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Nr. 3. Johs. Schmidt: ON THE PELAGIC POST-LARVAL STAGES OF THE LINGS (*MOLVA MOLVA* [LINNÉ] AND *MOLVA BYRKELANGE* [WALBAUM]). WITH ONE PLATE AND THREE FIGURES IN THE TEXT

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ON THE PELAGIC POST-LARVAL STAGES OF THE LINGS

(*MOLVA MOLVA* [LINNÉ] AND *MOLVA BYRKELANGE* [WALBAUM])

BY

JOHS. SCHMIDT

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Whilst the history of the larval development of the common ling (*Molva molva*) and likewise some of the stages of its postlarval development have been described in literature, almost nothing has hitherto been known of the early stages of the blue ling (*Molva byrkelange* [Walb.] syn. *M. abyssorum* Nilsson) which lives in deeper water. Therefore, as it is very interesting to understand the post-larval history of that species, which has been very generally found in the Atlantic Ocean south of Iceland and west of Scotland, and as it is, moreover, very important to be able to distinguish it from *M. molva* in every stage, I shall here, on the basis of the "Thor's" collections, give an account of the postlarval developmental history of the two species and demonstrate, by means of figures, the differences between them.

I first give a description of the post-larval developmental history, in so far as the available material permits. After that comes a verification of the determinations, and finally a survey of the diagnostic characters of the two species and allied forms.

With regard to the terminology, especially that concerning the pigment, I refer the reader to my monograph on the genus of *Gadus*, Part I, 1905 (see Literature). The following abbreviations have been employed here:

D^1 = 1st Dorsal Fin,
D^2 = 2nd do.
A = Anal Fin.

A. Description of the post-larval developmental history

I. *Molva molva* (Linné), Common Ling

Principal literature and figures:

Larval stages: Mc Intosh and Prince, 1889, p. 827 ff. Pl. XVII, Fig. 9—10. Holt, 1893. Mc Intosh and Masterman 1897, p. 278 ff., Pl. XI, Fig. 4—5 Heincke and Ehrenbaum 1900, p. 256. — Post-larval stages: Mc Intosh and Prince 1889, p. 829 ff. Pl. XVIII, Fig. 3—4. Mc Intosh and Masterman 1897, p. 278 ff., Pl. XI, Fig. 6—7. — Young stages: Mc Intosh and Masterman 1897, p. 278 ff., and Fig. in text, 7—8. Mc Intosh 1885, p. 62. Mc Intosh 1886, p. 209.

The position of affairs with regard to *Molva molva* is the same as in the case of many other useful fishes; whilst the eggs and larval stages are well known, inasmuch as artificially fertilised ling eggs have been hatched out, and its larval stages thereby rendered familiar, our knowledge of its post-larval stages is much more fragmentary and uncertain. Still, there is hardly any doubt that the two specimens depicted by Prince (Mc Intosh and Prince l. c. (Pl. XVIII, Fig. 3—4) which are also reproduced by Mc Intosh and Masterman (Pl. XI, Fig. 6—7) really belong to *M. molva*. In any case it is certain that the oldest specimen of about 20 mm. in length does so. The smaller specimen of about $8^1/_2$ mm. is not, judging from the way in which its caudal fin is drawn, like any Gadoid (it resembles rather a flounder)

and there is no decisive proof that it belongs to the genus *Molva*, much less the species *M. molva*. Judging from the pigmentation, I am nevertheless inclined to believe that both specimens belong really to *M. molva*, but if such be the case, then the caudal fin in the smallest specimen is wrongly represented.

Description

Pl. I, Fig. 14 **5 mm.** The form does not differ from the usual Gadoid type, but the body is very thin and slender, particularly in the postanal part. The notochord is quite straight. In the unpaired fins there is yet no trace of the interspinous regions, still less of fin rays. At most we can see below in the caudal portion a sligthly less transparent part in the embryonic fin. The pectoral fins are fan-shaped processes of the usual gadoid appearance, and are totally devoid of any trace of fin rays. On the other hand, the ventral fins are already much elongated. They contain 3 fin rays connected by a membrane. The hindmost ray is the longest, though there is not much difference in the length. The ventral fins are placed a little behind the middle of the preanal portion of the body and extend back as far as the vent. The length is between $^1/_2$ and $^3/_4$ mm. On the membrane, between the lengthened rays, there is fairly well-marked black pigment.

The pigment on the body is characteristic. On the preanal portion there is only a little pigment. On the back of the neck and above the pectoral region are to be found a few large chromatophores and some small ones on the snout and lower jaw. There is but little ventral preanal pigment in front of the base of the ventral fins. The postanal pigment consists of 2 transverse bars one of which (III) is in front of, the second (II) behind the middle of the postanal portion of the body. On the other hand, there is no hindmost pigment bar (I) which characterises *M. byrkelange* (and several *Gadus*-species, cf. Johs. Schmidt: "The pelagic post-larval stages of the Atlantic species of *Gadus*", Meddelelser fra Kommissionen for Havundersøgelser, Serie Fiskeri, Bind I, No. 4, 1905, p. 29). The two bars II and III consist each of a dorsal and a ventral portion, linear in form, the position of which can be seen in Fig. 1 in the text. The ventral portion is generally a little more strongly marked than the dorsal. Between the dorsal and ventral parts of the bars there is no pigment on the sides (in contrast to *M. byrkelange*).

Pl. I, Fig. 15 **5 mm.** Although the present specimen is of about the same length as the previous stage, still its development is further advanced, as is shown by the increase in the thickness of the body and in the greater length of the ventral fins.

There is as yet no distinctly defined trace of interspinous rays in the caudal fin and the other vertical fins, and the tip of the notochord is quite straight. The ventral fins consist as before of 3 much elongated rays and reach backwards far behind the anus, about to the end of pigment bar III. The 3 rays are for the most part joined by a membrane which is, however, easily split up, so that they remain free. There is black pigment between the rays throughout nearly their entire length.

The pigment is in all essentials as in the previous stage. There is however somewhat more neck and pectoral pigment.

Pl. I, Fig. 16 **6 mm.** The body is considerably heavier than in the previous stage. The tip of the notochord is still quite straight. There is an appearance of interspinous rays below and above in the caudal fin, but no trace of rays, and in the other unpaired fins any trace of interspinous regions is still completely absent. The ventral fins are much lengthened and go back quite to the middle of the interspace between pigment bars II and III. They are at least as long as the preanal portion of the body. The rays are free for the greater part of their length, but not proximally where there is distinct black pigment between them. There is only a little pigment at the distal end.

The pigment on the body is essentially the same as before. There is well-marked pigment on

the postoccipital and supraorbital regions. The ventral portion of the postanal bar III is more strongly developed than the dorsal, whereas in bar II both are almost equally developed.

In the living state yellow pigment was present at the following places: on the neck there is a little and also far forward on the back. Opposite the two postanal bars there is yellow pigment on the middle of the sides. The elongated ventral fins have also yellow pigment throughout their whole length. The eyes are light blue.

7 mm. The tip of the notochord is quite straight. The traces of interspinous bones in the caudal fin are more distinct than before, but still not very strong. Distinct traces of the interspinous regions are still not to be recognised in the dorsal and anal fins. The ventral fins reach about as far as bar II. There is a great deal of pigment on the neck. The postanal pigment is as before, but here there is now also a single lateral chromatophore opposite bar II. Pl. I, Fig. 17

8 1/2 mm. The tip of the notochord is still almost quite straight, and still very large. There are very distinct traces of interspinous bones in the caudal fin, where traces of rays are also beginning to appear. There are now distinct traces of interspinous regions in the anal fin, and in the second (but not in the first) dorsal fin. These appear in the shape of long low folds, which are most distinct posteriorly. There is as yet no trace of rays in these fins. The pigment is in the main as before, but there is a little more lateral pigment opposite the two postanal bars. Pl. I, Fig. 18

9 1/2 mm. The tip of the notochord is a very little bent. There is a fairly distinct appearance of interspinous bones above and below in the caudal fin, and a distinct trace of interspinous regions in the anal and dorsal fins. Extremely weak and short rays can be seen towards the posterior part of D^2 and A. The interspinous region in D^1 is separate from that in D^2. The ventral fins reach back quite to halfway between pigment bars II and III. The pigment has not undergone any alteration of importance. Pl. I, Fig. 19

10 3/4 mm. The tip of the notochord is now a little bent upwards, but is still heavy. The length of its free part is between 1/2 and 3/4 of the distance from its tip to the posterior edge of the caudal fin. The greater portion of the caudal fin has already developing rays. With regard to the other unpaired fins, it is to be noted that D^1 (first dorsal fin) is plainly distinct. In the second dorsal fin and in the anal fin rays are now present everywhere, but are still very short. The ventral fins are much elongated. Pl. I, Fig. 20

In addition to the 3 original rays there is now a fourth short, lower ray. There is only a little black pigment on the ventral fins, but in the living state these are rather strongly pigmented with yellow.

The pigment of the body is essentially as before. The two postanal bars are distinct and they also consist of abundant lateral as well as dorsal and ventral pigment.

14 mm. The tip of the notochord is much bent upwards and somewhat reduced. The length of its free portion is about one-third the distance from its tip to the posterior edge of the caudal fin. The caudal fin has rays everywhere posteriorly. The following number of rays were found in the unpaired fins: D^1 ca. 10, D^2 ca. 60, A ca. 56. The embryonic fin is still broad between the caudal fin and the dorsal and anal fins. The elongated ventral fins reach nearly to midway between pigment bars II and III. There are 5 rays present, the 2 lowest of which are much shorter than the 3 original ones. The skin connecting the elongated rays was in the present specimen preserved in almost its entire length. There is only a little pigment on the ventral fins, in part somewhat distal, and in part nearer to the base. Pl. I, Fig. 21

The original bar-arrangement of the post-anal pigment is no longer so prominent as before, as a little pigment is now also to be found medially on the sides which extends posteriorly almost right out to the end of tail. (Further, some interior pigment has developed posteriorly along the spinal column.) The original pigment is however easily recognised by the larger, more prominent chromatophores.

Pl. I, Fig. 22 **15½ mm.** The tip of the notochord is much reduced. The caudal fin is now very nearly separated from the dorsal and anal fins, the embryonic fin between them being very low. D^1 is now a little higher than D^2. The following number of rays was found: D^1 ca. 14, D^2 ca. 67, A ca. 62. The ventral fins extend posteriorly nearly to the middle of bar III, and are not so long as the preanal length. There are 5 rays as in the previous stage. At their distal end there is some black pigment.

The pigment of the body has developed more than in the previous stage. On the ventral part the two original bars have entirely or almost entirely coalesced, but in the dorsal part they are still distinct. In the middle of the sides a longitudinal band of pigment (cf. the mediolateral streak of the *Gadus* genus) has developed. (The beginning of this was already present in the previous stage). It is most marked in the hinder portion and extends right out to the tip of the tail. The original arrangement of pigment in the 2 transverse bars can still be recognised.

Pl. I, Fig. 23 **18½ mm.** The tip of the notochord is much reduced. The caudal fin is practically separated from the dorsal and anal fins. The following number of rays was found: D^1 ca. 14, D^2 ca. 66, A ca. 60. The pectoral fins are still broadly fan-shaped; ca. 19 distinct rays could be counted in them. The ventral fins reach backward to opposite pigment bar III. They consist of 6 rays, of which the 3 lowest are short. The ventral fins are slender and slightly pigmented.

The pigment on the body is essentially as in the previous stage, but the mediolateral longitudinal stripe is somewhat stronger, especially so in the posterior portion. The ventral portions of the two original bars have coalesced, but the dorsal parts on the other hand are still distinct. The original arrangement of the bars can be recognised by the fact that the primary chromatophores are larger and stronger. Looking at the specimen from its dorsal aspect the two original bars are seen with great distinctness. Whilst the ventral pigment is wanting preanally, the pigment on the postoccipital and supraorbital regions is distinct. In addition to this must be noted a shade of pigment which stretches longitudinally from the tip of the snout to the front margin of the eye, and from the hinder edge of the latter a little further backwards.

A fairly distinct barbel is present.

Pl. I, Fig. 24 **22 mm.** The unpaired fins are essentially the same in form as in the adult fish. The following number of rays was counted: D^1 15, D^2 64, A 65. The pectoral fins are somewhat narrower than before, and reach backwards almost to the middle of the space between D^1 and D^2. The ventral fins still extend a good distance behind the anus to opposite the original pigmentbar III. They are slender but rather strongly marked with pigment throughout their entire length.

The original pigment bars are still to be distinguished (by the somewhat larger chromatophores). In addition to the mediolateral longitudinal band or stripe which is still more strongly marked, there is now a dorsal and a ventral line of pigment, the first reaching about from D^1 to the tip of the tail, and the other about from the anus to the tip of the tail. Both are strongest posteriorly, as is the mediolateral longitudinal band. This latter is not, as in the case of the genus *Gadus*, restricted to the median line alone, and I therefore call it, not a mediolateral line or streak, as in the case of that genus, but a mediolateral band or stripe. It is stronger about the median line, but it includes in addition the greater portion of the sides, where as a rule there is practically no pigment, except opposite the two original bands, where some large ventro- and dorsolateral chromatophores are situated. The longitudinal band reaches in front to about the anus, but is strongest in the posterior portion. Other characteristic pigment is to be noted in the shape of a longitudinal stripe which reaches from the tip of the snout to the anterior margin of the eye, and from the posterior margin of the latter a little further back towards the base of the pectoral fin.

The diameter of the eye is a little less than the length of the snout. There is a strong barbel, about as long as the diameter of the eye.

In the course of the investigations carried out by the "Thor", no specimens of the common ling (*Molva molva*) longer than ca. 25 mm. were caught, presumably because the other post-larval stages occur later in the year (in the autumn). It will obviously be very easy to recognise these older post-larval stages, as the mediolateral pigment stripe or band which has been described always becomes more distinct, until by degrees it becomes quite dominant and gives the little fish a most characteristic appearance, as described by Mc Intosh (1885, p. 62). Mc Intosh there describes a young specimen in the bottom stage, $3^1/_8$ inches in length (i. e. ca. 79—80 mm.). It was caught in the middle of December at the East Rocks, St. Andrews, and is also described and figured in Mc Intosh and Masterman (1897, Fig. 7 in the text). Fig. 25 in the Plate accompanying this paper shows a reproduction of that specimen.

From this it is plain that the mediolateral pigment stripe which is found in the oldest specimens from the "Thor"[1] (Plate I, Fig. 24) is the commencement of the very strong and quite dominant longitudinal stripe which distinguishes Mc Intosh's specimen, and which is almost exactly of the same size as my largest specimen of *Molva byrkelange* (Pl. I, Fig. 13). We know now therefore, that the two *Molva* species up to about the length of 8 cm. differ extremely in pigmentation, since *M. molva* is striped longitudinally, *M. byrkelange* transversely, but how long these differences in the pigmentation subsequently hold we do not know.

Mc Intosh (1886) and Mc Intosh and Masterman (1897, Fig. 8 in text, p. 33, also p. 281) have described and drawn a young ling of ca. 7 in. (i. e. $17^1/_2$—18 cm.) in length. This specimen, which is given as a *Molva molva*, is however no longer striped longitudinally but, like *M. byrkelange* in its oldest post-larval stages (cf. my Pl. I, Fig. 12—13), has a large number of more or less complete transversal bars or blotches, and it is said that "fourteen or fifteen brownish blotches occur between the breast-fins and the base of the tail", i. e. exactly the same number as are found in the oldest post-larval blue ling (see my Plate I, Fig. 13). We see therefore, if the Scotch writers are correct in their determination of the young ling of ca. 7 in. ($17^1/_2$—18 cm.) as *Molva molva*, that *M. molva*, which in the youngest post-larval stages has the pigment arranged in transversal bars, loses this arrangement in the older post-larval stages and becomes striped longitudinally, only to assume later on, in the young bottom stages a transversally barred marking, similar to that which distinguishes *M. byrkelange* during its later post-larval development (up to a length of at least ca. 8 cm.).[2]

II. ***Molva byrkelange*** (Walb), **blue Ling**

(*Molva abyssorum* Nilsson)

Principal literature and figures:

Larval stages: undescribed. — Post-larval stages: undescribed. — Young stages: undescribed.

Nothing has been hitherto known about the developmental history of this species, which in the course of the investigations on board the "Thor" was found to be very general in the Atlantic west of the Scotland, and northwards as far as off the south and west coasts of Iceland. We caught its post-larval fry in greatest numbers off the west of Scotland over depths of nearly 1000 metres or more. It

[1] In these too we already have the longitudinal stripe of pigment which extends from the tip of the snout to the eye, aud thence a little backwards, but not yet so far as to make a junction with the developing postanal longitudinal stripe (cf. Pl I, Fig. 24).

[2] Something similar, though in less degree, is already known from the developmental history of the cod (*Gadus callarias*). As larva and in the youngest post-larval stages this form has three transverse bars of pigment but assumes later a mediolateral line of pigment (i. e. a longitudinal streak) and finally in the earliest bottom-stages a barred or chequered arrangement of the pigment (cf. my work cited on the *Gadus*-genus, 1905, Pl. I, Figs 1—9).

spawns in the Atlantic earlier than the common ling (*M. molva*)[1] and its younger post-larval stages are consequently already found in May, the older (up to ca. 80 mm. in length) in July and August.

The post-larval developmental series is very completely represented in the "Thor's" collections, which comprise all stages from about 6 mm. to about 80 mm. in length. All the "Thor's" specimens (several hundreds) were caught pelagically, so that we see that the fry of this species still leads a pelagic life at a length as great as almost 8 cm.

Description

Pl. I, Fig. 1 **6 mm.** The form shows nothing unusual. The angle of the lower jaw is projecting and forms a right angle. The tip of the notochord is quite straight. There is no appearance of interspinous regions in the unpaired fins. The pectoral fins are fan-shaped, ray-less flaps. The ventral fins are already much elongated. They consist of 3 rays of almost equal length, united by a membrane which however as a rule is split throughout the greater part of its length. The ventral fins extend backwards past the anus, but they are still not so long as the distance from the tip of the snout to the anus (this is $2^1/_2$ mm. and the length of the ventral fins is 1·44 mm.). There is strong black pigment between the rays throughout their whole length from the base to the tip, where they are considerably swollen (but not so much as in the case of *Brosmius*).

On the postoccipital and supraorbital regions there are some large stellate chromatophores and there is also a little pigment on the tip of the snout and the tip of the lower jaw. The ventral preanal pigment consists of one or a few chromatophores on the throat in front of the base of the ventral fins. The abdominal pigment is fairly strong, but is to a large extent not superficial. The postanal pigment consists of 3 transverse bars (I, II, III), the hindmost of which (I) is placed a little in front of the end of the tail (in contrast to *Brosmius*; see Fig. 2—3 in text), the central one (II) is a little behind and the foremost one (III) in front of the centre of the postanal part of the body. Bars II and III answer as regards position to the two bars on *M. molva* but that species is without the hindmost band (I). Of the 3 bars II is the most prominent. In addition to a dorsal and ventral portion (as in *M. molva*) it also has a lateral portion between the others and extends thus uninterruptedly like a ring round the side. It is stronger dorsally than ventrally (different to *Brosmius*, cf. Figs. 2—3 in text). Bar III consists of one single, very large lateral chromatophore, and bar I of several smaller ones, which are, for the most part, situated on the embryonic fin, as also on the tail itself. The dorsal portion is also most strongly developed in I, which is however not always the case.

Pl. I, Fig. 2 **$7^3/_4$ mm.** The volume of the body has considerably increased since the previous stage, and especially its preanal portion. The tip of the notochord is quite straight. In the caudal fin, above and below, opaque parts are present in the interspinous regions of the embryonic fin, but the interspinous bones have not yet been formed. In the other unpaired fins there is no sign of the formation of interspinous regions. The ventral fins are considerably longer than before; they extend to pigment bar II and are fully as long as the pre-anal length. The pigment is as before, and bar II is still much the strongest. Bars III and I are comparatively more prominent than before. Bar I is still placed a little in front of the tip of the notochord.

Pl. I, Fig. 3 **$8^1/_2$ mm.** The tip of the notochord is quite straight. The formation of the interspinous regions in the caudal fin is a little more distinct than before, but not yet altogether exactly defined, and distinct rays cannot be observed. There is still no appearance of interspinous regions in the other unpaired fins. The ventral fins remain pretty much as they were in the previous stage.

[1] This must be the reason why we found the older or oldest postlarval stages of this species in our investigations in the summer months but not the corresponding stages of *M. molva*. The older post-larval stages of the latter species occur presumably therefore in the autumn.

The pigment is also essentially as in the previous stage. As before, the chromatophores in bar I are not confined to the end of the tail itself, but extend out on to the embryonic fin.

11 mm. The tip of the notochord is still straight (cf. *Molva molva* of the same length). There is now a distinct appearance of interspinous bones in the caudal fin, but distinct rays are not yet visible; there is only an opaque part in the embryonic fin, below and above where the rays afterwards occur. The interspinous regions are now visible in the dorsal and anal fins as long, low folds, which are most distinct posteriorly, where they end almost midway between the pigment bars I and II. The ventral fins extend back as far as pigment bar II. In addition to the 3 original rays, there is now a very short fourth one. Pl. I, Fig. 4

The pigment has not undergone any change of importance since the previous stage.

13½ mm. The tip of the notochord is now a very little bent upwards, but it is still very large. Traces of rays can now be plainly seen in the caudal fin, and are not a little stronger below than above. A great deal of the central part of the caudal fin is still without rays. The embryonic fin is broad, also between the caudal fin and the dorsal and anal fins. There are low folds where the rays are developing in the dorsal and anal fins, most distinct posteriorly but disappearing in front. D^1 is separated from D^2. The ventral fins extend back quite to opposite pigment bar II. There are black pigment spots on the membrane between them, on nearly their entire length. As in *M. molva*, the rays in general are free throughout their entire length, but now and then specimens are seen in which the membrane between them has not divided. With regard to the body pigment, it must be noted that on the dorsal side the bars II and III are about to coalesce, whilst on the ventral side they are still separate (in contrast to *M. molva* where the contrary is the case). Some new pigment is appearing on the sides in front of and behind both II and III, but the original chromatophores are still the most predominant. Pl. I, Fig. 5

16 mm. The tip of the notochord is still only a little bent upwards, and is very thick. There are still no rays in a considerable portion of the middle of the caudal fin. The rays in the dorsal and anal fins are still far from extending out to the edge of the embryonic fin. The following numbers were counted: D^1 ca. 7, D^2 ca. 68—70. In A they were very indistinct in front. The ventral fins extend to opposite pigment bar II. There is strong black pigment between the rays throughout their entire length. Pl. I, Fig. 6

18½ mm. The tip of the notochord is bent a little upwards, but is still thick. The length of its free portion equals about half the distance between its hindmost point and the posterior edge of the caudal fin. There is still a small portion posteriorly in the caudal fin which is free from rays. The following number of rays were found: D^1 ca. 7—8, D^2 ca. 70, A ca. 68. The rays in the dorsal and anal fins now reach nearly but not quite out to the edge of the embryonic fin. The embryonic fin is still broad between the unpaired fins. The ventral fins reach about to pigment bar II; they are not evenly pigmented, but strongly pigmented bands alternate with others which are but slightly pigmented. The pigment on the body is essentially as before. There is some internal pigment posteriorly. Pl. I, Fig. 7

19¾ mm. The tip of the notochord is now strongly bent upwards and considerably reduced. There are rays everywhere in the caudal fin. The rays in the dorsal and anal fins now reach right out to the edge of the embryonic fin. Opposite the interspace between the caudal fin and D^2 and A, the embryonic fin is rather low. The following number of rays were found: D^1 ca. 10, D^2 ca. 80, A ca. 73. Pl. I, Fig. 8

The ventral fins extend quite to opposite the interspace between II and III. The fourth ray has now increased somewhat in length, and a short 5th ray is present.

The postoccipital and pectoral pigment (above) is very strong. The postanal pigment has developed more than before, but all the 3 original bars are still very distinct. The dorsal portions have coalesced,

so that a dorsal line or stripe has been formed, but there is no corresponding ventral stripe. More lateral pigment has appeared in front and behind bars II and III; this new pigment also consists of large stellate chromatophores like the original ones, but they are not nearly so strongly marked as the latter.

Pl. I, Fig. 9 **23 1/2 mm.** D^1 and D^2 are still not altogether separate, and D^1 is low. The embryonic fin between D^1 and D^2 and also between the caudal fin and the other unpaired fins is now low. The following number of rays was counted: D^1 ca. 12, D^2 ca. 74, A ca. 76. The ventral fins, which consist of 6 rays (4 long, 1 shorter and 1 very short) extend back to about halfway between bars II and III. There is as usual black pigment between the rays, but this black pigment is not evenly distributed, but arranged in bands which alternate with more lightly pigmented bands. The postanal pigment is characteristic. Besides the 3 original bars (I, II, III) the chromatophores of which are always distinguishable from the rest of the pigment by reason of their size, 5 secondary transverse bars of pigment have now appeared on the sides, namely the following: one in front of III (III B) and one behind III (III A), one in front of II (II B) and one behind II (II A) and one in front of I (I B). Of these the two centre ones (II B and II A) are the strongest. On the anal fin are pigment areas opposite I B, II A and II B, but they are not yet very strong. On the second dorsal fin is a small accumulation of pigment opposite II B. A barbel is distinctly noticeable, but is not yet as long as the diameter of the eye. A shade of pigment extends from the tip of the snout nearly to the anterior margin of the eye.

Pl. I, Fig. 10 **31 1/2 mm.** The unpaired fins have now essentially the same form as in the adult fish. D^1 is higher than D^2 and they are quite separate, as also the caudal fin, from D^2 and A. The following number of rays were found: D^1 ?, D^2 81, A 77. The ventral fins extend to midway between the pigment bars II and III. They have 5—6 bands of black pigment, but have no yellow pigment in the living state (in contrast to *M. molva*). The four upper rays of the ventral fin are long: the 5th reaches about to the anus, and the 6th not halfway to the anus.

The secondary postanal pigment bars have become still more distinct and regular, but the 3 primary bands are still evident on account of the large chromatophores. On the second dorsal fin a pigment group has appeared opposite the secondary bar II A. Bars II B and A together with III A are the strongest of the secondary bars, but I B is also distinct. On the anal fin are pigment groups opposite I B, II A and II B, and on the second dorsal fin opposite I B and II (weak).

Pl. I, Fig. 11 **36 1/2 mm.** The ventral fins are still very long, longer than the preanal length, and they reach back to quite midway between bars II and III. They have bands of strong black pigment, alternating with less pigmented bands. The following number of rays was counted in the unpaired fins: D^1 ?, D^2 ca. 74, A ca. 74.

The two original bars (II and III) may still be recognised by their particularly large chromatophores. The secondary bars are extraordinarily well-marked, particularly III A, and II A and B. III B is wedge-shaped and does not quite reach down to the ventral margin. There are now 4 patches of pigment on the anal fin opposite the secondary bars and on the second dorsal fin there are groups of pigment opposite I B, opposite the interspace between I B and II A, opposite II, opposite the interspace between II B and III A, opposite III and in front of III B. Further, the first dorsal fin has one group of pigment.

Pl. I, Fig. 12 **51 mm.** The length of the ventral fins is now considerably reduced; they are much shorter than the preanal length, and extend backwards to opposite bar III (or what is the same thing, to midway between III A and III B). The following number of rays were found: D^1 ca. 14, D^2 ca. 75, A ca. 74. (In three other specimens of about the same length were found: D^2 78, A 74; D^2 ?, A 75; D^2 79, A 79).

It may be noted with regard to the pigment of the body that the two primary bars II and III

are now but faint, though still not difficult to recognise. In other respects the pigment is as it was in the previous stage, but opposite the 7 pigment groups in the dorsal fins have appeared 7 smaller dorso-lateral groups, and two larger pigment groups also, likewise dorso-lateral, in front of the anus (which in view of their position may be named IV A and IV B). One of these is placed opposite the interspace between D^1 and D^2, and the other directly in front of D^1.

In the living state there is only a little coloured pigment; the eyes are dark blue. The sides of the abdomen are silvery. The neck is greyish brown and very closely pigmented. Along the sides is a faint bluish sheen, but in other respects coloured pigment is quite wanting.

78½ mm. This specimen is the largest I have taken. It was still pelagic. The ventral fins are now much reduced in length and extend backwards only as far as the anus. The pigment is mostly unchanged since the previous stage and very characteristic. In addition to bar I there are one (or 2) distinct pigment groups on the caudal fin and behind bar I. The two original bars II and III have now completely disappeared. There are 5 complete transverse bars (I, I B, II A, II B and III A) together with 3 large incomplete dorso-lateral ones (III B, IV A and IV B) and 6 smaller also imperfect and dorso-lateral (one between I B and II A, one opposite II, one between II B and III A, one opposite III, one between III B and IV A, and one opposite IV, i. e. opposite the 1st dorsal fin). The fins have essentially the same pigment as before. The number of rays was difficult to estimate, as the fins were partly closed. There were at least 75 rays in D^2 and at least 72 in the anal fin. Pl. I, Fig. 13

It will have been seen from the above descriptions that the two *Molva* species are very well characterised and easily distinguished. In both of them the ventral fins are much elongated and their rays are joined by a membrane which however, in the specimens examined, was as a rule divided, so that the rays were free. Owing to the fact that the membrane is divided and disappears more or less, the pigmentation of the ventral fins is often lost, wihch is the reason why the different specimens shown on Plate I do not exhibit any regularity or uniformity with regard to the pigmentation of the ventral fins. It must also be noted that, whilst the ventral fins in *Molva molva* in the living state are of a very strong yellow tint, the yellow pigment is absent in *M. byrkelange*. Amongst other characteristics which differentiate the two species must be mentioned the fact, that the eyes are considerably larger in *M. byrkelange* than in *M. molva*, and that the development of the fins is much further advanced in the latter than in the former. It will be well to compare for example the following Figures in Table I, which represent the stages of the two species in approximately the same state of development: Fig. 4 and Fig. 18, Fig. 5 and Fig. 19, Fig. 6 and Fig. 20, Fig. 20 and Fig. 21 etc. Afterwards, when the fry are older, we can of course make use of the same characteristics to differentiate between the 2 species as distinguish the adult fish (for example, length of the lower jaw in proportion to the snout, shape of D^1, shape of the whole body, etc., etc.) but to go into this is outside the province of this paper.

B. Verification of the determinations

It was not difficult to see that the two series of postlarval fry under consideration really belonged to the *Molva* genus, one short and one long dorsal fin being present, also one anal fin, and these fins had the same shape and position as in the genus *Molva*. That there were two species and not only one in the material at hand, was also obvious, and the specimens accordingly fell into two groups which, amongst other characteristics, were very different in pigmentation. Thus, there were 3 postanal transverse bars of pigment in the one, whilst the other only had two, the posterior bar (at the end of the tail) being absent.

In order to gather reliable data for the distinction of the two species, I examined a number of specimens of both species and of the allied *Brosmius brosme* on board the "Thor", near Iceland and the

Færoe Islands, with reference to the number of vertebrae and number of rays in the dorsal and anal fins. The result of this examination is contained in the annexed Table. from which it is seen that there is a considerable difference between the species.

The large specimens of the two series could be identified ere this by counting the fin rays in the second dorsal fin and in the anal fin, and thus it was already proved that the one series (with 3 post-anal bars) belonged to *M. byrkelange*, and the other (with 2 bars) to *M. molva* (cf. the number of rays quoted in the descriptions of the series).

But in addition, the number of vertebrae were also counted in 3 smaller specimens of each series (from ca. 5 to ca. 8 mm.) which were cleared in xylol. The result was as follows:

1st Series (2 pigment bars)	2nd Series (3 pigment bars)
No. 1 ca. 63 segments.	No. 1 ca. 78 segments.
No. 2 62—63 „	No. 2 79—80 „
No. 3 ca. 64 „	No. 3 ca. 77 „

As will be seen, these numbers agree perfectly with the numbers of vertebræ already known for *M. molva* and *M. byrkelange*, and it must in future be regarded as proved that the series with the two postanal pigment bars belongs to the common ling (*M. molva*) and the series with the 3 bars to the lesser ling (*M. byrkelange*) which occurs in deeper water.

Molva molva (Linné)

20 Specimens from Iceland and Færoes caught by the "Thor"

Vertebræ without and with lower arches	Number of specimens
25 + 38	1
25 + 39	2
26 + 37	1
26 + 38	9
26 + 39	6
27 + 38	1
Total: 63—65 vertebræ[1]	

Number of rays in dorsals	Number of rays in anal
15 + 65	58
15 + 64	65
14 + 62	62
13 + 64	63
14 + 65	60
15 + 66	65
13 + 65	60
14 + 64	62
D = 13—15 + 62—66 rays	**A = 58—65 rays**
Day: 13—16 + 63—70	57—66
Lilljeborg: 13—16 + 62—70	57—66
Krøyer: 14 + 65	61
Smitt: 13—16 + 60—70	57—66

Molva byrkelange (Walb.)

5 specimens from Iceland and Færoes caught by the "Thor"

Vertebræ without and with lower arches	Number of specimens
31 + 45	1
31 + 46	1
32 + 46	2
33 + 46	1
Total: 76—79 vertebræ[2]	

Number of rays in dorsals	Number of rays in anal
15 + 81	76
13 + 78	76
13 + 81	79
15 + 75	74
13 + 74	74
D = 13—15 + 74—81 rays	**A = 74—79 rays**
Lilljeborg: 13—14 + 78—85	75—80
Smitt: 11—14 + 74—83	70—81
Krøyer: 13 + 80	78

Brosmius brosme (Ascan.)

29 specimens from Iceland and Færoes caught by the "Thor"

Vertebræ without and with lower arches	Number of specimens
19 + 45	5
20 + 44	3
20 + 45	9
20 + 46	9
21 + 44	3
Total: 64—66 vertebræ	

Number of rays in dorsals	Number of rays in anal
97	71
98	69
105	71
101	71
102	68
95	69
96	71
93	66
107	77
106	73
98	67
D = 93—107 rays	**A = 66—77 rays**
Krøyer: 85—102	62—76
Lilljeborg: 90—102	71—76
Smitt: 90—105	71—76

[1] Day gives 27 + 37, Krøyer 26 + 39, Lilljeborg 64—65 and Smitt 64—65 vertebræ.

[2] Krøyer gives 31 + 47, Lilljeborg 78—79 and Smitt 78 vertebræ.

C. On the distinction between the postlarval stages of the two species of Ling (*M. molva* and *byrkelange*) and allied forms

As we come more and more to know the postlarval stages of the gadoids, we see that great elongation of the ventral fins is a feature which is common to the majority of the genera within this group of fishes. So far as we know at present, there is only one genus which does not possess a much elongated postlarval ventral fin, namely, the large *Gadus* genus, which is thereby easily distinguished with certainty from the other gadoid genera.

From the foregoing pages we see that it is very easy to distinguish the two *Molva* species and not least by means of the pigment, which offers such obvious and striking variations, even in the the youngest stages when we have only a few characteristics to take hold of (cf. Figures in text). There can thus be no question whatever of any confusion between even the youngest specimens of the 2 *Molva* species. It is remarkable too that the youngest stages of *M. byrkelange* do not resemble *M. molva* nearly as much as *Brosmius brosme,* whose developmental history I have already described (Meddelelser fra Kommissionen for Havundersøgelser, Serie Fiskeri, Bind I, No. 8, 1905).

I shall here say a few words about the distinction between these two species, which in reality presents no difficulty when rightly understood. As is well known, the torsk has only one dorsal fin and is further distinguished by its peculiar short rounded snout (not unlike *Anarrhichas*), and as soon as these characteristics begin to grow distinct there is consequently no difficulty about distinguishing it from *M. byrkelange.* It is only the youngest stages from ca. 8—10 mm. and under in length which are concerned, both the torsk and blue ling having 3 postanal pigment bars.

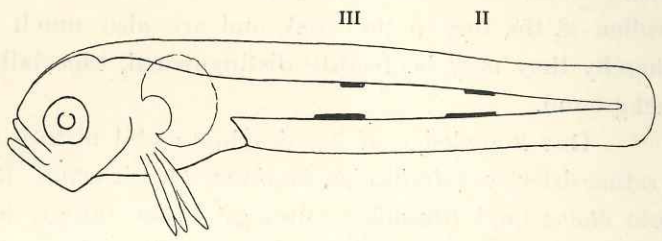

Fig. 1. *Molva molva.* (Length 5 mm.)
(Note the absence of the posterior pigment bar (I)

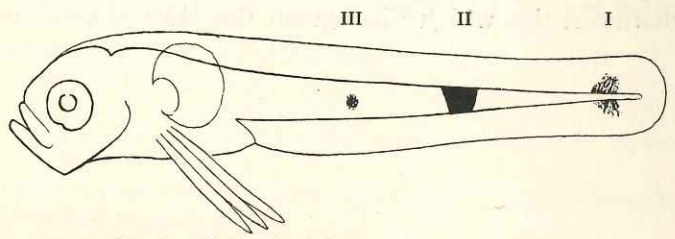

Fig. 2. *Molva byrkelange.* (Length 6 mm.)
(Note the form of bar II and that the tip of the notochord is free from pigment.)

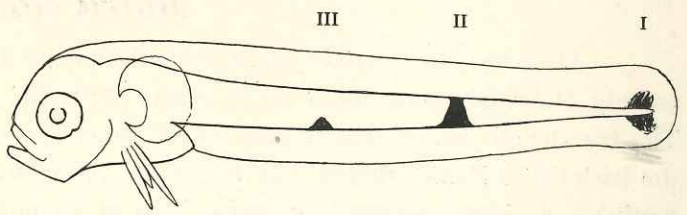

Fig. 3. *Brosmius brosme.* (Length 6 mm.)
(Note the short preanal portion, the form of bar II and that the tip of the notochord is covered with pigment.)

Semi-schematic Figures showing pigmentation in the youngest postlarval stages. (Length 5—6 mm.) Only the postanal pigment is shown.

The following differences are to be noted: (1) the body is, the length being the same, more slender in the torsk than in the blue ling and is more developed in the latter than in the former. In like manner the preanal portion of the body is in comparison much shorter in the torsk than in the blue ling. (2) In the torsk in contrast to the blue ling, the most central of the three developing rays in the ventral fin is at the beginning considerably shorter than the two others. (3) Further, the lesser ling has 76—79 vertebræ, whilst the torsk has only 64—66 (see Table) and it is often possible, even without clearing, to determine the number of segments in such young and therefore comparatively very transparent specimens. I was also able in the case of a torsk of 6 mm. to count ca. 64 segments and in a blue ling of the same length ca. 78. (4) Finally, the pigment, and especially the postanal pigment, is a distinguishing feature, for the differences in which the reader is referred to the semi-schematic Figures in the text.

In both species the postanal transverse bars consist, not only (as in *M. molva*) of one dorsal and one ventral part, but also of lateral pigment (on the middle of the sides). There is, however, this distinction that the ventral part of the pigment is comparatively the most strongly developed in the torsk, the dorsal part in the blue ling.[1] This condition is particularly noticeable in pigment bar II (the central one) which in both cases reminds one of a wedge, in the torsk turned up, in the lesser ling turned down (cf. Fig. 2—3 in the text). Another characteristic by means of which even the youngest postlarval stages of the two species can be distinguished is that the pigment of bar I (the hindmost) extends in the torsk right out to the tip of the notochord, whilst in the blue ling it does not extend so far backwards (cf. Figs. 2—3 in text). Moreover, the elongated ventral rays are much more swollen at the tips in the torsk and are also much more strongly pigmented than in the *Molva* species, whereby they may be readily distinguished, especially when the specimens are examined against a white background.

Our knowledge of the developmental history of the majority of the other common gadoid genera is rather defective (*Merluccius, Raniceps, Phycis, Onos*). *Raniceps* and *Onos* may however be easily distinguished from *Molva* (and *Brosmius*), amongst other things, by its much shorter and plumper shape, and in this and the other genera mentioned the number of vertebræ is considerably lower than in *Molva* and *Brosmius*, so that herein we have a means of distinguishing the youngest postlarval stages in cases where the characteristics which distinguish the older stages cannot yet be used.

Postscript

Molva elongata Risso

After the above pages were printed, I have found the postlarval stages of the third *Molva*-species, namely *Molva elongata* Risso on a cruise with the "Thor" in the Atlantic during May and June 1906. The fry (length ca. 30—ca. 60 mm.) were taken pelagically over great depths S. W. of Ireland (south of the Irish Outer Bank whereas the fry of *M. byrkelange* have hitherto only been met by me north of this Bank), and their capture thus shows that *M. elongata* occurs in addition to in the Mediterranean also in the adjacent parts of the Atlantic, where the bottom water has a high temperature.

A detailed description and figures of the postlarvæ of *M. elongata* will be given later; I shall only mention here that, as might have been expected, it resembles *M. byrkelange* much more than *M. molva*, but is nevertheless very easily distinguished and different from the blue ling. Like this form it has 3 postanal, primary pigment bars but is distinguished amongst other characters by the following:

(1) It is much more slender and elongated than *M. byrkelange* and the eyes are smaller.

(2) At a length of ca. 30 mm. the second dorsal fin and the anal fin have already along their margins [posteriorly a distinctly continuous black stripe of pigment, which grows stronger in the older postlarval stages. On the other hand they lack the black, detached pigment patches present on the anal fin and D^2 in *Molva byrkelange*. This marginal stripe reaches forward almost to the primary bar

[1] I have shown a similar state of things to exist in different species in the Genus *Gadus* ("The pelagic postlarval stages of the Atlantic species of *Gadus*, Part I—II", Medd. Kom. Havundersøgelser, Serie Fiskeri, Bind I, No. 4, 1905, Bind II, No. 2, 1906). (1) *Gadus callarias* and *saïda*, (2) *G. pollachius* and *virens*, (3) *G. luscus* and *Poutassou*. It will be plainly seen from the figures in my work on the developmental history of the Torsk, quoted above, that the ventral portion of the centre postanal bars is in comparison more strongly developed, and that the pigment of bar I extends right out to the tip of the notochord.

No. II or a little further. The three best marked secondary bars (at least at a length of ca. 40—60 mm.) are III A, III B and especially II A, which is longer than the others and longer than in *M. byrkelange*.

(3) The anus lies further back than in *M. byrkelange* and A reaches a little further back than D^2. In two specimens of *M. elongata* with fully developed fins there were respectively 10 and 11 rays in D^1, which is fewer than I have found in *M. byrkelange*.

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Id: On the larval and post-larval stages of the torsk (*Brosmius brosme* [Ascan.]) (Meddelelser fra Kommissionen for Havundersøgelser, Serie Fiskeri, Bind I, No. 8, **1905**).

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Description of Plate

Fig. 1. *Molva byrkelange,* **length 6 mm.**, "Thor", Stat. 63, 30th May 1905, 59° 49′ N., 8° 58′ W. Depth: 1150 meters. Young-fish trawl, 1200 meters wire out.

Fig. 2. *Molva byrkelange*, **length 7 3/4 mm.**, "Thor", Stat. 86, 2nd June 1903, 62° 05′ N, 13° 33′ W. Depth: more than 1000 fathoms. Young-fish trawl on the surface.

Fig. 3. *Molva byrkelange,* **length 8 1/2 mm.**, "Thor", Stat. 61, 28th May 1905, 61° 11′ N, 11° 00′ W. Depth: 963 meters. Young-fish trawl, 900 meters wire out.

Fig. 4. *Molva byrkelange,* **length 11 mm.**, "Thor", Stat. 63 (same station as Fig. 1). Young-fish trawl, 65 meters wire out.

Fig. 5. *Molva byrkelange,* **length 13 1/2 mm.**, "Thor", Stat. 87, 2nd June 1903, 61° 40′ N., 13° 33′ W. Depth: more than 1000 fathoms, Young-fish trawl on the surface.

Fig. 6. *Molva byrkelange,* **length 16 mm.**, "Thor", Stat. 64, 30th May 1905, 59° 17′ N, 7° 29′ W. Depth: 895 meters. Young-fish trawl 65 meters wire out.

Fig. 7. *Molva byrkelange,* **length 18 1/2 mm.**, "Thor", Stat. 64, 1905, same haul as Fig. 6.

Fig. 8. *Molva byrkelange,* **length 19 3/4 mm.**, "Thor", Stat. 63, 1905, same haul as Fig. 4.

Fig. 9. *Molva byrkelange,* **length 23 1/2 mm.**, "Thor", Stat. 64, 1905, same haul as Fig. 6.

Fig. 10. *Molva byrkelange,* **length 31 1/2 mm.**, "Thor", Stat. 63, 1905, same haul as Fig. 4.

Fig. 11. *Molva byrkelange,* **length 36 1/2 mm.**, "Thor", Stat. 71, 6th June 1905, 57° 47′ N., 11° 33′ W. Depth: 1985 meters. Young-fish trawl, 300 meters wire out.

Fig. 12. *Molva byrkelange,* **length 51 mm.**, "Thor", Stat. 190, 14th July 1904, 63° 29′ N., 21° 25′ W. (Selvogs-Bank, South Iceland). Depth: 94—120 meters. Young-fish trawl, 110 meters wire out.

Fig. 13. *Molva byrkelange,* **length 78 1/2 mm.**, "Thor", Stat. 185, 12th July 1904, 63° 16′ N., 19° 17′ W. Depth: 620 meters. Young-fish trawl, 75 meters wire out.

Fig. 14. *Molva molva,* **length 5 mm.**, "Thor", Stat. 26, 12th May 1905, 61° 14′ N, 1° 19′ E. Depth: 166 meters. Young-flsh trawl, 65 meters wire out.

Fig. 15. *Molva molva*, **length 5·1 mm.**, "Thor", Stat. 116, 16th July 1905, 58° 46′ N., 0° 07′ W. Depth: 140—119 meters. Young-fish trawl, 65 meters wire out.

Fig. 16. *Molva molva,* **length 6 mm.**, "Thor", Stat. 175, 8th July 1904, 63° 32′ N, 21° 30′ W (Selvogs-bank, South Iceland). Depth: 110 meters. Young-fish trawl, 110 meters wire out.

Fig. 17. *Molva molva*, **length 7 mm.**, "Thor", Stat. 66, 31th May 1905, 58° 07′ N., 6° 10′ W. Depth: 60 meters. Young-fish trawl, 65 meters wire out.

Fig. 18. *Molva molva,* **length 8 1/2 mm.**, "Thor", Stat. 66, 31th May 1905, same haul as Fig. 17.

Fig. 19. *Molva molva*, **length 9 1/2 mm.**, "Thor", Stat. 66, 1905, same haul as Fig. 17.

Fig. 20. *Molva molva,* **length 10 3/4 mm.**, "Thor", Stat 66, 31th May 1905, same haul as Fig. 17.

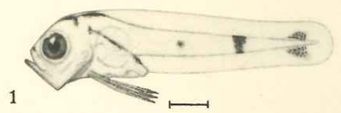
Fig 21. *Molva molva,* **length 14 mm.**, "Thor", Stat. 189, 14th July 1904. 63° 30′ N, 21° 03′ W Depth: 90 meters. Young-fish trawl, 100 meters wire out.

Fig. 22. *Molva molva,* **length 15 1/2 mm.**, "Thor", Stat. 189, 14th July 1904, same haul as Fig. 21.

Fig. 23. *Molva molva,* **length 18 1/2 mm.**, "Thor", Stat. 189, 14th July 1904, same haul as Fig. 21.

Fig. 24. *Molva molva,* **length 22 mm.**, "Thor", Stat. 68, 6th June 1905, 58° 02′ N., 8° 00′ W. Depth: 127 meters. Young-fish trawl, 25 meters wire out.

Fig. 25. *Molva molva,* **length 79 mm.** (3 1/8 inch.), Scotland, December. From Mc Intosh & Masterman, 1897.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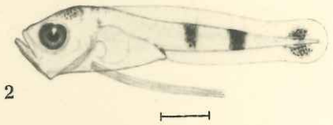
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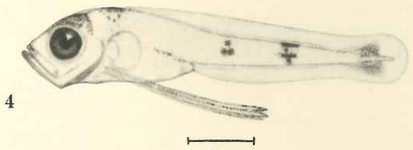
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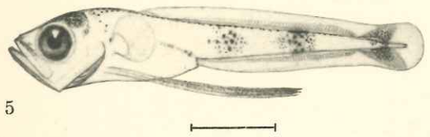
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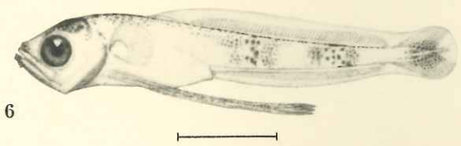
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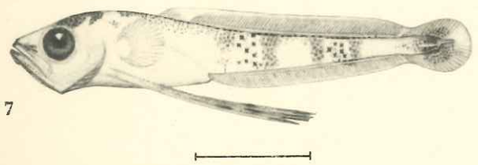
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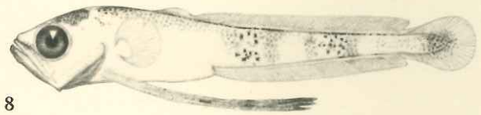
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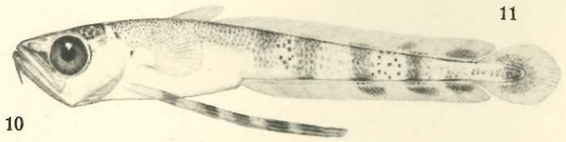
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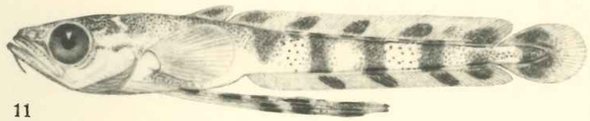
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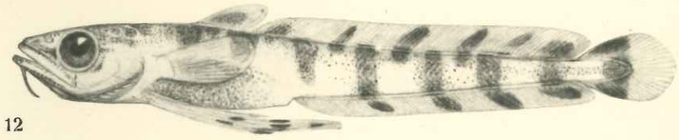
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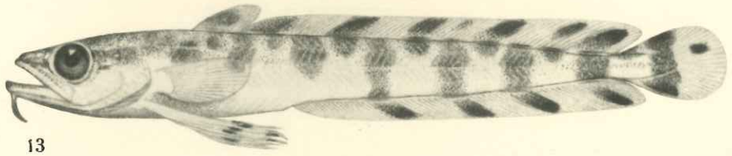
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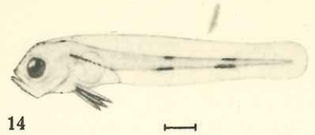
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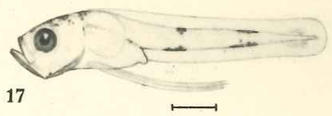
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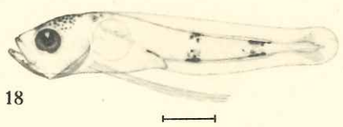
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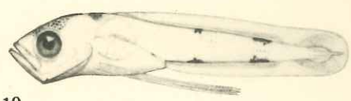
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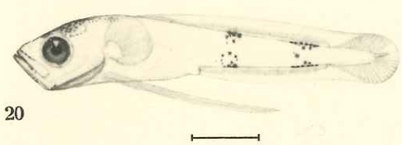
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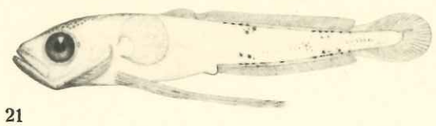
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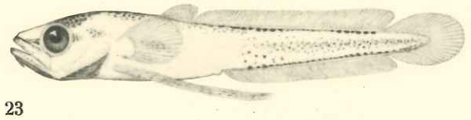
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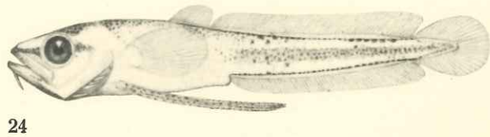
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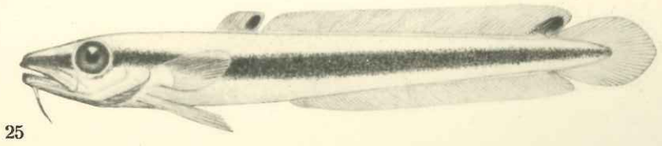
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