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Nr. 4. Johs. Schmidt: ON THE EARLY LARVAL STAGES OF THE FRESH-WATER EELS (*ANGUILLA*) AND SOME OTHER NORTH ATLANTIC MURÆNOIDS. WITH 4 PLATES AND 14 FIGURES IN THE TEXT

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THE FRESH-WATER EELS (*ANGUILLA*)

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BY

JOHS. SCHMIDT

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I. Introduction

In a previous work of this series[1] will be found an account of the investigations which rendered it possible for the first time to determine with certainty the species of various important Mediterranean Murænoids in their earliest ("preleptocephaline") stages. The work was based upon material collected during the cruises of the marine research vessel "Thor" in the Mediterranean 1908—1910, the species concerned including *Conger vulgaris, Conger mystax, Nettastoma melanurum, Muræna helena* and certain *Ophichthys* species.

I have not since been able to procure further material from the Mediterranean; the investigations there have, however, been continued by B. Grassi[2], who has succeeded in augmenting the number of Mediterranean species which may be identified in their preleptocephaline stages.

In the paper referred to above, I introduced the method of describing larval stages *inter alia* by stating on which myomeres the pigment spots were situated. This feature has been found to be highly characteristic and constant in the case of several species (e. g. of the genus *Ophichthys*) and the method has also been employed by Grassi in his recent papers above referred to.

As regards the North Atlantic, on the other hand, the material has been greatly augmented since the publication of my last work on the subject. A very large quantity of preleptocephaline stages of eel fishes has been collected, partly by stud. mag. P. Jespersen, on the cruise of the motor vessel "Margrethe" sent out by the Commission for Investigation of the Sea, in 1913, and partly by various Danish trading vessels on the transatlantic routes during the years 1910—15. These vessels fished with implements provided for the purpose by the Commission for Investigation of the Sea, and the results were in many cases extremely satisfactory, thanks to the zeal with which the Masters of vessels carried out the instructions of their owners.

The principal interest attaching to this present material lies in the further information which it affords with regard to the early development of the eel, and those who have followed the investigation of this problem from the commencement will see that we have here advanced a very considerable step towards a solution of the "Eel Question". The material collected during 1914—15 by vessels belonging to the East Asiatic Co. of Copenhagen, has in particular afforded most important results in this respect, and it is therefore my very pleasant duty to express here, on behalf of the Commission, our best thanks to the Directors of the Company for the extremely valuable service thus rendered to the cause of marine research.

[1] Johs. Schmidt: On the Identification of Murænoid Larvae in their early ("preleptocephaline") stages (Meddelelser fra Kommissionen for Havundersøgelser, Serie Fiskeri, Bind IV, No. 2, Kjøbenhavn, January 1913).

[2] B. Grassi: Metamorfosi dei Murenoidi (Monografia I del Comitato Talassografico Italiano, Jena, 1913); see also B. Grassi (1914 b) and (1915).

I have also had at my disposal a certain amount of material in addition to that procured through the instigation of the Commission for Investigation of the Sea. Additional matter has thus been received from the U. S. Fish Commission, Washington (Dr. HUGH M. SMITH), from the Zoological Museum of Copenhagen University (Prof. H. JUNGERSEN) and from the Zoological Museum of Upsala University (Prof. A. WIRÉN).

The following pages deal chiefly with the larvæ of the fresh-water eels (the genus *Anguilla*), descriptions and illustrations of other species being furnished for the most part only where it is of importance to know these in order to distinguish them from the fresh-water eels.

In compiling the present report, I have received valuable assistance from cand. mag. A. STRUBBERG, and stud. mag. P. JESPERSEN, to whom I here beg to express my best thanks. I am also greatly indebted to mag. sc. Ø. WINGE and Dr. C. U. MAALØE, who kindly undertook the work of photographing various developmental stages of larvæ shown here.

Copenhagen, 19. Sept. 1916.

II. The Fresh-water Eels (Genus *Anguilla*).

I have in previous papers (1906), (1909) given descriptions and illustrations of the full-grown larvæ of the European Eel and their transformation to the elver stage, with reduction both of length and height.

The present fresh material contains early larval stages of both Atlantic species of *Anguilla,* the European Eel *(A. vulgaris)* and the American Eel *(A. rostrata)*. In the case of the former especially, the material is very extensive, embracing all stages of development from a length of scarcely 9 mm. upwards, in so complete succession as to represent every single millimeter in the scale of length, from the tiny preleptocephaline stages (of scarcely 9 mm.) to full-grown larvæ 88 mm. long.

The task before us, then, is to describe and illustrate the early larval stages and their development up to the full-grown larva, the so-called "*Leptocephalus brevirostris*", thus bringing the work up into line with my previously published descriptions of this last-named stage and its transformation.

It is not, however, my intention to enter here upon any further discussion of the new localities from which finds of eel larvæ are now recorded, or to touch upon the conclusions which might thence be drawn in biological respects. I hope, before long, to take up this question thoroughly in a separate work, and will therefore merely state, for the present, that the material of early larval stages of the European and American fresh-water eel now to be dealt with was collected at the surface at various places in the North Atlantic between abt. 20° and abt. 40° N. Lat.

We may commence with:

A. The European Eel (*Anguilla vulgaris,* Turt.).

A selection of the youngest specimens varying in length from $8^3/_4$ to 24 mm. is shown on Pl. I of the present work. The illustrations are reproduced from microphotographs, taken by transmitted light, of specimens preserved in formol.

1. Description of a series of early larval stages ($8^3/_4$ to 24 mm. as shown on Pl. I).

$8^3/_4$ mm. (Pl. I, fig. 1). The smallest specimen met with measured between $8^1/_2$ and 9 mm. in length. It is here shown on Pl. I, Fig. 1. It will be seen from the figure, that the shape is here somewhat more slender than in the older specimens. There is an irregular incurvation of the intestine, due to accidental damage. The

dental formula is $\frac{1+3}{1+3}$, i. e. each half of the jaw exhibits three teeth in addition to the foremost long grasping tooth (Text figs. 1 and 2). Pectorals are present. The embryonic fin envelopes the body, and reveals no trace of fins in formation. 65 pre-anal and 50—55 postanal myomeres may be counted, making 115—120 myomeres in all. Save for the ocular pigment, there is no trace of pigmentation. The structure of the tail may be seen from Pl. III, Fig. 1; it will be noticed that the tail is quite straight and juvenile in appearance. A slight indication of the hypural elements is, however, visible as a somewhat darker portion on the ventral side of the chorda, near the point of the tail; this is still extremely faint, and is lacking in another specimen of about the same size.

This specimen, 12 mm. long, is, as will be seen from the figure (Fig. 2, Pl. I), somewhat broader in shape than the foregoing. The dental formula is $\frac{1+4}{1+4}$. There is no indication of fins in formation. 66 pre-anal and abt. 49 postanal myomeres may be counted, making in all abt. 115 myomeres. Pigment lacking save in the eye, as is also the case in all the later stages of development. Structure of the tail practically as in the foregoing specimen, shown in Fig. 1, Pl. III. 12 mm. (Pl. I, fig. 2).

14 mm., Pl. I, Fig. 3. Distinctly broader, approaching in shape that of the full-grown larva. Dental formula $\frac{1+5}{1+5}$. The embryonic fin still quite intact; no indication whatever of fins in formation. 67 pre-anal and abt. 50 postanal myomeres may be counted, making a total of 117 myomeres. Structure of the tail approximately as in the specimen shown in Fig. 2, Pl. III, from which it will be seen that the indications of hypural elements are here somewhat more marked than in the two foregoing specimens, though still but faint. 14 mm. (Pl. I, fig. 3).

16 mm., Pl. I, Fig. 4. Shape more or less at that of the full-grown larva. Dental formula $\frac{1+5}{1+5}$. No trace of fins in formation. 69 pre-anal and abt. 47 postanal myomeres may be counted, or abt. 116 myomeres in all. Tail somewhat more developed than in the earlier stages, and the urostyle slightly bent. 16 mm. (Pl. I, fig. 4).

$18^3/_4$ mm., Pl. I, Fig. 5. Shape more or less as that of the full-grown larva. Dental formula $\frac{1+5}{1+5}$. 69 pre-anal and abt. 48 postanal myomeres, or abt. 117 myomeres in all. The hypurals in formation have now increased considerably in size, as seen in Fig. 3, Pl. III, which represents a specimen of the same length as the present (abt $18^1/_2$ mm.); there is, however, no differentiation as yet. $18^3/_4$ mm. (Pl. I, fig. 5).

As regards indications of unpaired fins, such can hardly be said to be visible in the present specimen, but are far more distinct in that shown on PI. III, Fig. 3, which is of the same length. As will be seen from this figure, the earliest indications of interspinous rays to the dorsal and anal fins now make themselves apparent as a dark stripe in the embryonic fin, a little distance from the edge, most distinct in the posterior portion, near the point of the tail, and fading away towards the anterior.

20 mm., Pl. I, Fig. 6. Shape more or less as in the full-grown larvæ. Dental formula $\frac{1+6}{1+6}$. 68 pre-anal and abt. 46 postanal myomeres may be counted, making abt. 114 in all. The tail is now considerably further developed, as seen from Fig. 4, Pl. III, where it will be noticed that the urostyle is not a little bent, and somewhat reduced, the hypural formation also being differentiated into two parts, which together make up the preliminary stage of the penultimate hypural. The first indications of interspinous rays to the dorsal and anal fins are likewise now apparent as a darker stripe. In the case of the anal, however, this does not as yet extend forward to half-way between the anus and the point of tail. 20 mm. (Pl. I, fig. 6).

24 mm., Pl. I, Fig. 7. Shape as that of the full-grown larvæ. Dental formula $\frac{1+6}{1+6}$. 71 pre-anal and abt. 44 postanal myomeres, or 115 in all. Interspinous rays now distinctly apparent in posterior portion of dorsal and anal fins, but with no indication whatever of such in the anterior part; there is, moreover, no indication of rays either here or in the caudal fin. 24 mm. Pl. I, fig. 7).

2. Remarks on the Larval Development.

The subsequent larval stages of the eel, up to the full-grown "*Leptocephalus brevirostris*" are shown on Pl. II. The figures are reproduced from photographs taken by reflected light, and $2^1/_2$ times the natural

size. I have previously (1909, Pl. I) given similar illustrations of the full-grown larva *("Leptocephalus brevirostris")* and its transformation, with reduction in height and length, to the elver stage. Plate II in the present work thus forms a supplement to the earlier illustration, showing as it does the appearance of the eel larvæ during the process of increasing length, in contrast to the decrease which takes place during the retrograde metamorphosis[1]. The figures in both plates being on the same scale ($2^1/_2$ times natural size) are directly comparable, and furnish thus, with those of Pl. I in the present work, a complete series showing the appearance of the eel larvæ from shortly after birth, through all stages to that of the elver, which is in shape almost exactly identical with the full-grown eel.

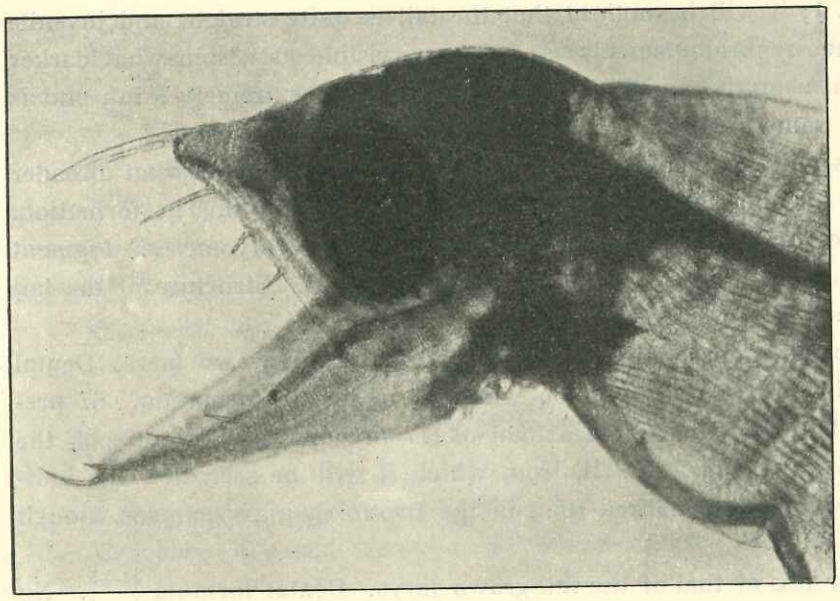

Fig. 1. *Anguilla vulgaris*, Turt. Total length: 9 mm. St. 789. Photo by transmitted light (Ö. Winge phot.) × 60.

From the figures in these three plates (Pl. I, 1909; Pl. I and II in the present work) it will be seen that the larva of our eel very soon — i. e. while yet quite small — attains a shape which is in all essentials identical with that of the full-grown larva before transformation. On the other hand, larvæ at one and the same stage of development may exhibit considerable individual difference in respect of shape, some being very slender, others of broader build. In this connection, the reader may refer to my first work on the eel (1906, Pl. VII), where a large number of larvæ are shown.

I will now proceed to mention certain details in the development of the growing larvæ; to wit, the development of the teeth, that of the anal and caudal fins, and finally, to give some measurements showing the alteration which takes place in the relative length of the tail during the growth of the larvæ.

As a general rule, it may be said that the degree of development varies greatly in regard to the total length. We may, for instance, find specimens which, though smaller than others, nevertheless exhibit a more developed caudal structure, etc. etc.

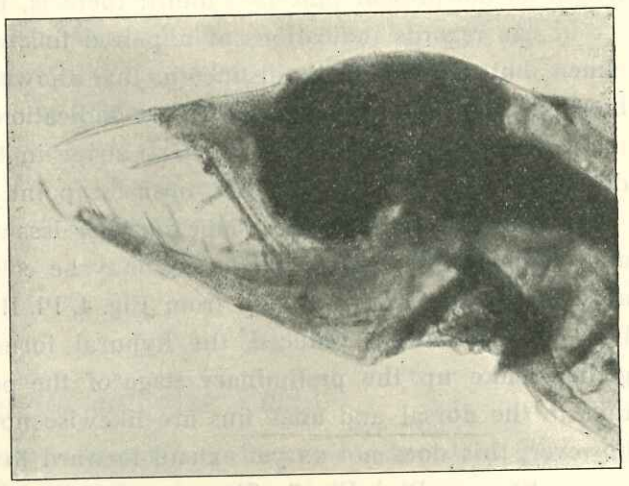

Fig. 2. *Anguilla vulgaris*, Turt. — Total length: 9 mm. St. 813. Photo by transmitted light (Ö. Winge phot.) × 60.

a. Development of the teeth.

In a previous work (1906, p. 165) I have referred to the number of teeth in the full-grown larvæ, and

[1] The smallest larva of which I have previously given an illustration (1906, Pl. VII, Fig. 7) measured 60 mm. in length. Since then, a specimen of 40—41 mm., taken during the cruise of the Norwegian vessel "Michael Sars" in 1910 in the North Atlantic, has been described with illustrations, no less than 3 times; viz; first by Johan Hjort (1910) later by Einar Lea (1913, Pl. I, Fig. 1) and finally by B. Grassi (1913, Pl. X, Fig. 25). The smallest larva known from the Mediterranean measured 51 mm. in length (Strömman, 1896, p. 11), (Grassi, 1914 a, p. 9). A considerably smaller specimen, $34^1/_2$ mm. in length was mentioned by me in 1912 (1912 b, p. 323) as having been captured in the North Atlantic by a Danish trading vessel.

quoted there figures obtained by actual count, showing that each half of the upper jaw contains from 16—20 teeth. Thus the formula for the upper jaw was for instance: 1 + I + 16, or 1 + I + (6 + 10) indicating one small tooth (1) at the foremost end of the jaw, in front of and above the large grasping tooth (I); thereafter 16 teeth, of which the first 6 are larger and stronger than the last 10.

In Figs. 1 and 2, p. 6, are reproduced two microphotographs of larvæ 9 mm. long, from which it will be seen that there are at this early stage 3 teeth in either half of the jaw, in addition to the large grasping tooth in front. The formula here is thus 0 + I + 3.

The following figures serve to show the manner in which the entire dental armament is gradually developed.

European eel *(Anguilla vulgaris)*.
Development of larval teeth.
(All the specimens examined came from the Atlantic Ocean).

Dental formula[1]	Length of specimens in mm.
0 + I + 3	8 3/4, 9
0 + I + 4	12
0 + I + 5	14, 16, 18 1/2
0 + I + 6	20, 24
1 + I + 6	22, 27
1 + I + 7	30
1 + I + 8	33
1 + I + 9	35
1 + I + 10	34, 39, 40, 41
1 + I + 11	34, 34, 35, 38, 42, 43, 44
1 + I + 12	38
1 + I + 13	35, 43
1 + I + 14	49, 49, 55, 77
1 + I + 15	48, 49, 50, 52, 63, 65, 72, 72, 78, 79, 82
1 + I + 16	47, 59, 62, 63, 65, 70, 75
1 + I + 17	59, 60, 70, 76, 80, 81
1 + I + 18	77, 78, 88

[1] I is the strong projecting grasping tooth, 1 the very thin and slender tooth above, and 3—18 the teeth behind the grasping tooth.

The table shows that the full quota of teeth may already be attained at a length of abt. 50 mm.

The small anterior tooth, (in front of the large grasping tooth, which latter is denoted by I) becomes apparent when a length of somewhat over 20 mm. is reached. For its appearance, the reader may refer to the work last quoted, 1906, p. 170, Fig. A.

A peculiarity worthy of note is the fact that the development of the teeth in point of size does not keep pace with the growth of the fish in length. Thus the teeth of the youngest larvæ are proportionately far larger than in the case of the older ones.

b. Development of the anal fin.

Specimens under 15 mm. length or thereabout exhibit as yet no indication of the anal fin (or of the dorsal, the development of which latter accompanies that of the former.) Some such young specimens are shown in Pl. III, Figs. 1—2, from which it will be seen that the embryonic fin is still perfectly intact. In the very next stage, however, — Fig. 3, a specimen of 18 1/2 mm. — we find the first indications of dorsal and anal fin apparent as a faint stripe within the margin of the embryonic fin. This stripe is most pronounced in the posterior portion of the fin, near the end of the tail, vanishing in the anterior part of the embryonic fin, whence we see, that the development of the anal and dorsal fins proceeds in a forward direction, i. e. from the tail towards the head. The stripe in question, representing the earliest stage of the anal and dorsal fins, is as yet not differentiated into distinct elements; this differentiation, however, soon takes place, the posterior portion breaking up into a series of joints somewhat resembling a row of beads. Each of these joints corresponds to an interspinous ray; as is the rule among fishes, the interspinous rays are formed long before the rays themselves. Stages of this character will be found in Pl. III, Figs. 4—5, from specimens of 19—20 mm. in length. Later on, the interspinous rays become more distinctly separated, presenting the appearance of close-set staves, at first quite short, then increasing in length. This may be seen from Figs. 5—7, Pl. III, representing specimens 19, 24 and 22 mm. in length.

At a length of 27 mm. the interspinous rays are indicated along the entire posterior half of the anal fin, and about the same time, the first traces of rays appear in the extreme posterior portion of the

anal fin. I have no illustration exactly corresponding to this; a slightly younger stage of development will be found, however, in Fig. 7, Pl. I. In this specimen — length 24 mm. — the process has not yet reached to midway between the anus and the point of the tail.

In a specimen 33 mm. long, indications of interspinous rays were found throughout slightly more than the posterior half of the anal fin, and of rays in the posterior fifth. A specimen of 38 mm. had interspinous rays indicated throughout almost the whole length of the fin; in the anterior fifth, however, only just visible, and not sharply divided.

One specimen of 42 mm. length had interspinous rays distinctly developed throughout the entire length of the fin, while rays were indicated in the posterior fourth. Another specimen, of 44 mm., showed very much the same development.

In a specimen of 49 mm. rays were indicated in nearly the posterior third of the anal fin; another of 52 mm. very much the same.

A specimen of 59 mm. had rays throughout the entire length of the anal fin, though still more or less indistinct in the anterior third.

The development of the anal fin may thus be briefly summarised as follows:

The fin developes in a forward direction, the part nearest the tail appearing first. The earliest indications of interspinous rays are found at a length of 15—20 mm.; not until a length af about 40 mm. is reached, however, are all the interspinous rays present. The rays commence to appear at a length of 25—30 mm., but the full quota is not completed until a length of abt. 60 mm. is reached. During the further growth of the larvæ up to full-grown length — which averages about 75 mm. — and during the retrograde metamorphosis, the rays gradually become fully formed.

c. Development of the Caudal Fin.

The structure of the tail in Murænoids has been made the subject of detailed study by GRASSI (e. g. in 1913) who has shown, *inter alia*, that this character is of great importance in systematic respects.

GRASSI has also given several illustrations of the tail in full-grown specimens of the larva of the European eel. It will therefore suffice to describe and illustrate the development of the tail in the younger larval stages. The illustrations in question will be found on Pl. III, showing nine stages of development, from microphotographs.

a. Hypurals.

The development of the hypurals is shown in Pl. III, containing nine reproductions from microphotographs of the end of the tail in larvæ of the European eel, varying in length from $8^3/_4$ to 39 mm.

Pl. III, Figs. 1 and 2, show two very juvenile stages, total length $8^3/_4$ and 14 mm. respectively. In the former, there is as yet practically no indication of hypurals; in Fig. 2, however, we find, below the chorda, near the point of the tail, a faintly defined, darker portion, representing the earliest beginnings of the hypurals. In the specimen shown in Fig. 3, length $18^1/_2$ mm., this portion has greatly increased in extent, its limits at the same time becoming more distinct; there is, however, still no division apparent. In the next specimen (length 20 mm., Fig. 4) we find a line, running at an angle of about 45° to the chorda, dividing this area into two more or less equal parts, which together make up the penultimate hypural, this being, as we here see, originally double. In the next stage, (length 19 mm., Fig. 5) yet another element has appeared, situated behind the penultimate hypural, between it and the chorda, almost parallel with the latter. This new element is the commencement of the last hypural. In the following stage,

(length 24 mm., Fig. 6) the antepenultimate hypural, which was already faintly apparent in Fig. 5, has now developed; it is situated in front of the double penultimate hypural, parallel with this and close against it. A darker area, above the posterior portion of the indicated last hypural referred to, and near the end of the chorda, marks the first commencement of the upper portion of the last hypural. In Fig. 7, Pl. III (total length of specimen: 22 mm.) this upper portion of the last hypural is distinctly formed, but is far smaller than the lower portion of the same. Later on it increases in size, without, however, attaining the dimensions of the lower portion (Fig. 8, total length 39 mm.) and finally, the two halves fuse more or less completely into one (Fig. 9, total length $38^1/_2$ mm.), but in most cases, with a slight fissure between, albeit this is not the case with the specimen shown in Fig. 9.

It is this cleft or fissure which GRASSI has referred to (1914 a); he is of opinion that its presence at a later stage (the elver) might furnish a systematic character for distinction between different races of the eel. I have in a previous work (1915) pointed out that GRASSI's theories in this respect are untenable.

We see, then, from the course of development shown here, that the last hypural, like the penultimate, is originally double, though I am unable to determine whether or no the two halves are at any stage entirely separate at their proximal parts.

The course of development in the hypural elements is then as follows: First to appear are the two portions of the penultimate hypural, then follow the lower part of the last and the antepenultimate, and finally the upper portion of the last hypural. The antepenultimate hypural is of single origin, both the penultimate and the last, however, being here double, albeit the twin parts later fuse together; in the case of the penultimate hypural, this fusion is only partial, whereas the two portions making up the last hypural often fuse completely into one.

β. Caudal Rays.

Two specimens, of 19,5 and 22 mm., showed no indications of rays in the caudal fin.

In one specimen of 27 mm., however, the earliest indications of rays in the caudal fin were visible, as also in the case of another, 30 mm. long. In one specimen of 38 mm., the indicated rays were so distinctly apparent, that it was possible to count them. In a specimen of 44 mm. several at any rate of the caudal rays were distinctly bifid in their distal portions; in another of 49 mm. all caudal rays were distinctly bifid[1].

γ. Comparative length of tail during development.

The Italian zoologist MASSIMO SELLA has, in a valuable work on the anatomy and metamorphosis of the *Conger*-larva, (1911) introduced the principle of indicating degree of development in Leptocephali by the proportion between total length and length of the tail (ano-caudal distance) and has further shown, how this proportion ("rapporto") alters during development. In our investigations on the larvæ of the common eel we have employed a similar method. The result of the investigations, carried out by stud. mag. P. JESPERSEN, will be found in the accompanying graphical scheme (Fig. 3). In preparing this, the specimens were divided into groups for each cm. interval. Eight specimens of each group were then examined with regard to the proportion between total length and length of tail, and the mean of the

[1] The previously mentioned specimen of 40—41 mm. taken during the cruise of the "M. Sars" in 1910 in the Atlantic has been examined and shown in illustration from this point of view by B. GRASSI (1913, Pl. X, Fig. 26) according to whom, the rays of the caudal were not yet bifid.

eight results thereafter calculated.[1] Finally, a curve was drawn on the basis of the eight average values thus found.

From the graph in question it will be seen that the relative length of the tail increases from the smallest to the largest specimen, rapidly at first (until the larvæ have reached about half their full length), after which the actual length of the tail remains more or less constant until the retrograde metamorphosis sets in. During this process, the length of the tail increases rapidly, as may be seen from the graph in Fig. 4, which is based on the eight stages of metamorphosis in eel larvæ given in my previous work (1909, Pl. I).

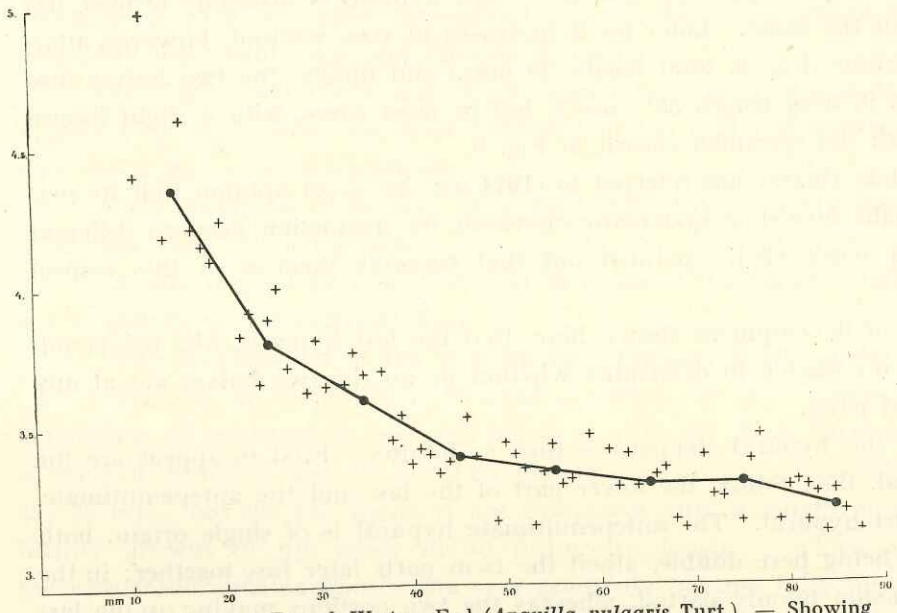

Fig. 3. European Fresh-Water Eel (*Anguilla vulgaris* Turt.). — Showing ratio between total length and length of tail during larval development. For details compare the text p. 9—10.

The relative length of the tail is, it should be noted, not the only proportion undergoing change during larval development. E. Lea (1913, p. 10) has, in his valuable work on the murænoid larvæ taken on board the research steamer "Michael Sars" in 1910, given some measurements of half-grown to full-grown larvæ of the European eel (length $40^1/_2$ to 82 mm.), whence it appears that the length of the head in proportion to total length decreases during the course of development. If the early stages also be taken into consideration, this feature will become even more strikingly apparent, as may easily be seen by a glance at the preleptocephaline stages shown on Pl. I of the present work.

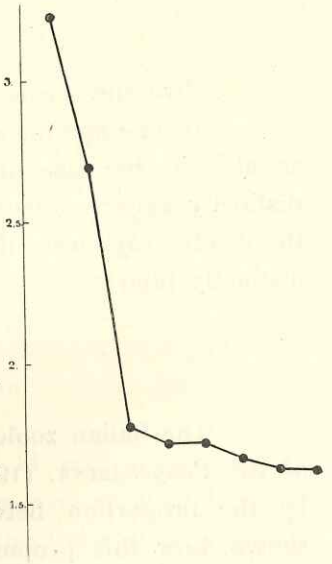

Fig. 4. European Fresh-water Eel (*Anguilla vulgaris,* Turt.). Showing ratio between total length and length of tail during metamorphosis (Compare the text, p. 10).

B. The American Eel (*Anguilla rostrata*, Lesueur).

The available material of larval stages of the American fresh-water eel is greatly inferior in quantity to that of the European. This applies both to the early preleptocephaline stages and to the older larval stages. Despite its paucity, however, this material is nevertheless of considerable interest; the history of development of the American eel has hitherto been but incompletely known, and we are now enabled to throw light upon the same, not only as regards the structure of the early larval stages, but also with respect to the transformation of the larval stages to the elver.

1. Description of some early larval stages.

The material bearing upon this section consists of four specimens only. Three of these I found in a very large collection of Leptocephali procured in the spring of 1914 by the U. S. S. "Bache" in the Gulf Stream area, and sent to me

[1] For greater accuracy, the smaller specimens (under abt. 30 mm. length) have been measured from enlarged photographs. Only specimens from the Atlantic have been included, and only such full-grown larvæ as had apparently not yet commenced their retrograde metamorphosis (only specimens with the full dental armament, and of these only such as were taken in spring and summer, before the 15th of June.)

for investigation by the U. S. Commissioner of Fisheries, Dr. HUGH M. SMITH, of Washington. The fourth specimen, which is somewhat imperfect, I found in an older collection of Leptocephali, brought together at the close of the past century by masters of Swedish vessels on transatlantic routes. This collection, belonging to the Zoological Museum of the University of Upsala, and forwarded to me by the Director, Prof. A. WIRÉN, is identical with that treated by P. H. STRÖMMAN (1896).

The preleptocephaline stages of *A. rostrata* resemble, as might be expected, in a very high degree the corresponding stages of the European eel; so much so, indeed, that it is scarcely possible to distinguish between the two species from their external appearance, but only by the number of myomeres. The above-mentioned 3 specimens of *A. rostrata*, however, from the U. S. S. "Bache's" Station No. 10 208, exhibited distinct pigmentation, consisting of a few black stellate chromatophores on the embryonic fin near the tip of the tail, (not on the tail itself) — a feature which I have not been able to discover in any preleptocephaline stages of the European fresh-water eel which I have examined.

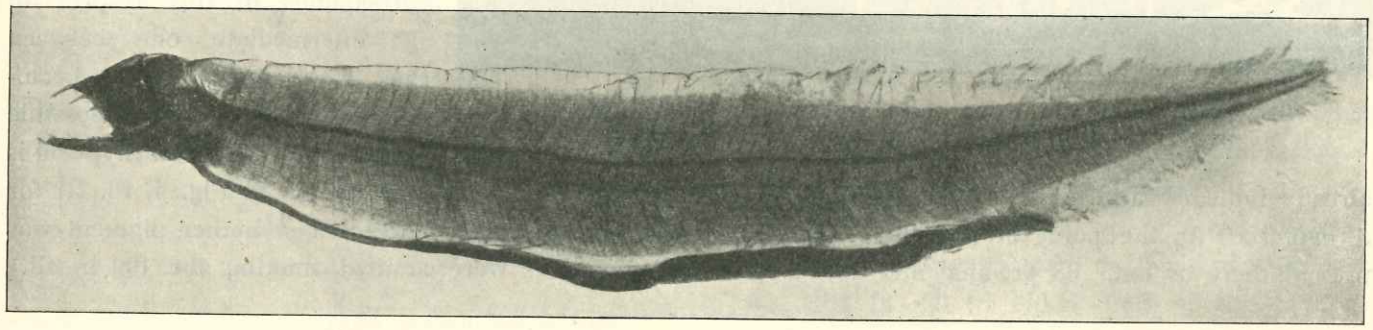

Fig. 5. *Anguilla rostrata*, Lesueur. Length: $10^1/_2$ mm., Stat. U. S. S. "Bache" 10 208, 100—0 m. Photo by transmitted light (Ö. WINGE phot.).

The smallest of our present specimens, which is in extremely fine preservation, measures $10^1/_2$ mm. $10^1/_2$ mm. Fig. 5. in length. It is shown in Fig. 5. As will be seen from the figure, its shape is somewhat more slender than is the case with the full-grown larvæ of *A. rostrata*, exactly as with the youngest larval stages of the European eel. The dental formula is $\frac{1+3}{1+3}$.

The tail is quite embryonic as yet, the chorda-end strong and straight, with no indication of hypural elements. The embryonic fin surrounds the body in the form of a fairly heavy fringe, exhibiting no trace of anal or dorsal fins in formation. A few black stellate chromatophores are visible in the embryonic fin, near the point of the tail. The myomeres number 63 preanal and 41—47 postanal, making 104—110 in all.

The next specimen, likewise from the U. S. S. "Bache" St. 10 208, measures $14^1/_4$ mm. in length. $14^1/_4$ mm. There is no illustration of this. The shape is broader than in the first specimen mentioned, thus more approaching that of the full-grown larva. Dental formula $\frac{1+4}{1+3}$. No trace of anal or dorsal fins in formation. Indication of penultimate hypural in development, somewhat fainter than shown in Fig. 3, Pl. III for *A. vulgaris*, or say midway between the stages shown in Fig. 2 and Fig. 3, Pl. III. Some few chromatophores on the embryonic fin, near point of tail. 64 preanal and abt. 44 postanal myomeres were counted, making abt. 108 in all.

The next specimen, likewise from the U. S. S. "Bache" St. 10 208, measures $15^3/_4$ mm. in length, $15^3/_4$ mm. and is shown in Fig. 6. In shape, still broader than the foregoing specimen, and thus differing but little Fig 6. from the full-grown larva. Dental formula $\frac{1+5}{1+4}$. The chorda end is slightly bent. Indications of penultimate hypural, at a stage of development midway between those shown in Figs. 2 and 3, Pl. III for *A. vulgaris*. The embryonic fin does not as yet show any distinct indications of interspinous rays to the anal and dorsal fins. Behind the point of the tail, 8 black chromatophores are visible on the point of

the embryonic fin; there is no pigment on the tail itself. 64 pre-anal and abt. 45 postanal myomeres were counted, making abt. 109 in all.

22 mm. Fig. 7 and Pl. IV, fig. 1

The next specimen measures abt. 22 mm. in length, and was taken by the late Swedish Captain ECKMAN at abt. 26° N. lat. and abt. 73° W. long (Fig. 1, Pl. IV and text figure 7). It is slightly damaged, the point of the embryonic fin being lost; save for this, however, in excellent preservation. The shape is here already very broad, almost as that of the full-grown larva. Dental formula $\frac{1+6}{1+5-6}$. The posterior portion of the embryonic fin shows very distinct indications of interspinous rays for the hinder parts of the unpaired fins. They appear as a dark stripe, broken up into a series of joints like a row of beads, fading away in the anterior portior of the fins. The stage corresponds in this respect to an intermediate one between Figs. 4 and 5, Pl. III for *A. vulgaris*. As far as it is possible to see, the penultimate hypural is already indicated and divided, corresponding apparently more or less to that shown in Fig. 4, Pl. III for *A. vulgaris*. As the point of the embryonic fin is lacking, it is impossible to say whether pigment was present there or not. 68 pre-anal and abt. 41 postanal myomeres were counted, making abt. 109 in all.

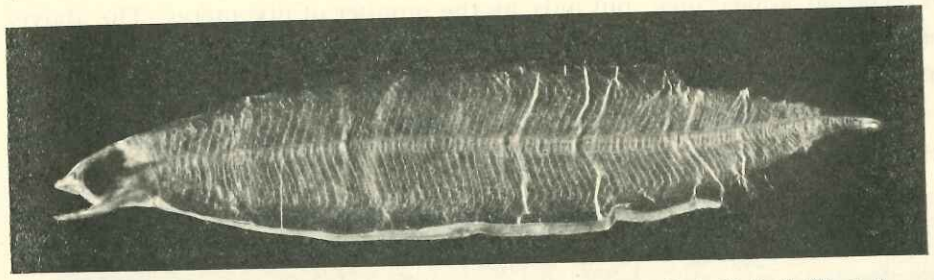

Fig. 6. *Anguilla rostrata* Lesueur. Length: 15¾ mm.. Stat. U. S. S. "Bache" 10 208, 100—0 m. Photo by reflected light (C. U. MAALØE phot.).

The proof that the preleptocephaline stages here described belong to the cycle of development of *A. rostrata* lies in the fact that they correspond closely to the specimens of *A. vulgaris* already mentioned, save only as regards the number of myomeres, which is somewhat less in *A. rostrata* for the pre-anal as well as the postanal. It may further be mentioned, that the localities of origin are situated farther west than those recorded for the earliest stages in the developmental cycle of *A. vulgaris*, a feature which I hope to take up for further discussion in a subsequent work.

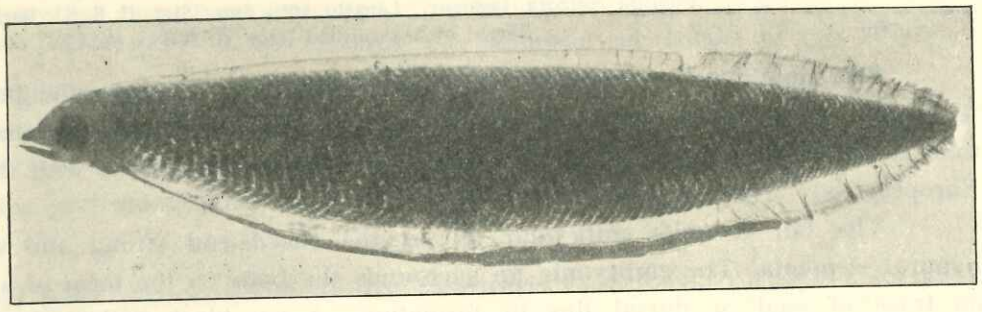

Fig. 7. *Anguilla rostrata* Lesueur. Length: 22 mm., ca. 26° Lat. N., 73° Long. W.; collected by the Swedish captain Eckman. Photo by transmitted light (Ö. WINGE phot.).

2. Older larval stages.

The material of older larval stages of *A. rostrata* consists of 26 specimens from the collections made by the Commission for Investigation of the Sea, these being mostly from the cruise of the M/S. "Margrethe" in 1913; and further, of 6 specimens from the cruise of the U. S. S. "Bache" in the spring of 1914.[1] From this last-named source also, we have two specimens of young elvers, taken pelagically in

[1] A specimen was also taken in the 60's of the past century by Capt. ANDREA, who, at the instigation of JAPETUS STEENSTRUP, made most valuable collections of pelagic animals on his voyages. The specimen in question, which I found in a considerable collection of Leptocephali received for investigation from the Zoological Museum of Copenhagen University, was taken at 29° 20′ N. lat., 78° 44′ W. long. and measured (in spirits) 52 mm.

the Atlantic, near the coast of U. S. And finally, we have a large quantity of elvers taken in May 1913 in Little River., Mass., U. S. A., by Mr. W. W. Welsh, and excellently preserved in formol.

The earliest description and illustration of the American eel we owe to Eigenmann and Kennedy (1902) who possessed two specimens, of 47 and 49 mm. length. Since then, the present writer has (1912 b) mentioned some localities where larvæ of this species have been found; save for this, however, it is not referred to in extant works since Eigenmann and Kennedy. As the figure given by these writers is altogether schematic, and in some respects not strictly correct, I give on Pl IV some illustrations of the larva of this species, which will, moreover, show that it does not differ greatly from the larva of the European eel.

The present material contains specimens ranging from 40 to 63 mm. in length. Some few (three) of these are at the transformation stage.

The shape may best be seen from the figures of Pl. IV. It corresponds in the main to what we have seen in the larvæ of *A. vulgaris ("Leptocephalus brevirostris")* but may frequently be not a little broader, especially behind the middle. After long practice in dealing with eel larvæ, when the eye has grown accustomed to specific differences, it is even possible to pick out the larvæ of *A. rostrata* in mixed samples by the shape alone. As regards teeth, the dental armament has been shown by Eigenmann and Kennedy (1902, p. 84) who give 9 teeth in either half of the jaw. (The specimens were, it will be remembered, 47 and 49 mm. long) This can, however, hardly be correct. as will be seen from the following countings made with *A. rostrata* larvæ.

American eel *(Anguilla rostrata)*. Number of larval teeth.

Dental formula	Length of specimens in mm.
1 + I + 14	44
1 + I + 15	42, 43, 44, 57
1 + I + 16	55
1 + I + 17	54
1 + I + 18	51

We find then, that the larvæ of *A. rostrata* exhibit the same number of teeth as those of *A. vulgaris*, to wit, abt. 16—20 in either half of the jaw, the teeth themselves having also similar appearance and position. As in *A. vulgaris*, the teeth fall out when metamorphosis sets in; the specimens shown in Fig. 5—6, Pl. IV for instance, are toothless.

With regard to the development of the tail and of the unpaired fins, there is evidently no great difference in this respect between *A. rostrata* and *A. vulgaris*. A specimen of abt. 44 mm. (shown in Fig. 2. Pl. IV) shows the hypurals fully developed, very much as in the specimen of *A. vulgaris* shown on Pl. III Fig. 9, while the caudal rays are already bifid. All interspinous rays in anal and dorsal fins are indicated, albeit the foremost of these are as yet only faintly divided. There are still lacking rays, however, in the anterior portion of the anal fin. Pigment is altogether lacking save in the eye, the preleptocephaline chromatophores as found on the point of the embryonic caudal fin in the three specimens of $10^1/_2$ —$15^3/_4$ mm. having thus disappeared.

With regard to the transformation stages, we may refer to the figures 5—6, Pl. IV, which show that these are similar in shape and general appearance to those of the European eel.

The larvæ of *A. rostrata* are smaller than the corresponding stages of *A. vulgaris*, a fact to which I have called attention in a previous work (1906, p. 243—44). The material upon which my conclusions were then based was, however, but poor, consisting of only a small number of elvers and pigmented young eels, some of them ill-preserved, with finally Eigenmann and Kennedy's (1902) description and illustration of the before-mentioned two specimens of *Anguilla rostrata* larvæ, 47 and 49 mm. respectively. Having now a far better material available for consideration of this question, it will be but natural to go into the matter anew.

Save for the four early stages above mentioned, ($10^1/_2$—22 mm.) the material of *A. rostrata* larvæ consists of specimens varying in length from 40—63 mm. As long as transformation stages of *A. rostrata*

American Eel *(Anguilla rostrata)*.

Showing length of elvers (Stage VI A, II—IV). Little River, Mass. U. S. A. (W. W. Welsh legit). (Specimens measured by cand. mag. A. Strubberg).

5' May 1913		7' May 1913	
Length in mm.	No of specimens.	Length in mm.	No of specimens.
68		68	
	2		
66		66	2
	1		
64	2	64	5
	10		8
62	16	62	29
	18		52
60	31	60	74
	45		85
58	65	58	119
	76		156
56	73	56	145
	50		108
54	28	54	61
	12		65
52	11	52	15
	2		3
50	1	50	
			1
48		48	1
Total No. of specimens	443		929
Average length in mm.	57·278		56·947 mm.
σ (Standard deviation)	$\pm$2·608		$\pm$2·578
P. E. A. (Probable error of average)	$\pm$0·0836		$\pm$0·0848
P. F. A. (Probable fluctuation of average)	56·860—57·696		56·523—57·371

were unknown, it was difficult to assert with certainty that the material in question really did contain full-grown larvæ at all. Fortunately, however, we have, as already noted, some few specimens of *A. rostrata* larvæ actually in the transformation stage. These specimens measured 63 mm., 57 mm. and 58 mm. And from what we know as to *A. vulgaris*, it will be justifiable to conclude that these specimens, which are in retrograde metamorphosis, have lost about $^1/_2$ cm. in length during the process, and that their average length must thus have been abt. 65 mm. or a little less, prior to commencement of the metamorphosis.

An average length of 65 cm. or thereabouts for full-grown *A. rostrata* larvæ agrees very well with the measurements given in the accompanying table for the two large consignments of elvers from Little River, Mass. already referred to. These specimens were at the stage described by Strubberg (1913) as VI A. II—IV. The measurements show an average length of abt. 57 mm.; we should, however, doubtless reckon with a further reduction before minimal length is reached.

In the case of *A. vulgaris*, I have previously shown (1906), (1909) that the full-grown larva has an average length of abt. 75 mm. and that this is diminished (in north and west Europe) by nearly 1 cm. during metamorphosis. In *A. rostrata* then, the full-grown larva appears to be on an average about 1 cm. shorter than that of *A. vulgaris*, i. e. nearly 65 mm. while the length diminishes during metamorphosis on approximately the same scale as in *A. vulgaris* larvæ.

III. On the distinction between the Fresh-water Eels and other North-Atlantic Murænoids in their early ("preleptocephaline") larval stages.

I may commence by referring to my previous work on the early (preleptocephaline) stages of various Murænoids (1913). True, only Mediterranean forms are therein described, but the same, or closely related, forms are also found in the Atlantic. In the following pages, mention will be made of various species having a similar oceanic occurrence in the Atlantic to that of the fresh-water eels, showing also, how they differ from these in the early larval stages.

1. Conger balearicus aff. (*Leptocephalus Eckmani* Strömman emend.)

I have already (1912 a, Pl. III, Fig. 5—6) given an illustration of the larva of the Mediterranean *Conger balearicus*, as well as of a larva so closely resembling this as to place it beyond question as belonging to a Murænoid which cannot be different in species, at the outside only in race, from *Conger balearicus*. This larva is identical with that named by Strömman (1896) *Leptocephalus Eckmani*.

I give here a figure showing a preleptocephaline stage of this form, measuring 16 mm. in length. (St. 1029, 65 m. w.). Particularly characteristic are the following features: The extremely short tail ("ano-caudal distance"), the large pigment spots along the dorsal edge of the body, small chromatophores on the body under the chorda ("sublaterally") between the myomeres, and the elongated snout.

The smaller of two specimens examined (length 14 mm.) showed the following: Dental formula: $\frac{1+5}{1+(4-5)}$. Myomeres: 102 preanal and abt. 32 postanal, or abt. 134 in all.

The situation of the above-mentioned pigment on the dorsal edge was as follows: Eight large spots in all, off the following myomeres: 18—19, 27—28, 36—37, 43, 50—51, 60—62, 69—70, and 77—78, and in addition, two small spots off the 14th and 24th myomeres respectively. Ventrally, on the gut, there are abt. 12 spots, of which 3—4 large; the foremost situated on a level with the 11th myomere. Strong pigmentation at the end of the tail, consisting of a long dorsal and a shorter ventral stripe. Pigment on the body between the myomeres is found along the strip from the 20th myomere (between 20 and 21) and thence back to some few myomeres behind the anus; there are as a rule two points (rarely three); in the extreme posterior portion, however, only one to each myomere-limit.

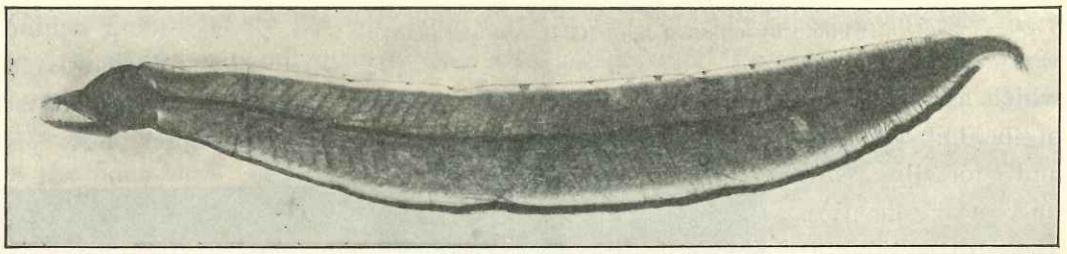

Fig. 8. *Conger (Congromuraena) balearicus* aff. Specimen 16 mm. in length, Stat. 1029, 65 m. w. Photo by transmitted light (Ö. Winge phot.).

As will be seen from the foregoing description, it is extremely easy to distinguish the preleptocephaline stages of this species from those of the fresh-water eel *(Anguilla)*, as well from the shape, as from the pigmentation, position of the anus, and number of myomeres; we need not therefore, waste more words on this. That they do belong to the form previously designated by me (1912 a) as *Conger balearicus aff.* (= *Leptocephalus Eckmani* Strömman emend.) is proved by a long series of transition stages procured in course of the investigations carried out by the Commission for Investigation of the Sea.[1]

[1] After becoming acquainted with the preleptocephaline stages of *Conger balearicus* aff. from the Atlantic, I feel confirmed in the opinion which I put forward already in June 1912 (1912 b) that the specimen of 14 mm. length shown by Grassi (1910, Fig 9 c) and by him doubtfully ascribed to *Anguilla vulgaris,* really belongs to *Conger balearicus.* Grassi shows, in a later work (1913, Pl. XII, Fig. 35) a specimen of 10 mm. which he ascribes, and doubtless correctly to this species. On the other hand, he expresses a doubt (1913, p. 198) as to the correctness of my identification of his figure from 1910 (Fig. 9 c) with *Conger balearicus.* As to this, I will merely observe that the two figures (1910 Fig. 9 c) and (1913, Pl. XII, Fig. 35) agree, save for the fact that the specimen shown in the former is somewhat damaged, quite well together.

I take this opportunity of mentioning, that I fully adhere to my previous remarks (1912 b, p. 332) as to the three tiny larval stages ascribed by Grassi in 1910 with (?) to *Anguilla vulgaris*, of which one, (9 c) is probably a larva of *Conger balearicus*, the second (9 b) probably a larva of *Conger mystax* and the third (9 a) indeterminable, though possibly a larva of *Conger vulgaris.*

I further maintain that Grassi, by his paper published in 1910, has clearly shown that he did not then know the preleptocephaline stages of the most common species. That he now (1913, p. 198), (1914), (1915) does know these, after they have been described and figured by me (1912 a and b), (1913) and he himself has thereafter continued the work with fresh material, is

2. Leptocephalus lanceolatus Strömman emend.

This species is the Murænoid with the greatest number of preleptocephaline stages in our material, where it often occurs together with those of *Anguilla*.

I have already referred to the species (1912 a) and was able there to show that it was identical with the one described by Strömman (1896).

I give here two figures showing some early stages, length 14½ and 21 mm. respectively (Stat. 1056, 80 m.w.). As will be seen from the figures, the shape somewhat resembles that of the youngest, preleptocephaline stages of *Anguilla*, but is more elongated than this. The shape of the head also is different, the snout being distinctly longer and more pointed. The contour of the occiput is higher, and the brain both larger and situated more above the eye than in *Anguilla* (where it lies more behind the eye). The end of the tail is peculiarly downward bent, which as a rule gives the species a very characteristic appearance. Pigment is restricted to the point of the tail, where there are a number of very strong chromatophores, both on the tail itself, ventrally and dorsally, (but only near the tip), and also on the embryonic fin. The dental formula in the smaller specimen was $\frac{1+4}{1+4}$, myomeres 86 pre-anal and abt. 80 postanal, abt. 166 in all; the larger had dental formula $\frac{1+5}{1+5}$ with abt. 89 preanal myomeres.

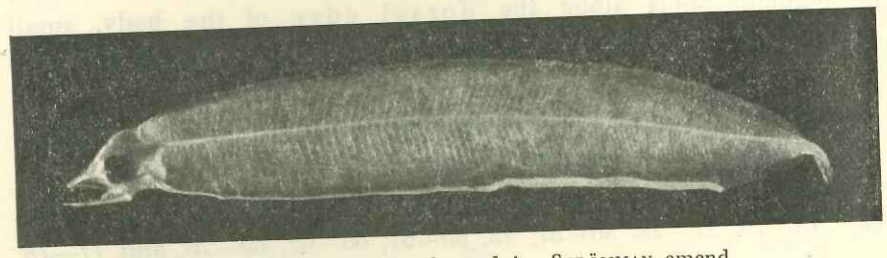

Fig. 9. *Leptocephalus lanceolatus* Strömman emend.
Length: 14½ mm, St. 1056, 80 m. w.
Photo by reflected light (C. U. Maaløe phot).

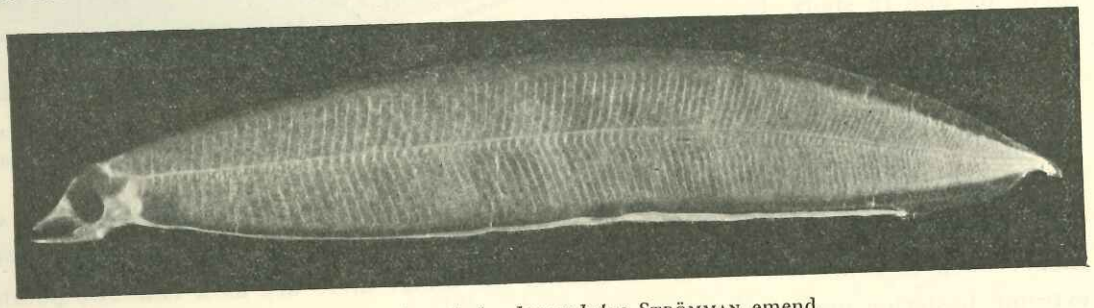

Fig. 10. *Leptocephalus lanceolatus* Strömman emend.
Length: 21 mm., St. 1056, 80 m. w. Photo by reflected light (C. U. Maaløe phot.).

another matter, and cannot alter the two facts: 1) that it was first by the cruises of the "Thor" in the Mediterranean 1908—1910 and my papers dealing therewith, that the preleptocephaline stages of Murænoids were ever determined with certainty as to species, and 2) that the same investigations and the mentioned works thereon have first definitely shown which of the Murænoids most commonly occurring in the Mediterranean, such as *Conger vulgaris*, *Conger mystax*, *Nettastoma melanurum*, etc, (but not *Anguilla!*) actually belong to — i. e. reproduce in — that Sea.

In the mentioned work (1913 p. 98, footnote) where Grassi reverts to my statements (1912 b) as to the three tiny larval stages ascribed by him in 1910 to *Anguilla*, he expresses surprise at my having been able to say that he, Grassi, did not then know the most common species in their prelarval stages, when he had himself, in the same work, identified with certainty a prelarva with *Muræna helena*. It is not my intention here to go further into this question, which can be of but slight interest to most readers; I would, however, refer any who might be inclined to pursue the subject to Grassi's paper (1910, p. 16) where the explanation of the figures contains the following notes anent the mentioned preleptocephaline stages:

"Fig. 8. Prelarva supposta di *Muræna helena*.

Fig. 9 *a*, *b*, *c*, Prelarva di *Anguilla vulgaris* (?) (sono le 9 *b* e *c* quelle chi piu fondatamente si possano suppore tali."

And I ask the reader: which of the two reservations with which Grassi puts forward his identification of his *Muræna* and *Anguilla* prelarvæ: "supposta" or "(?)" expresses the greater degree of certainty?

For my own part, I am content to have drawn the attention of marine zoologists to the fact, that Grassi, in 1910, could imagine that a prelarva having the pigmentation of a *Conger balearicus* (his Fig. 9 *c*) or a *Conger mystax* (his Fig. 9 *b*) could with any reason whatsoever be ascribed to *Anguilla vulgaris* ("che piu fondatamente si possano supporre tali").

The characters whereby this species is distinguished, in its preleptocephaline stages, from *Anguilla*, have already been noted in the description of the specimens figured.

Leptocephalus lanceolatus is an enormously common species in the North Atlantic, comprising, together with *Conger balearicus* aff., by far the greater part of our material of North Atlantic Leptocephali.

I am quite at a loss as to the question of which Murænoid form this larva represents.

3. Leptocephalus lanceolatoïdes n. sp.

Our collections from the central portion of the North Atlantic include the preleptocephaline stages of a species shown in the accompanying figure in a specimen of 13 mm. length (Stat. 1040, 65 m. w.). As will be seen from the figure, it has considerable outward resemblance to *Lept. lanceolatus* (whence the name). The shape, as regards body and head, is much the same; the length of tail also is similar, and it may not improbably belong to a Murænoid related to the form to which *Leptocephalus lanceolatus* belongs.

There is, however, a decided difference from *L. lanceolatus; inter alia* as regards pigmentation. As in *L. lanceolatus,* there is also here pigment on the tail, both dorsally and ventrally; this is, however, here found not only close to the tip of the tail, but extends over a longer portion. Furthermore, as the most strikingly distinctive character, there are spots of pigment on the sides of the body in a longitudinal row below the chorda. The series consists of spots situated on the boundary lines between the myomeres; i. e. a similar arrangement to that noted in the case of *Conger balearicus*; the series is, however, less regular, not every myomeral boundary having pigment, in addition to which, the pigment itself, in *L. lanceolatoïdes*, consists of single spots, whereas in *Conger balearicus* there are as a rule two together. There are also, at the upper margin of the eye, some black points which are lacking in *L. lanceolatus*.

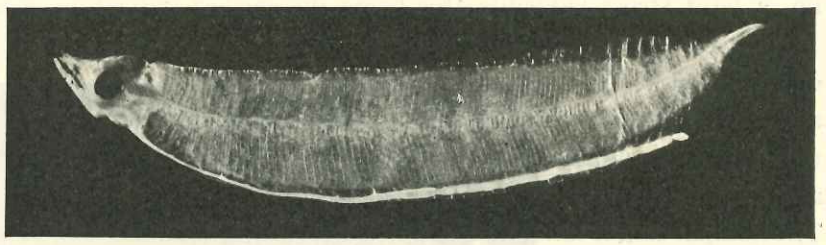

Fig. 11. *Leptocephalus lanceolatoïdes* n. sp. Length: 13 mm. St. 1040, 65 m. w. Photo by reflected light (C. U. Maaløe phot.)

The specimen shown had 87 pre-anal and abt. 76 postanal myomeres, or in all abt. 163. The subchordal pigment series commences at a point on the boundary between 17' and 18' myomeres extending backward nearly to the point where the caudal pigment begins.

L. lanceolatoïdes is easily distinguishable from *Anguilla* by its pigmentation.

The form to which *L. lanceolatoïdes* belongs is not known.

4. Leptocephalus anguilloïdes n. sp.

I have chosen this name to designate a larval form found especially in the southern portion of our investigation area, for the most part between 20° and 30° N- lat. and taken in sizes varying between abt. 1 and abt. 5 cm. It exhibits, as the name suggests, a certain resemblance to *Anguilla,* and is probably nearer in appearance to the larva of the fresh-water eel than any other species found in our area. The shape will be seen from the accompanying figures. It will be noted that the younger stages are somewhat more slender, the older on the other hand somewhat broader than *Anguilla*. In the older stages, also, the tail is more pointed and more abruptly tapering. The length of the tail does not differ greatly from that in the larvæ of *Anguilla*, the snout also, is short, as in the latter. The head, however, is somewhat more domed, and the brain larger in proportion to size of the eye, than is the case with *Anguilla*.

The smallest of the specimens shown was 16 mm. long (Stat. 1017, 65 m. w.). Dental formula $\frac{1+4}{1+4}$. There were 77 pre-anal and 50—60 postanal myomeres, or abt. 132 in all. The pigmentation resembles not a little that found in *Leptocephalus lanceolatoïdes*. There is pigment on the end of the tail, consisting of both dorsal and ventral spots. The lastnamed are continued forward in an irregular series of single chromatophores, like short streaks, along the sides, situated for the most part on a level with the ventral portion of the chorda. The series comes to an end in the anterior part, the foremost chromatophore being situated between myomeres Nos. 60 and 61.

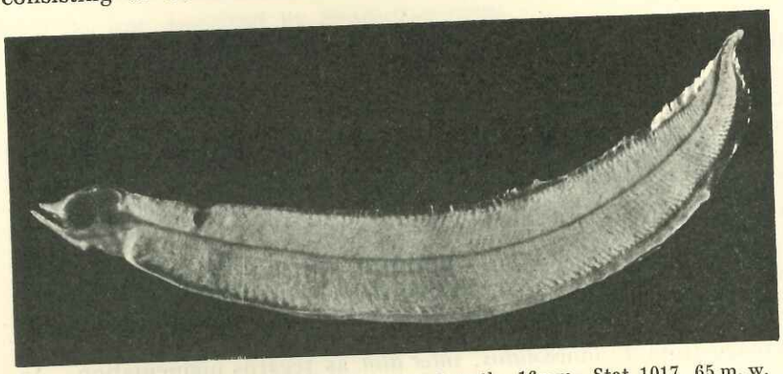

Fig. 12. *Leptocephalus anguilloïdes* n. sp. Length: 16mm., Stat. 1017, 65 m. w. Photo by reflected light (C. U. Maaløe phot.)

The next specimen, (St. 1017, 65 m. w.) is abt. 21 mm. in length. Dental formula $\frac{1+4}{1+4}$; myomeres 75 preanal, 50—60 postanal, or abt. 130 in all. Pigment somewhat more developed; the foremos chromatophore of those along the side being on the boundary between myomeres Nos 51 and 52. In the posterior portion of the embryonic fin, a faint stripe is visible, this being the earliest indication of the interspinous rays to anal and dorsal fins.

The oldest of the specimens shown (St. 432, 56 m. w., 20° 46′ N., 41° 16′ W.) was 48 mm. in length, dental formula 1+13 and with abt. 133 myomeres (abt. 77 pre-anal and abt. 56 postanal) The shape is not a little broader than in the case of the larvae of the fresh-water eel; the tail also more pointed. The hypural elements are developed, as are also the interspinous rays in the dorsal and anal fins. The subchordal pigment series is comparatively fainter than in the younger specimens; it extends forward to about the middle of the body.

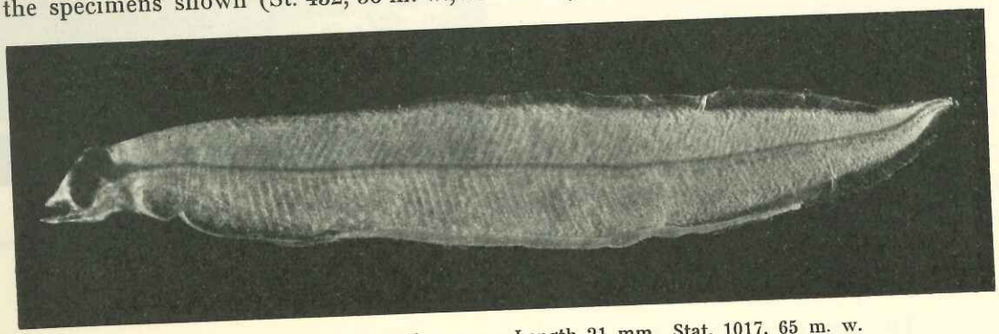

Fig. 13. *Leptocephalus anguilloïdes* n. sp. Length 21 mm., Stat. 1017, 65 m. w. Photo by reflected light (C. U. Maaløe phot.)

From what has here been said, as also from the figures, it will be seen that although a certain likeness exists between this species and *Anguilla*, the two are nevertheless very easily distinguished, even in the youngest stages investigated, both by the pigmentation and by the number of myomeres.

The form to which *L. anguilloïdes* belongs is unknown, but is doubtless not closely related to *Anguilla*, despite the external similarity of the larvæ to those of *Anguilla*.

I have now mentioned the most important preleptocephaline forms having similar oceanic occurrence to the corresponding stages of the fresh-water eel, and liable to confusion with the same. From the descriptions given of the different species, both in the present and in my earlier works on similar stages (1912 a, b), (1913) it will be seen that there are throughout objective characters whereby the fresh-water eels may be distinguished from the other species, whether the characters in question be found in the shape of the body, shape of the head, length and appearance of the tail, pigmentation, or number of

myomeres. Even those without many years experience in the work will thus find no difficulty in distinguishing even the smallest known stages of the larvæ of the fresh-water eel from the other forms which are found together therewith. It is of course possible that forms may in reality exist having a greater resemblance to the fresh-water eel than those here described; such have not, however, been found up to the present. And even should such more similar species be found, there are yet many other characters besides those here referred to which might be taken into consideration for purposes of distinction. I will here mention but one, *viz*; the large blood-vessels running vertically down the body, and their relation to the myomeres. It has been observed that such and such a blood-vessel is regularly found to be situated off a certain myomere,[1] — of course with a certain degree of individual variation — and it is thus possible to characterise the species according to this feature, just as I have shown that it was possible to characterise different species by means of the position occupied by the larger pigment spots relatively to the myomeres (1913).

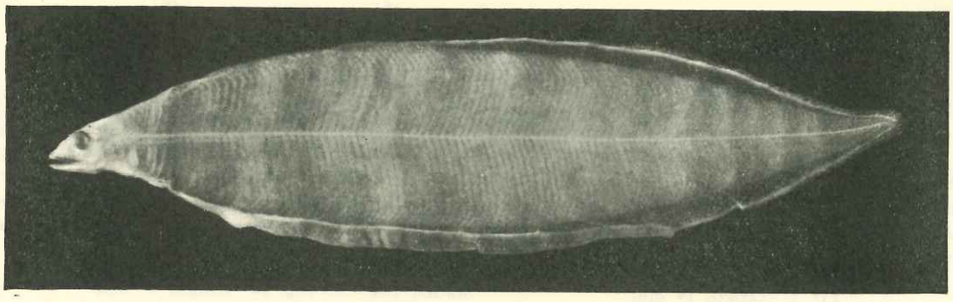

Fig. 14. *Leptocephalus anguilloïdes* n. sp. Length 48 mm., Stat. 432, 56 m. w. Photo by reflected light (Pacht & Crone phot.)

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[1] In *Anguilla vulgaris*, for instance, the foremost vertical blood-vessel is on a level with myomeres No. 12—14.

V. Explanation of the Plates.

Pl. I. European Fresh-Water Eel (*Anguilla vulgaris*, Turt.)

Reproduction of microphotographs by Ö. Winge, taken by transmitted light. Specimens preserved in formaline.

Fig. 1	Length	$8^3/_4$	mm. . . .	Station	789. (Gut of specimen somewhat damaged).
„ 2	—	12	„ . . .	—	789.
„ 3	—	14	„ . . .	—	794.
„ 4	—	16	„ . . .	—	789.
„ 5	—	$18^3/_4$	„ . . .	—	793.
„ 6	—	20	„ . . .	—	813
„ 7	—	24	„ . . .	—	813.

Pl. II. European Fresh-Water Eel (*Anguilla vulgaris*, Turt.)

Reproduction of photographs by Pacht & Crone, taken by reflected light and showing appearance of growing larvæ. Specimens preserved in formaline or in a mixture of glycerine and formaline. To be compared with Pl. I (1909) where similar figures on the same scale ($2^1/_2$ times natural size) are given of the full-grown larva *(Leptocephalus brevirostris)* and its transformation to the elver-stage. The two Plates thus furnish, with Pl. I of the present paper, a complete series showing the appearance of the larvæ of *A. vulgaris* from shortly after birth through all stages up to that of the elver.

Fig. 1	Length	14	mm.	Station	794	Fig. 10	Length	31	mm. . . . Station 813
„ 2	—	18	„	—	813	„ 11	—	34	„ . . Station 1040,110 m. w.
„ 3	—	18	„	—	813	„ 12	—	38	„ . . — 1042,80 —
„ 4	—	19	„	—	813	„ 13	—	40	„ . . — 1040,110 —
„ 5	—	20	„	—	813	„ 14	—	43	„ . . — 1058,80 —
„ 6	—	25	„	—	813	„ 15	—	47	„ . . — 1021,65 —
„ 7	—	27	„	—	813	„ 16	—	52	„ . . — 1031,65 —
„ 8	—	27	„	—	813	„ 17	—	60	„ . . — 1013,65 —
„ 9	—	29	„	—	813	„ 18	—	64	„ . . — 1013,65 —

Pl. III. European Fresh-Water Eel (*Anguilla vulgaris*, Turt.)

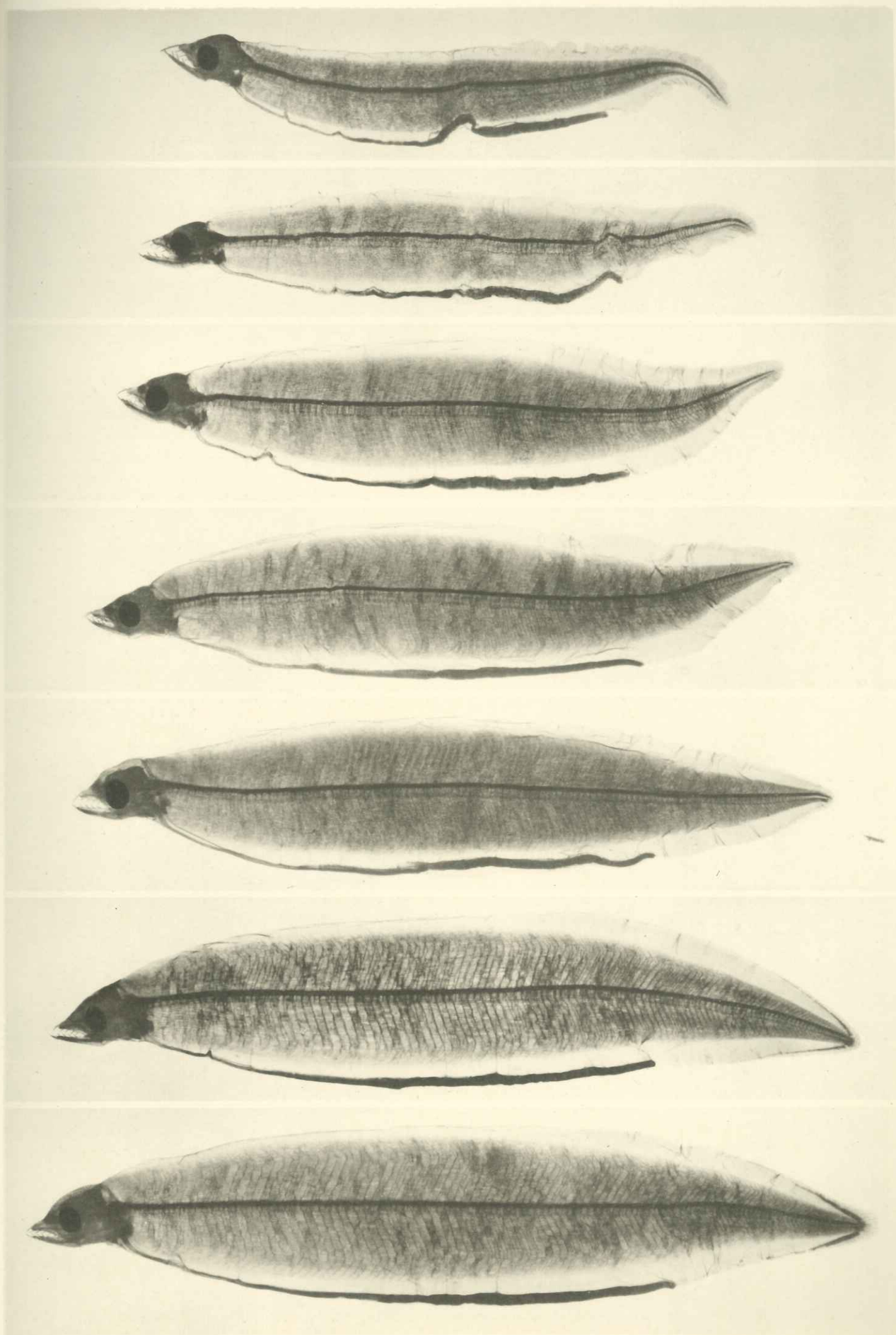
Reproduction of microphotographs by Ö. Winge, taken by transmitted light and showing the development of the tail. Specimens preserved in formaline, some of them stained with alizarine. Abt. 60 × nat. size.

Fig. 1	Total length	$8^3/_4$	mm. . .	Station	789.
„ 2	—	14	— . .	—	794.
„ 3	—	$18^1/_2$	— . .	—	793.
„ 4	—	20	— . .	—	813.
„ 5	—	19	— . .	—	813.
„ 6	—	24	— . .	—	813.
„ 7	—	22	— . .	—	813.
„ 8	—	39	—	Station	1040,65 m. w.
„ 9	—	$38^1/_2$	—	—	1033,65 —

Pl. IV. American Fresh-Water Eel (*Anguilla rostrata*, Les.)

Reproduction of photographs by Pacht & Crone, taken by reflected light and showing appearance of growing as well as of metamorphosing larvæ. Specimens preserved in formaline.

Fig. 1	Length	22	mm. . .	ca. 26° Lat. N., 73° Long W.	
„ 2	—	44	„ . .	Station	1029,25 m. w.
„ 3	—	55	„ . .	—	1027,80 —
„ 4	—	60	„ . .	—	1024,65 —
„ 5	—	57	„	Station U.S.S. "Bache"	10166,100-0 m.
„ 6	—	58	„	— — —	10180,75-0 m.
„ 7	—	61	„	— — —	10157,18-0 m.



1 Length: 8¾ mm.

2 Length: 12 mm.

3 Length: 14 mm.

4 Length: 16 mm.

5 Length: 18¾ mm.

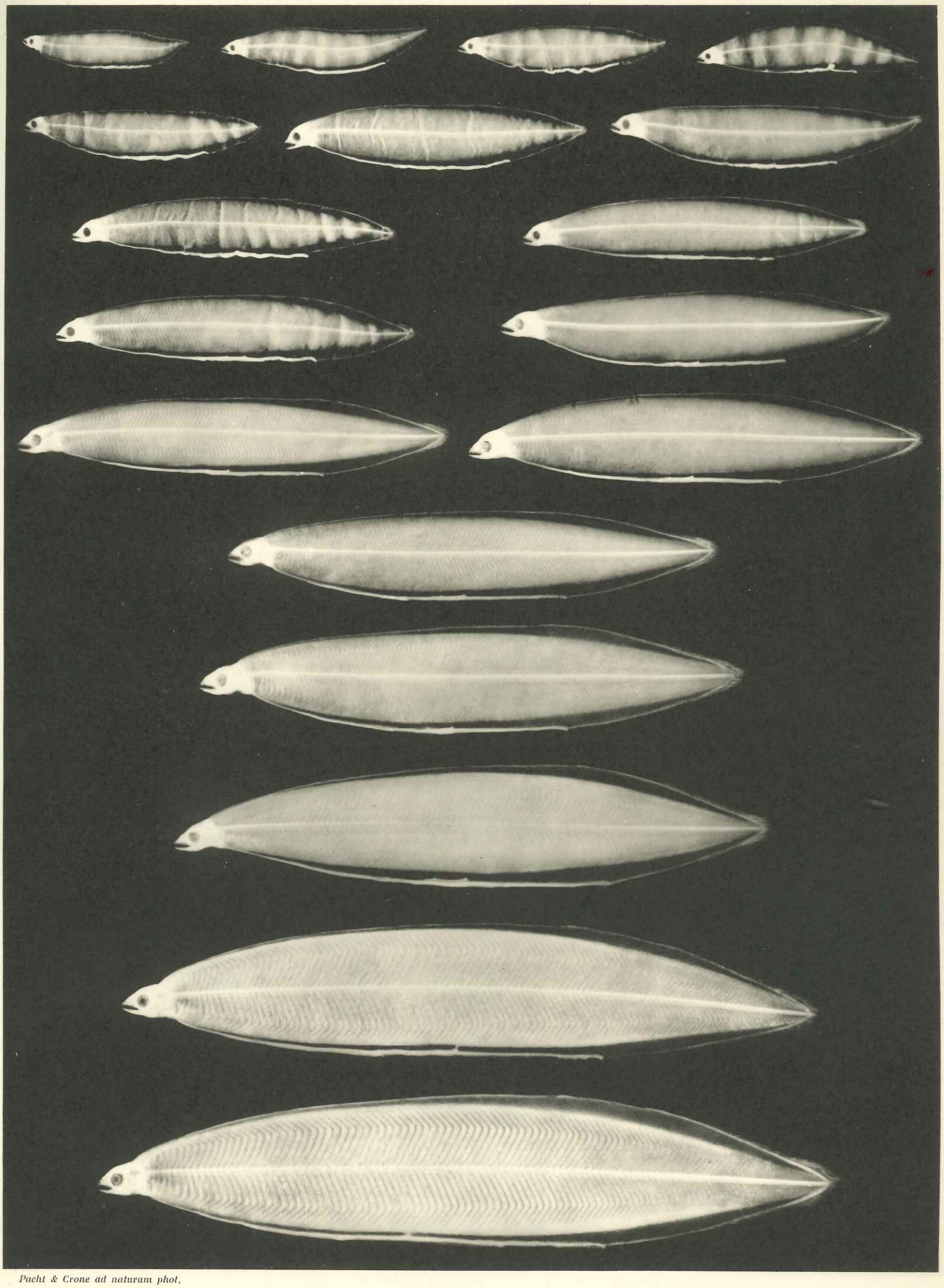
6 Length: 20 mm.

7 Length: 24 mm.

O. Winge ad naturam phot.

European Fresh-Water Eel (*Anguilla vulgaris*, Turt.). — **Early larval stages.**

(Reproduction from photographs by transmitted light of specimens preserved in formaline).



	Lengths:
1—4	14, 18, 18, 19 mm.
5—7	20, 25, 27 mm.
8—9	27, 29 mm.
10—11	31, 34 mm.
12—13	38, 40 mm.
14	43 mm.
15	47 mm.
16	52 mm.
17	60 mm.
18	64 mm

Pacht & Crone ad naturam phot.

European Fresh-Water Eel (*Anguilla vulgaris*, Turt.). — **Growing Larvae.**

All the figures about 2½ nat. size. Reproduction from photographs by reflected light of specimens preserved in formaline.
To be compared with Pl. I (**Johs. Schmidt**, 1909) which shows the older, metamorphosing stages.

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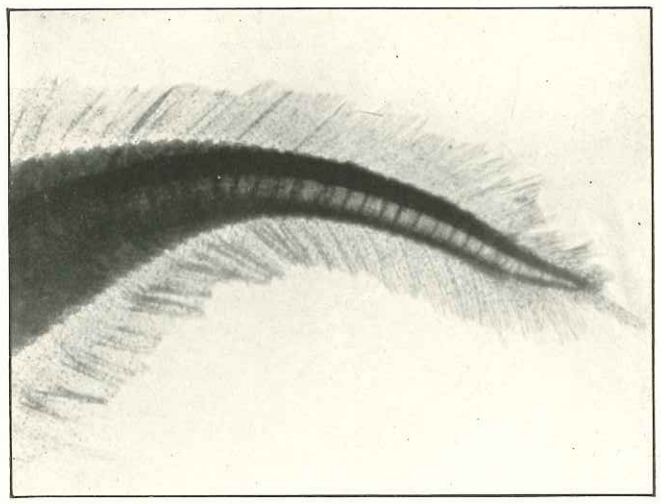

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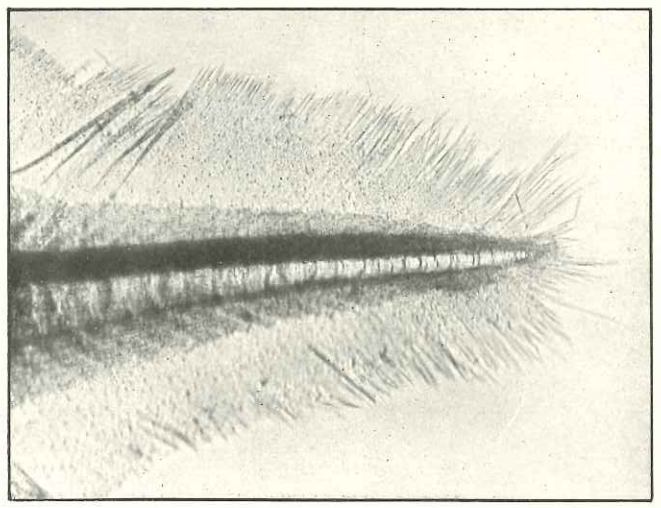

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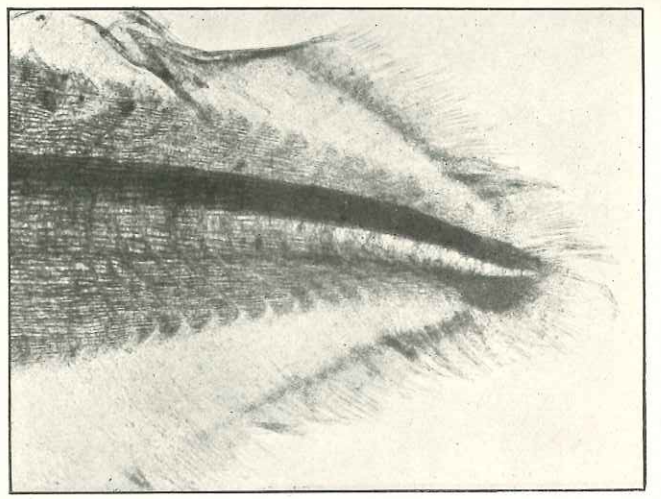

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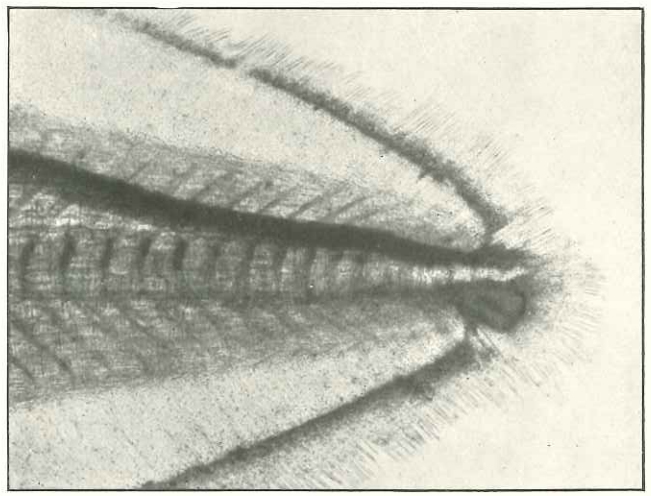

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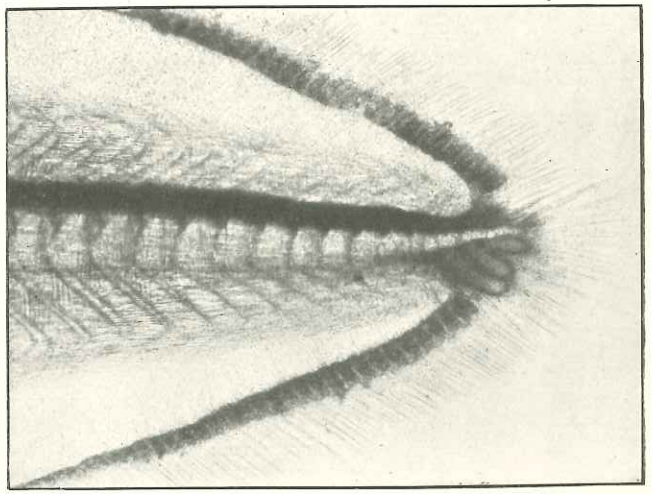

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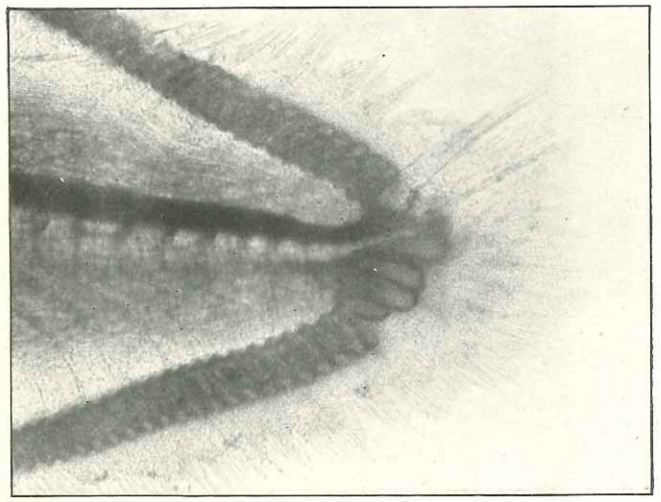

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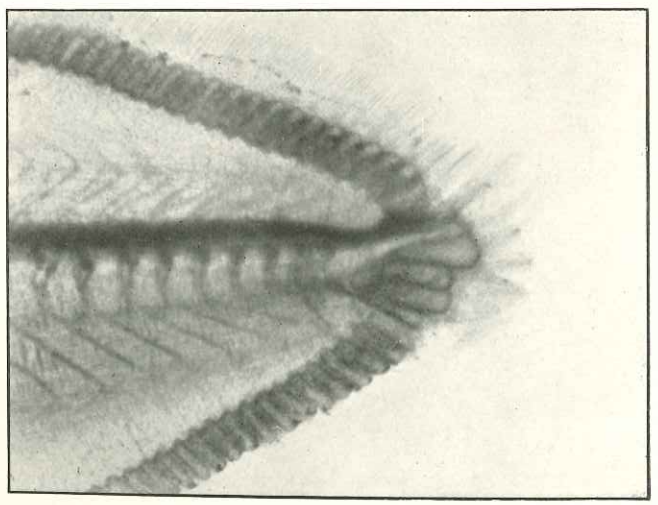

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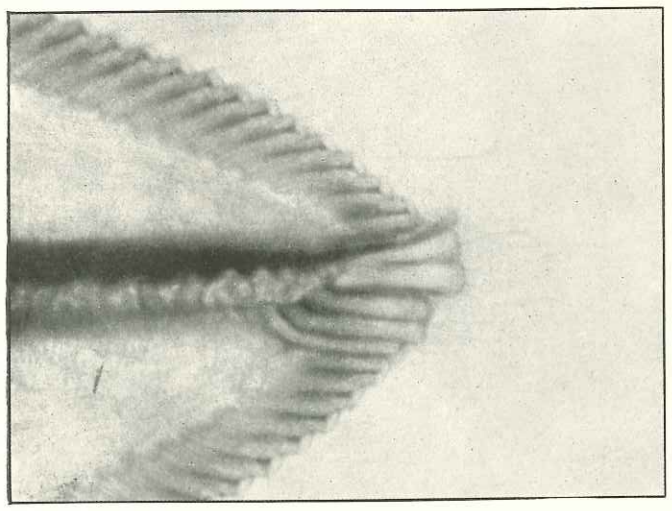

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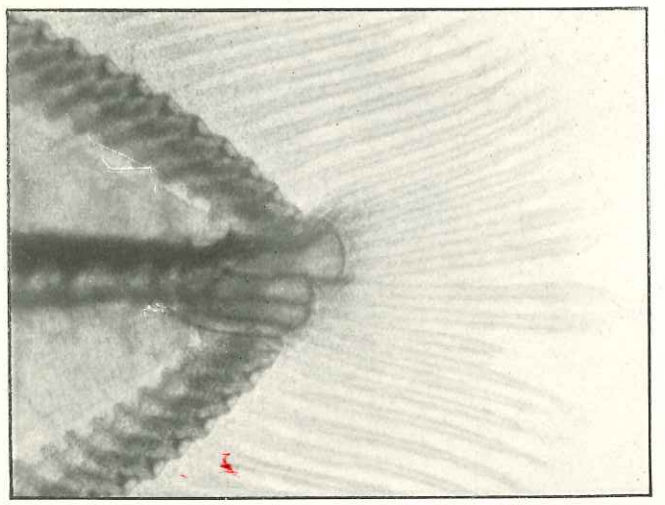

Ö. Winge ad naturam phot.

European Fresh-Water Eel (*Anguilla vulgaris*, Turt.). — **Development of tail.**

Reproduction of microphotographs (× 60) by transmitted light of specimens preserved in formaline.

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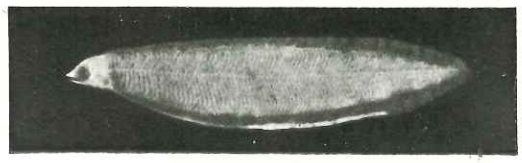

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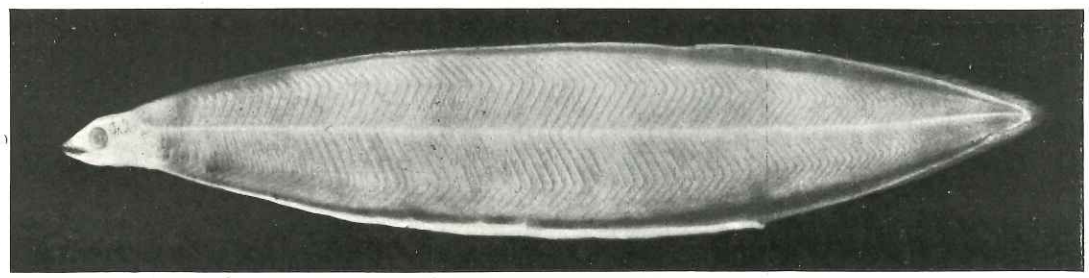

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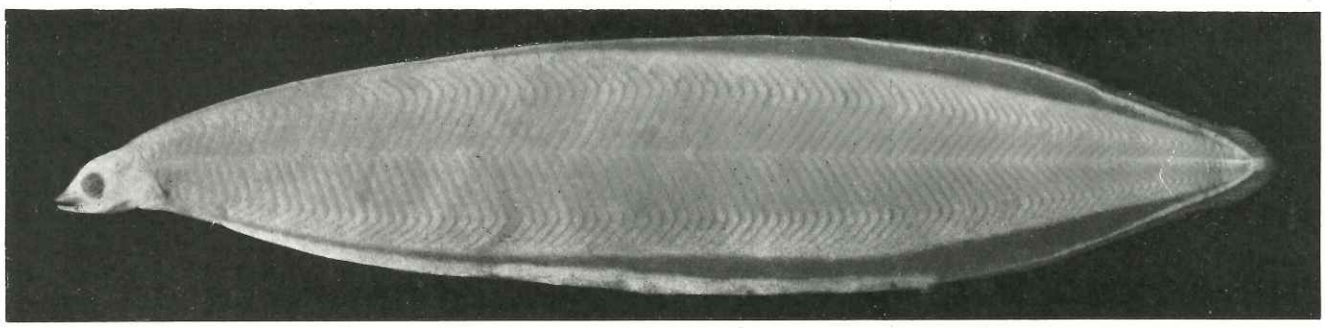

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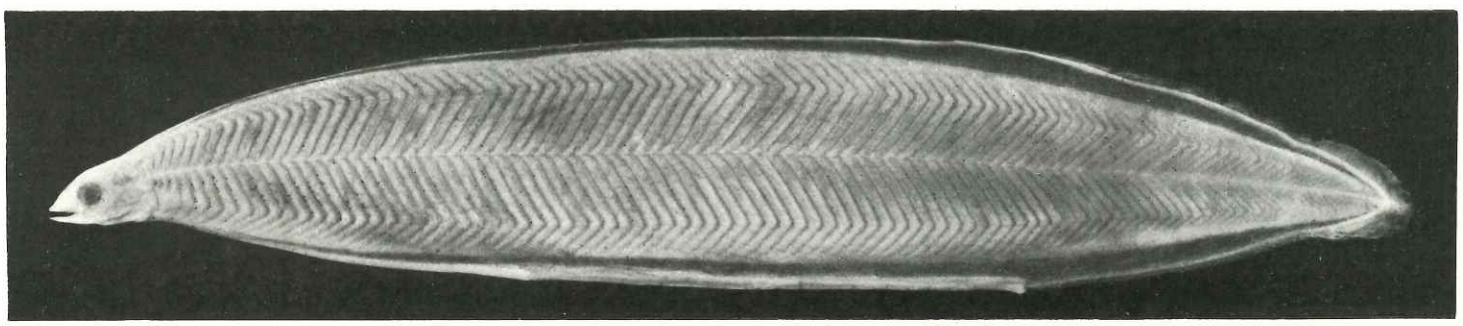

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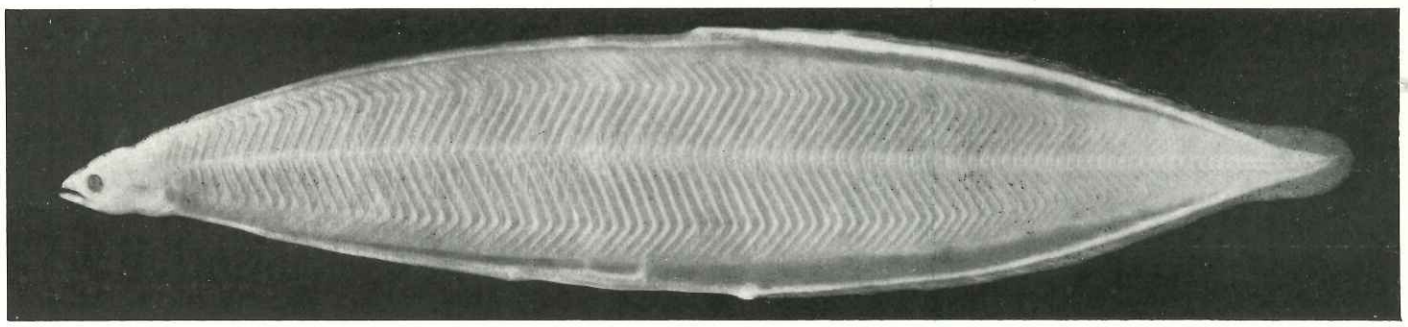

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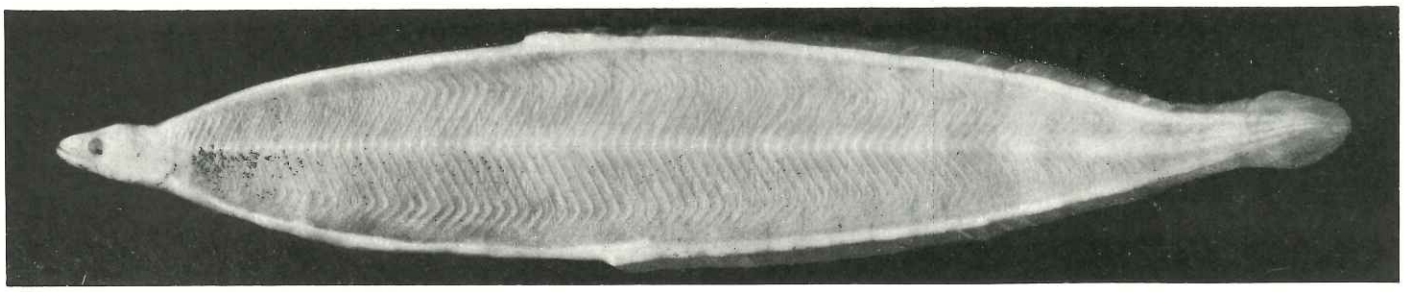

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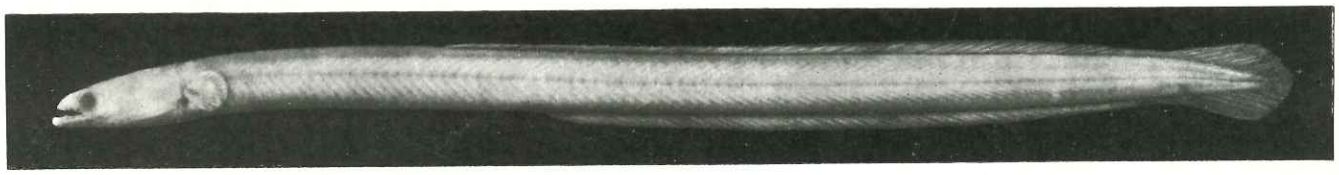

Pacht & Crone ad naturam phot.

American Fresh-Water Eel (*Anguilla rostrata*, Lesueur.)

All the figures about $2^1/_2$ nat. size. Reproduction from photographs by reflected light of specimens preserved in formaline.

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