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# THE SALPS OF INDIAN SEAS.

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The collection of Salps in the Indian Museum, on which the following paper is based, consists for the most part of collections made by the R. I. M. S. " Investigator " in various parts of the Arabian Sea (including the Laccadive Sea), the Bay of Bengal and the Andaman Sea.

Two papers, dealing with this collection, have already appeared in the *Records* and *Memoirs of the Indian Museum*, namely those by Bomford (1913) and Oka (1915). The first of these papers, by Bomford, is merely a short note dealing for the most part with collections that he himself made when officiating as Surgeon-Naturalist in 1911-13. Oka's paper (1915) deals with the Tunicata in general, and it appears that for some reason or other, but probably due to an oversight, only a small portion of the collection of Salps was forwarded to him. He mentions only five species, all of large size, and, furthermore, appears to have been completely unaware of Bomford's earlier paper. I have, therefore, thought it well to write an account of the collections as a whole, even though so doing necessitates a certain amount of repetition.

The Hemimyaria comprises a group of pelagic animals, the number of species in which are few but have a very wide geographical range. The group is usually subdivided into two genera, *Cyclosalpa* and *Salpa*; of these the former genus is a natural and well-defined one, but the same cannot be said for the latter. The genu *Salpa* (*sensu lato*) comprises a group of animals, in which the number of distinct species is comparatively small, but these exhibit *inter se* such a diversity of structure that in any other group it would be regarded as sufficient ground on which definitely to relegate them to distinct genera or even families. Indeed the retention of this so-called genus in its wide sense in the nomenclature appears to be due to a reverence for time honoured tradition rather than to any scientific basis.

The members of the family Salpidae are, as Metcalf (1918 has clearly shown, possessed of a remarkable degree of plasticity. Metcalf himself attributes the evolution of the various species to an innate tendency to vary, that has resulted in the evolution of widely diverse forms in spite of the general uniformity of the conditions under which these animals live. He remarks, (1918, p. 161) " the very considerable diversity of the species within the family Salpidae is correlated with the great specialization of the family for its pelagic life. The two sets of phenomena are but different phases of the fundamental physiological quality of plasticity. This plasticity, as indicated in the later stages of the evolution of the family, during the time of formation of the diverse species, seems due not to sensitiveness in response to environmental influences, but more probably to an inherent instability working itself out in many directions, without special relation to environmental influence. The external conditions under which the several species

live are remarkably uniform. Their divergence has not been in the nature of fitting into different types of environment. It must have resulted almost wholly from inherent qualities." Personally I am inclined to think, and my own researches in Indian waters certainly seem to indicate, that there is very much less uniformity in the ocean waters of this region than is generally supposed, and that planktonic organisms are subject to periodic and rhythmic changes in their environment that, though possibly small in amount, may have a very pronounced effect on the organisms. Individuals adapted to certain conditions, especially those of temperature and salinity, at one season of the year, will at another find themselves existing under adverse conditions. Within a few days or weeks conditions at the surface may so change that it may even cause the death of many individuals ; and the result is the production of a number of variations using the term in its widest sense.

The earlier workers on the genus *Salpa*, as was only natural, concentrated their attention largely on the musculature and it was in the main on the differences found to exist in this system that they based their scheme of classification. Herdman (1891) divided the sub-order Hemimyaria [=Desmomyaria Claus] into the two families Salpidae and Octacnemidae, the former comprising the genera *Cyclosalpa*, *Salpa*, *Thalia*, *Pegea* and *Jasis*, and the latter the single genus *Octacnemus*. Streiff (1908), again basing his conclusions largely on the musculature, attempted to split up the family Salpidae into what he considered to be natural groups and, discarding the genera *Thalia*, *Pegea* and *Jasis*, includes all the forms in the family in the two subgenera *Cyclosalpa* and *Salpa*, sub-dividing the latter sub-genus into two groups, Polymyaria and Oligomyaria. Metcalf (1918) has made a very careful study of the general anatomy of most of the known species and has, as a result, succeeded in evolving a scheme of classification that, based as it is on the structure of the animal as a whole and not merely on one particular system, seems to me to be a sound one, and one, moreover, that clearly reveals the relationships of the various subgenera to each other. He shows that, commencing with the more primitive sub-genus *Cyclosalpa*, the various members of the family have evolved along two diverging lines, the one embracing those subgenera that he includes in the group Sphaerodaea and the other those belonging to the group Cercodaea. It is interesting to note that in both lines of evolution there is, at any rate at first, a tendency towards an increase both in the number of muscles present in the body and in their complexity ; but in the Cercodaea this stage has again been succeeded by the opposite phase and in the species furthest removed from the primitive sub-genus *Cyclosalpa* we find a strongly marked tendency towards a reduction in the bodily musculature, presumably correlated with a more sluggish habit and a consequent nearer approach to the condition of a truly planktonic organism.

It is unfortunate that successive authors have adopted very different methods of nomenclature regarding the various groups of muscles in the body. I have throughout the following pages followed the system adopted by Metcalf, who divides the muscles into (*a*) an oral group,

composed of sphincters and retractors, (*b*) an intermediate muscle, usually connected with the oral system, but occasionally having more the character of a body muscle, (*c*) a series of body muscles, and (*d*) an anal group, again consisting of sphincters and retractors. As regards minor differences in the musculature of individuals of apparently the same or very closely related species, I would utter a word of warning. It must be remembered that, as Metcalf has pointed out, the various species are possessed of a very considerable degree of plasticity and therefore one must expect to find a certain amount of variability in the individual both as regards the actual numbers of the muscle-bands present and also in regard to the connections between neighbouring bands. Furthermore, all the Salps are animals of very delicate structure and constitution and in many the muscle-bands are extremely delicate. Anything of the nature of increased tension or rough handling may cause a rupture of the muscle-bands. One must therefore beware of concluding, because in any individual and especially in the more rare species a muscle-band stops short and is not continued across the middle line, as in many cases one finds to be the condition present in the delicate sphincters of the oral aperture that it is the normal condition for such an interruption to be present; or again, if in one example a connecting muscle band, that in others is found to run from one body muscle to another or to the anal sphincter, is found to be absent, it is not safe to conclude that one is dealing with a new variety or sub-species. If in such cases one finds the ends of the muscle fibres abruptly and irregularly truncated and the line from end to end continued by a blood sinus, one is, I think, justified in concluding that in the natural state the two ends were continuous and that the interruption is due to injury either *ante* or *post*-mortem.

In the following table I have given the classification followed in this paper, and have denoted the various species that are represented in the collections of the Indian Museum.

HEMIMYARIA Herdman [=DESMOMYARIA Claus].

*DOLICHODAEA.*

*Cyclosalpa* (Symmetricales).

*C. pinnata.*

*C. floridana.*

*C. affinis.*

*Cyclosalpa* (Asymmetricales).

*C. virgula.*

*SPHAERODAEA.*

*Apsteinia* (unrepresented).

*Salpa* (*sensu stricto*).

*S. fusiformis.*

*S. maxima.*

*S. cylindrica.*

*CERCODAEA.*

*Brooksia.*

*B. rostrata.*

*Ritteria.*
*R. amboinensis.*
*R. picteti.*
*R. hexagona.*
*Jasis.*
*J. zonoria.*
*Thalia.*
*T. democratica.*
*Theiys.*
*T vagina.*
*Pegea.*
*P. confoederata.*
*Traustedtia.*
*T multitentaculata.*

Group DOLICHODAEA.

Sub-genus **Cyclosalpa** Blainville.

Metcalf (1918, p. 8) divides this sub-genus into two groups: (*a*) Symmetrical forms, *Symmetricales*, including *Cyclosalpa pinnata* and its so-called variety *polae*, *C. affinis* and *C. floridana*; and (*b*) the *Asymmetricales*, including *C. bakeri* and *C. virgula*. All five species have been recorded from the Indian Ocean, and in the Indian Museum collections I can find representatives of all, with the single exception of *Cyclosalpa bakeri*. Bomford (1913, p. 243) has recorded the occurrence of *C. bakeri* in Indian waters, but his description of the specimen, which appears to have been mislaid, renders the identification highly improbable and I believe he was mistaken, the specimenbeing an example of *C. pinnata*.

**Cyclosalpa pinnata** (Forskal).

*Salpa pinnata*, Traustedt, 1885, p. 353, pl. i, figs. 1-5.
*Cyclosalpa pinnata*, Herdman, 1888, p. 87.
*Salpa pinnata*, Brooks, 1893, p. 2, pl. i, figs. 1—3, 5 and 6.
*Cyclosalpa pinnata*, Traustedt, 1893, p. 5.
*Cyclosalpa pinnata*, Apstein, 1894, p. 4.
*Cyclosalpa pinnata*, Apstein, 1901, p. 9, fig. 8, *a* and *b*.
*Cyclosalpa pinnata*, Apstein, 1905, p. 247.
*Cyclosalpa pinnata*, Apstein, 1906, p. 160, figs. 1 and 2.
*Cyclosalpa pinnata*, Streiff, 1908, p. 11, figs. 1—4.
*Cyclosalpa pinnata*, Apstein, 1910, p. 8, figs. 11 and 12.
*Cyclosalpa pinnata*, Ihle, 1910, p. 17.
*Cyclosalpa pinnata*, Ihle, 1912, p. 17, figs. 10 and 11.
*Cyclosalpa bakeri*, Bomford, 1913, p. 243.
*Cyclosalpa pinnata*, Sigl, 1913, p. 223.
*Cyclosalpa pinnata*, Metcalf, 1918, p. 9, pls. i and ii.

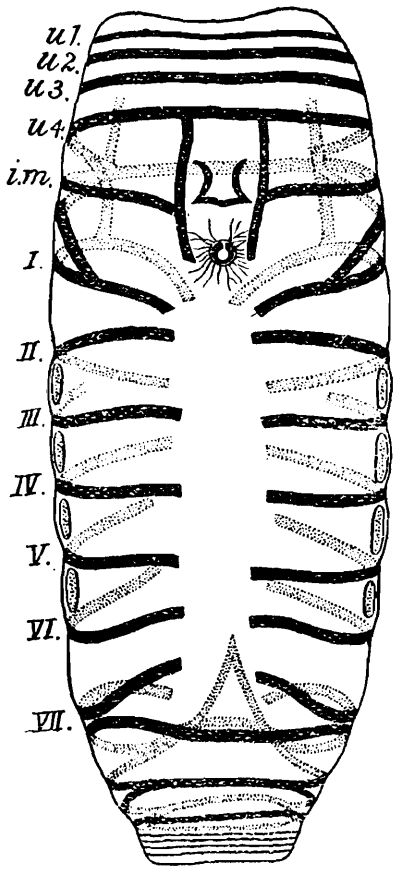
**Cyclosalpa pinnata** sub-sp. **polae** (Sigl).

*Cyclosalpa polae*, Sigl, 1912, p. 66, figs. 1-9.
*Cyclosalpa polae*, Sigl, 1913, p. 225, pl. i, figs. 16-.
*Cyclosalpa pinnata*, sub-sp. *polae*, Metcalf, 1918, p. 26. figs. 13, 14.

The species appears to be of somewhat rare occurrence in Indian waters, and not infrequently such specimens as are obtained are in bad condition, indicating that they had died and were already undergoing

the process of decomposition. Examples were obtained at the following stations :—

1. *Solitary Zooid* :
   (*a*) A few examples at " Investigator " Sta. 614, Nankauri Harbour, on the following dates :—
   Surface. January 22-23, 1922.[1]
   10 fathoms. February 4-5, 1922.
   (*b*) Five examples at " Investigator " Sta. 672, Revello Channel, Nicobars. Surface, April 7-8 and 8-9, 1925.
2. *Aggregated Zooid* :
   Several examples were obtained at " Investigator " Sta. 614, Nankauri Harbour on the following dates :—
   Surface. February 2-3, 4-5 and 6-7, 1922.
   10 fathoms. February 4-5, 1922.

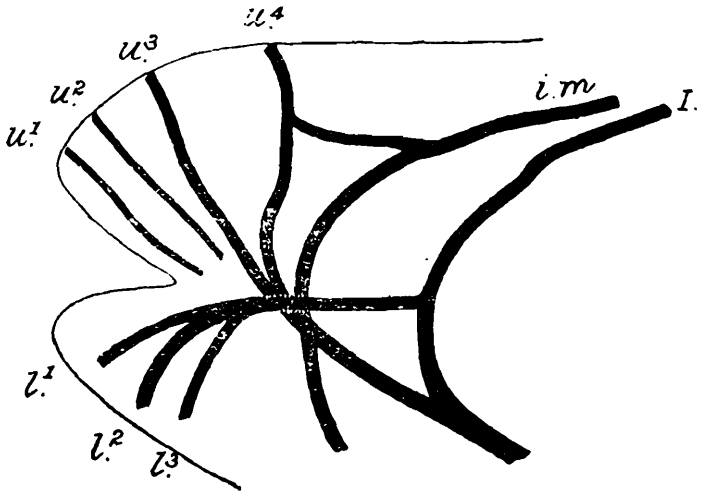



TEXT-FIG. 1.—*Cyclosalpa pinnata,* Indian form, from the dorsal side.

*Solitary Zooid.*—Every example obtained by the " Investigator " in Indian waters shows a constant difference from the type in that there are only four pairs of lateral or luminous organs present. In all previous accounts of this species it is stated that five of these organs are present on each side of the body situated in the interspaces between

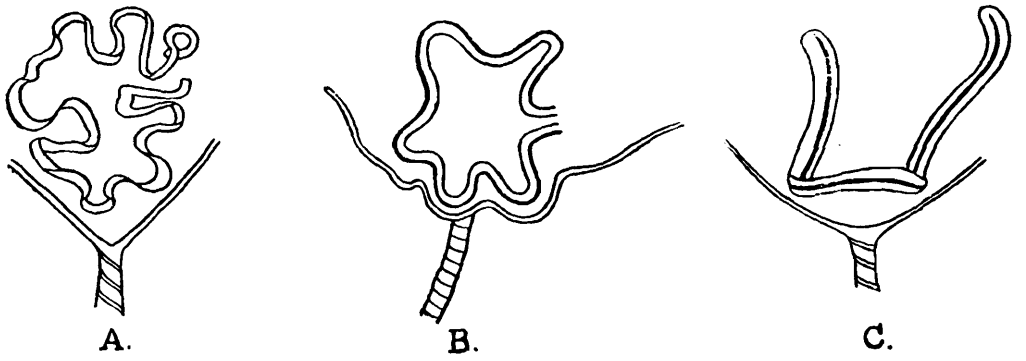
[1] It has been my custom on the " Investigator " to put out a tow-net, when the ship is at anchor, from 6 P.M. to 6 A.M. and to allow the tide to carry the surface organisms into it. All tow-nettings, therefore, unless specially stated to be otherwise, are right-hauls.

the body-muscles, the first lying between muscles I and II, and the fifth between muscles V and VI. In all Indian examples the first pair of these organs, lying between muscles I and II, is absent. Bomford (1913, p. 243) in his note on *Cyclosalpa bakeri* remarks, "but the 'lateral organs' number only four on each side, there being none between muscles 1 and 2. Muscle 6 also does not seem to be continued into a longitudinal band near the mid-dorsal line." One is, I think, justified in assuming from Bomford's own description that he was dealing with a member of this species and not *C. bakeri*, and furthermore that the absence of the first pair of lateral organs is a constant character of the Indian race of *C. pinnata*.




TEXT-FIG. 2.—*Cyclosalpa pinnata*. Solitary form. Oral muscles, lateral view.

The ciliated funnel or dorsal tubercle also in this form appears to differ somewhat from the normal or type. Metcalf figures it as somewhat rosette-shaped, whereas in these Indian examples it is in the form of a simple U (*vide* fig. 3,c), very similar to that in *C. bakeri*, and we thus get a gradual simplification of this organ, as we pass from the typical *C. pinnata* through *C. polae* to the Indian form.




TEXT-FIG. 3.—The ciliated funnel or dorsal tubercle in *Cyclosalpa pinnata*. A. Typical form (after Metcalf). B. Sub-sp. *polae* (after Sigl). C. Indian form.

In all the present examples the arrangement of the muscle bands agrees closely with Metcalf's description and figures of *C. pinnata*. The VIth body-muscle is not continued forward in the mid-dorsal line, but is clearly interrupted, as are all the other body muscles. As regards this character, therefore, the Indian form agrees with the type. The

oral and atrial muscles also agree exactly with the type. The anterior atrial sphincter is a well-developed loop, and is followed by a more delicate sphincter that, to quote Metcalf (1918, p. 13), "is peculiar in the fact that its ventral portio bends forwards, runs across the basal sphincter on the inside and crosses the ventral line well toward the last body-muscle at the level of the posterior ends of the two intestinal caeca."

It seems clear that the solitary zooid, while exhibiting certain minor racial characters, must undoubtedly be referred to the species *Cyclosalpa pinnata.*

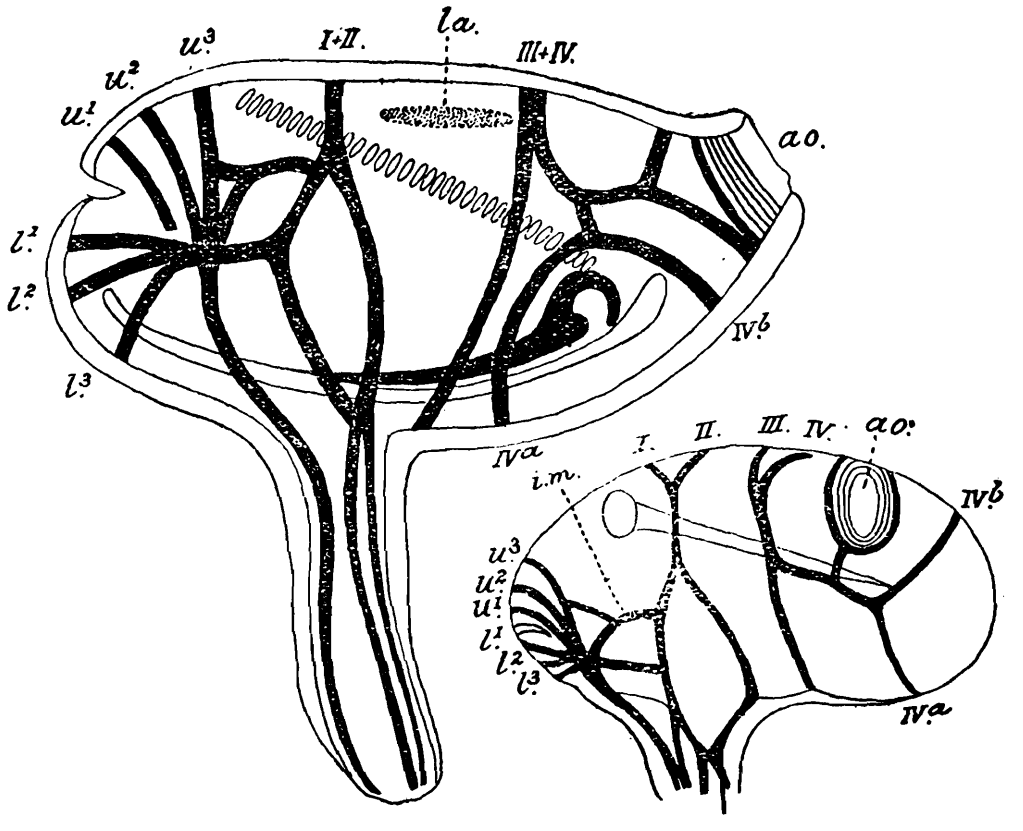
*Aggregated Zooid.*—In this generation the arrangement of the muscles is extremely interesting for it agrees almost exactly with the description and figures given by Sigl (1912, figs. 5 and 6 and 1913, Pl. I. figs. 4 and 6 ) of the musculature in the sexual stage of *Cyclosalpa polae.*

The oral musculature in these Indian examples consists of a single oral retractor from which arise the three sphincters of the lower lip. From the 1st body muscle arises a well-developed intermediate muscle, that is joined, where it crosses the oral retractor, by the 2nd and 3rd sphincters of the upper lip : a well-developed horizontal muscle also joins it to the 3rd sphincter. In the fully-grown individual the 1st sphincter of the upper lip is independent : it approaches close to but does not actually join either the oral retractor or the intermediate muscle. In a young example from the stolon, however, the connection is complete.

The arrangement of the body-muscles in *Cyclosalpa pinnata* and its so-called sub-species *polae,* is somewhat different. In the typical form the IIIrd and IVth body-muscles are separated in the mid-dorsal line by a somewhat narrow interval : both Metcalf (1918, Pl. I, fig. 3) and Apstein (1910, fig. 11) are agreed upon this point. On the other hand in *C. polae* and in my Indian examples these two muscles are fused together across the dorsal aspect. Streiff (1908, figs. 3 and 4) gives figures of the arrangement of these muscles in both full-grown and young forms. In the full-grown form the condition figured is that of *C. pinnata,* the two muscles being separated, while in the young form, taken from a well-developed stolon, the muscles are united, so that the condition agrees with that found in *C. polae.* Attached to an example of the solitary zooid taken at Sta. 614 was a well-developed stolon, the terminal zooids of which were sufficiently well-developed to enable me to make an examination of the muscle system, and a comparison of the figure given below with that given by Sigl (*loc. cit.*) shows that the arrangement of the muscles is identical.

Had I been dealing solely with examples of the aggregated zooid I should have had no hesitation in referring this form to the sub-species *polae* but, as I have already shown, the asexual generation must be referred to *C. pinnata.* It is impossible, therefore, to distinguish *Cyclosalpa polae* from *C. pinnata* even as a sub-species, and much less, as Sigl originally claimed, as a species. The characters shown by the aggregated zooid of *C. polae* appear to be those normally present in the early stages of development, but in the typical form certain muscles, such as the 1st sphincter of the upper-lip and body-muscles III

and IV, become separated in later life. A similar separation of the body muscles has been shown to occur, as development progresses, in the case of certain other Salps, and the differences between the




TEXT-FIG. 4.—(A). A full-grown aggregated zooid of *Cyclosalpa pinnata* from Indian waters. (B). A young individual from a well-developed stolon.

aggregated zooid of *C. pinnata* and *C. polae* are merely due to a retention in the one throughout life of an infantile character that is originally common to both forms.

## Cyclosalpa floridana (Apstein, 1894).

*Cyclosalpa dolicosoma-virgula.* Traustedt, 1893, p. 5.
*Salpa floridana,* Apstein, 1894, p. 9, pl. ii, figs. 1 to 4.
*Cyclosalpa floridana,* Brooks, 1908, p. 75, pls. i and ii.
*Cyclosalpa floridana,* Ihle, 1910, p. 19, pl i, figs. 1, 2 and 5.
*Cyclosalpa floridana,* Michaelson, 1915, p. 505.
*Cyclosalpa floridana,* Metcalf, 1918, p. 33, pl. iv, figs. 13 and 14, pl. v, figs. 15, 16 and pl. vi.

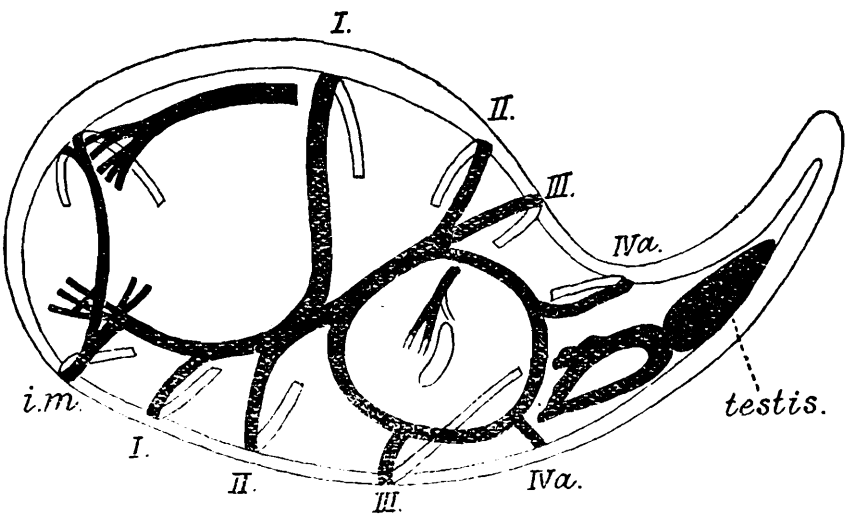
A single example of a young embryo was obtained by Dr. T. Southwell, in a surface tow-netting taken on the Ceylon Pearl Banks on 19th January, 1907 The occurrence of this rare species has been recorded by Apstein in the western part of the N. Atlantic, by Brooks in the neighbourhood of the Bahamas, by Metcalf in the Gulf of Mexico and by Ihle in the Malay Archipelago. It is clear in spite of its great rarity that it has a very wide distribution.

## **Cyclosalpa virgula** (Vogt).

*Salpa dolicosoma-virgula*, Traustedt, 1885, p. 360, pl. i, fig. 9.
[Not *Salpa dolicosoma-virgula*, Traustedt, 1893.]
*Salpa virgula*, Apstein, 1894, p. 4, figs. 1-5.
*Salpa virgula*, Apstein, 1905, p. 247, pl. xxvi, figs. 1 and 2.
*Cyclosalpa virgula*, Apstein, 1906, p. 161, figs. 5 and 6.
*Cyclosalpa virgula*, Streiff, 1908, p. 15, pl. i, figs. 5, 7 and 8.
*Cyclosalpa virgula*, Michaelsen, 1915, p. 504.
*Cyclosalpa virgula*, Metcalf, 1918, p. 43, pl. xx, figs. 26-28, pls. xii, xiii, and figs 18-21.

The occurrence of this Salp in the Indian Ocean has been noted previously on only one occasion, when the " Valdivia " obtained it, apparently, in the region of the Chagos Archipelago. Apstein, however, is by no means clear on this point ; in his Table, (1905, pp. 262-4) of the occurrence of Salps, he notes that *Cyclosalpa virgula* was taken at Sta. 223 (6° 19'S : 73° 18'E. Feb. 23, 1899] but in the previous table (pp. 257-260) giving the details of the various hauls, he shows a single example of the aggregate zooid of *C. floridana*, as the only Cyclosalp obtained at this Station. Possibly the position of the figure I in the column under the heading '*floridana*' has been printed in the wrong column and should be in the previous one under '*virgula*.' It would appear that only a single example was obtained.

In the " Investigator " collection from Sta. 672, Revello Channel, West side, Nicobars, March 6th-7th, 1925, we have 32 examples of the aggregated zooid. Both dextral and larval individuals are present, the arrangement of the muscles in the latter being a looking-glass reflection of those of the dextral individuals. Unfortunately, none of these examples is in a very good-state of preservation. In Text fig. 5 I give the arrangement of the muscle-bands, so far as I was able to make them out. They appear to agree very closely with the description given by




TEXT-FIG. 5 :—*Cyclosalpa virgula* ; aggregated zooid ; viewed from the dorsal aspect, a 'left-handed individual.

Metcalf (1918) and it will be noticed that the posterior branches of the last body-muscle are united posteriorly, as Metcalf showed.

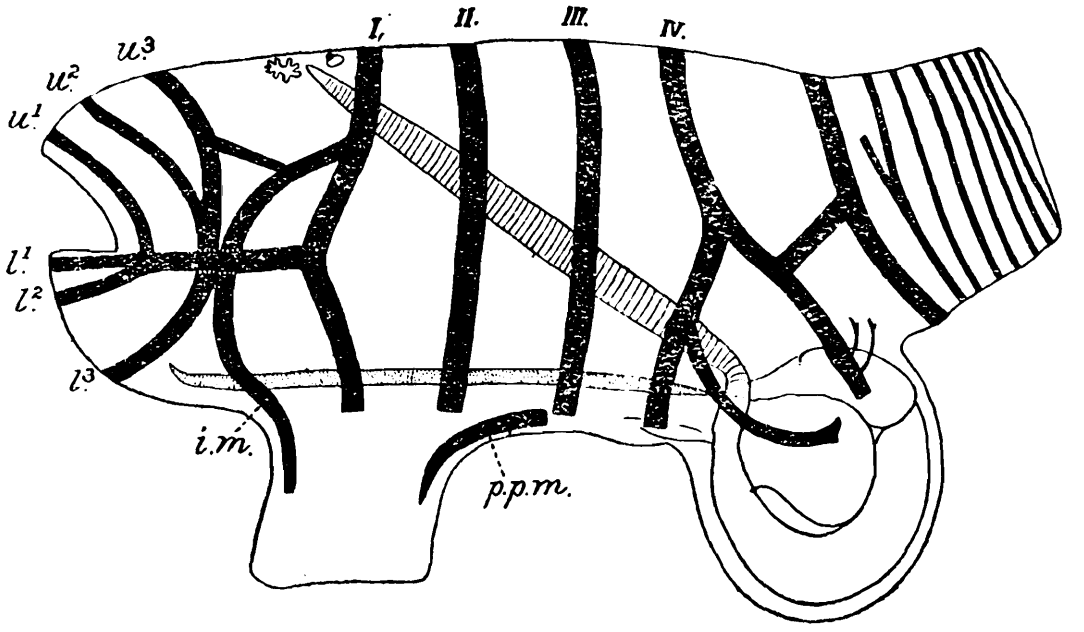
## **Cyclosalpa affinis** (Chamisso).

*Salpa affinis*, Traustedt, 1885, p. 357, pl. i, figs. 6-8.
*Cyclosalpa affinis*, Traustedt, 1893, p. 5.
*Salpa affinis*, Apstein, 1894, pp. 4, 32.
*Cyclosalpa affinis*, Apstein, 1905, pp. 247, 266.
*Cyclosalpa affinis*, Ritter, 1905, p. 59, figs. 9-11.
*Cyclosalpa affinis*, Ritter and Byxbee, 1905, p. 196.
*Cyclosalpa affinis*, Apstein, 1906, p. 161, figs. 3, 4.
*Cyclosalpa affinis*, Ritter and Johnson, 1910, p. 395, pls. 1-4.
*Cyclosalpa affinis*, Ihle, 1912, p. 19, figs. 12, 13.
*Cyclosalpa affinis*, Metcalf, 1918, p. 27, pl. iii and pl. iv, figs. 11, 12.

The occurrence of this species in Indian waters has already been recorded by Apstein in his account of the Salps collected by the " Valdivia." In the Indian Museum collection this species only occurs once, as follows :—

" Investigator " Sta. 672, Revello Channel, Nicobars, Surface, March 6th-7th 1925 ; 12 examples of the aggregated zooid.

*Aggregated Zooid*—The present examples show certain small differences from the account of the musculature given and figured by Metcalf (1918). As this author remarks, there is a close similarity between *Cyclosalpa affinis* and *C. pinnata*, but he figures (*loc. cit.*, pl. iii, fig. 10) *Cyclosalpa affinis* as having four sphincters in the upper lip and only two in the lower ; whereas in *C. pinnata* there are three in each. Ritter (1905 fig. 10, and p. 62) in his account states that there is " a well developed band in each lip of the branchial orifice meeting in a wide angle on each side ;" whereas later in collaboration with Johnson (1910, pl. ii, fig. 12) he shows two sphincters in each lip. In my examples there are distinct-




TEXT-FIG. 6—*Cyclosalpa affinis* ; aggregated zooid, from the left side.

ly three sphincters in each lip. The oral retractor muscle crosses externally the intermediate muscle and the third sphincter and then at a right angle gives off the 1st sphincter of the upper lip and divides into the 1st and 2nd of the lower lip. The 3rd sphincter muscle appears to touch, but not actually join with, the intermediate muscle ; above the level of the oral retractor this muscle band divides into two, an anterior

smaller portion, the 2nd sphincter of the upper lip, and a larger posterior band, which is joined by the horizontal muscle and forms the 3rd sphincter of the upper lip.

In all other respects these examples in the Indian Museum appear to agree exactly with Metcalf's description.

## Group SPHAERODEA.

### Sub-genus **Salpa** (*senso stricto*) (Forskål).

The genus *Salpa*, as defined by Metcalf, contains only three species, *Salpa maxima*, *S. fusiformis* and *S. cylindrica*, this latter species being one of the most common inhabitants of Indian waters.

So close are the resemblances between these three species that there can be no doubt that they form a natural group. Throughout the group we find a marked tendency in the aggregated zooids to assume an elongate fusiform shape. Such a shape is characteristic and may be considered normal in *Salpa fusiformis*, in which both anterior and posterior protuberances are large though in both the type form and in the form *aspera* they may be reduced. In *S. maxima* these protuberances are usually small, but in the so-called variety *tuberculata* they are as large as in the normal *S. fusiformis*. In *S. cylindrica* the aggregated zooid is usually described as having only small conical processes extending from the body at each end, while the test is more or less rounded. In certain cases, however, one may capture a shoal of these individuals in which one or both processes are enormously increased in size, so that the general shape of the body and test closely resembles that of the normal *S. fusiformis*. In such a shoal, in my experience, the extent of the increase in length is not constant but within limits varies in different individuals. It is not improbable that these projections are gradually developed as age and size increases ; certainly this seems to be the case in *Jasis zonaria*, in which the posterior conical projection is absent in very small and young examples and progressively increases in length with an increase in the size of the body.

### **Salpa fusiformis** Cuvier.

*Salpa runcinata-fusiformis*, Traustedt, 1885, p. 370, pl. ii, figs. 29-31 and 42.
*Salpa runcinata-fusiformis*, Herdman, 1888, p. 74, pl. vi, figs. 5-12.
*Salpa runcinata*, Brooks, 1893, p. 12, pl. xliii, fig. 2.
*Salpa runcinata-fusiformis*, Traustedt, 1893, p. 5.
*Salpa fusiformis*, Apstein, 1894, pp. 14, 34.
*Salpa fusiformis*, Apstein, 1901, p. 7.
*Salpa fusiformis*, Apstein, 1905, p. 268.
*Salpa fusiformis-runcinata*, Ritter, 1905, p. 64, figs. 12, 13
*Salpa fusiformis runcinata*, Ritter and Byxbee, 1905, p. 197.
*Salpa fusiformis*, Farran, 1906, p. 11.
*Salpa fusiformis*, Streiff, 1908, p. 24, fig. 15.
*Salpa fusiformis*, Apstein, 1910, p. 4, figs. 1 and 2.
*Salpa fusiformis*, Ihle, 1910, p. 30.
*Salpa fusiformis fusiformis*, Ihle, 1912, p. 39, figs. 37, 38.
*Salpa fusiformis*, Bomford, 1913, p. 243.
*Salpa fusiformis*, Sigl, 1913, p. 237.
*Salpa fusiformis*, forma *typica*, Michaelsen, 1915, p. 505.
*Salpa fusiformis*, Metcalf, 1918, p. 88, figs. 73-79.
*Salpa fusiformis fusiformis*, Stiasny, 1919, p. 11, fig. 3.

**Salpa fusiformis** form **aspera** (Chamisso).

*Salpa echinata*, Herdman, 1888, p. 66, pl. v, figs. 1-10.
*Salpa runcinata fusiformis*, var. *echinata*, Apstein, 1894, pp. 14, 34.
*Salpa fusiformis* forma *echinata*, Ritter, 1905, p. 67, figs. 14, 15.
*Salpa fusiformis* forma *echinata*, Apstein, 1905, pp. 250, 268, pl. xxvi, figs. 4-6.
*Salpa fusiformis-runcinata* form a *echinata*, Ritter and Byxbee, 1905, p. 199.
*Salpa fusiformis aspera*, Ihle, 1912, p. 40, figs. 39, 40.
*Salpa fusiformis* form a *aspera*, Metcalf, 1918, p. 92, figs. 80, 81.

The Indian Museum collection contains the following examples :—

*Solitary Zooid*—

(1) " Investigator " Sta. 166, Bay of Bengal, Lat. 13° 34′ 55″ N.; Long. 80° 32′ 12″E, 133 fms. February 8th 1894, one individual.

(2) " Investigator " Sta. 670, Laccadive Sea, Lat. 5° 56′N. Long 76° 22′E, 200 fms. to surface. April 23rd, 1924. Five examples ; test ridged but with little trace of denticulations.

(3) " Investigator " Sta. 679, Revello Channel, Nicobars, Surface. March 31st—April 1st, 1925.
One individual ; test ridged but with only slight degree of denticulation, and one empty test typically echinate.

*Aggregated Zooid*—

(1) " Investigator " Sta. 387, off Cape Negrais, Burma, Lat. 15° 25′N. Long. 93° 45′E, 40-49 fathoms. November 16th. 1909,

(2) " Investigator " Sta. 672, Revello Channel, Nicobars. Surface. March 6-7th, 1925. 5 examples ; all the aggregated zooids obtained are of the normal type.

Ritter (1905, p. 68) has attempted to provide a sound basis on which to separate the form *aspera* from the typical form in this species. He concludes that " a well-marked style or form of the species, which may be called *echinata*, must be recognised, but that it is not a distinct persistent variety, as Apstein has treated it, much less a species as Herdman concluded from his study of the Challenger material." According to Ritter the most striking difference between the type and the form *aspera* is to be found in the VIIIth and IXth body-muscles, which unite dorsally in the type but do not even converge in the form *aspera*. This divergence in the musculature he believes to be associated with age and he considers the form *aspera* to be an old-age form of the typical *fusiformis*. Farran (1906, p. 11) agrees with Ritter in inclining to the belief that the rough-tested form is an older stage of the smooth form, but he bases his conclusion on measurements of the length of the body and test in both forms, and not on any difference in the musculature, since, as he points out, " the musculature of the echinate form is quite in agreement with the typical *fusiformis*, but gives the appearance of the bands being thicker owing to the shortening of the animal." Metcalf (1918, p. 92) points out that the musculature and all the internal structure, including the character of the eyes, are practically identical in *S. fusiformis* and its form *aspera* in both the solitary and aggregated individuals. The aggregated zooids, as he remarks, of both the typical form and the form *aspera* may have either an elongate shape, such as

that originally described in *S. fusiformis* or a short form, such as that usually associated with the form *aspera*. Even the denticulate nature of the test, the character on which the form was originally founded, does not appear to provide a valid basis for the separation of the form from the type. Ritter (1905, p. 69) remarks that it is doubtful if denticulations are ever wholly absent in *S. fusiformis* : " certainly " he says, " if it is, it is so only exceptionally," and Metcalf, who has examined a large number of examples, states that there is a complete intergradation between the smooth and the most spinose.

Apstein (1905, p. 268) considers that the form *aspera* is the cold-water form of the type and according to him, with the exception of one single example, it was only taken by the " Valdivia " when working in deep water with vertical nets hauled from some considerable depth. This suggestion, however, cannot be accepted. In the United States National Museum are *echinata* examples that were captured on the surface in the Sulu Sea, Philippine Islands, where the temperature of the water was 80°F (=26·7°C) and in the China Sea, where the surface-temperature was 78°F (=25·6°C). Ihle also records its occurrence in the Malay Archipelago on the surface in warm water and Agassiz obtained it on the surface in the tropical part of the Pacific Ocean in Lat. 4° 30′ to 6° 41′ N. Long. 136° 54′ to 137° E. Under the circumstances it seems impossible to justify any separation, even as a distinct form, of those with a spinose test from those with a smooth one, though it is possible that Ritter and Farran are right in their belief that the spinose character is a mark of age.

### **Salpa cylindrica** Cuvier.

*Salpa cylindrica*, Traustedt, 1885, p. 377, pl. i, fig. 22 and pl. ii, figs. 35-37 and 43.
*Salpa cylindrica*, Herdman, 1888, p. 72, pl. vii, fig. 10.
*Salpa cylindrica*, Brooks, 1893, p. 12, pl. iii, figs. 5-7.
*Salpa cylindrica*, Traustedt, 1893, p. 6.
*Salpa cylindrica*, Apstein, 1894, pp. 16, 35.
*Salpa cylindrica*, Apstein, 1905, pp. 246, 266, pl. xxvii, fig. 7.
*Salpa cylindrica*, Ritter, 1905, p. 79, fig. 22.
*Salpa cylindrica*, Ritter and Byxbee, 1905, p. 199.
*Salpa cylindrica*, Apstein, 1906, p. 163, figs. 9, 10.
*Salpa cylindrica*, Ihle, 1910, p. 31.
*Salpa cylindrica*, Ihle, 1912, p. 41.
*Salpa cylindrica*, Bomford, 1913, p. 243.
*Salpa cylindrica*, Michaelsen, 1915, p. 505.
*Salpa cylindrica*, Oka, 1915, p. 31.
*Salpa cylindrica*, Metcalf, 1918, p. 93, figs. 82-89.
*Salpa cylindrica*, Stiasny, 1919, p. 12, fig. 4.

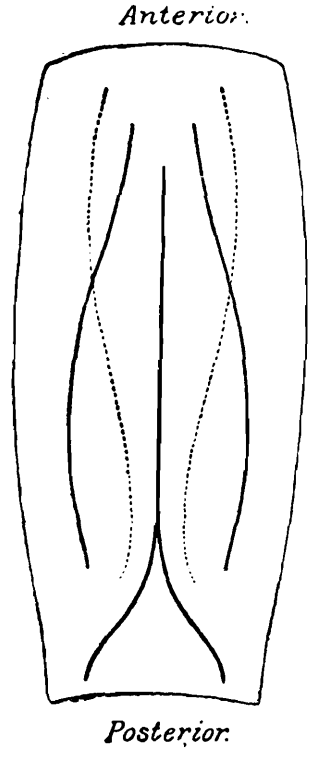
*Salpa cylindrica* is undoubtedly one of the most common species in Indian waters. With the single exception of *Thalia democratica* it occurs in larger numbers and in more hauls of the tow-net than any other Salp ; it is therefore well represented in the Indian Museum collection. Examples have been taken at the following stations :—

Andaman Sea, ? date, numerous examples of the solitary form.
Andaman Sea, Burma Coast, Surface, 1911.
January 3-4 several examples.
,, 4-5 numerous examples.
,, 18-20 a few examples.
,, 28-29 a few examples.

February 1-2 a few examples.
,, 6-8 a few examples.
,, 8-10 large numbers, 100.
,, 10-11 large numbers, 550 examples.
,, 12-13 to 17-18 a few examples.
,, 19-20 and 21-22 a few examples.
March 2-3 numerous examples.
,, 7-18 several examples.
April 4-5 numerous examples.
"Investigator" Sta. 402, Mergui Archipelago, 13° 2′N ; 98° 25′E, Surface, November 15-16, 1911.
,, ,, 475, Off entrance to Mergui Harbour, Surface, December 20, 1912.
,, ,, 476, Off entrance to Mergui Harbour, Surface, December 20-21, 1912.
,, ,, 484, Burma Coast, 13° 23′ 30″N ; 97° 53′E, Surface, December 31, 1912-January 1, 1913.
,, ,, 516, Burma Coast, Surface, February 24, 1913.
,, ,, 530, Burma Coast, 12° 20′N ; 97° 56′E, Surface. April 4-5, 1913.
,, ,, 544, Burma Coast, 13° 1′ 15″N ; 98° 29′ 30″E Surface, October 15-16, 1913.
,, ,, 588, Burma Coast, 11° 25′ 10″N ; 98° 35′E, Surface, February 9-10, 1914.
,, ,, 591, Burma Coast, 11° 16′ 15″N ; 98° 38′ 30″E, Surface, February 20-21, 22-23 and 23-24, 1914.
,, ,, 596, Burma Coast, 11° 12′N ; 98° 35′ 30″E, Surface, March 8-10, 1914.
,, ,, 597, Burma Coast, 11° 09′ 05″N ; 98° 35′ 07″E, Surface, March 10-11, 1914.
,, ,, 604 Burma Coast, 11° 17′ 20″N ; 98° 29′ 40″E, Surface, March 28-29 and 29-30, 1914.
,, ,, 606, Burma Coast, 11° 24′ 10″N ; 98° 27′ 50″E, Surface, April 1, 1914.
,, ,, 614, Nankauri Harbour, Nicobars, Surface, January 19-20, 22-23 and November 3-4, 1922.
,, ,, 631, Nankauri Harbour, near W Entrance, Surface, December 19, 1922.
,, ,, 632, Anchorage off Mus, Car Nicobar, Surface, December 22, 1922.
,, ,, 672, Revello Channel, Nicobars, W side, Surface, March 6-7, 1925.
,, ,, 679, Revello Channel, Nicobars, E. side. Surface, March 31—April 1, 1925.

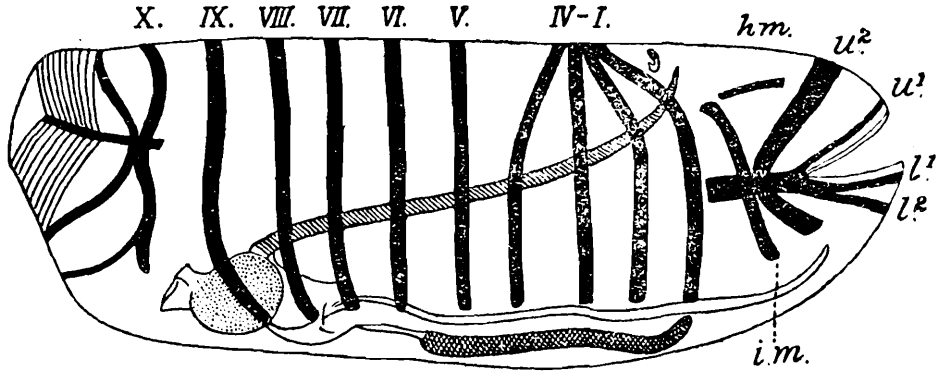
*Solitary Zooid.*—The gelatinous test is thicker on the ventral than on the dorsal side. It presents in a well-preserved example seven ridges running longitudinally, of which two are dorsal, two lateral, and three ventral. The dorsal ridges are further apart at the anterior end of the test than at the posterior end ; as one traces them backwards they diverge slightly and then bend towards the middle line so as to approach each

other. Of the ventral ridges the median one runs back for about $\frac{5}{8}$th the length of the test and then divides into two, which bend outwards towards the ventro-lateral angles of the posterior margin. The paired ridges are situated near the middle line anteriorly, but diverge from each other as one follows them backwards.




TEXT-FIG. 7.—The test of *Salpa cylindrica*, from the ventral aspect, showing the ridges.

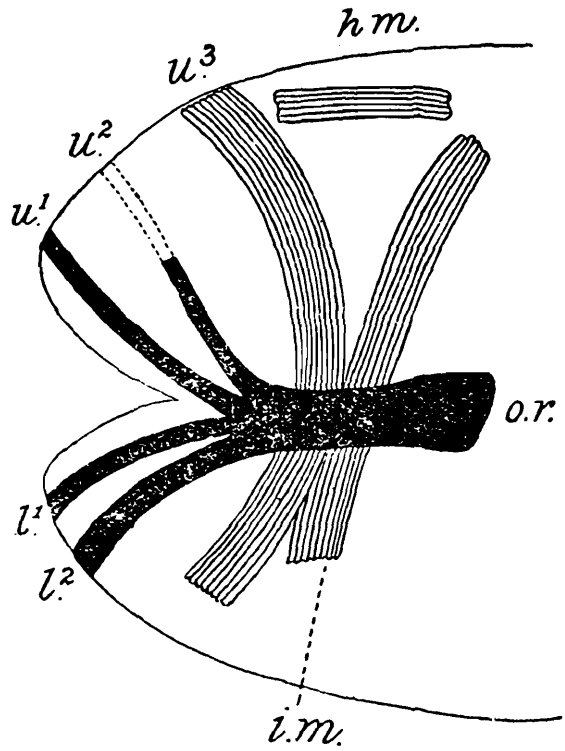
The musculature in this species appears to be particularly variable in character. Metcalf (1918, p. 95) describes the oral system as consisting of an oral retractor which gives rise to two sphincters of the lower lip and is connected with the 1st sphincter of the upper lip; a broad independent 2nd sphincter of the upper lip, and the intermediate muscle, both of these latter lying internal to the retractor. From near the dorsal end of the intermediate muscle a short horizontal muscle runs forwards.




TEXT-FIG. 8.—The arrangement of the muscles in *S. cylindrica*, from the right side.

'In two examples examined by me, both of which were large and measured about 4·5 cm. in length, there was an additional sphincter

in the upper lip. The broad oral retractor, after crossing the intermediate muscle and the 3rd sphincter of the upper lip, gives off a short 2nd sphincter, which ran in one example, as in the case of the same muscle in the aggregated form, but a little way beyond the angle of the mouth ; in the second example the muscle appeared to be continuous across the middle line. The retractor finally divided into the 1st sphincter of the upper lip and the 1st and 2nd sphincters of the lower lip, all three of which are continuous across the middle line. This abnormal condition of the oral muscles shows a very clear approximation to the condition found in the other two species of the sub-genus.

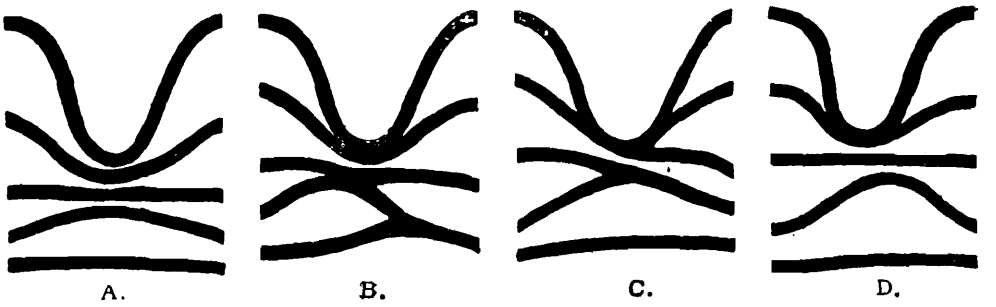



TEXT-FIG. 9.—Showing an unusual extra sphincter in the upper lip of *S. cylindrica*, from the left side.

The body-muscles also exhibit a considerable range of variation both in the number of such muscles, several examples possessing ten instead of nine, and especially as regards the connections of the first four. In the normal condition the first four muscles are in contact with each other in the mid-dorsal line, but this is not always the case. In text-fig. 10 I have given the arrangement of these muscles in four different individuals examined by me.

At the one end of the series (fig. A) the first three muscles are connected together, strands of muscle passing diagonally from one muscle band to the other in a manner very similar to that found in the dorsal anastomosis of the muscles in the genus *Ritteria*. In the next two examples there is an obvious asymmetry ; in both cases the muscles are connected in two groups, an anterior and a posterior. In fig. B the anterior group, composed of two body-muscles, is symmetrical, but in the posterior group the IIIrd and IVth bands unite in the middle line but on the right side the IVth band appears to be composite and to consist of the fused IVth and Vth bands. In fig. C both anterior and posterior groups are asymmetrical. The anterior group consists of

three muscle bands on the right side and only two on the left. This is followed on the right side by a single band which splits in the middle




TEXT-FIG. 10.—Showing variation in the connections of the anterior four or five body-muscles in *Salpa cylindrica* (solitary zooid).

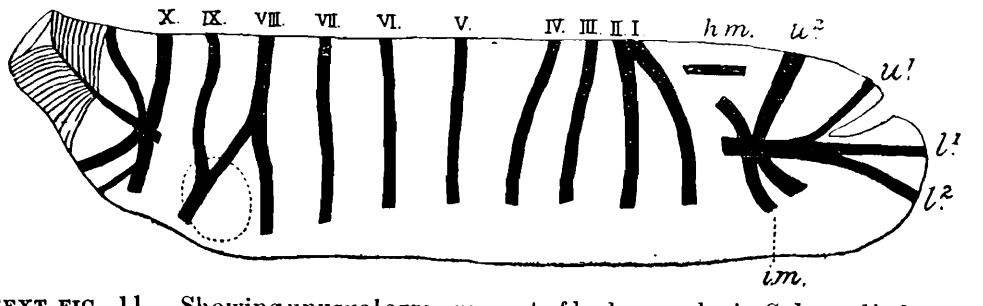
line into two; thus equalising the number of bands present on the two sides. The last type (Text-fig. D) is interesting as it forms a close link with *Salpa maxima*. Streiff (1908, p. 23), with regard to this latter species, remarks "Die Muskeln sind parallel, manchmal nähern sich die 3 ersten Muskeln ein weing i n der dorsalen Median line, besonders nahe rückt der 1 an der 2 heran." It is only a very small step further for the Ist and IInd muscles to fuse together in the dorsal region as in the above example of *S. cylindrica*. This latter arrangement of the muscles also appears in my examples to be associated with the presence of an extra body muscle, there being in each case ten instead of nine such bands. In one specimen there was on the right side a cross-connection between the VIIIth and the IXth body muscles, which may possibly indicate that the extra muscle is derived by a splitting of muscle VIII into two. Examples of this last type of musculature appear to be by no means uncommon in Indian seas, and were obtained at three different stations, as follows:—

"Investigator" Sta. 632. Off Mus, Car Nicobar, Surface, December 23, 1922.

"Investigator" Sta. 668. Revello Channel, Nicobars. Surface, February 18-19, 1924.

"Investigator" Sta. 679. Revello Channel, Nicobars. Surface, March 31-April 1, 1925.

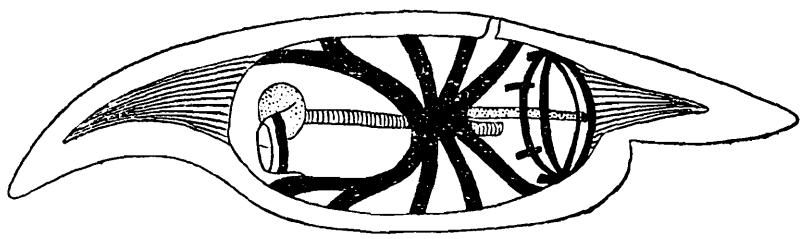
In all cases the arrangement of the oral and anal musculature was characteristic of *S. cylindrica*, as figured by Metcalf, so that I have no doubt that they were examples of this species.




TEXT-FIG. 11.—Showing unusual arrangement of body muscles in *Salpa cylindrica*.

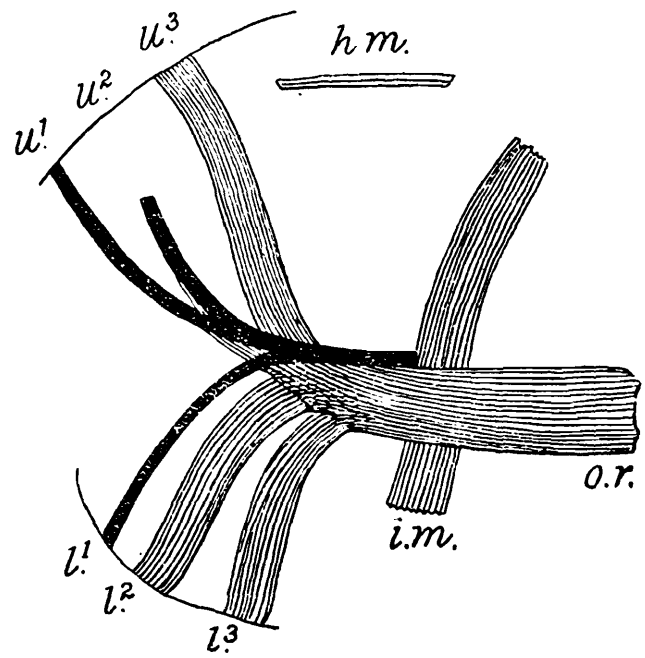
*Aggregated Zooid.*—The aggregated zooids are usually described as having a roughly oval test into which small hollow conical protrusions

from the body project in a slightly asymmetric manner, the asymmetry depending onwhether the individual is from the right or left side of the stolon. This is certainly the usual condition in examples from Indian seas, but a collection of aggregated zooids, numbering several hundreds, made by Dr. S.W Kemp off the end of the mole at Goa, consists entirely of individuals possessing a markedly elongate, fusiform shape that very closely resembles the condition normally present in *Salpa fusiformis*. In all these examples (*vide* fig. 12) the test is drawn out into long tapering processes, that at the posterior end being usually rather the longer of the two. At first sight these specimens might be confused with the aggregated zooid of *S. fusiformis*, but the arrangement of the muscle bands in the body leaves no shadow of doubt that they were *S. cylindrica*. Out of 54 examples examined, 29 showed a right-handed asymmetry and 25 a left-handed.



TEXT-FIG. 12.—An elongate form of the aggregated zooid of *Salpa cylindrica* from the right side of the stolon.

As Metcalf (1918, p. 97) has pointed out, the arrangement of the muscles in the oral group is a complicated one. According to him the




TEXT-FIG. 13.—Showing the two sets of muscle-fibres in the oral group of muscles of *Salpa cylindrica* (aggregated zooid).

main oral retractor consists of two sets of muscle fibres, an antero-ventral group which supplies fibres to all three sp incters in each lip and a

postero-dorsal group that runs to the 1st and 2nd sphincters of the upper lip and the first sphincter of the lower lip only. My examples show this very well and, moreover, they show a point overlooked by Metcalf, namely, that these fibres of the postero-dorsal group arise as a separate little bundle from the anterior margin of the intermediate muscle.

## **Salpa maxima** Forskål.

*Salpa africano-maxima*, Traustedt, 1885, p. 374, pl. ii, figs. 32—34 and [44-45].
*Salpa africano-maxima*, Herdman, 1888, p. 83.
*Salpa maxima*, Brooks, 1893, pl. iv, fig. 2.
*Salpa africano-maxima*, Traustedt, 1893, p. 6.
*Salpa africano-maxima*, Apstein, 1894, pp. 15, 35.
*Salpa maxima*, Apstein, 1901, p. 10, fig. 9 (*a*) and (*b*).
*Salpa maxima*, Apstein, 1905, p. 266.
*Salpa maxima*, Apstein, 1906, p. 164, figs. 11, 12.
*Salpa maxima*, Streiff, 1908, p. 21, pl. ii, figs. 11, 14.
*Salpa maxima*, Apstein, 1910, p. 8, figs. 9 and 10.
*Salpa maxima*, Ihle, 1912, p. 37, figs. 35 and 36.
*Salpa maxima*, Sigl, 1913, p. 234.
*Salpa maxima*, Michaelsen, 1915, p. 505.
*Salpa maxima*, Metcalf, 1918, p. 83, figs. 64—72.
*Salpa maxima*, Stiasny, 1919, p. 8, figs. 1 and 2.

This species appears to be rare in Indian seas. Neither the "Siboga" nor the "Valdivia" obtained examples in these waters. Two examples of the aggregated zooid were taken by the "Investigator" at Sta. 682, Laccadive Sea ; 10° 26′N ; 74° 32′ 30″E., 700 fathoms to surface, April 28, 1925. Both examples were of the normal type.

In view of the tendency throughout the whole genus for the length of the aggregated zooid to vary, thus producing at one end of the scale short, oval zooids with but small anterior and posterior projections, and at the other elongate zooids with enormously long projections, this character can hardly be regarded as a safe one on which to create a new variety. Nor can the presence of an echinate condition of the test be looked upon as a valid criterion, since, as Metcalf himself has shown in the case of the form *aspera* of *Salpa fusiformis*, we may find all stages of intergradation, if the collection of specimens is sufficiently large. Moreover, this occasional echinate condition of the test, either in general throughout its whole area or in certain definite areas, has been found to occur in other species in other genera and in both aggregated and solitary zooids ; for instance, it is found in the aggregated zooid of *Thalia democratica*, where the test may be echinate and may also have an elongate posterior projection, and in the solitary zooid of the same species, in which the posterior processes of the test may all bear denticulations. Similar denticulations are found on the posterior processes of the test in *Ritteria hexagona*. Under the circumstances I do not consider that Metcalf is justified in creating the variety *tuberculata* and I am incline to think that in all probability the condition is of exactly the same nature as the *aspera* form in *Salpa fusiformis*.

Group Cercodaea.

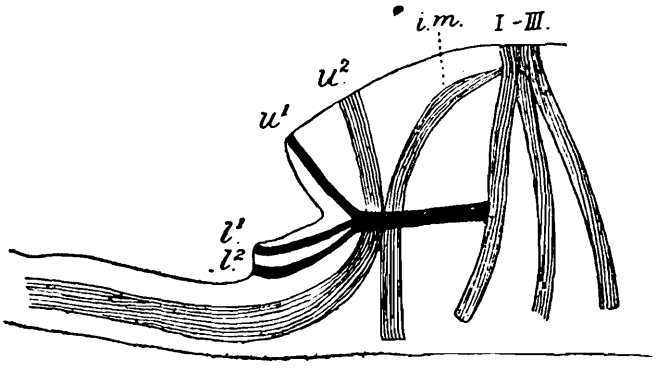
Sub-genus **Brooksia** Metcalf.

**Brooksia rostrata** (Traustedt).

*Salpa rostrata*, Traustedt, 1893, p. 8, pl. i, figs. 1—4.
*Salpa rostrata*, Apstein, 1894, pp. 16, 36, pl. ii, figs. 9, 17—19.
*Salpa rostrata*, Streiff, 1908, pp. 21, 69.
*Salpa rostrata*, Ihle, 1910, p. 27, pl. i, fig. 17.
*Salpa rostrata*, Ihle, 1912, p. 30, figs. 24 and 25.
*Salpa rostrata*, Sigl, 1913, p. 248.
*Brooksia rostrata*, Metcalf, 1918, p. 50.

A single example of the solitary zooid of this species, in rather bad condition, was obtained at " Investigator " Sta. 614, Nankauri Harbour, Nicobars, at the surface, on February 11-12, 1922 : and a further fragment, also in bad condition, at " Investigator " Sta. 672.

Judging from the condition of both examples of this rare species death had occurred and decomposition set in prior to their capture. The condition of the fragment, however, was such that I could make out the connections of the oral and body muscles.




Text-fig. 14.—The oral and anterior body muscles in *Brooksia rostrata* from the side.

As Metcalf (1918, p. 51) has pointed out there is considerable disagreement between the accounts of this species as given by Traustedt (1893) and Apstein (1894). According to the earlier account the body muscles are described and figured as being separate from each other, whereas Apstein shows the first three body muscles as fused together across the mid-dorsal line and the intermediate muscle joining the Ist body muscle near the dorsal aspect. It is possible that these differences may be due to the existence of two distinct species, but as regards this point a decision cannot be made until further material of this rare form has been obtained and carefully examined.

In the present examples the arrangement of the muscles in the anterior region of the body agrees almost exactly with Apstein's description of the embryo. There is a well marked oral retractor muscle that can be traced back across the intermediate muscle to become attached to the Ist body muscle; anteriorly the retractor gives off a single sphincter to the upper lip ($u^1$) and two sphincters to the lowe lip ($l^1$ and $l^2$), all of which are continuous from side to side. Between these sphincters and the intermediate muscle lies a strong muscle that appears to correspond with the third sphincter. It is continuous across the mid-dorsal line and on each side passes internally to the retractor muscle; it is in close contact with the intermediate muscle and then widening

out into a broad band it sweeps downwards and forwards along the great antero-ventral projection that is so characteristic a feature of the species. A comparison of Text-fig. 14, showing the arrangement of the oral group of muscles in *Brooksia rostrata*, with Text-fig. 15 shows that there is a striking resemblance between this species and *Ritteria amboinensis*. In my specimen the intermediate muscle joins the Ist body muscle high up in the lateral region of the body and, as Apstein described and figured them, the first three body muscles are all fused together in the mid-dorsal region.

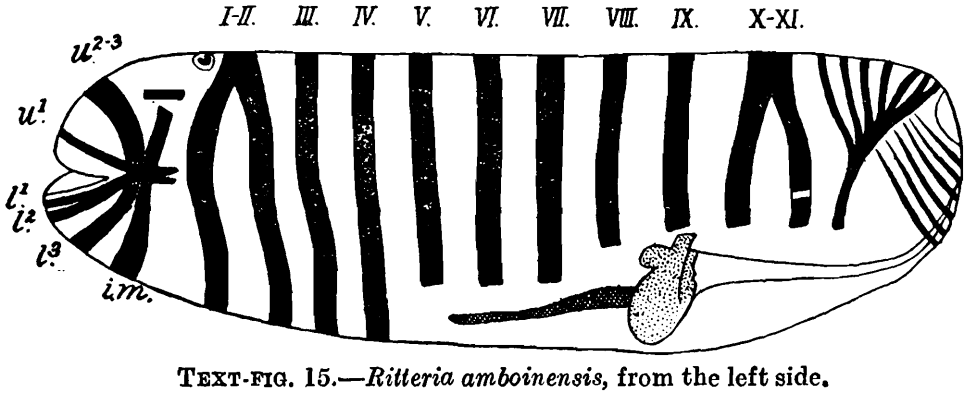
Sub-genus **Ritteria** Metcalf.

**Ritteria amboinensis** (Apstein).

*Salpa amboinensis*, Apstein, 1904, p. 651, pl. xii, figs. 2-10.
[Not *Salpa amboinensis*, Apstein, 1906.]
*Salpa amboinensis*, Ihle, 1910, p. 34, pl. i, figs. 7-15.
*Salpa amboinensis*, Ihle, 1912, p. 44, figs. 45-47.
*Ritteria amboinensis*, Metcalf, 1918, p. 56, figs 29—34.

A few examples of the solitary zooid of this rare species were obtained at "Investigator" Sta. 672, Revello Channel, Nicobars; Surface, March 6-7, 1925.

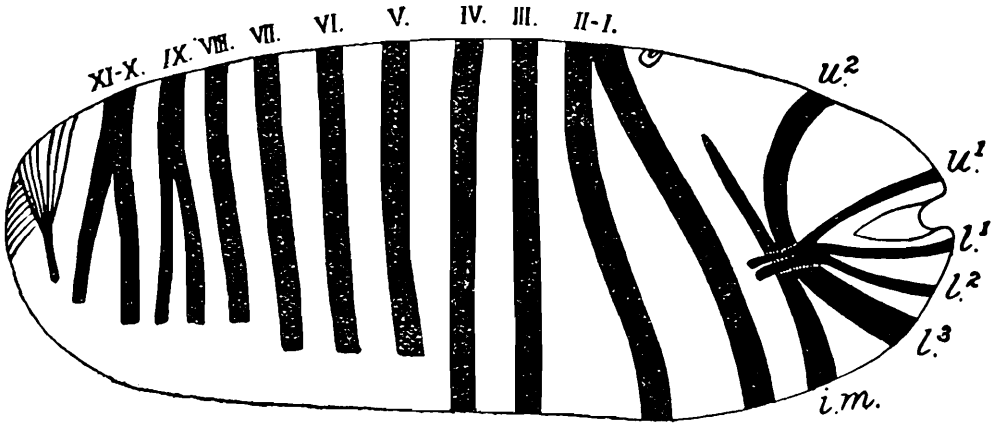
As I have already remarked, the musculature in these animals is liable to vary and this species proves to be no exception. Metcalf has described and figured the oral musculature as consisting of an oral retractor, which connects in front with the 1st sphincter of the lower lip and assists in the formation of the 2nd sphincter, most of the fibres of this latter muscle, however, being continued round the angle of the mouth to form the 1st sphincter of the upper lip; the 2nd and 3rd sphincters of the upper lip are continued ventrally across the retractor muscle as the 3rd and 4th sphincters of the lower lip. All my examples, however, appear to differ from this description, though the distinguishing feature may be apparent rather than real. In no case could I discover any trace of the band that forms the 2nd sphincter of the lower and the 1st sphincter of the upper lip. The oral retractor, which is distinctly




TEXT-FIG. 15.—*Ritteria amboinensis*, from the left side.

double at its proximal end, crosses the 3rd sphincter muscle, which forms a continuous ring round the oral orifice, and then appears to divide into three branches, one of which forms the 1st sphincter of the upper lip, while the other two run to the lower lip. The body muscles also exhibit a certain degree of variation for, whereas in two examples this

portion of the musculature was as described by Metcalf, in a third specimen the usual cross-connections between succeeding muscles in the mid-dorsal line were indistinguishable and the IXth body muscle on the right side divided into two broad bands (*vide* Text-fig. 16).




TEXT-FIG. 16.—*Ritteria amboinensis*, from the right side, showing an abnormal arrangement of the body muscles.

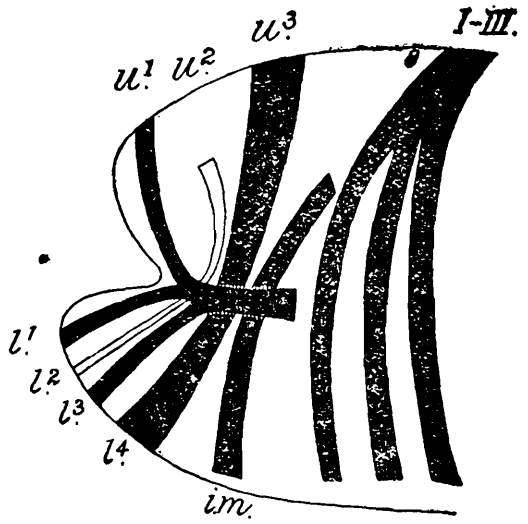
## **Ritteria picteti** (Apstein).

*Salpa picteti*, Apstein, 1904, p. 655, pl. xii, fig. 12.
*Salpa picteti*, Apstein, 1906, p. 252, pl. xxvii, figs. 18, 18(a).
*Salpa picteti*, Ihle, 1910, p. 43, pl. i, fig. 16.
*Salpa picteti*, Ihle, 1912, p. 46, figs. 49, 50.
*Ritteria picteti*, Metcalf, 1918, p. 55, figs. 26-28.

Our knowledge of this rare species is still confined to the solitary zooid. A single example of this form was taken at " Investigator " Sta. 670, Laccadive Sea, 5° 56′N ; 76° 22′E, 0-200 fathoms, April 23, 1924, and another at " Investigator " Sta. 672, Revello Channel, E. side, Nicobars, March 6-7 1925.

The arrangement of the oral musculature is interesting in that it appears to agree closely with the description given by Metcalf of the muscles in the closely-related species *Ritteria amboinensis*, though not with my examples of that species. There is a well-developed intermediate muscle, which does not connect with the 1st body muscle, and which is, like all the succeeding muscles, interrupted ventrally. Lying in front of this and forming, as in *R. amboinensis*, a complete band around the oral aperture is a broad sphincter muscle, forming the 3rd sphincter of the upper lip and the 4th sphincter of the lower. Crossing these two muscles is the oral retractor which gives off a branch to the upper lip, the 1st sphincter, and two to the lower lip, the 1st and 3rd sphincters. The 2nd sphincter of the lower lip passes upwards deeply to the oral retractor and is continued round the angle of the mouth as the 2nd sphincter of the upper lip ; its course in the upper lip is a short one and the muscle is widely interrupted across the middle dorsal region. It will be noticed that in this species it is apparently the 2nd sphincter of the upper lip that is short and interrupted, whereas in the descriptions of *R. amboinensis* it is stated to be the 1st sphincter that exhibits this character. There appears, however, to be some discrepancy between Metcalf's account and his figures 29 and 30. The difference between the rrangement of the sphincters in *R. picteti* and *R. amboinensis* is apparent rather than real due to the crossing of the first two sphincter

muscles of the upper lip in the latter species. The 3rd sphincter of the lower lip appears to be entirely derived from the retractor muscle. I, however, found the muscle fibres extremely difficult to trace across the point where they all converge and it is possible that the 1st upper sphincter and the 3rd lower, are continuous, at least in part. The difference in the character of the 1st two sphincters of the upper lip in this species and *R. amboinensis* may be due to an infolding of the upper lip, in which case the muscle which I have termed the 1st sphincter would in reality be the 2nd and the resemblance to *R. amboinensis* would thus be complete.




TEXT FIG. 17.—*Ritteria picteti*, lateral view of oral muscles.

In both my examples there are twenty-one body muscles, all of which are interrupted ventrally, and the anterior three are in close union with each other in the mid-dorsal region. Apstein (1904) originally showed 21 body muscles present, while in a second example (1906) he subsequently shows 26. The number of body muscles would therefore appear to be variable.

**Ritteria hexagona** (Quoy and Gaimard).

*Salpa hexagona*, Traustedt, 1885, p. 385, pl. i, figs. 14-17.
*Jasis hexagona*, Herdman, 1891, p. 63.
*Salpa hexagona*, Brooks, 1893, pl. iii, figs. 1 and 4.
*Salpa hexagona*, Apstein, 1894, p. 20.
*Salpa hexagona*, Apstein, 1904, p. 655.
*Salpa hexagona*, Apstein, 1905, p. 252.
*Salpa hexagona*, Apstein, 1906, p. 168, fig. 21.
*Salpa hexagona*, Ritter and Byxbee, 1905, p. 200.
*Salpa hexagona*, Ihle, 1910, p. 32, fig. 6.
*Salpa hexagona*, Ihle, 1912, p. 42, figs. 43 and 44.
*Salpa hexagona*, Bomford, 1913, p. 244.
*Salpa hexagona*, Oka, 1915, p. 30.
*Ritteria hexagona*, Metcalf, 1918, p. 62, figs. 35-47.

The occurrence of this species in Indian waters has already been recorded by Bomford (1913) and Oka (1915). The collections in the Indian Museum contain the following examples :—

*Solitary Zooid*—

1. Andaman Sea, off Port Blair, 244 fathoms, November 29, 1888. one specimen, 70 mm. in length.

2. " Investigator " Sta. 166, 13° 34′ 55″N ; 80° 32′ 12″E, 133 fathoms, February 8, 1894, one specimen (Oka records two, but the second is an example of *Jasis zonaria*).
3. " Investigator " Sta. 323, Bay of Bengal, 16° 25′N ; 93° 43′ 30″E, 463 fathoms, December 21, 1903, one specimen, 73 mm. in length.
4. " Investigator " Sta. 361, Arabian Sea, 13° 9′ 27″N ; 46° 45′ 15″E, 540 fathoms, March 24, 1906, one specimen, 77 mm. in length.
5. " Investigator " Sta. 393, Bay of Bengal, 7° 21′ 06″N ; 85° 07′ 15″E, 400 fathoms, October 21, 1911, one specimen, 73 mm. in length.
6. " Investigator " Sta. 611, Laccadive Sea, 9° 34′ 18″N ; 75° 37′ 48″E, 167-180 fathoms, April 26, 1914, one specimen, 82 mm. in length.

*Aggregated Zooid—*

7. " Investigator " Sta. 13, Andaman Sea, off Port Blair, 265 fathoms, April 25, 1888. Three specimens.
8. Andaman Sea. ? date. Three specimens.

These examples of both the solitary and aggregated generations agree closely with the descriptions given by Metcalf and others. The posterior processes of the test in the solitary zooid appear to exhibit a certain degree of variation. Metcalf (1918, p. 67) describes these as " conical denticulate protuberances ; " in most of the Indian examples these processes are ridged, five ridges running longitudinally along the length of the process and giving it a pentagonal cross-section. Apart from the somewhat irregular edges of these ridges there are no denticulations present. Another character in which these processes vary is in their length, relative to the length of the body. This appears to be a question of age, as they are much longer relatively in small examples than in big ones ; thus in examples having a length of—

30 mm. these processes are $\frac{1}{3}$ of the body length
57 ,, ,, ,, ,, $\frac{1}{5}$ ,, ,, ,, ,,
75 ,, ,, ,, ,, $\frac{1}{6}$ ,, ,, ,, ,,
110 ,, ,, ,, ,, ,, ,, ,, ,,

## Sub-genus **Jasis** Herdman.

### **Jasis zonaria** (Pallas).

*Salpa cordiformis-zonaria*, Traustedt, 1885, p. 382, pl. i, figs. 18-21.
*Salpa nitida*, Herdman, 1888, p. 81.
*Jasis cordiformis-zonaria*, Herdman, 1891, p. 647.
*Salpa zonaria*, Apstein, 1894, pp. 19, 36.
*Salpa cordiformis*, Brooks, 1893, pl. iii, fig. 23 ; pl. iv, figs. 5 and 6.
*Salpa cordiformis-zonaria*, Traustedt, 1893, p. 6.
*Salpa zonaria*, Apstein, 1901, p. 10.
*Salpa zonaria*, Apstein, 1905, p. 273.
*Salpa zonaria cordiformis*, Ritter, 1905, p. 76, figs. 20, 21.
*Salpa zonaria cordiformis*, Ritter and Byxbee, 1905, p. 199.
*Salpa zonaria*, Apstein, 1906, p. 173, figs. 32 and 33.
*Salpa zonaria*, Farran, 1906, p. 14.
*Salpa zonaria*, Streiff, 1908, p. 44, fig. K, pl. iv, fig. 33.
*Salpa zonaria*, Apstein, 1910, p. 7, figs. 7 and 8.
*Salpa zonaria*, Ihle, 1910, p. 48.

*Salpa zonaria*, Ihle, 1912, p. 54, figs. 60 and 61.
*Salpa zonaria*, Bomford, 1913, p. 245.
*Salpa zonaria*, Sigl, 1913, p. 251.
*Salpa cordiformis-zonaria*, Oka, 1915, p. 30.
*Jasis zonaria*, Metcalf, 1918, p. 100, figs. 90-103.
*Salpa zonaria*, Stiasny, 1919, p. 18.

This species, which appears to be of comparatively common occurrence in Indian Seas, is represented in the Indian Museum collection by the following specimens :—

*Solitary Zooid—*

1. Bay of Bengal, 65 fathoms, ? date. 9 specimens.
2. " Investigator " Sta. 11, W S. W of Gt. Nicobar Is. ; 5° 56'N ; 91° 05'E, 1590 fathoms, April 19, 1888. 2 specimens.
3. " Investigator " Sta. 15, N. of Port Blair, Andamans, 244 fathoms, November 29, 1888. 1 specimen.
4. " Investigator " Sta. 135, Arabian Sea, 15° 29'N; 72° 41'E., 559 fathoms, May 4, 1892. 1 specimen.
5. " Investigator " Sta. 393, Bay of Bengal, 7° 21' 06"N ; 85° 07' 15"E., 400-0 fathoms, October 21, 1911. 1 specimen.
6. " Investigator " Sta. 613, Arabian Sea, 15° 51' 45"N ; 73° 31' 40"E, Surface, May 1-2, 1914. 24 specimens.
7. " Investigator " Sta. 614, Nankauri Harbour, Nicobars, Surface, January 22-23, 1922. 3 specimens.
8. " Investigator " Sta. 668, off Dring Harbour, Camorta Is., Nicobars, Surface, February 18-19, 1924. 1 specimen.
9. " Investigator " Sta. 670, Laccadive Sea, 5° 56' N ; 76° 22'E., 0-200 fathoms, April 23, 1924. 1 specimen.
10. " Investigator " Sta. 679, Revello Channel, Nicobars, Surface, March 31-April 1, 1925. 1 specimen.

*Aggregated Zooid—*

1. Andaman Sea, ? date. 1 specimen.
2. " Investigator " Sta. 613, Arabian Sea, 15° 51' 45" N. 73° 31' 40"E, Surface, May 1-2, 1914. 15 specimens.
3. " Investigator " Sta. 670, Laccadive Sea, 5° 56'N ; 76° 22'E., 0-200 fathoms, April 23, 1924. 3 specimens.
4. " Investigator " Sta. 672, Revello Channel, Nicobars, Surface, March 6-7, 1925. 3 specimens (small).
5. " Investigator " Sta. 679, Revello Channel, Nicobars, Surface, March 31—April 1, 1925. 5 specimens.

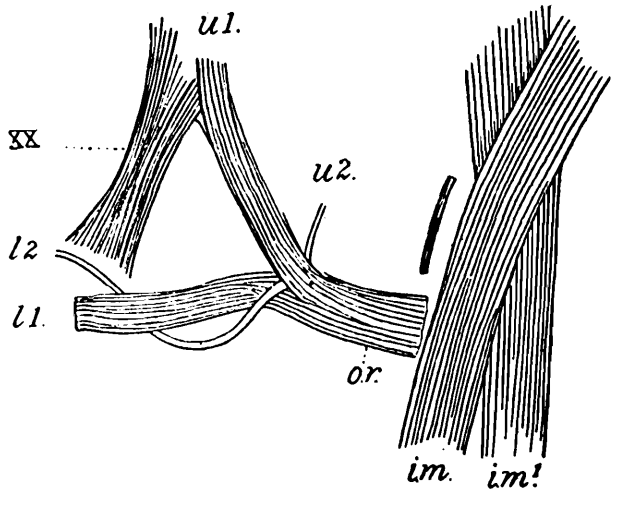
It is interesting to compare the numbers of this species obtained in different months. In the following table I have given these for both solitary and aggregated zooids during each month of the Survey season, the haul on March 31-April 1 being included in the month of April.

| | October | November | December | January | February | March | April | May |
|---|---|---|---|---|---|---|---|---|
| Solitary Zooid | 1 | 1 | .. | 3 | 1 | .. | 4 | 25 |
| Aggregated Zooid | .. | .. | .. | .. | .. | 3 | 8 | 15 |

These figures clearly indicate that the breeding season of this species occurs during the early months of the year, and that the numbers present in the surface waters is at its maximum in May or but little later. This is also corroborated by the small size and, therefore, presumably young condition of the three examples of the aggregated zooid captured in the month of March.

As regards their general structure these specimens agree well with the descriptions given by previous authors. Metcalf points out that there are certain discrepancies in the account of the oral musculature given by Streiff and in the examples that he examined. In the solitary zooid my examples agree very closely with the description and figures given by Metcalf (1918, p. 102, figs. 90 and 91).

In the case of the aggregated zooid, Metcalf and Streiff again disagree in their accounts. Metcalf (1918, p. 106) says " the condition of the oral musculature, in the very numerous individuals among my material, is considerably different from that figured and described by Streiff. I find no delicate second sphincter in the lower lip, such as he describes, and the dark coloured muscle at the angle of the mouth is situated more distally in my specimens." I have carefully examined several examples in the " Investigator " collection and find Streiff to be correct. There is a double intermediate muscle, and lying external to this is an oral retractor that gives rise to two sphincter muscles, one in each lip ; a second delicate sphincter arises, as Streiff figures it, at or near the point of bifurcation and crosses below the main sphincter of the lower lip to form a second delicate bundle running from side to side : from the same point, though Streiff does not show it, a still more delicate slip of muscle passes from the point of bifurcation for a short distance upwards towards the upper lip. At the level of the posterior end of the oral retractor and running dorsally for a short distance is another delicate muscle bundle. The antero-posterior relationships of the various muscles appears to differ in different individuals, probably depending largely on

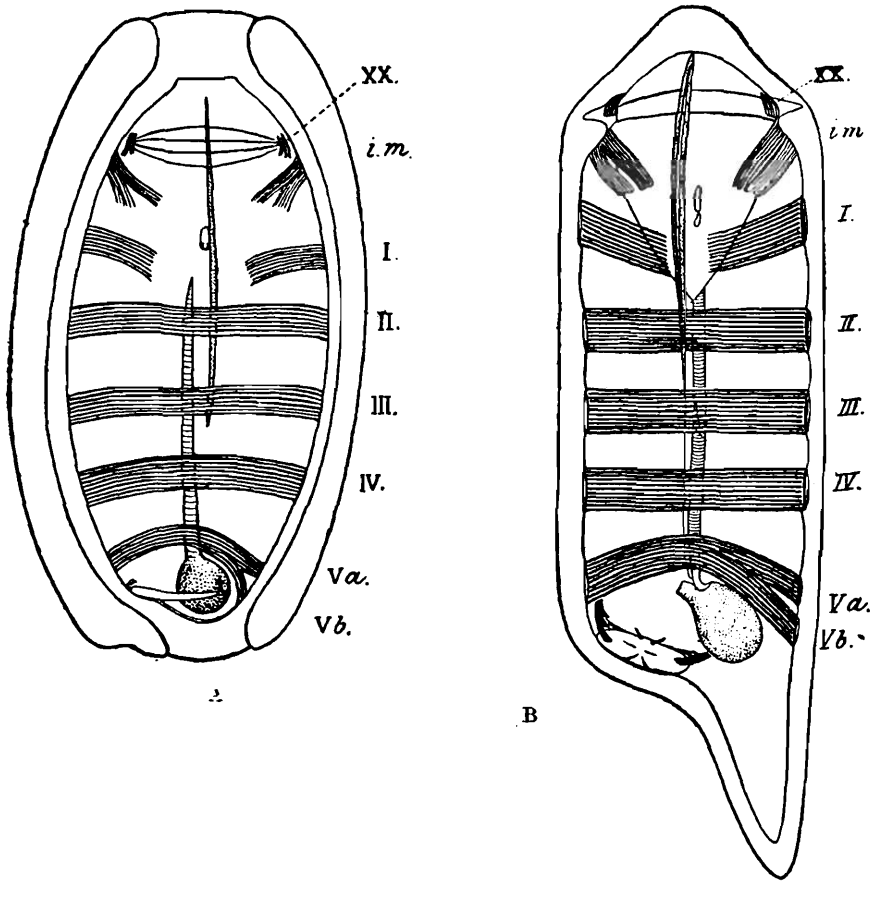



TEXT-FIG. 18 —Oral musculature of *Jasis zonaria*, aggregated zooid, from within

the degree of shrinkage of the tissues in the process of preservation ; in some the oral retractor overlaps the intermediate muscle, in others

it appears to arise at the level of the anterior margin. One cannot therefore place any reliance on Metcalf's remark that the dark coloured muscle at the angle of the mouth was more distal in his specimens as providing any reliable distinction between his and Streiff's specimens. In my examples it appears to vary considerably in position in different individuals.

There is also a certain degree of discrepancy in the accounts given of the general shape of the aggregated zooids. Apstein (1910, fig. 7) figures the zooid as having an oval shape with a very short pointed projection a little to one side of the middle line posteriorly. In the figure given by Traustedt (1885, Pl. I, fig. 17) this projection is rather more pronounced ; and Metcalf (1918, figs. 97 and 98) shows the animal as possessing a well-marked conical posterior projection, measuring approximately $\frac{1}{4}$th the length of the body proper. In some of my larger examples the length of this projection was more nearly $\frac{1}{3}$rd the body length. On the other hand in the smallest examples, that measure only 7 mm. in length, this posterior projection is barely distinguishable, and in examples




TEXT-FIG. 19.—*Jasis zonaria* (Pallas), aggregated zooid.

(A). A young example.

(B). A fully-grown specimen.

still *in situ* on a well developed stolon, I can detect no trace of it. It would appear, therefore, that this feature is gradually developed as age advances.

Sub-genus **Thalia** Blumenbach.

**Thalia democratica** (Forskål).

*Salpa democratica-mucronata*, Traustedt, 1885, p. 365, pl. ii, figs. 25-28.
*Thalia democratica-mucronata*, Herdman, 1888, p. 79.
*Salpa democratica*, Brooks, 1893, pl. ii, and pl. xlii, fig. 1.
*Salpa democratica*, Traustedt, 1893, p. 5.
*Salpa mucronata*, Apstein, 1894, pp. 13 and 32.
*Salpa mucronata*, Apstein, 1901, p. 5.
*Salpa democratica-mucronata*, Apstein, 1904, p. 656.
*Salpa mucronata*, Apstein, 1905, pp. 252 and 270, pl. xxviii, figs. 19 and 20.
*Salpa democratica-mucronata*, Ritter, 1905, p. 73, figs. 18 and 19.
*Salpa democratica-mucronata*, Ritter and Byxbee, 1905, p. 197.
*Salpa mucronata*, Apstein, 1906, p. 171, figs. 27 and 28.
*Salpa mucronata*, Farran, 1906, p. 8.
*Salpa mucronata*, Streiff, 1908, p. 38, pl. iii, fig. 28.
*Salpa mucronata*, Apstein, 1910, p. 5, figs. 3 and 4.
*Salpa mucronata*, Ihle, 1910, p. 47.
*Salpa democratica*, Ihle, 1912, p. 51, figs. 57 and 58.
*Salpa democratica*, Bomford, 1913, p. 244.
*Salpa democratica*, Sigl, 1913, p. 242.
*Salpa mucronata*, Michaelsen, 1915, p. 506.
*Thalia democratica*, Metcalf, 1918, p. 109, figs. 104-112.
*Salpa democratica*, Stiasny, 1919, p. 17, figs. 9 and 10.

This is by far the most common Salp in Indian Seas. It occurs in the Indian Museum collections as follows :—

'Investigator' Sta. 401, Mergui Archipelago, 13° 16′ N ; 98° 26′E., Surface, November 14-15, 1911.

'Investigator' Sta. 461, Bay of Bengal, 10° 15′ N ; 90° 15′E, 375-0 fathoms, April 19, 1912.

'Investigator' Sta. 475, off Mergui Harbour, Burma, 10 fathoms, December 20, 1912.

'Investigator' Sta. 476, off Mergui Harbour, Burma, Surface, December 20-21, 1912.

'Investigator' Sta. 482, Mergui Harbour, Burma, Surface, December 27, 1912.

'Investigator' Sta. 494, Mergui Harbour, Burma, Surface, January 14, 1913.

'Investigator' Sta. 498, Port Maria, Elphinstone Is., Mergui Archipelago, Surface, January 18, 1913.

'Investigator' Sta. 516, between Stuart and Metcalf Islands, Mergui Archipelago, Surface, February 24, 1913.

'Investigator' Sta. 531, Mergui Archipelago, 12° 20′N; 97° 56′E., Surface, April 15, 1913.

'Investigator' Sta. 546, Mergui Harbour, Burma, Surface, October 17-18, 1913.

'Investigator' Sta. 605, 11° 19′ 58″ N ; 98° 29′ 52″ E., Surface, March 30-31, 1914.

'Investigator' Sta. 606, 11° 24′ 10″ N ; 98° 27′ 50″ E., Surface, March 31, April 1, 1914.

'Investigator' Sta. 607, 11° 25′ 10″ N ; 98° 27′ 51″E., Surface, April 1-2, 1914.

'Investigator' Sta. 614, Nankauri Harbour, Nicobars, Surface, November, 5-6, 1921.

'Investigator' Sta. 614, Nankauri Harbour, Nicobars, Surface, January 18-19, 1922.

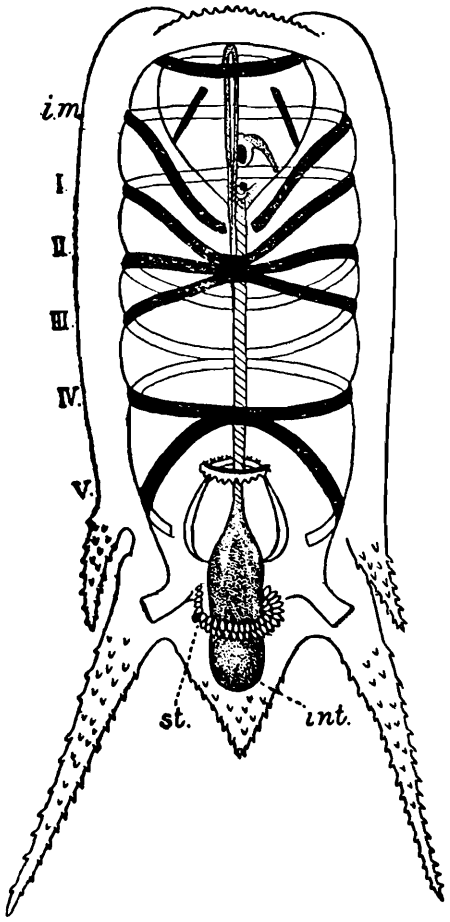
'Investigator' Sta. 614, Nankauri Harbour, Nicobars, 1 fathom, January 19-20, 1922.
'Investigator' Sta. 614, Nankauri Harbour, Nicobars, 1 fathom, January 22-23, 1922.
'Investigator' Sta. 614, Nankauri Harbour, Nicobars, Surface, February 1-2, 1922.
'Investigator' Sta. 614, Nankauri Harbour, Nicobars, Surface, February 6-7, 1922.
'Investigator' Sta. 614, Nankauri Harbour, Nicobars, Surface, February, 16-17, 1922.
'Investigator' Sta. 614, Nankauri Harbour, Nicobars, Surface, October 21-22, 1922.
'Investigator' Sta. 614, Nankauri Harbour, Nicobars, Surface, November, 1-2, 1922.
'Investigator' Sta. 614, Nankauri Harbour, Nicobars, Surface, November 3-4, 1922.
Investigator' Sta. 614, Nankauri Harbour, Nicobars, 12 fathoms, December 2-3, 1922.
'Investigator' Sta. 633, Nankauri Harbour, Nicobars, Surface, February 4-5, 1923.
'Investigator' Sta. 642, Nankauri Harbour, Nicobars, Surface, March 13, 1923.
'Investigator' Sta. 668, off Dring Harbour, Camorta Island, Nicobars, Surface, February 18-19, 1924.
'Investigator' Sta. 670, Laccadive Sea, 5° 56′ N; 76° 22′ E., 0-200 fathoms, April 23, 1924.
'Investigator' Sta. 672, Revello Channel, Nicobars, Surface, March 6-7, 1925.
'Investigator' Sta. 679, Revello Channel, Nicobars, Surface, March 31-April 1, 1925.

In their general structure the Indian examples of this species agree exactly with the descriptions given by previous authors. The only point on which they show any difference from the European examples is that of size. Bomford (1913, p. 244) has already called attention to this, and remarks that "the individuals are much smaller than some specimens from Plymouth, England, that are in the Indian Museum, the largest specimen of the solitary form that I have measured being only 11 mm. long. The posterior processes of the test are also relatively shorter than in those from English waters." It is probable that this variation in size is correlated with the density of the surface water. Stiasny (*loc. cit.*) gives the size of specimens from Java as 7-12 mm., which agrees very well with the Indian examples from the region of the Andaman Sea. Throughout both these regions the density of the surface water is low, 1020 to 1021. In the North Atlantic on the other hand, where specimens as large as 25 mm. in length may be obtained, the density of the sea water ranges from 1024-1027. As regards the length of the posterior processes, this seems to be correlated with the age of the individual. Apstein (1894, p. 13) remarks "Bei der solitären Form variären nur die Endanhänge in de Länge. Bei junger examplaren

waren sie noch ganz kurz und mit zacken besetzt, genau so, wie es Herdman zeichnet." The presence of these denticulations on the various processes of the test is however in my experience by no means confined to young specimens, nor is the shortness of the process an indication of youth; indeed, rather the contrary. I give below the average body-length and the length of the processes in a series of examples that I have measured—

| Body length (excluding processes). | Proportional lengths of processes and body. |
|---|---|
| 6·0 mm. | 1 : 2·1 |
| 7·0 mm. | 1 : 2·8 |
| 8·0 mm. | 1 : 3·3 |
| 11·0 mm. | 1 : 3·7 |

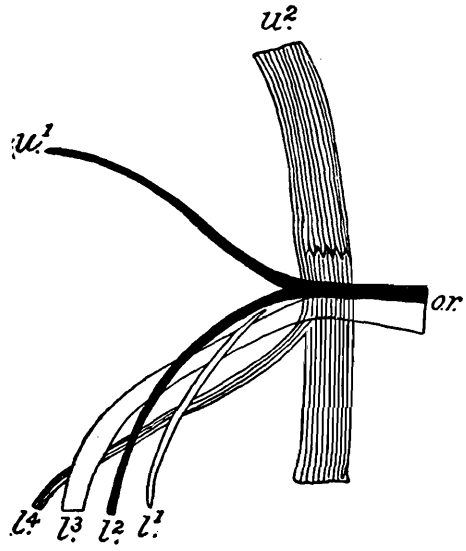
In very young individuals, having a length of much less than 6·0 mm, the processes are extremely short and it would appear, therefore, that they increase in length up to a certain stage, and then agai decrease: and during this second phase the denticulations become considerably reduced and may even disappear, indicating that the decrease in length is probably due to a wearing-away process. In addition to these denticulations on the posterior processes, both atrial and oral apertures are fringed along their lips with coarse denticulations and from the latter a line of them passes ventrally to the under-surface of the body.




Text-fig. 20.—*Thalia democratica* (Forskål), solitary zooid; showing the denticulation of the test.

The muscle system agrees closely with the descriptions given by Streiff (1908) and Metcalf (1918). As usual, the examination of a number

of individuals reveals certain occasional abnormalities that are, I think, worthy of notice. The oral musculature (Text-fig. 21) possesses a well developed intermediate muscle, that in this species, however, much more resembles a true body-muscle : it has no connection with the mouth and, except that it is incomplete in the mid-dorsal line and does not come into contact with the 1st body-muscle, closely resembles the succeeding muscle. Its place in the mechanism of the oral aperture appears to be taken by the broad 2nd sphincter of the upper lip. The oral retractor, which is a strong muscle and not, as Streiff figures it, two small fasciculi, crosses the 2nd sphincter and divides into two branches ; the first again divides into the 1st sphincter of the upper lip, which is incomplete in the mid-dorsal line, and the 2nd sphincter of the lower. The ventral portion of the oral retractor is continued on as the 3rd sphincter of the lower lip, while the 4th is derived as a small muscle bundle from the band of the 2nd sphincter of the upper lip.



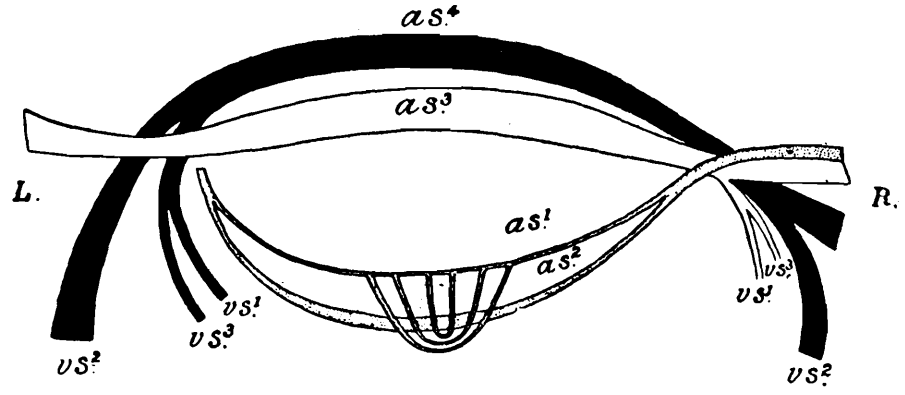

TEXT-FIG. 21.—The oral musculature of *Thalia democratica* (Forskål), solitary zooid, from the inside of the mouth.

The arrangement of the body muscles appears to be extremely constant, but in the Indian examples that I have examined the atrial system differs somewhat from the description given by Streiff.

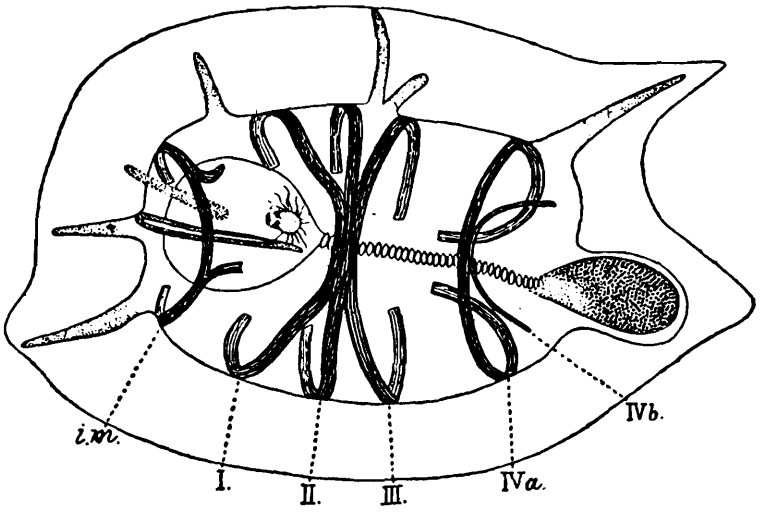
Both Streiff and Metcalf appear to consider that this system is symmetrical. In the Indian examples there is a very considerable difference, so far as my observations go, on the two sides. The atrial retractor on the right side is double : the posterior and ventral band gives off the broad 2nd sphincter of the lower lip and then, crossing the anterior dorsal band, is continued across the dorsal aspect of the body as the 4th upper sphincter to the left side : here it bends round and after giving off a branch, which divides into the 1st and 3rd ventral sphincters, is continued on as the broad 2nd sphincter muscle. The anterior and dorsal band of the atrial retractor on the right side is double, the uppermost fibres cross the muscle and after a short course divide into two bands, the 1st and 2nd sphincters of the upper lip of the atrial aperture. These two sphincters, of which the 1st possesses a series of loops in the valve-like

portion of the lip, re-unite on the left side into a single band, which ends abruptly and does not join any other muscle. The main portion of the retractor passes a ross as the 3rd sphincter of theupper lip and is continued on as the atrial retractor of the left side (*vide* Text-fig. 22).

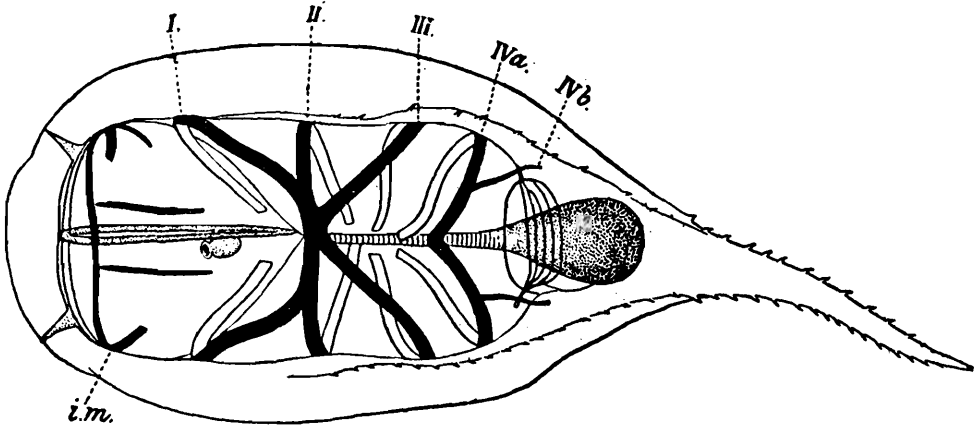
There is thus a distinct similarity in the arrangement of these atrial muscles to the corresponding musculature of the aggregated zooid.




TEXT-FIG. 22.—The atrial musculature of *Thalia democratica*, solitary zooid, the syphon is cut across and the ventral walls turned out.




TEXT-FIG. 23.—*Thalia democratica*, aggregated zooid, showing prolongations of mantle into the test.




TEXT-FIG. 24.—*Thalia democratica*, aggregated zooid, showing the posterior prolongation of the test.

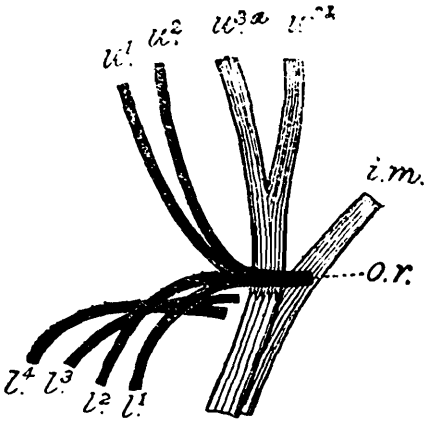
*Aggregated Zooid.*—The aggregated zooid of *Thalia democratica*, like that of *Salpa fusiformis* and *S. maxima*, may possess two forms. In

the normal condition the body is roughly oval, tapering somewhat at the posterior end and having on one side or other of the 'nucleus', depending on which side of the stolon it developed, a conical hollow process which stretches out into the test and may cause the latter to exhibit a corresponding conical projection.

Metcalf (1918) has already called attention to the differences in the aggregated zooids obtained in the open waters of the Atlantic and Pacific Oceans and those from the Philippine Islands and the western area of the Pacific. Most of the Indian examples that I have examined show a very distinct approximation to the Philippine type (*vide* Metcalf, 1918, p. 118). In these individuals (Text-fig. 23) the mantle sends a number of tubular processes into the test; the actual number of such processes appears to vary very considerably and it is probable that, were a sufficient number examined, all intermediate stages between the typical European form and the Philippine form could be traced.

While the evidence at my disposal is not absolutely convincing, it seems to indicate that in the Andaman Sea, from whence most of my specimens are derived, the Philippine form preponderates during the months December—February. This may be due to a true seasonal change occurring in this species or to the individuals having been swept in from the western waters of the Pacific through the Straits of Malacca by the inflowing current that is set up by the north-east monsoon.

Herdman (1888, p. 81 and pl. viii, fig. 4) first called attention to the fact that in certain individuals "the posterior end of the mantle runs out into a tapering process, in place of being simply rounded off behind the nucleus." Several examples of this form of aggregated zooid (Text-fig. 24) are present in the Indian Museum collection. In the smaller specimens, this posterior projection and often much of the test is covered with small denticulations (*vide* Apstein, 1906, p. 253, pl. xxvii, fig. 20), but in the larger examples these denticulations appear to become worn down and tend to disappear. The process itself is usually stained a pale buff colour.

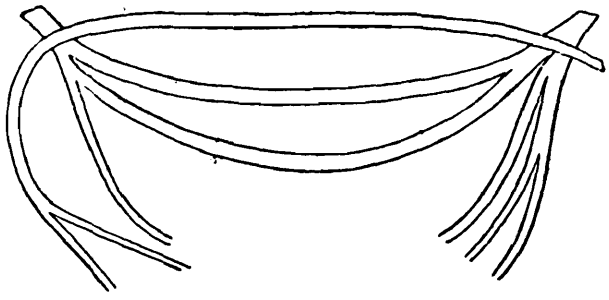



TEXT-FIG. 25.—Showing an abnormal 3rd Oral sphincter muscle in *Thalia democratica*.

The oral musculature agrees with the descriptions given by Streiff and Metcalf. In one specimen that I examined, however, the 3rd sphincter of the upper lip, instead of forming a single band across the

dorsal region was divided into two separate bundles, both of which were continuous.

The body-muscles occasionally show the same type of variation: a single muscle fibre may diverge from the band to which it belongs and after a short independent course rejoin it again or in a more extreme case the band may split into two, more or less equal, portions which diverge and re-unite.



TEXT-FIG. 26.—The atrial musculature in Indian examples of *Thalia democratica*.

In all examples that I have examined the atrial musculature conforms to a single type and agrees exactly with the condition found by Metcalf (1918, fig. 109-B) in specimens from the Atlantic coast of the United States. I could detect no difference whatever in specimens that possessed a spinose and elongate test or in the smooth and more rounded form, nor in examples that as regards the processes of the mantle conform to either the Atlantic or Pacific types. In all Indian examples the character of these muscles seems to be singularly constant.

## Sub-genus **Thetys** Tilesius.

### **Thetys vagina** Tilesius.

*Salpa costata-tilesii*, Traustedt, 1885, p. 379, pl. i, figs. 10, 11; pl. ii, figs. 38-41 and 47.
*Salpa costata-tilesii*, Herdman, 1888, p. 60, pl. iv, fig. 1.
*Iasis costata-tilesii*, Herdman, 1891, p. 647.
*Salpa costata*, Brooks, 1893, pl. iv, fig. 4; pl. viii, fig. 4.
*Salpa costata-tilesii*, Traustedt, 1893, p. 6.
*Salpa tilesii*, Apstein, 1894, pp. 16, 35.
*Salpa tilesii*, Apstein, 1901, p. 10.
*Salpa tilesii*, Apstein, 1905, p. 275.
*Salpa tilesii-costata*, Ritter, 1905, p. 70, figs. 16, 17.
*Salpa tilesii-costata*, Ritter and Byxbee, 1905, p. 199.
*Salpa tilesii*, Apstein, 1906, p. 173, figs. 34, 35.
*Salpa tilesii*, Streiff, 1908, pp. 30, 32.
*Salpa vagina*, Ihle, 1912, p. 47, figs. 51, 52.
*Salpa vagina*, Sigl, 1913, p. 252.
*Salpa costata-tilesii*, Oka, 1915, p. 30.
*Thetys vagina*, Metcalf, 1918, p. 121, figs. 114-118.

The Indian Museum collection contains examples of this species from the following localities :—

*Solitary Zooid* :—

'Investigator' Sta. 152, 11½ miles S. 83° W of Colombo, 26½ fathoms, December 12, 1893. 1 specimen.

'Investigator' Sta. 162, Bay of Bengal, 13° 51′ 12″ N.; 80° 28′ 12″ E., 145-250 fathoms, January 30, 1894. 1 specimen.

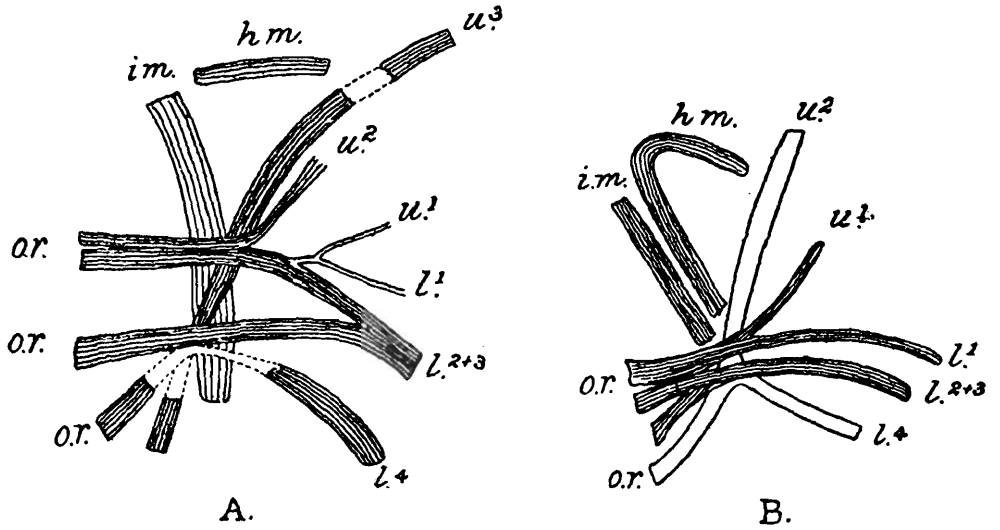
'Investigator' Sta. 358, Arabian Sea, 15° 55′ 30″ N.; 52° 38′ 30″ E., 585 fathoms, December 18, 1905. 4 specimens.

*Aggregated Zooid*:

'Investigator' Sta. 614, Nankauri Harbour, Nicobars, Surface, October 21-22, 1922.

These specimens agree very closely with the descriptions given by previous authors. It is, I think, worth noting that in the aggregated zooid the musculature of the oral aperture, so far as I have been able to make it out, differs somewhat from the account given by Metcalf (1918, p. 125). According to this author "the oral musculature, including the horizontal dorsal band, is like that of the solitary form, except that there are three, instead of two, dorsal sphincters, the first very short and very slender, the second also very short."

In the example that I examined of the aggregated generation, the intermediate muscle is clearly separated from all the others and lies internal to them. The oral retractor system consists of three muscle




TEXT-FIG. 27.—A. The oral musculature of *Thetys vagina*. Aggregated Zooid. B. The same in certain examples of *Pegea confoederata*. A somewhat rare arrangement.

bands. Of these the first or uppermost passes forwards superficially and gives off a short, interrupted second sphincter to the upper lip: it then passes on and, giving off a fine branch that after a short course sub-divides into the 1st sphincters of both upper and lower lips, ends by joining the middle oral retractor, which is a simple undivided band of muscle, to form the conjoined second and third sphincters of the lower lip. The lowermost oral retractor is a short block of muscle that is continued on as a blood sinus; this runs upwards and forwards deeply to the other two but superficially to the intermediate muscle; it gives off a branch at the level of the lower border of the middle retractor which turns forwards and downwards to join the fourth sphincter of the lower lip. Its upward continuation becomes connected with the middle retractor and so with the third sphincter of the lower lip. The small block of muscle lying in front of the lower portion of the 3rd retractor and behind and below the end of the intermediate muscle is in my examples isolated, and, though it shows no trace of a connection with the third

upper sphincter and the upper lip as Metcalf figures it, is in all probability a detached portion of this muscle. A comparison of the figure of this system with that of the oral musculature of the aggregated zooid of *Pegea confoederata* (Text-fig. 27-B) shows that the ground plan of the two systems is absolutely identical : the only distinguishing features being that in *Pegea confoederata* the very delicate branch, that forms the first sphincters of both lips, has been suppressed and the next two sphincters of the lower lip remain separate instead of being fused.

Sub-genus **Pegea** Savigny.

**Pegea confoederata** (Forskål).

*Salpa scutigera-confoederata*, Traustedt, 1885, p. 362, pl. ii, figs. 23, 24 and 46.
*Salpa quadrata*, Herdman, 1888, p. 84, pl. ix, fig. 1.
*Salpa scutigera-confoederata*, Herdman, 1888, p. 84, pl. ix, fig. 9.
*Salpa scutigera*, Brooks, 1893, pl. iv, figs. 1 and 7.
*Salpa confoederata*, Apstein, 1894, p. 12, pl. ii, fig. 16.
*Salpa scutigera-confoederata*, Apstein, 1904, p. 656.
*Salpa confoederata*, Apstein, 1905, p. 273.
*Salpa confoederata cutigera*, Ritter, 1905, p. 80, fig. 23.
*Salpa confoederata-scutigera*, Ritter and Byxbee, 1905, p. 196.
*Salpa confoederata*, Apstein, 1906, p. 172, figs. 30, 31.
*Salpa confoederata*, Farran, 1906, p. 10.
*Salpa confoederata*, Streiff, 1908, p. 32, pl. iii, fig. 25.
*Salpa confoederata*, Ihle, 1910, p. 46.
*Salpa confoederata*, Ihle, 1912, p. 49, figs. 53, 54.
*Salpa confoederata*, Bomford, 1913, p. 244.
*Salpa confoederata*, Sigl, 1913, p. 250.
*Salpa scutigera-confoederata*, Oka, 1915, p. 31.
*Pegea confoederata*, Metcalf, 1918, p. 127, figs. 119-127.
*Pegea confoederata*, subsp. *bicaudata*, Metcalf, 1918, p. 139, figs. 128-132.
*Salpa confoederata*, Stiasny, 1919, p. 14, figs. 6, 7.

This species, the occurrence of which in Indian waters has already been recorded by Bomford and Oka, is respresented in the Indian Museum collections by the following :—

*Solitary Zooid* :—

1. Off Cinque Island, Andamans, Surface, ? date. 1 specimen.
2. Andaman Sea. 2 specimens.
3. 'Investigator' Sta. 319, Laccadive Sea, 12° 02′ N. ; 73° 46′ E., 1154 fathoms, November 7, 1903. 5 specimens.
4. 'Investigator' Sta. 342, Gulf of Oman, 24° 46′ 15″ N. ; 57° 15′ E., 745 fathoms, October, 1904. 4 specimens.
5. Preparis N. Channel, 1-1½ fathoms, November 16, 1909. 3 specimens.
6. Arabian Sea, 600 miles from Bombay, ? depth, November 15, 1918. 8 specimens.
7. 'Investigator' Sta. 672, Revello Channel, Nicobars ; Surface, March 6-7, 1925. 2 specimens.

*Aggregated Zooid*—

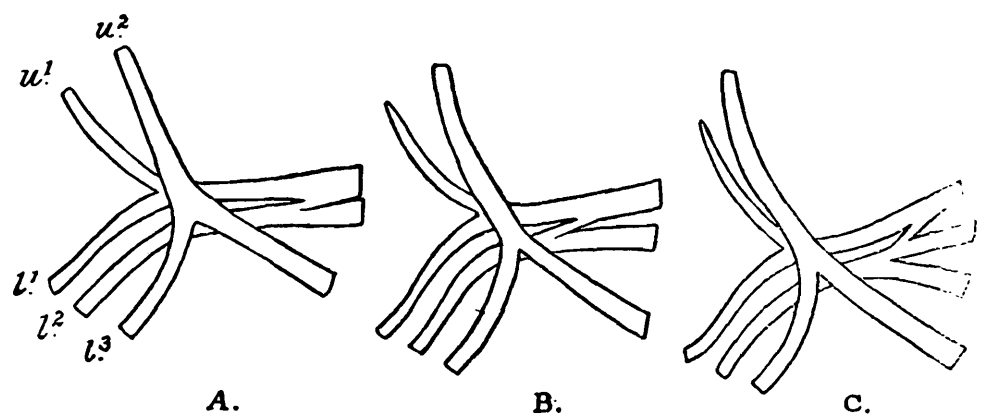
1. Preparis N. Channel, 1-1½ fathoms, November 16, 1909. 12 specimens.
2. 'Investigator' Sta. 672, Revello Channel, Nicobars, Surface, April 7-9, 1925. 3 specimens.

The examples of this species in the Indian Museum are of considerable interest, in that they appear to provide an intermediate link between the normal form and the form in which the aggregated zooid is characterised by the possession of a pair of long posterior processes. Metcalf, who has studied both forms, concludes that this latter form *bicaudata* is worthy of sub-specific rank, and bases his opinion on certain small differences in the character of the eye and of the musculature, as well as on the possession of the pair of appendages.

*Solitary Zooid.*—In one small example, measuring 19·0 mm. in length, the whole of the upper surface and lateral margins of the test was considerably thicker than usual and was covered with small thickened papilliform projections, so that it closely resembled the condition present in *Thetys vagina*, in which the test is covered with small denticulations. A somewhat similar condition of the test in this species is also recorded by Ritter and Byxbee (1905, p. 196) in certain specimens of the aggregated generation obtained by the " Albatross " in the Pacific Ocean.

In all other examples the test is smooth and thin, except for the thickening on the ventral aspect over the region of the " nucleus."

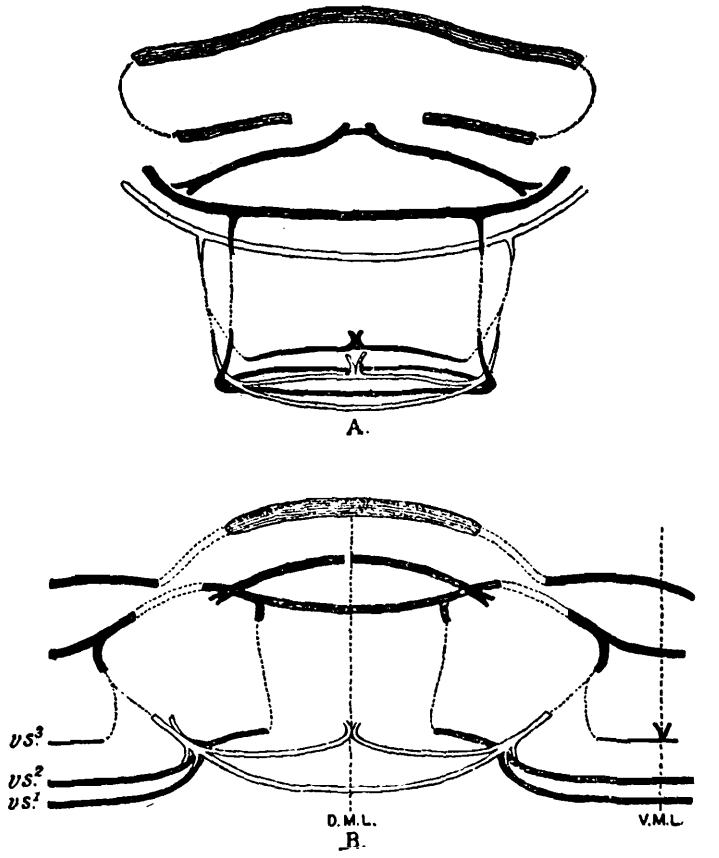
One of the features, on which Metcalf relies, to distinguish the normal form from his sub-species *bicaudata* is the arrangement of the oral musculature. In the normal form, as he remarks, the retractor muscle is " divided into dorsal and ventral divisions, the dorsal division having two branches anteriorly. The ventral retractor connects anteriorly with the broad sphincter of the upper lip, the only complete sphincter in this lip. It connects also with the third sphincter of the lower lip. The ventral branch of the dorsal oral retractor is continuous only with the second sphincter of the lower lip." On the other hand in the form *bicaudata* " the oral retractor instead of being divided into two, a dorsal retractor and a ventral retractor, is divided into three horizontal bands as in *Thalia*." Among the specimens in the " Investigator " collection taken at Sta. 672, not only are both the above types of oral musculature represented but there is one example of an even more advanced stage, for in this specimen there are not three but four oral retractors.




TEXT-FIG. 28.—Showing different types of oral musculature in *Pegea confoederata*.

The musculature of the atrial aperture is somewhat complicated, and the elucidation of the various connections and the mode of branching of the muscle bands is rendered still more difficult by the tendency for

the bands to be broken. Whether this is a natural condition in the living animal or is due to handling and *post mortem* changes I cannot say. In the specimens examined by me the atrial musculature consists of two sets of muscles (1) a basal set, comprising two sphincter muscles that probably in life are continuous but which become broken into irregular masses. I have in Text-fig. 29 given the various muscle blocks seen and have indicated what I believe to be the connections by dotted lines. The distal sphincter probably also forms a complete band, and in the lateral region each sphincter gives off a side branch, an upper and a lower atrial retractor, the continuation of which is in each case broken. (2) The distal set of muscles consists of the peripheral portion of the atrial retractors and the various atrial sphincters, into which they branch. It is this peripheral set of muscles only that Metcalf describes and figures. A comparison of fig. 29 with that given by Streiff (1908, Pl. III, fig. 22) reveals a close degree of similarity, the only differences of note occurring at the point where the two atrial retractors cross. Streiff shows the two basal sphincters, or rather isolated blocks of muscle belonging to these two bands, and indicates correctly the origin of the two atrial retractors, but at the point where these cross his specimen appears to be somewhat distorted, so that the actual continuation of the branches is not easy to follow. The sphincter muscles themselves




Text-fig. 29.—Atrial musculature of *Pegea confoederata*; solitary zooid.

A. With the atrial syphon intact.

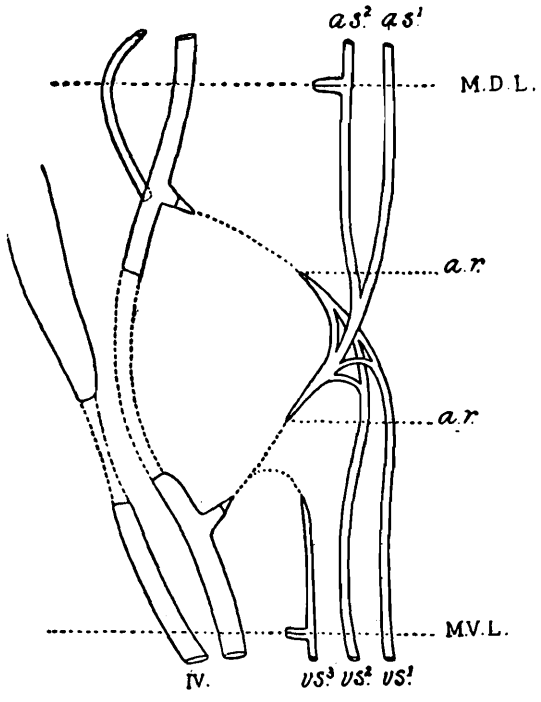
B. With the ventral wall cut through and the ends turned outwards. The ventral system is in black.

are quite clearly shown and the number, three on the ventral side and two dorsally, agrees with my observations. The ventral atrial retractor,

besides dividing into two main branches to form the dorsal sphincters, also sends a few fibres to the first and second ventral sphincter muscles.

Here again one finds small variations in the musculature of different individuals, for in one example that I examined and which I figure in Text-fig 29 B, the short third dorsal sphincter was apparently absent, its place being taken by the conjoined continuation of the 1st and 2nd ventral sphincter muscles. In the small example of the solitary zooid that I have mentioned above, in which the test was abnormally thick, the delicate structure of the atrial funnel has been beautifully preserved and in consequence the muscle connections were intact. Each of the atrial retractors on both sides were connected by a single and very delicate muscle-fibre with the projecting muscular offshoot of the basal atrial sphincter, and from the connecting fibre from the lower retractor ran a branch to the third ventral sphincter.

In Text-fig. 30 I have reproduced Streiff's diagram in a modified form so as to show the true muscle connections, and I have continued it so as to include the whole circumference of the syphon. A comparison of this figure with Metcalf's (1918, p. 133, fig. 122) reveals at once the resemblance between the two accounts, and shows that there is little if any difference in the normal form and the sub-species *bicaudata*.

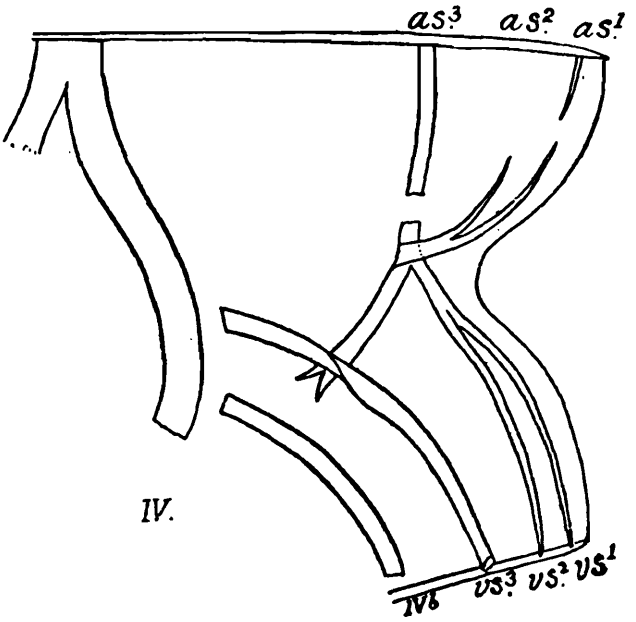



TEXT-FIG. 30.— Atrial musculature of *Pegea confoederata* : solitary zooid, modified from Streiff.

*Aggregated Zooid.*—As regards their external appearance all my examples conform to the n rmal type ; there was no trace in any of the posterior processes characteristic of the form *bicaudata*. In their internal structure, however, these specimens, as I have already shown in the solitary zooid, are intermediate between the normal form and the descriptions given by Metcalf and Streiff of the *bicaudata* form.

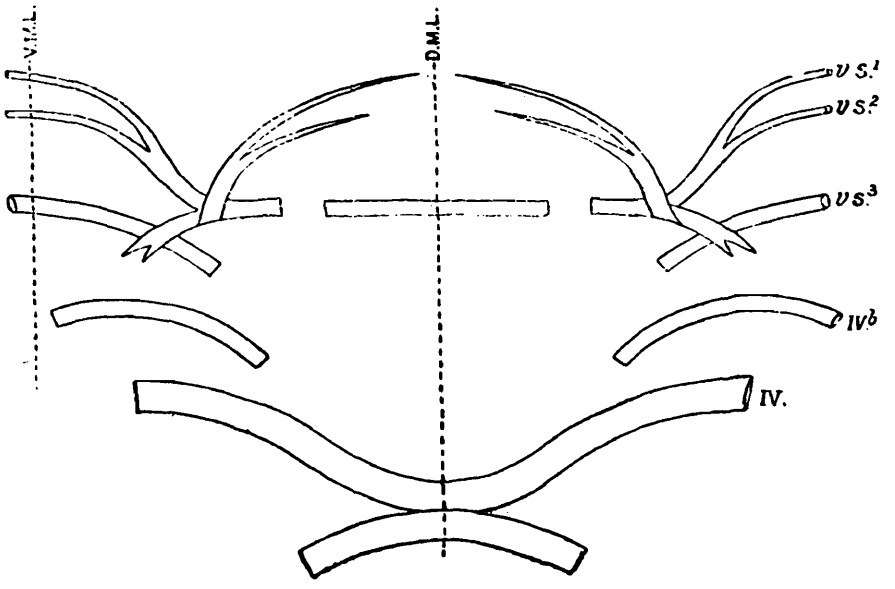
The oral musculature agrees with that of the normal form ; the oral retractor is composed of an upper and a lower portion, that are in contact

with each other throughout the greater part of their length, and the various sphincters agree exactly with those in the solitary zooid. The body muscles are also normal. The atrial musculature, on the whole, conforms to the account given by Metcalf (1918, p. 142, fig. 131) for the *bicaudata* form, though in one detail it was more near to that of the normal.




TEXT-FIG. 31.—The atrial musculature of *Pegea confoederata*, aggregated zooid, from the side.

Neither the muscle IV (*b*) nor the third ventral sphincter are connected with the fourth body muscle, and there are three ventral sphincters present. In one example the two halves of the 1st dorsal sphincter almost meet in the middle line (as shown in Text-fig. 32) instead of there being an intermediate portion. In all cases the third dorsal sphincter muscles is broken across in the lateral region.




TEXT-FIG. 32.—The atrial musculature in *Pegea confoederata*; aggregated zooid.

In Text-fig. 32 I have represented the atrial musculature as if the syphon had been cut across near the ventral middle line and the whole opened up. A comparison of this figure with that given of this system

in the solitary zooid (Text-fig 29B) reveals that both are founded upon the same basic plan.

TEXT-FIG. 33.—The eye of *Pegea confoederata*; dorsal view.

The eye in all my examples was carried on the end of a stalk formed by the optic nerve and its sheath, so that in this respect again they conform to the *bicaudata* type.

Under the circumstances I can see no justification for considering the *bicaudata* form to be even a variety, and much less a distinct subspecies, as Metcalf has done.

## Sub-genus **Traustedtia** Metcalf.

The correct taxonomy of this sub-genus offers a problem that must still await its final solution. Metcalf, who created the sub-genus in 1918, has attempted to recognise two distinct species and one subspecies, namely :—

*Traustedtia multitentaculata* (sensu stricto) (Quoy and Gaimard)
*Traustedtia multitentaculata* subsp. *bicristata* Metcalf, and
*Traustedtia radiata* Metcalf.

He bases his views on small details of structure, more particularly of the body-muscles, and on the number of tentacles present in the solitary zooid. He gives the following key for the identification of these three forms :—

| | |
|---|---|
| Solitary form with numerous tubular appendages from different parts of the body | *Traustedtia.* |
| Appendages in solitary form 20 or more, gut forming a horizontal spindle-shaped mass. Aggregated zooid probably not known . . . | *radiata.* |
| Appendages in solitary form not more than 13, gut forming a vertical spindle-shaped mass. Aggregated form with a single unequal pair of posterolateral appendages. | |
| Appendages of the solitary form 8, the posterior pair about as long as the body. Oral muscles continuous across the middorsal line . . . | (type) *multitentaculata.* |
| Appendages of the solitary form 13, oral muscles very short dorsally, hardly extending above the angles of the mouth | *multitentaculata*, subspecies *bicristata.* |

### **Traustedtia multitentaculata** (Quoy and Gaimard).

*Salpa henseni*, Traustedt, 1893, p. 9, pl. i, figs. 6-9 (Aggregated zooid).
*Salpa verrucosa*, Apstein, 1894, p. 12, pl. ii, figs. 11-13 (Solitary zooid).
*Salpa henseni*, Apstein, 1894, p. 19, pl. ii, fig. 8.
?*Salpa henseni*, Apstein, 1905, p. 256, pl. xxix, fig. 28.
*Salpa multitentaculata*, Ihle, 1911, p. 588.
?*Salpa multitentaculata*, Ihle, 1912, p. 50, fig. 55 (Solitary zooid).
*Salpa multitentaculata*, Ihle, 1912, p. 51, fig. 56 (Solitary zooid).
*Salpa multitentaculata*, Bomford, 1913, p. 244.
*Traustedtia multitentaculata*, Metcalf, 1918, p. 147.
*Traustedtia multitentaculata*, subsp. *bicristata*, Metcalf, 1918, p. 143, pl. xiv.

The "Investigator" collection of Salps includes the following examples of this species :—

*Solitary Zooid* :—

1 "Investigator" Sta. 614, Nankauri Harbour, Nicobars, Surface, January 22-23, 1923. 1 specimen.

2. " Investigator " Sta. 670, Laccadive Sea, 5° 56′ N. ; 76° 22′ E, 0-200 fathoms, April 23, 1924. 1 individual.
3. " Investigator " Sta. 672, Revello Channel, Nicobars, Surface, April 7-9, 1925. 2 individuals.
4. " Investigator " Sta. 682, Laccadive Sea, 10° 26′ N. ; 74° 32′ 30″ E., 0-700 fathoms, April 28, 1925. 2 individuals.

*Aggregated Zooid* :—

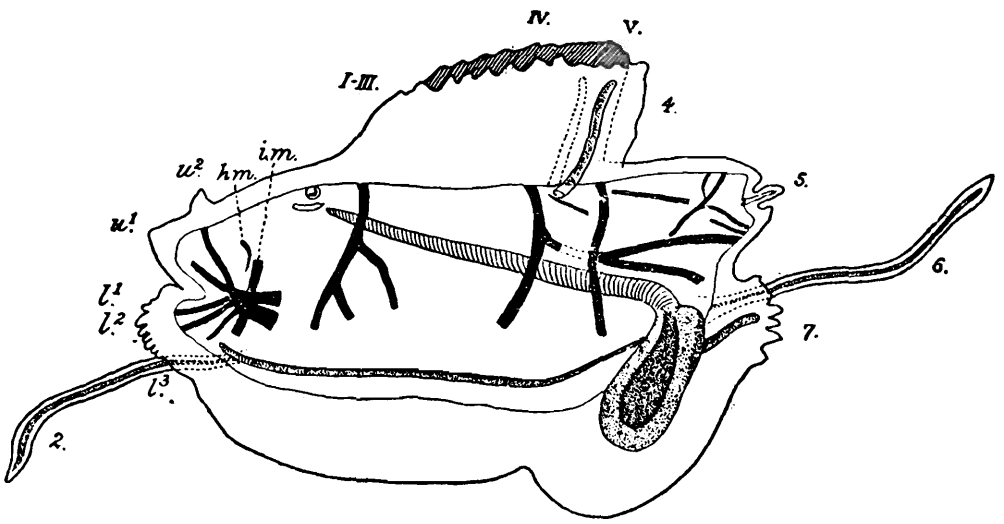
1. " Investigator " Sta. 461, Bay of Bengal, 10° 15′ N. ; 90° 15′ E., 0-375 fathoms, April 19, 1912. Several examples.
2. " Investigator " Sta. 670, Laccadive Sea, 5° 56′ N., 76° 22′ E., 0-200 fathoms, April 23, 1924. 14 individuals.
3. " Investigator " Sta. 679, Revello Channel, Nicobars, Surface, March 31—April 1, 1925. 1 individual.

A study of these examples of both the solitary and aggregated generations and a careful examination of their structure appears to me to provide sufficient indication that Metcalf's distinction between *Traustedtia multitentaculata* (sensu stricto) and its sub-species *bicristata* cannot be regarded as a valid one and, moreover, renders it very doubtful in my opinion whether *Traustedtia radiata* is a good species.

*Solitary Zooid.*—The form of the body is usually described as an elongate ovoid. It appears from the " Investigator " examples, however, that the shape differs very materially in individuals of different sizes. In the smallest example, measuring 4 mm. in length, the body is almost spherical ; in those of intermediate size, 7-9 mm. in length, it has the typical ovoid shape, (Text-fig. 34) : but in a single large specimen, measuring 11 mm. in length, the body is much compressed dorso-ventrally and is almost circular in outline when viewed from the dorsum (Text-fig. 35). From this aspect the body of this individual shows a marked agreement with the form that Metcalf calls *Traustedtia radiata.* It would seem probable that this alteration of shape is a growth-change, but it must be remembered that these animals are extremely soft and delicate, and that distortion may very easily occur as a result of pressure in the tow net. In every case the upper surface of the test exhibits a thin median strip, on either side of which lies a thickened crest : the size and degree of prominence of these crests vary in different individuals, being most marked in medium-sized specimens. In the large flattened example obtained at Sta. 670 the crests are barely noticeable; a careful examination, however, reveals the characteristic denticulate margin. In every case each crest is penetrated at its posterior end by a tubular prolongation of the mantle that arises on either side of the middle line in close proximity to the fourth body muscle. As Metcalf (1918, p.147) points out, Apstein in his original description of *Salpa verrucosa*, which was based on a single individual, mentions only a single crest. This I believe to be due to overlapping caused by lateral compression. Although Apstein (1905, p. 256, pl. xxix, fig. 28) in his description of the form regarded by Metcalf as *T radiata* makes no mention of any crests, he shows that one pair of tubular outgrowths

from the mantle arise exactly in the correct portion from near the middle of the dorsal aspect.

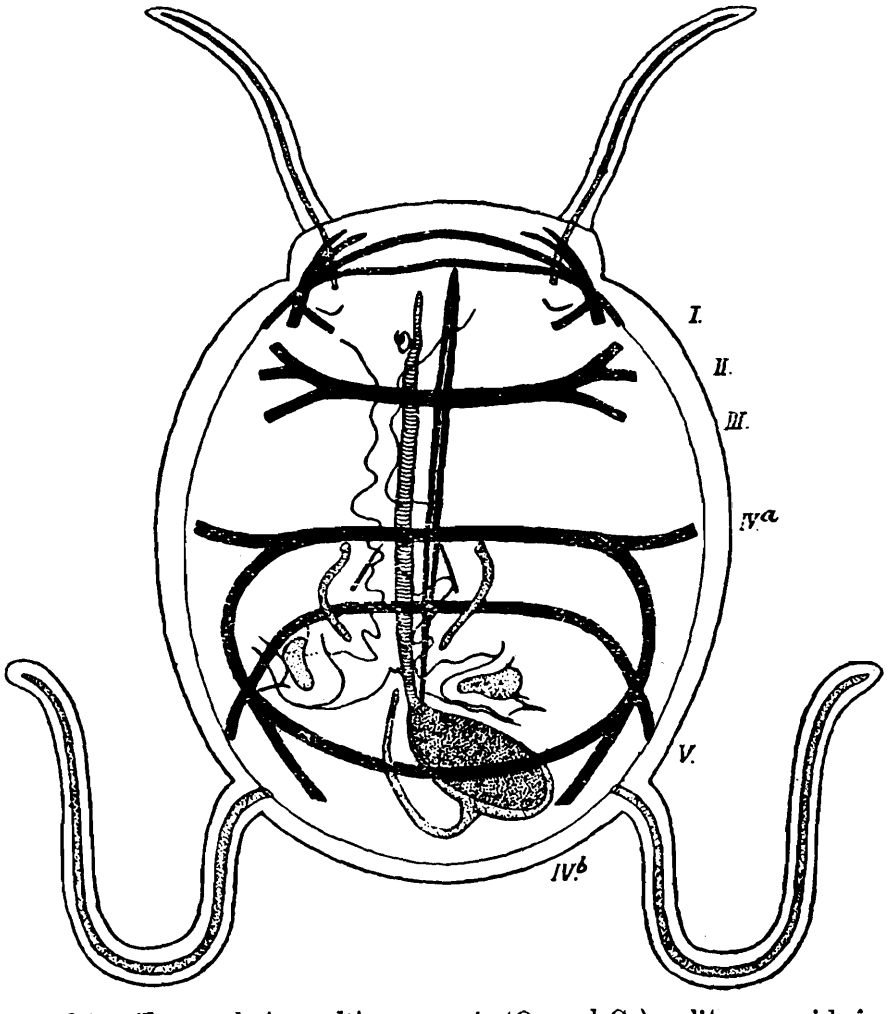
The mantle gives off, in addition to the two tubular processes, noted above, that enter the dorsal crests, a number of other processes, some of which in my examples merely enter the test, while others pass through it to be prolonged as true tentacles that project beyond the level of the body surface, though, of course, covered by similar prolongations of the test itself. The number of tentacles, using the term in its restricted sense to denote prolongations of the mantle *beyond* the general outline of the body, is invariably four ; a pair that have their origin anteriorly, below and to the inner side of the oral retractor muscles, and a second pair that arise posteriorly near the termination of the posterior branch from the IVth body-muscle. These two pairs of tentacles correspond clearly with the pairs that Metcalf in *Traustedia multitentaculata* calls the 2nd and 6th, and with the anterior and posterior long tentacles that Apstein (1905, p. 256) remarks on in his description of the " Valdivia " example ; "Am Vorder—und Hinterende finden sich je 2 längere Fortsätze." The relative length of these tentacles varies considerably with the size of the specimen : in the smallest example (5 mm. in length) they are quite short and only measure about $\frac{1}{8}$ the length of the body ; whereas in the largest example (11 mm. in length) they are from $\frac{1}{3}$ to $\frac{1}{2}$ the length of the body, those of the medium-sized individuals being intermediate. The posterior pair of tentacles are in my examples invariably the longer.




TEXT-FIG. 34.—*Traustedtia multitentaculata* (Q. and G.) from the left side ; only one each of the paired tentacles on each side are shown in the figure.
(From a medium-sized specimen).

In addition to these tentacles there are certain other tubular projections from the mantle, except in the smallest example of all, in which I could detect no further protrusions than those already described, that is the two pairs of tentacles proper and the protrusions into the dorsal crests. In larger examples there is a pair of protrusions into the anal lappets, corresponding to the pair that Metcalf numbers 5, and a median unpaired protrusion corresponding to Metcalf's number 7. In these examples, obtained in Indian waters, we thus find only 9 protru-

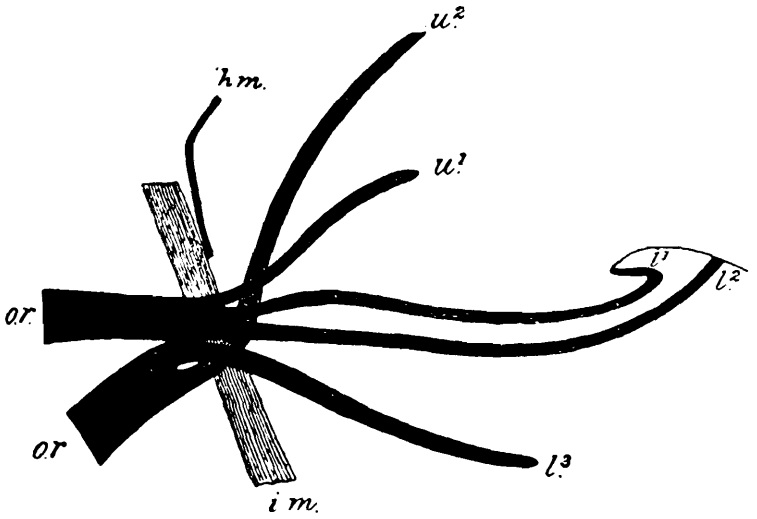
sions of the mantle in all, whereas Metcalf's specimens showed 13 and Dober's and Apstein's 20-23. We thus seem to be dealing with a progressive series; the differences between individuals being possibly of a geographical rather than a specific nature, and similar to the differences noted by Metcalf himself between the aggregated zooids of *Thalia democratica* from the Philippine region of the Pacific and those from the Atlantic Ocean.




Text-fig. 35.—*Traustedtia multitentaculata* (Q. and G.), solitary zooid, from above. (From the largest specimen of 11 mm. in length.)

Metcalf (1918, p. 148) remarks " one would without hesitation assign both specimens (*i.e.*, his own and Apstein's) to the same species were it not for the different condition of the muscles. There is such disagreement in the oral and intermediate muscles as Apstein and we describe them as to necessitate treating his specimen and ours as representing distinct subspecies." In most of my examples the oral musculature has the arrangement shown in Text-fig. 36. The intermediate muscle is a broad short band passing downwards internal to the oral retractors. Two oral retractors are present. The upper retractor sends a branch into the upper lip, the first upper sphincter, which terminates after a short course, and two branches to the lower lip, the first and second sphincters, both of which are continuous from side to side. The second lower sphincter also receives an accessory muscle-slip from the

lower oral retractor. The lower oral retractor divides into two main branches, of these the first turns upwards and, passing internally to the first and second sphincters of the lower lip, forms the second sphincter of the upper lip: in most examples this muscle has only a short course, as Metcalf describes it, but the two ends

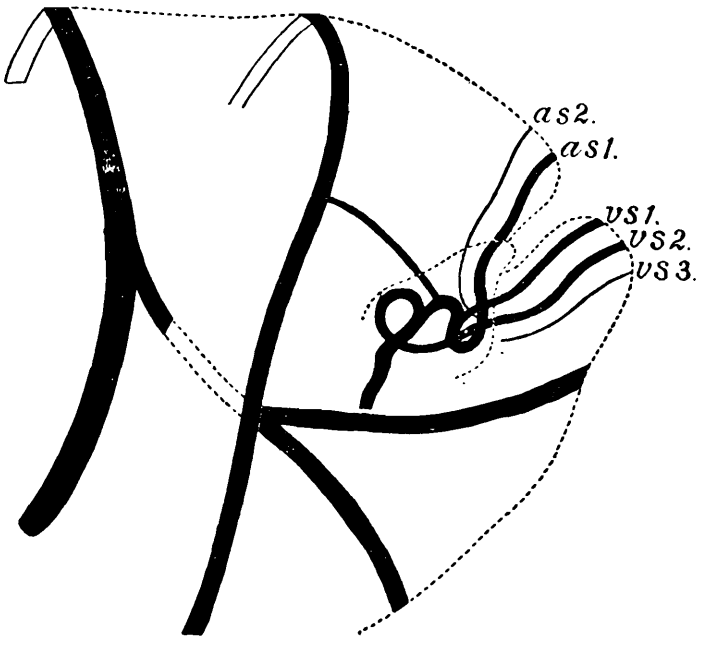



TEXT-FIG. 36.—Oral musculature of *Traustedtia multitentaculata* (Q. and G.) solitary zooid, from the side.

are clearly connected across the middle line by a blood sinus, and in my smallest example the muscle band is itself continuous, as figured by Apstein. It seems clear to me that originally this muscle is continuous from side to side across the mid-dorsal line. Metcalf remarks that in his example there is no dorsal horizontal muscle, but in my examples there is present a small band that runs upwards along the anterior margin of the intermediate muscle and bends forwards towards the edge of the lip in a manner very similar to the corresponding muscle in *Pegea confoederata*: indeed, the whole oral musculature exhibits a marked similarity of arrangement in the two species.

The body muscles, of which there are five according to Metcalf's notation, agree in different individuals with both Metcalf's and Apstein's accounts. Muscles I, II and III are fused together across the dorsal region of the body, the composite nature of the band being, however, clearly indicated by the three branches into which the band divides in each lateral region. The IVth muscle runs across the dorsal aspect and usually in each lateral region divides into a branch that passes downwards and forwards and a smaller branch that turns backwards and is continued across the Vth body muscle to form a continuous band around the posterior aspect of the body below the atrial syphon; a branch from this band passes downwards on each side of the body towards the visceral mass. In one specimen (Text-fig. 37), however, the portion of the muscle that lies between its origin from muscle IV and the point where it crosses muscle V was missing; its original line of continuity was, however, indicated by a blood-sinus. This specimen, therefore, agrees clearly with Apstein's figure. The Vth body-muscle is continuous across the mid-dorsal line and passing downwards on each side of the body crosses the

posterior branch of the IVth muscle, at the point where it divides. It sends a small strand back towards the anterior atrial sphincter muscle.




TEXT-FIG. 37.—Atrial musculature of *Traustedtia multitentaculata* (Q. and G.), solitary zooid, from the side.

The arrangement of the atrial musculature in my examples appears to be identical with that described by Metcalf (1918, p. 146 and pl. xiv, fig. 35), though in his figure the distribution of the various branches appears to have been considerably simplified. Arising close to, but not actually forming any connection with the upper branch of the posterior division of body-muscle IV, is a short band, the actual retractor muscle, that runs upwards and backwards towards the base of the atrial tentacle ; it here gives off a branch, that can be traced on as the 2nd ventral sphincter ; the main band is then continued on for a short course and divides into two branches (1) the 1st ventral sphincter and (2) the dorsal sphincter muscle, which again divides into the first and second dorsal sphincters. The 2nd dorsal sphincter is a very delicate muscle consisting for the most part of a single fibre. There is a very delicate third ventral sphincter, which does not, so far as I can discover, connect with any other muscle band. In my examples this arrangement of the atrial muscles is difficult to make out, owing to the manner in which the various branches twist and cross each other. As Metcalf point out, the atrial muscles are not continued into the atrial tentacle, but they are, nevertheless, closely connected with its base and appear to form a loop around it (*vide* Text-fig. 37).

According to Metcalf, one of the distinguishing features between *Traustedtia multitentaculata* and *T radiata* is the vertical position of the spindle-shaped mass formed by the gut in the former and its horizontal position in the latter. A character such as this can, in my opinion, be of very little diagnostic value in such a case, where, as I have already pointed out, the general shape of the body may be completely altered by growth or by post-mortem distortion. As long as the shape of the body remains oval, as it has done in my examples of small or moderate

size, the gut occupies a vertical position; but in the large example, that is considerably flattened from above downwards, it is situated horizontally, but is somewhat twisted over towards the right instead of lying in the antero-posterior line, as figured by Dober and Apstein in the form that Metcalf calls *T radiata.*

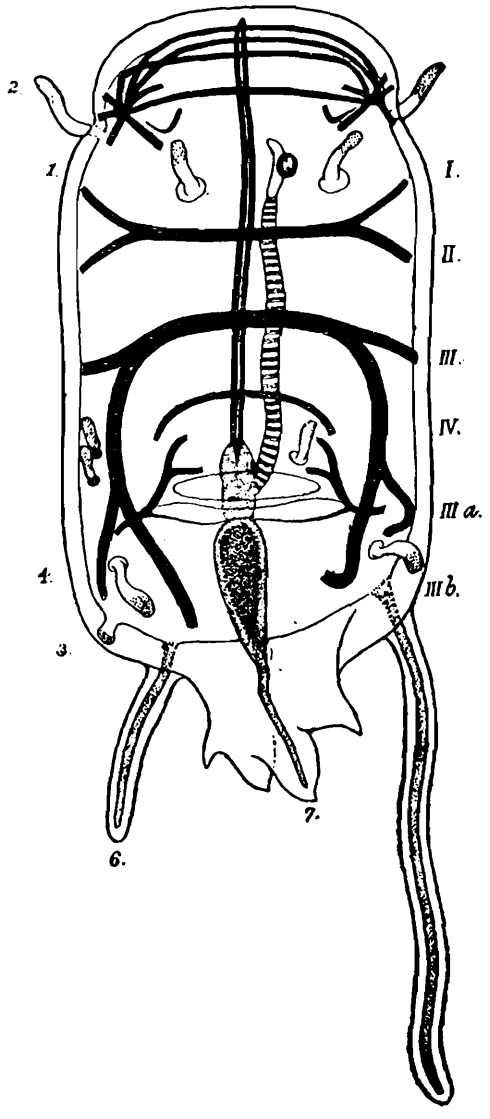
The present state of our knowledge regarding these various forms of the solitary zooid, included in the sub-genus *Traustedtia*, appears to me to be this. We have here a collection of rare and somewhat aberrant Salps, all of which clearly can be grouped together as a sub-genus distinct from all other Salps. The earlier accounts, based in several cases on a single individual, are often lacking in detail, and differ in a few points, especially regarding the connections or extent of the main muscle-bands. Throughout the whole of Metcalf's admirable study of the Salpidae one finds references to similar differences in other species. Bands of muscle, continuous in one specimen from side to side of the body or along the antero-posterior length, are in other examples found to be discontinuous; and yet in these cases he does not consider them and rightly so, to be of sufficient importance to warrant the creation of sub-specific or specific rank. One certainly is not justified in laying any emphasis on such differences in the case of these rare individuals of the sub-genus *Traustedtia.* Were these differences constantly associated with a difference in shape and in the number of " tentacles " present, one might be justified in considering such forms to be representatives of either true varieties or sub-species, but the series of examples that I have examined leaves little doubt that the shape may vary, either as a result of artificial distortion or with age, in individuals which in my opinion undoubtedly belong to the same species. We are left then with the number of tentacles as the sole feature on which to base the separation of the members of this genus into two species and one sub-species: and here again we find no clear line of demarkation. My examples all show 9 such tentacles. Apstein, in his account, shows 8 but has almost certainly overlooked the two pairs in the dorsal crests and the atrial lappets as well as the median posterior one, so that his specimens probably possessed 13, as did Metcalf's; and finally in the form described by Dober and Apstein there are 20-23, though here again it is not unlikely that Dober overlooked the pair of tentacles in the dorsal crests: as I have already pointed out Apstein figures these clearly, but Dober's figure shows no trace of them (*vide* Metcalf, 1918, figs. 138 and 139). We thus get three groups exhibiting 9, 13 and 22-23 tentacles respectively. Do these groups correspond to species and sub-species or are they merely variable forms of one species? That my examples, exhibiting only 9 tentacles, belong to the same species as those exhibiting 13 I have not the least doubt: nor in view of the manner in which, in other respects, these specimens form a link between all such examples, that is to say between the form denoted by Metcalf as *T. multitentaculata* (sensu stricto) and his sub-species *bicristata*, have I any hesitation in including them all in one species, and in declining to recognize the form *bicristata* as worthy of sub-specific rank. The final question whether the form with 20-23 tentacles is a separate species, *T. radiata*, can only be decided by a careful study of its anatomy, but I

am greatly disposed to agree with Apstein that even these are members of the species *T multitentaculata*, and that all examples of the genus *Traustedtia* are specifically identical but exhibit a wide range of variation in shape and in the number of tentacles, the change in shape being probably due to growth, and the number of tentacles, in view of the obviously sluggish habit as shown by the character of the body-muscles, correlated with the salinity of the water in which the animal lives and the necessity of possessing a specific surface, that will enable the animal to maintain itself at a suitable level. Owing to the altered relationship between surface and volume, large individuals will have a greater tendency to sink than small ones. This altered relationship can be compensated by the increase in size or numbers of the tentacles, so in small individuals the tentacles are short, whereas in larger ones they are seen to have markedly increased in relative length. A further increase in size can be compensated by an increased number of tentacles, and thus in my examples, with a length of 5-11 mm., there are 4, in Metcalf's, with a body length of 7·5 mm., there are 8, and in Apstein's form *T radiata*, with a length of 25 mm., there are 20-23.

*Aggregated Zooid.*—As Metcalf (1918, p. 151) has pointed out "all the aggregated Traustedtias hitherto described seem to belong to the species *multitentaculata*," and the "Investigator" specimens are no exception.

All my examples agree closely in shape with the figure given by Traustedt (1893, pl. i, fig. 6). A characteristic feature of this form is the possession of a pair of long tentacles that arise from the dorsal aspect of the postero-lateral region of the body, and of these two that on the right side is almost invariably the longer and often very much so. Apstein's figure (1894, pl. ii, fig. 8) of a young example shows that even at a very early stage in its life history this feature is present and, furthermore, it indicates that, as in the solitary form, the relative length of the tentacles increases as size, and presumably age, progresses. The test around the oral aperture is produced in a number of small papillae, exactly as in the solitary zooid, and around the posterior end of the body and especially covering the "nucleus" it is very considerably thickened and is produced in a number of prominences that taper to a blunt point. The nucleus itself lies in the horizontal plane, and from the posterior end a protrusion of the mantle extends backward towards the apex of the test. This protrusion undoubtedly corresponds to the median posterior protrusion found in the solitary zooid, but, unlike the condition found in that generation, in the aggregated zooid it may be continued beyond the ordinary level of the test to form a true median tentacle (*vide* Text-fig. 39) which is usually stained a brown colour. On the ventral and lateral aspects of the body a careful examination shows that, again as in the solitary zooid, the mantle is produced in a series of paired tubular outgrowths, which are, however, short and do not pass beyond the level of the test. These paired outgrowths, which closely resemble the processes of the mantle in the Philippine form of the aggregated zooid of *Thalia democratica*, appear to correspond with the paired tentacles found in the solitary zooid, and which Metcalf in his figure (1918, pl. xiv) numbers 1 to 4. The posterior and upper

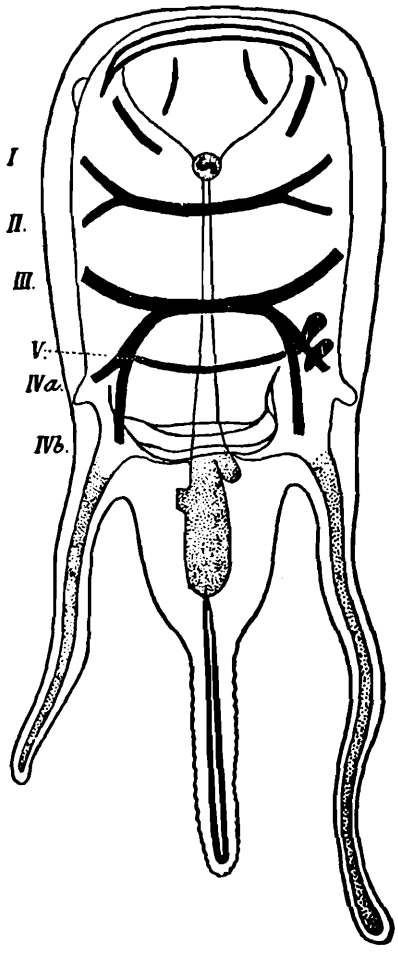
pair (Text-figs. 38 and 40) which in the solitary zooid arise on the dorsal aspect and run out into the crests of the test, in this generation are, owing to the dorso-ventral flattening of the body, pushed outwards and downwards and now arise from the side and somewhat asymmetrically. I have been unable to detect any atrial lappets, and in consequence the corresponding pair of protrusions of the mantle are absent, but with this exception, the aggregated and solitary zooids show a complete agreement. The possession of these small protrusions into the test in these Indian examples is all the more remarkable since, as I have shown in the case of the solitary zooid, no trace of tentacles 2 and 3 can be found.



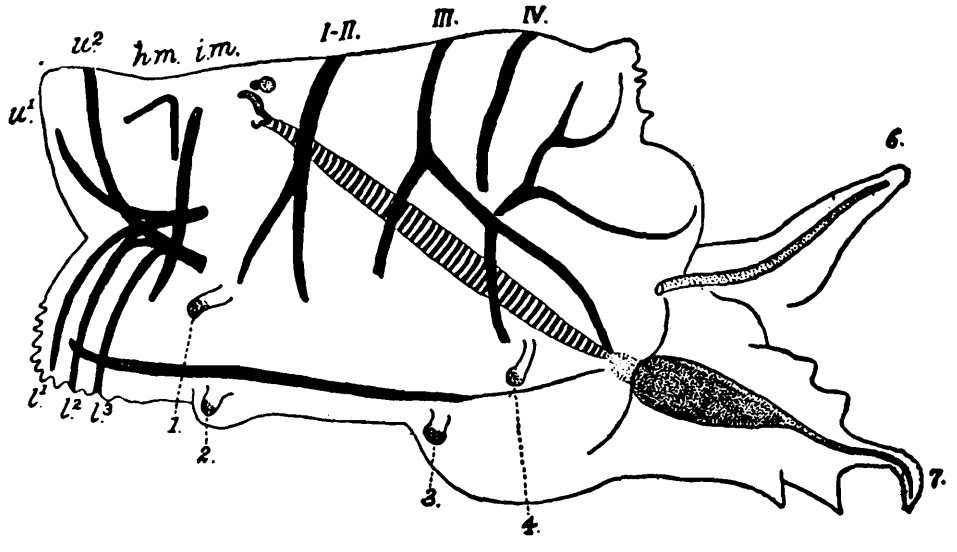

TEXT-FIG. 38.—*Traustedtia multitentaculata* (Q. and G.), aggregated zooid. The lower lip is inverted and hence the order of the lower sphincter muscles is reversed.

The oral musculature closely resembles that of the solitary zooid. A well-developed intermediate muscle is present and in front and above this is a delicate curved horizontal muscle. The oral retractor is double. From the upper muscle arise the 1st sphincter of the upper lip, which extends only a short distance into the lip, and the 1st and 2nd sphincters

of the lower lip, both of which are continuous across the middle line. The lower retractor gives off the 3rd sphincter of the lower lip, which is




TEXT-FIG. 39.— *Traustedtia multitentaculata* (Q. and G.), aggregated zooid, showing an unusual prolongation of the test in the middle line of the posterior end of the body.




TEXT-FIG. 40.—*Traustedtia multitentaculata* (Q. and G.), aggregated zooid, viewed from the left side.

continuous from side to side ; it then gives a few fibres to the 2nd sphincter of the lower lip, and finally is continued on as the continuous 2nd sphincter of the upper lip. There are only four body muscles in this

generation. Muscles I and II are fused together in the mid-dorsal region. Muscle III, which corresponds to muscle IV in the solitary zooid, sends off a branch that runs downwards and forwards, it then curves backwards for a short distance and divides into two bands, one of which passes downwards, and the other downwards and backwards toward the visceral mass but is not continuous around the posterior end. The IVth muscle, which corresponds to muscle V in the solitary zooid, passes from side to side across the body in front of the atrial syphon and ends near to, but does not cross, the bifurcation of the posterior branch of muscle III. The atrial musculature consists of a short atrial retractor, situated near the bifurcation of muscle III and behind and below muscle IV. This after a short course gives off a branch, the ventral sphincter muscle, that is continuous from side to side ; in one specimen this muscle appears to divide into a first and second ventral sphincter both of which are continuous. The main retractor muscle is then continued on and divides into two, usually short, dorsal sphincters which apparently may be continuous from side to side or may terminate after a short course.

It has long been recognised that the HEMIMYARIA are for the most part warm-water inhabitants and attain their maximum of concentration and distribution in the region of the Tropics ; it is, therefore, not surprising that the collection in the Indian Museum contains representatives of most of the known species. In the following table I give a list of all known species and have indicated their distribution in the three great oceans. Species that are represented in the Indian Museum collections are denoted by an asterisk after the name.

TABLE II.—*List of all known species.*

| Species. | Atlantic Ocean. | Indian Ocean. | Pacific Ocean. |
|---|---|---|---|
| *Cyclosalpa pinnata** .. .. | + | + | + |
| *Cyclosalpa bakeri* .. .. .. | + | + | .. |
| *Cyclosalpa affinis** .. .. .. | + | + | + |
| *Cyclosalpa floridana** .. .. | + | + | .. |
| *Cyclosalpa virgula** .. .. | + | + | .. |
| *Apsteinia punctata* .. .. .. | + | .. | .. |
| *Apsteinia asymmetrica* .. .. | + | .. | .. |
| *Apsteinia magalhanica* .. .. | + | .. | + |
| *Brooksia rostrata** .. .. .. | + | + | .. |
| *Ritteria picteti** .. .. .. | .. | + | + |
| *Ritteria amboinensis** .. .. | + | + | + |

TABLE II.—*List of all known species*—contd.

| Species. | Atlantic Ocean. | Indian Ocean. | Pacific Ocean. |
|---|---|---|---|
| *Ritteria hexagona** .. .. | + | + | + |
| *Salpa fusiformis** .. .. .. | + | + | + |
| *Salpa cylindrica** .. .. .. | + | + | + |
| *Salpa maxima** .. .. .. | + | + | + |
| *Jasis zonaria** .. .. .. | + | + | + |
| *Thalia democratica** .. .. | + | + | + |
| *Thalia longicauda* .. .. .. | + | + | + |
| *Thetys vagina** .. .. .. | + | + | + |
| *Pegea confoederata** .. .. | + | + | + |
| *Traustedtia multitentaculata** .. .. | + | + | + |
| (?) *Traustedtia radiata* .. .. | .. | + | .. |

It will be noticed that the only species not as yet recorded from the Indian Ocean are the three members of the genus *Apsteinia* Metcalf.

Apstein (1905, p. 276) remarks " Die Salpen sind typische Hochsea bewohner, die zum grosten Teile in warmen wasser leben, während nur wenige arten an kateres oder kaltes wasser gebunden sind," and he points out that the movement of surface currents, such as the Gulf Stream, can carry these forms into high latitudes. He gives as an example of this the occurrence from the region of the Hebrides, Iceland and Greenland of *Salpa fusiformis*, *Thalia democratica* and *Jasis zonaria*. Murray and Hjort (1912, pp. 710-711) also give an account of similar invasions of these animals, and especially of *S. fusiformis*, in the Faroe-Shetland channel, and into the North Sea round the coast of Scotland. In his report on the collection of Tunicata made by the " Challenger " Herdman records the taking of *Salpa fusiformis*, *S. cylindrica* and *S. maxima* at stations well to the south of the usual limits of distribution of these species, and it is probable that here again their occurrence was due to a movement pole-wards of surface-water; the fact, which he records, that many of the specimens were in bad condition may possibly have been due to the animals having been killed off by the admixture of cold water with the warm current that was responsible for their movements. As Apstein (1905, p. 383) shows, the distribution of the Salps depends on " the hydrographic relations of the currents, the temperature and the salinity," and when one considers the great interchange of water that is constantly going on between the three great oceans, it becomes all the more surprising that a complete genus, *Apstenia*, is unrepresented in Indian waters. The most probable explanation of this peculiarity seems to be that, unlike all other Salps, this genus has adopted a cold-water

habitat and that its surface distribution is limited, at any rate very largely, to the circum-polar regions.

The collection of Salps made by the R. I. M. S. "Investigator" clearly indicates that the distribution of these animals in Indian waters is by no means uniform and that there is a very clear seasonal periodicity in their occurrence in the surface waters. In the following table I have given a list of the different species and have indicated the months in which the two forms—solitary or aggregated—have been obtained: the occurrence of the solitary form is indicated by + and of the aggregated by 0.

TABLE III.—*Showing the occurrence, month by month, o the various species of Salps in Indian waters.*

| | October. | November. | December. | January. | February. | March. | April. | May. |
|---|---|---|---|---|---|---|---|---|
| *Cyclosalpa pinnata* .. | .. | +0 | .. | +0 | +0 | +0 | .. | .. |
| *Cyclosalpa affinis* .. | .. | .. | .. | | .. | 0 | .. | .. |
| *Cyclosalpa floridana* .. | .. | .. | .. | + | .. | .. | .. | .. |
| *Cyclosalpa virgula* .. | .. | .. | .. | .. | .. | 0 | .. | .. |
| *Salpa fusiformis* .. | .. | .. | .. | .. | .. | + | +0 | .. |
| *Salpa cylindrica* .. | + | + | +0 | +0 | +0 | +0 | +0 | .. |
| *Salpa maxima* .. .. | .. | .. | .. | .. | .. | .. | 0 | .. |
| *Brooksia rostrata* .. | .. | .. | .. | .. | + | .. | .. | .. |
| *Ritteria picteti* .. .. | .. | .. | .. | .. | .. | .. | + | .. |
| *Ritteria amboinensis* .. | .. | .. | .. | .. | .. | + | + | .. |
| *Ritteria hexagona* .. | + | .. | .. | .. | + | + | +0 | .. |
| *Jasis zonaria* .. .. | .. | + | .. | + | + | +0 | +0 | +0 |
| *Thalia democratica* .. | + | +0 | +0 | +0 | +0 | +0 | +0 | .. |
| *Thetys vagina* .. | 0 | .. | + | + | .. | .. | .. | .. |
| *Pegea confoederata* .. | + | +0 | .. | .. | .. | + | +0 | .. |
| *Traustedtia multitentaculata* | .. | .. | .. | + | .. | .. | +0 | .. |
| | 4.1. | 5.2. | 3.2. | 7.3. | 6.3 | 8.6. | 9.8 | 1.1. |
| Total number of species | 5 | 5 | 3 | 7 | 6 | 10 | 10 | 1 |

The first point to which I would call attention is the manner in which the number of species, obtained in each month, decreases from November to December and then rises again to a maximum in April. A study of the salinity of the surface water shows that here too we find a maximum in Indian seas in October and November and that this is followed

by a fall in January or February and a second rise in April. It would appear probable then that the number of species obtained each month in Indian seas is directly correlated with the salinity. It must, however, be borne in mind that the majority of the deep-sea Trawls, carried out by the R. I. M. S. "Investigator," occur either at the beginning or end of the Survey season during the voyage to or from Bombay. Of the five species recorded as occurring, in the "Investigator" collections, in the month of October, only two were actually taken on the surface, namely, *Thalia democratica* and *Salpa cylindrica* and, moreover, the occurrence of even these species in the upper layers does not appear to be constant for, as I shall show later, the number of individuals of both species that are captured on the surface is liable to great and apparently periodic fluctuations.

Apstein (1905, p. 283) has pointed out that in the Gulf of Guinea, where the influx of fresh water from the Niger and Congo Rivers causes a marked diminution of the salinity of the surface-waters, there is a disappearance or at any rate a great reduction in number of Salps obtained in the upper layers. Throughout Indian waters and especially in the Bay of Bengal the salinity of the surface-water is low owing to the influx of many great rivers, and, moreover, varies from season to season in accordance with the two Monsoons. It seems to me that the "Investigator" collections contain evidence that in Indian waters the majority of Salps normally inhabit or have their maximum concentration not at the surface but at some, though possibly only slight, depth below. One species that appears to possess this habit is *Pegea confoederata.* Metcalf (1918, p. 137, *et seq*) discussing the vertical distribution of this species concludes, "It seems not unlikely that the solitary *Pegea confoederata* lies generally in deep water the year round, a few wholly adult individuals coming to the surface only occasionally, the great majority probably never coming to the surface except more or less by accident." I am inclined to doubt whether the appearance on the surface of adults of this species is truly accidental and it seems much more probable that at certain definite periods the normally deep-dwelling Salps may approach near the surface or even invade the surface-water for the purpose of breeding. It is a well-known fact that many inhabitants of the deep-sea pass through their larval stages at depths considerably less than those occupied by the adult, and, I believe, that certain Salps follow this custom. Be that as it may, the records of the occurrence of *Pegea confoederata* in the "Investigator" collections certainly bears out Metcalf's view that normally the species inhabits deep-water. Out of seven occasions, on which the solitary zooid of this species was obtained, we have in one instance no record of the depth, but judging from the label "Andaman Sea," it was probably obtained in a trawl; on two other occasions it was captured in the trawl somewhere between the depths of 1,154 or 745 fathoms and the surface; on one occasion it was captured at a depth of 1—1½ fathoms and twice it was taken on the surface. A species that in Indian waters at any rate is much more consistently a deep-water inhabitant is *Ritteria hexagona.* In spite of all the hundreds of tow-nettings taken on the surface this species has never once been captured; on every occasion, when specimens have been

taken, it has been brought up in the trawl, either a bottom trawl or one in mid-water, from depths ranging between 540 and 133 fathoms. In other oceans this species, both the solitary and aggregated zooid, has been taken on the surface, but never so in Indian seas. Another member of the same sub-genus, *R. picteti*, is also probably an inhabitant of the deeper waters, though occasionally individuals may appear at the surface. The "Valdivia" obtained examples in deep water only, the species occurring twice in vertical hauls of the tow-net from depths of 2,400-0 metres and 1,644-0 metres respectively, and the "Investigator" has taken it on two occasions only, once in a tow-netting from 200 fathoms [=366 metres]-0 and once on the surface. *Thetys vagina* is another species that in these waters appears to inhabit the deeper levels, as the only occasions on which the solitary form has been obtained were all in hauls of the mid-water net from depths ranging from 26½ to 585 fathoms. *Jasis zonaria* and probably also *Salpa fusiformis*, so far as their occurrence in the "Investigator" collections is a guide, appear to have very much the same habitat. The solitary generation of the former has been taken on six occasions in the trawl at depths ranging from 1,590 to 65 fathoms, and on only four occasions on the surface, and of the latter on two occasions in the trawl at depths of 200 and 133 fathoms and only once on the surface.

It would appear probable that so far as the habitat of the solitary generation is concerned, the Indian Salps fall into two groups.

A. Species whose solitary zooid normally inhabits deep waters but occasionally comes near or to the surface :—

*Ritteria hexagona*
*Ritteria picteti*
*Salpa fusiformis*
*Jasis zonaria*
*Thetys vagina*
*Pegea confoederata*

B. Species whose solitary zooid normally inhabits the upper layers but usually in Indian waters at some little depth below the actual surface.

*Cyclosalpa pinnata*
*Cyclosalpa floridana*
*Brooksia rostrata*
*Salpa cylindrica*
*Ritteria amboinensis*
*Thalia democratica*
*Traustedtia multitentaculata*

Three additional species, namely, *Cyclosalpa affinis*, *Cyclosalpa virgula and Salpa maxima* I am at present unable to refer to either group, as only the aggregated zooids have been obtained in Indian waters.

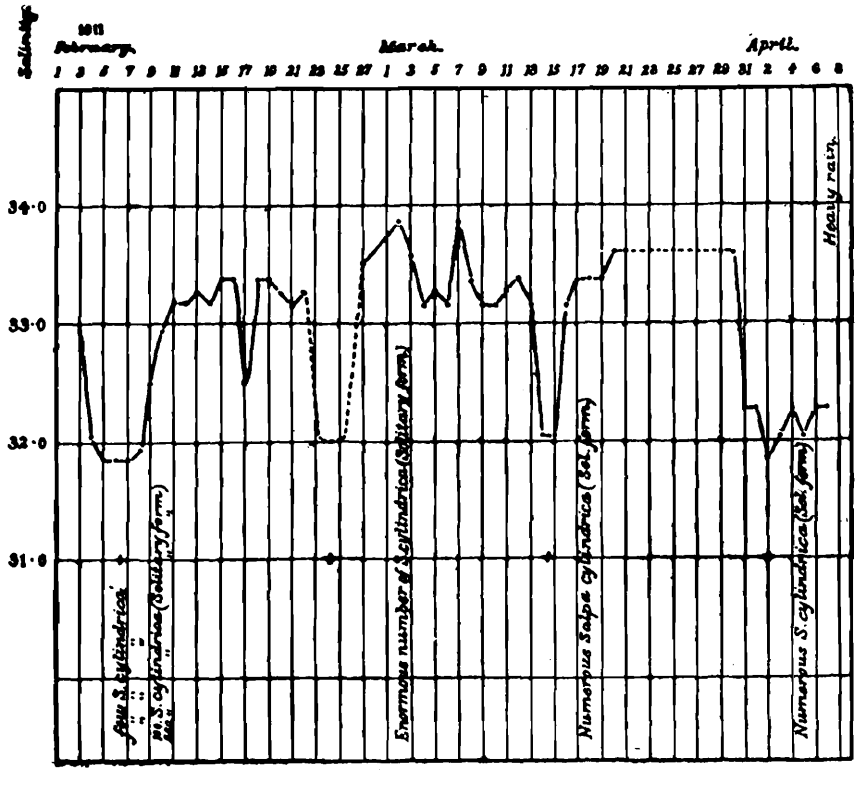
The number of species represented by the aggregated zooid in the surface water gradually increases from October to April and it seems probable that the breeding season of the solitary zooid occurs from October to May or possibly later, having its maximum in April. It will be noticed that, with the single exception of *Thetys vagina*, the

aggregated zooids have been taken one to four months after the appearance of the solitary zooid and it is probable that prior to the breeding season this generation gradually approaches nearer to the surface.

I have already mentioned that only two species, namely, *Thalia democratica* and *Salpa cylindrica* have been obtained at all months of the survey-season and a study of the numbers obtained leaves little doubt that there is a decided periodicity in their occurrence and in the numbers present in the surface layers. I have never attempted to carry out a strict quantitative estimation of the various organisms obtained in the tow-net at different seasons of the year, but each day's catch is, when time is available, roughly analysed and I have noted in the Surgeon-Naturalist's Register the occurrence of any abnormal number of examples of a particular species. On going through these records it at once becomes obvious that within a period of a few days the numbers of Salps present may increase to a very large amount, only for them to decline or even totally to disappear again a few days later. Instances of this sudden and temporary increase in numbers are too regular to admit of its being due merely to the haphazard drifting of large shoals on the surface. During the course of my researches on the salinity of the surface-water in Indian seas I have obtained evidence that in any given area there is a periodic rise and fall. Commencing with a period of low salinity, a daily estimate of the chlorine present in each sample will reveal a gradual rise to a maximum followed by a fall back again to a minimum, and in any given area the time occupied by each successive oscillation is remarkably constant: thus on the east side of the Andaman Sea basin the time occupied by each complete rise and fall during the survey-season 1910-11, when the "Investigator" was surveying the region to the north of Tavoy River, was 18½ days, and an exactly similar result was obtained in 1913-14, when working in the area south of Mergui. I give below the record of the occurrence of examples of *Salpa cylindrica* (solitary zooid) in the surface tow-net during the period January—April 1911.

| Date. | Remarks. |
|---|---|
| 1911. | |
| January 3-4 .. | "Several specimens of *Salpa cylindrica*" |
| *January 4-5 .. | Numerous *S. cylindrica* |
| January 18-19 .. | Several *S. cylindrica* |
| January 19-20 .. | A few *Salpa cylindrica* |
| ("Investigator" returned to port for coaling, January 21-27.) | |
| January 28-29 .. | *Salpa cylindrica* present |
| February 1-2 .. | *Salpa cylindrica* present |
| February 6-7 .. | Several *Salpa cylindrica* |
| February 7-8 .. | Several *Salpa cylindrica* |
| * February 8-9 .. | Large numbers of *Salpa cylindrica* |
| * February 9-10 .. | Large number of *Salpa cylindrica*; 100 examples |
| * February 10-11 .. | Large numbers of *Salpa cylindrica*; 550 examples |
| February 12-13 .. To February 17-18 .. | *Salpa cylindrica* present |
| February 19-20 .. | *Salpa cylindrica* present |
| February 21-22 .. | *Salpa cylindrica* present |
| ("Investigator" returned to port for coaling, February 22 to March 1.) | |
| *March 2-3 | Numerous *Salpa cylindrica* |
| * March 17-18 .. | Numerous *S. cylindrica* present |
| "Investigator" returned to port for coaling, March 22—28) | |
| * April 4-5 .. | Numerous *Salpa cylindrica* |

It will be noticed that the period of time from the occurrence of one shoal of Salps to the next, which I have indicated above by an asterisk against the date, is either eighteen or thirty six days, with the exception of the period from March 2-3 to March 17-18, which is only fifteen days, and as I was away from the survey ground for a week previous to the 2nd it is possible that I missed the maximum density of the shoal. Furthermore, the " Investigator " was away from the survey ground recoaling on January 23rd, when, if the strict sequence of 18½ days was maintained, a shoal might have been expected. It seems clear then that both the oscillations of the surface salinity and the occurrence of large numbers of *Salpa cylindrica* on the surface exhibit the same periodicity, *viz.*, 18½ days, and a comparison of the two shows that the manner in which they synchronise is extremely striking. In the accompanying Text-fig. 41 I have plotted out for each day the salinity of the surface water and have given opposite each day the corre-



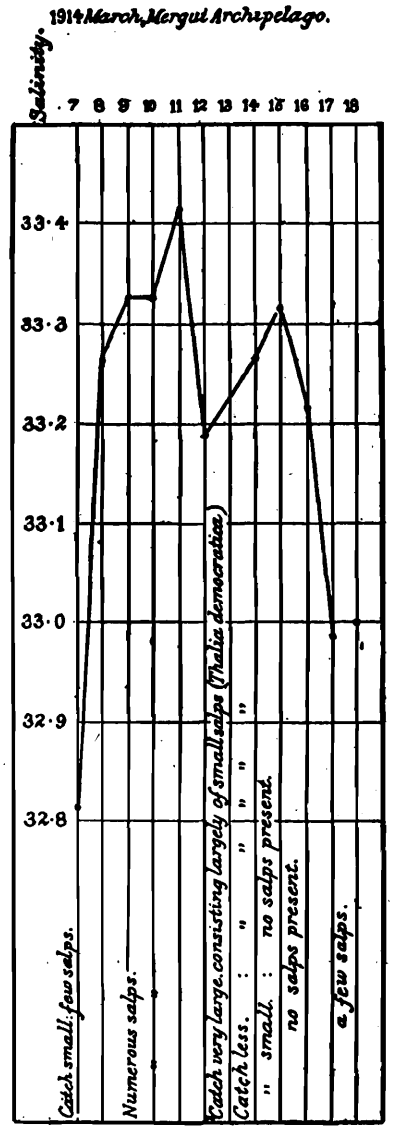

TEXT-FIG. 41.—Showing the relationship between the surface salinity and the occurrence of *Salpa cylindrica* on the surface. Burma Coast, 1911.

sponding note on the occurrence of the Salp and it is at once clear that a rise in the salinity is associated with the appearance on the surface of these shoals. In 1914, when the " Investigator " was engaged in surveying the Mergui Archipelago, a very similar periodicity was observed, but on this occasion the species present was *Thalia*

*democratica.* I give below the data regarding the occurrence of one of these shoals.

| Date. | REMARKS. |
|---|---|
| March 6-7 | Total catch small; few salps. |
| March 9-10 | Numerous salps. |
| March 10-11 | Ditto. |
| March 12-13 | Catch very large; consisting mainly of small salps (*Thalia democratica.*). |
| March 13-14 | Catch less; but still consisting mainly of small salps (*Thalia democratica.*). |
| March 14-15 | Catch small; no salps present. |
| March 15-16 | No salps present. |
| March 17-18 | A few salps. |

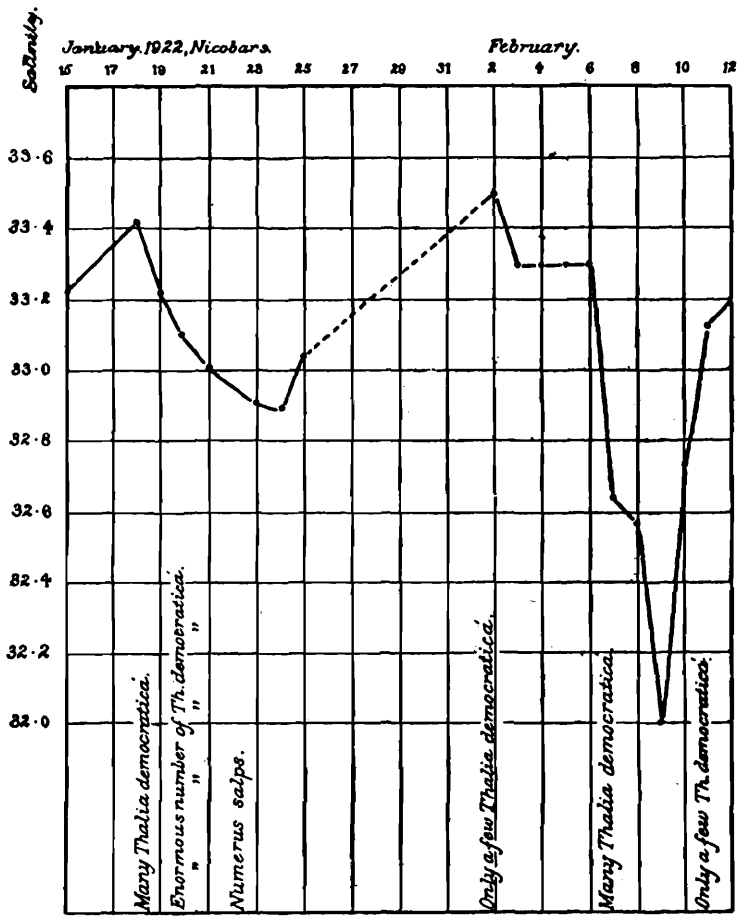
If now one compares the time of occurrence of the shoal with the rise and fall of salinity (*vide* Text-fig. 42), one sees that here again there is a very exact agreement, and the maximum concentration of Salps on the surface follows exactly twenty-four hours after the maximum




TEXT-FIG. 42.—Showing the occurrence of *Thalia democratica* in Burmese waters, 1914.

salinity. I have already mentioned that the period of oscillation of the salinity of the surface water differs in different areas of Indian waters.

During 1922-23 the "Investigator" was working in the central group of the Nicobar Islands and here it was found that the period of oscillation was fifteen days. Again I found that the appearance of shoals of Salps, again for the most part *Thalia democratica*, coincided with or followed closely after the occurrence of maximum salinity. In Text-fig. 43 I have given the observed rise and fall of the salinity of the surface-water and have indicated the prevalence or otherwise of this particular Salp. It will be noticed that the increase in numbers present on the surface follows a few days after the occurrence of maximum salinity.




TEXT-FIG. 43.—Showing the relationship of the members of *Thalia democratia* and the surface salinity, Nankauri Harbour, 1922.

The explanation of the periodic rise and fall in the salinity of the surface water in these regions appears to depend on the existence of a "Seiche." I do not propose to discuss this point in detail here, as I am at present engaged on a paper giving the full details of my observations; suffice it to say that the time periods of these observed oscillations of salinity agree, with extraordinary precision, with the theoretical time that such a "Seiche" would occupy during one complete swing, *viz.*, 18½ days for the Andaman Sea and 15 days for the Bay of Bengal. The conditions that exist in these seas, namely, a deep, more saline layer and a superficial, less saline and river-polluted layer, as well as the periodic changes from north-east to south-west in the direction of the winds during the monsoons, are ideal for the production of such

an oscillation of the deeper stratum. Round the margin of each basin or inlet each oscillation will bring the denser water nearer to the surface, and by wave action there will be a certain degree of mixing between the layers, resulting in a periodic rise and fall of salinity in the surface-water itself, and, as I believe, in a rhythmical appearance on the surface of certain species of animals and especially of those that are planktonic in character, such as the Salps, which normally live at some depth below the surface, probably somewhere about the level where the two water strata are in contact.

## LIST OF ABBREVIATIONS USED IN THE TEXT-FIGURES.

| | |
|---|---|
| *ao* | Atrial orifice. |
| *ar* | Atrial retractor muscle. |
| $as^1$, $as^2$, $as^3$, etc. | Sphincter muscles of upper lip of atrial orifice. |
| *hm* | Horizontal muscle. |
| *i.m.* | Intermediate muscle. |
| *int.* | Intestine. |
| $l^1$, $l^2$, $l^3$, etc. | Sphincter muscles of lower lip of oral aperture. |
| *or* . | Oral retractor muscle. |
| *p.p.m.* | Posterior peduncular muscle. |
| *st.* | Stolon. |
| $u^1$, $u^2$, $u^3$, etc. | Sphincter muscles of upper lip of oral aperture. |
| $vs,^1$, $vs^2$, $vs^3$, etc. | Sphincter muscles of lower lip of atrial orifice. |
| xx | Brown muscle of oral syphon in *Jasis zonaria*. |
| I, II, III, etc. | Body muscles. |
| 1, 2, 3, etc. | Tentacular processes in *Traustedtia multitentaculata*. |

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# A REVISION OF THE SUB-FAMILY CALLIPHORINAE IN THE ORIENTAL REGION.

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The present paper forms Part IV of the general revision of the old family Muscidae in the Oriental Region, of which three parts have already appeared.[1] The Group now dealt with is rather a heterogenous one, a fact which has always been recognized, Robineau-Desvoidy having separated off the non-metallic coloured genera as *Muscidae Testaceae* so long ago as 1830, a division which has persisted right up to the present day. Though Villeneuve (1920) has attempted to justify this separation on the number of pre-sutural acrostichals, the division, which is primarily based on colour, is not good, and the Group is morphologically a single unit. Biologically, however, it is not homogenous. The metallic coloured genera are saprophages, the early stages of many of which have long been known, and the life histories of some of the rarer species of which have been elucidated in recent years by Major Patton, who has shown that they include certain predatory species, and even one biontophage, though the latter is probably not truly within that class, but only secondarily so, following on septic conditions. Of the testaceous-coloured genera, the life-histories of a few of the Ethiopian species have been made out, and such have proved to be true biontophages of parasitic habit on various mammals, these including the 'Congo Floor-Maggot,' *Auchmeromyia luteola* F. and the 'Tumbu-Fly,' *Cordylobia anthropophaga* Blanch., parasites of Man. Of the Oriental species of Testaceae, only a single species has its life-history known, revealing the same mammalian-parasitic habit. In both regions, the life-histories of the large genus *Bengalia* rest in complete obscurity.

Phylogenetically, the group probably connects with the *Muscinae* by way of *Lucilia* and *Orthellia*, placed with the latter, and with the *Sarcophaginae* through *Cynomyia*. As stated in Part III of this revision there is probably a phylogenetic connection through to the Rhiniinae by way of *Anastellorhina* and *Pollenia*.

Once again, the history of the systematics of the sub-family follows along the lines given in Parts I and III of this series of papers for Sarcophaginae and Rhiniinae respectively. There is a period of profuse and

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[1] *Sarcophaginae*, by R. Senior-White, *Rec. Ind. Mus.*, xxvi, 197-283, May, 1924. *Musca*, by W. S. Patton and R. Senior-White, *Rec. Ind. Mus.*, xxvi, 553-577, November, 1924. *Rhiniinae*, by R. Senior-White, *Rec. Ind. Mus.*, xxvii, 81-96, March, 1925. It was originally intended that the present part of the Revision should be the joint work of Major Patton and the author. The former's departure to China with the Kala Azar Commission of the Royal Society threw the burden of writing up the notes and material onto myself, but it must be understood that the synonomy, especially of the metallic genera, is to be entirely credited to Major Patton, whose descriptions in this section form the ground-work for that part of the paper dealing with them.

confused description, again terminating with Bigot in 1887, and, thereafter, a gap of twenty-six years, until Bezzi in 1913 first attempted to revise the Oriental species of the genus *Bengalia*. The first general revision of the Testaceae of the World, by de Surcouf, seems to have been nearly ready for press in the following year, but the outbreak of the World War deferred its publication until 1920. From 1921 to date a series of preparatory papers by Major Patton and the author have appeared, of which the present publication is the logical outcome. In the course of their studies the author believes that Major Patton and himself have had access to all the material available in at least the British collections in the East, and to older material, including many of the types, in the museums of Europe. None the less, many old names of Walker and Bigot still require synonymizing, and the completion of the synonomy will have to wait for the catalogue which will form the final part of the revision.

As nearly every species has been treated of by Major Patton or myself during recent years, in easily accessible journals, all in one language, it has not been considered necessary to repeat descriptions in full here, only a few species which have been inaccessibly or poorly described are now re-described in full. For the remainder, references to good descriptions and figures are given, but most of the noticeable characters have been made use of in drawing up the specific keys.

Location of a species in the sub-family can be accomplished with the aid of the composite table on page 219 of Part I of this series.

| | | |
|---|---|---|
| 1. | ♂ Sub-holoptic, or frons distinctly narrowed .. .. | 2 |
| | ♂ Broadly dichoptic, as in ♀ .. .. .. | *Bengalia* R.-D. |
| 2. | Sterno-pleurals 2:1 .. .. .. .. | 3 |
| | Sterno-pleurals 1:1 .. .. .. .. | 7 |
| 3. | Vein III above bristly on node only .. .. | 4 |
| | Vein III above bristly half-way to anterior cross-vein .. | 6 |
| 4. | Eyes bare .. .. .. .. .. | 5 |
| | Eyes hairy .. .. .. .. | *Paradichosia* S.-W. |
| 5. | Facial ridges bristly for two-thirds distance to lunule .. | *Calliphora* R.-D. |
| | Facial ridges with only a few hairs above vibrissae .. | *Paratricyclea* Vill. |
| 6. | Posterior acrostichals 2 or 3 .. .. .. | *Lucilia* R.-D. |
| | Posterior acrostichals one only .. .. .. | *Phumosia* R.-D. |
| 7. | Pre-sutural acrostichals present .. .. .. | 8 |
| | Pre-sutural acrostichals merged in general pubescence .. | *Chrysomyia* R.-D. |
| 8. | Two weak presutural acrostichals. Arista strongly biplumose .. .. .. .. | *Caiusa* Surc. |
| | Always two and often three stronger presutural acrostichals. Arista bare on lower side .. .. | *Booponus* Aldr. |

## **Calliphora** Robineau-Desvoidy.

? *Mufetia* R.-D.; *Myia* Rond.; *Mya* Rond.; *Somomyia* Rond.; *Somomya* Rond.

♂ Frons greatly narrowed, ♀ frons broad. Verticals strong, crossed, no outer pair in ♂, a strong pair in ♀, also a weak post-vertical. ♀ with 2 fronto-orbitals. Arista long plumose. Acrostichals 2-3. Dorsocentrals 3 : 3. Humerals 4. Posthumerals 2. Notopleurals 2. Supra-alars 4. Post-alars 2. Sternopleurals 2:1. Scutellars 10 marginal, 2 discal. Vein I bare basally. Vein III bristly on node only.

*Key to the Oriental species of* CALLIPHORA.

| | | |
|---|---|---|
| 1. | Cheeks black .. .. .. .. | 2 |
| | Cheeks yellowish-red .. .. .. .. | *erythrocephala* Meig. |
| 2. | Hairs on cheeks reddish .. .. .. | *vomitoria* Linn. |
| | Hairs on cheeks black .. .. .. | *aucta* Wlk. |

### **Calliphora vomitoria** Linnaeus.

*Musca affinis* Macq. ; *Calliphora antarctica* Schin. ; *Calliphora brunnibarbis* R.-D. ; *Calliphora capensis* B. & Bg. ; *Musca carnaria* Scop. ; *Musca carnaria ccerulea* deGeer ; *Musca carnivora* Fb. ; *Calliphora croceipalpis* Jaenn. ; *Calliphora erythrocephala* Macq. *nec* Meig. ; *Calliphora ? fulvibarbis* R.-D. ; *Calliphora loewi* Enderl. ; *Musca obscura* Esch. ; *Calliphora vicaria* Schin.

*Head* : face blackish, white shimmering, with pale yellowish-red reflections on the jowls, often reaching to the epistome. Cheeks black, thickly covered below with foxy-red hairs. Antennae blackish-brown, third segment basally reddish-yellow, white shimmering above. Palpi reddish-yellow. ♀ frons very broad, as is also the black or brownish-red frontal stripe. Parafrons grey shimmering. *Thorax* blackish blue, with slaty-blue reflections and four black, not very distinct stripes. *Abdomen* with white and slaty-blue reflections, first segment with a narrow, blackish, posterior band and a median stripe. *Legs* black. *Wings* very pale greyish. Squamae blackish, white margined. Long. 10 mm.

Only recorded within the Oriental Region from the Simla District.

### **Calliphora erythrocephala** Meigen.

*Calliphora insidiosa* R.-D. ; *Musca lilaea* Wlk. ; *Calliphora littoralis* R.-D. ; *Calliphora monspeliaca* R.-D. ; *Calliphora musca* R.-D. ; *Calliphora nana* R.-D. ; *Calliphora scutellata* Macq. ; *Calliphora spitzbergensis* R.-D. ; *Calliphora vicina* R.-D. ; *Musca vomitoria minimus* Harr. ; *Volucella vomitoria* Fb. ; *Musca vomitoria auctt., nec* Linn.

Very like *vomitoria*, from which it separates only on the wholly yellowish-red face, and the broader frons in the ♂. Generally, it is more pollinose, and has a lighter appearance. Every other detail, including size, as in the preceding species.

Apparently enters the Oriental Region rather further than the preceding species. Though only recorded from the Simla District, I have seen numerous specimens from Cherat, N.-W. F. P. (Casling).

### **Calliphora aucta** Walker.

*Head* : frons and face black, the latter with some greyish pollen. Parafrons and parafacials black, with a few shining, whitish flecks at intervals, against the eye margins. Antennae black, base of third segment brown. Epistomal margin yellowish. Palpi orange. Genae black, with black hairs. Thorax very dark blue, almost black, with some greyish-white pollen, mainly anteriorly, but only visible in certain lights. *Abdomen* very dark, shining, metallic blue, more distinctly so than the thorax. No distinct darker bands to segments. *Legs* black throughout. *Wings* grey, slightly infuscated in costal cell. Long. 10 mm.

Found throughout the Himalaya from Kashmir eastwards, and at high elevations (over 5,000 ft.), in the Khasia Hills.

It will thus be seen that this genus hardly enters the Oriental Region proper, being confined to high elevations on its northern boundary with the Palaearctic.

## **Lucilia** Robineau-Desvoidy.

*Phaenicia* R.-D.; *Paralucilia* (p. p.) B. & Bg.; *Somomyia* Rond.

♂ Frons more or less narrowed. ♀ frons more or less wide, with inner and outer verticals and three fronto-orbitals. Arista long plumose. Acrostichals 2:2-3. Dorso-centrals 3:3. Humerals 3-4. Post-humerals 1. Presutural 1. Notopleurals 2. Intra-alars 2. Supra-alars 3, (large). Post-alars 3, (one small). Scutellars 10 marginal and 2 discal. Sternopleurals 2:1. Radius basally not ciliate above. First section of vein III bristly for half its length above and below.

### *Key to the Oriental species of* LUCILIA.

| | |
|---|---|
| 1. Two posterior acrostichals .. .. .. | 2 |
| Three posterior acrostichals .. .. .. | 5 |
| 2. Antennae black or very dark orange .. .. | 3 |
| Antennae bright orange .. .. .. | *pulchra* Wied. |
| 3. ♂ frons sub-holoptic .. .. .. .. | 4 |
| ♂ frons ¼ or more of head-width. Abdomen unbanded, first segment black .. .. .. .. | *coerulea* Wied. |
| 4. Purplish-blue species. Abdomen unbanded .. .. | *inducta* Wlk. |
| Green species with much white pollen. Abdomen distinctly banded .. .. .. .. | *albopilosa* sp. nov. |
| 5. Third antennal segment 2-2½ times length of second .. | *cuprina* Wied. |
| Third antennal segment at least 3 times length of second | *sericata* Meig. |

## **Lucilia coerulea** Wiedemann.

*Lucilia ballardi* Patt.; *Lucilia flavipennis* Macq.; *Musca metilia* Wlk.

For description see Patton (1922D) and (1922E, tab. lxiii, fig. 10), as *ballardi*. Known from Nepal, South India, Ceylon and Java.

## **Lucilia pulchra** Wiedemann.

*Somomyia coeruleolimbata* Big.; *Somomyia pagodina* Big.; *Lucilia phellia* Wlk.; *Lucilia ruficornis* Macq.

For description see Patton (1922D) and (1922E, tab. lxiii, fig. 9). Known from Bihar and Southern India, and from Java.

## **Lucilia inducta** Walker.

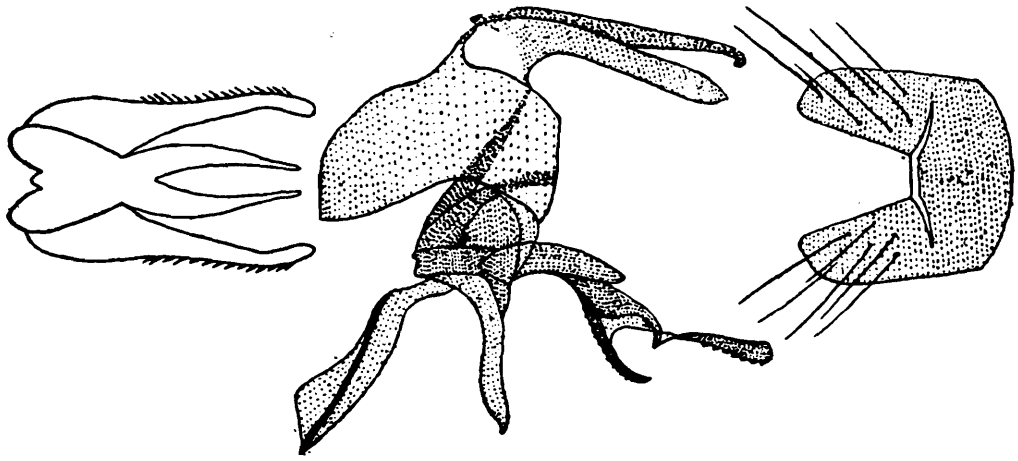
*Lucilia craggi* Patt.; *Somomyia obesa* Big.; *Somomyia pachysoma* Big.; *Lucilia porphyrina* Wlk.

For description see Patton (1922A) and (1922E, tab. lxiii, fig. 8), as *craggi*. Known from the Himalaya, the Khasia Hills, Nilgiri Hills, Ceylon, Malaya and Java.

## **Lucilia albopilosa** sp. nov.

*Head*: ♂ sub-holoptic; ♀ frons about ¼ head-width. Front black, face greyish. Parafrons and parafacia broad, silvery. Epistomal

margins dull luteous. Antennae brown. Palpi orange. Occipital margin broad, silvery. *Thorax* green, thickly covered with white pile. *Abdomen* greenish-coppery, occasionally with a bluish tinge. First segment black. Margins of other segments distinctly, though not broadly blue-



*Lucilia albopilosa*, sp. nov. ♂ genitalia.

black banded. *Legs* black. *Wings* grey, costal margin slightly infuscated. Long. 6-9 mm. Type ♂ and ♀ from Suduganga, Matale, Ceylon, 15-vi-20 and 28-vi-18, in Author's collection. Co-types in Major Patton's collection.

Known from Gauhati, North Bihar, Kallar (foot of Nilgiris), and Ceylon submontane zone.

It is improbable that this common species has escaped prior description, but neither I nor Major Patton have so far been able to identify it with any of the earlier descriptions or types.

### **Lucilia sericata** Meigen.

*Lucilia brunnicornis* Macq.; *Lucilia caeruleiviridis* Macq.; *Musca caerulescens* Meig.; *Lucilia sayi* Jsenn.

*Head*: frons and face more or less yellowish, with silvery pruinescence. ♂ front not extremely narrowed. ♀ front as broad as long, frons more than twice the width of the parafrons, which is distinctly narrower than the parafacials. Antennae black. Palpi yellow. Genal hairs black. *Thorax* green with silvery pollen. Three posterior acrostichals. *Abdomen* coppery to greenish, with silvery pruinescence. First segment darker than the others. *Legs* black. *Wings* clear, base of costa light yellowish. Long. 8-10 mm.

This Palaearctic species only enters the Oriental Region in the Kurram Valley on the North-West Frontier of India.

### **Lucilia cuprina** Wiedemann.

*Lucilia argyricephala* Macq.; *Musca fuscina* Wlk.; *Lucilia indica* R.-D.; *Lucilia leucodes* Frnfld.; *Musca serenissima* Wlk.; *Musca temperata* Wlk.

For description see Patton (1922A) and (1922E, tab. lxiii, fig. 7), as *argyricephala*.

Known from India (general), Singapore, China, Seychelles, and throughout Africa.

## **Chrysomyia** Robineau-Desvoidy.

*Paracompsomyia* Hough ; *Paralucilia* (p. p.) B. & Bg. ; *Pycnosoma* B. & Bg. ; *Psilostoma* Surc.

♂ Frons greatly narrowed. ♀ frons wide. ♂ with inner verticals only, ♀ with both pairs. Only 2 very weak fronto-orbitals in ♀, outwardly directed, not proclinate. Arista long plumose. Acrostichals 0·1. Dorso-centrals 1: 2-3, the anterior posterior one very weak. Humerals 3. Post-humerals 1. Notopleurals 2. Supra-alars 3. Post-alars 2. Sternopleurals 1:1. Scutellars 8 marginal, 2 discal. Vein I basally strongly bristled above. Vein III below bristly to cross-vein.

### *Key to the Oriental species of* Chrysomyia.

| | |
|---|---|
| 1. Wings hyaline .. .. .. .. | 2 |
| Base and costa of wing infuscated .. .. | *marginalis* Wied. |
| 2. Cheeks orange .. .. .. .. | 3 |
| Cheeks black .. .. .. .. | 4 |
| Cheeks silvery white .. .. .. .. | *albiceps* Wied. |
| 3. ♂ eye facets all same size. ♀ frontal stripe grey-brown .. | *bezziana* Villen. |
| ♂ eye with upper facets enlarged. ♀ frontal stripe red-brown .. .. .. .. .. | *megacephala* Fb. |
| 4. ♂ eyes approximated, upper facets enlarged. ♀ frons ⅓ of head width. Legs black, femora normal .. | *combrea* Wlk. |
| ♂ eyes separated, all facets equal. ♀ frons ¼ head-width. Femora blue, dilated. ♂ abdomen black fringed .. | *villeneuvi* Patt. |

## **Chrysomyia megacephala** Fabricius.

*Musca bata* Wlk. ; *Somomyia cyaneocincta* Big. ; *Lucilia cyanescens* Lw. ; *Somomyia dives* Big. ; *Chrysomyia duvaucellii* R.-D. ; *Musca dux* Esch. ; *Lucilia flaviceps* Macq. ; *Somomyia pfeifferi* Big. ; *Musca remuria* Wlk. ; *Somomyia saffranea* Big.

For description see Patton (1922B) and (1922E, tab. lxiii, fig. 2). Distributed generally throughout India and the Dutch East Indies. Ceylon. Chagos Archipelago. Guam. Australia. Does not occur in Africa.

## **Chrysomyia bezziana** Villeneuve.

*Pycnosoma dux, auctt. nec* Esch.

For description see Patton (1920) and (1922E, tab. lxiii, figs. 1 and 12). Distributed generally throughout India and Africa. Ceylon. Philippines. This species has only once been captured in nature adult, a ♂, Calcutta, in kitchen, (Strickland), —all other specimens known have been bred from larvae.

## **Chrysomyia albiceps** Wiedemann.

*Lucilia bengalensis* R.-D. ; *Musca bibula* Wied. ; *Musca elara* Wlk. ; *Musca emoda* Wlk. ; *Musca himella* Wlk. ; *Somomyia nubiana* Big. ; *Lucilia orientalis* Macq. ; *Lucilia pavonia* Schin. ; *Musca putoria* Wied. ; *Calliphora rufifacies* Frogg.

For description see Patton (1922C) and (1922E, tab. lxiii, fig. 4). In the Oriental Region it is recorded from India (general), Ceylon and Sumatra. There are some slight differences between the species in this

Region and in Africa, which might justify the separation of the Oriental form as var. *putoria* Wied., but such distinction seems hardly necessary. It occurs generally throughout Africa, and in Australia and New Zealand.

**Chrysomyia marginalis** Wiedemann.

*Compsomyia nigripennis* Hough ; *Chrysomyia regalis* R.-D.

I am indebted to Major E. E. Austen for the following redescription of this species.

*Head* : Eyes in ♂ meeting above, in ♀ separated by the orange frons, which is practically one-third of head in width ; ♂ upper eye facets enlarged. Antennae orange, arista brown. *Thorax* plum purple to metallic green, with pollinose pearl-grey transverse band on anterior and posterior borders, appearing in certain lights as a dark transverse band. *Abdomen* ground colour as thorax, basal portion of second segment and lateral patches on third and fourth segments with shimmering pollinosity ; first segment, and hind borders of second and third segments usually darker than remainder of abdomen. *Legs* metallic purplish brown or black. *Wings* hyaline, with a dark brown basal patch, which is continued as a stripe along the fore border to the end of the second vein. Long. 9-13 mm.

See also Patton (1922E, tab. lxiii, fig. 6).

A widely distributed African species which has been taken at Quetta (Baluchistan), just within the boundaries of the Oriental Region. Major Austen has also taken it at St. Vincent, Cape Verde Islands.

**Chrysomyia combrea** Walker.

*Musca defixa* Wlk. ; *Chrysomyia nigriceps* Patt. ; *Lucilia pinguis* Wlk.

For description see Patton (1922B) and (1922E, tab. lxiii, fig. 3), as *nigriceps*. Found in hill districts throughout India. Also in Malaya.

**Chrysomyia villeneuvi** Patton.

For description see Patton (1922C) and (1922E, tab. lxiii, fig. 5).

Only so far recorded from Coonoor, Nilgiri Hills.

**Phumosia** Robineau-Desvoidy.

*Ochromyia* B. & Bg. *nec* Macq.; *Plinthomyia* Rond.

♂ sub-holoptic, ♀ frons with 2 exterior fronto-orbitals. Sternopleurals 2 : 1 : Vein III bristly half way to anterior cross-vein. A pair of small bristles on the face just below the tips of the antennae.

*Key to the Oriental species of* PHUMOSIA.

1. Second abdominal segment with a median, triangular, blue patch. Third segment all blue dorsally .. *abdominalis* R.-D.
2. Second and third abdominal segments with posterior borders only blue .. .. .. .. *analis* Macq.

The difference between the two species is one of abdominal colour only, and it is probable that further material will show that they represent only forms of a single species.

**Phumosia abdominalis** R.-D.

*Head*: eyes bare. ♀ frons ¾ of an eye-width. Frontal stripe brown. Parafrontals yellowish. Antennae yellow, third segment thrice the length of second. Arista biplumose to tip. Palpi yellow, lightly claviform. *Thorax* yellow, with brown lines very slightly distinct from general coloration, and some black pile. Scutellum similar to mesonotum. *Abdomen* short-cordiform. First segment all yellow. Second segment yellow anteriorly, with a median triangular patch over posterior two-thirds metallic blue, which extends laterally towards the margins. Third segment blue dorsally, yellow laterally. Fourth segment blue anteriorly, sides and tip yellow. *Legs* yellow, tarsal segments darkened apically. *Wings* clear, base yellowish. Long. 9 mm.

I have not seen any specimens of this species. It is recorded from the Dutch East Indies, Philippines and Borneo.

**Phumosia anulis** Macq.

*Head* and *thorax* similar to the preceding species. *Abdomen* yellow, the first and second segments indistinctly bordered with violet, the third with a narrow posterior, fourth with a narrow anterior violet border. *Legs* yellow, apical segments of tarsi brown. *Wings* yellow, costal margin brownish, especially apically. Long. 9 mm.

Described from New Holland, but not since recorded from Australia. Known from the Philippines, the Molluccas, and Buru Island.

**Caiusa** de Surçouf.

Very close to *Phumosia*, differing by the sternopleurals 1:1, and the peristomal hairs being finer and more numerous than in the former genus. The small pair of sub-antennal facial bristles is absent.

*Key to the Oriental species of* CAIUSA.

| | |
|---|---|
| Disc of mesonotum dark, with broad testaceous lateral margins .. .. .. .. | *indica* Surc. |
| Disc of mesonotum all testaceous .. .. .. | *testacea* S.-W. |
| Disc of mesonotum shining black, tinged bluish posteriorly | *nigronitens* S.-W. |

**Caiusa indica** de Surcouf.

For description see Senior-White (1923A).
Known from South India and Ceylon.

**Caiusa testacea** Senior-White.

For description see Senior-White (1923A).
Known from Ceylon and Malaya. Probably occurs in South India.

**Caiusa nigronitens** Senior-White.

For description see Senior-White (1923B).
Known only from Singapore.

**Paratricyclea** Villeneuve.

♀ with two external fronto-orbitals. Internal frontals commencing below the lower external fronto-orbital. One or more small, irregular, internal frontals. Arista plumose to tip. Acrostichals 1: 1-3, the posterior may be feeble or wanting. Sternopleurals 2:1. The genotype has the third vein bristly to at least half-way to cross-vein, (in ♂ right to it), but in the Oriental species this vein is bristly on the node only. The latter have also a second weak posterior acrostichal.

*Key to the Oriental species of* PARATRICYCLEA.

1. Legs yellow. Third antennal segment not more than thrice second .. .. .. .. *asiatica* S.-W.
2. Legs black. Third antennal segment fives times second *toxopei* sp. nov.

**Paratricyclea asiatica** Senior-White.

For description see Senior-White (1923B).
Only recorded from Matheran (Western Ghats, India).

**Paratricyclea toxopei** sp. nov.

♀. *Head*: Frontal stripe black, deeply incised above by greyish-yellow ocellar area. Parafrons and parafacia greyish. Facial bristles reaching to half length of third antennal segment, but very weak in upper part of row. Antennae dark grey, third segment very elongate. Vibrissae very strong, crossed. Palpi yellow, narrow throughout. *Thorax* dark grey with paler whitish-grey areas. A pair of well-defined presutural black stripes between the acrostichals and dorso-centrals. Scutellum concolorous. Acrostichals 1: 3. Dorso-centrals 2:3. *Abdomen* black and grey tesselate. Third segment with a row of very strong marginals. *Legs* black. *Wings* grey, base of costa slightly more infuscate. Third vein bristly on node only. Long. 8 mm.

Described from Buru Island, Dutch East Indies, station 9, 17·v·21, (Toxopeus). Type in author's collection.

It is possible that the two species placed in this genus may ultimately separate off as a separate genus, or that this and the next genus, *Paradichosia*, may both sink in a slightly more broadly defined *Tricyclea* Wulp, but until the World genera are far better known in this group than they are at present it seems best neither to erect more nor yet suppress any of the genera already existing.

**Paradichosia** Senior-White.

*Head*: Eyes sparcely but distinctly pubescent, ♂ eyes closely approximated. Arista plumose nearly to tip. Cheeks about one-third the height of an eye. Facial ridges bristly to level of middle of third antennal joint. Vibrissae well above mouth margin. Genal row of many bristles. Postocular row distinct on upper half of head. Palpi elongate claviform. Proboscis somewhat elongate, haustellum twice as long as rostrum, strongly chitinized, labella small,

*Thorax*: chaetotaxy—acrostichals 2 : 3; dorso-centrals 2 : 3; post-humerals 3; humerals 3, notopleurals 2; supra-alars 2 : 2; (the posterior weak); intra-alars 2; post-alars 3 (the interior weak); propleural 1, with a decumbent tuft of bristles below it; mesopleuron with hinder marginal fan of about 8, and some hairs along upper margin and upper half of anterior margin; pteropleuron with some weak bristly hairs; sternopleurals 2:1; hypopleuron with an angled row of about 8; scutellars, a lightly crossed apical, 3 marginals and a pre-apical pair. *Abdomen*: strong marginals to second apparent segment laterally, and on all of third and fourth segments, the last with irregular discals.

*Wings*: costal spine weak. Vein I bare. Vein III bristly on node only above and below. Squamae bare.

**Paradichosia scutellata** Senior-White.

For description see Senior-White (1923A).
Only known from the Darjiling District.

**Booponus** Aldrich.

♀ only. Eye small, genae below half its height. Frons one-third of head-width, the median stripe occupying two-thirds of this. Ocellars strong. Verticals two pairs, the inner convergent. . Two small orbitals placed high up, opposite the second and third frontals. Parafrons and paraface covered with small, black hairs which extend over the genae, except in a small clear space near the vibrissae. Vibrissae hardly more than half as far apart as facial ridges at their middle. Face much depressed, receding, parafrons-paraface junction at root of antennae one-third its width in front of eye. Facial ridges hairy and sharp. Antennae small, arista bare below, pectinate above with short hairs which at longest are barely twice the thickness of the shaft, the basal half of which is very thick. Palpi normal. Proboscis short. *Thorax*: acrostichals 2-3:3. Doso-centrals 2:3. Humerals 3. Interhumerals 1. Posthumerals 2. Presuturals 2. Notopleurals 2. Intra-alars 3. Supra-alars 2. Post-alars 2. Sternopleurals 1:1. *Abdomen* without macrochaetae. Hind edge of all four segments with a row of longer hairs, not conspicuous. Sternal plates uncovered. *Legs*: mid tibia on last fourth with one small bristle on inner side and one on outer front. Hind tibia with two small bristles exteriorly. *Wings*: fourth vein nearly closing first posterior cell. Third vein with 9-10 bristles from node. No costal spine. Halteres yellow. Squama and supra-squamal ridge both bare.

**Booponus intonsus** Aldrich.

♀. Wholly light yellow, including tarsi, except a trace of brownish on anterior part of thoracic dorsum. Wings sub-hyaline with yellow veins. Front, face, genae, mesonotum, scutellum, abdomen and femora with numerous, evenly placed black hairs. Long. 6½ mm.

Only known from the Philippines, where it has been bred from the foot of the water buffalo.

## **Bengalia** Robineau-Desvoidy.

*Anisomyia* Wlk.; *Ochromyia* Macq.

*Head* : ♂ eyes as widely separated as ♀, frons one-third of head-width. ♀ with two pairs of fronto-orbitals. Clypeus, (pre-labrum, Bezzi), usually large, distinct and outstanding. Vibrissae either at level of, or well above , the epistomal margin, in the latter case associated with a specially strong development of the clypeus. Antennae long, arista strongly plumose to tip. Palpi long, at most weakly claviform. *Thorax* quadrate, often paler at borders than on disc. A prescutellar pair of acrostichals only. Dorso-centrals usually 1-2:4. Sternopleurals 1:1. *Abdomen* : third and fourth segments with marginal macrochaetae. One group of the genus has also a pair of discal macrochaetae on fourth segment. This includes all the African species. *Legs* : front tibia in ♂ in two groups of the genus bears specifically characteristic arrangements of spines. In the third group (with discal macrochaetae on IV), these spines are practically absent, but the hind tibiae then have long fringes of hairs in the ♂ sex, *Sarcophaga*-like. The resemblance to the latter genus is accentuated by the frequent development of a comb-like set of bristles on the lower side of the mid femur on its apical half. *Wings* : third vein bristly at least half way to anterior cross vein.

### *Key to the Oriental species of* BENGALIA.

| | | |
|---|---|---|
| 1. | Abdomen without discal macrochaetae on fourth segment | 2 |
| | Abdomen with discal macrochaetae on fourth segment .. | 7 |
| 2. | Clypeus strongly projecting, vibrissae far above mouth margin .. .. .. .. .. | 3 |
| | Clypeus less strongly projecting, vibrissae level with mouth margin .. .. .. .. | 6 |
| 3. | Large species, front tibia in ♂ variously armed .. | 4 |
| | Small species, front tibia with ? pairs of bristles. ♂ abdomen with two strong spines ventrally on third segment | *hastativentris* S.-W. |
| 4. | Femora and tibiae yellow .. .. .. | 5 |
| | Femora more or less black .. .. .. | *jejuna* var. *quadrinotata* Big. |
| 5. | Front tibia with 7 or more spines in one row, 5th longest | *siamensis* S.-W. |
| | Front tibia armed 5:2 .. .. .. | *jejuna* Fb. |
| | Front tibia armed 3:0 .. .. .. | *lateralis* Macq. |
| 6. | Femora with black rings .. .. .. | *escheri* Bzi. |
| | Femora all yellowish .. .. .. .. | *xanthopyga* S.-W. |
| 7. | ♂ hind tibiae shaggily fringed .. .. .. | *varicolor* Fb. |
| | ♂ hind tibiae not shaggily fringed .. .. | 8 |
| 8. | Abdomen usually blackish. Accessory forceps a plain edged plate .. .. .. .. | *bezzii* S.-W. |
| | Abdomen usually yellowish. Accessory forceps bilobed .. | *surcoufi* S.-W. |

## **Bengalia jejuna** Fabricius.

*Bengalia testacea* R.-D. *Musca torosa* Wied.

For description see Senior-White (1923A).

Occurs throughout the plains of India, as far as the Indus. Also in South India and Ceylon in hill localities. I have seen specimens from Siam (Bangkok). In the Madras Agricultural Department collection is

a ♂, Coimbatore, 5-vi-14, from pupa in soil (Ramakrishna). This would appear to be the first record of the breeding of any member of the genus. Unfortunately, the puparium has not been preserved.

**Bengalia jejuna** var. **quadrinotata** Bigot.

*Bengalia quadrinota* Big.

For description see Senior-White (1923A).

I have seen every intermediate stage between the type form and the extreme variety. Originally described as a separate species as from Ceylon, further specimens from that island have not come to hand. It is common on the Indo-Gangetic plain right up to the Indus. I have seen specimens from the Madras Presidency as far south as Walayar Forests in Malabar.

**Bengalia lateralis** Macquart.

*Musca* (*Anisomyia*) *favillacea* Wlk.; *Homodexia obscuripennis* Big.

For description see Senior-White (1923A).

I have seen Indian material of this species from Mussoorie and Naini Tal in the Himalayas to Cochin in S.-W. India. It is also known from Ceylon, Malaya and the Philippines. Walker's synonym is from Celebes.

**Bengalia siamensis** Senior-White.

For description see Senior-White (1924).

Only known from the type locality in North Siam.

**Bengalia hastativentris** Senior-White.

For description see Senior-White (1923A).

Only known as yet from the Matale District of Ceylon.

**Bengalia escheri** Bezzi.

*Head*: Frons dull greyish yellow, shortly and sparsely haired. Occiput blackish grey, with a yellow vertical mark. Face grey, a broad black fleck at level of base of antennae. Antennae, third segment yellow, darkened above and on outer side. Palpi yellow, slightly clavate. *Thorax* brownish black, with thick greyish-yellow tomentum, the short pubescence and the bristles all black. Dorsocentrals 1:4. Mesopleurae on lower half with a broad black fleck, broadly white-margined above, and in front and below bounded with a similar fleck above the fore coxae. Pleurae all over fairly long black haired. Scutellum paler (sub-opaque), marginally. *Abdomen* blackish brown, no discal macrochaetae on fourth segment. First segment with a yellow, transparent band, narrowed, but not interrupted, in the middle. Second segment with a similar band on the fore margin, broadly interrupted in the middle. Third segment sometimes with such a band on the fore margin, sometimes all black, like the fourth. The whole abdomen with much white shimmering pollen forming broad bands on the anterior halves of the segments. ♂ hypopygium black. *Legs* yellow, hind tibiae

whitish, with darker tips. Femora with broad black rings, least developed on the front and most on the mid pair, but sometimes not distinct on any pair of legs. ♂ front tibia with 6-7 strong bristles, mid femora with apical 'comb' of spines very strongly developed. ♂ hind femora shortly but thickly haired, hind tibiae with short, rather closely-set pubescence. *Wings* considerably darkened, base and fore margin somewhat yellowish. Long. 14-15 mm.

Described from Formosa, it is also found on the Khasia and Garo Hills in Assam.

**Bengalia xanthopyga** Senior-White.

For description see Senior-White (1924).

Described from Singapore and the Philippines.

**Bengalia bezzii** Senior-White.

For description see Senior-White (1923A).

Originally described from Ceylon, occurs throughout the plains of India from the extreme south of the Peninsula to the Indus. Sixty-five per cent of the collection of the Madras Agricultural Department in this group proved to consist of this generally not very common species. From notes by Isaac in this collection this species shares the habits of the larger ones of preying on ant pupae. The Cherat specimens I have seen are twice the normal size, and with their pale yellow abdomen are superficially quite unlike the general form of the species (*vide* Senior-White 1924), but the ♂ genitalia are identical.

**Bengalia surcoufi** Senior-White.

For description see Senior-White (1923A).

A Himalayan species, extending at least as far west as Dehra Dun, and eastwards onto the Khasia Hills in Assam. Also found in the Western Ghats (Matheran).

**Bengalia varicolor** Fabricius.

*Bengalia latro* Meij.

For description see Senior-White (1923A) as *latro* Meij.

The type form is browner and smaller than the blackish form described as a separate species by de Meijère, but the ♂ genitalia prove the conspecificness.

Known from South India, Ceylon, Java, the Philippines and Formosa.

**Zonochroa dioclea** Wlk.

The name of this species should be deleted from the Oriental List. I am greatly indebted to Major E. E. Austen for the following information. *Musca dioclea*, Wlk. List. Dept. B. M., iv, 869. (1849), was described from an unknown locality (given by Walker, *loc. cit.*, as " ?"). What *may* be the type is now a badly damaged specimen, minus abdomen, proboscis and palpi, and devoid of all legs, except the front femur and tibia on the right hand side. The wings agree fairly well with Walker's

escription, but in certain other respects, so far as the condition of the specimen permits judgment, there are some discrepancies, but not more so than in the usual Walkerian description.

Subsequently, when describing the Diptera collected by Wallace in Borneo, [Proc. Linn. Soc., i, 128, (1857)], Walker recorded *Bengalia dioclea* Wlk., [Cat. Dipt. iv, 869, (*Musca*)], as occurring in Sarawak, and on the strength of this record the species was included by Wulp in his Catalogue, under the genus *Ochromyia* Macq. The specimen collected by Wallace in Sarawak, and identified by Walker as his "*Musca*" *dioclea*, is still in the British Museum and bears the label "Dioclea Walk." in Walker's own handwriting, but is not conspecific with the damaged specimen, (possibly the type) referred to above, neither does it agree with Walker's description of *M. dioclea*.

With respect to the possible type of *Musca dioclea*, Wlk., which certainly belongs to the genus *Zonochroa*, Major Austen informs me that he suspects that this was actually obtained in West Africa. The Museum does not appear to possess any other examples of the same species, but a comparison with allied species suggests the conclusion stated.

In regard to the Sarawak specimen, which I briefly examined when working through the Oriental material in this group for "Senior-White 1924" this specimen is now nameless, and as I stated, is quite unlike any other Oriental species known to me. There is, therefore, at least one undescribed Oriental species of Calliphorine. The Malayan fauna probably holds further novelties in this group, as in most others.

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