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SERIE: FISKERI · BIND IV

NR. 2. JOHS. SCHMIDT: ON THE IDENTIFICATION OF MURAENOID LARVAE. IN THEIR EARLY ("PRELEPTOCEPHALINE") STAGES. WITH ONE PLATE

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IDENTIFICATION OF MURAENOID LARVAE

IN THEIR EARLY ("PRELEPTOCEPHALINE") STAGES

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By means of the material collected during the cruises of the Danish research steamer "Thor" in the Mediterranean in 1908—1910 it has for the first time been possible to identify the tiny "preleptocephaline" stages and eggs of eels and thereby also for the first time to state with certainty which species of eels spawn in the Mediterranean. To find bottom-stages or old, full-grown larval forms of muraenoid species is not the same as to have proved that they are indigenous to the waters where they were found; this subject has been dealt with previously by me in papers on the duration of the leptocephaline stages (1911, 1912 a) and on the great velocity of the surface-current running into the Mediterranean from the Gibraltar Straits (1912 c).

The identification of the "preleptocephaline" stages ca. 1 cm long has only been possible after procuring a large material of transitional forms from the tiny developmental stages to the older full-grown larvae, which could easily be referred to the parental form. The method employed has been the same as for northern species of fishes, namely, by means of series of different developmental stages to carry back the identification to still younger stages. As was the case with the larvae of the gadoids the pigmentation has proved to be of great diagnostic value in the youngest stages (Schmidt, 1905 etc.) and it is especially by means thereof and of the number of myomeres, that it has in many cases been possible to determine the youngest stages, even the embryos.

We are still far from the end of these interesting studies, for which the Mediterranean offers such excellent possibilities, but I hope that these lines and figures may contribute to their further advancement, so that we may soon be able to determine the species and genera whose preleptocephaline stages and eggs have not yet been identified. To ascertain the generic types in the youngest stages will also be of the greatest importance for future investigations outside the Mediterranean, where the difficulties of identification are naturally much greater owing to insufficient knowledge of the occurrence of the parental forms.

All the specimens examined and figured here have been preserved in a 5 % solution of formaline in sea-water. The figures are reproduced from microphotographs taken by Dr. C. U. Maaløe of Copenhagen.

Regarding the descriptions I may make the following remarks: the formula for the teeth $\frac{1+3}{1+3}$ means that in each half-jaw, both lower and upper, there are 3 teeth in addition to the long grasping tooth in front.

The enumeration of the myomeres includes also the incomplete front ones. In this way I obtain somewhat higher numbers of myomeres than other authors and arrive at a total number which is a little higher than the number of vertebrae in the species.

The limit between preanal and postanal myomeres is determined by taking an imaginary line through the middle of the anus at right angles to the axis; the myomere cut across at the axis by this line is the last of the preanal. The position of the pigment dots or groups has been determined in the same way.

I have to thank the Institut Océanographique of Monaco, Stazione Zoologica in Naples and the Zoological Museum of Copenhagen for lending me material of adult eel-fishes etc. Further, I offer my best thanks to Consul COSTANTINO TROMBETTA of Messina for sending me large and valuable collections of Leptocephali from the Messina Straits. From the same waters also comes a sample of newly hatched larvae sent me by Dr. ASHWORTH of Edinburgh.

Mr. C. TATE REGAN of London has kindly given me information regarding certain eel-fishes in the British Museum.

Cand. mag. STRUBBERG has given me excellent assistance in the examination of the material, and has, for example, carried out all enumerations of the vertebrae in the older eel-fishes.

Copenhagen, November 16th 1912.

Conger.

In earlier papers (1912 a, 1912 c) I have already mentioned and figured the tiny larvae of 2 species of *Conger*. I shall now give a more extensive description of these. In the Mediterranean there are 3 species of *Conger* i. e. *Conger vulgaris*, *Conger (Congromuraena) mystax* and *Conger (Congromuraena) balearicus*. Of all 3 species we have taken numerous larval specimens, among them many of the smallest sizes of the two first-named whereas, strangely enough, we have not obtained any of the tiniest stages of the last-named *(C. balearicus)*. As previously emphasized however (1912, c p. 23), I consider GRASSI's 14 mm long larva referred by him with a ? to Anguilla (1910 c. fig. 9 c) as belonging to the species *C. balearicus*, in support of which conclusion I may mention the dorsal and lateral pigmentation, which is distinctly seen on his figure and which is not present in this shape in any other species of Leptocephali in the Mediterranean.

The tiny larvae of *C. vulgaris* and *C. mystax* may be distinguished from the other species known from the Mediterranean by their elongated shape, the position of the anus far back, the absence of prominent, swollen regions on the digestive tract and by a row of large isolated chromatophores along the gut.

The following table, giving the number of myomeres in a number of specimens, illustrates how the proportion between the preanal and postanal myomeres of these species changes during development.

Conger vulgaris, Cuv.				*Conger mystax*, (De la Roche)			
Length mm	Preanal myomeres	Postanal myomeres	Total	Length mm	Preanal myomeres	Postanal myomeres	Total
9	89	> 57	> 146	12·5	80	> 55	> 135
10·5	94	> 58	> 152	14·5	92		
11	92			19	101	ca. 37	ca. 138
11	98			22	106		
12.5	100	> 53	> 153	27	112	27	139
13	105			30.5	115	26	141
17	105	ca. 56	ca. 161	39	112		
20	111			63	115		
33	121			67	117		
45	122	36	159	105	111	26	137
74	125	35	158				
105	124	36	160				
113	122	35	157				
130	121	38	159				

It is seen that the number of preanal myomeres increases greatly from the youngest developmental stages examined until the final number is reached, at a much greater length than e. g. in *Muraena helena*, *Nettastoma melanurum* a. o.

The two species *C. vulgaris* and *C. mystax* are easily distinguished even in the earliest developmental stages. From the figures (figs. 1 and 2) it is seen at once, that *C. vulgaris* has a shorter snout but a longer tail than *C. mystax*. These features however are only observed when comparisons are made, whereas from the pigmentation it can be seen at once to which of the two species a specimen is to be referred. While the young stages of both species possess a row of isolated stellate chromatophores along the gut and lack pigment along the side, the postanal pigmentation is different. In *C. vulgaris* it consists (1) of a ventral row of ca. 10, fairly equidistant, well-marked cromatophores beginning close behind the anus and reaching almost as far as the point of the tail and (2) of sparse, faint dorsal chromatophores near the latter. In *C. mystax* on the other hand the postanal pigment is restricted to near the point of the tail and the dorsal part, in contrast to what we find in *C. vulgaris*, is more developed than the ventral. The specimen of *C. mystax* figured had 4 dorsal pigment dots at the end of the tail, the most posterior the strongest. Further, *C. mystax* has on the lower jaw (in the middle) some scattered pigment dots which are not found in *C. vulgaris*. Finally, the gut pigment consists of fewer, more remote chromatophores in *C. vulgaris* than in *C. mystax*, a condition that becomes more conspicuous with age. The characteristic row of strong, medio-lateral pigment dots found in the older larval stages of *C. vulgaris* are not present in the tiny stages. Not until the larva has reached a length of 30—40 mm does more pigment begin to develop from the end of the tail as starting point and in some specimens a little more than 6 mm in length it reached no further forward than to round the anus.

In addition, the two tiny specimens figured have the following features:

Conger vulgaris. Length $10^1/_2$ mm. Teeth $\frac{1+2}{1+2}$. Ca. 98 preanal myomeres. Ca. 10 large chroma- Fig. 1.
tophores along the gut, the hindmost near the anus, the foremost below the 19th myomere between the body and the gut.

Conger mystax. Length $12^1/_2$ mm. Teeth $\frac{1+3}{1+3}$. Ca. 80 preanal myomeres. Ca. 15 chromatophores Fig. 2.
along the gut, the hindmost near the anus, the foremost below the 17th myomere between the body and the gut.

That the above tiny larvae do belong to *C. vulgaris* and *C. mystax* is proved by their connection, through a long series of developmental stages of increasing age, with the easily determinable larval forms of the two species, and further from the number of myomeres, which may be determined already in specimens of less than 20 mm in length with an accuracy, sufficient with the other characters to guarantee the correctness of the identification.

In his paper of 1910 Grassi mentions and figures (fig. 9 a and 9 b) two larvae, $11^1/_2$ and 9 mm long respectively, from the collections of the Zoological Station in Naples. He refers both — though with doubt — to Anguilla. I have previously pointed out that this determination is incorrect, because these larvae have pigment along the gut, which is wanting in the Anguilla larvae. I expressed the opinion (1912 c), that the larva of fig. 9 b probably belonged to *C. mystax* and the one of fig. 9 a possibly to *C. vulgaris*. The former I conclude from the gut- and caudal pigment, the length of the snout, the position of the anus and finally from being able to count ca. 84 preanal myomeres on the figure, which almost corresponds to the number I have found in similar developmental stages of *C. mystax*. With regard to the $11^1/_2$ long larva of fig. 9 a, if the gut is undamaged and the position of the anus therefore correctly indicated in relation to the myomeres, i. e. under the 52th myomere, it is nevertheless impossible to refer it to *C. vulgaris*, which at this developmental stage has a much greater number of myomeres.

Muraena helena, L.

The Leptocephalus of this species has been excellently described and figured (Grassi 1910), in contrast to the other Leptocephali living in the Mediterranean.

Fig. 3. The specimen figured has a total length of 12 mm but in our material there are several smaller specimens (down to a length of 8½—9 mm). The teeth $\frac{1+3}{1+3}$ are very strong. The lower jaw projects somewhat in front of the upper jaw though not so much as in the species of *Conger* and *Ophichthys*. The body is elongated, tapering only slightly towards the head which is very strongly developed, and has a short, conical snout. Embryonic pectorals are present, though pectorals are wanting in the full-grown fish (cf. the remark on *Nettastoma*, p. 8). It has 80 preanal myomeres.

The pigmentation is very inconspicuous, yet characteristic. It consists only of small, dot-like chromatophores, so minute that they are not seen on the figure. Very characteristic, for instance, is a row of pigment dots extending from the end of the tail to near the head. In contrast to the rest of the pigment this row of dots is not on the surface but lies along the axis below. There is still no surface pigmentation behind the anus. The preanal surface pigment is distributed as follows: Between the gut and the body, a little in front of the anus, there is a row of 4 pigment dots (under the 72nd, 73rd, 74th and 76th myomere, the anus being under the 80th). Further in front under the 57th and 58th myomere there are also some similar dots between the body and the gut (in older stages a continuous row of pigment dots is formed along the dorsal border of the gut).

Lastly, some dots of pigment, seen most clearly under the 20th to the 25th myomeres, are present along the under side of the first half of the gut (under 17th to the 32nd myomere). This pigment along the under side of the gut is however not present in the tiniest (9—10 mm long) larvae whose only pigment consists of the internal pigment along the spinal cord and the few dots in front of the anus along the dorsal border of the gut.

The proof that the larva figured here belongs to the species *Muraena helena* is obtained in the same way as for the other species; by means of a series of intermediate stages the connection is established with older larvae which are easily identified as belonging to this species.

In an adult specimen of *Muraena helena* from Messina 70 + 73 = 143 vertebrae were found.

In good agreement herewith is the number of myomeres found in older and younger *Muraena* larvae, as shown by the following table.

Larvae of *Muraena helena*

Length mm	Preanal myomeres	Postanal myomeres	Total
9	80		
12	80	ca. 68	ca. 148
17·5	80	67—68	147—148
44.5	80	64	144

2—3 myomeres (corresponding to the incomplete ones in front) should be deducted to obtain the true number of vertebrae.

Among the large number of muraenoid eggs taken by the "Thor" in the Mediterranean *Muraena helena* is richly represented from all parts of this Sea. The diameter of the eggs is 4—4·5 mm. They have thick capsules and a large perivitelline space; there is no oil-globule. The embryo is far advanced in development in the egg and before leaving it has teeth as well as complete eye pigment and the above-mentioned pigment dots in front of the anus as well as the internal pigment along the axis begin to appear. Correspondingly the yolk is almost used up when the embryo leaves the egg, and lies like an elongated sausage along the gut. In no other muraenoids I know of does the embryo reach such an advanced stage of development before leaving the egg (cf. the figure, Pl. IX, in Schmidt [1912 c]).

I may give here the following measurements and enumerations:

Eggs of *Muraena helena*

Diameter	Preanal myomeres of the embryo	Postanal myomeres of the embryo
4·0	ca. 79	
4·1	- 78	
4·3	- 80	>45
4·3	- 76	>45
4·3	- 80	>45

From the table it is seen that the full number of the preanal myomeres is present already in the embryonic stage (cf. the condition in *Conger*). That the eggs belong to *Muraena helena* is evident from the complete agreement between the oldest embryo and the tiniest specimens of the larvae mentioned above.

In his paper of 1910 GRASSI mentions and figures (fig. 8) a young, artificially hatched, larval stage which is supposed to belong to the species *Muraena helena*. It is stated to have come from an egg $5^1/_2$ mm in diameter from Messina. GRASSI has not however seen the egg himself but has had the artificially hatched larva sent to him. He gives no proof that this larva belongs to *Muraena helena;* nevertheless, as the number of preanal myomeres as well as the pigmentation is in agreement with the tiny larvae examined by me, all the transitional forms of which I have been able to refer with certainty to the full-grown larval stage of *Muraena helena* described by GRASSI, there is hardly any reason to doubt the correctness of his supposition, though the total number of myomeres in GRASSI's larva (ca. 152) is a little high.

I found the eggs of *Muraena helena* to be widely distributed in the Mediterranean from Gibraltar to Rhodes in the upper water-layers over the coastal banks or in the neighbourhood thereof but not out in the middle of the basins. The eggs were found in July, August and September, from which we may draw the conclusion that the species spawns in the middle of summer.

Nettastoma melanurum, Raf.

The specimen figured here has a total length of 12 mm. Teeth $\frac{1+3}{1+3}$ those in the lower jaw stronger than those of the upper, which is not a usual feature. The snout is not yet prolonged and the lower jaw projects a little further out than the upper jaw. Already in this tiny stage the body is comparatively high, much more so than is the case in the other species mentioned and the tail ends in a thread-like, strongly pigmented tip. Fig. 4.

It has 64 preanal myomeres.

The pigmentation is very characteristic. It is restricted to 3 well-marked groups, two of which are preanal the third postanal. The last, which is not sufficiently clear in the figure, is placed a little in front of the end of the tail[1] and consists of an intensely black, elongated group, placed both dorsally and ventrally on the tail and on the embryonic fin. The preanal pigment consists as already mentioned of two conspicuous groups. The foremost is found on the front swelling of the gut (liver), the other on its

[1] In an older specimen 2 cm long the postanal group of pigment is already 2 mm in front of the end of the tail right over the axis, and in another specimen 4 cm long the postanal group is $11^1/_2$ mm away from the end of the tail. During development the postanal pigment thus moves further forwards, as is also the case with the anus.

hindmost swelling a little in front of the anus on the 55th and 56th myomere. Both groups consist of stellate chromatophores and extend on to the ventral part of the body. No other pigment but the 3 groups mentioned occurs.

That the above-described larva belongs to *Nettastoma melanurum* is proved through a series of transitional stages up to the older larvae (the so-called "*Hyoprorus messinensis*") which may easily be identified with this species. In an adult specimen of *Nettastoma melanurum* from the Mediterranean 63 (abdominal) + 136 (135) = 199 (198) vertebrae were found and in another specimen also from the Mediterranean (Monaco) ca. 202 (ca. 49 preanal and ca. 153 postanal) segments were counted by means of the myomeres.

In good agreement herewith is the number of myomeres found in older specimens of the larvae of the present species, as shown by the following table, about 3 myomeres (corresponding to the incomplete front ones) having to be deducted to get the true number of vertebrae.

Larvae of *Nettastoma melanurum*

Length mm	Preanal myomeres	Postanal myomeres	Total
12	64		
ca. 20	63	ca. 143	ca. 206
ca. 41	64	140	204
ca. 82	66	140	206

From the above table it is also seen that in contrast to the species of *Conger* the *Nettastoma* larvae have already at 12 mm the full number of preanal myomeres.

All the larvae examined possess fully developed embryonic pectorals. I have previously (1912 c p. 55) called attention to the fact, that pectoral fins may well be present in the larvae of the Muraenoids though wanting in the full-grown fish.

Grassi has mentioned and described some muraenoid eggs (1910 p. 13. figs. 10-11) which he referred with doubt to *Anguilla*. I have already shown (1912 c, p. 23), that to judge from his description, especially of the pigmentation of the hatched larvae, they must probably be considered to belong to *Nettastoma melanurum*, a view that gains in probability from the fact, that the number of preanal myomeres corresponds fairly well to the number found by me in the tiny larvae of this species (not artificially hatched), and from their being taken in the autumn. That *Nettastoma melanurum* in contrast to all the other species mentioned here, except the parental form of *Leptocephalus telescopicus*, does not spawn during the warm time of the year is evident from the discovery of tiny larvae in the month of March, which shows that the spawning time of *Nettastoma melanurum* falls in the cold period. In this connection I may mention that the "Thor" took a large number of muraenoid eggs in January and February in the Balearic and Tyrrhenian Seas, in the surface as well as in deeper layers. They were 2—3 mm. in diameter, without oil-globule and the embryos had no teeth or pigment; the number of preanal myomeres was ca. 60 (55—60). I consider it probable, in connection with what has been said above, that these eggs, the only muraenoid eggs found by the "Thor" on our winter Mediterranean cruises, as far as our present examination of the large material goes, belong to *Nettastoma melanurum*, which evidently is a very common species in deep water, e. g. in the northern part of the western basin.

Ophichthys

Grassi and Calandruccio were the first to point out, that Kaup's "Leptocephalus Kefersteini" is a collective "species" comprising the larvae of species of *Ophichthys* (1892, 1893. 1894 etc.). Later (1896)

they claim in a preliminary paper to have identified the larvae of 4 species (*O. serpens, hispanus, imberbis* and *coecus*) of this genus from the Mediterranean. As the Italian authors give no proof of the results arrived at nor any sufficient description of the various forms, I have unfortunately been unable to use their work but have been obliged to study the whole of this difficult question again from the beginning. We must however hope to find the proofs wanted in GRASSI's coming work and I shall therefore only mention here the preleptocephaline stage of the 3 species figured and postpone dealing with the other *Ophichthys*-species discovered by me.

That "*Leptocephalus Kefersteini*" comprises the larvae of species of *Ophichthys* is without doubt. Common to all the larvae of the different species is the elongated, narrow, tape-like body and a number of large, conspicuous groups of pigment along the gut and usually also postanally on the sides. By means of this pigmentation the older larvae of the *Ophichthys* species, living outside as well as in the Mediterranean, are generally recognized at a glance.

The following table gives the number of vertebrae found on examination of adult specimens of *Ophichthys* from Monaco and Naples

	Abdominal vertebrae	Caudal vertebrae	Total
Ophichthys serpens	81	128	209
„ *hispanus*	65	92	157
	62	92	154
„ *imberbis*	72	84	156

Unfortunately, I have not been able to get material of the older stages of any other species of *Ophichthys* but the three mentioned here, which occur in all samples from the Mediterranean sent to me; thus, I am unable to identify the larvae of the other species found during our Mediterranean cruises.

As seen from the figures, the pigmentation of the tiny *Ophichthys*-larvae is very characteristic. All three species (and also the others which I am unable to identify) have a number of large conspicuous groups of pigment along the gut ("the gut patches"), more or less extending on to the ventral part of the body. The postanal pigment is also of the same type in all three species. It consists of a well-marked patch at the end of the tail (dorsally and ventrally) and besides of 1, 2 or 3 spots along the ventral border of the tail.

Common to the species are the local swellings of the digestive tract (liver etc.).

In all three species the lower jaw projects greatly in front of the upper. The tooth formula is in all $\frac{1+3}{1+3}$ and the grasping teeth are exceedingly long. The teeth of the upper jaw are longer than those of the lower jaw. Embryonic pectorals are present in all the species, also in those where they disappear later (cf. the remark on *Muraena helena* and *Nettastoma melanurum*).

I may give here a short description of the specimens photographed and figured, from which the differences between the three species will be seen.

Ophichthys serpens, (L.)

Total length 11 mm. The specimen figured has 89 (90) preanal myomeres 3 or 4 of which are incomplete and ca. 123 postanal i. e. 212 in all. This is the most elongated of the three species. Fig. 5.

Pigmentation. The preanal pigment consists of 6 distinct gut patches, the postanal of 2 patches, besides one near the end of the tail. They are placed under the following myomeres: 14, 26, 37, 50, 63, 81 (preanal) and 107 and 127 (the first two postanal).

This species is easily identified by means of the high number of myomeres, a number that is greater than in any other larvae of this genus I have found and fully agrees with the number of vertebrae.

Ophichthys hispanus, (Bellotti.)

Fig. 6. Total length $8^3/_4$ mm. There are 68 preanal and ca. 91 postanal myomeres, about 159 in all.

Pigmentation. The preanal pigment consists of 9 gut patches, the first of which (No. 1) is found near the head, the last (No. 9) just in front of the anus. They are not so large as those of the preceding species. It has 3 postanal patches of pigment besides one near the end of the tail. The preanal patches are placed under the following myomeres: 5, 12, 19, 25, 33, 43, 51, 58 and 66, the postanal under 74, 87 and 99. There is well-marked pigment on the point of the lower jaw.

In an artificially hatched, much less developed larva of $10^1/_2$ mm. in length (vertical mouth and not fully pigmented eyes) I found exactly the same pigmentation: 8 gut patches below the following myomeres: 5, 11, 20, 27, 33, 42, 49, 59. The last patch (No. 9) was not yet developed and the anus was found under the 66th myomere. Besides the patch near the end of the tail only the two first postanal patches were developed as yet and were placed under the 75th and 86th myomeres.

In an artificially hatched, still younger larva $9^1/_2$ mm. long the preanal patches were found under the following myomeres: 5, 11, 18, 28, (35), 44, (51) and 59 (the brackets indicate that these patches were fainter than the others); it had 66 preanal myomeres. The postanal patches were found under the 75th and 86th myomeres.

Ophichthys imberbis, (De la Roche)

Fig. 7. Total length $8^1/_2$ mm. The specimen figured has 77 preanal myomeres, 2 or 3 of the front ones incomplete, and ca. 82 postanal, i. e. about 159 in all. It is the shortest of the three species dealt with here.

Pigmentation. The preanal pigment consists of 5 very large gut patches placed under the following myomeres: 11, 20, 33, 49 and 68. The position of the first patch corresponds to patch No. 2 in *Ophichthys hispanus* (see figs. 6 and 7). Besides the patch on the end of the tail the postanal pigment consists of 1 large patch under the 90th myomere (a somewhat larger specimen $12^1/_2$ mm. long had another small patch behind the last-mentioned.

In an artificially hatched larva $7^1/_2$ mm. long and much less developed (vertical mouth and not fully pigmented eyes) I found the same pigmentation as in fig. 7, namely, 5 preanal patches under the following myomeres: 13, 23, 34, 48 and 68 and a postanal patch below the 89th besides one near the end of the tail. The anus was placed under the 74th myomere.

While, as already mentioned, the identification of the tiny larvae of *Ophichthys serpens* was very easy, this was not the case with those of the two last-mentioned species. As can be seen from the numbers on p. 9, *Ophichthys hispanus* and *Ophichthys imberbis* have almost the same number of vertebrae i. e. about 155. If we make a distinction however between abdominal and caudal vertebrae, there is fortunately a difference between the two species, *Ophichthys hispanus* having 62—65 and *Ophichthys imberbis* 72 abdominal vertebrae. For this and various other reasons I have referred the larvae with the low number of preanal myomeres (less than 70) to *Ophichthys hispanus* and the larvae with the high number (above 70) to *Ophichthys imberbis*, noting however, that our collections contain other species than the three described here, though these others can be excluded by means of other characters.

Among the quantities of muraenoid eggs taken by the "Thor" in the Mediterranean a very large number belong to the genus *Ophichthys*. This I conclude from the fact that the embryos and artificially hatched larvae have exactly the same characteristic pigmentation and distribution of the pigment as the preleptocephaline stages figured here, and that the number of the preanal myomeres are also in agreement. Muraenoid eggs from the Mediterranean have been described and figured by RAFFAELE (1888) and also by BOEKE (1903) and from the waters off the United States by EIGENMANN (1902). The two first-named authors have not ventured to make any identification but have arranged them under different numbers whereas EIGENMANN refers them to *Conger vulgaris*. That none of the three authors have been able to identify them as belonging to the genus *Ophichthys* is doubtless due to the fact, that they have not known such stages of *Ophichthys*-larvae as those figured here and the transitional forms to still older stages. Here as in many other cases of the identification of fish larvae, the pigmentation is of the greatest importance. Unfortunately, the pigmentation of the eggs and larvae mentioned by RAFFAELE and BOEKE is so insufficiently described or figured, that it is impossible to state with certainty to which species of *Ophichthys* the eggs belong in all cases. There is however hardly any doubt that RAFFAELE's "Species No. 7" and BOEKE's "*Muraena* No. 3" belong to *Ophichthys hispanus* while the last-named author's "*Muraena* No. 2" probably belongs to *Ophichthys serpens*. In any case I am able to say that the eggs of *Ophichthys serpens* and *Ophichthys hispanus* are large, between 3 and 4 mm. in diameter and that they correspond to the description and figure the two authors have given of "Species No. 7" (RAFFAELE) and "Muraena No. 2 and 3" (BOEKE), though with the exception that in the eggs of *Ophichthys serpens* with well developed embryos I find a somewhat higher number of myomeres than BOEKE, namely, more than 80 preanal myomeres. In both species the mouth is open and most of the gut patches and at any rate 2 of the postanal patches developed before the larva leaves the egg. It is characteristic of both, that the so-called "borsa stomacale" described by RAFFAELE attains to very considerable dimensions and that the yolk-sac is of a peculiar stalked shape, as is well figured by RAFFAELE for example in his fig. 8, Pl. 5, for "Species No. 7" which undoubtedly is *Ophichthys hispanus*.

I shall enter no further however into the details of these and other muraenoid eggs collected during the cruises of the "Thor" in the Mediterranean[1]. To deal satisfactorily with this question it will be necessary to keep and hatch out the eggs in aquaria in a fuller manner than is possible on board a research steamer with its quite different methods of investigation. The biological stations on the coasts of the Mediterranean have here a very interesting work before them and I hope that the information given in the present report may contribute to the matter being taken up again on another basis and with more reliable starting-points than those of RAFFAELE in 1888 and BOEKE in 1903. That the eggs of the two species of *Ophichthys* as of *Muraena helena* and the majority of the eggs taken by us in the Mediterranean, belong to the upper layers over shallow water in the coastal belt has previously been pointed out by me (1911, 1912 a and b).

Leptocephalus telescopicus nov. sp.

Total length 10 mm. Teeth: $\frac{1+3}{1+4}$, which with the exception of the front grasping teeth are comparatively short and strong. The specimen has 79 preanal myomeres (the 4 front ones incomplete) and ca. 130 postanal (the 10 last of these cannot be determined with absolute certainty but are not 5 wrong). The number of the vertebrae would thus be ca. 205 (between 200 and 210). Fig. 8.

It can be distinguished from all the other species known by the peculiar shape and structure of the head. The snout is very much elongated; the eyes are distinctly telescopic (the same as was the

[1] To judge from the number of different eggs in our collections, I am of opinion that during our cruises with the "Thor" we have obtained the eggs of the majority of the muraenoid species which occur in the Mediterranean.

case with the species previously described by me, *Leptocephalus rostratus* and *Leptocephalus synaphobranchi pinnati*) and, still more strange, the eyes are placed far in front of the brain, as is clearly seen in the figure. Embryonic pectorals are present.

The pigmentation resembles that in the species of *Ophichthys* and is, as in the tiniest stages of these, restricted to the ventral margin of the body. Besides some dots on the point of the lower jaw and two medio-ventral patches (under the brain) the preanal pigmentation consists of 7 fairly equidistant groups of pigment under the gut, the first on the front swelling (liver), the last a little in front of the anus (see fig. 8). The pigment patches are found under the following myomeres: 16—17, 24, 31—32, 39—40, 48—49, 60—61, 74. They are of a rounded shape. The postanal pigment reaches from a little behind the anus to the end of the tail and is only found ventrally. The first 4 patches are elongated, the long direction crossing the axis, and are placed partly on the embryonic fin and partly on the tail; the hindmost are grouped more closely together along the ventral part of the tail and are smaller. Furthest back near the end of the tail there are also some faint pigment dots.

Of this species, previously mentioned by me as *"Nettastoma sp."* (1912 c), we have only taken one specimen in January in the Tyrrhenian Sea. I was of opinion that it might belong to the *Nettastoma brevirostre* described by Facciolà (raised by Grassi and Calandruccio to a new genus *Todarus brevirostris*). Whether this is right or not I cannot say as yet, because I do not know the number of vertebrae in this species.

The single specimen was taken in January in the Tyrrhenian Sea, so that the species spawns in winter.

Leptocephalus telescopicus differs greatly from all other Leptocephali known to me both in the peculiar shape of the head and in the position of the eyes far in front of the brain.

The conditions found in *Muraena helena* and *Ophichthys* show that a shortening of the body of the tiny larvae may take place after the yolk is absorbed. Thus, an embryo of *Muraena helena* measured 14 mm., when ready to leave the egg, while among the specimens floating in the sea we have taken several down to a length of $8^1/_2$ mm. In the same way I have seen 10—11 mm. long larvae of *Ophichthys hispanus* with remnants of the yolk sac, while the length of much older larvae whose yolk-sac had been absorbed was only 8—9 mm. My observations are too few, however, to decide whether we have here a general rule or only individual peculiarities (shrinking of the specimens in formaline?).

From enumeration of the preanal myomeres of the younger and older larvae of the same species, it has been seen that the number of preanal myomeres is smallest in the youngest stages (or embryos) but that it increases during development and reaches a maximum, in some species very early (in *Muraena helena* e. g. already in the egg) in others considerably later (the *Conger*-species). The maximum then remains constant until metamorphosis takes place, when it is often reduced very considerably owing to the movement forward of the anus. As far as our present investigations go, we may give as a general rule, that in any species the number of preanal myomeres in the larval stage does not seem to be less than the number of abdominal vertebrae in the adult; the difference may be very small *(Nettastoma, Muraena, Ophichthys)* but may however also be very considerable (*Anguilla, Conger*, a. o.).

It seems also to be a general rule that all muraenoids have larval pectoral fins, even those in which they disappear later; the time for their disappearance being very variable in the different species. This rule applies at any rate to all the species examined by me *(Muraena helena, Nettastoma melanurum, Saurenchelys cancrivorus* and *Ophichthys imberbis)*.

The majority of the species mentioned here *(Conger, Muraena, Ophichthys)* spawn in summer, as all the tiny larvae and eggs are taken during this time of the year. The only exceptions among the species dealt with are *Nettastoma* and *Leptocephalus telescopicus* which spawn in the cold period of the year.

Summary of the species described in the present paper

For the sake of convenience I may give a general summary of the most conspicuous characters of the tiny larvae (less than 15 mm. long) of the species described here; only forms found in the Mediterranean are included.

I. The digestive tract without distinct swellings; its pigment is not collected in distinctly separated, conspicuous groups of chromatophores.

1. The pigment on the gut consists of a row of isolated, stellate, branched chromatophores. Internal axial pigment wanting ..... *Conger.*

a. The postanal, ventral pigment stronger than the dorsal and reaching from the end of the tail to near the anus. No pigment on the under jaw. Spawns in early summer and summer ..... *Conger vulgaris.* Fig. 1.

b. The postanal, ventral pigment is fainter than the dorsal and is restricted to near the end of the tail. The lower jaw is pigmented. Spawns in summer and autumn ..... *Conger mystax.* Fig. 2.

2. The pigment on the gut consists of some faint dots placed medioventrally under the liver and of some points near the anus. Internal axial pigment present. Spawns in summer *Muraena helena.* Fig. 3.

II. The digestive tract with distinctly marked swellings or at any rate with the pigment collected into conspicuous groups of chromatophores.

1. No telescopic eyes.

a. 2 very strong pigment patches on the gut, the front one at the liver, the posterior one a little before the anus. Spawns in winter ..... *Nettastoma melanurum.* Fig. 4.

b. 6 gut patches. More than 80 preanal myomeres. Spawns in summer. *Ophichthys serpens.* Fig. 5.

c. 5 gut patches. More than 70 preanal myomeres. Spawns in summer. *Ophichthys imberbis.* Fig. 7.

d. 9 gut patches.[1] Less than 70 preanal myomeres. Spawns in summer. *Ophichthys hispanus.* Fig. 6.

2. Telescopic eyes placed far in front of the brain. Spawns in winter. *Leptocephalus telescopicus.* Fig. 8.

[1] In contrast to the two other species of *Ophichthys* the first gut patch in *Ophichthys hispanus* is placed far in front below the front part of the notochord. The position of the second patch corresponds to that of the first in the two other species.

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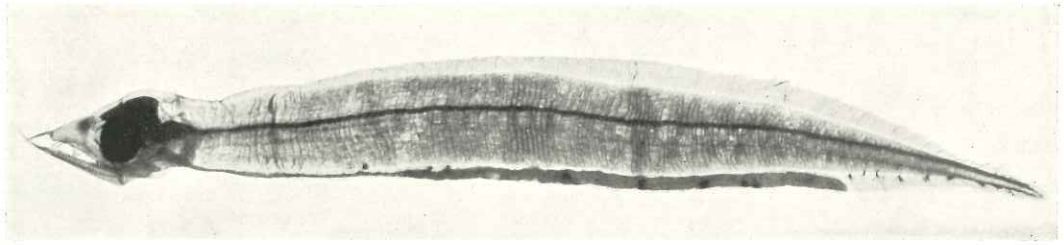

Fig. 1. *Conger vulgaris* (Length: $10^1/_2$ mm.)

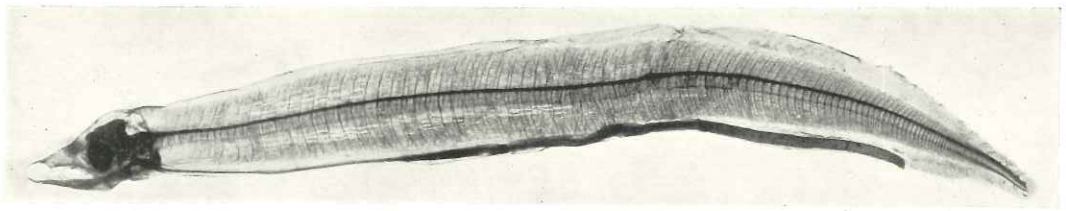

Fig. 2. *Conger mystax* (Length: $12^1/_4$ mm.)

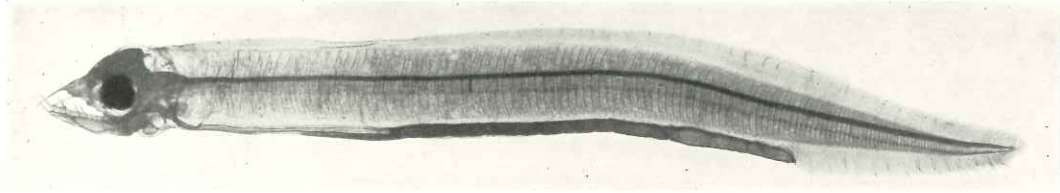

Fig. 3. *Murœna helena* (Length: 12 mm.)

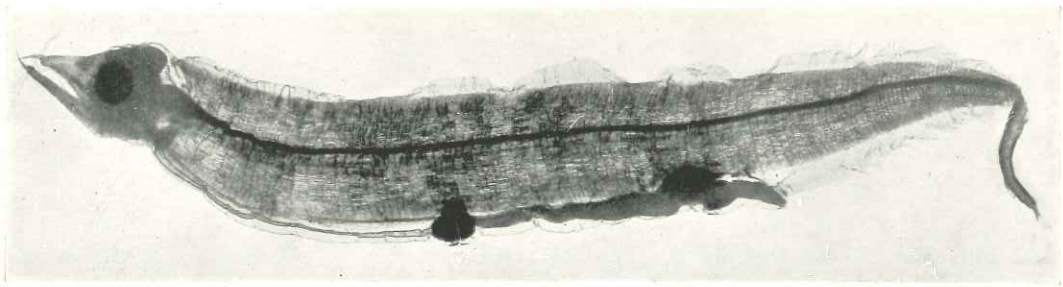

Fig. 4. *Nettastoma melanurum* (Length: 12 mm.)

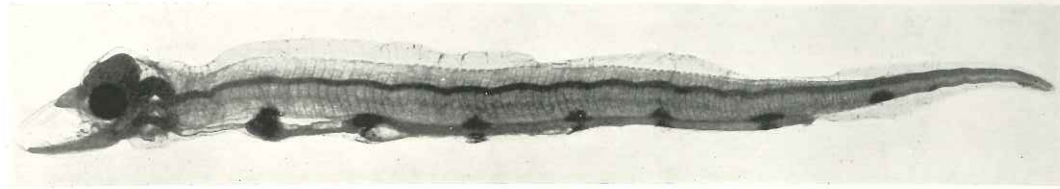

Fig. 5. *Ophichthys serpens* (Length: 11 mm.)

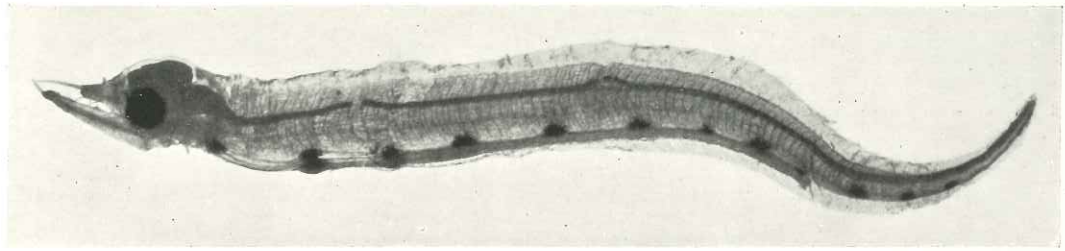

Fig. 6. *Ophichthys hispanus* (Length: $8^3/_4$ mm.)

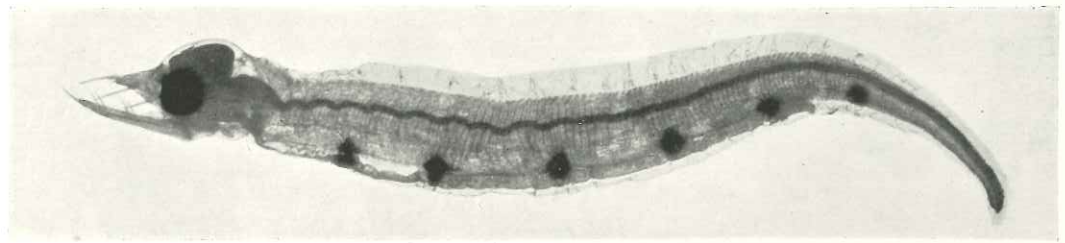

Fig. 7. *Ophichthys imberbis* (Length: $8^1/_2$ mm.)

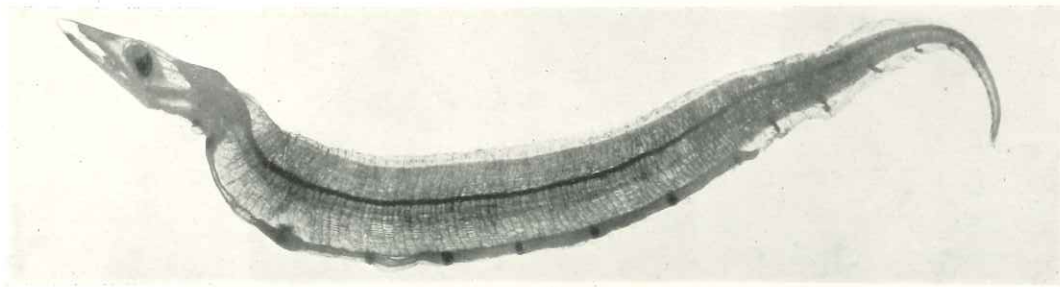

Fig. 8. *Leptocephalus telescopicus* (Length: 10 mm.)

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