THE THALIACEA OF THE MADRAS PLANKTON

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INTRODUCTION.

From the Madras plankton as many as sixteen species of Thaliacea have been obtained—the largest number ever recorded from the plankton of any particular place. The great expeditions such as the " Challenger," " Siboga," " Valdivia " and " Investigator," collected most of the known species of Thaliacea from widely different parts of the great oceans. Even the Great Barrier Reef Expedition, which confined its investigations to definite places obtained only nine species of Thaliacea (Hastings, 1931). Dakin and Colefax (1940) record only seven forms from the Australian plankton.

The " Investigator " Expedition, the only expedition that made collections also from the Bay of Bengal and whose survey period extended over a number of years, collected altogether twelve species of *Salpa* and four species of *Cyclosalpa* from the Indian seas. These collections were mostly from the Burma coast, the Mergui Archipelago, the Revello Channel, the Nankauri harbour and other places (Bomford, 1913 ; Oka, 1915 and Sewell, 1926). The Expedition visited the Madras coast and collected only *Thetys vagina*, *Salpa fusiformis* and *Metcalfina hexagona* during the months of January and February, 1894, from depths ranging from 133 to 250 fathoms ; even the more common forms like *Thalia democratica* and *Salpa cylindrica* were not recorded from this coast (plate VI). On the other hand it must be stated that *Thetys vagina* and *Salpa fusiformis* recorded from this coast by the " Investigator " Expedition are not represented in the Madras collection. This curious fact has also been noted by Russell and Colman (1935) in the case of *Salpa fusiformis*. This species was not represented in their collection even though the form has been recorded by previous authors from the vicinity.

Recently, Menon (1931) while investigating the plankton of the Madras coast has recorded that swarms of *Thalia democratica* occur during the months of September and October. He adds that they then become sparse till February, when swarms appear again. In March they are quite common, but disappear in April.

In this connection mention may be made of two collections of *Salpa* made from the neighbouring seas of the Bay of Bengal. Herdman (1906) has recorded the occurrence of solitary and aggregate individuals of *Salpa cylindrica*, *Salpa runcinata-fusiformis*, and *Salpa democratica-mucronata* from the Ceylon seas. The German Deep Sea Expedition on " Valdivia " which made extensive collections in the Indian Ocean while passing from Sumatra to Nicobar Islands and then to Ceylon collected *Cyclosalpa pinnata*, *Cyclosalpa*

affinis, *Cyclosalpa floridana*, *Salpa fusiformis*, *Salpa fusiformis* forma *echinata*, *Salpa amboinensis*, *Salpa hexagona*, *Salpa mucronata*, and *Salpa zonaria* (Apstein, 1905).

Family Doliolidae Bronn has not been recorded so far from the Bay of Bengal. From the Ceylon waters Herdman (1906) collected small adult specimens of *Doliolum* sp. (?) from Galle harbour and " Nurse Forms " with broad bands from West Cheval and Periya Paars and recorded the occurrence of the genus from both ends of the Island. The only other account of the Doliolids occurring in the neighbouring seas of the Bay of Bengal is that by Neumann (1906) in his work on the collection made by the German Deep Sea Expedition. The " Valdivia " Expedition in its cruise from Sumatra to Colombo collected *Doliolum nationalis*, *Doliolum indicum*, *Doliolum krohni*, *Doliolum gegenbauri*, *Doliolum mulleri* and " Nurse Forms."

Except *Metcalfina hexagona* and *Thalia democratica* the forms dealt with in this paper are recorded from the Madras coast for the first time (Nair and Aiyar, 1943). Similarly, the solitary form of *Cyclosalpa pinnata* var. *polae*, *Salpa maxima*, *Salpa maxima* var. *tuberculata*, *Doliolum denticulatum*, *Dolioletta gegenbauri* and " Nurse Forms " are recorded for the first time from the Bay of Bengal. The " Investigator " Expedition collected from the Bay of Bengal only the aggregate form of *Cyclosalpa pinnata* var. *polae* while a couple of specimens of *Salpa maxima* were collected from the Laccadive seas. The other two Salps were not represented in the " Investigator " collections.

MATERIAL AND METHODS.

The material for this study was obtained from the plankton collections made from the Madras coast. The method of collection was rather crude, as only a catamaran and a townet of fine mull were used for the purpose. Hauls were made up to a depth of 10 fathoms. Under normal conditions collections were brought to the laboratory twice or thrice a week and they were examined for Thaliacea in the fresh condition. The bigger forms like *Salpa cylindrica* were easily picked out, but, while collecting the smaller ones such as *Brooksia rostrata* the sediment was examined under the binocular microscope. Wherever possible, the animals were studied in the living condition. Preserved specimens taken out from previous collections have also formed a considerable portion of the material for this study. All the material for this paper was collected from the plankton collections made from 1st January, 1937 to 31st December, 1943. Altogether four hundred and seven collections, made during these seven years, were examined out of which one hundred and fortytwo collections were found to contain one or more of the *Hemimyaria* described in this paper and of the above collections relating to the period from 1st January, 1937 to 31st December, 1940, one hundred and sixtytwo collections were examined for *Cyclomyaria* also and only thirty-three collections contained gonozooids or oozooids. The following list gives the names of the species collected.

HEMIMYARIA.

GROUP DOLICHODAEA.

1. *Cyclosalpa pinnata* var. *sewelli* Metcalf. ...	Solitary.
2. *Cyclosalpa pinnata* var. *polae* (Sigl). ...	Solitary and Aggregate.

GROUP CIRCODEA.

1. *Brooksia rostrata* (Traustedt).	Solitary.
2. *Ritteriella amboinensis* (Apstein).	Do.
3. *Metcalfina hexagona* (Quoy and Gaimard).	Do.
4. *Jasis zonaria* (Pallas).	Solitary and Aggregate.
5. *Thalia democratica* (Forskål).	Do.
6. *Pegea confoederata* (Forskål).	Do.
7. *Traustedtia multitentaculata* (Quoy and Gaimard).	Solitary.

GROUP SPHAERODAEA.

1. *Salpa maxima* Forskål.	Aggregate.
2. *Salpa maxima* var. *tuberculata* Metcalf. ...	Do.
3. *Salpa cylindrica* Cuvier.	Solitary and Aggregate.

CYCLOMYARIA.

1. *Doliolum denticulatum* Quoy and Gaimard.
2. *Dolioletta gegenbauri* Uljanin.

Two kinds of " Nurse Forms."

For quantitative analysis, except *Thalia democratica, Doliolum* and " Nurse Forms," all the Tunicates dealt with in this paper were counted individually after removal from the plankton. Since swarms of the above-mentioned three forms often occur in the plankton collections, the same method of counting was not adopted. So, after removing all other macroplankton, the sediment was diluted to a known volume and from this 10 cc. was taken with the aid of a wide-mouthed graduated plankton pipette and was spread uniformly in a ruled petri dish. The number of each of the forms present in this volume was then counted under the binocular microscope. The number given in the analytical table for these three forms represents the total number of specimens present in the whole plankton collection estimated in such a manner. Regarding *Doliolum* it should be mentioned that the number in the analytical table represents the total number of the two species present in the plankton collection. Quantitative estimation after identification was seriously handicapped and made impossible by the bad preservation of these delicate forms in most of the plankton collections.

HEMIMYARIA.

GROUP DOLICHODAEA.

Cyclosalpa pinnata var. **sewelli** Metcalf.

Cyclosalpa pinnata Sewell, 1926.

Cyclosalpa pinnata var. *sewelli* Metcalf, 1927.

Solitary Form: (plate I, fig. 1).—Though the species is the first and the best known form in Salpidae, the variety *sewelli* was created only in the year 1927 by Metcalf for Sewell's species of *Cyclosalpa pinnata* with four pairs of luminous organs and a simple ciliated funnel. This variety has been recorded by the " Investigator " from the Nankauri harbour and the Revello Channel of the Andaman sea.

Stray specimens of this variety are met with in the Madras plankton. The thick covering of test round the animal is soft, deteriorates quickly and often gathers much debris from the plankton. The animals are very slow in their movements. The specimens collected from the Madras coast, like those of Bomford (1913) and Sewell (1926), show only four pairs of luminous organs. They are situated between the second and the sixth body muscles. The first pair found in the type species between the first and the second body muscles is absent in the variety. The absence of the first, and the presence of only four pairs of luminous organs on the sides are constant features of this Indian variety of *Cyclosalpa pinnata*. Further, the ciliated funnel in this variety is simple, in the shape of a 'U' and not like a rosette as in the typical European form.

The body has a barrel-shaped appearance and is perfectly symmetrical. Seven body muscles are present, which are interrupted dorsally as well as ventrally. The ventral ends of the intermediate muscles alone meet on the ventral side and are continuous.

The oral musculature consists of the prominent horizontal oral retractor starting from the middle of the first body muscle and running external to the intermediate muscle to the corners of the mouth (plate III, fig. 1). The anterior end of the oral retractor gives off two branches running as the first and the second ventral sphincters. The first and the second dorsal sphincters approach the anterior end of the oral retractor, but are not united with it. In addition to this oral retractor, there is a ventral oral retractor taking its origin from the first body muscle lower down and running obliquely upwards and forwards. The ventral oral retractor also divides into two branches at the place where it crosses the oral retractor and the intermediate muscle. The ventral branch is continued to the lower lip as the third ventral sphincter. The broader dorsal branch after running for a short distance divides into two branches, the third and the fourth dorsal sphincters.

The horizontal muscle starts from the middle of the fourth dorsal oral sphincter on either side and runs posteriorly. In its course backwards, the horizontal muscle fuses with the dorsal end of the intermediate muscle.

The atrial musculature consists of a series of fine, complete, hoop-like sphincters, usually six in number. The first anterior sphincter is strongly developed and is attached to the seventh body muscle on the sides. The ventral region of the second atrial sphincter crosses the first atrial sphincter internally and runs towards the intestinal caeca.

Cyclosalpa pinnata var. **polae** (Sigl).

Cyclosalpa polae Sigl, 1912.
Cyclosalpa pinnata var. *polae* Metcalf, 1918.

Solitary Form : This is recorded for the first time from the Bay of Bengal. Sewell doubted the validity of this subspecies for reasons discussed under the aggregate form.

The solitary form of this variety is more common in the Madras plankton than the variety *sewelli*. Unlike var. *sewelli* where only four pairs of luminous organs are present, in this the usual five pairs are present between the first six body muscles. As Sigl (1912) has pointed out, the solitary form of this variety is easily distinguished from the species by the fusion of the sixth body muscle on the mid-dorsal line and its continuance forwards as a median muscle band reaching almost to the level of the second body muscle. The ciliated funnel is a simple rosette. In all other essential characters of the musculature this variety agrees with the species and var. *sewelli*.

Aggregate Form : (plate I, fig. 2).—The aggregate generations are very common in the Madras plankton. The test is thick and soft. The zooids have a rough oval shape with a fairly long peduncle on the ventral side. According to Sigl, the long peduncle of the aggregate zooids of the variety is another feature distinguishing it from that of the species. There is only a single pair of fairly elongate luminous organs situated on the sides between the second and the third body muscles.

There are four body muscles present which are continuous dorsally. The first and the second, and the third and the fourth body muscles are fused on the mid-dorsal line. In the aggregate form of the species the third and the fourth body muscles are separate on the mid-dorsal line. But in the embryonic condition these two body muscles are fused (Streiff, 1908).

There is only a single oral retractor (plate III, fig. 2). The three ventral oral sphincters arise as branches from the oral retractor. The first dorsal oral sphincter is independent ; it approaches the oral retractor but does not join it. The second and the third dorsal oral sphincters are united with the intermediate muscle near the oral retractor. The intermediate

muscle after fusion with the second and the third dorsal oral sphincters proceeds postero-dorsally and unites with the upper portion of the first body muscle. Ventrally the intermediate muscles of either side meet as in the solitary form, and are continued into the peduncle. The fourth body muscle is continuous ventrally and gives off at the side an anterior branch which stops at a level with the ventral end of the third body muscle. The ventral ends of the first and the second body muscles of each side are united to form a broad band which is continued into the peduncle.

There is a horizontal atrial retractor taking its origin from the fourth body muscle at the side. There are five unbranched, complete, hoop-like atrial sphincters round the atrial opening. The first sphincter is well developed and is connected with the atrial retractor.

From the " Investigator " collections Sewell got only solitary forms of *C. pinnata* var. *sewelli* with four luminous organs and aggregate forms of var. *polae*. He assigned the solitary forms to *C. pinnata*, even though they showed certain minor racial characters ; and he considered the aggregate zooids also as those of *C. pinnata*, even when they showed fusion of the third and fourth body muscles. Further, in the description of the aggregate zooid he says, " Had I been dealing solely with examples of the aggregated zooid I should have had no hesitation in referring this form to the var. *polae*, but as I have already shown, the asexual generation must be referred to *C. pinnata*. It is impossible, therefore, to distinguish *C. polae* from *C. pinnata* even as a subspecies and much less, as Sigl originally claimed, as a species." Because he has identified the solitary form as *C. pinnata*, it does not necessarily follow that the aggregate generations which he collected along with it should be that of the same species. He did not get the solitary forms of var. *polae*. But in Madras the solitary forms of *C. pinnata* var. *sewelli* and var. *polae* have been collected. So, naturally, Sewell's description of the aggregate forms of *C. pinnata* is really that of its var. *polae* whereas the aggregate form of *C. pinnata* var. *sewelli* itself remains unrecorded.

Group Circodea.

Brooksia rostrata (Traustedt).

Salpa rostrata Traustedt, 1893 ; Apstein, 1894 ; Streiff, 1908 ; Ihle, 1910.
Brooksia rostrata Metcalf, 1918 ; Sewell, 1926 ; Ihle, 1935.

Solitary Form : (plate I, fig. 3).—The " Investigator " Expedition got a single dead specimen of this very rare Salp in a bad condition from the Nankauri harbour and another fragment from the Revello Channel. The Madras collection contains three badly preserved specimens of this species, two obtained from the plankton collection made on the 15th August, 1939 and the third from the collection of the 14th October, 1942. The biggest specimen measures about 13 mm. including the anterior projection.

Brooksia rostrata is characterised by the presence of a large antero-ventral projection as long as the body itself, starting from the base of the mouth. This proboscis is provided with two pairs of strong, broad muscle bands traversing its whole length. The dorsal pair of muscle bands is a continuation of the strongly developed second dorsal oral sphincter. The ventral pair of muscle bands is continued posteriorly along the ventral side in close proximity with, and on either side of, the endostyle up to the ventral ends of the sixth body muscle and the anterior portion of the nucleus. This pair, like the dorsal pair, is considerably broad in the region of the proboscis. The ventral ends of all the body muscles, excepting the last, touch the muscle bands of this pair. The ventral ends of the intermediate muscles alone merge into the muscle fibres of this band.

The musculature of *B. rostrata* has not been studied satisfactorily, largely due to its rarity. The accounts of this form by previous authors, Traustedt (1893), Apstein (1894) and Ihle (1910) do not agree. In the Madras form, seven strongly developed body muscles are present continuous on the dorsal side, while on the ventral side they are separate ; and the free ends, except those of the last body muscle, touch the ventral pair of the proboscis muscles as previously mentioned. The body muscles are arranged in two groups composed of the first three and the last four body muscles. The edges of the body muscles of each group meet and fuse mid-dorsally. The dorsal end of the intermediate muscle is attached to the first body muscle dorso-laterally. The fairly long horizontal muscle is present on either side of the eye between the second dorsal oral sphincter and the first body muscle.

The oral retractor is well developed and is attached to the first body muscle a little below the attachment of the intermediate muscle (plate III, fig. 3). The oral retractor crosses the intermediate muscle and the second dorsal oral sphincter and gives off three branches, one going to the upper lip as the first dorsal oral sphincter, and the other two to the lower lip as the ventral oral sphincters.

Owing to the bad preservation of the specimens the atrial musculature could not be made out satisfactorily. Yet, the presence of four continuous rings of sphincters round the atrial opening could be made out in one specimen.

The nucleus is fairly big and in each of the three specimens a well developed stolon is present consisting of two rows of individuals. The eye which is situated anterior to the ganglion has the usual horse-shoe shape. A small posterior prolongation of the mantle behind the nucleus and below the atrial siphon has been noticed in both the specimens collected on the 15th August, 1939.

Ritteriella amboinensis (Apstein).

Salpa amboinensis Apstein, 1904 ; Ihle, 1910.
Ritteria amboinensis Metcalf, 1918 ; Sewell, 1926.
Ritteriella amboinensis Metcalf, 1919 ; Ihle, 1935.

Solitary Form : (plate I, fig. 4).—Sewell obtained a few specimens of the solitary form of this rare species from the Revello Channel, Nicobars. Eleven specimens of the solitary generation of this Salp were collected during the seven years' plankton analysis, the biggest of which measures 20 mm. in length. A well-developed stolon was present in some of the larger individuals.

All the specimens show the usual eleven body muscles. The first four are continuous across the mid-ventral line also. The rest are interrupted and the ends are widely separate ventrally. The first two as well as the last two body muscles are fused on the dorsal side. All the body muscles are somewhat symmetrically continuous along the dorsal aspect in a zig-zag manner.

The musculature of the mouth seems to vary considerably. The oral musculature of the Madras form tallies with the description of the form by Metcalf (1918) with the exception of a few minor differences. The oral retractor, after crossing the intermediate muscle and the broad third dorsal sphincter, divides into two branches at the corner of the mouth, the anterior of which runs as a discontinuous first lower sphincter along the margin of the valve of the lower lip, while the posterior second branch runs as the continuous second lower sphincter (plate III, fig. 4). Sewell has also shown the origin of the first dorsal sphincter from the oral retractor. The corresponding sphincter in the Madras specimens fuses with the broad third dorsal sphincter at the region where it crosses the oral retractor and the fused band divides into two branches ventrally to form the third and the fourth ventral oral sphincters. The first sphincter of the upper lip is discontinuous dorsally and is situated at the margin of the corners of the mouth. On the dorsal side it crosses obliquely the second dorsal sphincter while its ventral end comes in contact with the second ventral sphincter.

The intermediate muscles, like the four anterior body muscles, are continuous only on the mid-ventral line.

The anterior end of the horizontal muscle projects above the broad third dorsal oral sphincter, while the posterior end is situated very near the dorsal end of the intermediate muscle.

The atrial musculature is simple. The atrial retractor instead of being horizontal takes its course ventrally, on a level with the ventral ends of the posterior body muscles and runs obliquely towards the corners of the atrium. Its ventral end is forked. In its postero-dorsal course the atrial retractor gives off seven to eight dorsal atrial sphincters at regular intervals. The ventral lip of the atrial opening also contains a similar number of ventral sphincters which do not fuse with the atrial retractor but crosses it and ends in fine strands.

Metcalfina hexagona (Quoy and Gaimard).

Salpa hexagona Quoy and Gaimard, 1824 ; Traustedt, 1885 ; Apstein, 1894 ; Ible, 1910 ; Oka, 1915.

Jasis hexagona Herdman, 1891.
Ritteria hexagona Metcalf, 1918 ; Sewell, 1926.
Ritteriella hexagona Metcalf, 1919.
Metcalfina hexagona Ihle, 1935.

Solitary Form : (plate I, fig. 5 and plate IV, fig. 1).—A single solitary zooid of this warm water species was obtained on the 29th May, 1943. The specimen was brought to the laboratory in a dead condition with the body muscles of the middle region torn in some places. It was caught in the deep water fishing nets. *Metcalfina hexagona* has never been found in the many townet collections made so far on the Madras coast. It is apparently a deep water form of the Indian seas. But this species has been collected from the surface waters of the other oceans. Sewell has drawn attention to this interesting feature, namely, its deep water habitation in the Indian Ocean only. The specimen measures about 90 mm in length excluding the two posterior protuberances of the test. This is the biggest of the Thaliacea obtained so far from the Madras coast.

The fairly thick test of *M. hexagona* is soft in the anterior region and hard in the posterior region. Prominent longitudinal ridges are present on the test, especially in the posterior half. At the posterior end, the test gives off two prolongations measuring about 7 mm. in length. As in *Thalia democratica* tubular prolongations of the mantle cavity extend into them for a short distance. Metcalf has described these processes as denticulate. Like Sewell's specimens, the Madras specimen also does not bear any denticulations on these prolongations. Five faint longitudinal ridges are present on each one of them.

All the body muscles are broad. Those of the posterior region gradually become broader, the last one being about twice the width of the first body muscle. They are continuous across the dorsal side in an irregular, zig-zag manner as in *Ritteriella amboinensis*. Consequently there is no typical number of muscle bands for this species. On the left side nine body muscles are present while the other side bears ten. Considerable variation in the number and arrangement of the body muscles has been noted before.

The intermediate muscle is as wide as the anterior body muscles and resembles them in general appearance. Like the body muscles, this muscle is also continuous across the dorsal side and is interrupted very widely on the ventral side.

Though the oral retractor takes its origin very near the first body muscle as a well defined strip of muscle band it is interrupted in the region where it crosses the intermediate muscle, and the course is represented only by a few faint streaks (plate III, fig. 5). The broad third sphincter of the upper lip crosses internally the anterior bit of the oral retractor and extends on the sides to the same distance as the intermediate muscle. The second dorsal sphincter is very narrow and starts as a small anterior branch of the third dorsal sphincter. The first admarginal sphincter of the upper lip maintains its connection with the oral retractor as well as the third dorsal sphincter. The lower lip is provided with three sphincters and

all of them commence from the oral retractor. The admarginal first sphincter is at the margin of the strongly incurved ventral lip. The second and the third lower sphincters, after taking their origin from the oral retractor, run close together at the base of the fold of the ventral lip. No horizontal muscles have been observed in the specimen.

The well developed atrial retractor, after taking its origin a little in front of the posterior edge of the last body muscle, runs posteriorly to the corners of the atrial opening giving off about nineteen atrial sphincters to both the upper and the lower lips. The first anterior sphincter is the broadest and a gradual decrease in breadth is seen in the succeeding sphincters. The posterior-most sphincters are only mere fibres. The antero-posterior edges of some of the sphincters meet and appear to be united in places. There are strands of muscle fibres on the ventral side connecting the postero-ventral corner of the last body muscle with the first lower atrial sphincter.

The gut is a simple loop, the course of which can be followed even without the aid of a lens. A well developed stolon is present consisting of about fifty aggregate zooids measuring 3 mm. in length. The neural gland with the eye is situated beneath the posterior border of the third muscle band of the left side or the fourth of the right side.

Jasis zonaria (Pallas).

Holothurium zonarium Pallas, 1774.
Salpa cordiformis Traustedt, 1885 ; Oka, 1915.
Salpa nitida Herdman, 1888.
Salpa cordiformis-zonaria Herdman, 1891.
Salpa zonaria Apstein, 1894 ; Streiff, 1908 ; Ihle, 1910 ; Bomford, 1913.
Iasis zonaria Metcallf, 1918 ; Ihle, 1935.
Jasis zonaria Sewell, 1926.

The "Investigator" found this species to be of comparatively common occurrence in the Indian Ocean. It has been recorded by the Expedition from many places in the Bay and the neighbouring seas. *Jasis zonaria* occurs commonly in the Madras plankton. The occurrence of solitary individuals of different sizes in the same plankton collection has been frequently noticed. The biggest specimen was obtained from the plankton collection made on the 9th March, 1943 and measured 35 mm. in length. During the study of the seven years' collections, the one made on this date contained the greatest number of both the solitary and the aggregate individuals of this species. The movement of the solitary form is quite characteristic and differs markedly from the other members of Salpidae, in which the movement is almost in a straight line effected by a series of jerks. But in this form the course is invariably in circles. This peculiar movement in circles is mainly due to the wedge-like shape of the body and the conical, downwardly directed, posterior prolongation of the test. A similar, but less striking movement, is performed also by the solitary generation of *Thalia democratica.*

Solitary Form : (plate I, fig. 6 and plate IV, fig. 2).—The shape of the solitary form of *Jasis zonaria* is very characteristic and has the appearance of a wedge. The anterior region is flattened dorso-ventrally and the oral opening is in the form of a slit in the anterior flattened extremity. The posterior-most region is more or less rectangular in shape, due to the presence of strong ridges on the test. The posterior end tapers into a downwardly directed, short, conical prolongation in which the nucleus is placed. The test is uniformly hard and in the posterior region it is fairly thick. The nucleus with the gut forming a close loop is pure white in colour. A well developed stolon has been noticed in many of the solitary forms.

There are five body muscles which are interrupted both dorsally and ventrally. The first four body muscles are broad while the fifth is only half as wide as the others. Laterally the fifth body muscle extends only up to the base of the atrial retractor and it is not in general conformity with the other body muscles in appearance. On the contrary, the intermediate muscle is of the same size and appearance as the body muscles and performs the same function.

The oral musculature agrees with the previous descriptions. Only a single strong oral sphincter is present in each of the strongly incurved lips. The dorsal and ventral sphincters unite at the angles of the very much flattened oral opening and run posteriorly external to the intermediate muscle as the oral retractor. Lying mid-way between the anterior end of the animal and the oral retractor, and at the angles of the oral siphon is the strong muscle characteristic of the subgenus, coloured brown in preserved specimens and opaque white in living ones. The ends of this muscle extend only for a short distance to the dorsal and ventral sides of the oral siphon. Metcalf has described the dorsal and ventral oral sphincters as interrupted in the middle line. Sewell too found no deviation from the condition described by Metcalf in the specimens examined by him. In the Madras form both the oral sphincters are perfectly continuous throughout their course without any interruption.

The atrial musculature consists of the strong atrial retractor, three dorsal and three ventral atrial sphincters (plate III, fig. 6). The atrial retractor is a strong muscle the base of which is flattened and spreads out like a fan while the narrow dorsal portion terminates in five or six short branches. The first admarginal dorsal and ventral sphincters are continuous at the corners of the atrial opening. The extremities of the second ventral sphincter project a short distance forward after crossing the dorsal end of the atrial retractor externally. The strand-like ends of the third dorsal atrial sphincter approach the bases of the second ventral sphincter. The third dorsal sphincter of one half gives off four regularly arranged branches which are continuous with their fellows of the other half and present a pattern very much similar to that of the solitary zooid of *Thalia democratica*. The second dorsal atrial sphincter is a short piece of muscle which is interrupted in the middle and the interrupted ends curve anteriorly. Each piece lies symmetrically on either side of the middle

line of the upper lip of the atrium. The ends of the third ventral sphincter are attached to the outside of the middle portion of the atrial retractor by means of two branches. The dorsal atrial lip forms a triangular plate-like flap over the atrial opening.

Aggregate Form : (plate I, fig. 7 and plate IV, fig. 2).—The biggest zooid measures 27 mm. in length including the anterior and posterior projections. Connective tissue fibres are present in these projections of the mantle into the test reaching up to the tip. These fibres are more prominent in the posterior projection. Like the aggregate forms of other Salps, this form is also asymmetrical mainly in the lateral shifting of the atrial siphon and the conical posterior projection. The usual eight attachment protuberances of the mantle are clearly seen in the aggregate individual. As in *Thalia democratica* and in *Pegea confoederata*, the arrangement is quite characteristic of the species. A group of three protuberances is found at the tip of the anterior mantle prolongation while another group of a similar number is present on the ventral side at the base of the dorsally tilted posterior mantle prolongation. The remaining two protuberances are found on the mid-ventral line on a level with the interspace between body muscles two and three. This type of disposition of the mantle protuberances is in accordance with the end to end lengthwise attachment of the individuals in the chain condition which has been clearly figured by Brooks (1893).

There are five broad body muscles which, with the exception of the first, are continuous across the mid-dorsal line. They are interrupted and widely separated on the ventral side. The right lateral portion of the fifth body muscle divides into a long anterior and short posterior branches.

The well developed intermediate muscle is composed of two muscle bands which are closely apposed together. These two muscle bands extend as far on the ventral side as the body muscles. Dorsally they extend only a short distance.

At the angle of the mouth is the short oral retractor which divides into two sphincters going to the two strongly incurved lips (plate III, fig. 7). Metcalf described only a single set of oral sphincters. Streiff (1908) and Sewell showed the presence of another set of delicate oral sphincters in addition to the one described by Metcalf. This set of sphincters is very delicate and easily escapes notice. It originates at the point of bifurcation of the oral retractor and runs as a delicate continuous strand in the lower lip, while the one entering the upper lip is feebly developed and extends only for a short distance. Situated externally and anterior to the point of bifurcation of the oral retractor is the short piece of brown muscle band of the oral siphon characteristic of *J. zonaria*.

The atrial musculature consists of a pair of strong atrial retractors placed at the angles of the atrial opening. The dorsal ends of these muscles are branched (plate III, fig. 8). There are four ventral atrial sphincters. The last three take their origin from the oral retractor. The first ventral sphincter is continuous with the admarginal first dorsal sphincter. The place of origin of the second and third ventral sphincters from the oral

retractor is the same and sometimes the ends of the two sphincters merge with each other while the fourth takes its origin a little ventrally. The second dorsal atrial sphincter is not attached anywhere but the two ends come in apposition with the second ventral atrial sphincter, at the angles of the atrial opening. This sphincter breaks up into branches medially.

Thalia democratica (Forskål).

Salpa democratica Forskål, 1775 ; Brooks, 1893 ; Traustedt, 1893 ; Ihle, 1912 ; Bomford, 1913.

Salpa mucronata Forskål, 1775 ; Apstein, 1894 ; Streiff, 1908 ; Ihle, 1910.
Salpa democratica-mucronata Traustedt, 1885 ; Apstein, 1904.
Thalia democratica-mucronata Herdman, 1888.
Thalia democratica Metcalf, 1918 ; Sewell, 1926 ; Ihle, 1935.

Of all the Salps, *Thalia democratica* is the most widely distributed and abundant species. This has been recorded from all the tropical and temperate seas excepting the Eastern Mediterranean, West Indian waters and the Pacific Ocean north of Lat. 30° N. This has been collected by the " Investigator " from the Bay of Bengal, many places round the Mergui Archipelago, the Mergui harbour, the Nankauri harbour, the Revello Channel and other places. Menon has observed the occurrence of swarms of this species during September and October in the Madras plankton.

The biggest solitary specimen obtained so far measured only 11 mm. in length excluding the posterior processes. Previous workers are agreed that the specimens found in the tropics are smaller. In the North Atlantic specimens measuring about 25 mm. in length have been reported to be common. Sewell has attributed this deficiency in size of the tropical forms to the lower density of the surface waters of the tropics.

Nothing is known about the span of life or time required by the two generations to attain maturity. Since the zooids were obtained in sufficient numbers attempts were made to rear them in the laboratory tanks. Usually the healthy specimens survived only for a couple of days. Though the attempts were not successful, the results were encouraging, especially with regard to the rate of growth of the chain forms. It is well known that the stolon in the solitary forms contains from three to four blocks of aggregate individuals when the distal block is ready to emerge from the mantle cavity to the exterior. It was found when reared under laboratory conditions that the individuals in the distal block measuring about 290 microns in length grew to a size of about 1,010 microns overnight. Next day the chain often got detached from the parent while sometimes it was found still attached to the mother. The significant fact is that the growth of *T. democratica* seems to be very rapid under tropical conditions.

Solitary Form : (plate I, fig. 8 and plate IV, fig. 3).—The solitary form has a barrel-shaped appearance with the test covered uniformly by numerous minute denticulations. The posterior end tapers into a ventrally directed short prolongation which ends in two short, pointed processes. Two pairs of tapering processes of the test are present on either side of the median process. The anterior ventro-lateral pair is very short when compared with the posteriorly situated dorso-lateral pair which is nearly a third of the length of the individual. On either side of the atrial opening is a pair of flattened prolongations. All the eight prolongations of the test are also covered by denticulations. In the very young solitary forms the paired processes have a leaf-like appearance.

There are five body muscles arranged in two groups. The anterior group is composed of the first, second and third body muscles which meet in the mid-dorsal line. The posterior second group consists of the remaining two body muscles which also meet in the mid-dorsal line. The body muscles, like the muscle bands of *Doliolum*, are continuous throughout and are in the form of hoops.

The intermediate muscle is also well developed and is continuous on the ventral side but is interrupted dorsally. This muscle resembles the body muscles in size and disposition. Its place in the working of the oral aperture appears to be taken by the very strongly developed second oral sphincter of the upper lip.

The strongly developed oral retractor divides into three branches anteriorly (plate III, fig. 9). The dorsal branch runs as the admarginal first sphincter of the upper lip which is interrupted on the dorsal side. The middle and the ventral branches run as the second and third sphincters of the lower lip respectively. The ends of the admarginal first sphincter of the lower lip extend up to the anterior branched portion of the oral retractor. The strongly developed second dorsal sphincter, at the region where it crosses the oral retractor, gives off an anterior small branch which is continued to the lower lip as the fourth sphincter. The main posterior broader branch extends ventrally. The homology of this branch is uncertain. Streiff regards this as one of the two divisions of the intermediate muscle, while Metcalf compares it with the ventral extension of the posterior dorsal lip sphincter of *Cyclosalpa.*

The dorsal horizontal muscles are present in the usual place between the intermediate muscle and the second dorsal oral sphincter.

The strong atrial retractor is connected with the broad third dorsal atrial sphincter and with a ventral branch which divides to form the first and the third ventral atrial sphincters (plate III, fig. 10). Anterior to this there is another strong continuous band representing the broad fourth dorsal atrial sphincter and the second ventral atrial sphincter. The first and second dorsal atrial sphincters are very small and their bases are joined together. Three concentric, horse-shoe shaped muscles join the first dorsal atrial sphincter in the mid-dorsal line.

Aggregate Form : (plate I, fig. 9 and plate IV, fig. 3).—Active chain forms are frequently obtained when the aggregate generations appear in large numbers. Like other

species of Salpidae, the aggregate zooids of this species are also slightly asymmetrical and possess two forms depending on the side occupied by the individual in the chain. The asymmetrical nature is more pronounced in the slight shifting of the atrial opening and the mantle protuberances. The body is roughly oval with the test tapering at the posterior end into a denticulated prolongation. In young specimens the posterior prolongation of the test is short and increases in length according to the age of the individual.

The individuals in a chain are held together by processes of the test intended for attachment, with prolongations of the mantle extending into them (plate I, fig. 11). Each aggregate individual has only eight such protuberances for attachment situated on the ventral and lateral sides (plate I, fig. 10). This is naturally accounted for by the fact that the individuals are arranged side by side in a row and the two rows are apposed together by their ventral sides. In the Madras forms the number of these processes is constant and no variation has been noticed. The figure shows the disposition and relative size of the processes for attachment on an individual taken from the right side of the chain. The processes for attachment on the individual on the left side are a mirror image of those of the individual on the right side. When an individual gets detached from the chain there is a tendency for these prolongations, especially the smaller ones situated on the ventral side, to disappear. After some time the bigger anterior and the posterior processes alone persist.

Metcalf says about the specimens of *Thalia democratica* collected from the Atlantic coast of the United States that " there are but few tubular protuberances of the mantle into the test. If there are others they are generally weakly developed ". Evidently his specimens were detached individuals of the chain form collected after a lapse of time when the smaller of the protuberances had begun to disappear. On the contrary his Phillippine specimens showed " more numerous and much more developed mantle protuberances ". His figure of this form shows only eight such processes. This will be the typical condition of the protuberances when the aggregate individuals freshly detached from the chain condition are examined. But his figure shows all the protuberances as arising from the sides which cannot be the case as has already been explained. Sewell too says, " most of the Indian examples that I have examined show a very distinct approximation to the Philippine type " of Metcalf. " In these individuals the mantle sends out a number of tubular processes into the test (his figure shows only six) but the actual number of such processes appears to vary very considerably " and he concludes by saying that " were a sufficient number examined, all intermediate stages between the typical European form and the Philippine form could be traced " even though he could not find any difference in the musculature of these forms from the normal specimens.

Normally *T. democratica*, when in the actual chain condition will have only eight protuberances of the test for attachment. An individual is connected with the adjoining individual of the chain by means of two processes. Each individual in a chain is in contact with four of its fellows and thus all the four pairs of processes are engaged.

There are four body muscles continuous dorsally but interrupted and widely separated ventrally. The first three body muscles are joined together in the mid-dorsal line. The fourth body muscle gives off a thin branch extending up to the base of the atrial opening.

The well developed intermediate muscle is composed of an anterior and a posterior division (plate III, fig. 11). The posterior one, after crossing the oral retractor, runs upwards and backwards for a short distance while the anterior stops at the region of the oral retractor. The strongly developed third sphincter of the upper lip joins the anterior branch of the intermediate muscle.

The short oral retractor divides into four branches which are continued as the first and the second dorsal oral sphincters and the first and the third ventral oral sphincters (plate III, fig. 11). The second and the fourth ventral oral sphincters are independent and are united at their bases at the corner of the mouth.

The atrial musculature consists essentially of three dorsal and three ventral sphincters (plate III, fig. 12). The atrial retractor gives off three branches which are continued as the first and the second dorsal atrial sphincters and the first ventral atrial sphincter. The third dorsal atrial sphincter ends abruptly on the right side near the oral retractor while on the left side it divides into the second and the third ventral atrial sphincters. These two sphincters on the right side fuse together and ultimately join the oral retractor of the right side.

Pegea confoederata (Forskål).

Salpa confoederata Forskål, 1775 ; Apstein, 1894 ; Streiff, 1908 ; Ihle, 1910 ; Bomford, 1913.

Salpa quadrata Herdman, 1888.

Pegea scutigero-confoederata Traustedt, 1885 ; Herdman, 1891 ; Apstein, 1904 ; Oka, 1915.

Pegea confoederata Metcalf, 1918 ; Sewell, 1926.

Previously this species has been recorded from the Arabian sea, the Revello Channel, Preparis North Channel and other places in the Bay of Bengal. Next to *Thalia democratica*, *Salpa cylindrica* and *Jasis zonaria*, this is the commonest form occurring in the Madras plankton. The occurrence of numerous dead specimens of *Pegea confoederata* comprising mostly the aggregate form along the Madras coast on the 12th October, 1943 under very abnormal conditions is worth recording here. Madras experienced very heavy and continuous rains for about a week during the preceding days and this resulted in the complete flooding of the city on the 10th and the 11th of October, 1943. Due to the draining of this water by the river Cooum, the sea was discoloured to a great extent and the salinity very low. Probably the current set up in the sea by the flow of large quantities of water from the flooded city along the overflowing Cooum and the very low salinity of the sea water might have been the reasons for the occurrence of large numbers of stranded specimens along the Madras

coast. This collection consists of two hundred and thirty three aggregate and seven solitary individuals, and a very long chain form composed of small aggregate individuals (plate IV, fig. 4). One side of a beautiful chain condition of medium-sized aggregate individuals was obtained from inside the Madras harbour on 4th October, 1935 (plate IV, fig.5).

Solitary Form : (plate II, fig. 1).—The solitary forms are represented in my collection by twenty nine specimens (including the specimens collected on the 12th October, 1943) of which thirteen are embryos. The biggest specimen from the townet collection of 15th August, 1939, measures 50 mm.

The scarcity of the solitary generations of *P. confoederata* in the surface waters has been emphasised by all previous workers on Salpidae. The " Investigator " collection contained thirty individuals including the embryonic forms. The Deep Sea Expedition collected twelve individuals, while the " Siboga " Expedition recorded only a single specimen. Ritter (quoted by Metcalf), after examining thousands of *P. confoederata*, got only two solitary individuals. Metcalf's explanation for the scarcity of the solitary generation, that they lie deep in the sea throughout the year and never come to the surface, seems to be plausible. The suggestion that the solitary individuals may be much more abundant in the deeper waters is supported by the data of collection of the previous authors.

The two generations of *P. confoederata* differ very little in the musculature and general features. The nucleus in the aggregate form occupies an extreme posterior position with a very thick covering of test round it, while in the solitary generation it is placed on the ventral side at two-thirds of the length from the anterior end. Further the presence of the protuberances for attachment in the aggregate individuals enables us to distinguish them easily from the other generation.

There are four body muscles on the dorsal side which do not extend laterally. The first and the second body muscles join together in the mid-dorsal line. The middle portions of the third and the fourth body muscles approach each other very close but do not join.

The intermediate muscle is composed of an anterior and a posterior muscle band and the peripharyngeal groove runs between these two bands. The dorsal end of the anterior muscle band is continuous with the posterior end of the dorsal horizontal band.

The oral musculature consists of the oral retractors situated at the corners of the mouth, and each is composed of two muscle bands, a dorsal and a ventral (plate III, fig. 13). The dorsal oral retractor divides anteriorly into two branches, the dorsal of which is continued as the first sphincter of the lower lip. The dorsal branch of the dorsal oral retractor gives off a short branch which runs for a short distance along the margin of the upper lip. The ventral branch of the dorsal oral retractor is continued as the second sphincter of the lower lip. The ventral oral retractor is continuous with the only complete sphincter of the upper lip and also with the third sphincter of the lower lip. As Sewell has pointed out the oral

retractor varies considerably in different individuals. Such variation has been observed also in the same individual. In one of the specimens in the collection the posterior end of the dorsal oral retractor of the left side is branched into two while that of the right side is normal. In another specimen the right dorsal oral retractor is branched into three while the left has only two branches.

The atrial musculature is rather complicated and consists of two sets, namely, a basal set and a distal set composed of the atrial retractors and sphincters (plate III, fig. 14). The basal set consists of a dorsal band which appears branched owing to the origin of another strand from near its middle, and a ventral muscle band. Sewell suggests that these two bands might have been continuous in the living condition, but broken up into bits when killed. Similarly, he also suggests that the small bit of muscle lying anterior to the ventral band of the basal set might be a broken remnant of the fourth body muscle. These two suggestions require confirmation. The distal set consists of three atrial sphincters of the upper lip and the three ventral sphincters of the lower lip. The three dorsal atrial sphincters are connected with the atrial retractor. The third dorsal atrial sphincter is not continuous on the dorsal side. The first ventral atrial sphincter also joins the atrial retractor while the second crosses it and proceeds for a short distance dorsally in the form of a fourth dorsal atrial sphincter. The third ventral atrial sphincter is confined to the ventral side and does not approach the atrial retractor.

In most of the specimens the placenta was present on the ventral side just below the nucleus as an oval disc. This suggests that the specimens are still young though the stolon has made its appearance round the compact nucleus.

Aggregate Form : (plate II, fig. 2).—The biggest of the specimens obtained from the collection of 15th August, 1939 measures 60 mm. The musculature of the aggregate zooid closely resembles that of the solitary one. The four usual body mucles are present on the dorsal side in two groups. In this form, unlike the solitary generation, the third and the fourth body muscles meet dorsally.

The intermediate muscles as well as the oral musculature of this form are similar to those of the solitary zooid.

The atrial musculature is different. The atrial retractor is continued on the dorsal side as the broad third atrial sphincter, which is interrupted on the sides (plate III, fig. 15). Lying at the corners of the atrial opening and in contact with the atrial retractor is a strip of broad muscle which divides dorsally into two branches. The posterior branch runs as the first dorsal atrial sphincter, which again, like the third sphincter, is not continuous, but broken at the sides. The anterior short branch is the second dorsal atrial sphincter. This sphincter is incomplete on the dorsal side and extends on the sides for a short distance only. The first and the second ventral sphincters arise from a single root at the junction of the atrial retractor

with the dorsal atrial sphincters. The third ventral sphincter crosses the ventral end of the atrial retractor internally and approaches the fourth body muscle, but does not join it. All the ventral atrial sphincters are continuous. Anterior to the third ventral sphincter lies a muscle band which is morphologically the posterior branch of the fourth body muscle.

The test in the region of the nucleus is very thick and hard. Each individual carries only a single embryo on the right side between the third and the fourth body muscles. All the specimens collected here possess eight protuberances for attachment, four on the sides near the ends of the first and the fourth body muscles and the other four on the ventral side.

Traustedtia multitentaculata (Quoy and Gaimard).

Salpa henseni Traustedt, 1893 ; Apstein, 1894.
Salpa multitentaculata Ihle, 1911 ; Bomford, 1913.
Traustedtia multitentaculata Metcalf, 1918 ; Sewell, 1926 ; Ihle, 1935.

Solitary Form : (plate II, fig. 3).—It is well known that *T. multitentaculata* is a very rare form and so it is not surprising that a single specimen of the solitary zooid alone was represented in the Madras collection, even though many plankton samples were examined. This species, like *Brooksia rostrata*, is apparently a very casual visitor to the Madras coast. The single specimen was obtained from the plankton collection made on the 27th September, 1940. It measured about 12 mm. in length excluding the tentacular processes. The preservation of the specimen was unsatisfactory ; for the test had become white and opaque, and the muscles in the vicinity of the atrial opening including the atrial sphincters were broken. The " Investigator " collected six specimens of this species from the Nankauri harbour, the Revello Channel and the Laccadive sea and also a fair number of the aggregate forms.

The shape of the zooid is more oval than spherical with a slight compression of the body dorso-ventrally. The nucleus is spindle-shaped and is placed vertically at the posterior end and projects on the ventral side much beyond the general contour of the body with a fairly thick covering of test round it. On the dorso-lateral side a pair of crests is formed by thickened projections of the test. The crests are coarsely toothed on the free edge. The anterior part of the test of the ventral oral lip also bears a row of teeth. Metcalf (1918) and Oka (1921) describe the presence of thirteen tentacular processes in the solitary form of this species. But in the specimens occurring in the Indian waters, Sewell has noted only nine such processes and considers this variation as of geographical nature only. In the single specimen of the Madras collection also only nine tentacles have been observed. Only four of these, namely, the anterior ventro-lateral pair and the posterior ventro-lateral pair are long and contain tubular prolongations of the mantle into them up to the tip. The anterior pair is about the length of the body while the posterior pair is about one and a half times longer. The remaining five tentacles are mere tubular projections of the mantle into the test and do not pass beyond the general outline of the body. A pair of tubular protrusions arises on the dorsal side from near the fourth body muscle and projects into the posterior end of the dorsal

crests. Another pair is present at the angles of the atrial opening. These two pairs are very small and barely noticeable. The median unpaired protrusion takes its origin from behind the middle portion of the nucleus and passes vertically upwards, terminating near the border of the test on the dorsal side. A fairly well developed stolon is present in the specimen.

There are five body muscles which occupy only the dorsal side of the animal. The first three form a group and are completely fused together medially. This group of body muscles has the appearance of a single muscle band with three branches at the ends. The fourth body muscle at the sides gives off a small posterior branch which runs backwards to the base of the atrial opening. This branch, where it crosses the fifth body muscle, divides into two, the dorsal of which fuses with its fellow of the other side to form a continuous band at the base of the atrial siphon, while the ventral branch runs towards the visceral mass. The fifth body muscle is situated very near the atrial opening. Near the corner of the atrial opening this muscle sends off a small posterior branch which runs towards the bases of the atrial sphincters (plate III, fig. 17).

The intermediate muscle is a short strip lying inside the oral retractors.

The horizontal muscle is thin and very small and lies at the dorsal end of the intermediate muscle along the peripharyngeal groove.

Two short oral retractors are present (plate III, fig. 16). The dorsal oral retractor divides into three branches ; the first running as the incomplete, short, first dorsal sphincter, while the remaining two branches run as the first and second ventral sphincters. Both these sphincters are continuous from side to side and their bases are united for some length. The first ventral sphincter is well developed while the second is a thin strand of muscle fibres. The ventral oral retractor gives off two branches which run as the second dorsal sphincter and the third ventral sphincter. These two sphincters are interrupted medially and appear as short stumps from the sides. Owing to the bad state of the specimen blood sinuses connecting the ends of these sphincters could not be made out.

Arising close to the dorsal branch of the posterior division of the fourth body muscle is the short and weakly developed atrial retractor, which runs upwards to the corner of the atrial opening (plate III, fig. 17). Due to the unsatisfactory preservation of the specimen the atrial sphincters were detached from the atrial retractor, and so the origin of the atrial sphincters from the atrial retractor could not be made out. There are two dorsal atrial sphincters the admarginal of which is well developed and strong, while the second is delicate and weakly developed. The ends of these two sphincters are united for a short distance. There are three ventral atrial sphincters of which the strongly developed admarginal is continuous with the bases of the fused dorsal atrial sphincters at the corners of the atrial opening. Like the second dorsal sphincter the second ventral is also very thin and approaches the atrial retractor at the sides. The third sphincter is confined to the median region of the ventral lip and does not approach the corners of the atrial opening.

GROUP SPHAERODAEA.

Salpa maxima Forskål.

Salpa maxima Forskål, 1775 ; Apstein, 1894 ; Striff, 1908 ; Ihle, 1912, 1935 ; Metcalf, 1918 ; Sewell, 1926.

Salpa africana Forskål, 1775.

Salpa africana-maxima Traustedt, 1885 ; Herdman, 1888 ; Apstein, 1894.

Aggregate Form: (plate II, fig. 4).—Only the aggregate individuals of this species have been collected from the Madras coast. The " Investigator " got only two examples of the aggregate zooids collected from the Laccadive sea. So this is the first record of the occurrence of *Salpa maxima* in the Bay of Bengal. Evidently it is not a very rare species, for, as many as thirty-seven specimens of the aggregate zooids have been collected from a single plankton collection. But it is curious that neither the " Siboga " nor the " Valdivia " has as yet obtained this specimen from the Indian waters while the " Investigator " got only two specimens from the Arabian sea.

Almost all the specimens in the collection are of the same size and they measure about 10 mm. including the mantle protuberances. The zooids are asymmetrical especially in the lateral shifting of the prolongations of the mantle.

There are six well developed body muscles arranged in two groups, one consisting of the anterior four and the other of the remaining two body muscles. The body muscles of the first group are fused together medially on the dorsal side. The first and the second body muscles are fused for the greater part of their length. Similarly the two body muscles constituting the posterior group are also fused dorso-medially. All the body muscles extend well on the ventral side. The sixth body muscle gives off a branch at the sides. The two branches of either side curve round the corners of the atrial siphon and sometimes meet at its base close to the dorsal side of the nucleus.

The intermediate muscle is well developed and is present in its usual place on the sides. The horizontal muscles are comparatively small.

A strong oral retractor is present at the corner of the oral opening lying internal to the intermediate muscle (plate III, fig. 18). There are three dorsal oral sphincters on the upper lip, of which the third is well developed and is also supplied with a few strands of muscle fibres from the intermediate muscle. Similarly, the usual three sphincters are also present on the ventral lip. The first and second of these run very close together. All the sphincters are continuous and originate from the oral retractor.

The atrial musculature consists of an atrial retractor and four or five pairs of atrial sphincters running to the upper and lower lips of the atrial opening. The first pair of sphincters is better developed than the rest.

Salpa maxima var. tuberculata Metcalf.

Salpa maxima var. *tuberculata* Metcalf, 1918.

Aggregate Form: (plate II, fig. 5).—This variety was created by Metcalf in 1918 for the reception of the aggregate zooid of a Salp, the solitary generation of which has not yet been discovered. Previously the variety has been collected from the Philippine sea. As the " Investigator " Expedition did not get any specimen of this variety the occurrence of this variety in the Bay of Bengal is recorded here for the first time. In the Madras collection the variety is represented by only four specimens of which the largest caught in the plankton of the 18th January, 1938 measured 85 mm. including the anterior and the posterior prolongations of the test containing mantle protuberances. Two distinctive features, namely, the elongation of the anterior and posterior asymmetrical mantle protuberances approaching the condition found in the aggregate zooids of *S. fusiformis* and the presence of two, thick and rounded areas in the test with triangular spines on them on either side of the atrial siphon, distinguish the variety from the species. All the other characters, especially the musculature, resemble those of the species. The test round the nucleus is considerably thick and hard while it is soft and thin in the anterior region. The largest specimen contained a fairly well developed embryo (plate IV, fig. 6).

Salpa cylindrica Cuvier.

Salpa cylindrica Traustedt, 1885 ; Herdman, 1888 ; Apstein, 1894 ; Ihle, 1910 ; Bomford, 1913 ; Oka, 1915 ; Metcalf, 1918 ; Sewell, 1926.

This species is one of the most common Salpidae in the Madras plankton next to *T. democratica*. The " Investigator " collected many specimens of this species, mostly from the Burma coast, the Nankauri harbour and the Revello Channel of the Andaman sea. The aggregate zooids occur more abundantly than the solitary ones and chain forms were obtained from the townet collection made on the 21st October, 1942. The solitary form often has the tendency to shed its test under extremely unfavourable conditions.

Solitary Form: (plate II, fig. 6).—The biggest specimen obtained measures 45 mm. in length. The test is very thick and hard with prominent ridges on the ventral side. The test on the dorsal side is thin and soft. Only nine body muscles have been observed in the specimens collected so far excepting the single specimen obtained from the plankton collection of the 15th April, 1943, which had ten body muscles. Sewell obtained several examples possessing ten body muscles and showing considerable variations in the nature of connection between the first four body muscles on the dorsal side. In the Madras specimens the first four body muscles are invariably separate from one another and the interspace between them is about half the width of the body muscles. In a few cases the first and the

second body muscles meet dorsally. This tendency for the first four body muscles to remain separate is probably a step towards the condition found in *Salpa maxima.* The fusion of the first four body muscles is subject to variation and cannot be taken as a distinguishing characteristic of the species.

There is an intermediate muscle associated with the oral musculature and lying internal to the oral retractor.

The oral musculature differs considerably from its description given by Metcalf and Sewell. Metcalf described only two dorsal and two ventral oral sphincters. Sewell noted in two specimens of his collection another dorsal oral sphincter, which, in one specimen, was interrupted dorsally. In the Madras specimens three dorsal and three ventral oral sphincters have been noticed (plate III, fig. 19). The oral retractor, after crossing the intermediate and the third broad sphincter of the upper lip, divides into five branches. The first two branches are very thin and run as the first and the second dorsal sphincters. The admarginal first dorsal sphincter is interrupted dorsally. Sewell has observed this condition in the second dorsal sphincter of one of his specimens. The broad third dorsal sphincter is continued ventrally for a short distance only after crossing the oral retractor. The remaining three branches of the oral retractor run as the three sphincters of the lower lip. The course of the first ventral sphincter is interesting and escapes notice easily unless dissected and examined carefully. Immediately on arising from the oral retractor it makes a very sharp turn and runs closely below the second broad ventral sphincter. Throughout its course the first sphincter is completely covered and hidden by the second sphincter. All the ventral sphincters are continuous.

The horizontal muscles are present in the usual place between the intermediate muscle and the third dorsal oral sphincter.

The well developed atrial retractor starting anterior to the ninth body muscle, after crossing it, gives off about twelve dorsal and ventral atrial sphincters of which the first pair is prominent, well developed and usually in contact with the ninth body muscle at the sides. The second pair is slightly smaller than the first and the rest are thin strands of muscles. The ninth body muscle gives off a small branch to the posterior side. The two branches of either side extend as far as the mid-ventral line, behind the nucleus.

Aggregate Form : (plate II, fig. 7).—The test in this zooid also is hard and roughly rectangular in shape. There is an anterior and a posterior hollow conical protuberance of the body into the test with connective tissue fibres inside them. The five body muscles are in contact dorsally, but are separate and interrupted ventrally. The fifth body muscle gives off on either side a posterior branch, which, after passing along the sides of the atrial opening, is continued on the right side to the base of the atrial siphon where the two sometimes unite to form a single broad band and enter the posterior protuberance.

The horizontal muscles situated very near the third dorsal oral sphincter are small.

The intermediate muscles are placed ventrally below the oral opening and their anterior ends are situated at the base of the anterior protuberance of the body.

The oral musculature is rather complicated. The oral retractor is well developed and consists of an antero-ventral group of muscle fibres supplying all the three sphincters of the upper and lower lips and of a few postero-dorsal strands which run to the first and the second sphincters of the upper lip and the first sphincter of the lower lip (plate III, fig. 20). Except the second dorsal all the sphincters are continuous. The third dorsal and the second and the third ventral sphincters are well developed while the other oral sphincters are only weakly developed.

The well developed atrial retractor takes its origin from very near the fifth body muscle. The retractor gives off about four or five sphincters to each lip of which the basal ones are better developed.

CYCLOMYARIA.

The gonozooids of the genus *Doliolum* have been recently classified into four subdivisions by Garstang (1933) based mainly on the course of the alimentary canal. The four subdivisions are *Doliolina*, *Dolioloides*, *Dolioletta* and *Doliolum*; this classification is followed in this paper.

In the Madras plankton two types of gonozooids, one belonging to *Doliolum* and the other to *Dolioletta* have been noted. In *Doliolum* the alimentary canal forms a wide dextral arch round the cloacal floor with the anus parietal on the right side. In *Dolioletta* the alimentary canal forms a close dextral coil in the middle of the cloacal floor with median anus. Two kinds of gonozooids or "Nurse Forms" have also been collected on many occasions, sometimes along with the gonozooids.

Doliolum denticulatum Quoy and Gaimard.

Doliolum (*Dolioletta*) *denticulatum* Herdman, 1888; Neumann, 1906; Garstang, 1933.

This species is recorded for the first time from the Bay of Bengal. The biggest gonozooid so far obtained measured 4 mm. in length. The transparent body is barrel-shaped with the oral and atrial openings at the extremities. As usual, twelve lobes are present round the mouth and ten round the atrial opening. There are eight muscle bands in the form of

hoops of which the anterior and the posterior ones act as the oral and the atrial sphincters respectively (plate II, fig. 8). The stigmata are arranged in two rows and the branchial septum takes its origin dorsally from the second muscle band. The septum runs postero-ventrally, and on a level with the fifth muscle band and the stomach, it curves and runs anteriorly and is attached ventrally near the third muscle band. The ventrally placed short, straight endostyle extends from the second to the fourth muscle band. The alimentary canal forms a wide dextral arch round the cloacal floor with the anus parietal on the right side. The hermaphrodite reproductive organs are placed ventrally in the coil of the alimentary canal and consists of a rounded ovary and an elongated testis. The testis takes its origin from very near the ovary and runs horizontally extending up to the second muscle band. The heart is placed ventrally close to the oesophageal aperture. The dorsal ganglion is placed in the interspace between the third and the fourth muscle bands, but nearer the latter.

Dolioletta gegenbauri Uljanin

Dolioletta (*Doliolum*) *gegenbauri* Uljanin, 1884; Neumann, 1906; Garstang, 1933.

This species also is recorded for the first time from the Bay of Bengal. As Garstang has pointed out, the difference between *Dolioletta tritonis* and *Dolioletta gegenbauri* is negligible and the ventral attachment of the branchial septum in front of the fifth muscle band in *D. tritonis* instead of on the fifth muscle band as in *D. gegenbauri*, cannot be taken as a specific character. Garstang is, therefore, correct in regarding *D. tritonis* as a synonym of *D. gegenbauri*. In Madras both the varieties have been taken from the townet collections. The *gegenbauri*-like form is very rare while the *tritonis*-like form is the most abundant of the two *Doliolum* recorded in this paper and the swarms of gonozooids met with in the plankton collections were composed invariably of this form. Huge swarms of the gonozooids of this species were also present in the plankton collection made on the 29th July, 1941.

The biggest gonozooid obtained measured 7 mm., in length. The characters of *D. gegenbauri* are the same as those of *D. denticulatum* except for a few differences in the disposition of the internal organs. The alimentary canal forms a close dextral coil in the middle of the cloacal floor and the anus is median. Unlike *D. denticulatum* the testis is very long and proceeds antero-dorsally along the left side and extends as far as the second muscle band. In some specimens the testis, after reaching the second muscle band, takes a sudden turn and continues its course backwards (plate IV, fig. 7). The branchial septum is attached dorsally near the third muscle band extending backwards as far as the sixth muscle band and is attached ventrally on, or in front of, the fifth muscle band. The anterior and the posterior ends of the endostyle extend mid-way between the interspaces of the muscle

bands two to three and four to five respectively. The dorsal ganglion is situated nearer the third muscle band posteriorly.

" NURSE FORMS. "

With our present knowledge a proper correlation of the oozooids with the gonozooids is impossible and practically no attempt has been made in this direction probably due to the difficulties encountered in such attempts.

Two types of " Nurse Forms " are commonly met with in the Madras plankton and are easily distinguished from each other by their relative sizes (plate IV, fig. 8). One is very broad and long and measures 10 mm., in length and 5 mm. in breadth while the other is very narrow and measures 12 mm. long and 2 mm. broad. The narrow " Nurse Forms " are the most common in the townet collections. Both the forms have been noted to occur in swarms and sometimes along with the gonozooids. Of the usual nine muscle bands the anterior and the posterior ones are very narrow. The other muscle bands are very broad and the edges are very closely approximated, but do not come into contact. The musculature approaches the holomyonic condition. The third and the fourth muscle bands are slightly broader than the rest. The seventh muscle band is interrupted dorsally and the ends are continued into the backwardly directed cadophore. The ganglion is situated between the fourth and the fifth muscle bands.

SEASONAL OCCURRENCE OF THALIACEA ON THE MADRAS COAST.

The physico-chemical conditions of the Madras waters have not been investigated satisfactorily. In the absence of such definite information which is very essential for a work of this kind, the correlation of the occurrence of Thaliacea with the hydrographical conditions of the coastal waters of Madras is impossible. Further, as has already been mentioned, the methods employed for plankton collection are also not altogether satisfactory. For, only a catamaran was used for this purpose ; as such a craft has a tendency to be drifted along the surface of the sea in the direction of the ocean currents, it is very difficult to determine either the speed of the craft or the amount of water drained through the townet in a known time. These are serious handicaps in an investigation of this kind and detailed work as done by Michael (1918) can only be undertaken when better facilities for hydrographical investigations and improved methods of collection are available.

The figures in the analytical table represent the number of individuals of each of the species present in the plankton collections brought to the laboratory but not the number of the form in a known volume of sea water. However, they serve to give an idea of the seasonal abundance of the various common forms in the plankton of this coast. The conclusions drawn in the following pages regarding the seasonal occurrence of the various species of Thaliacea based on such data can only be of a general nature.

Thalia democratica.—On the Madras coast the occurrence of this most abundant and widely distributed species of Salpidae has been noticed to be very regular and it constitutes a typical planktonic organism. During the seven years of analysis the solitary and aggregate zooids of this species have been collected during January to May, July to October and December. As is evident from the analytical table, huge swarms of both generations of this species are met with commonly in the month of January and also in the month of March. The almost complete exclusion of all other usual planktonic organisms like the Copepods, etc., is an interesting phenomenon of the plankton collections containing swarms of *T. democratica*. Chain forms of the aggregated zooids of different sizes and growth occur frequently in collections made during these months. The graph (plate V) shows the occurrence of the solitary and the aggregate zooids of *T. democratica* in the Madras plankton during an year constructed from the data obtained as a result of the analysis of the plankton made during the years 1937 to 1943. The months are represented in the abscissa and the ordinate represents the average of the number of individuals present in collections made in a month during the years under investigation. It is evident that there are two periods of maxima in the occurrence of *T. democratica* on the Madras coast. The first period extends from January to March and the second period includes September and October. The maximum occurrence of both the zooids of *T. democratica* in the Madras plankton is during the month of January. In February there is a considerable fall in the number of the two zooids occurring in the plankton followed again by an abundance during March. A gradual decrease in the number of individuals is evident in the succeeding months and during June *T. democratica* is not represented in the plankton collections of the Madras coast. Again, the Salp makes its appearance in fairly good numbers and the secondary maximum in the occurrence of *T. democratica* is reached during September and October for the solitary and aggregate individuals respectively. After this period the number of individuals present in the plankton collections decreases and in November they are practically absent. So it can be concluded that *T. democratica* reaches the maximum numerical intensity in its occurrence on the Madras coast during January to March and a secondary maximum during September and October.

Salpa cylindrica.—The next common form in the Madras plankton is *Salpa cylindrica*. As in *T. democratica*, a definite periodicity in the occurrence of *S. cylindrica* in this coast has been noted. During the period under investigation, the solitary as well as the aggregate individuals have been collected during the periods extending from January to April and August to December. It is clear from the tables that there are two periods in the occurrence of this species on the Madras coast. As the number of *S. cylindrica* occurring in each plankton collection is very small when compared to that of *T. democratica* it is not possible to find out the period of maximum intensity or the period of secondary maximum of this species on the Madras coast. Hence from the available analytical data it can be said that the maximum number of *S. cylindrica* occurs during the months of March and October.

Jasis zonaria.—In the case of the next common form in the Madras plankton, namely, *Jasis zonaria*, a periodicity similar to that of the preceding forms has been observed. The sudden appearance of this species in the plankton, its continued presence for a few days and the sudden disappearance are probably characteristic of the species. Both the zooids have been recorded during March and April, July and August and the aggregate forms only in September and December. During these two periods the maximum number has been noted to occur during March and July. Almost all the aggregate individuals obtained in a particular collection have been noted to be of the same size. This suggests that they are probably separated individuals belonging to a single chain or chains of the same size. On the other hand, solitary individuals of various sizes have been noticed to occur in the same collection.

Pegea confoederata.—The only other form which definitely exhibits a seasonal variation in occurrence in the Madras plankton is *Pegea confoederata*. During the period of investigation both the zooids have been obtained during March, August and September. Stray specimens of aggregate zooids have been obtained during January and April. Also solitary zooids have been collected in October. March and August are the favourable months for the occurrence of this species on the Madras coast when fair numbers of both the solitary (embryos included) and the aggregate individuals make their appearance in the townet collections. It may be mentioned here that a very fine specimen of a solitary individual with a long extruded stolon consisting of one hundred and thirty three aggregate individuals each measuring 6 mm. in length was obtained in the plankton collection made on the 27th September, 1937. The chain was very long but broke up into pieces when put in formalin. Another fine specimen of a chain of aggregate individuals of *P. confoederata* (one side only) was obtained from within the Madras harbour on the 4th October, 1935 (plate IV, fig. 5). The chain was intact even after fixation and the individuals measured 30 mm. in length. Yet another long chain of aggregate individuals measuring 3 mm., in length was obtained along with the stranded specimens collected on the 12th October, 1943 immediately after the floods (plate IV, fig. 4). Taking into consideration these instances it seems probable that chain individuals of *P. confoederata* could be expected on the Madras coast during the months of September and October.

Regarding the remaining forms, nothing can be said definitely about their periodicity of occurrence in the Madras plankton. For, when compared to the forms discussed above, the number of individuals of these occurring on the Madras coast is very small. From a knowledge of the date of capture of these forms fair conclusions regarding their occurrence in the Madras plankton can be drawn. In a general way there is a tendency for some forms such as *Ritteriella amboinensis*, *Salpa maxima* and its variety *tuberculata* to conform to the periods of occurrence of the commoner species of Salpidae. The months given under each form represent only the period of collection of the particular form and may be taken as the months of occurrence of the form on the Madras coast.

Cyclosalpa pinnata var. **polae.**—The solitary forms are rare on the Madras coast and have been collected only during the months July and October. The aggregate forms are comparatively common in the Madras plankton and were collected during the months January, March, April and July to December.

Cyclosalpa pinnata var. **sewelli.**—The solitary forms have been collected from the Madras coast during the months January, March, July and August. The aggregate forms are unknown to science.

Salpa maxima.—Only the aggregate forms have been collected from the Madras plankton and these were obtained in the months of March and August.

Salpa maxima var. **tuberculata.**—This species is rare on the Madras coast and is represented in the collection by four specimens of aggregate zooids collected during January, July and August.

Ritteriella amboinensis.—The solitary forms alone have been collected during the months of March, July, August and December.

Brooksia rostrata.—This is another rare species and a casual visitor to the Madras coast. Three specimens of the solitary zooids were obtained during August and October.

Traustedtia multitentaculata.—This is a very rare species and only a single specimen of the solitary zooid was obtained from the plankton in the month of September.

Metcalfina hexagona.—This species in a deep water form in the Indian Ocean and, as has already been mentioned, the species has never been obtained from the many plankton collections made so far from this coast. The collection contains a single specimen of the solitary form, with a well developed stolon, caught in the month of May in deep water fishing nets.

Doliolum.—When compared to the Salps, the paucity of *Doliolum* in the Madras plankton is quite apparent, for only two types of gonozooids and two types of oozooids have been collected during these years. Further, only one-fifth of the collections made during the years 1937—1940 contained the zooids. The gonozooids have been collected in the months, January to April, June and August to October, while the oozooids occurred in the plankton from January to March, June, August, September and December. Yet, from the numbers in the analytical tables it is clear that there is a definite periodicity in the occurrence of swarms of the two zooids on the Madras coast. March and August, especially the latter, are the most favourable months for their occurrence in swarms. During August, huge swarms have been collected on two occasions. This is in general conformity with the seasonal occurrence of the Salps of the Madras plankton.

Taking the Thaliacea as a whole it may be definitely mentioned that large numbers of this pelagic group occur in abundance on the Madras coast regularly during two periods in the year, namely, during the months of March and August. The seasonal occurrence of *T. democratica*

is the only exception to this general rule. During March large numbers of forms like *T. democratica, S. cylindrica, J. zonaria, P. confoederata, C. pinnata* var. *polae* and var. *sewelli* and *Doliolum* have been collected and this is the period for the maximum quantitative abundance of Thaliacea in the Madras plankton. Gradually, a decline sets in and during May and June, the hottest part of the year, they are almost completely absent. Later in the year, in August, a secondary maximum is reached when forms like *T. democratica, S. maxima, P. confoederata, J. zonaria, C. pinnata* var. *polae, R. amboinensis, S. cylindrica* and *Doliolum* recur once again in fair numbers. Further, the qualitative maximum in the occurrence of Salpidae on the Madras coast is also reached during the month of August. It is during this month that out of the total twelve species of Salpidae recorded from this coast, seven varieties of the solitary and seven of the aggregate individuals belonging to ten species have been collected. In this connexion, it is interesting to mention that, in the plankton collection made on the 15th August, 1939, as many as eight species were represented. In no other collection made during these years was such a great number represented in a single collection.

Our knowledge of the hydrographical data of the Madras coast is very meagre. The following table is given by Subramaniam and Aiyar (1936) :—

Month.	Temperature° F.	Salinity per mille.
December	75·9	28.73
January	76·01	30·59
February	79·16	31·94
March	82·94	33.88
April	83·12	34·48
May	85·28	34·81
June	83·48	35·39
July	83·48	35·16

Sewell's (1929) work on the hydrographical conditions of the Bay of Bengal cannot strictly be used in the present work because it deals mainly with those of the open sea and in Sewell's own words " in many features, the conditions existing in those two different areas, namely, the open sea and the coastal region, have been found to present a noticeable contrast, and the results obtained indicate that in the open waters the surface of the ocean is completely exposed to the outside influences that result in the production of a number of extremely interesting phenomena."

Consequently, the only relevant data for a discussion of the seasonal occurrence of Thaliacea on this coast are those given above. Unfortunately, these authors have not given the observations for the months August to November. It is evident from the table that the temperature and the salinity are the lowest in the month of December. Then the temperature and the salinity gradually increase, and the highest temperature is reached in the month of May and the highest salinity in the month of June. The temperature and the salinity are on the decline during July. For the remaining four months, even though no data are available regarding the temperature and the salinity, a gradual decrease can be expected to occur culminating in the lowest figures in December. In March, the temperature is about 83° F. and the salinity about 34 per mille. In August also, the same conditions may be expected, for, after reaching the maximum in May and June, both the temperature and the salinity are on the decline as is evident from the readings for July. These facts strongly suggest that these are the optimum conditions for the occurrence of Thaliacea on the Madras coast. The optimum conditions for the occurrence in huge swarms of *T. democratica* on the Madras coast are different from those for the occurrence of the other members of the group. For large swarms of both generations have been collected in January when the temperature is about 76°F. and the salinity about 31 per mille. Similarly, the secondary maximum has been found to be in September and October for the solitary and aggregate individuals respectively when both the temperature and the salinity are less than what they are in August.

The observations made in this paper regarding the occurrence of Thaliacea especially of *T. democratica*, are in general agreement with those of Russell and Colman (1935) on the seasonal occurrence of *T. democratica* in the Barrier Reef lagoons. They observed the maximum abundance of both the generations of *T. democratica* during two periods in the year and their complete absence during the remaining months of the year. The two periods are when the temperature rises from about 24 to 28°C. and when it falls from 28 to 24°C. A complete absence of *T. democratica* has been noted by them when the temperature reaches its maximum of 28 to 29°C. They doubted whether salinity has any effect at all on the seasonal occurrence of *T. democratica*, and suggested the possibility that the abundance of this species is connected with the temperature of the sea water. On the other hand, Sewell has tried to correlate the number of species obtained each month in the Indian seas with salinity. Further investigations are likely to show that both these factors, as I have indicated, exert great influence on the seasonal abundance of these forms in any particular area.

Lastly, mention may be made of the value of pelagic Tunicates as indicators of changing oceanographic conditions. The utilization of certain easily distinguishable organisms in the plankton as indicators of the water in which they are found has come to the fore in recent years mainly by the work of Russell (1935). It is now admitted that in places where several water masses mix the types of planktonic animals found can give reliable clues as to the different sources of these waters. Pelagic Tunicates, particularly the Thaliacea, are ideal

planktonic animals for this purpose and a few references to species used as indicators may not be out of place here. Bowman (1922) drew attention to the possible connexion between the occurrence of certain Salps and the influx of Atlantic water to the North Sea region. Russell and Hastings (1933) suggest the possibility of pelagic Tunicates acting as indicators of movements of Atlantic water into the English Channel. Thompson and Frost (1935) suggest that the occurrence of different species of Copelata could be used to indicate the annual and seasonal variations in the degrees of occurrence of Arctic and Atlantic waters in the New Foundland fishing areas. McKenzie (1939) followed large scale shoreward movements of Gulf Stream water in the Nova Scotian region through the occurrence of *Jasis zonaria*. Aida (1897) and Tokioka (1940) state that oceanic species of pelagic Tunicates are brought by the Black current along the Japanese coast. Essenberg (1926) similarly showed the relationship of the occurrence of the different species of Copelata to the cold and warm water currents along the Californian coast. It is premature to suggest which of the species dealt with in this paper are useful as indicators of water movements along the Madras coast, for, very little is known about the geographical distribution of the Thaliacea in the Bay of Bengal and the current systems of the coast.

SUMMARY.

Detailed descriptions of the solitary forms of *Cyclosalpa pinnata* var. *sewelli*, *Brooksia rostrata*, *Ritteriella amboinensis*, *Metcalfina hexagona* and *Traustedtia multitentaculata*, the aggregate forms of *Salpa maxima* and *Salpa maxima* var. *tuberculata*, the solitary and aggregate forms of *Cyclosalpa pinnata* var. *polae*, *Jasis zonaria*, *Thalia democratica*, *Pegea confoederata and Salpa cylindrica*, *Doliolum denticulatum*, *Dolioletta gegenbauri* and " Nurse Forms " obtained from the plankton collections made during the years 1937 to 1943 are given in the paper. The periodicity of occurrence of the different species in relation to the hydrographical conditions of the Madras coast is briefly discussed.

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REFERENCES TO LITERATURE.

AIDA, T. ... ... 1907 ... Appendicularia of Japanese Waters. Imp. Univ. Tokyo Journ. Coll. Sci., XXIII, No. 5.

APSTEIN, C. ... ... 1894 ... Die Thaliacea der Plankton Expedition. B. Vertheilung der Salpen. Ergebn. der Plankton Exped. der Humboldt-Stiftung, II. E. a. B.

————* ... ... 1904 ... Salpes d' Amboine. Rev. Suisse de Zool., XII.

———— ... ... 1905 ... Salpen der Deutschen Tiefsee Expedition. Wiss. Ergebn. der Deutsch. Tiefsee Exped., XII.

BOMFORD, T. L. ... 1913 ... Some Salps taken by R.I.M.S.S. "Investigator" in the Bay of Bengal and Andaman Sea. Rec. Ind. Mus., IX.

BORGERT, A. ... ... 1894 ... Die Thaliacea der Plankton Expedition. C. Vertheilung der Doliolen. Ergebn. der Plankton Exped. der Humboldt-Stiftung, II. E. a. C.

BOWMAN, A. ... ... 1922 ... The biological interchange between the Atlantic and the North Sea. Rep. Brit. Assoc. Adv. Sci., London, 90th Meeting.

BROOKS, W. K. ... 1893 ... The genus Salpa with a supplementary paper by Maynard M. Metcalf. Mem. Johns Hopkins Univ., III.

DAKIN, W.J. AND COLEFAX, A.N. 1940 ... The Plankton of the Australian Coastal Waters off New South Wales. Publ. Univ. Sydney, Dept. Zool., Monogr., I.

ESSENBERG, C. E. ... 1926 ... Copelata from the San Diego Region. Univ. Calif. Publ. Zool., XXVIII.

FORSKÅL, P.* ... ... 1775 ... Descriptiones Animalium, etc., quae in itinere orientali observatit. (Salpa). Hafniae.

GARSTANG, W. ... 1933 ... Report on the Tunicata. Part I. Doliolida. British Antarctic ("Terra Nova") Expedition 1910. Rep. Bri. Mus. Zoology, IV, No. 6.

HASTINGS, A. P. ... 1931 ... Tunicata. Great Barrier Reef Expedition. Bri. Mus. Sci. Rep., IV.

HERDMAN, W. A. ... 1888 ... Report on the Tunicata collected during the Voyage of H.M.S. "Challenger" during the years 1873-76. Part III. Challenger Reports, Zoology, XXVII.

———— ... 1891 ... A revised classification of the Tunicata, with definitions of the orders, suborders, families, subfamilies and genera and analytical keys to the species. Journ. Linn. Soc. Lond., Zoology, XXIII.

HERDMAN, W. A. ... 1906 ... On the Tunicata. Pearl Oyster Fish. Rep., pt. 5, Suppl. Rep. Ceylon.

IHLE, J. E. W. ... ... 1910 ... Die Thaliaceen (einschliesslich Pyrosomen) der Siboga Expedition. Siboga Exped. Monogr., LVI D.

———— ... ... 1911 ... Uber die Nomenklatur der Salpen. Zool. Anz., XXXVIII.

———— ... ... 1912 ... Desmomyaria. Das Tierreich, Lief 32.

————* ... ... 1935 ... Desmomyaria. Kukenthal u. Krumbach Handb. d. Zoologie, Bd. 5 (2, 5).

————* ... ... 1937 ... Thaliacea. Dritte Ordnung. Desmomyaria, Salpen Familie Salpidae. Bronns Klassen u. Ordnungen des Tierreichs. Bd. 3, Suppl. Abt. 2, Buch 2, Lfg. 2.

McKENZIE, R. A. * ... 1939 ... Some marine Fish and Salpa records. Proc. Nova Scotian Inst. Sci., XX, pt. 1.

MENON, K. S. ... ... 1931 ... A preliminary account of the Madras Plankton. Rec. Ind. Mus., XXXIII.

METCALF, M. M. ... 1918 ... The Salpidae: A taxonomic study. U.S. Nat. Mus. Bull., 100, II, pt. 2.

———— ... 1919 ... Metcalf and Bell upon Salpidae. Science, N.Y., L.

———— ... 1927 ... Seymour Sewell on "Salps of Indian Seas." Science, N.Y., LXV.

MICHAEL, E. L. ... 1918 ... Differentials in behaviour of the two generations of *Salpa democratica* relative to the temperature of the Sea. Univ. Calif. Publ. Zool., XVIII, No. 12.

NAIR, R. V. AND AIYAR, R. G. 1943 ... On the Thaliacea of the Madras Plankton. Curr. Sci., XII, No. 4.

NEUMANN, G. ... ... 1906 ... Doliolum. Wiss. Ergebn. der Deutsch. Tiefsee Exped., XII, Lief 2, pts. 1 and 2.

OKA, A. ... ... 1915 ... The Tunicata of the Indian Museum. Mem. Ind. Mus., IV, No. 1.

———— ... ... 1921 ... Uber *Traustedtia multitentaculata* (Quoy et Gaimard), eine Seltene Salpe. Annot. Zool. Japon., X, No. 1.

PALLAS, P. S. *... ... 1774 ... Spicelegia Zoologica, 1 (10): 17-18 etc.

QUOY, J. R. C. AND GAIMARD. J. P.* 1824 ... Voyage autour du Monde, sur les corvettes de S.M. l' Uranie et la Physicienne 1817-20. Zoologie.

RITTER, W. E.*... ... 1905 ... The pelagic Tunicata of the San Deigo region excepting the Larvacea. Univ. Calif. Publ. Zool., II.

RUSSELL, F. S. ... 1935 ... On the Value of Certain Plankton Animals as Indicators of Water Movements in the English Channel and North Sea. Journ. Mar. Biol. Assoc., XX.

RUSSELL, F. S. AND COLMAN, J. S. 1935 ... The Zooplankton IV. The occurrence and seasonal distribution of the Tunicata, Mollusca and Coelenterata (Siphonophora). Great Barrier Reef Expedition, Sci. Rep., II, No. 7.

RUSSELL, F. S. AND HASTINGS, A. B. 1933 ... On the occurrence of Pelagic Tunicates (Thaliaceae) in the waters of the English Channel off Plymouth. Journ. Mar. Biol. Assoc., XVIII.

SEWELL, R. B. S. ... 1926 ... The Salps of the Indian Seas. Rec. Ind. Mus., XXVIII, pt. 2.

——— ... 1929 ... Geographic and Oceanographic Research in Indian Waters. Mem. Asiatic Soc. Bengal, IX, No. 5.

SIGL, M. A. ... ... 1912 ... *Cyclosalpa polae* n. sp. aus dem Ostlichen mittelmeer. Zool. Anz., XXXIX, No. 2.

STREIFF, R. ... ... 1908 ... Uber die Muskulatur der Salpen und ihre Systematische Bedeutung. Zool. Jahr., XXVII, No. 1.

SUBRAMANIAM, M. K. AND AIYAR, R. G. 1936 ... On the possible effect of the environment on the cytoplasmic inclusions in the oocytes and oogonia of *Dasychone cingulata*, *Salmacis bicolor* and *Clibanarius olivaceus*. Proc. Indian Acad. Sci., III, No. 3.

THOMPSON, H. AND * FROST, N. 1935 ... Plankton Investigations. Rep. Fish. Res. Lab., Newfoundland, II, No. 5.

TOKIOKA, T. * ... 1940 ... Some additional notes on the Japanese Appendicularian Fauna. Rec. Oceano. Works in Japan, II, No. 1.

TRAUSTEDT, M. P. A. * 1885 ... Spolia Atlantica 1. Bidrag til Kundskab om Salperne. Danske Vid. Selsk. Skrift., VI, No. 2.

——— ... 1893 ... Die Thaliacea der Plankton Expedition. Ergebn. der Plankton Exped. der Humboldt-Stiftung, II. E. a. A.

ULJANIN, B. N. ... 1884 ... Die Arten des Gattung Doliolum im Golfe von Neapel und den angrenzen den Meeresabschnitten. Fauna und Flora des Golfes von Neapel, X.

NOTE.—References marked with an asterisk have not been referred to in the original.

ANALYTICAL TABLE.

Date of plankton collection.	C. pinnata var sewelli	C. pinnata var. polae.		B. rostrata.	R. ambonensis.	M. hexagona.	J. zonaria.		T. democratica.		P. confoederata.		T. multitentaculata.	S. maxima.	S. maxima var. tuberculata.	S. cylindrica.		Doliolum.	"Nurse forms"
	S	S	A	S	S	S	S	A	S	A	S	A	S	A	A	S	A		
1937																			
February 4 ...			...	.		..	.	..	.	500	..	.	..	..	.	.	1	..	...
,, 8		...	..	.		..	..	...	135	290	...	.	.	..	.	..	..	.	...
,, 25	...	...		.	.	.	...		540	4,720	...	.	..	.	...	...	..	.	...
,, 26	..	.		.	.	.	..	.	240	860	.	.	.	...	...	...	.	...	...
March 11	..		..	..	..	.	.	..	380	781	..	..	...	...	...	.	...	...	620
,, 15	..	...	..	...	..	.	...	.			...	.	..	..	.	.	...	1,550	430
,, 22	...	...	...	...	.	...	...	.	39	194	...	...	..	...	...	...	...	..	...
April 9 ...	...	.		..	..		.	...	..	.	.	...	...	.	...	...	.	78	..
June 12 .		...		...	..	...	..	..	...	.	..	.	..	..	...	..	..	233	233
,, 14 ...	..	...	...	.	.	..	.	...		..		..	..	...	..	..	.	58	116
August 10 .	...	.	...	...	...	..	..	...		...	...	.	...	...	...		...	407	750
,, 13 ...	.			..	...	..	..	...	.	120	...	..	...	..	...	..	..	407	1,860
,, 23 ...	..	.	.	..	..	...	...	..	..	.	1	12	..	.	...	...	...	..	...
September 27	.	...	...	...		.	...	...	...	58	1	133*	.	..	...	...	...	..	...
December 7	...	...	...	..	..		...	...	.	39	...	.	...	...	..	..	...	.	..
,, 14	..	..		...	...		..		.	233	233	.	.	...	...	..	.	...	...	39
1938.																			
January 8	..	.	...			.	...	...	...	58	58	...	.	..	...	...	.	...	...	...
,, 18 ...	...	1	.	5		...	...	.	...	...	194	..	1	..	...	1	...	.	...	...
,, 22 ...	...	..	..	..		...	...	...	...	.	271	.	...	...	...	..	..	..	...	...
,, 25 ...	...	..	.	...		.	...	...	..	39	78	.	...	..	...	..	1	1	...	..
February 1	...	.	...	...	.	..	...	.	..	116	930	...		...	...	...	...	...	...	...
,, 4	...	.	...	...	...	...	..	..	.	....	...	...	...	...	...	...	1	...	...	...
,, 19	...	...	...	...	.	..	...		.	...	39	...	...	...	...	...	...	...	...	...
March 21 ...	...	.		..	.	.	...	..	.	58	...	...	..	..	...	...	..	...	...	...
,, 28 . .	...	..	.	..	.	..		.	.	...	78	...	...	.	...	.	.	.	..	..
August 13	..	...	..	..	.	...			...	58	58	...	..	...	..	.	..	...	..	58
,, 25	...	.	.				.		...	58	...	..	...	..	..	.	..	..	..	..
October 12	...	...			.	.	.		.	...	.	..	..	.	..	..	...	.	58	..
,, 18	..	...	.				..	.	.	...	...	.	..	...	..	...	...	.	116	..
November 14	..	..	.	5	..	...	.	..	..	...	.	.	.	..	..	...	..	..	...	...

1939.																							
January 26	..	.	.	.	...	..	...	.	.	..	..	..	.	...	..	...	...	...	58	...			
February 6	...	...	.	...	..	...	..	..	.	58	.	..		...	..	..	..	...	58	...			
,, 13	...	..	...		.	...	..	.	.	58	233	...	.		...	..	...	.	...	58			
,, 21	..	.	.	..	..	.	..	.		58	174		.	..	..	..	...	..	..	..			
,, 23	..	.	*	...	...	.	.	...	...	233	1,279	...		..	...	...	...	...	58	..			
,, 28	...	...	.	.	..	..	..	..	..	...	349	...		.	..	..	...	...	.	58			
March 1 ...	...	..	.	.	..	.	.	..	.	174	1,104	..	..	.	...	...	...	...	...	58			
,, 4 ...	...	.		..	.	.	.	..	.	349	2,558	.	..	.		..	.	...	..	.			
,, 10 ..	..	..	.		..	.	..		..	116	233	..	.		...	.	...	...	..	...			
,, 14 ..	...	..	.	...	.	.		..	1	174	291	..	.	..	.	..	...	..	...	..			
,, 17 ...	..	..		.	..	.		.	.	..	174	..	.	.	.	.	1	32	..	...			
July 13 .	..		.	...	..	.	.	1	.	.	.	.	..		..	.	..	...	...	...			
,, 15 .		..	.	.				1	6	..	.	...	.		.	1	...	..	..	..			
,, 20 ..	.	...		1	.	.	.	..		.	..	...		.	..		..	..	.	..			
,, 24 .	.		.	.	..			1	.	.	..	.	.	..	..	..	...	..	...	...			
,, 29 .	.	..	.	.	...			2	12		..	...	.		..	..	.	..	..	...			
August 7 ..	..	..		.	.			.	.	58	.	.	.	.	.	.		..	58	..			
,, 10 .	...	...	.		.	.	..	.	19		.	.	I	...	..	..	.	.	.	.			
,, 15 ...	...	.	...	1	2	7	.	..	.	155	620	13†	44		37	2	.	5	465	1,550			
,, 17 .	.	I	.	1	..	..	..	2	..	..	...	..	.	.	1	.	7	...	39	116			
,, 18 .		..	.	..	.	.	..	..	...	.	..	.	.	.	.	.	1	..	..	.			
September 6 ..		.	..		.	.	.	..	..		..	.	..	.	.		..	..	39	.			
December 12 .		.	.		.			.	..	..	..	..	..	..	...	.	..	..	..	58			
1940																							
January 12 .	..	.			..	.	.	..	...	1,705	6,278	..	..	.	.	.	...	..	..	...			
,, 16 ..	.	..	...		.	.	..	..	..	1,008	7,673	...	..	.	..	...	.	..	78	..			
,, 26 ...	..	.	.	...	..	.	.	...		639	407	...	..	...		...	1	..	116	58			
February 2 .					...	.	.	.	.	..	116	..	..	.	.	...	.	..	..	..			
,, 9 .	..		..	..	..	.	..	..	...	.	174	.	..	.	..	..	..	..	233	...			
,, 21 ..			..	.	.		..	..	...	174	581	..	..	.	...	...	..	...	58	...			
,, 24 ...	.		.	..	.	..	..	.			310	..	..	.	..	.		37	...	...			
,, 27 ..		.	.	.	.	.		.	.	174	698	.	.		..	..	1	...	..	..			
March 2 ..	...	.	.		..	.	.			465	5,344	.	..		.	.		...	...	...			
,, 9 ..	..	.	.	1	.	..	.		...	..	78	.	.	.		.		..	...	...			
,, 12 .	.		..	4	..	..	.		..	78	310	.	..	..	..	..		..	.	..			
,, 18 .	.	..	.		..	..	..	..	..	310	853	..	.	.		..		..	155	...			
,, 28 .	.	..	.	.	.	.	.	...	.	.	..	...	...	.	.	.		...	116	...			
,, 30 ..	.	.	.		.	...	..	..	..	..	155	.	..	.	.	..	..	...	...	..			
April 3 ..	..	..	.		..	..	.	..			97	.	..	.	..	..	....	...	...	...			
,, 11 ...	.	..	.		.	.	.			.		.	...	..	.	..	..	...	78	...			
,, 29 ...	...	..			.	..	.		..	..	.	..	..	.	..	..	..	...	78	...			
July 31 ...	...	.	.	.	.	..		..	...	.	.		..		..	..	..	..	..	156			
August 2 .	..	.	.	.	.	.	..		.	.				I	.		..	..	...	...			
September 9 .		.		.				.	5			.	I				..	..	...	..			
,, 16 .	.	..	.		.					349	581	.		.	..		.	..	...	..			
,, 20 ..	..	..	.	..		.		.	..		116	.	.	.			..	..	...	..			
,, 27 ...	..	.	..		.				.	58	..		.		I	..	...	..	..	...			
,, 30 ..	..	.	.	.	.				.		..	.	.	.	.	.		..	..	58			
October 7 .		.	.			.					..	2	.				.	.	78	.			

* Chain.

† Ten embryos.

ANALYTICAL TABLE—*cont.*

Date of plankton collection.	C. pinnata var. sewelli.	C. pinnata var polae.		B. rostrata.	R. amboinensis.	M. hexagona.	J. zonaria.		T. democratica.		P. confoederata.		T. multitentaculata.	S maxima.	S. maxima var. tuberculata.	S. cylindrica.	
	S	S	A	S	S	S	S	A	S	A	S	A	S	A	A	S	A
1941.																	
January 27	..	...	...	..	...	...	...	...	...	.	...	..	.	.	..	1	...
„ 29	...	..	...	...	...	...	.	.	6,684	15,984	...	..	...		...	...	...
„ 31	...	...	...	..	...	...	..	..	465	2,790	...	...	...	...	.	...	25
March 5	...	...	...	...	.	.	...	...	...	58	...		..	.	..	..	...
„ 14	...	...	...	.	.	...	...	...	581	6,491	...	..	...	.	...	..	...
„ 17	..	...	..	..	...	..	..	..	1,938	9,106	..	..	...	...	..	..	...
„ 21	...	...	..	...	...	...	..	..	78	2,248	...	...	.	.		...	..
July 16	...	...	...	...	.	..	...	.	...	78	...	.	.	..	...	...	..
December 23	..	...	...	1	.	2	..	.	31	...	.	..	..	...	...	..	2	2
1942.									..								
January 2	.	...	..	...	.	..	.	..	.	78	2,170	...	...	...	...	..	1	1
„ 16	..	...	...	...	...	.	...	...	.	78		.	...	...	...	...	...	...
„ 29	...	...	...	..	...	...	..	..	.	349	1,046	...	..	..		..	.	...
February 3	...	...	...	...	..	...	..	.	..	78	194	...	.	..	.	..	...	...
„ 4	.	...	...	..	..	...	.		.	39	775	...	.	...	..	..	...	...
„ 13	.	...	..	..	...	..	.	.	..	39		..	...	...	...	...	...	..
„ 16	..	...	..	..	..	..	...	..	.	C	C	...	...	...	...	...	..	..
„ 20	.	...	...	.	...	..	..	..	...	C	C	..	..	...	...	...	..	...
„ 21	..	...	...	...	...	...	.	.	...	..	S	S	...	...	...	..	...	..
„ 25	..	...	..	...	.	...	.	..		...	S	S	...	...	..	..	...	...
„ 26	...	...	..	...	...	...	.	...		.	C	C	..	..	..	..	..	...
„ 27	..	...	..	...	..	...	.	...	.	...	F	F	..	...	..	...	...	...
March 2	..	...	.	...	..	...	..	...	..	...	C	C	.	..	.	...	...	...
„ 4	...	...	...	...	..	...	.	...	...	...	F	F	.	.		...	...	...
„ 7	..	...	..	...	..	...	.			...	1,938	1,841	..	1	..	...	..	142
„ 9	...	...	..	..	..	...	...		..		1,066	48	...	..	...	...	...	11
„ 11	...	...	..	...	..	...	...			.	388	2,015	.	..	...	...	...	..
„ 14	...	...	...	...	.	..	...	..		...	...	.	31†	32	...	...	...	..
„ 16	...	...	...	...	.	..	.	.	..	58	58	.	.	.	..	..	..	...
„ 19	...	...	9	...	9	...	...	...	...	..	174	349		6	..	.	7	..
„ 21	...	...	...	...	1	..	1	..	.	...	58	116	...	.	..	8	...	...
„ 24	...	...	...	..	...	..	...	..	..	...	291	388	..	..	..	.	.	...
„ 28	...	...	...	...	...	...	...	..	..	.	F	F	...	...	...	...	...	...

,, 30	..	...	...				..	...	.	.	388	4,941		...	.	.	..	4	...
April 6	...	...	.	.	..	.	..	.	.	...	.	.	.		.		..	4†	315
,, 8	..	...			5	..	..	..	..	.	..	1,841	.	I			.	13	9
,, 11	..	...	.		..	..	..	..	..	...	.	620	...	.	.	..	...	.	72
July 15	...	..	I	I	I	.	..	...	..	.	..	465		.	.		.	.	.
,, 17	..	...	3	I	II	.	..	.	..	..		..	.		..	..	..	.	..
,, 20	...	..	.	.	.	..	I	..	...		.	..	.	..	..		..	..	..
August 17	..	...	I	..	II	..	..	...	.	..	.	S		.	.	5	.	.	..
September 17	...	..	.	.	..	.	..	..	...	..	S	S			.	..	..	.	.
,, 26	...	.	...	...	...	..	.	...	...	..		349	I	I	.	..	..	11	15
,, 28	...	...		.	.	.	...	...	.	.	639	1,220	I	.	..	.	.	...	...
,, 30	..	.	.	4		..	...	...	..	.	...	..	..		..	.	.	..	..
October 2	...	...	..	.	2	.	..	..	...	.	58	814	...	..	..	.	..		.
,, 5	...	...	.	2	I	.	..	..	..	..	..	..	.	.	.	..	.	.	.
,, 8	...	...	...	I	..	...	..	...	..	..	.	.	.	..	...	.	..	..	..
,, 14	...	..	...	..	..	I	...	.	...	.	..	.	..	...	.		.	...	...
,, 19	...	.	..	..	..	.	..	..	.	...	.	..	.	.	..	.	..	3	4
,, 21	.	...	...	...	.	.	..	...	.		..	.	.	.	...	.	..	53	106
,, 23	.	..	..	.	.		...	...	...	...	.	..	...	...	.	..	.	13	11
December 27		...	...	..	I	...	..	..	...	..	..	..	...	...	..	...		...	...
1943.																			
January 22	...	..	...	..	.	.	..	..	.	.	155	465	..	..	.	.	...	..	...
,, 29	...	...	...	...	..	..	..	...	..	.	2,139	21,925		...	..	..		...	...
,, 30	..	.	.	.	..	...	..	.	...		2,480	15,035		.		..	..	...	.
February 24		..	...		..	.	..	...	...	.	58	58	.	..	.		..	..	...
March 3	..	...	...	..	...	.	..	...	.		.	524	.	.			.	.	..
,, 4	..	...	..	.	..	..	.	..	...	.	.	233	.	.	..		.	..	..
,, 5	..	.	...	..	.	..	..	..	.		388	2,558		.	..		..	..	..
,, 9	...	...	.	..	..	.	..	...	15	67	581	11,044	.	..		..	..	...	.
,, 10	...	...	.	..	..	..	..	.	6	17		.	.	..	.			.	.
,, 12	...	..	...	...	..	..	...	..	3	22			.	...	..	..	.	..	
,, 16	..	..	...	.	.	..	...	..	.	.	78	2,015	..	..	..	.	.	...	.
,, 31	...	..	..	...	..	..	..	.	...			194	.	.	.		..	...	..
April 2	...	...	..	..	..	..	.	...	.		388	543	..	..	.		.	..	
,, 12	..	...	..	...	..	...	..	...	.		174	291	.	.	..		.	...	.
,, 13	...	...	...	.	.	.	..	..	.	.	174	465	.	..		.	.	...	..
,, 14	...	...	..	...	..	..	..	.			174	233		...		..		..	.
,, 15	...	...	..	.	.	..	..				58	116	..	.			..	I	..
,, 16	...	...	...	..	...	...	..	..	.		116	291	.	..		.	.		.
,, 22	...	...	..	.	...	.	.	.	I	3	58	174	..	.			.		
,, 23	...	...	...	...	...	..	...				58	116	.	.		.	.	...	...
May 10	...	...	..	..	..	...	..	.	.		58	349	.	..			.		
,, 29	...	...	..	...	...	.	..	I*	.		..	.		..			.		.
August 21	...	...	...	...	..	..	..	.			58	58		..		.	.		.
,, 23	...	...	..	..	...	..	..		..		58	698	.	..	.	.	.		.
September 21		...	...	...	I	..	...	.	...	..		..	..	..	..	..	.	.	.
November 4		...	...	..	...	.	...		..	.	.	.	..	...	..	.	..	4	9
,, 6		...	...	..	...		..	.	.	.	.	..	..	..	..	..	.	4†	3

S = Swarms. C = Common. F = Few. * From fisherman. † Embryos.

THE OCCURRENCE MONTH BY MONTH OF THE VARIOUS SPECIES OF SALPS ON THE MADRAS COAST (1937—1943).

Species.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
C. pinnata var. sewelli	S	...	S	.	.	..	S	S	.	..	..	.
C. pinnata var. polae ...	A	..	A	A	.	..	S A	A	A	S A	A	A
B. rostrata	..	..	..	...	...	..		S	..	S	...	.
R amboinensis .. .	...		S	...	..	..	S	S	...	..	.	S
M. hexagona	.	..	..	..	S	..	..		.	..	..	..
S maxima	.	..	A	.	...	..	.	A	.	...	...	..
S. maxima var. tuberculata	A	..	.	...	..	..	A	A	..	...	...	..
S. cylindrica	S A	S A	S A	S A	..	...	.	S A	S A	S A	S A	S A
J. zonaria	..	.	S A	S A	..	..	S A	S A	A	.	...	A
T. democratica .. .	S A	S A	S A	S A	S A	..	S A	S A	S A	S A	..	S A
P. confoederata ..	A	..	S A	A	.	..	...	S A	S A	S	..	..
T. multitentaculata ..	.		.	...	...			.	S	..	...	...
	3 5	2 2	6 6	3 5	2 1	...	5 4	7 7	4 5	5 3	1 2	3 4
Total number of species.	6	2	8	5	2	..	6	10	6	5	2	5

S = Solitary. A = Aggregate.

KEY TO LETTERING.

al.c.	álimentary canal.
a.p.	attachment protuberance.
a.r.	atrial retractor.
a.s. 1,a.s. 2, etc.	dorsal atrial sphincters.
e.	embryo.
end.	endostyle.
h.m.	horizontal muscle.
ht.	heart.
i.m.	intermediate muscle.
l.1, l.2, etc.	ventral oral sphincters.
o.r.	oral retractor.
ov.	ovary.
pd.	peduncle.
s.	stolon.
te.	testis.
t.p.	tentacular processes.
u.1, u.2, etc.	dorsal oral sphincters.
v.s.1, v.s. 2, etc.	ventral atrial sphincters.
xx.	muscle characteristic of the oral siphon of *Jasis zonaria*.
I, II, III, etc.	body muscles.

Plate I.

Fig. 1. Side view of the solitary form of *Cyclosalpa pinnata* var. *sewelli*. × 3-3/5.

2. Side view of the aggregate form of *Cyclosalpa pinnata* var. *polae*. × 3-1/5.

3. Side view of the solitary form of *Brooksia rostrata*. × 6.

4. Side view of the solitary form of *Ritteriella amboinensis*. × 3-1/5.

5. Dorsal view of the solitary form of *Metcalfina hexagona*. × 4/5.

6. Dorsal view of the solitary form of *Jasis zonaria*. × 2.

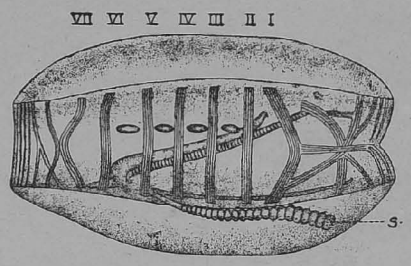
7. Dorsal view of the aggregate form of *Jasis zonaria*. × 2-2/5.

8. Dorsal view of the solitary form of *Thalia democratica*. × 4.

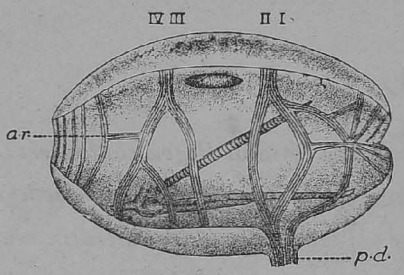
9. Dorsal view of the aggregate form of *Thalia democratica*. × 8.

10. Ventral view of an aggregate form of *Thalia democratica* from the right side of a chain showing the attachment protuberances. × 10.

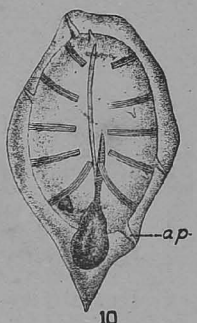
11. Dorsal view of a chain of aggregate forms of *Thalia democratica*. × 10.



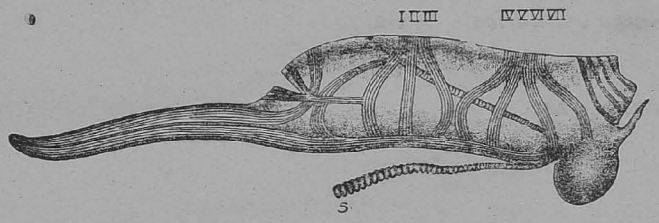
1



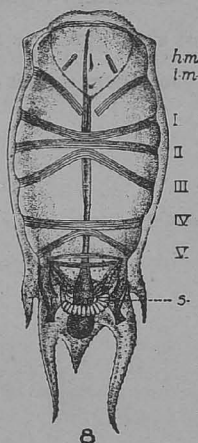
2



10



3



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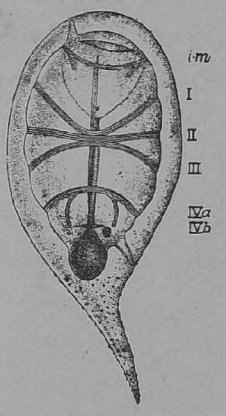

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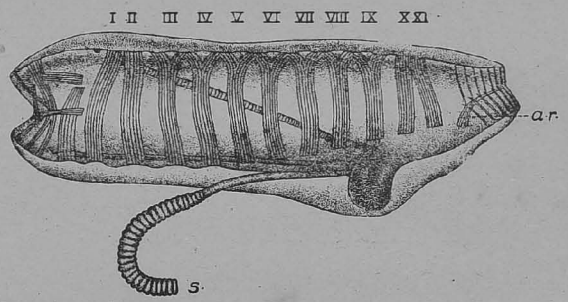

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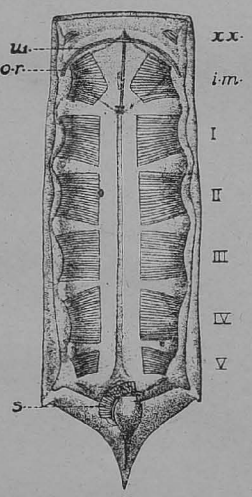

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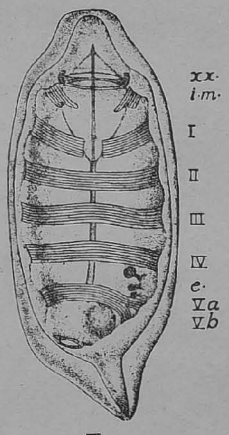

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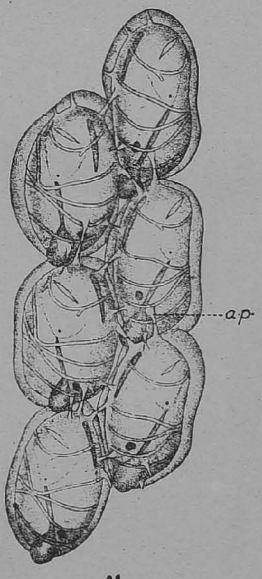

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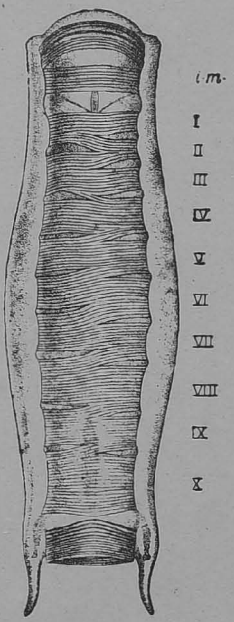

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Plate II.

Fig. 1. Side view of the solitary form of *Pegea confoederata*. × 1-5/7.

2. Side view of the aggregate form of *Pegea confoederata*. × 1-5/7.

3. Dorsal view of the solitary form of *Traustedtia multitentaculata*. × 3.

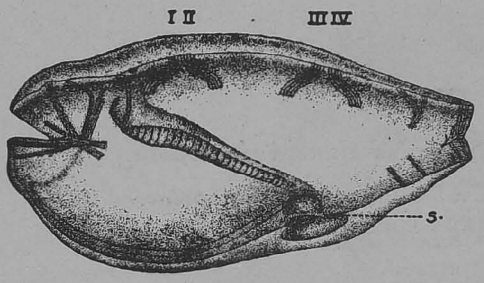
4. Dorsal view of the aggregate form of *Salpa maxima*. × 6-3/7.

5. Dorsal view of the aggregate form of *Salpa maxima* var. *tuberculata*. × 1-2/7.

6. Side view of the solitary form of *Salpa cylindrica*. × 1-2/7.

7. Dorsal view of the aggregate form of *Salpa cylindrica*. × 4-2/7.

8. Side view of *Doliolum denticulatum*. × 24.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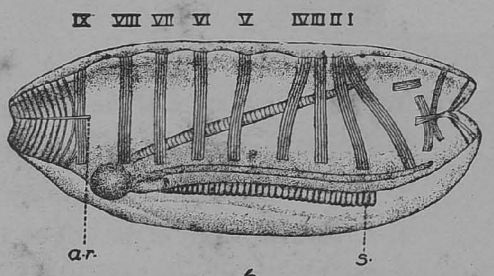
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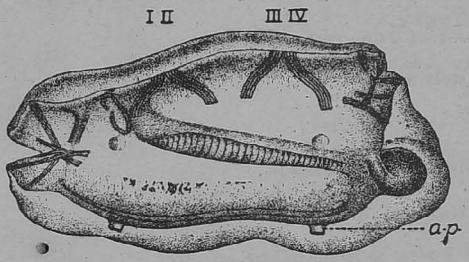
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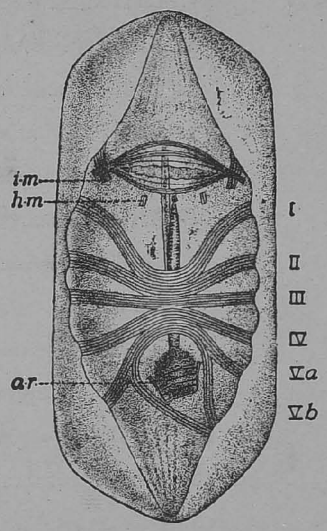
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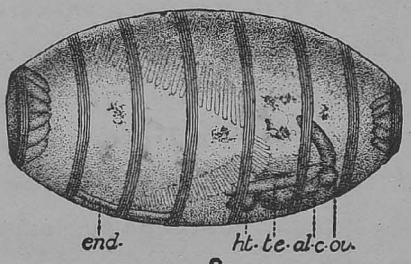
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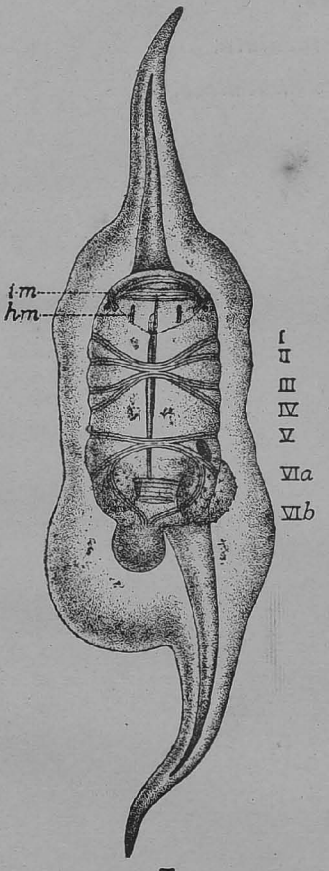
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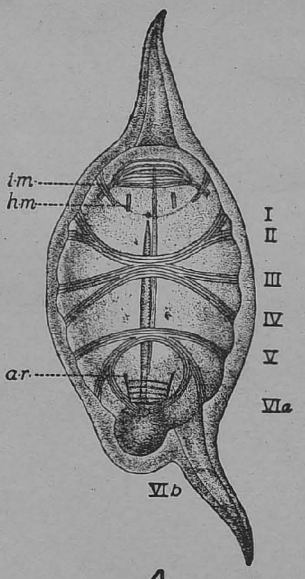
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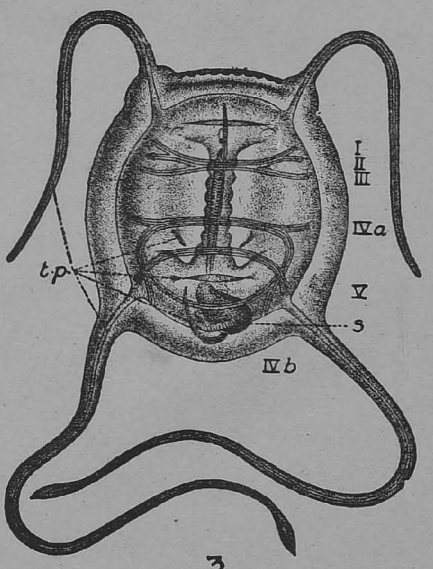
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Plate III.

Fig. 1. Oral musculature of the solitary form of *Cyclosalpa pinnata* var. *sewelli*.

2. Oral musculature of the aggregate form of *Cyclosalpa pinnata* var. *polae*.

3. Oral musculature of the solitary form of *Brooksia rostrata*.

4. Oral musculature of the solitary form of *Ritteriella amboinensis*.

5. Oral musculature of the solitary form of *Metcalfina hexagona*.

6. Atrial musculature of the solitary form of *Jasis zonaria*.

7. Oral musculature of the aggregate form of *Jasis zonaria*.

8. Atrial musculature of the aggregate form of *Jasis zonaria*.

9. Oral musculature of the solitary form of *Thalia democratica*.

10. Atrial musculature of the solitary form of *Thalia democratica*.

11. Oral musculature of the aggregate form of *Thalia democratica*.

12. Atrial musculature of the aggregate form of *Thalia democratica*.

13. Oral musculature of the solitary form of *Pegea confoederata*.

14. Atrial musculature of the solitary form of *Pegea confoederata*.

15. Atrial musculature of the aggregate form of *Pegea confoederata*.

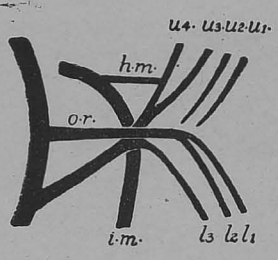
16. Oral musculature of the solitary form of *Traustedtia multitentaculata*.

17. Atrial musculature of the solitary form of *Traustedtia multitentaculata*.

18. Oral musculature of the aggregate form of *Salpa maxima*.

19. Oral musculature of the solitary form of *Salpa cylindrica*.

20. Oral musculature of the aggregate form of *Salpa cylindrica*.



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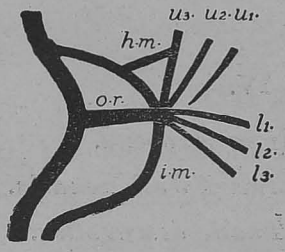

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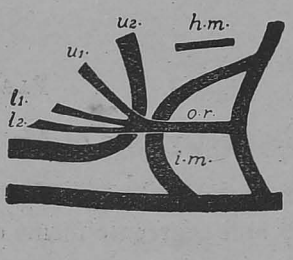

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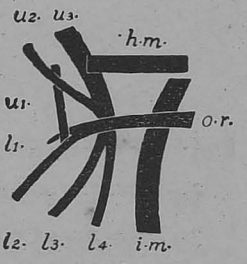

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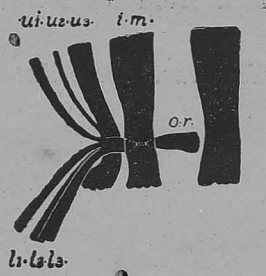

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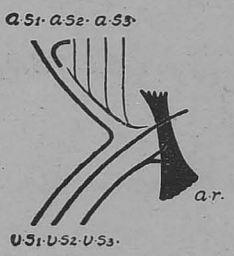

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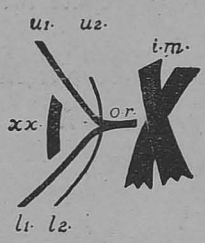

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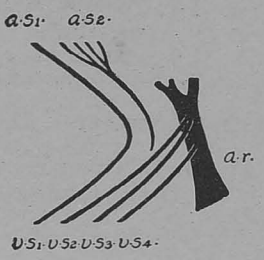

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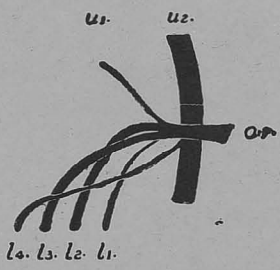

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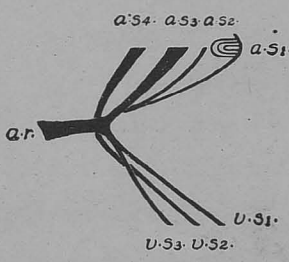

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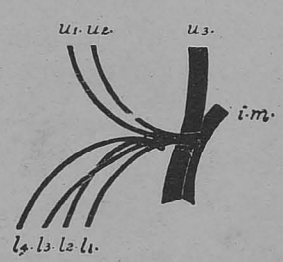

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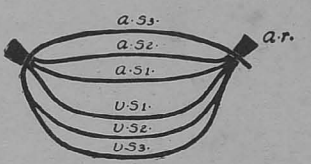

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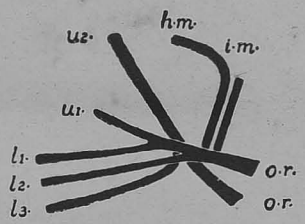

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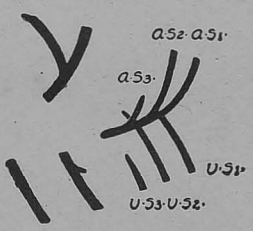

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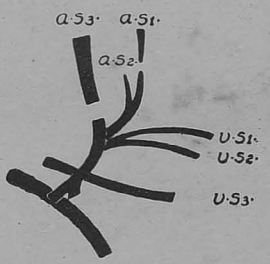

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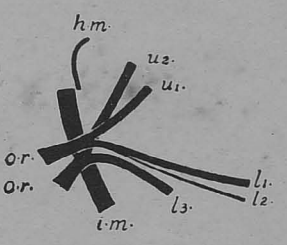

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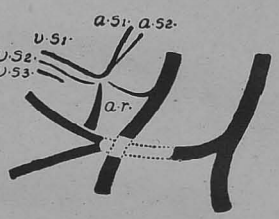

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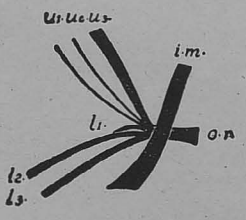

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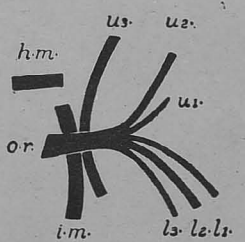

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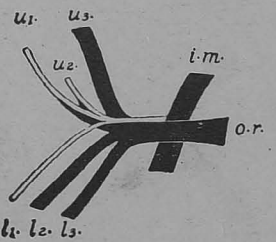

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Plate IV.

Fig. 1. Ventral view of the solitary form of *Metcalfina hexagona.*

2. Dorsal view of the solitary and aggregate forms of *Jasis zonaria.*

3. Swarms of solitary and aggregate forms of *Thalia democratica.*

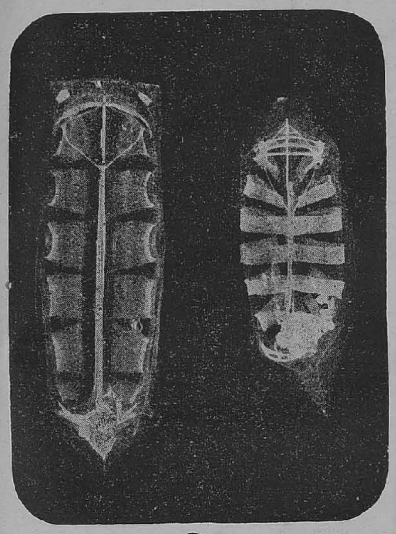
4. Chain of aggregate forms of *Pegea confoederata* obtained from the Madras beach.

5. One side of a chain of aggregate forms of *Pegea confoederata* obtained from the Madras harbour.

6. Photomicrograph of the embryo from the aggregate form of *Salpa maxima* var. *tuberculata.*

7. Swarm of *Dolioletta gegenbauri.*

8. " Nurse Forms " (two kinds).



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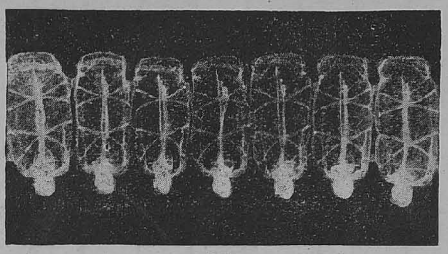

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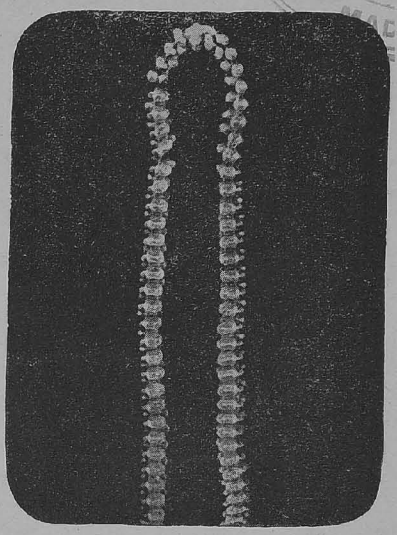

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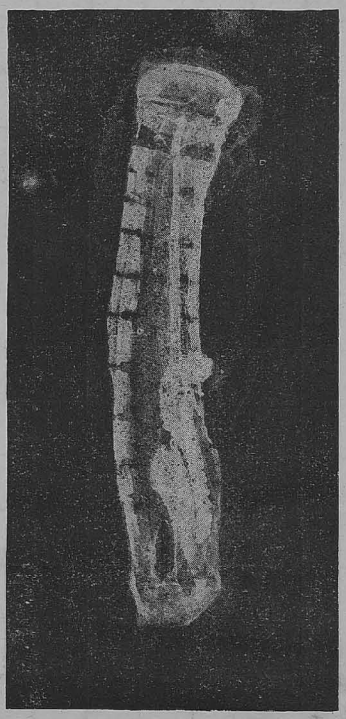

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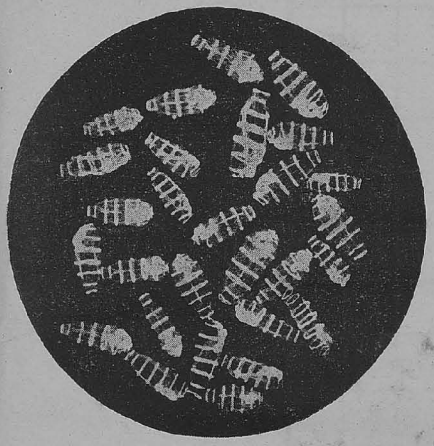

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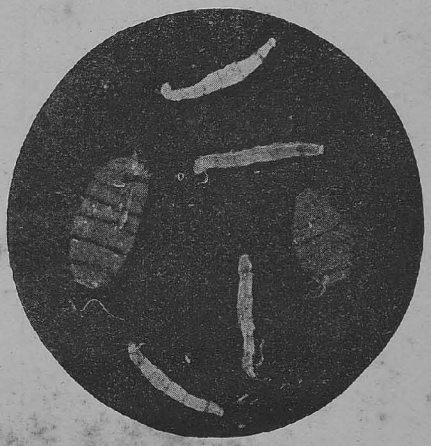

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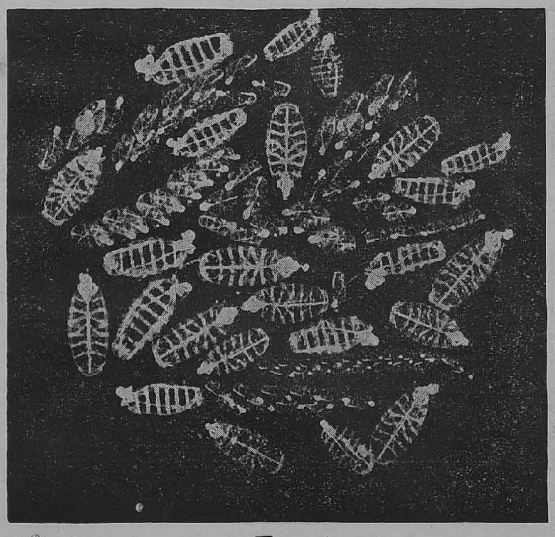

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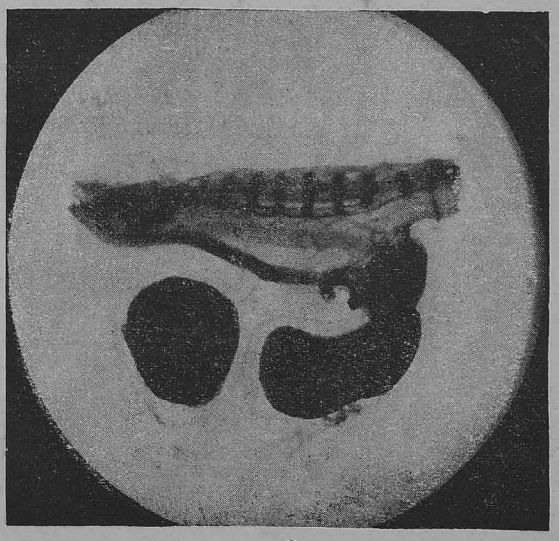

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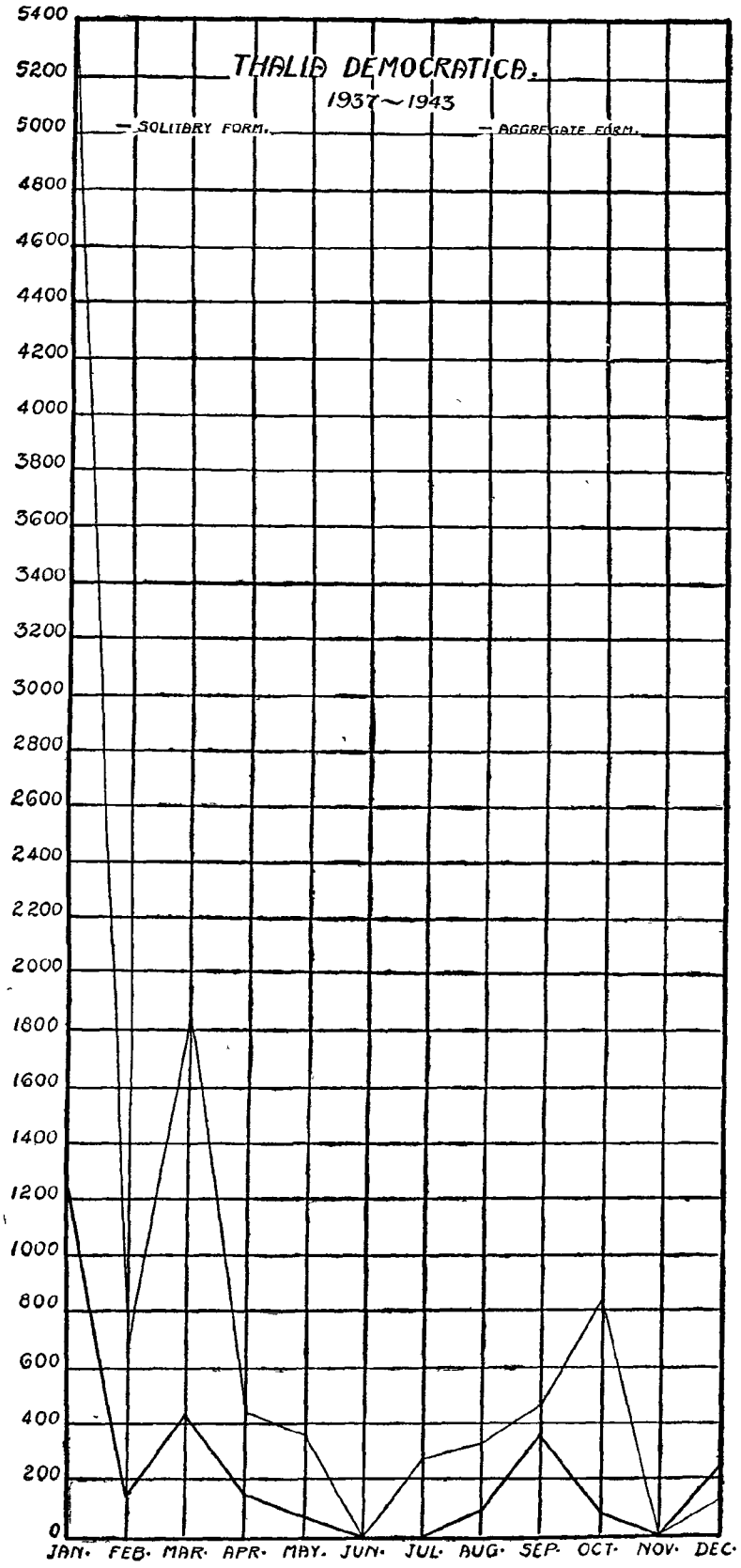
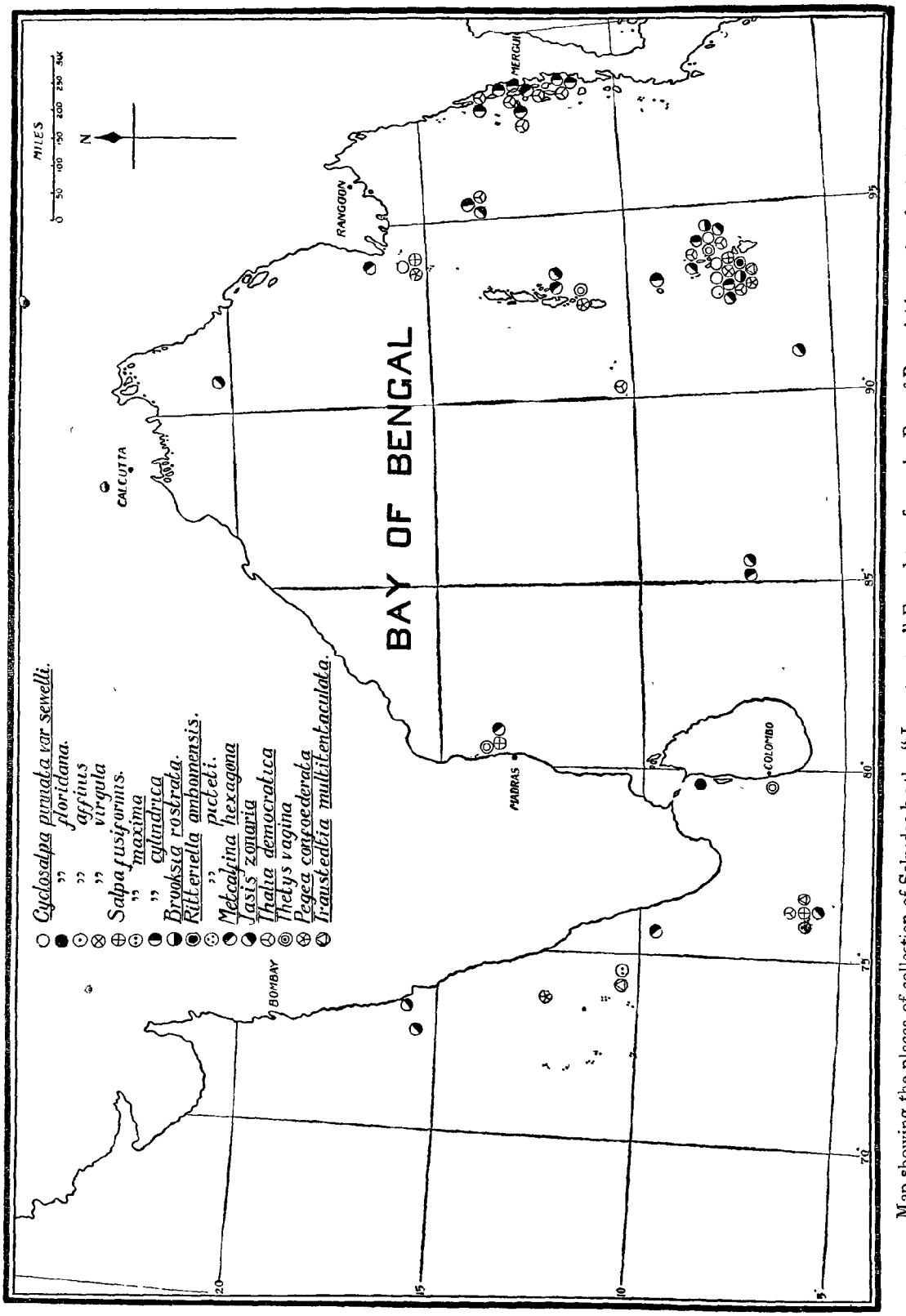


Graph showing the occurrence of the two generations of *Thalia democratica* in a year.



Map showing the places of collection of Salpidae by the "Investigator" Expedition from the Bay of Bengal (drawn by the Author).