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Notes on the Reproduction of Teleostean Fishes in the South-Western District.

By

Ernest W. L. Holt.

THESE notes are intended to be explanatory of the record of tow-net stages of Teleosteans kept by Mr. S. D. Scott and myself. Although my own name appears alone under the title, it must be understood that the observations were in the sole charge of Mr. Scott until the beginning of March. The record of the 5th April is also Mr. Scott's. The rest were kept by myself. The credit of any scientific result that may accrue from the observations previous to the 30th March belongs therefore solely to Mr. Scott, since his notes and figures are so complete as to render my own share of this part of the work a very simple one.

This journal is not designed for the publication of such profusely illustrated papers as are best suited for the explanation of the earliest stages of Teleosteans. It so happens that in the present instance I am able in most cases to refer either to figures already published, or to others now in the press. A series of notes made at Professor Marion's laboratory at Endoûme, Marseilles, was prepared for the press during 1897. Observations made at Plymouth during the same period were found to have an obvious bearing on the subject-matter of my researches at Marseilles, and by the generous permission of Professor Marion I have been allowed to include in a paper shortly to be published in the *Annales du Musée de Marseille** a number of drawings made from Plymouth specimens. I am therefore able in many instances to eke out somewhat inadequate descriptions by references to figures in the *Annales*.

The subjoined notes on the reproduction of different species call for no introductory remarks; but one feature which has not, as I believe, been hitherto noticed, appears to require a little attention. That the largest fish are the earliest spawners is, as I imagine, the general

* "Sur La Reproduction des Poissons osseux, surtout dans le Golfe de Marseille," *loc. cit.*, v., Fasc. II., 1898.

experience of those who have had occasion to examine spawning fish; but that the larger fish of a species lay the larger eggs is a proposition which I have not seen in print, at least as regards marine forms. I am led to believe that this is the case from measurements of the ova of several species during successive months, both at Plymouth and Marseilles. My observations are at present of a sporadic nature, and suggestive rather than conclusive. I hope to continue them during the present year in a more methodical manner. I have previously alluded to the experience of the late Sir J. Gibson-Maitland, to the effect that among the Salmonidæ the larger parents of a species give rise to the larger eggs, from which alone, speaking generally, offspring of large potential size can be procured. If, as my experience leads me to expect, the same relation of size of egg to size of parent holds good for marine fishes or for some of them, it is not unreasonable to suspect that the young derived from the smaller and later spawned eggs are, like their representatives among the Salmonidæ, of little account in the up-keep of specimens of large size. The question has obviously a most important bearing on measures that may be adopted for the preservation of our marine fisheries. I have been myself an enthusiastic advocate of the protection of immature fishes; but if the contention which I now advance holds good, it must be recognised that this measure will not alone secure an abundance of large specimens. It cannot, by itself, go further than to protect fish until the period at which they become capable of producing offspring incapable for the most part of attaining a respectable size. That over-fishing results, whether in a river or at sea, not so much in the reduction of the numbers of a species as in a diminution of fine specimens, if not entirely a matter of common knowledge, has, at any rate, been pointed out by Herdman some years ago (*Trans. Liv. Biol. Assoc.*, vii., 1892, p. 121). Its explanation seems to be that though many fish survive to the first breeding season, comparatively few reach a size at which they are capable of producing vigorous and potentially large offspring. The proposition, if applied to domestic stock, would be by no means startling to breeders. In the case of fish I suspect that there may be found a certain correspondence between the size of the adolescent fish at spawning and the average potential size of its offspring. It may, perhaps, be reasonably suspected that the rate of growth of the offspring of small parents differs considerably from that of the young of large specimens; a condition which, however difficult to tabulate, furnishes some clue to the extraordinary variation in this respect, which must be familiar to everyone who has endeavoured to understand the apparent anomalies of the sizes of young fish taken in company.

I do not propose to discuss, except incidentally, the developmental habitat of the species dealt with, these notes being only designed to assist in the determination of the young stages. A word is necessary with regard to the references given under various species to M'Intosh and Masterman's *Life Histories of British Fishes*. This book conveniently summarises the numerous and important observations of Professor M'Intosh, which appeared originally in a great number of papers in the Scottish Fishery Board reports and elsewhere; it may also be taken as setting forth his most recent opinion on matters of doubt. I have therefore referred to it in preference to the original papers.

Trigla lineata. *Gm. Linn.* Polperro bull-dog, Parrot gurnard.

The Polperro bull-dog, as it is generally called at Plymouth, is one of the commonest gurnards of the district. It frequents the rather deep water from a few miles beyond the Breakwater outwards, though I have known it to be taken on one occasion in Cawsand Bay. The young stages have not been found in the estuary or inshore waters, and I do not think that we have ever taken the ova in tow-nets. It therefore spawns in all probability on off-shore grounds, and apparently towards the end of the summer. A female taken on the 31st July, 1897, proved to be nearly ready to spawn, since the ovaries contained a few translucent eggs. Artificial fertilisation was attempted. After the lapse of an hour and thirty-five minutes three eggs were still floating. One had reached the two-cell stage, the others may or may not have been impregnated.

These eggs measure from 1·29 to 1·33 mm. in diameter. The single dark, but not conspicuously coloured oil-globule measures, in all three cases, ·24 mm. The zona is strongly ridged, but this is probably an ovarian character. The ova were all dead on the following day.

Trigla hirundo. *Bloch.* Tub (Plymouth), Latchett (North Sea).

? Marion, A. F., *Annales Mus. Mars.*, iv., 1891, I., p. 120, Pl. II., Fig. 19. *Early larva.*

Holt, E. W. L., *Ann. Mus. Mars.*, v., Fasc. II., 1898. *Tow-net egg, larva, young pelagic form.*

The Tub is the most economically important gurnard of the Plymouth district; but, although young specimens are common throughout the year, the adults appear to leave the grounds near Plymouth before the breeding season. I have never had an opportunity of submitting ova, obtained directly from the parent, to exact observation. Speaking rather generally, I can say that spawning takes place in the summer or early autumn.

Trigloid ova obtained at Marseilles by Marion, and subsequently by myself, appear, from local considerations, to be referable to this species. The only two which I observed measured 1·25 and 1·36 mm. in diameter, with a single oil-globule of ·26 and ·28 mm. The characters of the larva, according to my notes, cannot be stated in such a way as to clearly distinguish the species from either *T. gurnardus* or *T. pini*, and I suspect that all gurnards are practically identical in conformation and pigment in the vitelligerous condition.

Since the tub attains a large size in the Mediterranean I suppose that the dimensions of ova taken in that district may be of some service in the determination of Plymouth tow-net material. I have therefore assigned with due reserve to this species a Trigloid egg taken between the Eddystone and Hand deeps on the 27th July. It measures 1·35 mm. in diameter, with an oil-globule of ·28 mm. It is chiefly the large size of the globule that inclines me to refer it to the tub rather than to the Polperro bull-dog.

Only two species of gurnard, viz., the tub and the grey gurnard, *T. gurnardus*, appear to make their way into the Plymouth estuary. Neither of them would appear to breed to any great extent in the neighbourhood, yet the young of the season appear in some numbers in the river in the autumn and winter. I do not propose to discuss the matter here, but will merely remark that the *Trigla nigripes* of Malm is certainly the young of *T. hirundo*. Smitt, who gives (*Hist. Scand. Fish.*, Ed. ii., 1895, I.) a figure of one of Malm's specimens, seems to incline to the same view; but makes a reservation to the effect that (1) the fin-rays of *T. nigripes* may increase in number in the further development of the individual, so as to bring it in harmony with some species other than *T. hirundo;* (2) the ossicles of the lateral line of *T. nigripes* are not present in the adult.

Malm's specimen is about 20 mm. long. Plymouth examples of about 30 mm. agree equally well in fin-ray formula with *T. hirundo*, so that it seems probable no increase of fin-rays takes place. The double row of lateral-line ossicles is quite distinct from the single row of much stouter bony structures in a *T. gurnardus* which is only a little larger than the young *T. hirundo*.

It appears from Smitt's remarks that the Scandinavian naturalists have found a difficulty in associating *T. nigripes* with *T. hirundo* on account of the rarity of the latter. But the Tub or Latchett is not rare on the Danish coast in summer, and the drift of the surface water has been shown by Fulton to pass, under certain conditions of wind, from the Danish to the Scandinavian coast. The young *T. hirundo* seems to have a longer pelagic existence than other gurnards, since a specimen

of about 30 mm. has been taken during 1897 at the surface,* while there is no record, that I know of, of the occurrence of any other species at the surface at such an advanced stage of development.† The Bohüslan examples of *T. nigripes* may therefore be derived, in all probability, from North Sea parents rather than from the few adults of the Norwegian coast.

Callionymus lyra. *Linn.* Dragonet, Skulpin, Sting-fish.

M'Intosh, W. C., *Ann. Nat. Hist.*, 1885, p. 480. *Ovarian egg.*
Holt, E. W. L., *Sci. Trans. R. Dub. Soc.*, S. II., iv., 1891, p. 442, Pl. LI. *Egg and larva of C. lyra or C. maculatus.*
Cunningham, J. T., *Journ. M. B. Assoc.*, N.S., ii., 1891, p. 89, Pl. V. *Egg and larva.*
Prince, E. E., *Ninth Ann. Rep. S.F.B.*, 1891, p. 349, Pl. XIII. *Egg and larva.*
Holt, E. W. L., *Sci. Trans. R. Dub. Soc.*, S. II., 1893, p. 36, Pl. III. *Egg, larva, metamorphosing stages.*

Mr. Scott's observations show that the dragonet begins to spawn in January. It is one of the commonest fishes in the Plymouth district, and I think that our records show that the eggs are deposited, in some instances, in or near the Sound, as well as out towards the Eddystone, which seems to be one of the chief haunts of the larger members of the species.

The other British member of the genus, *C. maculatus*, has only recently been found on the south-west coast, one specimen having been trawled in Falmouth Bay and another off the Plymouth Mewstone. It is probable that the two species lay eggs which closely resemble each other, but as *C. lyra* is a far larger form than *C. maculatus*, I imagine that a corresponding difference holds good with regard to the ovarian products. I have been able to assign a Mediterranean tow-net egg, with a reasonable degree of probability, to *C. maculatus*. It is ·73 mm. in diameter, and the early larva is quite destitute of black pigment. The zona radiata resembles that of *C. lyra*, but the latter species is extremely rare at Marseilles.

In the first description which I gave of the larva of *C. lyra*, from the Irish coast, I omitted all mention of black chromatophores, having failed to observe any. The correctness of my description in this respect was challenged independently by Cunningham and Prince, while I myself had noticed black pigment in embryos of *C. lyra* before the papers referred to appeared. A re-examination of the only preserved specimen of those on which I had based my first description,

* In July, exact date not recorded: another was seen about the same time.

† I am not speaking of large specimens. I have been credibly informed of instances of a large gurnard pursuing smaller fish at the surface. As a matter of fact the only species identified was *T. hirundo*.

substantially bore out its correctness, and, on making acquaintance with the Mediterranean egg which probably belongs to *C. maculatus*, I concluded that I must really have been dealing with that species. *C. maculatus* is apparently not very rare on the Irish coast, and I had not measured the eggs from which my first Irish larvæ were hatched.

However, it is a fact that black pigment is not invariably present in the early larva of *C. lyra*. In examining a drawing made by Mr. Scott in January from a larva a few hours old, I noticed that no black chromatophores were shown. The specimen was again examined by Mr. Scott and by myself, and the drawing proved to be correct. The egg from which the larva was hatched measured ·90 mm. in diameter, and belonged without any doubt to *C. lyra*. The absence of black pigment must, nevertheless, be regarded as exceptional, since I was careful to examine all subsequent ova of Callionymus, and in all cases the embryo or larva exhibited some black chromatophores.

I think that without much doubt all the ova we obtained are those of *C. lyra*, since the difference in size observed seems to be roughly in accord with the date, though by no means all the eggs obtained were measured. The sizes run as follows:—January, ·90; February, ·83; March, ·91 and ·92; April, no observations; May, ·78 to ·84. I hope that it may be possible during 1898 to pay more continuous attention to the subject.

Scomber scomber. *Linn.* Mackerel.

? Agassiz and Whitman, *Mem. Mus. Comp. Zool. Harv.*, xiv., 1885, p. 36, Pl. XVII. *Unidentified Sp.* 10, *in part.*

Cunningham, J. T., *Journ. M.B. Assoc.*, N.S., i., 1889, p. 25, Pls. III., IV. *Egg.*

Cunningham, J. T., *ibid.*, N.S., ii., 1891, p. 71, Pl. IV. *Vitelligerous larva.*

Holt, E. W. L., *Sci. Trans. R. Dub. Soc.*, S. II., v., 1893, p. 10, Pl. I. *Egg, vitelligerous stages of larva.*

Holt, E. W. L., *Journ. M.B. Assoc.*, N.S., ii., 1892, p. 396. *Late larval stages.*

Holt, E. W. L., *Ann. Mus. Marseille*, 1898, *Sp.* I., *egg and larva referred to Mediterranean mackerel.*

Young stages of the mackerel are conspicuously absent from our tow-net records for 1897, although the fish was common enough in the neighbourhood in June. The spawning period is protracted at least as late as that month, and the eggs and larvæ are quite familiar to me. I must therefore conclude that little if any spawning took place on the grounds over which the tow-nets were worked, or at any point close to them. It will be observed that our expeditions did not extend beyond four or five miles off the Mewstone in the early part of the month, while during the latter part of May the *Busy Bee* was occupied in the bays east of the Start.

It is a matter of common knowledge that Mediterranean mackerel are much smaller than their Atlantic brethren. I believe that certain pelagic ova which I found at Marseilles in 1895 belong to the local variety of the species. They are smaller than those of mackerel from the British coasts, which is not remarkable. The larva, however, while closely resembling that of an Atlantic mackerel (*vide* Cunningham, Holt, *op. cit.*), differs from it in having an additional patch of yellow pigment in the middle of the tail. So far as my experience goes this patch is always present in the larva, so that, if it is really a mackerel, the Mediterranean race of the species shows a distinctive character at the very earliest stage. I have already noted that the unknown egg, Sp. 10, of Agassiz and Whitman, strongly resembles that of the mackerel. If this egg is rightly associated with the tow-net larvæ figured on the same plate, it would appear that the American race also differs in larval pigment from the British. The authors, however, do not insist upon the identity of the egg and larvæ, and the younger larva figured appears to be distinct. The older larva bears a much closer resemblance to the British form.

Some years ago I gave a brief description of some young mackerel taken in the eastern part of the North Sea (*vide* Journal, N.S., ii., 1892, p. 396). So far as I know they are the only specimens which have come under the notice of a naturalist, and it appears advisable to give a somewhat fuller account of them.

Including all my material, the details of locality and date are as follows:—

9th July, 1892, 20 to 22 mi. N.N.E. of Horn Reef, Denmark.
12 specimens, 6 to 9·5 mm.

23rd July, 1892, 250 mi. E., ½ N. of Spurn Head.
2 specimens, 14 and 19 mm. *ca.*

27th and 28th July, 1892, "Clay Deep," 150 mi. E. by N. of Spurn Head.
3 specimens, 13·5 to 19·25 mm.

The bearings are magnetic, and it will be seen from the map at the end of vol. iii. of this journal that all the specimens were taken between the Dogger Bank and the Danish and German coasts, and at considerable distances from land. The capture was effected by means of a ring tow-net of mosquito mesh, towed at the surface by a steam-trawler while trawling. As the strain was often sufficient to burst the net, it may be imagined that the smaller specimens suffered considerably.

Indeed, with regard to the smallest specimens, it can only be said that they agree in pigmentation with mackerel larvæ reared from the

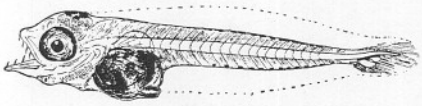
egg. A specimen of 7 mm. is fairly well preserved, at least on one side, and while agreeing in pigment and conformation with the smallest it can clearly be associated with the older forms, which, though incompletely metamorphosed, are quite recognisable by the characters of the adult.

The specimen of 7 mm. (Fig. 1) is in its present state of preservation somewhat laterally compressed; the abdomen projects boldly below the plane of the ventral contour of the caudal part of the trunk. The pre-anal region, exclusive of the lower jaw, occupies two-fifths of the total length. The snout is pointed, the lower jaw the longer, and both jaws bear a single series of large recurved and rather widely set teeth. The eye measures rather more than one-third of the length of the head. The post-anal region is still elongate and rather slender, though markedly deeper than in the vitelligerous stages; its extremity is slightly upturned by a trilobate hypural mass, beset with developing rays, and similar rays are also present dorsally. The marginal fins are mostly frayed away; the pectorals, also in bad condition, seem to have been of moderate size. The eye, noted at the time of capture to be blue, is now a dense black; a patch of black chromatophores is present on the top of the head, probably in the pia mater, and the roof of the peritoneum (and in part its sides) is beset with black chromatophores. From a short distance behind the anal region dorsal and ventral rows of black chromatophores run back as far as the caudal peduncle, and a few small black specks are present hypurally. Yellow pigment was not observed at the time of capture; it would not in any case be visible in the preserved condition, unless very profuse or in large corpuscles.

Allowing for the difference in age, the specimen of 7 mm. agrees in all respects with the late vitelligerous stage shown in Pl. I., Fig. 7, of my Irish paper. This figure was drawn from a larva of nine days, 4·88 mm. in length. With regard to the pigment the two specimens are practically identical.

Another specimen (Fig. 2) in fairly good preservation is 9·5 mm. long. The pre-anal region is still shorter than the post-anal part, but the distance between the anus and the tip of the urochord only exceeds the pre-anal length by less than one-eighth of the latter. The ventral contour of the abdomen is much less abrupt, though its hinder part still projects somewhat from the caudal part of the trunk. The pointed snout is nearly as long as the eye; both jaws have teeth as in the preceding stage, but relatively smaller. The tail of a larval fish of some sort protrudes from the mouth, while the head can be detected far back in the abdomen.

The metamorphosis of the tail (of the mackerel larva) is advanced,



G. 1. YOUNG MACKEREL. Specimen 7 mm. long × 8.

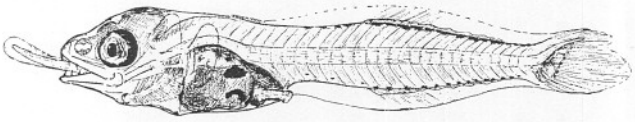


FIG. 2. YOUNG MACKEREL. Specimen 9·5 mm. long × 8.

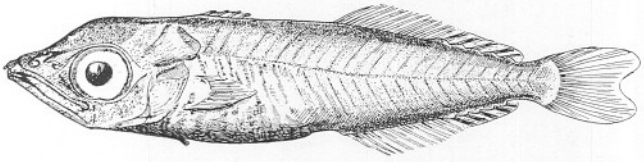


FIG. 3. YOUNG MACKEREL. Specimen 14 mm. long × 6.

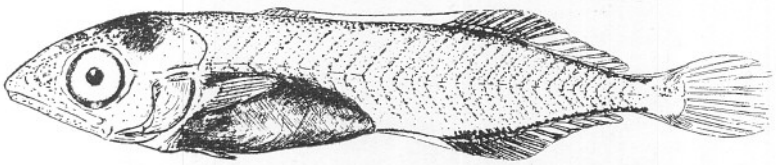


FIG. 4. YOUNG MACKEREL. Specimen 18 mm. long × 6.

"TELEOSTEAN FISHES." *Face page* 114.

the urochord with its embryonic rays being boldly thrust upwards by the hypural mass, the margin of which is still oblique. The caudal part of the trunk is most elevated at about half-way from the anal region to the caudal peduncle; on the slightly salient dorsal and ventral edges appear the interspinous ridges of the future second dorsal and anal fins. Each ridge (dorsal and anal) is continuous, but while the basal lobes of the anterior part are closely crowded together the most posterior of the series appear as rather widely separate nodules, or elevations of the crest of the ridge. Five of these isolated crests, the bases of the future finlets, can be counted on the dorsum. The anal fin region is not so well preserved. The ridges terminate at a point considerably anterior to the caudal fin. The embryonic marginal fin is continuous, but much collapsed in the present state of the specimen. A slight dorsal ridge about half-way from the shoulder to the level of the anus perhaps represents the first dorsal, but is by no means distinct. The black pigment is very similar in distribution to the last stage; but the dorsal post-anal chromatophores are larger and more numerous, forming a practically continuous line on either side of the ridge of the second dorsal and its finlets.

A badly-preserved specimen of about 13 mm. differs from the last chiefly in the greater length and more pointed contour of the snout, and in the elongation of the abdominal region. It forms a transitional stage to the more advanced condition shown in Figures 3 and 4. Fig. 3 is drawn from an example about 14 mm. in length, viewed as an opaque object; it is somewhat shorter and deeper than the specimen of about 18 mm. shown in Fig. 4, but the stage of development seems to be about the same. The bones of the head are well defined. There are no cephalic spines, but a strong longitudinal ridge at the upper extremity of the gill-cover may represent a part of the spinous armature of the young *Naucrates*. The outline of the head in Fig. 3 is probably unnatural, since three out of four specimens at about the same stage have the convex antero-superior profile of Fig. 4. The jaws are sub-equal, but the upper projects slightly, and is furnished with a pair of hooked teeth quite outside the gape. The general conformation can be gathered from the figures, the body being laterally compressed, but not more so than usual in young fish of similar stages. So far as I can gather from the examination of my material, the natural condition of the dorsal and anal fins is shown in Fig. 4. In frayed examples the finlets appear separated, but I am satisfied that the marginal fin really extends without any serious break in its outline from the first dorsal to the end of the dorsal series of finlets, and ventrally from the anus to the end of the anal finlets. It does not appear to be continuous, either dorsally or ventrally, with the caudal

fin. I cannot count the rays of the dorsal and anal in any of my specimens; they are not fully developed, but seem in general agreement with the adult formula. As regards the finlets, judging from my best specimens, each isolated basal lobe bears at its apex a single stout somewhat fan-shaped ray, divided distally into numerous fibres. The caudal is injured in most of my specimens. It appears to be slightly forked, as in Fig. 3. Small dark chromatophores are present on nearly all parts of the head and trunk. Larger chromatophores occur on the top of the head and along the dorsum, especially along the base of the second dorsal and dorsal finlets, while there is a corresponding ventral band at the base of the anal fin and finlets. The sides and under-surface of the abdomen are somewhat silvery. On the sides of the trunk the chromatophores are set more thickly at the lines of division of the myomeres than elsewhere. I never saw these large specimens in the fresh condition. As I received them, a few days after they were placed in alcohol, they appeared to have been of a general bluish-grey colour, with silvery eye, gill-cover and abdomen.

Caranx trachurus. *Linn.* Scad, Horse-mackerel.

Holt, E. W. L., *Journ. M. B. Assoc.*, N.S., iii., 1894, p. 190. *Ripe ovarian egg.*

(?) M'Intosh, W. C., *Eleventh Ann. Rep. S. F. B.*, 1893, p. 245, Pl. IX., fig. 8. *Unidentified egg, 1·2954 mm. in diameter.*

Holt, E. W. L., *Annales du Musée de Marseille*, 1898. *Egg, larvæ, various stages of metamorphosis.*

My previous communication on the reproduction of this species dealt with ova obtained from dead North Sea specimens. Though milt was added to the water into which the female fish were stripped, I do not think that the eggs were fertilised, since the expansion of the zona and the development of the protoplasmic mound, which I then described, is often if not always achieved by ripe ovarian eggs without any aid from the male product. The observation served to demonstrate the pelagic nature and extreme buoyancy of the egg, and the complete segmentation of the yolk.

At the time of writing I had not access to Agassiz and Whitman's memoir on the "Pelagic stages" (*Mem. Mus. Comp. Zool. Harv.*, xiv., 1885, p. 12, Pls. IV., V.), and erroneously asserted that the scad furnished the only instance of an Acanthopterygian egg with completely segmented yolk. As a matter of fact these authors have given a beautifully illustrated account of the egg of *Temnodon saltator*, a Carangoid allied to Caranx, and their figures showing the gradual phases in the segmentation of the yolk are probably equally applicable to the scad, in which I was able to note that the formation of the yolk spherules is accomplished, at least in part, after the deposition

of the egg. The unidentified form doubtfully assigned by Raffaele to Coryphæna furnishes probably another instance of a completely segmented yolk in the Acanthopterygian group.

I have failed to secure any further scad in spawning condition, but have no hesitation in assigning to this species certain tow-net ova obtained first at Marseilles in 1895 and again at Plymouth in 1897. I have described and figured these eggs, with the larvæ hatched from them, and some later stages, in the *Annales du Musée de Marseille*, and must refer to that publication for the illustration of my present remarks.

It will be remembered that the ripe ovarian eggs obtained at Grimsby exhibited an oil-globule, indifferently cupreous, yellow or colourless, and usually divided into several small globules at the time of spawning. The Plymouth eggs are smaller than the Grimsby specimens, but larger than those met with at Marseilles.

	Diameter of egg.		Diameter of oil-globule.
*Grimsby . .	1·03–1·09 mm.	...	·26–·27 mm.
Plymouth . .	·81– ·93 „	...	·22–·23 „
Marseilles . .	·76– ·78 „	...	·19–·20 „

I believe that this difference corresponds to the size of the parent fish in the several localities. As between the North Sea and the south-west coast I am not sure that the difference is considerable, but as spawning seems to be at its height in the North Sea in May, and my Plymouth ova were not taken before July, I suppose that the latter were derived from the smallest parents, which seem to spawn as a rule later than the large ones. As to the Mediterranean scad, all that I saw at Marseilles were very much smaller than the large Atlantic variety or race, and I imagine that in comparative size the scad differs, in the two seas, as the mackerel and pilchard are well known to differ.

Apart from the difference of dimensions the Plymouth and Marseilles ova are identical, and agree in character with the ovarian egg of the scad. The yolk appears to me to be absorbed rather more quickly than in the majority of pelagic eggs, having regard to the degree of development of the embryo, a circumstance which seems to be possibly explained by the greater extent of the protoplasmic element, limited in most ova to the periblast, but here extending inwards as the walls

* An unidentified egg, 1·29 mm. in diameter with an oil-globule of ·19 mm., is described and figured by M'Intosh (*loc. cit.*) from the east coast of Scotland. It may possibly be that of *C. trachurus*, but the nature of the markings shown on the yolk, which rather resemble yolk segments, was not ascertained. As the author observes, they may be simply superficial.

of the yolk segments. Be this as it may, while the egg has but an inconsiderable perivitelline space in its early stages, towards the time of hatching the embryo has ample room within the confines of the zona. A characteristic feature is the transverse elongation of the yolk at this stage. Yellow and black pigment is present when the embryo has acquired a short tail. A few pairs of large yellow patches occur along the head and trunk, accompanied by irregular black chromatophores. Yellow and black pigment is present about the oil-globule.

The early vitelligerous larva bears a close resemblance to that of *Temnodon saltator*, but the oil-globule is always anterior instead of posterior, a feature which also serves, *inter alia*, to distinguish the scad larva from that attributed by Raffaele to Coryphæna. At the stage at which the larva seems to be usually liberated, the anus is about median in position and therefore somewhat widely separated from the hind end of the yolk. The marginal fins are rather wide, but the dorsal does not extend in front of the head. Yellow pigment occurs in variable quantity along the dorsal and ventral region, except on the posterior half of the tail. Submarginal yellow patches, often of conspicuous size, are or may be present on the dorsal and ventral marginal fins, except on the posterior half of the tail. Yellow pigment occurs also about the rectum, the oil-globule, and to a variable extent over the general surface of the yolk. Black chromatophores, nowhere numerous, and variable in number, coexist with the yellow, and extend far back along the tail. The notochord is multicolumnar, the vacuoles being arranged in about two series. Except for the rather reduced condition of the yolk the larva cannot be said to be unusually far advanced at the time of hatching.

A larva, hatched at Marseilles from an egg which I did not measure, was much less advanced than any other which I have seen. The yolk was very large, the larva had only a very short tail, and the gut ended indefinitely a little behind the yolk. A day later the larva had acquired much the same size and conformation as those which hatched at what appears to be the normal stage, but the marginal fins were still devoid of pigment. This, however, judging from the analogy of Temnodon, appears unimportant.

A Plymouth larva, about fifteen hours after hatching, measures 3·03 mm. A Mediterranean specimen, at about the same stage, is 2·47 mm. long. The Mediterranean larva last referred to as exceptional was only 1·71 mm. long when first observed, but had reached a length of 2·63 mm. a day later. I have not succeeded in keeping these larvæ alive for more than a few days. They are exceedingly active, and rapidly injure themselves if confined in small vessels.

I do not imagine that there is any doubt as to the identity of these forms. The characters of the ova correspond to those observed in the ovarian egg of the scad, and that fish is common both at Marseilles and at Plymouth. Its ally, *Capros aper*, is known to possess quite a different egg. The egg of the John dory, *Zeus faber*, is certainly unknown. It is perhaps permissible to suppose that it will be found to resemble that of Capros rather than the form now under discussion.

An advanced larva taken at the surface of Plymouth Sound on the 6th August, 1897, is undoubtedly a scad, as is sufficiently indicated by the fin-ray formula, though the spines of the dorsal are as yet short, and those of the anal are not separated by a notch from the succeeding soft rays. The conformation is of interest.

The head is very large, its length contained about $2\frac{5}{6}$ times in the total length without the caudal fin. The height of the body is a little less than the length of the head. Both head and trunk are laterally compressed, and the general contour bears a resemblance to that of the adult Capros. The total length is 11·5 mm. The colour is olive-green, clouded almost uniformly with large black stellate chromatophores, but the median fins and the caudal peduncle are unpigmented.

The next stages known to me are represented by a number of examples taken by Mr. F. W. Gamble in August, 1896, from under the umbrella of a large Rhizostoma in the Irish Sea. There are seventy-nine little scad altogether, ranging in size, as preserved, from 16 to about 45 mm. The smallest have lost the somewhat abruptly elevated contour of the specimen of 11·5 mm., and the whole series are fusiform in shape, the elevation of the body being naturally greatest in the smaller examples. Of the British Carangoids they may be most readily compared to Lichia. At a length of 31 mm. the transverse keels of the lateral line scales are present on the posterior part of that structure. At 44 mm. the line is keeled throughout its length, but the scales do not appear to acquire the full development of the adult condition until the fish is about 54 mm. in length. Shoals of little scad from about 50 mm. upwards appeared in the estuaries of the Tamar and Plym during the autumn, so that, with the forms already referred to, we have most of the stages in the life-history of the species. Cephalic spines are not represented in any stage which I have examined.

An important gap is left between the vitelligerous larva and the specimen of 11·5 mm. At the latter size we may say that the scad is Capros-like in conformation, passing thence into an intermediate Lichia stage, from which the true Caranx conformation is finally evolved. So far as fishery matters are concerned the scad is important only as a nuisance, but the metamorphosis which we have been able to follow

seems to throw an important light on the phylogeny of the whole Scombroid tribe. It appears almost certain that Caranx has been evolved from a somewhat elevated laterally compressed ancestor, bearing in this respect a resemblance to the Capros of the present day. An elevated compressed form may therefore have been a primitive feature in the evolution of a part of the tribe, intensified in the evolution of various genera, such as Zeus and Platax, reduced in others, as certainly in Caranx, and perhaps in Lichia. Scomber has lost in its ontogeny all trace of an elevated ancestry, if it ever possessed one. The importance of a primitive elevated and compressed form may extend far beyond the limits of those fish which are usually associated in the broadest sense as Scombroids. As a matter of pure conjecture it may even be suspected to throw light on the systematic position of the Pleuronectidæ. I have already suggested (*Proc. Zool. Soc.*, 1894, p. 438) that these fish are derived from vertically swimming but elevated and laterally compressed ancestors, and the absence of stout spines in the fin-rays, considering the requirements of the habit evolution, requires no explanation at all.

Capros aper. *Linn.* Cuckoo, Boarfish.

Cunningham, J. T., *Journ. M. B. Assoc.*, N.S., i., 1889, p. 10. *Early stages of egg derived from parent.*

Holt, E. W. L., *ibid.*, v., 1897, p. 41. *Egg and larvæ derived from parent; tow-net egg and larva; late larvæ referred to C. aper.*

Holt, E. W. L., *Ann. Mus. Mars.*, v., 1898, Fasc. II. *As above, illustrated by numerous figures.*

With regard to the ova, I have little to add to the observations published in the last number of the journal. It will be seen from our records that the species must have been spawning in the neighbourhood of Plymouth from the beginning of June to the end of August. Trawlers regard it as a vagabond, here one day and gone the next, but never moving very far as long as it favours the coastal waters with its unwelcome presence. It was noted on the 3rd August that no cuckoos were caught in the trawl, though their ova, in an early stage of development, were fairly numerous on the surface above the ground trawled. So closely do these fish seem to congregate that a large shoal may have been quite near us at the time.

It appears worth while to recapitulate from our records the sizes of the eggs measured on different dates, in order to set forth what evidence we have of the diminution in size towards the end of the season. The notes of interrogation signify a doubt as to the correct determination of the species.

April	27	·98	mm. ?
June	4	·96–1·01	"
"	4	1·04	" ?
"	12	·90	"
"	25	·97– ·99	"
"	29	·99	" ?
July	6	·93– ·99	"
"	23	·96	"
"	27	·93– ·97	"
"	29	·93	"
August	25	·91	"
"	27	·93	"

In describing some late larvæ taken off the Fowey river on the 29th and 30th June, I omitted to point out the close resemblance which they bear, in pigmentation, to young Lepadogaster of about the same size. The arrangement of the black chromatophores is practically identical. The supposed Capros are, however, deeper in the body. I cannot find, examining them either as opaque objects or clarified in xylol, that they have any trace of a sucker, while at 5·5 mm. the development of the tail is much more advanced than in a *Lepadogaster bimaculatus* (with well-developed sucker) of 7·5 mm. The condition of the dorsal and anal fins would refer the supposed Capros larvæ to that species of Lepadogaster, if to any. The differences noted above dispose of such a suggestion, but the resemblance in pigmentation is interesting.

Lophius piscatorius. *Linn.* Monk, &c.

The ripe ovaries of a monk were brought to the Laboratory on the 20th January, 1898. I saw, but did not closely examine, the ovaries of another specimen on the same day; they appeared also to be ripe. Thompson, according to Day, observed a female with advanced ovaries in December, so that the spawning season would appear to commence very early in the year.

The ovaries were placed in sea-water, and as much as possible of the delicate ovarian wall stripped off. The mucous sheet soon swelled to a considerable width, and the spawn-mass floated for an hour or more. The oil-globules imparted to the whole a brilliant orange or salmon-colour. They were found to be divided, in a number of eggs examined, into numerous particles of various sizes. The mucous matter was only slightly adherent externally.

As is well known, the spawn, although a very conspicuous object, is rarely encountered at the surface. Is it possible that the parent manages to hitch it in some way to a submarine object?

Blennius ocellaris. *Linn.* Butterfly blenny.

1889

Cunningham, J. T., *Journ. M. B. Assoc.*, N.S., i., ~~1891~~, p. 36, Fig. XXV. *Egg.*
Holt, E. W. L., *Ann. Mus. Marseille*, v., 1898, Fasc. II. *Newly hatched and late pelagic larva.*

This blenny must probably be regarded as difficult to catch rather than as actually rare in the Plymouth district. Two adults, both males, were taken in 1897. Cunningham has already described the ova, which were found in an ox-bone, and identified by the presence of the male parent.

On the 20th June, 1896, Mr. Beaumont dredged a large whelk-shell off the Plymouth Mewstone. In the mouth of the shell was a male Butterfly blenny, guarding a great number of eggs. Higher up in the shell a *Lepadogaster bimaculatus* was similarly occupied. I did not specially examine the eggs of the blenny, but Guitel's researches (*Arch. Zool. Exper.*, S. iii., I., 1893, p. 325) render it very probable that in this species, as in others, the egg adheres by means of a series of long attachment filaments situate around the micropyle. The eggs were in various advanced stages of development, and many had hatched before the *Busy Bee* arrived at the Laboratory, but some had not hatched on the following day. Very probably they had not all been spawned at the same time. All unhatched eggs appeared bright red, the colour being that of the yolk.

A larva, from twelve to twenty-four hours old, measures 6·30 mm., of which the greater part is occupied by the tail. The distance between the snout and the hind end of the yolk is only 1·85 mm., and of this ·95 mm. pertains to the head. The rectum occurs immediately behind the yolk. The head is bluntly rounded in contour, and the edges of the marginal fins show a bold inflection towards the end of the tail, the caudal part being spatulate. The pectoral fin is large, with well-developed rays, the longest of which, when laid parallel to the body, extend ·12 mm. beyond the anus. This fin is yellow, with black chromatophores along the rays. The brain and anterior tissues generally are buff by transmitted light. Black chromatophores occur on the top of the head and about the posterior end of the trunk. The marginal fins are devoid of pigment. The notochord is multi-columnar.

I was unable to study any later stages as an accident to the escape pipe caused the loss of all my material. The larvæ appeared delicate, since many died soon after hatching; but as they were exceedingly active it is quite possible that they injured themselves against the sides of the bell-jar in which they were confined.

A much more advanced larva, taken in the little bay under Professor Marion's laboratory, at Endoûme, appears to belong to the species now

under consideration. The total length is 18 mm. The conformation approaches that of the adult, and the fin-ray formula agrees with that of *B. ocellaris;* while local considerations seem to eliminate from the list of probable parents such other blennies as exhibit a practically identical formula. The pectorals, 5 mm. in length, are olive-green, finely dotted with black—a character of *B. ocellaris.* The head and anterior part of the body are pale yellow; several olive-green bands radiate from the large blue eye. There is a patch of olive-green on the top of the head, a band along the middle of the side, and another along the base of the anterior part of the anal. Anteriorly a series of short bars descend from the dorsum. The dorsal and anal fins are colourless, and there is no pigment whatever on the hinder half of the post-anal region. There are no well-developed cephalic tentacles, and the dorsal, though deeply notched, is not conspicuously elevated in front. The little fish, when first observed, was swimming at the surface, the pigmented parts being alone visible. The resemblance to a butterfly was very much more apparent than in the adult condition.

The relatively enormous pectorals of the larva, though vigorously employed, cannot be regarded as very effective organs of locomotion, since the result achieved is by no means remarkable either for pace or staying power. Their significance is, perhaps, ancestral rather than adaptive. The resemblance, not only in the pectoral development but also in the contour of the head, to Dactylopterus, may be, so to speak, accidental. The young blenny is entirely devoid of cephalic armature. Both of the larval stages described above are figured in the *Annales du Musée de Marseille.*

Blennius pholis. *Linn.* Shanny.

M'Intosh and Masterman, *Life-Histories Brit. Food-Fish.*, 1897, p. 206. *Late larval stages.*

Holt, E. W. L., *Ann. Mus. Mars.*, 1898, v., Fasc. II. *Pelagic larval stage, with figure.*

The early development of the shanny seems never to have been the object of exact observation. The later larval stages have been dealt with by M'Intosh and Masterman.

On the 15th July, 1897, a larva of 15·5 mm. was found by Mr. Beaumont and myself in a dahlia flower which was floating under St. Anthony lighthouse, Falmouth. The fin-ray formula is that of the adult; in other respects the specimen is very similar to the young *B. ocellaris* of 18 mm., but the colours are different. The dorsal and anal fins and the hinder half of the post-anal region are entirely devoid of pigment. The ground colour of the anterior parts is canary-

yellow, with a deeper patch near the middle of the post-anal region. Several bands of black chromatophores radiate from the eye; there is a black patch on the top of the head and a row of black chromatophores on the cheeks. A band of black, notched at intervals, occurs on the dorsum, a row of black along the base of the anterior part of the anal, and there are some small black chromatophores along the lateral line. The pectorals are reddish brown, with very large transversely elongated black chromatophores, or groups of chromatophores, arranged on the interradial membrane so as to form rows transverse to the long axis of the fin. The pigment differs thus in colour rather than in general distribution from that of *B. ocellaris*. The pigmentation of the pectoral is practically that of the adult *Dactylopterus volitans*. The specimen is figured in the Marseilles paper.

On the same day I saw, but failed to catch, what were probably similar larvæ. They were among the Laminaria at the sides of a tidal pool near the place of capture of the specimen described. A day later we found another—a little larger—in the Helford river zostera bed, at low water. Older specimens, 19·5 and 20 mm. long, were taken at the surface in Plymouth Sound on the 7th September, but I omitted to note the presence or absence of any floating body to which they might have been clinging. A feature of note is the extraordinary activity of the larva when out of its native element. Its leaping powers are most respectable, and no injury seems to ensue from contact with terrestrial matters. I suppose that its locomotion on land is accomplished in the same way as that of Periophthalmus; but my specimens were a great deal too lively to make sure of this. I imagine that the young shanny is not infrequently stranded by the falling tide, in which case its jumping powers may serve it in good stead.

Ctenolabrus rupestris. *Linn.*

Holt, E. W. L., *Sci. Trans. R. Dub. Soc.*, S. II., iv., 1891, p. 465, Pls. XLVIII., XLIX. *Tow-net egg and larva, Sp.* iv.

Pelagic ova taken on the west coast of Ireland were referred to this species on account of the close resemblance they bore to those of the American connor, *C. adspersus*. This identification has never been confirmed by the evidence of ovarian eggs, and perhaps hardly requires such confirmation. A glance at our records will show the frequency with which the egg has been taken in the Plymouth district during 1897. This is by no means surprising, as the parent species is exceedingly abundant on rocky ground both in the Sound and outside the Breakwater. It occurs also, if one may judge from the evidence of

tow-net eggs, on the outlying Eddystone rocks. Young examples are common in the zostera beds of Cawsand Bay and the Yealm estuary, but adults are rarely taken, at least by the Laboratory boats, on any ground fit for trawling. It would appear from our records that there is no special migration in connection with the spawning instinct, but that the ova are liberated on the grounds ordinarily inhabited by the species. The breeding season appears to be prolonged from April to August, and such measurements as were made afford evidence of a diminution in the size of the ova as the season advances. The actual numbers will be found in the records, while the subjoined list may be taken as a summary:—

April	·90 to 1·01 mm.
May	·87 „ ·94 „
June	·84 „ ·87 „
July	·78 „ ·82 „
August. . . .	·72

An egg of ·67 mm., taken on the 28th June, can probably be assigned to this species; as it presents certain indications of immaturity, it cannot fairly be utilised as evidence of size variation. Excluding this specimen, the variation is ·29 mm., or more than one-fourth of the size of the largest specimen.

It may be urged that the ova which we have assigned to *C. rupestris* may really have been contributed by more than one species of wrasse, but I do not think that this is the case. The common wrasses of Plymouth are *L. maculatus, L. mixtus, Cr. melops, Ce. exoletus,* and *Ct. rupestris.* The first three may be discarded, since their ova are demersal. Of the ova of *Centrolabrus exoletus* I know nothing, but I found at Marseilles, where *C. exoletus* is not known to exist, a similar variation and seasonal diminution in the size of tow-net ova referable to *Ct. rupestris.*

April	·80, ·83 mm.
May	no observations.
June	·75, ·76 mm.
July	·70 mm.

Moreover the occurrence of young specimens in the Plymouth zostera beds affords evidence that the spawning season is really as prolonged as would appear from the tow-net gatherings. Preliminary experiments indicate that the species can easily be reared from a very small size, and it may be possible to study its development continuously.

Unidentified Labroid, resembling **Coris.**

Holt, E. W. L., *Sci. Trans. R. Dub. Soc.*, S. II., iv., 1891, p. 467, Pls. XLVIII., LI., *Sp.* v., Coris-like.

Holt, E. W. L., *Ann. Mus. Marseille*, v., 1898, Fasc. II. *Egg and larva, with figure.*

An egg which appears to have unquestionable Labroid affinities was taken in the Plymouth district in July and August, 1897. Our records show that it occurred on more or less off-shore grounds. I have no doubt but that it is identical with ova already described from the west coast of Ireland, but the parentage remains in doubt.

The Irish specimens measured from ·80 to ·83 mm. in diameter, the oil-globule measuring ·15 mm. Those taken at Plymouth measure from ·78 to ·81, the oil-globule from ·13 to ·15 mm. The yolk is homogeneous, the oil-globule colourless, but, in the Plymouth examples at all events, very dark. A larva, measured very soon after hatching, is 2·21 mm. long. A somewhat more advanced specimen from Ireland measured 2·44 mm. The conformation of the larva bears a striking resemblance to *Coris julis* (*vide* Raffaele, *Mittheil. Zool. Stat. Neap.*, viii., 1888, Tav. II., Figs. 18, 19). The yolk is pyriform, its narrow end, having the globule at the apex, projecting boldly in front of the head. The rectum is separated by a considerable interval from the hind end of the yolk. The marginal fins are of moderate width, the dorsal arising behind the head. My notes distinctly state that the edges of the marginal fins are not serrated as in Coris. The notochord, in Irish specimens, is of a peculiar type. For the most part arranged in a double series, the vacuoles are occasionally unicolumnar. This appears to me a strong indication of Labroid affinity, since both Coris and Ctenolabrus exhibit a notochord intermediate in character between the unicolumnar and multicolumnar conditions, though the approach to the former condition is much more marked than in the form before us. I must add that I did not find any unicolumnar cells in a Plymouth example which I examined; it is probably a variable feature, but, on account of its rarity, in so far as my knowledge extends, in other groups of fishes, not the less useful.

The pigment is all black, and has the same distribution as in Coris, but resembles perhaps even more closely that of Mullus. Indeed, save for the presence of cortical yolk segments in Mullus and for the separation of the yolk and rectum in our unidentified larva, the two forms are extremely alike.

I believe that the Labroid affinities of the parent are fairly well demonstrated by the characters of the embryo and larva. The difficulty is to find a Labroid parent. Labrus, Crenilabrus, and Ctenolabrus are naturally eliminated. *Centrolabrus exoletus* spawns, at least in great

part, at a season earlier than the date of capture of the ova, as is demonstrated by the presence of the young in the zostera beds. It seems also to be a rather littoral fish, and it is quite possible that its ova are demersal. *Acantholabrus Palloni* may exist in the Plymouth district, but is only known to British zoology by a few examples recorded by Couch from the Cornish coast. *Coris julis* has been taken at Plymouth, but not to my knowledge in recent years, while the eggs of Mediterranean specimens, according to Raffaele's observations and my own, measure from ·58 to ·70 mm. in diameter, with an oil-globule of ·12 to ·14 (·18) mm., and, as already noted, the fin-edges of the larva are serrated. The difference is thus not only one of dimensions, though it is possible that I overrate the importance of the fin serration as a constant character.

The Mediterranean *Coris speciosa* of Risso is regarded by Marion (*Annales Mus. Mars.*, i., 1882, Mem. 2, p. 20, foot-note 3) as a deep-water variety of the common littoral *C. julis*. So far as my knowledge of the forms allows me to hold an opinion, it is in agreement with that of Marion. *C. speciosa* is known only from large specimens and may be, as I suppose, simply the ultimate phase of the development of *C. julis;* but, on the other hand, since its anterior dorsal rays are proportionately shorter than those of the fully developed *C. julis* of coastal waters, it may be a true variety. I have not had an opportunity of examining the British Museum specimens of Coris from the S.W. coast, but Day's remarks appear to indicate that at least one specimen is of the *C. speciosa* type.

Since Coris is little liable to capture by ordinary British fishing apparatus, it is quite possible that it really exists in some numbers in our district, and our undetermined ova may be thus accounted for, assuming that the British variety is larger and lays larger eggs than the Mediterranean coastal form, and that the serration of the larval fin is either variable or only present in the offspring of the smaller form or stage.

It is quite possible that our undetermined form is not a Labroid at all, but referable to one of the too numerous common fishes of which the early stages are still unknown to us. I do not think that this is the case, imperfect as is our present knowledge of Teleostean development.

The Topknots. Zeugopterus and Phrynorhombus.

Brook, G., *4th Ann. Rep. S.F.B.*, 1886, p. 226. *Ovarian egg of P. unimaculatus.*

M'Intosh, W. C., M'Intosh and Prince. *See M'Intosh and Masterman.*

Cunningham, J. T., *Journ. M. B. Assoc.*, N.S., ii., 1892, p. 325. *Ovarian egg of Rh. norvegicus.*

Holt, E. W. L., *Sci. Trans. R. Dub. Soc.*, S. II., iv., 1893, pp. 96 to 103. Pls. II., VII., VIII. *Sp.* x., xi., *and* xii., *undetermined tow-net eggs, now referred indiscriminately to the topknots.*

Holt, E. W. L., p. 104, Pl. XI., *Sp.* xiii., *Metamorphosing larvæ, now referred to P. unimaculatus.*

Holt, E. W. L., p. 111, Pl. XII. *Sp.* xiv., *Metamorphosing larvæ with periotic spines, now referred to Rh. punctatus.*

Cunningham, J. T., *Journ. M. B. Assoc.*, N.S., iii., 1894, p. 202. *Rh. punctatus, advanced metamorphosing larvæ with periotic spines.*

Petersen, C. G. J., *Rep. Dan. Biol. Stat.*, 1893 (1894), p. 135, Pl. II., Fig. 16. *Late metamorphosing larva of Rh. norvegicus.*

Ehrenbaum, E., *Wiss. Meeresuntersuch, Komm. deutsch. Meer. Biol. Anst. Helgoland, Neue Folge,* ii., 1897, i., p. 317. *Tow-net egg referred to Sp. F. of M'Intosh and Prince.*

M'Intosh and Masterman, *Life-Hist. Brit. Mar. Food-Fish.*, 1897. *Summary of previous observations by M'Intosh and M'Intosh and Prince. Ovarian egg of Rh. punctatus; tow-net eggs referred by authors to same. Metamorphosing larvæ with periotic spines, provisionally referred by authors to Rh. norvegicus. Metamorphosing larvæ without periotic spines, referred by authors to Rh. punctatus.*

Holt, E. W. L., *Journ. M. B. Assoc.*, N.S., v., 1897, p. 45. *Egg and larva of P. unimaculatus.*

Holt, E. W. L., *Annales Mus. Nat. Hist. Marseille*, v., 1898, Fasc. II. *Larva of P. unimaculatus, early larva of Rh. punctatus with periotic spines, figures.*

Under the designation of Topknot, our record includes a number of eggs taken between the 24th February and the 5th April, with, perhaps, another which occurred on the 4th June. It is impossible to decide to how many species these eggs really belong. The three British topknots all occur in the neighbourhood of Plymouth, and one, at least, of them must be very common there, namely *Rhombus norvegicus.* Another, *Rh. punctatus,* is certainly not rare. The third, *Phrynorhombus unimaculatus,* is less often met with, but as these fish by no means lend themselves to capture by the ordinary methods of fishing, it is impossible to make any exact statement as to their comparative abundance.

With regard to the spawning period in this district, Cunningham has recorded a ripe female of *Rh. norvegicus* taken on the 21st March, and I have trawled two *Phr. unimaculatus* in similar condition on the 1st June. I do not know of any record of the spawning of *Rh. punctatus* from the S.W. coast, but M'Intosh and Prince give the 16th May as the date of the capture of a ripe female at St. Andrews. Judging by the analogy of other species, this topknot should spawn on the S.W. coast at least as early as on the N.E. of Great Britain.

Rh. norvegicus and *Rh. punctatus* may therefore be safely regarded as early spawners. *P. unimaculatus* may or may not spawn, as a species,

a little later than the others. So far as the few recorded observations go, there seems to be no possibility of distinguishing their eggs by dimensions alone. Thus, from a single example of each species, the various authors who have dealt with them give the following sizes:—

Rh. punctatus, unfertilised . . d. 1·05 *ca.* o.g. 0·20 mm. *ca.*
Rh. norvegicus, „ . . „ ·90 „ ·15 „
P. unimaculatus, „ . . ·92–·93 „ (·16–·18) mm.

Fertilised ova from the last specimen measured from ·90 to ·99 mm. in diameter, the oil-globule from ·16 to ·18 mm.

If the fertilised eggs of a single parent show a variation *inter se* of ·09 mm., it is more than probable that the variation of the eggs of the species as a whole is really much greater. For *P. unimaculatus*, Brooks' measurement of the ripe ovarian egg, after preservation, is ·96 mm. Without further words, I think it will be plain that the eggs of the three species overlap each other in so far as dimensions are concerned, although in all probability the egg of *Rh. punctatus* is on an average the largest, that of *Rh. norvegicus* the smallest of the three. Such comparative sizes of the eggs conform to those of the parent species, so far as they are known to me.

The eggs taken in our tow-nets may be recapitulated as follows, the dimensions of each individual egg being given:—

	Diam. of egg.	Diam. of oil-globule.
February 24 . .	1·05	
„ 26 . .	1·02	... ·19
March 1 . . .	1·04	... ·21
	·99	... ·18
	1·05	... ·17
	1·08	... ·19
March 30 . . .	·90	... ·13
	·91	... ·13
	1·04	... ·19
	1·07	... ·21
	1·07	... ·21
April 5 . . .	1·03	... ·17
June 4 . . .	1·04	... ·20

The egg of June 4th, only observed in its early condition, belongs perhaps more probably to *Capros aper* than to a Topknot.

With regard to the rest it appears at first sight possible to select two, measuring ·90 and ·91 mm. in diameter, as differing markedly from the rest; but it is necessary to remember that the difference of ·15 mm. which separates the smallest of these two from the largest of the whole series is no more than is met with in a single species having ova of

about the same size. For instance, tow-net ova, which can be referred with reasonable certainty to *Callionymus lyra* and *Ctenolabrus rupestris*, show variations of ·12 and ·29 mm. respectively (*vide* pp. 112 and 125). The discrepancy in size cannot therefore be regarded as of specific moment.

Appeal to the characters of the embryo and larva does not afford much positive assistance, since of the three Topknots but one is certainly known in its early stages, and that only from a few artificially-fertilised eggs and a single newly-hatched larva. This larva has been described in the last number of the journal, and will be figured in the *Annales du Musée de Marseille*. The Plymouth tow-net eggs yield larvæ which do not appear to offer important differences, though in certain characters they are certainly variable. Taking those which have come under my own observation, apparently similar to those studied by Mr. Scott during the earlier part of the season, the larvæ may be said to be identical with some Irish examples which I have described and figured under the title of Sp. xi. Moreover, it now appears to me that my Species x. and xii. were separated from the last on insufficient grounds. I do not wish to assert that all the eggs which I have described under those titles were spawned by one and the same species; but that, in the light of the Plymouth specimens, I now hesitate to rely on the characters which I formerly considered as specific.

Sp. x. is a St. Andrews form, and is no doubt identical with an egg and larva subsequently attributed by M'Intosh (*Twelfth Ann. Rep. S. F. B.*, 1894, p. 222, Pl. IV.), who appears to have overlooked my previous description in this journal of the ova and larvæ of the turbot, to that important food-fish. According to my observations the egg, which occurred at St. Andrews in April, May, and July, and in Clew Bay, Ireland, in April, has a diameter of 1·00 to 1·05, and an oil-globule of ·18 to ·20 mm.

Sp. xi. is from Ireland, March and April; the diameter is from 1·01 to 1·07, that of the oil-globule ·18 mm.

Sp. xii. is a title applied for the sake of continuity to a form already described by M'Intosh and Prince as Sp. F. According to my own measurements in Scotland and Ireland the diameter of the egg is from ·75 to ·85 mm., that of the oil-globule from ·14 to ·15 mm. According to M'Intosh it may reach a diameter of ·9906 mm. The same egg has been found by Ehrenbaum at Heligoland.

Sp. F. or xii. differs from the rest in that the epidermis is beset with small papillæ or tubercles, connected with each other by a network of fine raised lines. I have already explained in the last number of this journal that I can no longer regard this epidermal feature as of specific

importance. It is a common, perhaps a normal feature of the embryo of Arnoglossus, but it is not constant, even in the species of that genus. In typical specimens of Sp. F or xii. it is extremely well marked, but the Topknot eggs which I have seen at Plymouth do not lend themselves to discrimination by this character. Two of them, and it is necessary to remark that these two (·90, ·91, 0·9, ·13) are the smallest of the series, have the reticulo-papillate epidermal character most strongly marked, but the rest are variable. Some have the skin practically smooth. In others it is more or less papillate, with an approach in some instances to reticulation. Moreover, the typically reticulo-papillate condition was observed as an exceptional, perhaps a pathological feature in a species which does not appear from the characters of the larva to be a Pleuronectid (*vide* the egg and larva temporarily assigned to a Gadoid, p. 145).

Apart from the papillation of the skin, I now believe that the various early Topknot larvæ, which have been described from tow-net ova, cannot be distinguished by characters of pigment and conformation. Those which have come under my notice at Plymouth seemed to be referable to my Species x., xi., and xii., but, on the other hand, they appeared capable of bridging over the differences which I had supposed sufficient to separate those species. Species x. was originally supposed by myself to have a Trigloid affinity, on account of the rather precocious development of the pectoral fin and a certain Trigloid character of the pigment of the marginal fins. I am now convinced of error in this respect, and it appears reasonably certain that all our British Triglæ have much larger eggs.

An inevitable want of continuity in our tow-netting operations during the period when these eggs occurred, seems to me to greatly prejudice any discussion based on the comparative sizes of the eggs taken. As to the general question of the determination, by the characters of the vitelligerous larva, of the eggs of the several species of Topknot, I do not think it is possible, as yet, to pronounce a definite opinion. The single larva which I was able to rear from artificially fertilised ova of *P. unimaculatus* seems to me to suggest that some of the ova which have been described under Sp. F belong to that form. Further, it would appear that the reticulo-papillate larva is perhaps more commonly hatched from the smaller of the eggs which may safely be assigned to Topknots. M'Intosh and Masterman deal with the egg and larva F under *Rh. punctatus*, but it does not appear that they wish to definitely identify them with that species. It seems at least possible that the reticulo-papillate condition may be more or less pathological; and if, as I suppose to be the case, the smaller spawning members of a species give rise to

small and often weakly offspring, it is quite possible that the occurrence of the character rather in small eggs than large may be explained in this way. On such a supposition one must class the smaller ova with reticulo-papillate larvæ merely as the offspring of small individuals, of one or more species, and not as a distinct species. I put forward the suggestion for what it may be worth. A papillate condition of the skin is certainly a pathological condition in the larvæ of many species, but is certainly present in some cases in individuals which appear to be quite healthy.

There is, I imagine, no means of deciding how many Topknots have contributed to the ova taken in our tow-nets this spring, although the apparent lateness of the spawning period and certain characters of my solitary larva of *P. unimaculatus* seem to indicate that the share of that species is, at any rate, unimportant. Failing any observation of larvæ derived from the artificially fertilised eggs of *Rh. punctatus* and *Rh. norvegicus*, it is impossible to say whether one or both of these species are represented.

Some help may perhaps be derived from a consideration of the few metamorphosing larvæ of Topknots which were obtained during the year.

I have described from Ireland, as Sp. xiv., a very conspicuously characterised pleuronectid larva, which can now be referred, without any doubt, to a Topknot. It is most readily recognised by the presence of a pair of relatively enormous spines on each otocyst, and is further characterised by a very distinctly banded black pigmentation. In discussing the affinities of this larva, I at first considered that it must belong either to the Brill (*Rh. lævis*) or to *Rh. norvegicus*. Confirmation of Raffaele's earlier observation of the young stages of the Brill has shown that it is certainly not the parent of the larva with periotic spines. On the other hand, Cunningham seems to me to have proved, by the examination of older stages, that *Rh. punctatus* has a spined larva similar to my Sp. xiv. A specimen examined by this author has D. 90, A. 69, and he rightly contends that, of the possible parents, *Rh. punctatus* is by far the most probable. My largest specimen had D. 80 *ca.*, A. 66 *ca.* It was not possible to count all the rays. Cunningham makes the reservation that there may be more than one species with a spined larval condition.

A larva with periotic spines was formerly considered by M'Intosh to be possibly a young *Rh. punctatus*, representing an older stage of another larval form apparently similar to that which I doubtfully assigned, under Sp. xiii., to *P. unimaculatus*. His latest discussion of the matter (M'Intosh and Masterman) refers the last-named larva, which has no periotic spines, to *Rh. punctatus*, while the former, including my Sp. xiv.,

is assigned with some reserve to *Rh. norvegicus*. No St. Andrews larva is assigned to *P. unimaculatus*, because that species has never been recorded in the district, but the capture of a single specimen of *Rh. norvegicus* seems to be considered to have afforded sufficient warrant for changing the determination of the spined larva.

The Irish larva without periotic spines, Sp. xiii., is, if one takes into account the stages of the metamorphosis which the two forms exhibit, much smaller than the spined Sp. xiv. Thus at a length of 10·62 mm. the latter is still nearly symmetrical, with a heterocercal tail, while at 9·37 mm. the former has the eye at the ridge, and the tail quite homocercal. I should imagine that the larva which, at any given size, has the metamorphosis most advanced, would be universally held to belong to the smaller species. Yet M'Intosh and Masterman put forward the same comparison as an argument in favour of an exactly converse conclusion.

Cunningham's observation of the later stages of the spined larva seems to me too positive to permit of any doubt as to the spinigerous nature of the larva of *Rh. punctatus*, unless, as is most unlikely, he was dealing with a specimen with an exceptionally large number of fin-rays. The St. Andrews authors, however, refer the larva without spines to that species, with the simple remark that they are unable to concur with Cunningham's opinion.

During the present season we have twice taken a larva with periotic spines, corresponding exactly in this respect, and in the disposition of the pigment, with my Irish series, but less advanced in metamorphosis. They measure respectively 5·11 and 4·5 *ca.* mm., the latter specimen being bent and difficult to measure with accuracy. The body is still elongated, and shows no signs of elevation. The contour of the head is still rounded, although the jaws protrude somewhat, and the general appearance is that of a larva not long after the final absorption of the yolk. Yet the periotic spines are conspicuously developed, the upper one being somewhat the larger, and rather backwardly deflected. The larvæ, which will be figured in the *Annales de Musée de Marseille*, are certainly identical with the Irish forms, and I refer them without hesitation to *Rh. punctatus*.

They occurred on the 8th and 24th of April (*vide* record), that is to say at the end of the period of occurrence of the Topknot ova, while Cunningham's advanced larvæ were taken on the 4th May. Taking into consideration dates and localities, one is led to suppose that these larvæ must be derived from ova similar to those which have been referred to the Topknot generally. In other words the said eggs are in part, at least, those of *Rh. punctatus*.

From the date, locality, and dimensions of the ova, it is obviously

probable enough that some of the latter may belong to *Rh. norvegicus*, but I do not think that there is any satisfactory evidence of the nature of the metamorphosing larva of that species. It may, as M'Intosh and Masterman suppose, be characterised by the possession of periotic spines, but I should say that the conformation of the St. Andrews specimen of 11 mm. (if correctly represented by M'Intosh and Masterman), referred to *Rh. norvegicus*, bears certainly a greater resemblance to that of *Rh. punctatus*.

Apart from the spinigerous forms there is another larva or group of larvæ which can be definitely associated with the Topknots.

Under Sp. xiii. a typical series of this form, from the symmetrical condition to an advanced stage of metamorphosis, has been figured and described by myself. It has no spines at all, and at parallel stages of the metamorphosis is very much smaller than the spined form, and shows moreover no trace of the bold pigmentation of the latter. From the conformation at the most advanced stages, and from the fin-ray formula, I considered that this form belonged to *P. unimaculatus*, and so far as is possible, the appearance of the early vitelligerous larva of that species confirms my opinion.

Metamorphosing larvæ, either identical with or at least very similar to the Irish specimens, have been met with at St. Andrews, and are referred, as we have seen, by M'Intosh and Masterman to *Rh. punctatus*. As that species has certainly a spined larva, it appears to me that the spineless forms from St. Andrews must belong either to *P. unimaculatus* or to *Rh. norvegicus*. It is simply a question of whether the larva of the last-named has periotic spines or has none.

The few spineless sinistral larvæ which have been taken at Plymouth in 1897 leave the matter in doubt. One, 8 mm. in length, presents the stage of metamorphosis of an Irish specimen of 8·87 mm. (*op. cit.*, Pl. XI., Fig. 92). The two are very much alike, but the Plymouth example is somewhat more profusely and generally pigmented. Does the difference in size justify us in supposing that the Plymouth larva belongs to a smaller species than *P. unimaculatus?* I should say that it is possible, but not certain, since individual larvæ vary in the size at which they assume the different phases of metamorphosis. Another larva, about 3 mm. long after preservation, connects itself more readily with the younger stages of the St. Andrews spineless larvæ than with any of the Irish series. The head is large, but the trunk is narrow and elongate, without any trace of Pleuronectid metamorphosis, but the abdomen is relatively enormous, a condition apparently due to the viscera being distended with food. Whether naturally or by accident, the abdomen is laterallly compressed. Pigment is present in the form of minute black chromatophores scattered over the general surface, but

scarce about the middle of the tail; larger black chromatophores occur along the edges of the dorsal and of the posterior part of the ventral marginal fins.

Seeing that they were taken on the inner Eddystone ground, a haunt of *Rh. norvegicus*, it is not improbable that these larvæ belong to that species, but in view of the resemblance of the larger specimen to the Irish larvæ, which appear to belong to *P. unimaculatus*, I am not inclined to make any positive assertion without further material.

A larger sinistral larva, taken from the stomach of a gurnard (*T. lineata*) on the 10th June, is so macerated that it is only possible to say that it has no spines and bears, in conformation, a fair resemblance to *Rh. norvegicus*. The total length is about 9·5 mm.; the eye is on the ridge.

Arnoglossus laterna. *Günther.* Scaldfish, Scaldback.

Since the last number of this journal was published I have had no further opportunity of measuring ova taken from the parent, but, as may be seen from the records, tow-net specimens, certainly referable to this species, were taken up to the 29th July. They cannot be regarded either as particularly rare or as specially confined to the lower strata of the water. The last egg belonging to the genus was observed on the 3rd August.

The difference already noted as existing between ova taken from the small undifferentiated females and those from large specimens with elongated dorsal rays seems to be accidental. Large females yielded ova of ·75 to ·76 mm., with a globule of ·12 to ·13 mm., while small females gave ova of ·67 to ·69 mm., with a globule of ·14 to ·15 mm. The difference in the size of the egg might be regarded as correlated to the size of the parent, but it was not apparent why the smaller egg should have the larger globule, if the two forms belong to the same species.

Tow-net eggs have since been found measuring ·63 and ·66 mm., in both cases with an oil-globule of ·13 mm. They can be identified from the characters of the larva with *A. laterna*. It follows that the full variation in the dimensions of the ova of this species, and of the proportionate size of the oil-globule, are not represented by the measurements which I took from the spawn of a few specimens.

Regarding *A. conspersus* of the Mediterranean as not entitled to specific distinction from *A. laterna*, my observations suggest that the northern representatives have larger eggs than the southern. Ova measured at Marseilles range from ·61 to ·68 mm., with an oil-globule of ·11 to ·13 mm. The larva is also smaller, but, allowing for variation observed in both localities, identical in pigment and other characters

with the northern form. Both British and Mediterranean examples are illustrated in my paper in the *Annales*. So far as I know, large differentiated Scaldfish have never been observed at Marseilles, though they are known from other parts of the Mediterranean.

Arnoglossus Grohmanni. *Bonap.*

Raffaele, F., *Mittheil. Zool. Stat. Neap.*, viii., 1888, p. 49, Tav. iv. *Larva hatched from tow-net eggs resembling those of various species of Arnoglossus, Rhomboidichthys, and Citharus.*

Holt, E. W. L., *Annales Mus. Mars.*, v., 1897, Fasc. I., Note 4., p. 33. *Preliminary notice of egg and larva provisionally referred to A. Grohmanni.*

Holt, E. W. L., *ibid.*, v., 1898, Fasc. II. *Ova and larvæ, Mediterranean and British, referred to A. Grohmanni; with figures.*

In all, eight specimens of *A. Grohmanni* were trawled by the *Busy Bee* in 1897 and in January, 1898, viz., six at Plymouth and two in Falmouth Bay. The latter, taken on the 8th July, were females, very nearly ready to spawn. The species can no longer be regarded as extremely rare on our south-western coast. I have never noticed it among the large numbers of large *A. laterna* which have been brought to me from the off-shore trawling grounds; it seems rather to prefer the neighbourhood of rocks or rough ground nearer the shore, and may perhaps be common in actually rocky places inaccessible to trawling.

I associate with this species ova measuring ·67 to ·68 mm., oil-globule ·12 to ·13 mm., at Marseilles, and ·72 and ·74 mm., oil-globule ·12 mm., at Plymouth. The Plymouth specimens, with another not measured, occurred in July.

The larva, which is certainly that figured by Raffaele (*loc. cit.*), is readily distinguished from *A. laterna* by the presence of two post-anal pigment bars or patches, of which the last is near the caudal extremity. *A. laterna*, apart from some pigment sometimes present about the origin of the tail, has only one, approximately median, post-anal band or patch of pigment.

The pigment is perhaps more vividly red or orange in *A. Grohmanni*. In general conformation, in the unicolumnar character of the notochord, in the presence of digitiform cells along the edge of the marginal fin, and in the frequently reticulo-papillate condition of the skin, the two larvæ are identical. A newly-hatched larva of *A. Grohmanni* (Plymouth) measures 2·32 mm. Allowing for individual variation in the degree of development at which hatching takes place, Mediterranean examples appear to be of about the same size, or a little smaller.

By those who may still regard *A. laterna* and *A. lophotes* (the large form with elongated dorsal rays) as distinct species, it may be suggested that the larva which I refer to *A. Grohmanni* may be really that of

A. lophotes. The latter, however, as has already been noted, seems to be unknown at Marseilles, where *A. Grohmanni* is common. It is not likely that so well-marked a form as *A. lophotes* would have escaped the keen attention of Professor Marion and his subordinates, if it ever ventured into a region whence the very rapidly developing ova could have found their way into our hand-net, never employed far out at sea. The economic value even of such a comparatively small fish as the scaldback in its "Lophotes" form, would certainly ensure its prompt recognition in the Marseilles market; although, as we know, its worthlessness from the point of view of the British consumer long concealed the very same fish from the knowledge of naturalists in this country. I think it is almost certain that the scaldback is only present in the Marseilles grounds in its small undifferentiated form.

On our own coast, when I have trawled large differentiated and small undifferentiated *A. laterna* in company, I have found the ovaries of the first the more advanced, whereas the tow-net eggs of *A. laterna* began to occur before those referred to *A. Grohmanni.* This argument, it must be confessed, would have more weight if the numbers were larger.

Solea variegata. *Donov.* Thick-back.

Cunningham, J. T., *Journ. M. B. Assoc.*, N.S., i., 1889, p. 23, Figs. 14, 15. *Ovarian egg and tow-net egg referred to S. variegata.*

Cunningham, J. T., *Treatise on the Common Sole*, 1890, p. 90, Pls. XVI., XVII. *Egg, vitelligerous larva.*

Only one egg of this species was taken during 1897. It occurred on the 27th July between the Eddystone and Hand deeps. The adult seems to be oftener found outside the Eddystone than on the grounds nearer shore. The egg was first examined by Mr. Beaumont, and had died before I looked at it on the following day; there was, however, but little evidence of decomposition. The embryo, devoid of a caudal rudiment, showed only yellow pigment. The cortical vesicles of the yolk were quite apparent. I counted in all thirty-seven yellow oil-globules ranging in diameter from ·03 to ·11 mm., but for the most part exceeding ·05 mm. Mr. Beaumont observed no material change in this respect since the egg was examined on the previous day. The diameter of the whole egg was 1·11 mm.

I have made no effort to ascertain the duration of the spawning season, but as Cunningham records the occurrence of a ripe female on the 30th May, it is evident that our specimen belongs to a late clutch. The diameter is ·20 less than that of the tow-net egg recorded by Cunningham as having occurred on the 17th July.

Solea lascaris. *Risso.* Sand sole.

(?) Holt, E. W. L., *Sci. Trans. R. Dub. Soc.*, S. II., iv., 1891, p. 457, Pls. XLIX., L., *Solea, Sp.* i. *Advanced egg and larva.*

(?) Holt, E. W. L., *Ann. Mus. Mars.*, v., 1898, Fasc. II. *Early and advanced egg referred, with above, to S. lascaris.*

S. lascaris was common enough in the Plymouth market in the early part of 1897, but could not be found during the spawning season, which, as I computed, would occur a little later than that of *S. vulgaris.* The ovarian egg remains unknown, and I have no reason to think that *S. lascaris* is represented among the few eggs of Solea entered in our records.

I have described and figured in the *Annales* two stages of a sole egg taken at Marseilles. At an early stage of development the egg does not essentially differ in the character and arrangement of its globules from that of *S. vulgaris,* but as development proceeds the originally minute globules tend to coalesce so as to form larger ones. In this condition the egg appears identical with the Irish Solea Sp. i. The dimensions agree closely. I have set forth in my Marseilles paper the considerations which suggest that *S. lascaris* is probably the parent of both forms. Other tow-net ova are provisionally referred, in the same paper, to *S. Kleinii* and *S. hispida.*

Gadus.

The most abundant Gadus in the inshore waters of this district is the pollack, *G. pollachius.* The bib or blind and the pout (the names have no constancy of specific application), *G. luscus* and *G. minutus,* are commonest outside the Sound—the former about outlying rocks, the latter on the Eddystone trawling grounds. The whiting, *G. merlangus,* is at times abundant, but erratic in its distribution. The cod, *G. morrhua,* is not very plentiful, while the haddock, *G. æglefinus,* and the coal-fish or "roamer," *G. virens,* are decidedly exceptional.

In spite of much that has been written about them, the young stages, especially of those with which we are here concerned, are very difficult to distinguish one from the other. The ova approach each other closely in dimensions, and the variations in this respect have not hitherto been studied in a methodic manner. It is only possible, therefore, to identify the ova mentioned in our records in a provisional manner.

Gadus luscus. *Will.* Bib, Blind, Pout, Brassie.

Cunningham, J. T., *Journal M. B. Assoc.*, N.S., i., p. 46, Fig. 35: *Tow-net egg and larva.* P. 375: *Dimensions of ripe egg.*

Cunningham provisionally identified with this fish tow-net ova, 1·13 mm. in diameter, taken on January 20th, 1888. Ripe ova taken

from a female in the Aquarium in March, were found by the same author to measure 1·05 to 1·15 mm. The larva, hatched from a tow-net egg, is figured. It has an irregular series of dorsal and ventral black chromatophores from the head to near the extremity of the tail.

Observations in January, 1898, show that large examples of *G. luscus* contained ripe ova, of which the largest measured 1·13 mm. one hour after extrusion into sea-water, on the 10th of the month. This dimension would be subject to further increase, but the eggs were not fertilised and died. Ova of corresponding dimensions, giving rise to larvæ resembling Cunningham's figure, first appeared on the 4th January, 1898, from grounds known to be frequented by *G. luscus*. It is therefore reasonably certain that Cunningham's identification is correct, and we have therefore associated with *G. luscus* those forms which in date, dimensions, and larval characters appear to sufficiently fulfil the required conditions. It will be seen that these ova, observed by Mr. Scott, occurred from the 28th January to the 6th February. The diameter ranges from ·90 to 1·10 mm., so that the eggs are rather small as compared with those obtained from parents in January of the present year. The smallest ova I have as yet found are derived from a female twelve inches long (20th Jan., 1898), and measure ·98 mm. after twenty-two hours' immersion in sea-water. If I am right in supposing that the smaller members of the species spawn later and have smaller eggs than their larger sisters, the small size of some of the 1897 tow-net ova is accounted for. The dimensions do not serve to distinguish them from eggs of *G. minutus*, but such evidence as I have points to a rather later spawning season for that species. Ten females, examined on the 12th January, 1898, were still far from ripe.

In every case when the development of the embryo was followed, the ova entered as *G. luscus* can be associated with the larva that appears to belong to this form. It is characterised by a *rather regular double series of dorsal and ventral black chromatophores*, extending from the head to the neighbourhood of the caudal extremity. In larvæ of a few days old the supra-cephalic ampullation, common to several if not to all Gadus larvæ, is well developed. *Only black pigment is usually visible*, but I am able to affirm the presence of yellow chromatophores also, an observation which explains existing discrepancies in the descriptions of various authors of other Gadus larvæ.

In the larvæ (of *G. luscus*) which I have observed no coloured chromatophores can be made out as long as the specimen is in full health and vigour; but a greenish or yellowish refraction is noticeable, often very faintly, on the salient parts, such as the front end of the yolk or the head. I have not succeeded by any manipulation of the light in detecting the presence of coloured chromatophores, and as a similar

tinge is often visible in the blastodermic mound of a fish-egg, and certainly is not due in that case to pigment, I concluded that only black pigment was present. However, it so happened that a larva injured itself on the stage of my microscope, and during the development of the usual morbid symptoms I became aware of the presence of minute yellow chromatophores, rather closely set over the greater part of the skin.

It appears therefore that yellow chromatophores, though present in large numbers, cannot (in all cases, if at all) be detected in healthy larvæ. So far as my experience goes, a larva of *G. luscus* with conspicuous (*i.e.* contracted) yellow chromatophores would be exceptional.

In the case of *G. minutus*, I have seen and described Irish tow-net specimens, almost certainly belonging to the species, in which no yellow chromatophores were visible. The larva of this form was first described from the Mediterranean by Raffaele, its correct identification being beyond doubt. Only black pigment was observed; and larvæ observed by myself at Marseilles agree in this respect with Raffaele's description and figure; while, though only tow-net material was studied, the identification was, from the known fauna of the district, beyond doubt. I have seen similar larvæ at St. Andrews, yet M'Intosh's, the only British specimens hatched from artificially fertilised ova, are very conspicuously decorated with yellow chromatophores. (M'Intosh and Masterman. Pl. X., Figs. 1–3.) The absence of yellow pigment from Mediterranean larvæ may be actual as well as apparent, since a regional variation may very well exist in this particular. As to British forms, the figures (1 and 2) of M'Intosh's youngest larvæ appear to have been drawn from unhealthy specimens, and the yellow chromatophores appear to be contracted. It is possible, though I do not insist on the suggestion, that in perfectly normal British larvæ of *G. minutus* the yellow chromatophores may be too diffusely expanded to be conspicuous.

The larvæ of the cod and haddock have been so extensively studied that I do not think that yellow chromatophores, if present, could have failed to attract observation, for the other characters of these two species are sufficient to ensure their distinction (if occasionally coloured). Larvæ of the whiting have been described by M'Intosh and Prince, from artificially fertilised eggs, and by myself, from tow-net material, as profusely adorned with yellow. On the other hand Cunningham (*Journal*, N.S., i., p. 46, Fig. 34) makes no mention of yellow pigment in a larva which he refers to the whiting. It is possible that the yellow pigment, which seems to be usually conspicuous in this species, may be occasionally invisible as in *G. luscus*. Cunningham's ova, from which the supposed whiting larva was derived, measured 1·23 mm. in diameter, and

were taken on the 6th February, 1888. I should myself regard this date as rather early for the species, but as my observations are far from complete, I am not inclined to set my own opinion against Cunningham's.

To return to *Gadus luscus*, the smallest Gadoid fish which can with certainty be referred to this species is 18 mm. long. The depth of the body is quite characteristic. Rows of dark chromatophores extend at the bases of the dorsal and anal fins to the first third of the posterior fin: each series is connected by a more or less continuous sheet of chromatophores which extends forwards, supra-abdominally to the top of the head. Dark patches are present on the distal part of the first and second dorsal and first anal fin. As this and a few other specimens of only a slightly larger size occurred at the end of May and beginning of June, it would appear that the rate of growth is slow, unless, as is probable enough, these examples were derived from late-spawned ova of small parents.

Gadus pollachius. *Linn.* Pollack, lythe.

M'Intosh, W. C. 11*th Ann. Rep., S. F. B.*, 1893, p. 246: *Dimensions of egg.*
14*th Ann. Rep.*, 1896, p. 171, Pl. V.: *Egg, larva.*
Holt, E. W. L. *Sci. Trans. R. Dub. Soc.*, S. II., v., 1893, p. 55. *Egg.*

So far as they have been observed from material directly derived from the parent the egg measures, after fertilisation, from 1·10 to 1·14 mm., but as there is a large range of size among female pollack which have attained to sexual maturity, it is probable that the eggs show a more extensive variation than has been noted. The larva is only known from a prematurely hatched and obviously abnormal specimen figured by M'Intosh. It is impossible to say how far the pigmentation is characteristic of the normal condition, but Mr. Scott's notes deal with a larva which closely corresponds in this respect to M'Intosh's figure, and which appears to be perfectly healthy. It was hatched from ova of 1·40 to 1·45 mm. in diameter, taken a mile outside the Breakwater, on the 5th February. The larva measures 4·2 mm. in length, and has a single lateral row of stellate black chromatophores extending from the head to about midway along the tail. No other pigment was observed. The conformation, being that common to the genus, calls for no special remark. Mr. Scott has noted the resemblance, in character of egg and larva, to the haddock, *G. æglefinus*. The pigment, however, is more regular than in the haddock, which, in any case, is on account of its rarity practically eliminated from consideration. I believe that we have to do with the offspring of a large pollack, and that Mr. Scott has been the first to observe a normal larva of that species. I have no

exact knowledge of the spawning season of the pollack on this coast, but the first young Gadus to appear in the tow-nets seem to connect themselves with older forms, having the specific characters of *G. pollachius*, so that this fish would appear to be one of the earliest spawners of the genus.

A smaller larva, 3 mm. in length, hatched from ova taken on the 15th February, is described by Mr. Scott as having no pigment at all. The eggs were not measured. I have seen a similar larva, hatched in transmission from the west coast of Ireland, but a yellowish tinge in this specimen may have been due to the presence of yellow chromatophores. It is possible that both these forms may be somewhat abnormal pollack, since the species seems to have but little black pigment as compared with others, although *G. minutus* has certainly not very much.

With regard to other ova of Gadus entered in our records I have only to say that they have been provisionally named in accordance with their apparent relationships. The dimensions, where noted, are given; the same remarks apply to the later stages, with which it is proposed to deal more fully when sufficient material has been accumulated.

Motella.—The Rocklings.

Our records comprise a great number of eggs which can be referred with certainty to the genus Motella. I do not think it is at present possible to identify them, in all cases, with any particular species. Ova directly derived from *M. mustela* and *M. tricirrata* have been described by Brook and M'Intosh and Prince (*M. mustela*) and by Raffaele (*M. tricirrata*). The descriptions do not, however, materially assist us to distinguish tow-net specimens, since the observed differences of dimensions might easily be obscured by variation in this respect. It is well-known that the newly extruded egg has usually a number of oil-globules which subsequently fuse into one. In the case of both the species mentioned the ova hitherto described as directly derived from the parent showed no colouration of the oil-globule. Raffaele, nevertheless, identifies with *M. tricirrata* a tow-net egg, having an oil-globule the colour of olive-oil. It is quite possible that this identification is correct, since the oil-globules of Solea (and Trachinus?) do not acquire their characteristic colouration until some time after extrusion. Other forms, which need not be recapitulated, give rise to ova in which the globules are coloured even before the egg is ripe, but this is not necessarily a constant feature. Thus from different females of *Trigla cuculus* and *Caranx trachurus* I have pressed ova of which the globules showed

various phases of colouration, from a well-marked cupreous tint through paler shades to a practical absence of any distinct colour at all. The variation, in so far as I have observed it, usually affects individual parents and not individual ova from the same parent, but, while preparing these notes for press, I find among the ova just liberated by a large *Motella mustela* some few with distinctly cupreous globules, while those of the majority are colourless or only very faintly tinted. Its explanation probably involves a physiological and chemical discussion, which I am not qualified to enter upon. For my present purpose it suffices to point out that the known existence of such a variation renders it very unsafe to rely on resemblances or differences in colouration of the oil-globule for purposes of specific determination. I must plead guilty to having done so myself, since the Motella Sp. iii. of my Irish series (*Trans. R. Dub. Soc.*, S. II., iv., 1891, p. 464, Pl. XLVII.; and v., 1893, p. 95, Pl. VI.) is chiefly based on the greenish colour of the oil-globule. I must add that I have since found that this greenish colour is identical with the olive-oil yellow of Raffaele, the former being converted into the latter by the use of a condenser. I am therefore of opinion that my Species iii. can no longer be regarded as sufficiently characterised.

M'Intosh and Masterman (*Life-Hist. Brit. Fish.*, 1897, p. 284) consider that they can distinguish three species of rockling eggs in the tow-net material of their district. I am in a less fortunate position here, for I cannot find among the large number collected any distinctive character which I consider absolutely reliable. Two rocklings, *M. mustela* and *M. tricirrata*, are certainly common here, and no doubt the eggs of both species have frequently come under the observation of Mr. Scott and myself, but it has not so far been possible to check the tow-net material by observation of the spawning of both species. I know that *M. mustela* was spawning in March, 1897, while it has been taken full of roe in January, 1898.*

Of the spawning of *M. tricirrata* in this district I know nothing definite; and the question is further complicated by the undoubted existence in the district of *M. cimbria* and *M. maculata*, and possibly of other forms which may require specific distinction. I do not suppose that the ova of *M. maculata* are small enough to be readily mistaken for

* During the months mentioned females full of roe were seined in the estuary, at the mouth of the Lynher in March, at the same place and also a little higher up the river in January. A specimen transferred to the Laboratory, on the 12th January, spawned at least as early as the 19th, since great numbers of eggs were found in the tank on that date. On the same day rockling eggs were found in Plymouth Sound in water which Mr. Garstang pronounced to be estuarine in character, so that it is practically certain that *M. mustela* spawns to some extent in the estuary. Rockling are known from Petersen's observations to spawn in the Limfjord.

those of other British species, but *M. cimbria* does not seem to be a very large form. The pelagic larval rockling, commonly known as "Mackerel midges," would afford more assistance to a knowledge of the spawning season if it were possible to identify them with absolute certainty, but it seems quite possible that those usually associated with *M. tricirrata* may not all belong to that species.

On the whole I do not think it would be profitable to enter at present upon a detailed discussion of the probable parentage to the tow-net ova. It may be noted that the eggs with colourless globules correspond in character with the descriptions of *M. mustela*, and in date with the known spawning period of that species at Plymouth. The cupreous colour of the globule, noted in several ova by Mr. Scott in January, is the same as has been referred to above as observed in newly extruded ova of the same species. The yellow, which under different conditions of illumination is either the "olive-oil" of Raffaele or the green of my Irish notes, has not been noted in ova directly derived from the female of any species. The ova with yellow globules, first observed in January, continued to occur until the middle of September, and after April were much commoner than those with colourless globules, of which the last was observed in June. If the yellow colour is really a constant character and occurs only in one species, then that species must have a spawning season of nine months. I have failed to recognise any differences in the pigmentation of larvæ with colourless and yellow globules respectively. In our records the colour of the oil-globule is stated whenever it was noted. The record of dimensions was very insufficiently kept by myself during the later months of the year, and it is partly on this account that I defer a discussion of this part of the question. It appears, however, sufficiently plain that there is considerable variation, not only in the diameter of the egg, but in that of the oil-globule, proportionally as well as actual, in ova which are similar in colouration of the globule and in embryonic and larval characters.

Mr. Scott's notes contain references to, and a drawing of, an egg with very numerous oil-globules. It is identical with a form described by M'Intosh and Masterman (p. 396, Pl. IV., Fig. 13) as closely allied to *Solea lutea*, and is in reality the egg of a rockling, probably liberated before it was perfectly ripe. I have seen very similar ova at St. Andrews, which ultimately, by coalescence of the oil-globules, assumed the ordinary appearance, and have also obtained them at Plymouth directly from a female of *M. mustela*. I do not think that any of the tow-net specimens were fertilised.

A "definite pale area, slightly refractive and apparently differentiated from the yolk," noticed by M'Intosh and Masterman (p. 296) in the egg of a rockling, is a common feature in unfertilised eggs of *G. luscus*. It

is there associated evidently with imperfect maturation of the vitellus, and has probably no taxonomic value. If my recollection serves me, it occurs not infrequently in eggs other than those of the Gadidæ.

Unidentified egg, with apparently Gadoid characters.

Holt, E. W. L., *Sci. Trans. R. Dub. Soc.*, S. II., iv., 1891, p. 471, Pls. XLIX., L. *Unidentified egg and larva, Sp.* viii.
Holt, E. W. L., *Ann. Mus. Mars.*, v., 1898, Fasc. II. *Egg and larva.*

This species, the "unidentified Gadoid (?)" of our record, is certainly identical with the species of my Irish paper. I am able to add some details omitted in my former description, and have given more detailed figures in my paper in the *Annales du Musée de Marseille.*

The Irish specimens, taken in June, measured ·775 mm. with an oil-globule of ·14 mm. Examples taken at Plymouth in June and July are from ·84 to ·91 mm., the oil-globule from ·16 to ·17 mm.; in August from ·78 to ·84 mm., the oil-globule ·15 to ·17 mm. Two out of eleven eggs examined had two oil-globules in the early stages of development.

The yolk is homogeneous, the oil-globule dark but colourless, the perivitelline space small. The zona is devoid of any distinctive characteristics.

At about the epoch of the appearance of the caudal rudiment numerous minute black chromatophores appear on the trunk of the embryo and about the posterior hemisphere of the yolk. Very soon afterwards small yellow chromatophores are seen in company with the black. They are of a canary-yellow by reflected, golden-brown by transmitted light. Usually they rapidly assume a dendritic form, imparting to the region affected a diffuse yellow colouration, and practically masking the black chromatophores. In some cases, however, they remain simple, and the appearance of the embryo is greatly affected by their condition. Individuals showing the extremes of expansion and contraction of the chromatophores might readily be referred to separate species.

As is shown in my figures in the *Sci. Trans. R. Dub. Soc.*, Pl. X., Fig. 54, the larva appears to be Gadoid in character, that is to say the intestine terminates below the trunk, and does not extend to the edge of the ventral marginal fin-fold. This condition is well known to occur, exceptionally, in larvæ in no way related to the Gadoids, but its occurrence as a constant feature has only been observed within the limits of that group. Our knowledge of the Teleostean larvæ generally is not such as to justify us in saying that a larva of this character is necessarily Gadoid, although the presumption, whatever it may be worth, points in that direction.

I have examined at Plymouth five larvæ. All are recently hatched,

and all have dendritic yellow pigment, so that it is probable that the chromatophores always assume this form before hatching takes place. The pigment has much the distribution shown in the figure of the Irish larva, but in the most recently hatched specimens there is none on the dorsal fin, which has no elevation anteriorly. Black chromatophores are present, but are almost entirely masked by the yellow. I suspect that they occurred also in the Irish specimen, but escaped my observation owing to the cabin of the S. S. *Fingal* being very badly lighted. In one Plymouth specimen there is no post-anal pigment except a single patch near the middle of the tail. The larvæ were exceedingly delicate, and only one survived even to the early stage of the Irish figure. It had acquired the same elevation of the anterior part of the dorsal marginal fin, accompanied, as in the Irish larva, by pigment. A Plymouth larva, apparently newly hatched, measures 2·02 mm. The Irish specimen, about twelve hours old, measured 2·68 mm.

I imagine that the normal larva exhibits no epidermal peculiarity. None was present in the Irish specimen, nor in one of the Plymouth examples. In others the skin was tuberculated, while in one I observed a reticulo-papillate condition exactly similar to that met with in Arnoglossus and in Sp. F of M'Intosh and Prince. The absence of submarginal pigment patches from the dorsal fin, coupled with the anterior elevation of that fin, sufficiently distinguishes the form before us from Sp. F, but otherwise a papillate specimen in which the connecting ridges are also developed comes very near to that supposed species; a fact which illustrates the danger of relying on the reticulo-papillate epidermal character for purposes of specific determination. The Laboratory was often very hot during the months in which these larvæ were obtained. My specimens, necessarily confined in small vessels for periodic observation, suffered great mortality, and I have no doubt that the tuberculation of the skin was simply pathological.

The question of the parent species must remain for the present quite uncertain. I am not at all satisfied that we are dealing with a Gadoid, but as the characters appear to connect the larva with that group rather than any other, it may be as well to consider whether any local Gadoid species can be reasonably regarded as the parent. It is unnecessary to recapitulate the forms of which the young stages are known, since their larvæ cannot possibly be confused with the one before us. There remain but a few species worthy of serious consideration. These include some of the rarer rocklings, Motella. *M. mustela* and *M. tricirrata* need not be considered. Their ova and larvæ, however difficult to distinguish from each other, are well known. *M. cimbria* exists, and may be common in the district, though rarely observed. *M. maculata* is known to me from a single specimen taken in Start

Bay. As it is not a shore species, it is quite impossible to say whether it is common or rare, since rockling can keep out of the way of ordinary fishing gear. I do not know to what extent we are justified in supposing that the ova and larvæ of the rocklings resemble each other. I certainly imagine that *M. cimbria* in its young stages resembles *M. mustela* and *M. tricirrata*, but *M. maculata* is a much larger and more brilliantly coloured fish. It is possibly, though not, as I think, very probably, the parent of the larva before us.

Phycis blennioides is regarded by the local fishermen as rare. I do not know any reason why it should not be often caught, if common. It is a deep-water fish on our coasts, but I have known one taken in Kenmare Bay in Ireland, and another was trawled here in Cawsand Bay some years ago, so that the species cannot be exclusively confined to deep water. Nothing is known of its ova and larvæ. The larva with which we are dealing shows an elevation of the dorsal fin, accompanied by pigment; a condition sometimes associated with the development of a filamentous ray, such as Phycis possesses in front of the first dorsal. Most of our ova were taken some way outside the Breakwater, though one occurred, on the ebb, in Cawsand Bay. I do not think that the balance of the evidence points very strongly to Phycis as the parent.

It must, in any case, be borne in mind that our records cover only a single year, and that, in certain features, an exceptional one. Mackerel were present in the inshore waters of Plymouth in the summer and autumn in very unusual quantity. "Mackerel Britt," that is to say young sprats and probably other young Clupeoids also, and scad old and young were also exceedingly abundant. Whether the young sprats were more abundant than usual I have no means of knowing, but whatever cause induced the influx of mackerel may have influenced other fish as well, while predaceous forms may have followed the mackerel. It is therefore quite possible that our ova and larvæ may belong to some species which does not usually occur, at any rate in the spawning season, in the neighbourhood of Plymouth. Their occurrence or absence in succeeding years may throw some light on this point.

Atherina presbyter. *Linn.* Sand smelt.

I believe that the young stages of the sand smelt are for the first time described and figured by myself in the *Annales du Musée de Marseille*, 1898. Agassiz, however, long ago figured the larvæ of the American *Atherinichthys notata* (*Proc. Amer. Acad.*, xvii., 1882, p. 277, Pls. X., XI.), which are very similar. The ova and larvæ of the Mediterranean *A. hepsetus* have been described by Raffaele (*Mittheil. Zool. Stat. Neap.*, ix., 1889, p. 306), and of this species a description, with figures, of the egg and early larva has been given by Marion (*Ann. Mus. Mars.*, iv., 1891, Fasc. I., VIII., p. 93, Pl. I.). Various larval stages of *A. Boyeri*, which is said to have occurred in British waters, are figured and described by myself in the paper alluded to.

It is rather remarkable that the presumably conspicuous eggs of the sand smelt have never come under the notice of naturalists. Such Atherine ova as are known are of large size, and furnished with long attachment filaments arising from all parts of the zona. In this character they are indistinguishable from the ova of the Scombresocidæ. In both families, as far as one can judge from limited material, the yolk appears to be translucent and practically homogeneous. One or more species of Atherina exhibit a number of small oil-globules, while in one species of Belone there are none. It is impossible to say to what extent the members of the respective families adhere to this distinction, which is, after all, of little importance. The fact remains that in the general characters of the egg the Atherinidæ and Scombresocidæ, though not apparently very closely related, are practically identical.

The larvæ of all Atherines seem to be very much alike. I found no difficulty in identifying those of *A. presbyter* from their resemblance to Agassiz's figures of *A. notata*. My specimens were found swimming at the surface in rock pools at Penzance on the 22nd June, 1891. They were in two shoals, each occupying about the space of the palm of a hand, the individuals very closely packed and hardly visible but for the large blue eyes and the black patch on the pia mater of the mid-brain. Each shoal consisted, as I suppose, of the hatch of a single clutch of eggs; in any case, the individuals were all of about the same size. A specimen from the younger shoal measured 9 mm., one from the older shoal 11·5 mm. The figures of Agassiz, Raffaele, Marion, and my own illustrate equally well the general conformation. The main features are the rounded head, large eye, very short abdomen, and very long tail. In the specimens of 9 mm. the pre-anal length is only 2·09 mm. In those of 11·5 mm. the same region measures 3·15 mm.

The smaller specimens, judging by Marion's figures of *A. hepsetus*,

are probably, at most, a few days old, but the organs of the head are well developed, although the large otocyst shows but little internal complication. The yolk appears to have been entirely absorbed; an air-bladder is present, though not clearly visible on account of the dense black pigmentation of the abdominal roof. In serial transverse sections I failed to find any connection between the bladder and the alimentary canal. The large fan-shaped pectorals extend some way beyond the anus; they are entirely devoid of pigment. In this respect, therefore, the young Atherine offers a marked contrast to the young Blenny, which it otherwise resembles rather closely. The end of the multicolumnar notochord is not yet upturned, but there is a slight opacity of the sub-notochordal region, marked by a black chromatophore and by a number of embryonic caudal rays. The marginal fins are of moderate width. The dorsal arises a little behind the level of the anus: both dorsal and anal are constricted in the peduncular region, expanding again to form the spatulate caudal. The notochord is multicolumnar. The brain-tissues are of a bright yellow colour, not apparently due to pigment. Very large black chromatophores occur in the pia mater of the mid-brain in variable number. The roof of the peritoneal cavity is densely coated with black, intermingled with yellow pigment. Elongated black chromatophores occur at intervals along the lateral line. Black chromatophores occur variably along the dorsal and ventral margin of the post-anal region. The marginal fins are devoid of pigment.

In the specimens of 11·5 mm. the trunk is deeper, the snout longer and more pointed. The abdomen is, proportionally as well as actually, somewhat elongated. The gills have become pectinate. The notochord shows signs of segmentation, and its extremity is upturned by the development of a tri-lobed hypural mass. Embryonic fin-rays mark the sites of the second dorsal and anal fins. The axis of the pectoral is obliquely rotated. Pigment changes are chiefly confined to a backward extension of the dorsal cephalic chromatophores.

I did not again meet with the young sand smelt until the 14th July, 1897, when I caught several at low water in Falmouth Harbour, above St. Mawes. They were swimming in a small shoal near the surface at the point of a projecting rock, a habit I have noticed in similar stages of the Mediterranean *A. Boyeri*. The specimens caught were of various sizes. Apart from the fact that *A. presbyter* is practically the only British Atherine, the larger specimens can readily be identified with that species by the fin-ray formula.

A specimen of 12 mm. has the abdomen relatively short, the anus still remote from the anal fin. The pelvics are in the form of small flaps on either side of, and a little above, the anus. A conspicuous fold

of embryonic fin is present in front of the true anal, and, in fact, the embryonic marginal fin is still continuous. The tail is in the heterocercal condition, the urochord projecting freely. At 18 mm. the pelvics, with well-developed rays, have united on the ventral surface, the anus having migrated in a posterior direction. The caudal fin is homocercal. An isolated fragment of the embryonic marginal fin persists between the anus and the anal fin.

At 22 mm. the fragment of embryonic fin is still present. The anus has nearly, but not quite, reached the limit of its posterior migration. Even in the adult condition there is between the anus and the anal fin a greater interval than in most Teleosteans, and I imagine that this may be due to the rather recent suppression of an anterior part of the anal, now represented only by the vestige of the embryonic fin fold. The second dorsal and the anal fins have the adult formula, viz., 1/14, 1/16. The first dorsal is still but little developed. No scales are as yet visible.

Compared with similar stages of *A. Boyeri* the larva of *A. presbyter* can be distinguished by the smaller eye, and by the greater length in relation to the degree of development. A young *A. Boyeri* of 32·5 mm. exhibits a stumpy fin-ray midway between the first and second dorsal fins, and in front of and behind this ray are a series of tubercles which are evidently of a similar nature.* These structures represent, I imagine, the vestiges of a continuous dorsal fin, and afford support to the supposition that the restriction of the dorsal and anal fins is of comparatively recent date.

The larval *A. presbyter* of 22 mm., though presenting the broad features of adult Atherine conformation, is still far from exhibiting the adult pigmentation. The lateral "stole" in particular is very imperfectly represented. Young *A. Boyeri* of the same size are much more advanced in this respect as in others.

I suppose that sand smelts, on account of the robust character of the larva, and its capability of assimilating comparatively large organisms, could be artificially reared with much less trouble than most other marine food-fishes, but their economical value is hardly sufficient to encourage the attempt. The larval stages appear to me to be chiefly interesting from the taxonomic point of view. It is generally conceded that the Atherines and the Grey Mullets are closely allied, yet in their ontogeny they differ most widely. The eggs of the former are, as we have seen, large, demersal, and furnished with long attachment processes. Some, at least, of the Grey Mullets have

* Vestigial fin-rays have been observed in the larvæ of another fish; but I cannot recall either the species or the name of the observer.

small pelagic eggs, and none, I believe, are known to have eggs furnished with attachment processes. It is true that Ryder at one time supposed that the ova of *Mugil albula* resembled those of the Atherines;* but as no observations have been brought forward in proof it may be supposed that this view was subsequently abandoned. *M. albula*, a species of which Günther could find no description (Cat. iii., p. 410), has been subsequently identified by naturalists of the U.S. Fish Commission with *M. cephalus*.

It has recently been stated by Sir James Hector (*Protection of Mullet*, Parliamentary paper, New Zealand, Sess. II., 1897, H.–17) that the eggs of the New Zealand *M. Perusii* are demersal, the proof being that ova described as ripe sank in sea-water. Further observations, especially with material the ripeness of which can be demonstrated by its impregnation, are certainly desirable, since the controversy as to the pelagic or demersal nature of the pilchard's egg furnishes ample proof that naturalists of considerable experience may sometimes be mistaken on this point. The matter is, however, of no great importance in connection with my present remarks, for the marked difference which exists between the ova of Atherines and Grey Mullets is not materially lessened by some of the latter being demersal.

The difference in the larvæ of the two families is at least as striking. One naturally expects that the larva newly hatched from a large demersal egg will be larger and more advanced in development than a larva from a small pelagic egg, and this holds good in most respects in the case before us. But in one particular, viz., the elongation of the abdominal region, the larva of the Grey Mullet is, at hatching, very far in advance of the young Atherine. In fact a glance at Raffaele's figure (*op. cit.*, Pl. II., Fig. 17) shows that an extensive elongation of the abdominal region has no part in the metamorphosis of the larva. The much more advanced larva referred by Cunningham (*Journ. M. B. Assoc.*, N.S., ii., 1891, p. 73, Pl. IV.) to *M. chelo* confirms this, while the larvæ entered in our records illustrate a further point. These larvæ are similar in size and conformation to Cunningham's, and require no separate description beyond the remark that the positions of the second dorsal and of the anal fin are clearly indicated by the developing fin-rays. The anus is just in front of the anal fin, a position never attained in the backward migration of the anus in the Atherine larva.

In comparing the Atherine with the Grey Mullet larva it therefore

* *Bull. U.S. Fish Comm.*, i., 1881, p. 283.

appears that the former passes through a long-tailed phase, which is not at all represented in the latter. The question is, Has this phase been suppressed in the ontogeny of the Grey Mullet, or has it been evolved as a specialised feature in the phylogeny of the Atherine? since the adult resemblances probably justify us in regarding both as derived from a common stock. I do not think that the knowledge which we at present possess of the systematic relations of individual groups of Teleostean fishes furnishes us with any answer. I believe it is generally held that the forms with elongated abdominal cavities are the more primitive, or it may rather be said that an elongated abdomen is most commonly met with in what appear to be the more primitive members of the Teleostomi. So far as concerns the families with which we are now dealing, the elongated abdomen appears less primitive, since the arrest in this elongation in Atherina would seem, from the evidence of the persistent ventral embryonic fin and of the vestigial dorsal rays, to result from the more recent restriction of the permanent dorsal and anal fins in that genus to the proportions which are now common to the adults of both families. The force of this evidence depends of course on the assumption that a continuously rayed fin-fold is a primitive condition, and is never achieved by a reversion from an intermediate detached-finned condition.

I am not acquainted with any British larvæ of Mugil except those already alluded to; but a Mediterranean specimen of 14 mm. (figured in my paper in *Ann. Mus. Mars.*, and referred from local considerations to *M. auratus*), appears to afford some evidence of the relative antiquity of the Atherines and the Grey Mullets. In essential features of conformation it is a true Mugil, but it exhibits a most distinct black "stole" or lateral pigment band. This is a feature of the adult Atherine, but not of the adult of any Grey Mullet with which the specimen can be associated; nor, as far as I know, of any Mugil at all. The appearance of this "stole" as a transitional larval pigment-phase of Mugil and its retention in Atherina must be regarded, if of any value as evidence of phylogeny, as indicating that the latter is the more primitive form. The resemblance, however, may be merely superficial, since I cannot say that the pigment stripe of the young Mugil is ever associated with the peculiar characters of the "stole" of the adult Atherine.

Coming to the characters of the ova, the large demersal type appears, *prima facie*, to be that most suitable to the requirements of the presumably fluviatile ancestors of modern Teleostei, which is perhaps the most conclusive argument forthcoming. The attachment process of the zona of the Atherine egg certainly indicates a high degree of specialisation; but, as such would presumably be lost in the evolution

of the pelagic from the demersal type, they are not necessarily important in this connection. It may be noted, however, that the ova of all the Blennies studied by Guitel have precisely similar filaments for attachment, only they are confined to the neighbourhood of the micropyle. It has already been remarked that the early Atherine larva closely resembles that of the Blenny, a form in which the ontogeny is marked by no material change of conformation and by hardly any reduction of the embryonic fin area. It is chiefly by the absence of marked Acanthopterygian characters that the Mugiliformes and Blenniiformes are placed close together in modern classifications, and the larval resemblances are perhaps evidence of the correctness of their proximity.

So far as I can see, the points noted above certainly appear to suggest that the Mugilidæ have been evolved from an Atherine-like type, the long-tailed larval phase being suppressed in the ontogeny, while there is a further suggestion that both Atherines and Blennies are derived from a common ancestor resembling the latter in general characters.

I am, however, far from seeking to imply that all Teleosteans with elongated abdomen are similarly derived. In fact it can hardly be doubted that the Blenny-like form is, in respect to the abbreviation of the abdomen, already far from primitive. This is the conclusion arrived at by Raffaele, who has discussed in beautifully illustrated detail the migration of the anus in *A. hepsetus*. He regards as primitive the condition in such fish as the Clupeoids and Salmonoids. The secondary condition is retained throughout life in the Blennies, while a tertiary condition is attained by such an ontogenetic migration as takes place in Atherina. My own contention is that Mugil, which Raffaele does not seem to have had an opportunity of studying, belongs also to this tertiary group, an ancestral secondary phase being suppressed in its ontogeny.

Unidentified larva.

I am unable to identify a vitelligerous larva found by Mr. E. T. Browne in tow-net material from near the merchant moorings in Plymouth Sound on the 22nd September. I did not see it until after it had been preserved in formol.

The total length is 2·09 mm., of which the pre-anal part occupies ·90 mm. The rectum is separated from the yolk by an interval of ·21 mm. The yolk is still fairly large, there is no oil-globule; and I cannot make out any cortical segments, though such may have been present at an earlier stage. The marginal fins are broad, the dorsal commencing in front of the head. Black chromatophores are present on the head, along the dorsum in a continuous row as far as the middle

of the tail. A few occur on the ventral part of the trunk and on the rectum. There are several large dendritic black chromatophores on the dorsal near its margin, while two are seen on the post-anal part of the ventral. A patch of pigment occurs above and below the caudal extremity. In all cases the black pigment of the marginal fins is accompanied by paler chromatophores, the colour of which has been destroyed by the reagent. I cannot speak definitely as to the nature of the notochord. The stage of development suggests most strongly that the larva is derived from a pelagic egg. It may possibly be a belated specimen of *Callionymus lyra*, but it does not closely agree with any example of that species which I have seen.

Clupea harengus.—*Linn.* Herring.

The young stages of the herring may be most conveniently reserved for consideration in connection with the distribution of young fishes in the Plymouth district. I only purpose at present to call attention to the occasional occurrence of an abnormal feature in the egg. It is well known that the ova of the pilchard and sardine and of the shads are characterised by the formation, after immersion in sea water, of a very large perivitelline space. The sprat ovum has only a very small perivitelline space, while that of the herring ovum is normally of moderate proportions. It is difficult to take accurate measurements if the spawn is allowed to adhere together, since the zona is then apt to assume a polyhedral form, but this can be obviated by the use of starch as recommended in the United States *Manual of Fish Culture*. I find among the spawn of three fish treated in this way, that the largest normal eggs measure 1·76 mm. in total diameter, the yolk mass measuring 1·25 mm., 24 hours after fertilisation. There are, however, several eggs of a much larger size. One slightly elliptical, but not at all flattened, has the greatest diameter 2·42 mm., the least 2·34 mm.; it appears to be as large as any. It must be remarked that these specimens are all dead, as in all previous instances of abnormally large herring eggs which have come under my notice. So far as I can judge, the excess in size is confined to the perivitelline space, but it is not the case that dead herring ova have usually a larger space, that is to say a more inflated zona, than living specimens. The latter are usually the larger, at least when death takes place at an early stage.

I do not suppose that this observation is new to those who have had to deal with herring spawn, but I do not remember to have seen it recorded. It shows that the perivitelline space may exhibit exceptionally an approach to the dimensions normal in the shads and

pilchard. It may also help us to an appreciation of the due value of the perivitelline space as a character in the determination of undescribed ova. Cunningham has made known the occurrence in the egg of the pilchard of an exactly converse variation (*Journal*, N.S., iii., p. 150).