MEDDELELSER

FRA

KOMMISSIONEN FOR HAVUNDERSØGELSER

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ON THE LARVAL AND POST-LARVAL DEVELOPMENT OF THE ARGENTINES

(*ARGENTINA SILUS* [ASCAN.] AND *ARGENTINA SPHYRÆNA* LINNÉ)

WITH SOME NOTES ON *MALLOTUS VILLOSUS* [O. F. MÜLLER]

BY

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WITH TWO PLATES

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I. INTRODUCTION

In the years 1903, 1904, 1905 and 1906 the "Thor" has taken in deep water in the Atlantic, as also in the Skager Rak), the young of an elongated *Clupea*-like form, but provided with a number of large black pigment-spots. A close examination of these has shown that they belong to the salmonoid genus, *Argentina* and that both of the North Atlantic species of this genus, *Argentina silus* and *Argentina sphyraena,* are represented in the collections. It has proved at the same time, firstly, that the *Argentina* fry are very characteristic and easily recognizable and secondly, that the two species are very easily distinguished in the early stages. A description will be given in the following pages of the developmental history of the two species as shown by the material to hand from the "Thor". I give further a proof of the correctness of the determinations and a summary of the characteristics by means of which the *Argentina*-fry can be distinguished from forms of a similar appearance. At the same time some few, early developz mental stages of another marine salmonoid, namely the "lodde" *(Mallotus villosus)* are described and figured. This form has been taken by the "Thor" at Iceland in enormous quantities right from the earliest stages in each of the three years 1903 to 1905. A more detailed description of the developmental history of the "lodde" will not be given however until later in connection with that of the herring, which in outer appearance it resembles much more during the early stages of development than the *Argentina*-genus, with which indeed it can in no way be confused.

The eggs of the larger of the two *Argentina*-species, *Argentina silus,* have been taken and hatched out during the "Thor's" investigations, which have shown that they occur in large quantities floating in water-layers far from the surface over great depths. They are thus what is called bathypelagic. The developmental history and biology of *Argentina silus* in the earliest stages present on the whole several characteristics, which merit all the more attention in the following pages because this is the first deep-water fish whose life-history from the earliest stages has been traced. The facts will be described in more detail later and I shall only just mention here, that in several regards *Argentina* shows connecting links with the Muraenoids, amongst others some which contribute to an understanding of the developmental history and biology of these latter forms in the earliest stages.

II. Description of the developmental history

1. *Argentina silus*

a. Eggs

The eggs of *Argentina silus* are distinguished from most of the other pelagic fish-eggs by their remarkable size, measuring in diameter from a little under 3 to a little over $3^1/_2$ mm.[1] Of other known fish-eggs they most resemble those described by Raffaele as Muraenoid eggs, but they differ from these

[1] The following measurements in mm. may serve to illustrate the sizes:
Diameter of eggs: 3·24—3·48—3·25—3·38—3·41—3·20—3·07
Greatest diameter of the oil-globule: 1·16—1·09—1·16—1·09—1·14—1·09—0·95

in lacking a large perivitelline space.[1] Thus the yolk in the young egg, where the embryo has not yet begun to develop, fills the whole space right out to the membrane. The yolk is not homogeneous but, like that of the Clupeoids and Muraenoids, has a vesicular structure consisting of numerous small cell-like vesicles or spheres, which are comparatively speaking smaller than in those above-mentioned species the eggs of which they resemble.

The yolk contains a very large oil-globule which as a rule is not spherical but flattened on the one side and convex on the other. Sometimes in addition to the larger, there may be found some few smaller oil-globules but generally there is only one, the largest diameter of which is about 1 mm. (see measurements p. 3, footnote). Usually the oil-globule is colourless or it has a more or less reddish (pinkish), more rarely a golden tint[2]. Beyond a slight striation the egg-membrane has no conspicuous structure but the pellicle which directly invests the yolk is finely reticulated and is seen most distinctly in the newly hatched larvae.

As the experimental hatching of the *Argentina* eggs had always to be undertaken on board the "Thor" at sea, it was unfortunately impossible on account of the motion of the ship to make an exact study of the development or structure of the young. In the living state the eggs are clear and transparent, but preserved in formaline or alcohol they become perfectly opaque, especially those in the youngest developmental stages with most yolk.

In the young stages the yolk fills out the whole egg but gradually as embryonic development proceeds there arises, as is usual with fish-eggs, a space between the egg membrane and the yolk[3] (see figures, Pl. II).

In the living floating egg the oil-globule turns uppermost and the embryo arises on the side of the egg turned downwards, opposite to the oil-globule (see figures). Although the eggs of *Argentina* remind one strongly in many respects of those Muraenoid eggs described by RAFFAELE and EIGENMANN (Bull. U. S. Fish-Comm. XXI. 1902. p. 37—44) they, however, differ considerably in several regards. Thus, the yolk sac lacks the very characteristic posterior narrow stalk extending back below the alimentary canal, as is very clearly figured especially in EIGENMANN (l. c. figs. 1—14), and has the form and position occurring in ordinary fish-eggs. In the newly hatched larva the yolk-sac is very large, much larger than it appears to be in the Muraenoids (cf. figures of RAFFAELE and of EIGENMANN, also that of WILLIAMSON in MC INTOSH and MASTERMAN "Brit. Mar. Food-Fishes" 1897, Pl. XX) and as can be seen from my figures of the artificially hatched larvae of *Argentina silus* the reduction of the yolk only proceeds slowly after hatching in contrast to the Muraenoids described in the literature (cf. Pl. II).

In the older egg with large embryos, one may see that these spread over the greater portion of the circumference of the egg, generally with the exception of that part where the oil-globule is. The embryo is encircled by a very broad embryonic fin which exhibits a fine vesicular structure. The alimentary canal follows the trunk in the greater portion of its length diverging from it afterwards to end on the margin of the embryonic fin (— a contrast to the Muraenoids where it ends within the margin of the embryonic fin). In contrast to the Muraenoids the mouth is closed not only in the embryo immediately before hatching but also in the larva at least from four to five days after that (perhaps more); nor do the grasping teeth which characterise Muraenoids develop in *Argentina*. The eyes in the embryos of *Argentina* are wholly without pigment which is quite lacking on the whole before hatching. It is very

[1] Raffaele: Le Uove Gallegianti e le Larve dei Teleostei nel Golfo di Napoli (Mitth. aus der zool. Stat. Neapel, VIII p. 1—84, Pl. 1—5, 1888. Whether the early Muraenoid egg has really a large perivitelline space Raffaele does not explain as he has not found the youngest developmental stages of all his species, but to judge from his figures it seems to be the case.

[2] Curiously enough the oil-globules generally become yellow after the eggs have been preserved for some little time in formaline.

[3] In an egg the diameter of which was 3·34 mm. the diameter of the yolk was hardly 2·11 mm., in a second 3·41 and 2·14 respectively and in a third 3·24 and 2·50.

easy to count the segments, at all events the pre-anal ones, on the embryos freed from their membranes. For example, in eight embryos the following numbers of pre-anal segments were found: 46, 46, 46, 46, 47, 47, 47, 48 (— the last pre-anal segment was considered to be the one lying over the place where the end of the alimentary canal bends out from the body to end at the edge of the embryonic fin).

b. The larval and post-larval development

On the cruise of the "Thor" in 1906 I hatched out a large number of eggs of *Argentina silus* taken both in the Atlantic Ocean in June (W. from Scotland) and in September (S.W. from Ireland), and in the Skager Rak in the neighbourhood of Christianssand (at the end of July). The hatching of these large eggs which normally occur floating in deep water far from the surface was attended with greater difficulty than that of the ordinary fish-eggs occurring at the surface, and I only succeeded generally in hatching those eggs which were so far on in development that a distinct embryo could be detected. Without being able to give the reason with certainty it appeared that the eggs taken in the Atlantic hatched out more easily than those from the Skager Rak. Possibly this may be explained by the fact that the hatching experiments in the Skager Rak were undertaken in the month of July when it was very warm, and I could not on this account prevent the temperature mounting somewhat considerably in the small vessels holding about 8 litres in which the eggs were kept on board the "Thor", so that it was at all events several degrees above that at which the eggs normally lived in deep water. Another difficulty which asserted itself in the hatching experiments both in the Skager Rak and in the Atlantic was that the greater part of the eggs after a shorter or longer period generally sank to the bottom of the vessel, presumably owing to the abnormal conditions of pressure and temperature under which they lived. Then afterwards, on account of the ship's motion, they could not be checked from rolling backwards and forwards over the bottom of the vessel and this probably caused the death of many of them before hatching. Sometimes however I was able to get as many as 50 % of the eggs of a sample to hatch, although they lay on the bottom of the vessel during the hatching for as long as a week.

I have been able to keep the larvæ hatched out alive for up to 5 days but here again the same difficulty presented itself, namely, the rolling of the extremely delicate larvæ over the bottom of the vessel which certainly caused the death of several specimens. Nevertheless, some of the larvae were successfully carried so far forward in development that the identity between them and the larval and post-larval stages of *Argentina silus* (see Plate I, fig. 1—13) taken in the sea could be established with certainty.

When the larva comes out of the egg it lacks all traces of pigment both on the body and in the eyes. The yolk-sac in the lowest portion of which the oil-globule is placed is of large size and thus in great measure determines the movements of the little larva. These movements consist in a very quick waving of the part of the body behind the yolk sac, by which means the larva moves very quickly forward through the water. When the larva remains at rest the yolk sac is upwards (on account of the position of the lighter oil globule) and this also is usually the case when it moves.

A characteristic which I have not seen before in hatching out fish-eggs is that a greater or less portion of the yolk may be divided off, in such a manner that the larva does not carry all the yolk-mass from the egg but only a portion of it, and sometimes indeed a very large portion even that containing the oil-globule may be lost to the larva. This (abnormal?) phenomenon which I first noticed in June 1906 gave me a natural explanation of a peculiarity which, in earlier years, for example in preparing the figures of Plate I in the winter of 1905 before I had undertaken the hatching of *Argentina* eggs, I had not been able to understand, namely, that sometimes among the larval stages taken with the young-fish trawl there were tiny specimens with much smaller yolk sac than in the larger more developed larvæ

(cf. fig. 1, 2, 3, on Pl. I), whilst we should naturally expect the opposite. After some of the eggs of *Argentina* were hatched we sometimes found on the bottom of the vessel cut-off portions of the yolk-sac in addition to the larvæ and the egg-capsules and we sometimes even observed the parts falling off. This takes place when the larva is trying to escape from the egg-membrane and it was always the most posterior portion of the yolk-sac, which was cut-off.

As all the hatching experiments were undertaken on board the "Thor" at sea it was not possible on account of the movement of the ship to study closely or measure the hatched larvæ in the living state. The further examination was subsequently undertaken after the completion of the cruise and on material preserved in formaline.

The larvæ artificially hatched on board the "Thor"

I shall now describe the three larval stages (A, B, C) figured in Pl. II the first two of which were hatched in July 1906 from eggs taken in the Skager Rak, the third in June 1906 from an egg from the Atlantic west from Scotland.

Pl. II, Fig. 4 **Larva A.** It was preserved the same day it was hatched. It has, from the head to the end of the embryonic fin, a length of 7·4 mm., but, as the anterior portion of the body lies bent on the yolk-sac, the larva's real length is somewhat greater, namely 7·7 mm.[1] The mouth is closed, and all trace of pigment wanting. The length from the anus to the tip of the embryonic fin is 1·8 mm. so that the anus is situated far back. The yolk sac, which shows the same vesicular structure as described for the eggs, is very large and deep (the greatest length is 3·1 mm. and the greatest depth 2·4 mm.) and has the large oil-globule, which is colourless in the living condition, nearly in the middle of its ventral portion. The form and position of the yolk sac is otherwise quite as usual. The body is surrounded by a very broad embryonic fin (breadth about 1 mm.) which exhibits a fine vesicular structure. The gut lies close to the body in its anterior portion but bends out at the 47th segment to end on the margin of the embryonic fin. In addition to the 47 pre-anal there are about 20 post-anal segments of which the most posterior as in the embryos taken from the egg are not easy to count with absolute certainty.

Pl. II, Fig. 5 **Larva B.** The larva was preserved two days after hatching. Its total length is 8 mm. Like the first one described the mouth is not yet open and the eyes are quite destitute of pigment. On the whole it does not show any other essential difference from the first one than that pigment has begun to appear. Thus there is found a small rather weak group of black pigment points on the ventral surface of the body where the gut bends out before it ends on the embryonic fin. There are 48 pre-anal and about 20 post-anal segments.

Pl. II, Fig. 6 **Larva C.** This larva was living four days after hatching and on that day it was killed and preserved. The total length is $8^1/_2$ mm. The yolk sac is still very large. The mouth is still closed and the pigment lacking in the eyes. In addition to the pigment-group which had already appeared in Larva B and which is now very much stronger, and is not confined to the ventral portion of the body but spreads also to the gut, still another group has now been added. This is situated very far back a little in front of the notochord and is present on the ventral as well as on the dorsal side of it. Further, the chromatophores are still very weak. This pigment-group stretches anteriorly nearly to the 18th post-anal segment. Apart from these two mentioned groups pigment is quite lacking. Coloured pigment is absent both in this and all the following larval and post-larval stages. About 47 pre-anal and 20 post-anal segments can be counted.

[1] The length of the newly hatched larvæ I have found to vary considerably in my specimens, namely, from about 6 to about 9 mm.

The following larval and post-larval stages were taken in the sea with the young-fish trawl

Length ca. 10¼ mm. The specimen drawn is one of the youngest taken in the sea. The body Pl. I, Fig. 1
is very slender and elongated and thus in form reminds one of the larvæ of *Clupea, Ammodytes* &c. It is surrounded by a broad embryonic fin with reticular or vesicular structure. The anus is placed at the edge of the fin far back (as in *Clupeidæ* and *Muraenidæ*); thus the distance from the point of the snout to the anus is about 3½ times as great as the distance from the anus to the tip of the notochord. The mouth is not yet open and the eyes still have no black pigment. In the specimen figured there remained but little of the yolk sac (cf. this with the description given of the artificially hatched larvæ) although it was much larger in others of the same size. The yolk still retains however quite the same cellular or vesicular structure, as was described for the eggs. There are 47 very distinct preanal segments[1] and about 20 postanal the last of which however can only be counted with difficulty. The gut follows the contour of the body for the greater part of its length, bending out from it a little in front of the anus to end on the border of the embryonic fin.

With respect to the pigment, it is nearly the same as in the last described, artificially hatched specimen; no more pigment spots have been added since then. Thus the pigment consists firstly of a well-marked patch on the place where the gut posteriorly bends out from the body contour. This patch is composed of large stellate chromatophores which are placed ventrally on the body from which they also partly extend on to the gut itself. The group in the neighourhood of the end of the notochord is still faint. In contrast to the anal patch which is only placed ventrally it consists both of a ventral and a dorsal portion. In front, this pigment-group reaches to the 18th post-anal segment. The difference between the larval specimen taken in the sea and the last-described artificially hatched larva C, consists essentially only in this that the former has grown somewhat in length and thickness. The pigmentation is quite the same and in spite of the very considerable length of the specimen the mouth is still closed.

Length ca. 11¼ mm. The mouth has now begun to open, but pigment is still lacking in the Pl. I, Fig. 2
eyes (a little pigment may however, be present in other specimens of the same length). The yolk-sac is rather large though not so large as in the following specimen. 47 very distinct preanal segments could be counted as well as ca. 20 postanal, the posterior of which were rather indistinct.

With respect to the pigment the same two patches are present as in the foregoing specimen and besides these one still very weak preanal patch has appeared on the 30th preanal segment. For the sake of brevity I call this patch No. III, the anal one No. II and the patch situated near the end of the tail No. I. The three patches I, II and III are nearly equidistant.

Length ca. 12 mm. The mouth has opened completely and there is a little black pigment in Pl. I, Fig. 3
the eye. The yolk sac is proportionately very large, of a vesicular structure and contains one large (and one small) oil-globule, low down anteriorly in the yolk sac. As mentioned in the description of the eggs it is not wholly spherical (about 0·96 mm. broad and about 0·8 mm. deep). 47 preanal segments are present and ca. 20 post-anal the last of which are difficult to count with certainty. The pigment groups are the same as in the previous specimen but both I and II are much more pronounced. I extends posteriorly to a little distance in front of the tip of the notochord. It consists both of a ventral and a dorsal portion and is not restricted to the tail but extends also on to the embryonic fin and is therefore considerably larger than the two others (II and III) both of which consist only of a ventral portion. III, as yet the weakest, is placed on the 30th pre-anal segment.

[1] To the pre-anal segments are reckoned all those which lie in front of the angle made by the gut with the body, at the place where it bends out from this to end on the embryonic fin.

Pl. I, Fig. 4 **Length 16$^{3}/_{4}$ mm.** The yolk sac is not yet completely absorbed but in this and other specimens of the size always much reduced. It is almost sausage-shaped and narrower than the body[1]. The oil-globule (or globules) is still seen in it. The eyes are now entirely pigmented and deep black. There are 47 pre-anal segments and about 20 post-anal the last of which are difficult to count correctly. Under a strong magnifying power one can detect below in the tail-fin the very first traces of interspinous bones as an extremely slight eminence, but it is still too weak to be represented in the figure with this degree of magnification. The notochord is still quite straight. In addition to the three pigment groups there is now a fourth (IV). It is situated at the same distance in front of III as III is in front of II and consists like the other pre-anal groups only of a ventral portion. These four groups I, II, III, and IV are very regular in position and divide the whole length of the body into four portions of equal length No. III being equidistant from the snout and tail. Several specimens of this size occur where these four groups and no others are present. In the specimen figured one can already detect however a trace of a further development of the pigments, as there is sometimes a very faint spot (II a) midway between II and III and sometimes another (III a) midway between III and IV. In other specimens the first indication could further be seen of I a (midway between I and II) and IV a (midway between IV and tip of the snout).

Pl. I, Fig. 5 **Length 17 mm.** The yolk sac has now almost entirely disappeared; only a very small portion of it is present with the remains of the oil-globules. 47 preanal and about 20 postanal segments are present The notochord is quite straight. The interspinous rays in the lower part of the caudal fin are as in the previous specimen. The pigment-groups I, II, III, and IV are all pronounced. I a is very faint in the specimen figured, whereas II a, III a, and IV a are distinct, though not so pronounced as the four primary groups. The most posterior group (I) is the largest and spreads over the embryonic fin; it reaches posteriorly to the tip of the notochord (in contrast to *A. sphyræna*).

Pl. I, Fig. 6 **Length 19 mm.** The tip of the notochord is still straight. There is now a little more indication of the interspinous bones below in the caudal fin, but they are as yet rather indistinct. There are 45—46 preanal and about 20 postanal segments. All the eight pigment-groups (also I a) are now present, so that the body is divided into eight portions of about equal length. With the exception of I which consists of a dorsal and ventral portion (also extending on to the embryonic fin) the pigment-groups consist only of a ventral portion. There is still no trace of interspinous rays in the dorsal or anal fin, but in the former there are ca. 10 short, club-shaped, swollen threads extending out into the embryonic fin, in the latter about 8.

Pl. I, Fig. 7 **Length 22 mm.** The tip of the notochord is still straight. A somewhat considerable thickening in the ventral portion of the caudal fin indicates the developing interspinous rays. 45 preanal and about 20 postanal segments could be counted. The same eight pigment-groups as in the earlier stages are present. The pectorals are very short fan-shaped flaps and the ventral fins are quite absent. There are still no traces of interspinous rays in the dorsal or anal fins but the threads mentioned are longer than in the previous specimen.

Pl. I, Fig. 8 **Length 28 mm.** The tip of the notochord is now slightly bent upwards and there are very well-defined interspinous rays below in the caudal fin. Traces of rays are present in the greater part of the caudal fin below but are still weak, above they are quite lacking. The caudal fin has black pigment between the rays. Traces of rays in the dorsal and anal fins are not yet formed but the embryonic fin in the place where they appear later is a little more opaque than the rest. 47 preanal and 20 postanal segments could be counted. The same 8 pigment-groups are still present.

[1] Posteriorly it extends in the specimen figured a little behind the pigment-group III a.

Length 32½ mm. The tip of the notochord is much bent up but still very distinct. The rays have appeared over all the lower portion of the caudal fin, the upper portion however being still free of rays. On account of the sharp upturning of the tip of the notochord the caudal fin is about to adopt an apparently symmetrical appearance. Its posterior border is slightly concave and its upper lobe is still slightly larger than the lower. In the dorsal and anal fins are now seen traces of the interspinous rays, which appear in each of these fins as a curved, sickle-like streak in the embryonic fin nearly half-way between the contour of the body and the border of the embryonic fin. Here, therefore, we have the peculiarity that these two fins appear in the embryonic fin itself without direct connection with the body, from which nerve-strands are seen passing out through the embryonic fin to the interspinous regions. There are still no signs of rays in the dorsal or anal fins. There are 47 preanal and about 20 postanal segments. In the pectoral fins there are 18 rays, most of which are still weak. The same 8 pigment-groups are present as before. There is pigment between the rays of the caudal fin. The specimen described is almost at the same developmental stage as the *Argentina sphyræna* of 19¼ mm. described later. Pl. I, Fig. 9

Length 35½ mm. The tip of the notochord is curved strongly upwards, but its free part is still long. The caudal fin which has dots of pigment between the rays is now symmetrical and distinctly divided into equally large lobes. There are 19 long rays all of which are subnotochordal, but as yet none of the shorter which are developed later in front above as well as below. The rudiments of the dorsal and anal fins are still without connection with the body and are situated high up in the embryonic fin, which remains very broad. The developing dorsal and anal fins consist as yet chiefly of the interspinous streaks only (in the dorsal fin are about 10, and in the anal fin about 12 interspinous rays), but there are also weak traces of rays in both fins. The dorsal fin in this specimen, as in the younger and older stages, is situated opposite pigment-group III a (the sixth from the tail). 47 preanal and about 20 postanal segments can be counted. Pl. I, Fig. 10

Length 39 mm. The caudal fin is lobed. The dorsal fin has now moved downwards so that it touches the margin of the body in its whole length, which also applies to the anal fin except at its posterior part. In the dorsal fin about 11 and in the anal fin about 13 short rays can be counted. The embryonic fin is still very broad behind the dorsal and anal fins. Anteriorly it is narrower. The pigment groups are as before. 47—48 preanal and about 20 postanal segments can be counted. Pl. I, Fig. 11

Length 45 mm. In addition to the long, posterior rays in the caudal fin there are short but as yet quite indistinct rays in front both above and below. In the dorsal fin there are 11 rays but the anal was so damaged that it was impossible to count them. The pectoral fin has 18 rays. The 6 preanal pigment-groups are paired whereas the two postanal are unpaired. Looking at the specimen from the ventral aspect one can define these distinctly, as it is seen that I and I a are situated in the medio-ventral line whilst none of the other (preanal) groups is directly in the middle line, but on each side of this is a spot which towards the middle line is linear. There are about 47—48 preanal and about 18—20 postanal segments. Pl. I, Fig. 12

Length ca. 50 mm. The ventral fins are seen below the most posterior part of the dorsal fin which has 12 rays. In the anal fin there are 13 or 14 rays. The embryonic fin remains broad in spite of the specimen's large size. The adipose fin is therefore as yet not formed, though a little in front of the caudal fin there is a depression in the embryonic fin which presumably marks its boundary posteriorly. The pigment is essentially the same as before and 8 groups are still persistent in their original arrangement. Pl. I, Fig. 13

Still older post-larval stages have not been taken hitherto by the "Thor", but these will undoubtedly be easy to recognise. It is characteristic of this species that it attains so considerable a size as 5 cm. without as yet being transformed. In this respect it is distinguished from *A. sphyræna*, which at a total length of 5 cm. is already quite like the adult and amongst other characteristics has assumed the silvery lustre which distinguishes these species. As a common feature of all the larval and post-larval stages of *A. silus* examined it may finally be mentioned, that coloured pigment is quite absent which was also the case in the stages of *A. sphyræna* examined.

2. *Argentina sphyræna* Linné

The eggs and youngest larval stages of this smaller species are not found in the "Thor's" collections whereas the post-larval developmental stages are clearly and completely elucidated through the material to hand.

Pl. I, Fig. 14 **Length 7 1/4 mm**. The yolk sac is already greatly reduced and narrower than the body. The mouth is open but the eyes are as yet not black. As in *A. silus* the anus is placed far back and opens out on the border of the fin. There are 36 distinct preanal segments and about 17 postanal, the last 2—3 of which are not so distinct. The tip of the notochord is quite straight and all trace of interspinous rays is absent in the unpaired fins. The body pigment is already well forward in development so that all the pigment groups are seen. We cannot therefore as in *Argentina silus* trace their development. A group is found somewhat in front of the tip of the notochord (No. 1). In contrast to the other groups which only consist of a ventral portion, the most posterior patch has both dorsal and ventral. (It differs from the corresponding one in *A. silus* in that it is situated a greater distance in front of the tip of the notochord.) Another group (No. 2) occurs at the anus, and between the tip of the tail and the anus there is 1 a. Anterior to the anus there are four groups which divide the preanal portion of the body into 5 almost equal portions (in contrast to *A. silus* where there are 5 groups). These groups are called from behind forwards 2 a, 3, 3 a, and 4.

Pl. I, Fig. 15 **Length 11 mm**: No trace of the yolk sac is seen. The eyes are quite black. The tip of the notochord is quite straight but traces of interspinous rays are to be seen below in the caudal fin a little in front and of also opposite group 1 (seen under fairly high magnification). There are 36 distinct preanal segments and about 19 postanal the most posterior of which are less distinct. The same (7) pigment groups as in the previous specimen are present, and in addition there are found (between the gut and the body) a small faint group between 2 and 2 a and another, also faint, between 2 a and 3.

Pl. I, Fig. 16 **Length 13 mm**. Posteriorly the notochord is very slightly bent. In the lower part of the caudal fin there are distinct traces of interspinous rays, and an opaque portion below in the embryonic fin indicates the place where the rays will appear later. At the places where the dorsal and anal fins are later formed there are short, thick threads, club-shaped at the ends, which run out into the embryonic fin. About 36 preanal and about 18 postanal segments can be counted. The same 7 pigment groups as in the specimen first described are present (1, 1 a, 2, 2 a, 3, 3 a, 4) and in addition a faint group between II and II a.

Pl. I, Fig. 17 **Length 15 1/4 mm**. The tip of the notochord is somewhat bent upwards. In the lower part of the caudal fin there are now seen very distinct beginnings of the rays, between which pigment is present. In the dorsal fin (which is placed in front of pigment group 3) and in the anal fin the interspinous regions have been laid down as a faint streak up in the embryonic fin out of communication with

the contour of the body (just as in *A. silus*). There are ca. 37 preanal and about 18—19 postanal segments. The same 7 pigment-groups as in the stages first described are present and in addition a very distinct one between 2 and 2 a.

Length 17 mm. The tip of the notochord is somewhat bent upwards but still prominent. Only in the lower part of the caudal fin are there interspinous bones and rays. The greater part of this now has rays. The interspinous regions in the dorsal and anal fins are now distinctly outlined, almost sickle-like, and are still placed in the embryonic fin quite out of connection with the body itself. There are ca. 37—38 preanal and ca. 17 postanal segments. With respect to the pigment there is no essential change. Pl. I, Fig. 18

Length 19¼ mm. The tip of the notochord is strongly bent upwards and the rays are present everywhere in the caudal fin below, whilst they are entirely absent above. On account of the strong upward curve of the tip of the notochord the caudal fin is now about to take an apparently symmetrical appearance. The rudiments of the dorsal and anal fins are still out of direct connection with the body and consist as yet only of the interspinous regions, which form a very definite sickle-like streak in the embryonic fin, into which the nerve-strands are seen passing out from the body to the rudiment of the interspinous rays. Traces of rays are not yet seen but the embryonic fin opposite the interspinous regions where the rays appear later is a little more opaque than previously. About 36 preanal and about 18 postanal segments are present. Just as in the previous stage, 8 pigment groups are seen, i. e. 7 + one between 2 and 2 a which last is nearly of the same intensity as the other seven. Pl. I, Fig. 19

Length 23¼ mm. The tip of the notochord is strongly bent upwards and much reduced. The caudal fin is slightly concave and nearly symmetrical but the upper lobe is as yet the larger. There are about 19 long caudal rays (behind). In the upper part of the caudal fin rays are still absent. With respect to the dorsal fin there is a difference from the previous stages as the interspinous streak has now approached the body with which it is now quite united except posteriorly. The rays are formed but are as yet weak. The dorsal fin is situated in front of pigment-group 3 or somewhat in front of the middle of the body. The interspinous region in the anal fin also now touches the body-contour, except posteriorly. There are 11 distinct interspinous rays and a corresponding number of fin-rays, which are not all equally distinct. A row of pigment spots is present on the interspinous rays. About 37 preanal and about 17 postanal segments could be counted. There are 9 pigment groups, viz., in addition to the 7, one between 2 and 2 a and another between 2 a and 3 both of which are now almost as distinct as the original ones. Pl. I, Fig. 20

Length 27½ mm. The caudal fin is symmetrical and deeply lobed. It has posteriorly 19 long rays, above and in front ca. 3—4 weak ones and below and in front ca. 4 likewise weak. The anterior rays both above and below are short. The dorsal fin has 10 and the anal fin 12 rays, the middle ones in both fins being most distinct. They extend quite out to the border of the still broad embryonic fin. The interspinous streaks in both these fins now lie in the whole of their length close to the body-contour. Pl. I, Fig. 21

37 or 38 preanal and ca. 18 postanal segments are present. The pigment is comparatively faint in this particular specimen but otherwise it is similar to the previous stage.

Length ca. 29 mm.[1] The embryonic fin is broad between the dorsal and caudal fin but in front of the dorsal fin and ventrally it is narrow. In the caudal fin which is deeply lobed there are 19 long Pl. I, Fig. 22

[1] A part of the caudal fin was broken off so that the exact length cannot be given; the total length to the beginning of the caudal fin was 25½ mm.

rays posteriorly in addition to the shorter anterior ones above and below. In the dorsal fin there are about 10 and in the anal fin about 12 rays. The pectoral fins possess 14 rays. There are 37 preanal and about 16 postanal segments.

The pigment groups are large and rounded, but for the most part not superficial. The dorsal fin is situated over group 3. From before backwards there are the following pigment groups: 4 (in front of this there is, just as in the earlier stages a group on the gill-cover which is situated higher than the others) which lies nearly at the root of the pectoral fins. After that comes 3 a, then 3, next a group between 3 and 2 a, then 2 a (the last groups are situated relatively nearer to each other than the others) then a group between 2 a and 2, then 2 (a little before the anus). Lastly there is 1 a between the anus and the tip of the caudal fin and the remains of 1 on the tip of the caudal fin. Between 1 a and 2 there is besides a short line of pigment on the interspinous rays of the anal fin.

Pl. I, Fig. 23 **Length 38½ mm.** The embryonic fin has now for the most part disappeared, but a portion of it between the dorsal and caudal fins still remains and forms the adipose fin by which the fish is immediately seen to belong to the *Salmonidæ*. The following rumber of rays occurs in the unpaired fins; the caudal has posteriorly 19 long rays and anteriorly both above and below about 10 short ones. In the dorsal fin there are about 10 and in the anal 12 rays. 37 preanal and about 17 postanal segments are present. The original pigment grouping is no longer seen distinctly. The original groups are best recognised on looking at the fish from the ventral aspect. On the sides medially and on the dorso-ventral aspect a number of fine pigment spots have been added since the previous stage.

To describe still older developmental stages is scarcely necessary as these are easily recognisable. The young *Argentina sphyræna* are already silvery at the length of 50 mm.

III. On the distinction between the early stages of *Argentina silus* and *Argentina sphyræna*.

It will be apparent from the foregoing description, that there is a very considerable difference in the developmental histories of the two species which makes it always possible to separate them in well-preserved specimens. For convenience I shall here give a short recapitulation of the chief distinguishing characters.

In *A. sphyræna* the larval and post-larval stages of a given length are very much more advanced in development than specimens of *A. silus* of a similar size. In *A. sphyræna* of about 8 mm. the mouth is for example open and the yolk-sac very greatly reduced in size, just as almost all the pigment groups (at least 7) characteristic of the species are present (cf. Pl. I, Fig. 14). An *Argentina silus* of about 8 mm. is quite a delicate larva with closed mouth and very large yolk-sac, and of the 8 pigment groups which appear later there is only one (the anal) or two (viz. the one furthest back in front of the tip of the notochord) (cf. Pl. II, Fig. 4–6). Whilst the tip of the notochord in *A. sphyræna* begins already to bend up at a total length of ca. 13—14 mm., it does not do so in *Argentina silus* before it has reached a length of over 20 mm. At a somewhat greater length than that at which the notochord in the two species begins to bend upwards (viz. 15 mm. and 25—30 mm. respectively) the first indications of rays begin to show themselves in the dorsal and anal fins (compare Figs. 16–17, Pl. I with Figs. 7—8).

In *Argentina silus* in the post-larval stages there are 8 very regularly placed pigment groups (viz. in addition to the 2 postanal and 1 anal, 5 preanal, the foremost of which is situated opposite the pectoral fins). The distance between these groups is equally great (there are 8 or 9 segments between each group) and no more pigment groups appear than these 8, which develop almost at the time as the

yolk sac with the oil-globule is being reduced (see Figs. 5—13, Pl. I). In *Argentina sphyræna* in the youngest post-larval stages there are only 7 pigment groups (viz. in addition to the 2 postanal and 1 anal, 4 preanal the most anterior of which is situated opposite the pectoral fins). Later, there appear 2 preanal groups so that the total number becomes 9 and of these the middle preanal groups are closer to one another than the others (cf. Plate I, Figs. 14—22). Lastly, in the post-larval stages the most posterior pigment group is placed nearer the tip of the notochord in *Arg. silus* than in *Arg. sphyræna*, and in agreement with this one finds in the older post-larval stages of the former that the greater part of the caudal fin itself is covereed with dots of pigment, whilst in *A. sphyræna* only the basal portion of the caudal fin is pigmented. By counting the number of preanal segments one is able to distinguish the two species with certainty and ease. *Argentina silus* has ca. 46—49 and *Argentina sphyræna* ca. 36—38 preanal segments As a rule there is no difficulty in counting the segments, if the microscope has a good illuminating apparatus (e. g. Abbé's); xylol, glycerine and such like are not required to clear the specimens in order to count the segments. This can be accomplished in material preserved in formaline.

IV. Some characteristic features in the developmental history of *Argentina*.

We have thus seen from the foregoing account that the marine Salmonoids of the *Argentina* genus have pelagic eggs, and also, like the other physostomoid groups the *Clupeidæ* and *Murænidæ*, that the yolk is not homogeneous but segmented. From the Murænoid eggs, which they greatly resemble the *Argentina* eggs are distinguished by lacking the large perivitelline space (described by RAFFAELE l. c., e. g. Figs. 1—2, Pl. V) and in addition, by several features in the embryonic and larval development (the yolk has not a pedunculated portion, grasping teeth are not developed, the gut ends on the margin of the embryonic fin, not within the margin). On the other hand, the Argentines remind one of the Muræ-nidæ in that the dorsal and anal fins appear out in the very broad and long embryonic fin, so that the rudiments of the fins have from the beginning no connection, as is usual, with the contour of the body (see for example Fig. 10 on Plate I).[1]

The teeth may also be mentioned as a characteristic feature in *Argentina*'s post-larval stages. In each jaw there is a series of vertical, very closely set and numerous teeth which reminds one of the teeth in a comb. Lastly, the characteristic and regular arrangement of the pigment in 8 groups in *Argentina silus* and in 7—9 in *A. sphyræna* may be emphasized as especially characteristic of the post-larval development of these fishes which just for this reason are so extraordinarily easy to recognise.

V. Verification of the determinations

The proof that the stages here described and figured really belong to *Argentina silus* and *Argentina sphyræna* has not been attended with great difficulty. In the first place the collections of the "Thor" contained the post-larval and young metamorphosing stages of *A. sphyræna*, the last of which quite resembled the adult of this species in the form and position of the fins, in the number of fin rays and the presence of the adipose fin, so that a whole series of developmental stages right down to quite the youngest post-larval ones could be established. After it was proved that this series belonged to *A. sphyræna* it followed of necessity that the other series must belong to *A. silus* with which also the number of rays in the oldest stages stood in agreement. Further, the number of segments found in the specimens of the first series was ca. 51—55, in the second ca. 65—70, which numbers correspond well to those given in the

[1] That this is the condition in the Murænidæ I have had the opportunity to confirm on the "Thor's" cruise in the Atlantic in 1906 by finding the young incompletely developed larval (preleptocephalic) stages of some deep-sea murænoids. The detailed report on these will appear later.

Occurrence of the eggs, larval and postlarval stages of *Argentina silus*[1]).

Station No.	Date	Position	Depth (meters)	Young-fishtrawl; meters wire out	Duration of haul	Total number of specimens caught	Number of specimens: length less than 15 mm	Number of specimens: length 15-35 mm	Number of specimens: length 35-50 mm	Number of eggs
99	22-V-1904	61°15′ N., 9°35′ W.	970—872	1000	1 hour	...	...	...	...	c. 20
				1700	1 hour	...	...	...	...	c. 30
60	28-V-1905	61°50′ N., 11°38′ W.	1110	1000	1 hour	5	3	2	...	Several hundreds
61	28-V-1905	61°11′ N., 11°00′ W.	963	900	1 hour	11	11	...	...	About 1000
63	30-V-1905	59°49′ N., 8°58′ W.	1150	1200	1 hour	9	9	...	...	100—200
64	30-V-1905	59°17′ N., 7°29′ W.	895	65	1 hour	10	8	2	...	.....
				1000	1 hour	362	259	103	...	About 300
59	30-V-1906	51°58′ N., 10°25′ W.	83	120	3/4 hour	1	...	1	...	.....
60	31-V-1906	51°27′ N., 11°10′ W.	202	250	1 hour	1	...	1	...	.....
62	4-VI-1906	50°25′ N., 12°44′ W.	2480	200	2 hours	1	...	1	...	.....
64	5-VI-1906 / 6-VI-1905	49°17′ N., 14°03′ W.	more th. 2000	200	2 hours	3	...	2	1	.....
				300	2 hours	1	...	1	...	.....
71	7-VI-1905	57°47′ N., 11°33′ W.	1985	1500	1 hour	1	...	1	...	.....
72	8 / 9 VI-1905	57°52′ N., 9°53′ W.	1020—1550	300	4×2 hours	19	1	18	...	.....
				600	2 hours	8	...	8	...	.....
				1500	2 hours	28	12	16	...	.....
73	10-VI-1905	56°56′ N., 9°22′ W.	1180—1390	300	2 hours	1	...	1	...	.....
74	10-VI-1905	56°00′ N., 9°32′ W.	1040	300	2 hours	2	...	2	...	.....
76	11-VI-1905	55°56′ N., 9°40′ W.	1390—1405	300	7 1/2 hours	3	...	3	...	.....
82	14 / 15 VI-1905	51°00′ N., 11°43′ W.	1020—1370	300	9 1/2 hours	1	...	1	...	.....
			1210—1350	600	2 hours	1	...	1	...	.....
86	19-VI-1905	49°14′ N., 8°45′ W.	95	65	30 min.	1	...	1	...	.....
90	24-VI-1906	55°45′ N., 9°30′ W.	910	800	30 min.	3	1	1	1	35
103	4-VII-1906	59°15′ N., 4°45′ E.	265	350	1 hour	1	...	...	1	.....
177	8-VII-1904	63°11′ N., 21°30′ W.	320	400	30 min.	1	...	1	...	.....
178	9-VII-1904	63°08′ N., 21°30′ W.	700	750	45 min.	37	24	13	...	More than 90
179	9-VII-1904	62°44′ N., 20°44′ W.	more th. 2000	50	15 min.	2	2	...	...	.....
171	16-VII-1903	63°15′ N., 20°04′ W.	216—326	250	20 min.	2	...	2	...	.....
				500	15 min.	1	...	1	...	.....
172	17-VII-1903	63°16·5′ N., 19°57′ W.	390—260	250	20 min.	5	...	5	...	.....
				600	20 min.	2	1	1	...	.....
129	25-VII-1905	62°40′ N., 8°43′ W.	512	500	20 min.	9	...	8	1	.....
225	31-VII-1904	63°07′ N., 9°24′ W.	520	600	20 min.	3	...	3	...	.....
164	29-VIII-1905	61°20′ N., 11°00′ W.	1300	300	1 hour	2	...	2	...	.....
166	30-VIII-1905	58°53′ N., 10°15′ W.	1900	300	1 hour	1	...	...	1	.....
282	31-VIII-1904	63°24·5′ N., 20°03·5′ W.	145	150	2 1/2 hours	1	...	1	...	.....
283	31-VIII / 1-IX 1904	63°20′ N., 20°49′ W.	124	100	3 hours	7	...	6	1	.....
				150	3 hours	6	...	4	2	.....
167	31-VIII / 1-IX 1905	57°46′ N., 9°55′ W.	1175—1180	200	5 hours	18	...	17	1	.....
			1000—1310	300	10 1/2 hours	8	...	7	1	.....
				1500	2 hours	...	...	...	...	More than 17
285	1-IX-1904	62°49′ N., 18°46′ W.	more th. 2000	100	1 hour	2	...	2	...	.....
				500	1 hour	2	...	2	...	.....
173	6-IX-1905	57°52′ N., 8°01′ E.	520	65	1 hour	1	...	...	1	.....
				300	2 hours	4	...	4	...	.....
				600	1 hour	...	...	...	...	100—200
185	7-IX-1906	51°56′ N., 11°55′ W.	620—630	300	1 hour	...	...	...	...	1
			630—550	600	1 hour	...	...	...	...	c. 50
			550	900	1 hour	...	...	...	...	c. 100
			600	900	1 hour	...	...	...	...	c. 100
			640	900	2 hours	...	...	...	...	c. 250
			640—560	600	1 hour	...	...	...	...	c. 50
			560—500	300	2 hours	...	...	...	...	.....
	8-IX-1906		500—420	250	2 hours	...	...	...	...	.....
			420—350	300	2 hours	...	...	...	...	.....
			350—400	400	1 1/2 hour	...	...	...	...	.....
293	8-IX-1904	57°50′ N., 6°00′ E.	258	300	30 min.	2	...	2	...	.....

[1]) This list is not complete as the four years material has not yet been wholly worked up, but in the main it shows the distribution within the area explored.

literature and to the number of vertebræ found in *A. sphyræna* and *A. silus* during the "Thor's" investigations[1]. (If the number of segments found in the embryonic larval and post-larval specimens are generally 1 or 2 higher than the number of vertebræ in the adult fish, we must remember that one or two of the foremost segments are incomplete and do not correspond to vertebræ in the adult fish.)

That, finally, the large bathypelagic fish-eggs described here belong to *A. silus* is proved by the complete agreement between the artificially hatched larvæ and the larval and post-larval stages taken in the same hauls. This is true as regards the structure of the yolk, the form of the oil-globule, the size of the larvæ, the development and position of the pigment, the appearance of the gut and also the position of the anus (both in the embryos taken from the eggs and in the artificially hatched larvæ, the gut was found to bend out from the contour of the body to end at the margin of the embryonic fin at the same place as in the larval and post-larval specimens taken from the sea, namely, opposite segments 46—49).

VI. On the occurrence of the eggs and early stages of *Argentina*

Argentina silus

The first time I found the eggs of *A. silus* was on May 22nd 1904 in the Atlantic, West of the Færoe Isles (61° 15′ N, 9° 35′ W. Depth 970—872 m.). I did not know at that time to what species these eggs belonged, but they were very noticeable as compared with other ordinary fish eggs by their remarkable size and their mode of occurrence. The following hauls which display their mode of occurrence were made at this place.

1. Young-fish trawl 15 m. wire out, 45 minutes: No eggs,
2. „ „ 1000 „ „ „ (not at bottom) 1 hour: ca. 20 eggs of *A. silus*,
3. „ „ 1700 „ „ „ (at bottom) 1 hour: ca. 30 eggs of *A. silus*.

These three hauls show that the eggs are pelagic. This is seen from haul 2, where the net had certainly been deep down (scarcely 500 m. but had not touched the bottom (if this had been the case it would have been seen with the greatest ease, as is known, according as the net brought up bottom-material or not). Lastly, we see that the eggs are bathypelagic, as we only found them in the deep hauls and not at the surface. With the "Thor's" hydrographer, Cand. mag. J. N. Nielsen, I made the following experiment. Some of the *Argentina* eggs which were still living (quite clear and transparent) were placed in surface water with a specific gravity of 1·02738. In this most of them sank, only some few remained floating. The eggs which had sunk in the surface water were then put in water with a specific gravity of 1·02870 (surface-water with a mixture of salt), in which they all floated. Some of them already floated in water with a specific gravity 1·02831. This experiment proves consequently, that most of the eggs sank in the surface-water but remained floating in water with a little greater density. I have many times later, both in the Atlantic and in the Skager Rak, found the eggs of *A. silus* (from May to September) and have then been able to convince myself that they are bathypelagic. Some hauls of the young-fish trawl of 1 hour's duration on one of the "Thor's" stations in the Skager Rak (58° 05′ N. 8° 24′ E., depth about 520 meters) in July show the conditions well.[1]

[1] In the ichthyological works of Day and Smitt the following number of vertebræ is given:
A. silus 65 (Day); 65—68 (Smitt).
A. sphyræua 50—52 (Day); 51—52 (Smitt),
An examination by Cand. mag. A. Strubberg of specimens of the 2 species caught by the "Thor" gave for
A. sphyræna 53 vertebræ (1 specimen), for *A. silus* 66 (1 specimen).

[2] It may be remarked that the depth at which the young-fish trawl fishes may be estimated as between $^1/_2$ and $^1/_3$ of the length of wire run out.

(1)	50	meters	wire	1 egg
(2)	100	—	—	2 eggs
(3)	150	—	—	9 —
(4)	200	—	—	24 —
(5)	300	—	—	126 —
(6)	400	—	—	165 —
(7)	600	—	—	236 —
(8)	700	—	—	918 —

From the hauls in the Skager Rak it appears quite evident that the eggs of *A. silus* belong to the deeper water layers, even though a few of them may sometimes ascend to the surface, and the same is seen in all the many hauls the "Thor" has made in the Atlantic waters in the course of the years. Great numbers of *A. silus* eggs were taken there in hauls with the young-fish trawl, with, for example, 1800, 1500, 1200, 1000, 900, 800, 600 meters wire out[1], whereas only a few were taken with 300 meters wire out and none or only quite isolated specimens in all the hundreds of hauls with a length of from 100 to 15 meters wire which were made over the whole distance between Iceland and the northern coast of Spain.

The eggs of *Argentina silus*, are thus what is called bathypelagic, that is to say, they live in the deep water far from the surface, and there they are developed to larvæ which likewise pass through their future development without normally ascending to the surface-layers.

In addition to the eggs of *Argentina silus*, the "Thor" found in the Atlantic at least three species of large bathypelagic eggs (differing from those of *Argentina silus* by lacking an oil-globule). We see therefore that it is not only the surface-water layers which contain pelagic fish-eggs, but that eggs of deep-water fishes also occur in abundance floating in layers far from the surface, a fact which is obviously of great significance for the understanding of the biology of deep-water fishes or at least of some of them.

With regard to the geographical distribution of the eggs and the larval and post-larval stages of *Argentina silus* it may in general be said, judging from the "Thor's" investigations, that they are found in the Atlantic from Iceland and southwards as far as the S.W. of Ireland, and also in the Skager Rak and the Norwegian Channel (see the list p. 14). They occur generally in deeper water than the fry of *Argentina sphyræna* and are thus taken in quantity in the neighbourhood of the 1000 meter curve.

Argentina sphyræna

The eggs of this species have not been taken by the "Thor", but Dr. D. Damas has kindly informed me that they have been taken by the Norwegian investigation-steamer "Michael Sars" in Norway. From the "Thor's" investigations it appears that the post-larval stages found in the Atlantic from between Scotland and the Færoes and southwards right to the north coast of Spain (here in quantity) and in addition in the northern portion of the North Sea. It thus seems that *Argentina sphyræna* is a more southern species than *Argentina silus*. From a list of the stations where they were taken it appears, likewise, that they are met with in shallower water than *Argentina silus*.

VII. *Mallotus villosus* (O. F. Müller)

Of this marine salmonoid, which the "Thor" has only taken at Iceland but at this place in tens of thousands of specimens, 5 young developmental stages are figured which show that it stands very far from the *Argentina*-species in these stages and in outer appearance resembles more the herring (*Clupea*).

[1] The greatest number taken in a 1 hour's haul was about 1000 eggs, namely on the 28th of May 1905 in 61° 11′N and 11° 00′ W, depth 963 metres, in a haul with 900 metres out.

Occurrence of the pelagic, larval and postlarval stages of *Argentina sphyræna*.[1]

Stations No.	Date	Position	Depth (meters)	Young-fish trawl meters wire out	Duration of haul	Total number of specimens caught	Number of specimens: length less than 15 mm	length 15-25 mm	length 25-40 mm
26	12-V-1905	61°14′ N., 1°19′ E.	166	65	30 min.	2	2	...	...
				170	30 min.	32	14	18	...
27	12-V-1905	61°31′ N., 0°39′ W.	180	65	30 min.	6	1	4	1
				220	30 min.	2	1	1	...
41	14-V-1906	43°23′ N., 2°01′ W.	102	15	2 hours	17	...	1	16
				60	2 hours	67	...	7	60
				120	2 hours	14	...	10	4
45	16-V-1906	44°19′ N., 1°51′ W.	125	60	30 min.	4	...	1	3
47	17-V-1906	45°00′ N., 2°57′ W.	1015—830	300	2 hours	1	...	...	1
59	30-V-1906	51°58′ N., 10°25′ W.	83	80	1 hour	2	2	...	...
65	31-V-1905	58°45′ N., 6°26′ W.	100	65	30 min.	10	1	4	5
71	7-VI-1905	57°47′ N., 11°33′ W.	1985	300	1 hour	5	2	2	1
				1500	1 hour	1	1	...	...
72	8/9 VI-1905	57°52′ N., 9°53′ W.	1020—1550	300	4×2 hours	5	...	4	1
83	16-VI-1905	51°13′ N., 10°30′ W.	146	65	30 min.	3	...	...	3
90	24-VI-1906	55°45′ N., 9°30′ W.	910	800	30 min.	1	...	...	1
106	5-VII-1906	57°47′ N., 1°05′ E.	135	200	1 hour	1	...	1	...
122	22-VII-1905	59°48′ N., 1°23′ W.	85	125	30 min.	4	...	4	...
123	23-VII-1905	60°15′ N., 2°38′ W.	157	65	30 min.	9	1	8	...
288	4-IX-1904	59°34′ N., 5°41′ W.	105	70	1 hour	63	...	15	48
				120	50 min.	210	...	88	122
246	11-IX-1903	60°00′ N., 0°38′ W.	c. 120	200	10 min.	2	...	2	...

Length 8 mm. The eyes are fully pigmented and the yolk sac has disappeared. The notochord is quite straight and there are no traces of fin-rays in the unpaired fins. The anus is situated far back as in *Argentina* and opens on the border of the fin. The pigment is very different from that of *Argentina*. On the ventral aspect in the median line there is a row of ca. 15 large linear patches of pigment, which extends from the anus forwards but is far from reaching to the pectoral fins. Behind the anus there are 3 similar streak-like pigment groups, which however do not begin immediately behind the anus but further back. Besides these large linear median spots there is on each side of the body, along the line of junction of the gut with the latter, a row of numerous smaller pigment spots, which reaches almost from the pectoral fin right to the anus. Pl. I, Fig. 24

Length 14 mm. The notochord is no longer quite straight. There are traces of the interspinous bones in the dorsal and anal fins, but as yet no rays. Below in the caudal fin there are distinct signs of the interspinous bones together with very faint traces of rays. About 49 preanal and about 22 postanal segments could be counted. Pl. I, Fig. 25

Length 17 mm. The tip of the notochord is somewhat bent upwards. In the dorsal fin there are faint signs of the rays. The adipose fin is beginning to form. There are about 20 medio-ventral large pigment spots in front of the anus and three very distinct ones behind this. About 49 preanal and about 21 postanal segments could be counted. Pl. I, Fig. 26

[1] This list is not complete, as the "Thor's" material has not yet been wholly worked up, but it shows the distribution within our area very well.

Pl. I, Fig. 27 **Length 23 mm.** The end of the notochord is much bent and reduced, and the development of the hypural elements is so far advanced that the posterior border of the tail (not tail-fin) is vertical. The caudal fin has ca. 19 long rays posteriorly but as yet no short ones anteriorly neither below nor above. In outward appearance it is a little heterocercal as the lower lobe is the larger, and its posterior border is somewhat concave. On its proximal portion there is a little pigment. The dorsal fin has ca. 12 distinct rays and the anal fin ca. 17—18 less distinct. The adipose fin is formed, the embryonic fin having disappeared in front of it and being quite low behind. Ca. 48 preanal and ca. 23 postanal segments could be counted.

Pl. I, Fig. 28 **Length 27$^1/_2$ mm.** In the caudal fin which is lobed and has pigment near the base there are now small indistinct fin-rays above and below anteriorly in addition to the 19 long posterior rays. In the dorsal fin there are 15 and in the anal 21 or 22 rays. The adipose fin is distinctly marked off both before and behind. In the caudal fin the l o w e r lobe is distinctly l a r g e r than the upper. The form of the snout is characteristic both in this and the other stages, being pointed and the portion between the eyes and the tip of the snout depressed. With regard to the pigment it may be said that there are about 20 large medio-ventral spots in front of the anus and also well-marked pigment behind it.

To describe still older post-larval stages of the "lodde" is superfluous as the presence of the adipose fin makes them easily recognisable.

The post-larval stages of the "lodde" have as mentioned a great outward resemblance to the herring (*Clupea harengus*), which also occurs in great numbers at Iceland, but is distinguished, in addition to the number of segments (ca. 51—58 in the herring), by the postanal ventral pigment, which is wanting or very faint in the herring, by the presence of the adipose fin &c &c.

In contrast to *Argentina* the "lodde" has demersal eggs, which are attached to the marine algæ &c in the shallow water like the herring's. We thus find in the marine Salmonoids as in other groups that one species may have demersal and the other pelagic eggs.

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550 ^{20}/XII 1906

Description of Plates

Plate I

Fig. 1. *Argentina silus,* **length 10 1/4 mm.**, "Thor", Stat. 64, 30th May 1905, 59° 17′ N. 7° 29′ W. Depth: 895 meters. Young-fish trawl, 1000 meters wire out.

Fig. 2. *Argentina silus,* **length 11 1/4 mm.**, "Thor" Stat. 64, 30th May 1905, same haul as Fig. 1.

Fig. 3. *Argentina silus,* **length 12 mm.**, "Thor", Stat. 99, 22nd May 1904, 61° 15′ N, 9° 35′ W. Depth: 970—872 meters. Young-fish trawl, 1000 meters wire out.

Fig. 4. *Argentina silus,* **length 16 3/4 mm.**, "Thor", Stat. 72, 8th—9th June 1905. 57° 52′ N, 9° 53′ W. Depth: 1020—1550 meters. Young-fish trawl, 1500 meters wire out.

Fig. 5. *Argentina silus,* **length 17 mm.**, "Thor", Stat. 72, 8th—9th June 1905, same haul as Fig. 4.

Fig. 6. *Argentina silus,* **length 19 mm.**, "Thor", Stat. 72 8th—9th June 1905, same haul as Fig. 4.

Fig. 7. *Argentina silus,* **length 22 mm.**, "Thor", Stat. 171, 16th July 1903, 63° 15′ N, 20° 04 W. Depth: 216—236 meters. Young-fish trawl, 250 meters wire out.

Fig. 8. *Argentina silus,* **length 28 mm.**, "Thor", Stat. 129, 25th July 1905, 62° 40′ N, 8° 43′ W. Depth: 512 metres. Young-fish trawl 500 meters wire out.

Fig. 9. *Argentina silus,* **length 32 1/2 mm.**, "Thor", Stat. 129, 25th July 1905, same haul as Fig. 8.

Fig. 10. *Argentina silus,* **length 35 1/2 mm.**, "Thor", Stat. 283, 31st August 1904, 63° 20′ N, 20° 49′ W. Depth: 124 meters. Young-fish trawl, 100 meters wire out.

Fig. 11. *Argentina silus,* **length 39 mm.**, "Thor", Stat. 166, 30th August 1905, 58° 53′ N., 10° 15′ W. Depth: 1900 meters. Young-fish trawl, 300 meters wire out.

Fig. 12. *Argentina silus,* **length 45 mm.**, "Thor", Stat. 166, 30th August 1905, same haul as Fig. 11.

Fig. 13. *Argentina silus,* **length 50 mm.**, "Thor", Stat. 167, 1st September 1905, 57° 46′ N, 9° 55′ W. Depth: 625—1425 meters. Young fish trawl, 75 meters wire out.

Fig. 14. *Argentina sphyræna,* **length 7 1/2 mm.**, "Thor", Stat. 26, 12th May 1905, 61° 14′ N, 1° 19′ E. Depth: 166 meters. Young-fish trawl, 65 meters wire out.

Fig. 15. *Argentina sphyræna,* **length 11 mm.**, "Thor", Stat. 26, 12th May 1905, same haul as Fig. 14.

Fig. 16. *Argentina sphyræna,* **length 13 mm.**, "Thor", Stat. 71, 7th June 1905, 57° 47′ N, 11° 33′ W. Depth: 1985 meters. Young-fish trawl, 300 meters wire out.

Fig. 17. *Argentina sphyræna,* **length 15 1/4 mm.**, "Thor", Stat. 123, 23rd July 1905, 60° 15′ N., 2° 38′ W. Depth: 157 meters. Young-fish trawl, 65 meters wire out.

Fig. 18. *Argentina sphyræna,* **length 17 mm.**, "Thor", Stat. 123, 23rd July 1905, same haul as Fig. 17.

Fig. 19. *Argentina sphyræna,* **length 19 1/4 mm.**, "Thor", Stat. 27, 12th May 1905, 61° 31′ N, 0° 39′ W. Depth: 180 meters. Young-fish trawl, 220 meters wire out.

Fig. 20. *Argentina sphyræna,* **length 23 1/4 mm.**, "Thor", Stat. 65, 31st May 1905, 58° 45′ N, 6° 26′ W. Depth: 100 meters. Young-fish trawl, 65 meters wire out.

Fig 21. *Argentina sphyræna,* **length 27 1/2 mm.**, "Thor", Stat. 65, 31st May 1905, same haul as Fig. 20.

Fig. 22. *Argentina sphyræna,* **length 29 mm.**, "Thor", Stat. 288, 4th September 1904, 59° 34′ N, 5° 41 W. Depth: 105 meters. Young-fish trawl, 120 meters wire out.

Fig. 23. *Argentina sphyræna,* **length 38 1/2 mm.**, "Thor", Stat. 65, 31st May 1905, same haul as Fig. 20.

Fig. 24. *Mallotus villosus,* **length 8 mm.**, "Thor", Stat. 115, 24th May 1904, 63° 51′ N, 16° 25′ W. Depth: 60 meters. Young-fish trawl, 15 meters wire out.

Fig. 25. *Mallotus villosus,* **length 14 mm.**, "Thor", Stat. 115, 24th May 1904, same haul as Fig. 24.

Fig. 26. *Mallotus villosus,* **length 17 mm.**, "Thor", Stat. 148, 18th June 1905, 65° 52′ N, 25° 32′ W. Depth: 115 meters. Young-fish trawl, 15 meters wire out.

Fig. 27. *Mallotus villosus,* **length 23 mm.**, "Thor", Stat. 163, 27th June 1904, 65° 10 1/2′ N, 24° 05′ W. Depth: 79 meters. Young-fish trawl, 85 meters wire out.

Fig. 28. *Mallotus villosus,* **length 27 1/2 mm.**, "Thor", Stat. 163, 27th June 1904, same haul as Fig. 27.

Plate II (*Argentina silus* [Ascan.])

Fig. 1. "Thor", Stat. 63, 30th May 1905, 59° 49′ N, 8° 58′ W. Depth: 1150 meters. Young-fish trawl, 1200 meters wire out. Diameter of egg = 3·40 mm.

Fig. 2. "Thor", Stat. 64, 30th May 1905, 59° 17′ N, 7° 29′ W. Depth: 895 meters. Young-fish trawl, 1000 meters wire out. Diameter of egg = 3·43 mm.

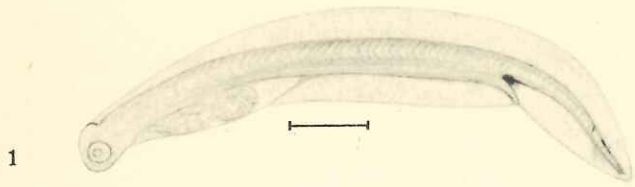
Fig. 3. "Thor", Stat. 129, 25th July 1906, 58° 05′ N, 8° 24′ E (Skager Rak). Depth: 520 meters. Young-fish trawl, 700 meters wire out. Diameter of egg = 3·24 mm.

Fig. 4. "Thor", Stat. 90, 24th June 1906, 55° 45′ N, 9° 30′ W. Depth: 910 meters. Young-fish trawl, 800 meters wire out. Larva hatched onboard and preserved the same day it was hatched. **Length 7·7 mm.**

Fig. 5. "Thor", Stat. 129, 25th July 1906, 58° 05′ N, 8° 24′ E (Skager Rak). Depth: 520 meters. Young-fish trawl, 600 meters wire out. Larva hatched onboard and preserved two days after hatching. **Length 8 mm.**

Fig. 6. "Thor", Stat. 185, 7th September 1906, 51° 56′ N, 11° 55′ W. Depth: 550 meters. Young-fish trawl, 900 meters wire out. Larva hatched onboard and preserved 4 days after hatching. **Length 8½ mm.**

Fig. 7. "Thor". Stat. 64, 30th May 1905, same haul as Fig. 1. **Length 12 mm.**



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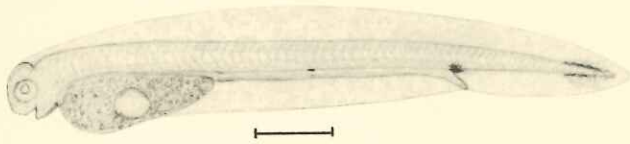

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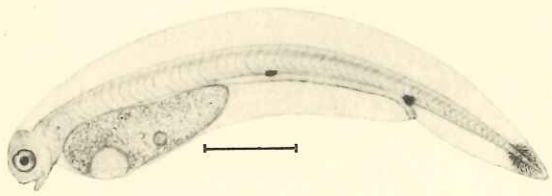

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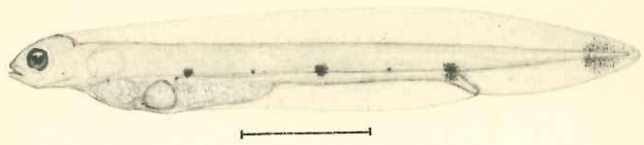

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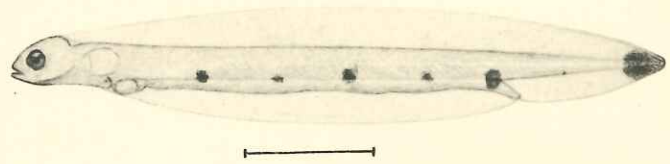

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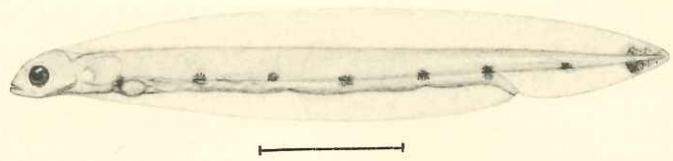

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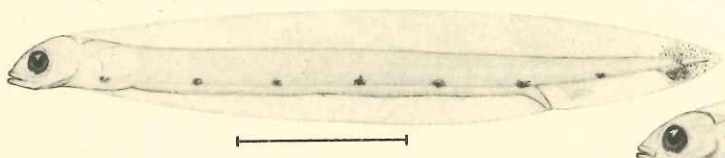

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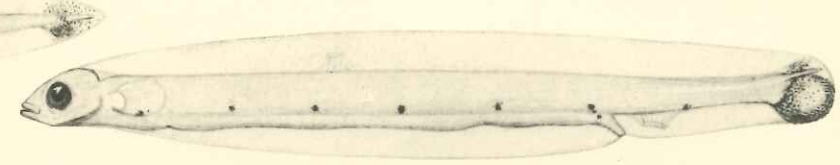

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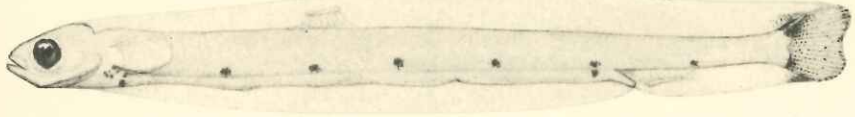

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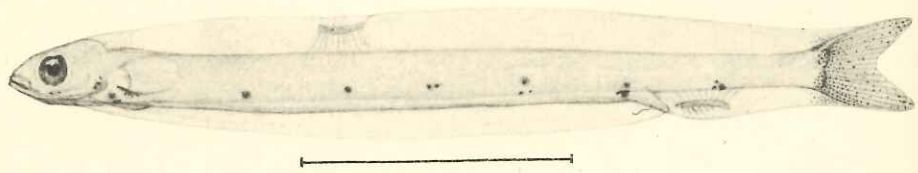

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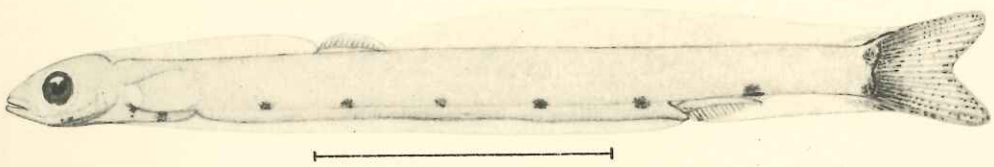

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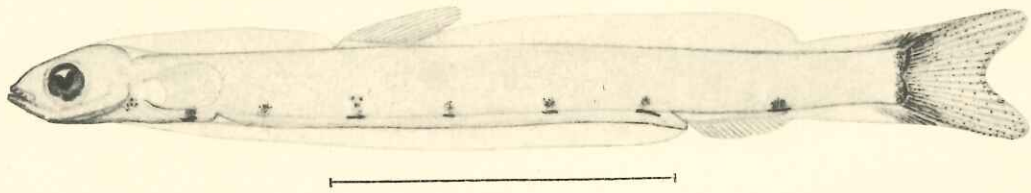

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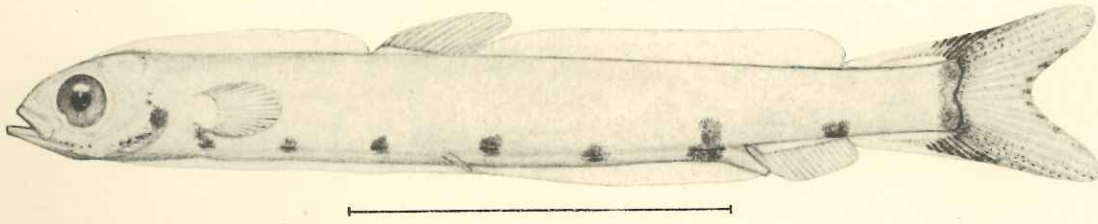

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Fig. 1—13 *Argentina silus* (Ascan.). Fig. 14—23 *Argent*

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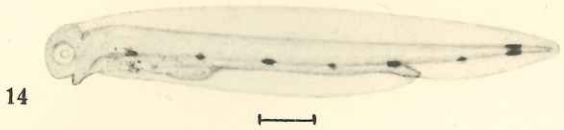

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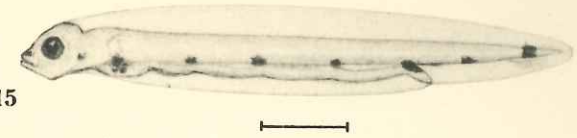

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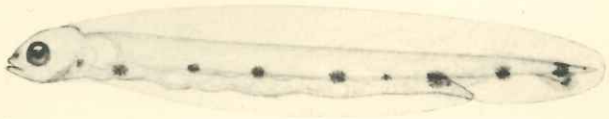

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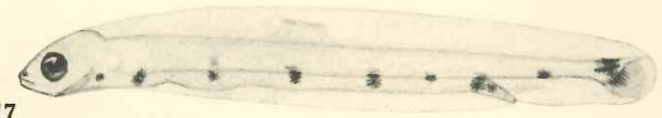

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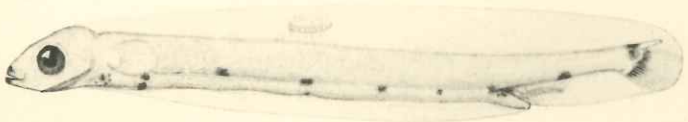

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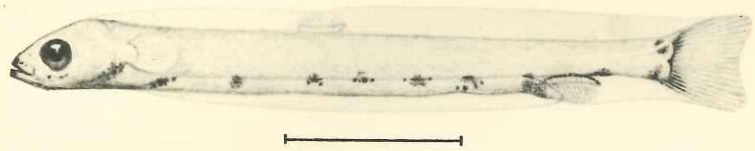

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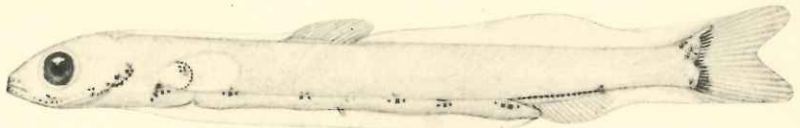

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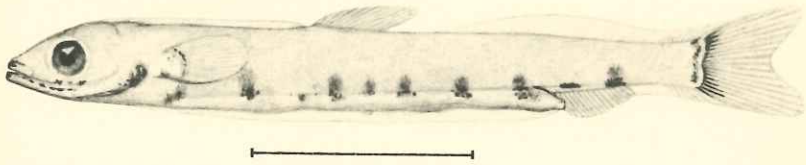

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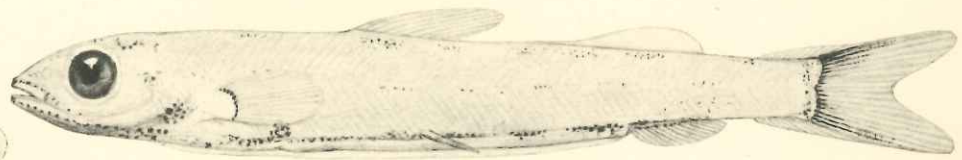

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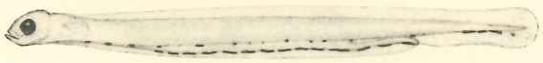

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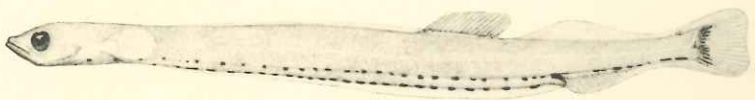

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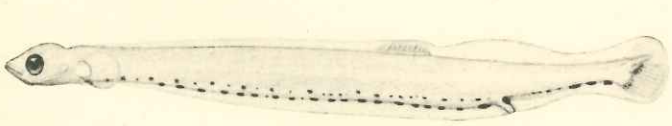

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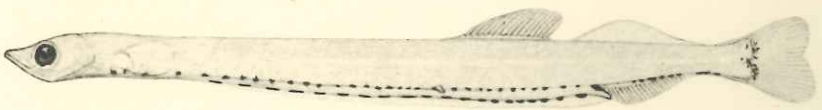

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graena Linné. Fig. 24–28 *Mallotus villosus* (O. F. Müll.).

Pacht & Crone phototyp.

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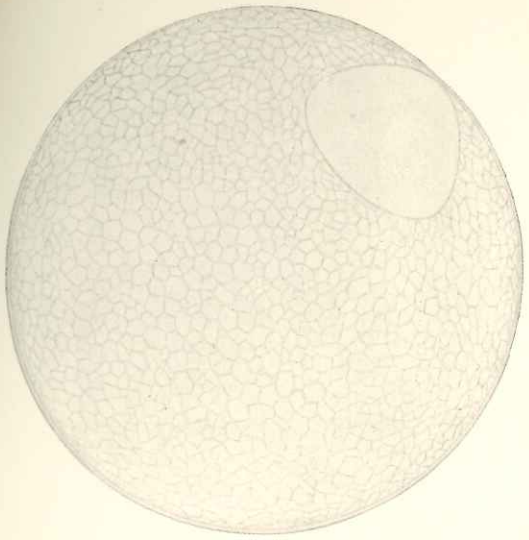

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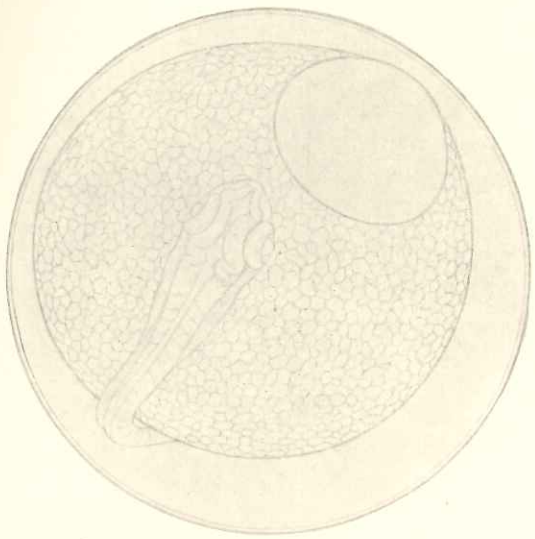

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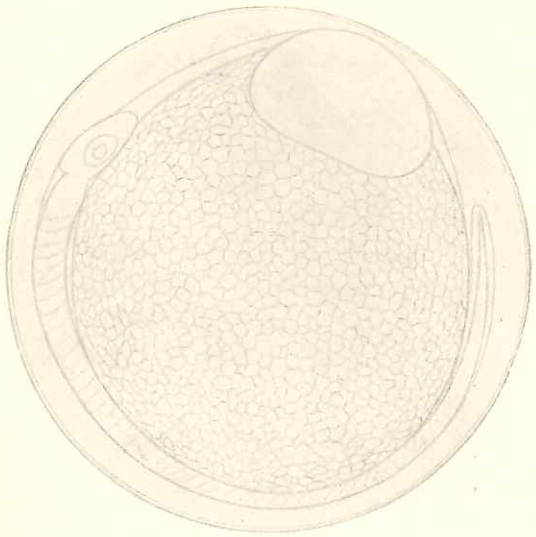

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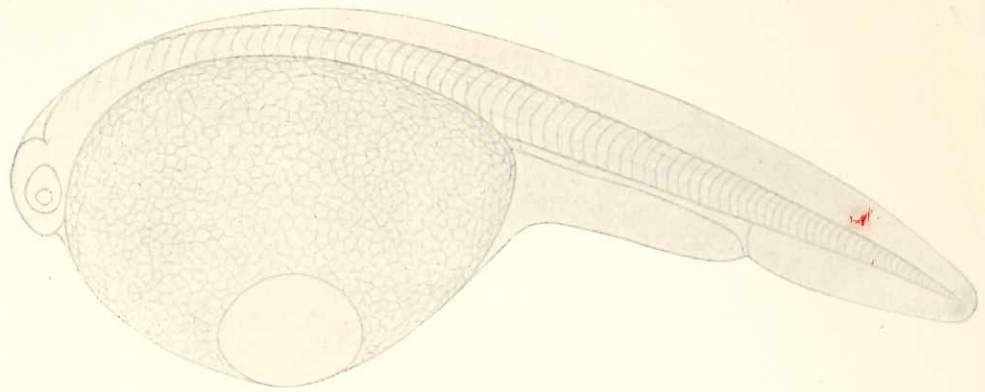

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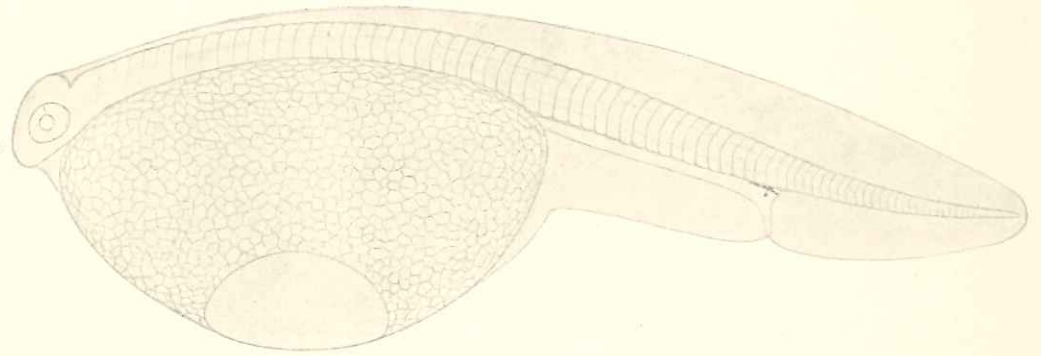

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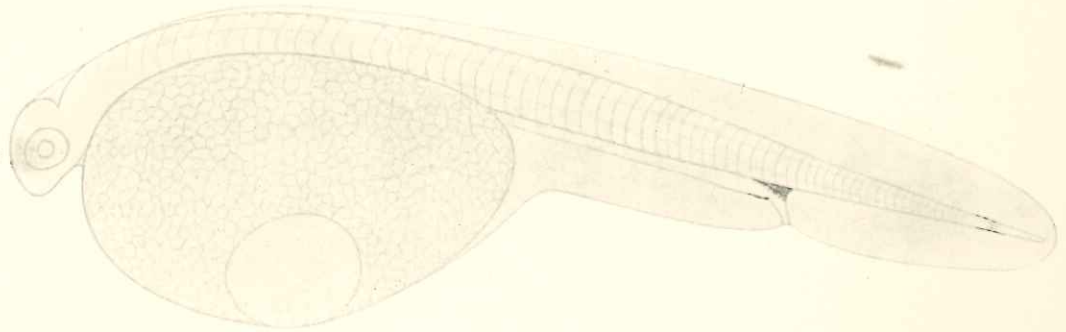

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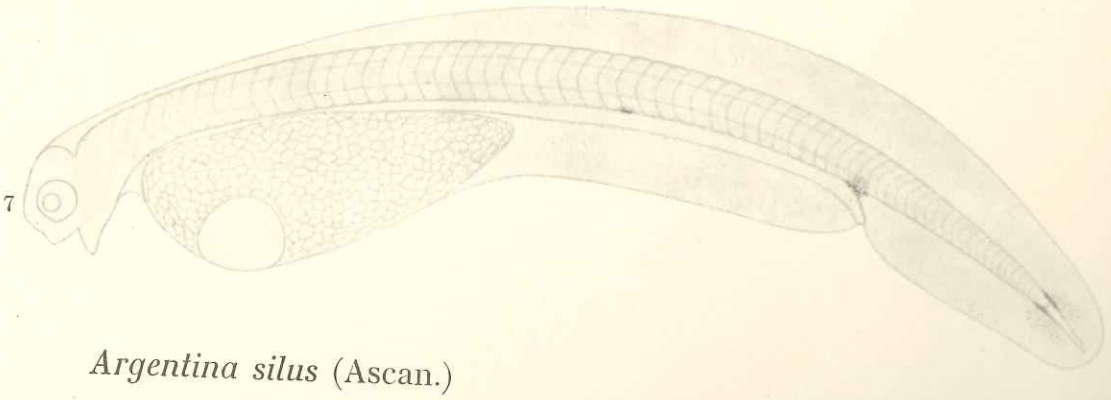

Argentina silus (Ascan.)

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