FISH EGGS AND LARVAE FROM THE JAVA SEA [1])

by

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18. The genus Cybium,

with remarks on a few other Scombridae.

Determination of the number of myotomes is a valuable expedient — too little made use of thus far — in identifying the pelagic larvae of fishes and, by means of these, the eggs from which they hatch. The efficiency of this method is, however, limited by three difficulties. As a matter of fact the total number of myotomes in the larva corresponds fairly well to the number of vertebrae in the adult. Generally it is not easy, indeed, to determine exactly which is the last myotome in the tail, the limits becoming gradually less distinct. But this first difficulty is the least serious of the three, as approximate determination is quite possible and proves fairly reliable.

The determination of the foremost myotomes is, as a rule, not difficult. More exact results, therefore, could be obtained in this direction, if we could rely on the constancy of the number of trunk, i.e. pre-anal, myotomes and vertebrae, i.e. if the place of the anus should be fixed. We have repeatedly seen, however, that this is by no means the case. In clupeid fishes we have found it to be a general rule that the anus moves forward, often over a fairly considerable distance, during the metamorphosis of the larva into the young fish. By this process the number of trunk segments increases and that of the tail segments decreases at the same rate. On the reverse, we have seen that in the genus *Trichiurus* a similar backward shifting of the anus during development takes place. Thus the evidence afforded by counting the number of trunk myotomes in the larva must be handled with caution. Its results are more or less reliable only in combination with different other considerations.

A third difficulty in identifying fish larvae by means of the number of myotomes is afforded by the fact that there are large groups of fishes in which the number of vertebrae shows, if any, only an insignificant variation. In herring-like and eel-like fishes, with a relatively high number of vertebrae, the variations may be considerable and may be found even between closely related species. In marine percoid and related fishes, however, the number of vertebrae and myotomes is fairly well fixed, being as a rule about 10 + 15. It seems, therefore, a hopeless task to identify the various eggs and larvae of these fishes by means of this feature.

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1) cf. Treubia Vol II, p. 97, Vol III, p. 38, Vol V, p. 408, Vol VI, p. 297, Vol VIII, p. 199 and p. 389, Vol IX, p. 338, Vol XI, p. 275, Vol XII, p. 37 and 367 and Vol XIII, p. 217.

A group of fishes which gives more hope of success in this respect is that of the Scombriformes, comprising the Carangidae, Scombridae, Trichiuridae and a few smaller families. The number of vertebrae is often fairly high and subject to considerable variations. As a matter of fact, for the genus *Caranx* 10—14 seems to be characteristic, for the higher forms, such as *Caranx gallus*, as well as for the more elongated species. In different species of *Chorinemus* I counted 10—15 or 16. These numbers deviate very little from those found in percoid fishes.

For the Scombridae and Echeneidae, however, I found in:

Elacate nigra	11 + 14 = 25
Echeneis naucrates	14 + 16 = 30
Scomber kanagurta, neglectus	13 + 18 = 31
Euthynnus thunnina	19 + 19 = 38
Cybium commersonii	20 + 25 = 45
Cybium kuhlii	20 + 25 = 45
Cybium guttatum	20 + 25 = 45
Cybium lineolatum	21 + 29 = 50

In the Trichiuridae, finally, these numbers are:
Lepidopus caudatus 41 + 70 - 73 = 110 - 113 (STRUBERG, 1918)
Trichiurus sp. div. 30 - 40 + 115 - 131 = 155 - 167.

We have dealt with the latter family in a previous article (Treubia, Vol. IX, p. 338) and will occupy ourselves now with the Scombridae only. In this group of rapid pelagic swimmers the number of vertebrae tends to increase, and at the same time the anus tends to shift backward. The pelvic bones, however, remain directly attached to the cleithra, as has been shown by TATE REGAN [1]).

Only in the Trichiurids this direct connection gets lost and at the same time the pelvis itself, together with the ventral fins, gets rudimentary or disappears altogether. Where it is still present, as in *Lepidopus*, the connection consists of a long ligament.

The sheerfishes, belonging to the genus *Cybium* Cuv., or *Scomberomorus* Lacépède, are represented in the Java Sea by several species, all known as t e n g i r i (malay). They are fairly large-sized fishes, regularly to be found at the fish market and much appreciated by their consumers. One of the commonest species is *Cybium guttatum* which seems to frequent the neighbourhood of the river mouths. Evidently it is closely related to the so-called spanish mackerel, *Cybium maculatum* of Cuvier, *Scomberomorus maculatus* Mitchill of most later authors. This is found as well along the Atlantic as along the Pacific coast of tropical America [2]). Its eggs and early development have been carefully studied and described about half a century ago by JOHN A. RYDER [3])

[1]) C. TATE REGAN, 1909, On the Anatomy and Classification of the Scombroid fishes. Ann. Mag. Nat. Hist. Vol. III (8th series).

[2]) cf. MEEK and HILDEBRAND, 1923, The Marine Fishes of Panama, Part I p. 325.

[3]) RYDER, J.A. 1882, Development of the Spanish Mackerel (*Cybium maculatum*) Bulletin U.S. Fish Commission, Vol I, for 1881.

who succeeded in carrying out artificial fertilization. He pointed out that spawning finds place at night, as I have found to be the case with many Indian species also. At the same time he gives us the solution of the problem why artificial fertilization of the eggs of tropical seafishes has yielded so little success thus far. The supposition that the fishes mentioned above have fully ripe eggs only against night seems to be obvious. This supposition is confirmed by RYDER's experience: only at night did he succeed in obtaining artificial fertilization. Regarding the eggs of the japanese mackerel (*Scomber japonicus*) KAMIYA [1]) observes: "By the continuous collection of the natural eggs, the spawning-time was found to be strictly confined from sunset to sunrise, with its height between sunset and midnight".

In the Java Sea, along the coast and especially near rivermouths, we may fairly regularly find an egg showing a great resemblance to the one described for *Cybium maculatum* by RYDER. I was struck by this resemblance, however, only after I had independently come to the conclusion that this egg belonged to *Cybium guttatum*.

I had arrived at this conclusion i.a. by the method of counting the myotomes of the larva, a method neglected by RYDER as well as by most later workers on the development of pelagic fish eggs. And I thought my conclusion satisfactorily confirmed when the egg of *Cybium guttatum* proved to bear such a close resemblance to that of *Cybium guttatum*.

The egg of *Cybium guttatum* has, as a rule, a diameter of 1,1—1,2 mm, that of *Cybium maculatum*, according to RYDER, a diameter of $^1/_{25}$ to $^1/_{20}$ inch = 1,0—1,27 mm. Practically speaking therefore these values coincide. The egg contains an oil-globule of which the diameter may vary from 0.3 to nearly 0.4 mm, whereas in the egg of *Cybium maculatum*, according to RYDER, it hardly surpasses 0.25 mm (0.01 inch).

Sometimes, however, I have found bigger eggs, with a bigger oil-globule. They seem to occur especially in river mouths where the water is more or less brackish. So in the mouth of the Sampit (Borneo) I found the diameter of the egg to vary from 1,13 to 1,26 mm, that of the oil-globule being 0,45 mm. In the mouth of the Koemai (Borneo) these values were 1,24—1,32 and 0,5 resp. and near Bengkalis (Sumatra) I found even eggs with a diameter of 1,36 mm and an oil-globule of 0,56 mm. The salinities in these three places were 26‰, 25,5‰ and 23‰ resp. So not only the diameter of the egg but also that of the oil-globule seems to increase when the salinity of the water gets lower. The dimensions given first were those of eggs fished in water with a salinity of 30—32‰, near Cheribon (Java), Bagan Si Api Api and Amphitrite Bay (Sumatra). I once found three eggs with a diameter as low as 1,05 mm in water with a salinity of 32,8‰ (near Tandjong Bobos, north coast of Java, Sept. 20th, 1929). So we easily come to the conclusion that the size of the egg depends on the salinity of the water, increasing or decreasing in proportion to the latter getting lower or higher. The same phenomenon has been

[1]) Journal Imp. Fisheries Institute Vol. 21, p. (30), 1925.

observed in other pelagic eggs, the eggs of the Baltic Sea fishes e.g. being bigger than the corresponding eggs of the North Sea. The same phenomenon will probably be observed in other eggs from the Java Sea also. So I have described in nr. 14 of this series (Treubia Vol. IX, p. 37) two *Pellona* eggs differing in hardly any respect but their size. The eggs are often found together with those of *Cybium,* occurring in the same localities. The smaller one was ascribed by me to *Pellona elongata,* the bigger one to the closely allied *P. amblyuroptera.* Considering the salinity of the water in which they were found, we see that the smaller egg occurred in water with a salinity of 29,2 $^0/_{00}$ —29,6 $^0/_{00}$, the bigger one was found near Bagan (Sumatra) in water of 28,8 $^0/_{00}$ and afterwards in great numbers in the Kumai (Borneo) in water of 25,5 $^0/_{00}$ (Sept. 30th and Oct. 1st, 1930). Here the diameter of the eggs (without the gelatinous coat) amounted to 1,6—1,8 mm. On the other hand I found the smaller eggs afterwards in water of 34,2—34,4 $^0/_{00}$ (near Sumatra and Gresik, October 3rd and 6th, 1930). Here the diameter was 1,44—1,5 mm (without gelatinous coat). I feel inclined now to ascribe these variations no longer to a specific difference, but to the influence of the salinity. In the light of this it seems to me more doubtful than ever whether *Pellona elongata* and *amblyuroptera* are to be considered as separate species or as variations only.

The same probably holds good, partly at least, for the eggs of *Cybium guttatum,* but, as we shall see further on, we may not lose sight of the possibility that among the eggs mentioned in this article there may be also some which belong to other species of *Cybium.*

The egg of *Cybium guttatum* was found in great quantities fairly high up the river Kumai (Borneo) towards the end of the east monsoon (Sept.-Oct.), together with the above-mentioned eggs of *Pellona elongata* or *amblyuroptera,* and with the eggs of *Stolephorus baganensis.* During the east monsoon the whole lower part of that river is flooded with seawater, and sea fishes, especially *Cybium guttatum* and *Pellona* spp, are caught then by the inhabitants of the village of Kumai, situated about 12 miles from the mouth.

Fig. 1. Egg from the Kumai (Borneo), fished off the village of Kumai, September 29th, 1930, 11 a.m. × 26.

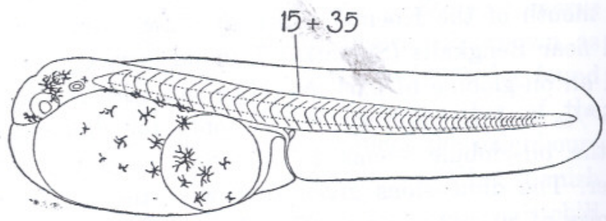

Fig. 2. Newly hatched larva from similar egg, × 26.

The *Cybium* eggs fished in the morning (fig. 1) all show a young embryo with the tail growing out. Black pigment spots are present on the left and right sides of the trunk of the embryo and on the dorsal surface of the yolk (so in fig. 1 they are seen through the yolk, not on the surface exposed to the observer).

The colourless oil-globule is situated ventrally. Branching black pigment spots are present on the inner half of the oil-globule, i.e. the side turned towards the yolk (so, in fig 1 they also are seen through the oil-globule). Yellow pigment dots, too, were observed now and then.

As a rule hatching occurs in the course of the afternoon. A few times, however, I saw these eggs hatch during the morning already.

The newly hatched larva is represented in fig. 2. The young larvae again offer a great resemblance to those shown by RYDER for the Spanish mackerel. A certain likeness to the larvae of *Trichiurus,* described by me in nr. 11 of this series, cannot be denied either. A fairly high number of myotomes, especially in the tail, is characteristic of both groups of larvae. In *Cybium* indeed the number is not nearly so high as in *Trichiurus*. I counted 14 myotomes in the trunk and about 35 in the tail, thus

$$15 + 35 = 50$$

whereas in the adult *Cybium guttatum* the number of vertebrae is

$$20 + 26 = 46$$

As a rule in newly hatched fish larvae we could count a few more tail myotomes than in larvae of 1 or 2 days old. Here also in slightly older larvae no more than 33 tail myotomes could, as a rule, be counted. I got the impression that also the number of trunk myotomes showed a slight decrease in these latter stages, the total number not surpassing 13 or 14. So in a larva of 3 days old I counted

$$13 + 33 = 46$$

which tallies with the total number of vertebrae in the adult.

Such a slight decrease of the number of trunk vertebrae during the first

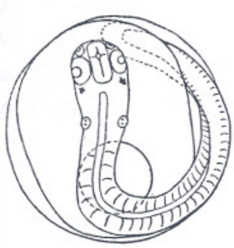

Fig. 3. Egg from Amphitrite Bay (Sumatra), immediately before hatching, November 22th, 1923, 8.30 a.m. × 26.

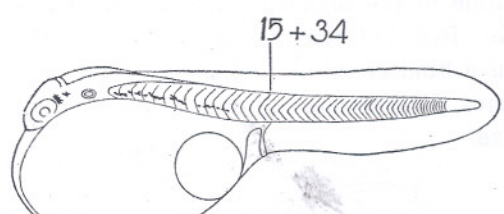

Fig. 4. Newly hatched larva from similar egg, × 26.

days after hatching was observed by me in *Trichiurus* also. Afterwards, however, it is followed by a backward movement of the anus causing the number of trunk myotomes to increase and that of the tail myotomes to decrease. If now we compare the numbers of vertebrae in the adult *Cybium guttatum* with the numbers of myotomes in the larva we see that also in *Cybium* the anus moves backward, just as we found this to be the case in *Trichiurus*. In the latter genus we stated a backward shifting over a distance corresponding to about 10 myotomes, in *Cybium guttatum* to 6 or 7 myotomes. This gives us reason to suggest that, whereas a forward shifting of the anus during larval development is characteristic of the clupeiform fishes (cf. nrs. 2, 4, 7, 8, 10, 12, 13, 14, 15 and 17 of this series), a backward shifting of the anus is equally typical of the Scombroid fishes, at least of the more elongated forms.

Returning to the larva of fig. 2 we see that, just as in the egg, branching black pigment cells are present on the upper surface of the yolk and also of the oil-globule. On the head too a few similar pigment cells are present in front of and behind the eyes. No pigment is to be found in the tail. During further development pigmentation does not increase, the black pigment cells of the yolk surface gather at the inferior border of the trunk myotomes.

The description given above applies especially to the eggs fished in the Kumai and Sampit (Borneo). The eggs fished near the mouths of the Rokan and the Indragiri and near Bengkalis (Sumatra) do not show the branching black pigment cells on the dorsal part of the yolk but only a row of small pigment cells along the trunk myotomes, as shown by figs. 3—6. The surface of the yolk is practically free of pigment.

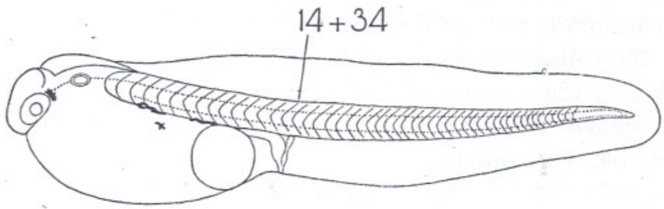

Fig. 5. Larva in the evening of the same day. × 26.

Eggs fished near Cheribon (Java) show again a somewhat different distribution of the pigment cells, as may be seen from figs. 7—9. Here the yolk is also free, but the pigment extends into the tail region and in fig. 9 even forms a kind of ring round the tail myotomes as may be noted also in RYDER's pictures. Yellow pigment was also well developed in these Cheribon eggs and larvae.

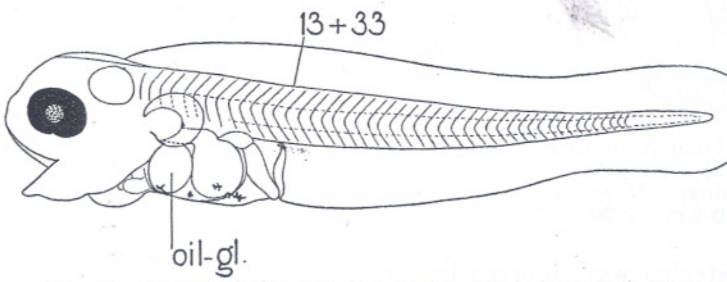

Fig. 6. Larva of the second morning after hatching. × 26.

The stage in which the eyes are black is reached about two days after hatching. The yolk has been practically resorbed then, but not the oil-globule.

Besides *Cybium guttatum* a few other species of *Cybium* are taken regularly in the Java Sea. I counted the number of vertebrae in the following species for which I found:

Cybium guttatum	$20 + 26 = 46$
Cybium commersonii	$20 + 25 = 45$
Cybium kuhlii	$20 + 25 = 45$
Cybium lineolatum	$21 + 29 = 50$

The four species show no great differences in the numbers of vertebrae. May be the eggs will not differ very much from each other either. As mentioned above, I have observed certain variations in the pigmentation of the newly hatched larvae. It is not impossible that these larvae, partly at least, belong

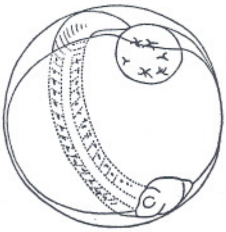

Fig. 7. Egg from the Bay of Cheribon (Java), April 27th, 1929, 8 a.m. × 26.

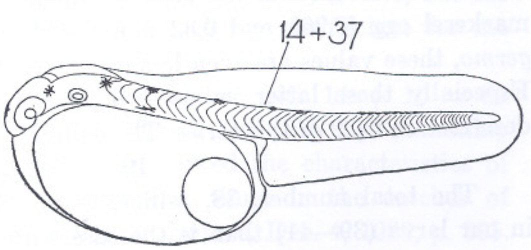

Fig. 8. Newly hatched larva from similar egg, 11 a.m. × 26.

to different species and that part of the differences shown by the eggs themselves must be explained in the same way. In Bagan Si Api Api e.g. *Cybium kuhlii* is the commonest species and one might therefore ask if not the egg and larvae of figs. 3—6 belong to this and those of figs. 7—9 to another species again. At present, however, we cannot get a definite answer to these questions.

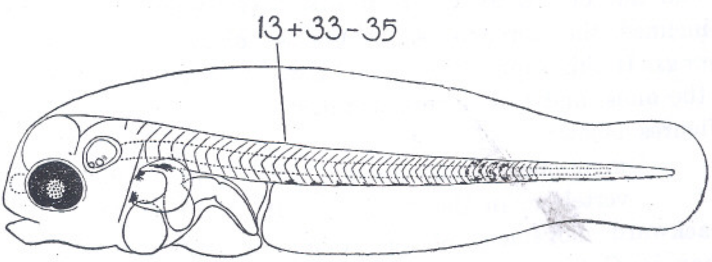

Fig. 9. Larva of the second morning after hatching. × 26.

What about the related genus *Scomber*? The Indian species of this genus have the same number of vertebrae as the European *Scomber scombrus*, viz. $13 + 18 = 31$. These species (*Scomber kanagurta*, *neglectus*) are fairly common in Indian waters and one might expect to find their eggs earlier or later in the catches of the egg net. Indeed, I have shown in nr. 9 of this series (Treubia Vol. VIII, p. 395) an egg which I ascribed to *Scomber kanagurta*. There was, indeed, one difficulty: the number of myotomes in the larva proved to be about

10 higher than the number of vertebrae in the adult. It was especially the number of tail myotomes which was higher than one might expect and this made me write already at that time: "this incongruity is apt to throw serious doubt on the correctness of our identification".

Since then, another possibility has occurred to me, viz. that the egg of nr. 9 should not belong to *Scomber* but to *Thynnus thunnina,* the tongkol. The latter also is caught regularly along the coast of Bawean (cf. nr. 9), be it not with the pajang-net but with hooks dragged behind fast-sailing outrigged canoes. SANZO [1]) has shown that the eggs of the big mediterranean tunny have about the same diameter (1—1,12 mm) as the eggs of the so much smaller mackerel (± 1,1—1,2 mm, according to SELLA and CIACCHI [2]), and contain an oil-globule the size of which is slightly smaller than that of the mackerel egg (0,265 and 0,32 mm resp.). For the long-finned tunny, *Orcynus germo,* these values are even less (diameter of egg 0,9, of oil-globule 0,24 mm [3]). Especially these latter values tally perfectly with what I found for the egg described in nr. 9 of this series. The number of vertebrae in *Thynnus thunnina* is:

$$19 + 19 = 38$$

The total number, 38, tallies better with the total number of myotomes in our larva (39—41) than is the case with *Scomber* (31). SANZO also mentions that he has counted 39 segments in the larva of *Orcynus thynnus,* 39—40 in that of *Orcynus germo.* For the number of vertebrae of these two species PARMA [4]) gives 39 and 40 resp. I was struck especially by the similarity in pigmentation of the tunny larva and our larva. In nr. 9 of this series (p. 397) I wrote: "I found a pair of yellow pigment spots close behind the eyes, another pair at a slight distance behind the otocysts, about the anterior myotomes, a third pair near the anus and one more about the middle of the tail". In the newly hatched tunny larva SANZO found: „je zwei gelbe Pigmentflecke vor und hinter den Augen sowie hinter den Gehörblasen, ferner über dem After und auf der Mitte des Schwanzes" (EHRENBAUM, p. 15 [5]).

I feel inclined, therefore, to ascribe the egg of nr. 9 no longer to *Scomber* but to *Thynnus.* If this supposition is right we must assume again a backward shifting of the anus, and this over a distance of about 9 myotomes, as follows from the figures below:

myotomes in the larva	$10 + 30 = 40$
vertebrae in the adult	$19 + 19 = 38$

The backward movement of the anus, therefore, would be greater in *Thynnus* than in *Cybium* where it amounts to 6—7 myotomes only. This is

[1]) L. SANZO, 1929. Uova e larve di tonno (*Orcynus thynnus* LTKN). Rendiconti della R. Academia Nazionale dei Lincei, Vol. IX, p. 104.

[2]) M. SELLA and O. CIACCHI, 1925, Uova e Larva dello Sombro del Mediterraneo (*Scomber scomber* LINN.). R. Comitato Talassografico Italiano, Memoria CXIV. For the egg of *Scomber japonicus* KAMIYA (1925 l.c.) gives a diameter of 0,93—1,15 mm.

[3]) L. SANZO, 1925, Uova e larve di Alalonga (*Orcynus germo* LTKN). Rendiconti R. Acc. Naz. Lincei, Vol. I, p. 131.

[4]) C. PARMA, 1919, Il tonno e la sua pesca. R. Comitato Thalassigrafico Italiano, Memoria LXVIII.

[5]) E. EHRENBAUM, 1924, Scombriformes, in Report Danish Oceanographical Expeditions 1908—1910 to the Mediterranean. Vol. II.

not exactly what one might have expected in view of the fact that the total number of vertebrae is lower in *Thynnus* than in *Cybium*. A smaller backward shifting would have answered our expectations better. Let us hope that future investigations on the numbers of myotomes in fish larvae, also in Europe and other parts of the world, will bring us nearer to the solution of this apparent incongruity.

Taking into consideration what we have found for *Trichiurus, Cybium* and *Thynnus,* we may expect a similar backward movement of the anus in the larvae of *Scomber*. In the adult fish the number of vertebrae is $13 + 18 = 31$. Thus in the larva we might expect something like $10 + 22 = 32$ myotomes. Among the numerous pelagic eggs from which I have reared the larvae there are some indeed in which the latter have similar numbers of myotomes, but the evidence that these eggs belong to *Scomber* is as yet too insufficient for me to venture to describe them as such.

Finally we have the sucker-fish, *Echeneis naucratus,* with $14 + 16 = 30$ vertebrae. I have been able to identify the eggs of this fish by examining quite mature females, in which the ovarial eggs showed the characteristics of certain planktonic eggs which I had found several times in the catches of the egg net. I have mentioned this egg in a note in Nature, Dec. 4, 1926, p. 805. The identification has been confirmed by a paper of SANZO (1927) [1]) who, in the Red Sea, found quite similar eggs and has identified them as belonging to *Echeneis naucrates* in exactly the same way as I did. Moreover, SANZO had more success than I in rearing the larvae from these eggs. As far as I know, however, he has not given any figures yet.

Fig. 10 shows an egg fished May 16th, 1924, at 11 a.m., south of Bawean (salinity 31 ‰). Generally speaking I have the impression that these eggs are more numerous in the eastern half of the Java Sea than in the western half. They are conspicuous by their big size, the diameter varying from 2,45 to 2,65 mm (SANZO gives 2,50—2,60 mm). The yolk is homogeneous. It contains a relatively small yellow oil-globule, with a diameter of 0,16 mm. The embryo itself also looks yellow through the presence of numerous, densely-crowded, yellow pigment cells. Also black pigment cells are to be found, especially in the head region, behind the eyes.

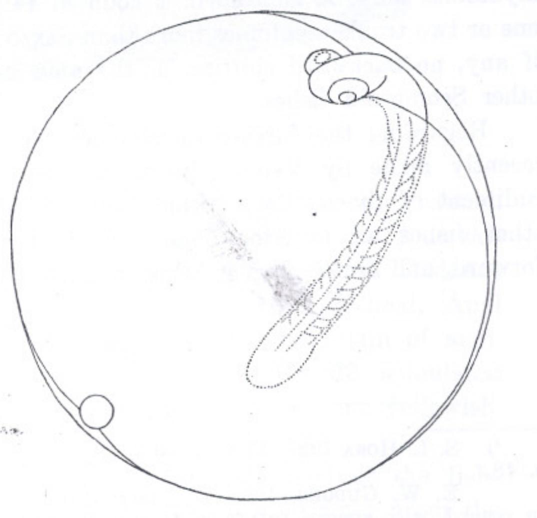

Fig. 10. Egg of the sucker-fish (*Echeneis naucrates*). May 16th, 1924, 11 a.m. × 26.

[1]) L. SANZO, 1927, Uova e larva di *Echeneis naucrates*. R. Comitato Thalassografico Italiano, Memoria CXXXIII.

The next day, at 11 a.m., the embryo has reached a length of 180° and the heart is beating, at a rate of 180 pulsations per minute.

As mentioned above, I have never succeeded in having these eggs hatched, however numerous my efforts. I suppose this is due to the high temperature of the water. In my rearing glasses, on board, the temperature of the water in the afternoon gets higher than in the sea and I fear the sucking fish eggs do not stand this. As the distribution range of *Echeneis naucrates* extends northward as far as Japan and Korea, I suppose the temperature of the tropical seas will be near the maximum at which the eggs can develop.

They gradually sink to the bottom of the glass and do not hatch. A few times I have freed the larva artificially but then it did not stretch itself completely. From such a larva, with the anterior part of the body bent, I made the reconstruction shown in fig. 11.

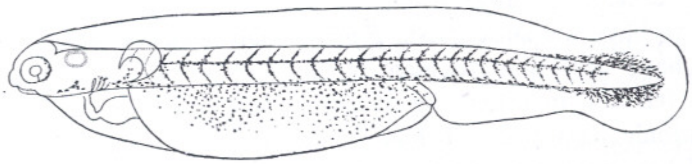

Fig. 11. Reconstruction after a curved larva which was artificially liberated from the egg membrane. × 13.

The number of myotomes could not be determined with great accuracy in my curved larvae. According to SANZO, who gives a description of his larvae which tallies very well with mine, 16 tail myotomes and about 14 trunk myotomes may be continued. I counted 14 tail myotomes only and probably one or two trunk myotomes more than SANZO did. At any rate it is evident that, if any, no backward shifting of the anus occurs in *Echeneis* as we found in other Scombroid fishes.

Regarding the further development of the sucker-fish [1]) the statements recently made by VEDEL TANING are most interesting. He shows that the rudiment of the sucker appears first behind the head at the place where in other fishes an anterior dorsal fin is found, and that, gradually moving forward, and broadening, it takes its final position on the head above the eyes.

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[1]) S. L. HORA 1925, The adhesive apparatus of the sucker fish, Nature, Vol CXV, p. 48.

E. W. GUDGER, 1926, A study of the smallest shark-suckers (*Echeneidiae*) on record, with special reference to metamorphosis. American Museum Novitates, nr. 234.

A. VEDEL TANING, 1926, Position du disque céphalique chez les Echénéides au cours de l'ontogénèse. Comptes rendus Ac. Sciences Paris, t. 182.

L. SANZO, 1927, Uova e larva di *Echeneis naucrates*. R. Comitato Thalassografico Italiano, Memoria 133.

L. SANZO, 1928, Uova e larva di *Remora remora*, ibid, Memoria 138.