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## Three Rare Tintinnoinea

By

Arthur Shackleton Campbell

During the past several years the opportunity to observe a number of different plankton samples has been my good fortune and these have come from a wide variety of localities in the Pacific and related waters. A number of different tintinnids were included in these samples and of them, there are three which are of particular importance. Two, while not new species are, nevertheless, of some interest; while the third species is described for the first time. All three species are closely related. These tropical and temperate forms are also interesting in that a great deal yet remains to be known of Asiatic plankton, for while systematic collecting has been exhaustive along the shores of our own continent and off Europe, only casual work has been done off Asia. Of course, some exploration has been carried on off Japan but the island Empire is rather isolated and does not extend far southward into the high tropics, or below the equator.

All of the material examined was preserved in weak formalin and was collected from the water circulation system of a steamer, by means of a faucet silk-net. All of the specimens discovered in this material were drawn to scale and their dimensions recorded. For the interest in collecting the material I am indebted to several sources.

### CODONELLOPSIS OSTENFELDI (SCHMIDT)

*Codonella ostenfeldi* Schmidt, 1901, p. 187, fig. 4; *Tintinnopsis ostenfeldi*, *partim*, Brandt, 1907, pp. 123, 125 (see also *Codonellopsis fenestrata*).

*Codonellopsis ostenfeldi*, Kofoid and Campbell, 1929, p. 84, *partim*, (see *Codonellopsis fenestrata* for fig. 160 and p. 84).

Description: The large, very tall and handsome lorica has a collar which is 2.2 times as long as the bowl, the collar with considerable suboral eversion forming a flaring brim, and of cylindrical shape, decreasing suddenly in its aboral 20% to a diameter of 0.7 of the oral diameter at the posterior end where it joins the bowl. The bowl is globular. The lorica has a length of 3.9 oral diameters or nearly 2.5 diameters of the bowl. The collar, below the very regular, thin and everted brim for a length of less than 6% of the length of the whole collar, is a narrow segment of an inverted, truncate cone of about 63° and immediately below this level it becomes a very symmetrical cylinder for the 0.84. Below this level it begins to contract suddenly in the remaining 0.2 and reaches a diameter of only 0.7 of the oral diameter at its level of union with the bowl; this part of the collar forms a segment of an inverted, regular, symmetrical cone of approximately 20°. The bowl is nearly always perfectly globular but in the type specimen it is about a tenth longer than wide; in the latter it reaches its maximum diameter which is 1.57 oral diameters, at a level about 0.73 of the total length below the oral margin. It rounds

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off neatly from the lower end of the collar with which it joins at the upper end, and does not form a shoulder, before it reaches the level at which it attains its greatest width. Below the latter level it narrows down somewhat more quickly than above it and describes an arc of 20% greater curvature. The aboral end is rounded evenly and regularly without any special characters.

The wall of the lorica is very regular and the lateral outline is exceedingly symmetrical and free from surface irregularities; especially is this true of the collar, but the bowl is not so irregular as in a good many of the other species of *Codonellopsis*. The suboral, flaring region of the collar is free from the characteristic fenestrae which are the outstanding character of the species and their places are taken by from one to six very narrow, tightly wound spiral bands; these are composed of minute, scarcely detectable primary prisms and they run from left to right. Below this region, which corresponds with the upper, suboral brim region of the collar the fenestrae begin to be evident. There are twelve rows of these fenestrae in the typical specimen in a vertical direction and

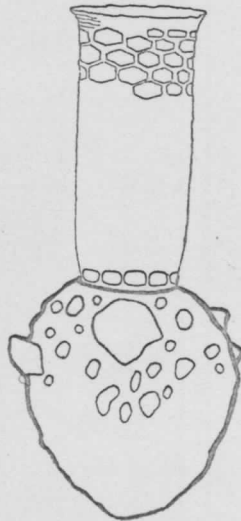


Fig 1. A lorica of *Codonellopsis ostensfeldi* from Singapore harbor.  $\times 225$ .

five rows across. They are hexagonal with rounded edges, or in other individuals they may be circular. The walls which surround the fenestrae are composed of thick beams which are lifted above the level of the enclosed panes that they surround. The rows of fenestrae ascend the collar from its lower end in a gentle spiral of approximately 30° from the vertical, and they start from the left and wind in a right hand direction toward the suboral region. The fenestrae are all about the same size and their longer dimensions are transverse to the long axis of the lorica. They continue to the suboral spiral bands from the base of the collar. All of the fenestrae are covered with thin panes. The fretwork and the panes

are composed of tiny, barely distinguishable prisms and secondary prismatic structure cannot be made out anywhere on the collar. The bowl, in sharp contrast with the collar, is heavy and blobby. Its outer surface is covered with rough, alveolar prisms of large size; a few of the blobs are very large, especially those located in the upper hemisphere. The wall of the collar is less than 0.1 of the oral diameter, while that of the bowl is twice as much, in thickness; the former is more or less uniform except suborally, while the latter is thickest in the upper hemisphere and thinnest toward the aboral end.

Nearly all of the loricae examined contained some evidence of the inhabitant but the preservation, in weak formalin, did not allow of much detailed study. There are eight oval macronuclei arranged in a spiral line although they are not connected with each other. The contracted animals fill a large part of the cavity of the bowl and, in life, must extend well out of the collar. The presence of some long cilia on the side of the body suggests that there is a ciliary membrane, and the membranelles are

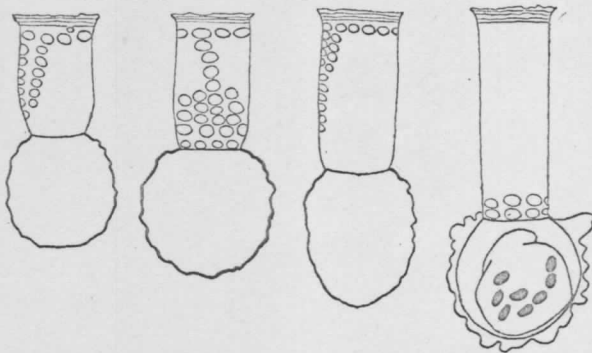


Fig. 2. Four loricae of *Codonellopsis ostensfeldi* illustrating variations in length, number of fenestrae, and in the shape of the bowl. All of these loricae came from Singapore harbor.  $\times 135$ .

probably about eighteen in number.

Dimensions: The length of the lorica ranges from 216-306  $\mu$ , that of the collar is 105-200  $\mu$ ; the oral diameter is 75-85  $\mu$ , and the bowl is 100-125  $\mu$  in diameter. The fenestrae are 6-8  $\mu$  in diameter. Schmidt's loricae were 125-204  $\mu$  in length, their collars were 77-119  $\mu$  in length; the oral diameters were 38-41  $\mu$ , and the bowls had diameters of 53-56  $\mu$ . The fenestrae were 7  $\mu$  in diameter. It is evident that my specimens are longer, on the average, and broader. Relationship with temperature is probable in regard to these differences obtaining between different collections.

Synonymy: *Codonellopsis ostensfeldi* was described by Schmidt (1901) and assigned by him to *Codonella*. Brandt (1907) also followed this usage but in certain parts of his monograph included it under the name of *Tintinnopsis ostensfeldi*. Kofoid and Campbell (1929) included

it in their enlarged treatment of *Codonellopsis*, with which genus characters it agrees in every particular. The confusion of this species with *Codonellopsis fenestrata* has been made by most authors but the two species are separated in this paper. The reasons for this separation are given in other sections.

Variation: Aside from considerable dimensional variation the bowl varies, in my material from globular to somewhat longer than a sphere and the number of fenestrae varies from as few as ten rows to a maximum, of a dozen. The proportions of the eight loricae examined were very constant, and the shape of the collar as well as its general surface differentiations, are all quite uniform characters. Schmidt's figured lorica, with a length of 4.5 oral diameters or 3.4 diameters of bowl is longer and proportionately more slender than mine. Schmidt's lorica lacks much contraction of the collar above the neck and the bowl is more pointed than in the usual run of individuals. There were sixteen rows of fenestrae as against a maximum of twelve in mine. Altogether there seems little

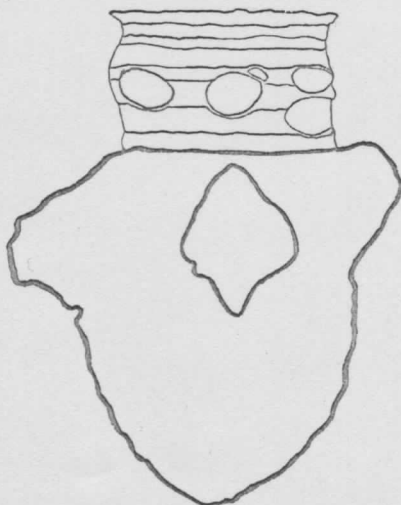


Fig. 3. A lorica of *Codonellopsis fenestrata* from Sidney harbor, Australia.  $\times 450$ .

doubt as to the identity of my specimens with Schmidt's material although this material is less variable in length.

Comparisons: Naturally, *Codonellopsis ostenfeldi* is most like *Codonellopsis fenestrata* and has been consistently confused with that species by most writers. The differences between the two are, however, outstanding. *Codonellopsis ostenfeldi* has very different proportions, being about four to five oral diameters in length, while *Codonellopsis fenestrata* is about two and a half oral diameters in length. It has ten to nineteen rows of fenestrae while the latter species has but two or three, or a maximum of six, rows of these structural elements. It has a deep supranucally constricted collar and *Codonellopsis fenestrata* distinctly

lacks this regular structural character. Its bowl is nearly always globular but that of the other species is longer than wide. Other species of the genus *Codonellopsis* have fenestrae than these two species but none have them so regularly or have so many. *Codonellopsis globosa* is somewhat like *Codonellopsis ostenfeldi* in general make up but is shorter (90 u) and much stouter—being about three oral diameters in length. *Codonellopsis americana* is somewhat similar but lacks fenestrae except as these are casual in location and few in numbers and its bowl is longer than wide. It is also smaller, being 76 to 111 u in length.

Occurrence: All of my specimens came from the harbor of Singapore where they were in moderate abundance. Schmidt's (1901) specimens came from Koh Kram, off Koh Chang, in the Gulf of Siam. This locality is not far removed from the place at which my specimens came and since there are no other records of this species elsewhere it is evident that *Codonellopsis ostenfeldi* is probably a local species in the warmest Asiatic waters.

Fission: A few specimens of *Codonellopsis ostenfeldi* gave some evidence of binary division and a lateral anlage was present with short membranelles. The lorica also gives some indication that there are definite periods involved in its formation. The collar presents three zones, as follows: a) a suboral region with spiral bands, b) a elongate cylindrical portion with vertical, spiral rows of fenestrae, and c) a supranuchal zone of contraction in which the fenestrate rows also continue. A fifth level involves the bowl. It is evident that there are two major changes in the material utilized in the formation of the shell, the collar and the bowl. The former is less dense and thin while the latter is dense and heavy. The three zones into which the collar is divided also indicate, as does the spiral disposition of the fenestrae, differential behavior as a factor in the construction of these loricae. Similar, although less marked, factors are concerned in the loricae of *Codonellopsis fenestrata* and *kofoidi*.

#### CODONELLOPSIS FENESTRATA (CLEVE)

*Codonella fenestrata* Cleve, 1901c, p. 53, pl. 7, fig. 15.

*Codonella morchella* var. *ostenfeldi*, Cleve, 1903b, p. 350.

*Codonella ostenfeldi*, Brandt, 1906, pp. 15, 17, pl. 14, figs. 1, 2, pl. 15, fig. 2, pl. 20, fig. 10; 1907 *partim*, pp. 123, 125 (see also *Codonellopsis ostenfeldi*), Okamura, 1907, p. 137, pl. 6, figs. 53a, b.

*Codonellopsis ostenfeldi*, Kofoid and Campbell, *partim*, 1929, p. 84, fig. 160 (see *Codonellopsis ostenfeldi*).

Description: The rather short, moderately thick-set lorica has a collar which is only 0.4 of the length of the bowl, the collar having some suboral eversion with something of a brim and of cylindrical shape without any sudden changes in lateral outline beyond local inequalities; it lacks any supranuchal differentiation except that it may increase a trifle in diameter near the neck. The bowl is somewhat longer than wide and it frequently has large, alveolar blobs in its upper section. The lorica has a

length of 2.2 oral diameters or nearly 1.8 diameters of the greatest diameter of the bowl. The collar has a very low, somewhat irregularly overhanging brim below which it retains about the same diameter throughout the remainder of its length. Its diameter is about 0.92 of the diameter of the spreading brim. It sets firmly into the bowl below. The bowl is about 0.8 of its length in width, and its greatest diameter is at a level of 0.46 of the total length below the oral margin. It rounds off from the wide neck which has a diameter of a little less than that of the oral aperture, to the widest level and there are four subequal, subequidistant, very large blobs near this level. These alveolar lobules are about 0.75 of their length in width or something over 0.67 of the oral diameter in length. Doubtlessly they are of some assistance to the organisms in flotation or in directed locomotion. Below the level of the greatest diameter the bowl decreases evenly and regularly to the neatly rounded but blunt aboral end.

The wall of the lorica is rather rough and with more irregularity than its neighbor, *Codonellopsis ostenfeldi*. The collar often has local bulges and contractions especially toward its mid-region. The collar is made up of a distinct, spirally wound lamina with eight to ten turns. These turns are narrowest suborally and widest toward the middle of the collar. There are eight to ten large, egg-shaped fenestrae. The largest of these is over 0.2 of the oral diameter in length. The spiral lamina is left wound and the fenestrae lean toward the opposite direction. They are contained in the widest, or middle turns of about three or four of the bands. Each of the fenestrae, which are subequal in size, is surrounded by a raised, thin, rim, and the pane thus enclosed is very thin. The bowl, aside from the very large alveolar blobs already mentioned, lacks pronounced irregularity. The collar is made up of fine primary prismatic elements, but the bowl, unlike it, is heavy and composed of denser, rougher structural elements. The wall of the collar is uniformly very thin while that of the bowl reaches upward of 0.15 of the oral diameter in local regions; generally the bowl is thickest at that part nearest the level of the greatest diameter.

The animals were found in a number of the loricae examined although, because of the preservation in formalin, very little could be made of the structure. There are, however, eight oval macronuclei.

Some specimens, at least, have coccoliths on the collar. These are narrowly oval in shape and with a dot-like, dark colored center. They probably belong to *Syracosphaera*. The coccoliths surround the rims of the fenestrae and are implanted in the trabiculae.

Dimensions: The length of the lorica is 110  $\mu$ , that of the collar is 45  $\mu$ ; the oral diameter is 64  $\mu$ , and the diameter of the bowl is 106  $\mu$ . Cleve's lorica (1901c) was 100  $\mu$  in length and the oral diameter was 40  $\mu$ . Brandt's (1907) material was 107-125  $\mu$  in length; the oral diameters were 30-60  $\mu$  and the bowls were 60-65  $\mu$  in diameter. Okamura's loricae (1907) were about 100  $\mu$  in length. The similarity in size between these various loricae from a wide variety of localities is marked.

Synonymy: *Codonellopsis fenestrata* which was described by Cleve (1901c) as a distinct species under the name of *Codonella fenestrata*, was reduced by the same author (1903b) to a variety of *Codonella morchella* as *C. morchella* var. *fenestrata*. Brandt (1907) included it with *Codonella ostenfeldi* although he expressed doubt regarding its status. He was followed by Okamura (1907) who had typical specimens of *Codonellopsis fenestrata*. Kofoid and Campbell (1929) included both *fenestrata* and *ostenfeldi* in the same species under the name of the latter and included it in their enlarged treatment of *Codonellopsis*. In this paper I have separated these two species again and presented evidence to support the contention that they are distinct.

Variation: The previous literature of *Codonellopsis fenestrata* gives indication of considerable variation. Cleve's (1901c) lorica is 2.6 oral diameters, or 2.1 diameters of the bowl in length. It has five rows of fenestrae and the sides of the bowl are somewhat flattened as in *Codonellopsis indica*. Okamura's (1907) two loricae are 2.4 - 2.5 oral diameters or 1.7 - 1.8 diameters of the bowl in length and they have five rows of fenestrae. Brandt's (1906) three excellently figured loricae, vary from 2.7 - 3.5 oral diameters or 1.70 - 1.95 diameters of the bowl in length. They have four to six rows of fenestrae and the bowls are flattened to rounded.

In my material the fenestrae are confined to only two rows to four rows of the spiral lamina while previously figured specimens have four to six rows of these striking structures. The collar is not as tall as in some specimens from the tropics and its length is possibly related in some way to the cooler water from which these specimens came. These cool water forms have more blobby bowls than the neater ones from the Indian Ocean, and it may be that the lesser number of fenestrae is also connected in some way with the same factor.

Comparisons: Brandt (1907) remarks that, "mine agree with Cleve's rather than with Schmidt's specimens." With this statement I am in full accord provided that allowance is made for Cleve's inferior figure and for differences in locality between which these different specimens came. Okamura's two figures are not much better than Cleve's but all three agree well in essential structural details.

*Codonellopsis ostenfeldi* is, perhaps, of all other species of *Codonellopsis* most like *Codonellopsis fenestrata*. The two disagree, however, in the following particulars, a) *fenestrata* always has fewer rows of fenestrae than *ostenfeldi* and the difference is always that the latter has more of these than the former species, b) the collar of *ostenfeldi* has a supranuchal contraction quite lacking in every specimen of *fenestrata*, c) the bowls are different shapes, being globular in *ostenfeldi* and with flattened sides in *fenestrata*. *Codonellopsis fenestrata* always has more fenestrae than *Codonellopsis kofoidi*, and its bowl is not Stenosemella-like as in the latter species.

Occurrence: All of my specimens were obtained in Sidney harbor, Australia, where the species constituted more than three-fourths of the

tintinnids. I have also seen specimens from the same locality which were communicated to Professor Kofoid from Dr. Dakin of the University of Sidney. It is evidently a common enough form along the coast of western Australia.

Previous records of *Codonellopsis fenestrata* were made by Cleve (1901c) from off the coast of Malay, and (1903b) from the Red Sea and the Arabian Sea. Okamura (1907) had specimens from off the Province of Tosa, Japan. Brandt (1907) recorded it from Borneo and from Zanzibar.

*Codonellopsis fenestrata* is evidently a widely spread, more or less subpelagic species mainly found in the southern hemisphere.

*CODONELLOPSIS KOFOIDI* SP. NOV.

Description: The short, plump, rounded lorica has a very low collar the length of which is only 0.13 of the length of the bowl, the collar with some, almost insignificant, suboral eversion, with a cylindrical shape and with a little median constriction: it lacks supranuchal modification. The bowl is a little less wide than long and usually has heavy, large, alveolar blobs, especially in the upper part. The lorica has a length of about 2.0-2.7 oral diameters, or 1.0-1.4 diameters of the greatest diameter of the

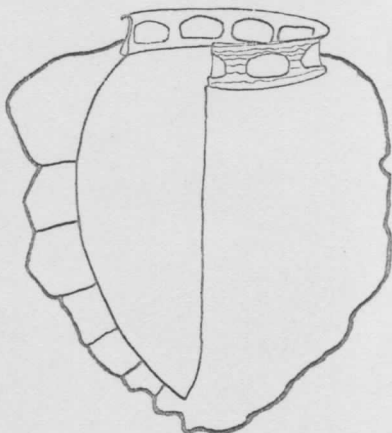


Fig. 4. A lorica of *Codonellopsis kofoidi* from Hong Kong.  $\times 450$ .

bowl. The collar has a very low, slightly overhanging, irregular brim below which it retains approximately the same diameter throughout with the exception that it is constricted to as much as 0.9 of the diameter of the brim toward the middle. Below the constricted region it swells out again and reaches the same diameter as that of the brim at the level of its junction with the bowl. It sets firmly into the bowl below. The bowl is about as long as wide and reaches its greatest diameter at a level 0.29-0.40 of the total length below the oral margin. It rounds off rather evenly and fairly suddenly to the level of greatest diameter from the narrow neck which is 0.52-0.61 of the greatest diameter in diameter. This region



is often, but not always, provided with very heavy, irregular, alveolar blobs. Some of these blobs, of which there are a considerable number, contain evidence that they are formed of smaller, secondary prismatic elements. Below the widest level the bowl usually decreases evenly and regularly to the bluntly pointed aboral end and lacks the heavy superstructure of the upper region of the bowl.

The wall of the lorica is rough and usually with heavy, irregular blobs. The collar lacks local modifications of considerable extent and is made up of a spirally wound lamina with three or four moderately wide suboral turns. There are four to ten quite large subrectangular fenestrae. They are all subequal and occupy about half of the length of the collar. The spiral lamina is left wound and the fenestrae lean toward that side of the collar. The fenestrae are surrounded by thin, raised, more or less puckered brims and the panes enclosed are much thinner than the rest of the wall. The collar is made up of very fine, primary prismatic structure but the panes appear to be structureless. The bowl is made up of the large, tertiary blobs already mentioned. The collar is very thin but the wall of the bowl ranges from 0.22 of the width of the greatest diameter of the bowl to a little less than 0.1 of the same diameter at the aboral end.

The animal is large, has approximately twenty membranelles and eight macronuclei. There is often a closing-apparatus with eight or ten blades while the posterior part forms a sack in which the body is loosely enclosed. Cocoliths were not observed on the collars but irregular, stringy material sometimes adheres to it and to the upper parts of the bowl.

Dimensions: The lorica has a length of 110  $\mu$ , and the collar is only 6  $\mu$  in length; the oral diameter is 64  $\mu$ , and the bowl is 106  $\mu$  in diameter. Most of the specimens do not vary greatly from these recorded dimensions.

Variations: *Codonellopsis kofoidi* is variable in the level at which the bowl reaches its greatest diameter, from 0.29 - 0.40 of the total length from the oral end. The bowl is considerably filled out with large blobs in some specimens and is quite regular in others. The number of fenestrae may be as few as two or three in some individuals and reaches up to ten in others; the lesser number is generally rarer than the greater number. In a similar way the spiral lamina made either a few obscure turns or more often has several of these. The fenestrae are either ovoidal or more often subrectangular. The striking characters of *Codonellopsis kofoidi* are the low, fenestrate collars and large, frequently blobby, bowls.

Comparisons: Although *Codonellopsis kofoidi* resembles *Stenosemella*, and especially those species which have lunulate window panes such as *S. pacifica*. *S. inflata* and more especially *S. punctata* there is no question that it does not belong to that genus. The grounds for this determination are these: a) the collar is spiral and not annular as in most of *Stenosemella*, b) the windows are not lunulate but instead rectangular, c) the collar is higher than that of *Stenosemella*, d) there is an overhanging brim such as is generally lacking in *Stenosemella* and lastly, e) the

animals have eight nuclei and a closing-apparatus such as is general in *Codonellopsis* and in contrast with all of the species of *Stenosemella* which have two nuclei and no closing-apparatus. The affinities of *Codonellopsis kofoidi* are with *Codonellopsis ostensfeldi* and with *Codonellopsis fenestrata* for these three species constitute the regularly fenestrate series of the genus; while it is true that other species have occasional fenestrae in these three species they are numerous, regularly spaced and in one to many definite rows. The bowl has a *Stenosemella*-like irregularity and blobbiness unlike the majority of the members of the genus, except, perhaps, *Codonellopsis tuberculata* which has, also, a low collar like *Codonellopsis kofoidi*. It shows clearly the interrelations of these genera and species and suggests that *Codonellopsis* may have had a *Stenosemella*-like ancestry.

*Codonellopsis kofoidi* does not have as many rows of fenestrae as either *Codonellopsis fenestrata* or *ostensfeldi*, having but one row instead of between four and nineteen and its bowl is unlike that of either species. It has fenestrae which *Codonellopsis tuberculata* wholly lacks.

Occurrence: All of my specimens came from Hong Kong about half way between Victoria and Kau Lung where they were obtained in considerable abundance, constituting about half of the tintinnid plankton. Since *Codonellopsis kofoidi* has not been recorded elsewhere it may be a local, subpelagic species in warm, Asiatic waters.

It is with singular pleasure that I select the name of this species, which appears to have some value as a connecting link between the genus *Codonellopsis* and *Stenosemella*, and call it after my distinguished teacher and colleague, Professor Charles A. Kofoid.

#### Summary

The three species which are included in this paper constitute a remarkably closely related series. All of them have fenestrate collars, but unlike other species of *Codonellopsis*, the fenestrae are regularly spaced and usually nearly equal in size. Beginning with *Codonellopsis kofoidi* which is the simplest one, the next in order is *Codonellopsis fenestrata* which is somewhat larger and has several rows of fenestrae, and the last is *Codonellopsis ostensfeldi* which has many rows of fenestrae and is the longest of the three species. It is thus evident that none of them belong in the *Codonellopsis morchella*-series where Brandt (1907) placed *Codonellopsis ostensfeldi*. Instead the three species are a homogeneous group, distinct from others. Their serial arrangement suggests that they have had a common origin and that the series is an orthogenetic one, in which increasing length, and number of fenestrae have been the advancing characters. It is interesting, and probably significant that both of these characters are quantitative in nature and that the progressive changes have been in the nature of additions.

The origin of *Codonellopsis* from *Stenosemella* is suggested by the similarity of the bowl in the two and by the fact that both genera have hyaline collars with a certain amount of spiral structure evident. The

presence of windows in the collars of some species of *Stenosemella* and of a single row of them in *Codonellopsis kofoidi* suggests genetic connections of great probability. The tendency to form windows also occurs in the genus *Dietyocysta* but in that genus the tendency stops with a maximum of two rows, which is attained in but a few of the many species. In *Codonellopsis* the tendency to form fenestrae continues and as many as nineteen rows are formed; there is in this character, then, a suggestion of relationship between these very distantly related genera.

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#### LIV CRUSTACEA

##### Schizopoda

Koehler, 1897, gave the first comprehensive account of the nervous system of *Mysis*.

The ventral ganglia are very simple, about one for a segment, and

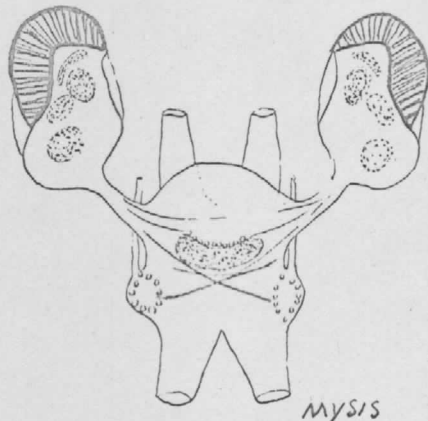


Fig. 140. Nervous system and eye of *Mysis* after Bellonci.