomen in *Diazona* and the formation of post-abdominal extensions in *Clavelina*, the cycle is much the same in the two genera and it is understandable that a superficial similarity results. The separation of the zoöids in large colonies of *Clavelina lepadiformis* in contrast to the condition in *C. picta* is due probably to the very thin test of the former, so thin that when the statoblasts grow into new individuals they form independent vertical extensions of it from the first.

Budding in these forms will be the subject of a much more detailed investigation.

Symplegma viride Herdman.

This species was described first by Herdman from material collected at Bermuda by the Challenger expedition, and has since been discovered throughout the West Indies, and in the East Indies from the Philippines to the Red Sea. A full description with illustration of a zoöid is given by Van Name (1921).

This form has at various times been included in the Styelidæ and in the Botryllidæ. A few additional observations made at Bermuda merely emphasize its relationship to both these groups. In fact it so completely bridges the gap, both in its adult structure and organization and in its development, between these two families that their maintenance as distinct families is an unnatural classification. It is accordingly proposed that the Botryllidæ be subordinated within the Styelidæ, either as a sub-family or merely as constituent genera.

The method of budding in its fundamentals is identical in the Polystyelidæ, Symplegma, and Botryllidæ.

Symplegma resembles polystyelids such as *Polyandrocarpa*, *Distomus*, or *Stolonica* inasmuch as each zoöid has its own atrial siphon, common cloacal cavities not being formed. Its general anatomy resembles that of *Polyandrocarpa* or *Polycarpa* except that its individuals are much smaller. Correlated with this reduction is a diminution in number of polycarps (to a single polycarp) and in number of rows of stigmata. Its structure differs from that of botryllids only in the absence of common cloacal cavities, and consequently in the lack of obvious systems in the colony. In other words, common cloacal cavities and the arrangement of zoöids into systems are the only major features that separate the botryllids from other styelids. Apart from these two characters *Symplegma* is so similar to *Botryllus* and *Botrylloides* that it exhibits the same degree of variation in colour and form of whole colonies. These varieties are even more definite and constant in *Symplegma* than in the Botryllidæ, the commoner

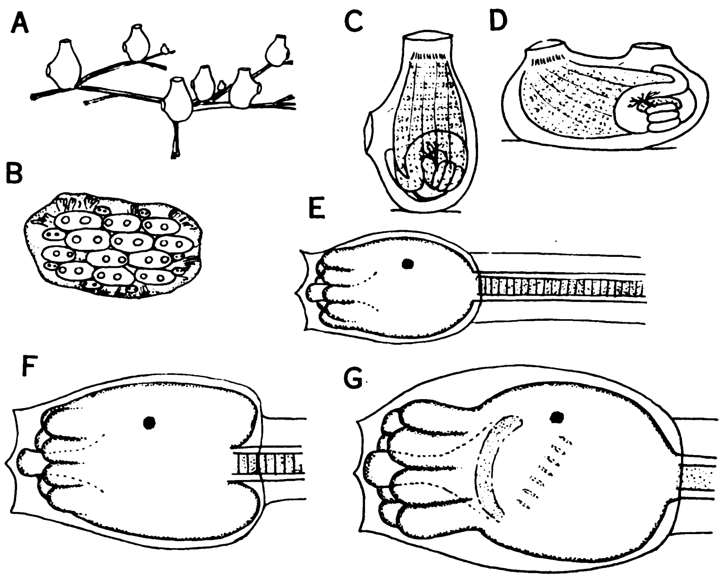

FIG. 5. A, colony of *Symplegma viride stolonica* n.v. B, colony of *Symplegma viride typica*. C, zoöid of *stolonica*. D, zoöid of *typica*. E, F, G, tadpoles of *Symplegma viride*, *Distomus variolosus*, and *Botryllus gigas*, respectively, drawn to the same scale.

colour varieties being,—green, green and white, green and brown, black and white, and orange. With the exception of the last, all colonies are very compact and sheet-like as in botryllids, the adult zoöids being pressed together, young buds appearing in large numbers together with clusters of ampullæ at the colony margin. The orange variety, however, is different. Instead of the budding stolons being very short, they are even longer than in *Stolonica socialis*, with the result that the zoöids are often widely separated from each other while the individual zoöids assume a comparatively vertical position. It may, in view of this difference, be worth recognizing the orange form as a definite variety. If so, it is suggested that it be named *Symplegma viride stolonica*.

The essential unity of such forms as *Symplegma*, *Botryllus*, and *Distomus* is perhaps best shown in the study of the development.

The tadpole of *Symplegma* is almost identical with those of *Distomus*, *Stolonica*, and *Styelopsis*, except that it is somewhat smaller. It has the same degree of organization; it has the same single but composite sense organ (probably developed from the otolith after the primitive eye was lost, an otolith and eye being found only in *Styela* itself); and in *Symplegma* and *Distomus* there is a long anterior mental process surrounded by a ring of ampullæ. *Botryllus* and *Botrylloides* both produce tadpoles with a similar mental process and ring of ampullæ, there being eight ampullæ in each of these genera and also in *Symplegma*. While the botryllid tadpoles are the more highly organized, the young oozoöids developing from these and from tadpoles of *Symplegma* are hardly to be distinguished.

Altogether there are greater differences between a genus such as *Styela* and the polystyelids than there are between these last and the botryllids.

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