THE DEVELOPMENT

OF

SOUTH AFRICAN FISHES.

PART I.

BY

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The following is a first contribution to our knowledge of the development of a few of the commoner Cape fishes. It is more of the nature of a preliminary report than an exhaustive account, and it would have been well for some reasons to delay publication until time and opportunity were available to go into the matter in more detail. For practical reasons, however, it may be preferable to review the information that has now been procured on some points. These practical reasons are the differences of opinion, involving considerable difficulty in legislative matters, as to the nature of the eggs and spawn of the common fish. Thus it is commonly alleged that the practice of netting, as carried on in the Zwartkops, the Buffalo, and other tidal rivers of South Africa, has proved destructive to the eggs and spawn of fish, those of this opinion asserting with confidence that quantities of fish spawn are brought on shore by the net and left to perish. Another occasion on which the same question arose was on the commencement of trawling in False Bay, and on the Agulhas Bank, near Mossel Bay by the Government Steamer. It was thought that the dragging of the net along the bottom of the sea caused the destruction of great quantities of the eggs and young of food fishes. The Cape fishermen, an observant and intelligent class of men, were of opinion that the fish

supply was being seriously endangered by such operations, and the question was felt to be so serious that a Commission of Parliament was appointed to enquire into the matter. The evidence seemed to indicate that many of the common fishes may deposit their eggs on the bottom of the sea. Thus one fisherman, who had had an experience of a life time in fishery matters in False Bay, was of opinion that all fish spawn was on the ground, and that the trawl runs across it, and must destroy it (*vide* Report of Select Committee, p. 13). Another equally experienced fisherman thought, however, that the spawn floats on the surface (p. 18). A fisherman of fifteen years experience at Kalk Bay could not agree with this (p. 21), while another was of opinion that the eggs floated, and could be taken up in the hands out of the water. A practical fisherman of forty-three years' experience considered that the spawn is on the ground, and also floats, adding the additional interesting information : "I have seen the spawn—whether of fish or not I cannot say, but it is alive—little round things like eggs, and they smell very nasty, like rotten pumpkins. I have seen it a foot thick on the water" (p. 24). Yet another witness thought that "the fish breed on the ground, but the spawn does not stop at the bottom." Another practical man gave evidence to the effect that the klip-fish deposits its spawn on the seaweed, and it is there destroyed by the trawl (p. 37). On the other hand, in all the instances where the mature eggs had been procured and successfully fertilized on the Government steamer, the "*Pieter Faure*," they were found to float on the surface of the water, and only after the larvae had been hatched out some time did they begin to sink to the bottom. It was also brought to the notice of the Commission that it had already been demonstrated in Northern waters that there was only one fish of practical economic importance depositing its eggs on the bottom (the herring), and only a small species of herring (*Clupea ocellata*), of little value to the present fishermen, occurs in the Cape seas. On the whole it was felt very necessary that further enquiries should be made into the subject and definite information obtained. Recently facilities have been afforded by Government for more careful examination on shore of the eggs and larvae procured by means of fine nets and from the mature fish, and the following is a review of some of the most important results.

The eggs and larvae of the following fish are dealt with :

Chrysophrys globiceps, C. & V.	...	White Stumpnose, p. 183.
„ gibbiceps, C. & V.	...	Red Stumpnose, p. 187.
Dentex argyrozona, C. & V.	...	Silver Fish, p. 188.
Pagellus mormyrus, Linn. ...	...	Zeverrim or Zee-basje, p. 188.

Agriopus verrucosus, C. & V.	...	Horse Fish, p. 189.
Trigla kumu, Less.	...	Red Gurnard, p. 190.
Sciæna aquila, Risso. ...	...	Kabeljaauw, p. 191.
Clinus superciliosus, Linn....	...	Klip-fish.
„ capensis, C. & V. ...	...	„
Synaptura pectoralis, Kaup.	...	Sole, p. 193.
Achirus capensis, Kaup. ...	...	„ p. 191.

The ova and larvae of fish as yet unknown are also described. These, designated Species I-XI, were found in fair abundance in tow nettings, and two (sp. I & II) were found in dredging, being attached to shells and rocks. One species (XI) was procured in the dredge and consisted of a cluster of eggs perhaps demersal. With the exception of these last three all the eggs examined were found to be pelagic or floating eggs.

Only two instances among the teleostean fishes have been found in which the young is brought forth alive. This is the case in two species of Klip-fish (*Clinus superciliosus* and *Clinus capensis*).*

FAM. SPARIDAE.

CHRYSOPHRYS GLOBICEPS. C. & V. (WHITE STUMPNOSE).

The development of this fish may be taken to represent a typical example of a free floating egg giving rise to a pelagic larval form. For this reason it is here treated in a little more detail than is necessary for specialistic purposes.

The fish is one of the commonest of Cape fishes, and is readily procured by the trawl. In November and December abundance of ripe eggs can be got from mature females, but the mature males have always been found in much greater numbers. With some practice the males and females can be readily distinguished as they come on deck, the males being of a somewhat darker steel blue colour than the females. A more definite mark of distinction, which has not yet been found to fail, is that the region between the ventral fins is white in the case of the females and blue in the male. As a rule also the profile of the head region rises much more abruptly from the end of the snout in the male than in the female, and there is usually present in the former a blue patch in this region between the end of the snout and the eyes.

* Note.—This fact was known for the first-named species as early as the time of Bloch.

The ripe eggs are transparent objects, perfectly spherical, and float freely in the water. If left undisturbed they slowly rise to the surface and remain there. Any slight movement of the water, however, causes them to move away from the surface. It is possible that the spawn described by Mr. Trouwbridge in his evidence before the Commission of 1898 may have been some such floating eggs.

The majority of the eggs (Plate I, figs 1-7) do not vary much in diameter. Out of 50, of a number taken from a female 34 inches in length, 17 were ·89 millimetres in diameter (the maximum), one was ·85 (the minimum), the average being ·88.

The surface of the eggs when examined with a high power of the microscope shows usually a series of short cross striations. The yolk itself is clear, and a layer of protoplasm may usually be seen at its periphery (fig. 1); this may become heaped up in the form of a typical germinal disc, though no fertilization has taken place, as shown in fig. 2. If not fertilized by the spermatozoa from the male, however, the yolk in a few hours begins to disintegrate, and the whole egg slowly sinks to the bottom.

The yolk contains one oil globule which presents great uniformity in size, being ·17 millim. in diameter. This oil globule moves about freely in the yolk, as can readily be ascertained by rolling the egg along a slide under the microscope.

Fertilization, which in nature is left more or less to chance, may be readily ensured by procuring the milt from the male and mixing it in the same jar of water with the ova. Ova of the White Stumpnose treated in this way soon shows a segregation of the protoplasm to one point, and this mass then becomes divided into two. Subsequently each of these segments become divided again into two, and this is repeated till the whole mass is a collection of small divisions. Fig. 3 shows the general aspect of a fertilized egg in which the germinal mass is divided into about 32 parts, and figs. 4 and 5 show a still later stage in which division has proceeded further, and the germinal disc begins to spread out over the yolk. Fig. 4 is a lateral view like fig. 3; fig. 5 shows the same egg as it normally comes to rest when left to float freely in the water; the heavier germinal disc being lowest, and the movable oil globule, of less specific gravity, being uppermost, a ventral view is thus presented of the segmenting mass. This process does not proceed with the same rapidity even among eggs fertilized together. Thus when some of the eggs presented the

two cell aspect others showed four divisions, and in a few traces of still further divisions were perceptible. Temperature also has much to do with the rapidity of development.

The formation of the "segmentation cavity" which appeared in about two hours after fertilization, and the growth of the germinal disc over the yolk need not here be described in detail. It need only be mentioned that in about ten hours the gastrula or expanding mass has spread well over the yolk, its thickened rim being beyond the equatorial region. An hour later the first traces of the embryo were seen when this thickened rim was $\frac{3}{4}$ over the yolk, and about an hour and a half after this the first traces of the eyes appeared at one end of the developing embryo, and at the other a small clear spot (Kupffer's vesicle). At this stage the blastopore has closed and the first segmentations of the body of the embryo have appeared. Figs. 6 and 7 represent a lateral and ventral view of a slightly later stage in which the segmentations of the body have increased in number, Kupffer's vesicle has disappeared, and spots of pigment are to be seen on the body of the embryo. A characteristic feature of this egg seems to be the temporary appearance of several spots on the yolk between the oil globule and the tail (*vide* fig. 7). These disappear completely soon afterwards. In $49\frac{1}{2}$ hours after fertilization the embryos began to hatch out, and six hours later most had hatched out and were very active. The mean temperature from fertilization to hatching was 65° Fahr. Fig. 8 represents one of the fish just after emerging from the egg. It was 2·5 millimetres in length and ·8 mm. in greatest depth, including the yolk. The front margin of the yolk falls under or slightly in front of the end of the snout. The yolk is slightly oval, being ·8 mm. in length and ·6 mm. in depth. Immediately behind the yolk is the descending part of the digestion tract. It curves slightly backwards, opening in a small indentation ventrally a little further back, at a distance from the yolk about $\frac{1}{2}$ the diameter of the oil globule. The oil globule is about the same size as in the egg, though drawn out slightly in a dorso-ventral direction. It is now fixed, and occupies the posterior angle of the yolk sac. The notochord is multi-columnar. The pigment cells, which begin to appear in the embryo at an early stage (about two days after fertilization) as small spots, yellow (by reflected light) and scattered irregularly along the side of the head and body, being absent from tail yolk and oil globule, have after the hatching process arranged themselves in a more definite manner as follows: Yellow pigment cells with many branchings on the head chiefly behind and on or in front of eyes. Above and below the body over the centre of the yolk there is a branching cell,

sometimes two. Further back over the rectum one occurs on the dorsal side of the body, and another on the ventral side, in the angle formed by the rectum and the caudal region of the body. Another two in corresponding positions, being above and below the body and sending branchings over towards each other, occur further back, between the anus and the extremity of the tail. The oil globule is covered with densely reticulated pigment cells. A few black dots occur irregularly on the body and head region. The three principal patches of yellow colour, viz., on the head, middle and caudal regions, are readily made out by the naked eye in the newly hatched larva, which soon becomes very active, and when a number are crowded together at the side of a jar they bear a striking resemblance in motion and appearance to copepods. It is possible that these yellow pigment spots, characteristic of many pelagic larva, may be a case of protective mimicry.

On the second day after hatching the yolk has greatly diminished and the larva has increased in size, as shown in fig. 9, which represents an embryo of about this age, but from a different hatching, and is selected to illustrate differences in arrangement of pigment in detail, and a difference sometimes observed in the position of the oil globule, which is here situated further forward. Further development is in the direction of the formation of the mouth, which is very apparent on the 4th day after hatching. On the 5th day a change has occurred in the head region. The anterior of the dorsal fin ascends somewhat more abruptly from the top of the head. This is still more marked on the 6th day after hatching (fig. 10). About this time the larva began to die off, and shortly afterwards only one was left. From the 7th to the 9th day after hatching a gradual change appeared in the anterior part of the dorsal fin, consisting of an indentation of the margin in the vertical from the centre of the visceral region. No increase in size was observed from the 7th day and the larvae died, apparently for want of suitable nourishment.

Some changes were noticed in the colouration on the 7th day after hatching. The yellow pigment cells were better defined in outline and position and were more branched. New black pigment patches appeared at the anal opening at its anterior margin (fig. 10) and a black tract between the digestion canal and the body, extending backwards, though much fainter, to half-way between the yellow caudal spot and the end of the tail.

CHRYSOPHRYS GIBBICEPS, C. & V. (RED STUMPNOSE).

The male can as a rule be distinguished from the female by the greater prominence of the frontal region. Exceptional cases are, however, met with where this feature is absent in the male, and others in which it is highly developed, the head projecting considerably beyond the vertical from the end of the snout.

The egg resembles that of the White Stumpnose in size and in having only one oil globule. Of 50 eggs, from a number taken in November from a female 39 inches in length, 20 measured ·85 mm. which was also the mean, one ·88 and one ·82 mm. The oil globule measured very uniformly ·19 mm. It appears therefore this egg may be distinguished from that of *C. gibbiceps*. The diameter is not sufficiently diagnostic, but taken along with that of the oil globule the specific determination could always be made with considerable confidence. Fig. 11 represents an egg 7½ hours after fertilization, and fig. 12 a stage about 12 hours later, showing the embryo well developed. The embryo (fig. 13) after hatching (which commenced 2 days and 3 hours after fertilization) can be distinguished from that of the White Stumpnose at the same stage. The rectum is somewhat further removed from the yolk, perhaps, however, a sign of a further stage of development, for the embryo seems to hatch out at different stages of growth. The oil globule is as a rule situated further forward than in the *C. globiceps*, but is occasionally in a more posterior position. The origin of the dorsal is also different. The colour, which is the chief distinguishing feature, is as follows : Yellow spots : One to three behind the head, between the eye and the otocyst, one on the body over centre of yolk, one at the angle between the body and the posterior margin of the yolk in front of rectum (in *C. globiceps* there was one behind), one superior to the latter on the body, one (sometimes two or more) on inferior caudal region of body. Two, one above and the other below, sending out branches towards each other over the trunk, as in the case of the *C. globiceps*, were never observed in *C gibbiceps*. Dark spots : There are dark stellate somewhat faint pigment spots on the head and extending along the dorsal side of body. At a later stage a few black dots had appeared on the ventral surface of the caudal region. The notochord is multicolumnar.

FAM. PRISTIPOMATIDAE.

DENTEX ARGYROZONA. C. & V. (SILVER FISH).

The maximum diameter of 50 eggs examined was ·89 mm.; the minimum ·83. Most of the eggs (¾ths) showed distinct cross markings on the zona radiata. Of the eggs examined those with weakly marked striae were all under the average in diameter. All striae became fainter as development proceeded. Yolk clear, one dark oil globule ·2 mm. in diameter.

The following will illustrate the rate of development at a temperature of 75° Fahr. and may be compared with the previous cases at 65° Fahr. Fertilized at 11-55 a.m. 16th December :—

Germinal cavity appeared	10.45 p.m.
Blastopore closed	6.15 a.m.
Kupffer's vesicle appeared	7 a.m.
Pigment cells appeared on body	2.30 p.m.
„ „ „ on oil globule ...	4 p.m.
Otocyst and movement of embryo	4.35 p.m.
Two per cent. of eggs hatched	9.30 p.m.

Colour of larva : greenish yellow pigment behind the eye and slight spots of the same colour on the dorsal aspect of the trunk, posterior angle of rectum and posterior of yolk sac at oil globule. Black pigment : slight traces appear between rectum and end of tail under the body. Dorsal and ventral fin without colour. The larva is on the whole characterised by feeble development of pigment. In general shape it resembles that of the White Stumpnose, the anus, however, being about half way between tip of snout and end of the tail. The oil globule is postero-ventral. The anterior margin of the yolk sac is in about the same vertical as the end of the snout, sometimes in front, sometimes behind.

FAM. SPARIDAE.

PAGELLUS MORMYRUS. LINN. (ZEVERRIM OR ZEE-BASJE).

The diameter of ten eggs was ·88 mm., oil globule ·16 mm. Fertilized 11.15 a.m. 15th January, 1900, (76° Fahr); at 6 p.m. germinal cavity appeared ; at 9-20 p.m. the blastopore

was closing up, its thickened rim being half way between equator and lower pole and traces of the embryonic shield were to be seen. At 10.30 p.m. the optic vesicule appeared, and at 11.35 p.m. the blastopore had closed, and by midnight the embryo extended over half the hemisphere of the yolk At 6 a.m. a number of yellow and black spots appeared all over the embryo with, however, fewer on head region ; the periphery of the oil globule appeared darker, and a few (1-4) branching pigment cells occurred on it. The eggs seemed to be of a greater specific gravity than those of the White Stumpnose, as when disturbed they ascended to the surface more slowly, and very slight motion was sufficient to send them to the bottom of the jar. At 11 a.m. a considerable part of the tail was free from the yolk, large branching pigment cells were seen behind the optic vesicle and small ones in front. Two large yellow cells with branchings over the body appeared at each side of the trunk a little behind the otocyst, and others about the middle of the body. Notochord multicolumnar.

At noon there were few at the surface, most being scattered throughout the water, at 2 p.m. only one or two on the surface, about 6 in mid water and the rest, over 100, at the bottom.

Hatching out took place at 4 p.m. The embryo had a rather long yolk sac projecting slightly beyond the snout and ending posteriorly about midway between snout and extremity of tail. There is no aggregation of pigment at any particular points, but it is scattered sparsely over the whole larva in dots and stellate pigment cells, sometimes extending on to dorsal and anal fin.

The oil globule is generally postero-ventral.

FAM. TRIGLIDAE.

AGRIOPUS VERRUCOSUS, C. & V. (HORSE FISH).

Repeated attempts were made to secure the egg of this peculiar fish, but only on one occasion were apparently ripe samples procured from a female 9½ inches long. Agriopus is not uncommonly got in the trawl, but a ripe male and female were never got at the same time.

The egg is large, 1·7 mm. to 1·53 mm. in diameter. No oil globule is present and the surface of the egg is covered by network of well marked striations.

TRIGLA KUMA. LESS. (RED GURNARD).

Mature males and females were procured in False Bay in December and artificial fertilization secured. The egg (Plate I, fig 14) is large. Of 30 which were measured the mean diameter was 1·2 mm., the maximum 1·21, and the minimum 1·07. The oil globule was uniformly ·23 mm. in diameter and was dark round the edges. The yolk soon becomes covered by a network of yellow and black stellate cells.

Hatching commenced on the 16th December at 2-30 p.m. of eggs fertilized on the 13th at 9-30 a.m. The mean temperature was about 65° Fahr.

The colouring of the larva (fig. 15) is very marked. Yellow stellate cells occur on the head and dorsal regions of body and on the dorsal and ventral aspect of the caudal region, but are absent towards the posterior extremity. The dorsal and ventral fins are characteristically pigmented, there being a series of stellate cells yellow and black just within the margin proceeding from the anterior end in each, and running parallel with, but not touching the border, and ceasing at a point a little anterior to the ending of the dark pigment matter which occurs on the superior and inferior border of the body. The whole yolk is covered with a close network of stellate cells, chiefly yellow, but a few black.

This agrees very closely with McIntosh's description of the first day's larva of *Trigla gurnardus*, but the pectoral fin, though appearing at this stage, is not so well developed, and is entirely destitute of pigment.

The oil globule is also similar, having a thick layer of protoplasm surrounding it, but its position is different, being well in advance of the posterior angle, the position in *T. gurnardus*.

The notochord is multicolumnar. The dorsal fin commences behind the head, and the pigment spots on the dorsal fin extend here to body. On the second day after hatching the pectoral fin is larger (about $\frac{2}{5}$ the diameter of the eye and less than double the otocyst.) The pigment cells have become more marked and ramified.

FAM. SCIAENIDAE.

SCIAENA AQUILA. RISSO. (KABELJAAUW).

The mean diameter of 100 ova (in formalin*) was ·88 mm. The maximum was ·91 (one specimen), the minimum ·82. There is usually one rather large oil globule ·2 mm. in diameter, but 11 out of 100 had two oil globules of a smaller size.

This egg cannot be distinguished from that of the White Stumpnose by its size, the mean diameter of each being the same, but the diameter of the oil globule is markedly different, being ·2 mm. as against ·17 mm. in the case of the White Stumpnose.

FAM. PLEURONECTIDAE.

ACHIRUS CAPENSIS. KAUP. (SOLE).

Specimens of this small sole are procurable in fair abundance in False Bay, and females, which may usually be readily distinguished from males by the well developed ovaries, were not uncommon in the months of November and December. The males were always procured in fewer numbers than the females. Artificial fertilization was repeatedly attempted, but was not successful. No visible spermatic fluid could be secured, and the testes were cut up and shaken in the jar containing unfertilized ripe eggs. In some instances these testes were first examined under the microscope and active spermatozoa were found. At first development seemed normal, and the protoplasm became heaped up in a germinal disc in the usual manner, but no subsequent division took place. On the following day the eggs, which had been floating at the surface, were found to have sunk to the bottom of the jar and to be in a decaying condition. It is possible that the unknown larva (Sp. V) hatched out from an egg (·98 mm.) procured in tow-nettings about the same time, was the young of this fish.

*A weak solution of formalin does not alter to any great extent the diameter Some eggs of the White Stumpnose were measured before and after being in formalin (four weeks) and were found to be practically the same for diagnostic purposes.

The egg (Plate I, fig. 16) has fairly well developed characteristics, being large, destitute of an oil globule, and with a series of striations and spots on its surface. It is also characterized by a cluster of clear thread-like markings as if hanging in a loose network from the under-side of the germinal disc down nearly half way into the yolk.

The mature females were found to vary considerably in size, and a good opportunity was afforded of ascertaining the relation, if any, between the size of the egg and the size of the female. Thus in one haul three perfectly ripe females were procured measuring 146, 117, and 96 millimetres respectively. The diameters of 25 eggs from each were determined with the following results.—

Length of female	146 mm.	117 mm.	96 mm.
Average diameter of 25 ova.	97 „	·94 „	·93 „
Maximum „ „ „ ...	·98 „	·96 „	1·02 „
Minimum „ „ „ ...	·94 „	·91 „	·91 „

With the exception of the maximum and minimum of the eggs of the smallest specimen this table shows a distinct proportion between the size of the egg and that of the parent. The maximum in this particular case is greater than the maximum of the largest specimen, and the minimum equals that of the 2nd largest. An examination of the actual measurements, however, in a manner explains this. The measurements were taken of the first 25 without selection, and as only one single egg was found of this very large size (1·02 mm.), it may perhaps be regarded as abnormal. The next largest egg was ·95 mm., which would be the usual proportion, and in glancing through about 100 this large egg was very distinctly of an exceptional size. As, however, it appeared of perfectly normal structure and in perfectly normal condition it was not rejected. The minimum (·91) of the smallest specimen also does not represent the actual proportions, as in the 2nd largest specimen, which has the same minimum, there was only one of this size, while in the smallest specimen there were four. There is certainly evidence from these measurements indicating a general relation between the size of ova and parent.

An opportunity was afforded on another occasion of measuring 100 eggs of another specimen of Achirus of a normal size, about that of the largest specimen mentioned above. The average size was ·97 mm. and they ranged from ·99 to ·94. Fertilization was attempted at 12.10 p.m. by shaking up teased testes among the ripe eggs, but by 6 p.m. they showed distinct signs of disintegration, and most had left the surface and lay on the bottom of the jar.

SYNAPTURA PECTORALIS, KAUP. (SOLE).

The mean diameter of 100 ova (in formalin) was ·8 mm., the maximum ·81 (3), the minimum ·72 (1).

The small size of the egg readily distinguishes it from the others, and it can at once be determined by the presence of a number of oil globules from one (rare) to twelve in number, and varying in size from ·04 to ·15 mm. Fertilization was readily secured on board the "*Pieter Faure*," and the larva kept alive 241 hours.

A description of the larva of this fish and of others preserved in formalin is deferred until fresh material and opportunity for further examination is afforded.

EGGS AND LARVAE OF UNKNOWN FISH.

SPECIES I.

(DEMERSAL.)

Several clusters of this egg were found in dredging on shells and stony ground in False Bay in November and December, as follows :—

Date.	Locality.	Depth (fms.)	Bottom.	Occurrence.
12.11.02	W. of Seal Isl. (False Bay)	16	Sand and shells.	In shell of Patella.
19.11.02	S. of Seal Isl. (False Bay)	11	Broken shells.	In shell of bivalve.
25.11.02	False Bay	10	Fine sand.	In shell of bivalve.
26.11.02	False Bay	9	Broken shells.	On stone.
12.12.02	W. of Seal Isl. (False Bay).	19	Broken shells.	On stone. (Pl. II, fig. 17)

The first lot was just on the point of hatching when procured and nearly the whole hatched out. Macroscopically these eggs presented the appearance of small globules of a semi-transparent gelatinous substance, with the exception of two minute black spots, the eyes of the developing embryo. Those procured on the 19th showed an earlier stage, being entirely destitute of pigment. There were about 500 in a bivalve shell, each about 1 mm. in diameter.

They were very firmly attached to the shell and could only with difficulty be removed without rupture. When viewed by transmitted light under the microscope they were found to be

filled with a granular mass in which were scattered many small oil globules. A dividing mass of protoplasm at about the 8 cell stage was also seen. The eggs were separated from each other by a distance about equal to their own diameter, and though there was a spreading out of base of the egg capsule so that it seemed to be continuous, yet when carefully removed each individual egg came off independently of those surrounding it.

The diameter of the egg and general appearances were not of course sufficient to identify these two lots of eggs, and as development proceeded in the younger lot appearances presented seemed to indicate that they belonged to a different fish. Three days after the egg was procured two thin black parallel streaks appeared near the periphery of the egg at one side, and these proved to be lines of black pigment running along each side of the body of the embryo. Ten days after this a marked difference was observed, the lines of pigment, which were found to have apparently converged posteriorly and become one on the ventral caudal region, began to break up into stellate black pigment cells. This process was accompanied by the appearance of branchings of the black pigment into the surrounding tissue. Plate II, fig. 18 is from a photograph (by transmitted light) of an embryo at this stage. Branchings are seen from the lateral pigment line, and the ventral caudal streak is becoming broken up. Fig. 19 is from a photograph of the eggs containing embryos at a somewhat later stage of development. They were photograped in situ attached to a stone (therefore by reflected light) and show various stages in this process from the two continuous black tracts merging into one, to the condition in which these parts are broken up into spots of pigment; in these latter a few yellow pigment spots appear among the black. A number of large oil globules not observed earlier were seen in the embryos at this stage. They varied in number from one to five. They may be the result of the fusion of the minuter globules of the earlier stages. When procured the eggs showed only a few divisions of the germinal disc, and had therefore probably been newly deposited. Seventeen days afterwards the first ova hatched out. The period of development in the egg is therefore very much longer than that of any of the pelagic eggs which usually hatched out in 2 days at the same temperature.

The newly hatched embryo (Plate II, fig. 20) has therefore a totally different appearance to those which hatch earlier. The pectoral fins are well developed. The otocyst is large, extending from the posterior border of the eye to the pectoral fin. The yolk sac protrudes very little, and disppeared on the following day.

Running along each side of the body are two rows of bright yellow (by reflected light) spots, extending from the pectoral to some distance behind the vent. Black pigment spots occur in irregular longitudinal rows among the yellow spots, also on the visceral region and the anal fin just behind the vent (the only pigment on any of the fins). On the following day these spots became stellate, and the whole pigment appeared denser.

SPECIES II.

(DEMERSAL.)

Only on one occasion were samples of this egg procured. They were dredged on the 18th November, 1902, in False Bay (Zwart Rlip bearing North, 1½ miles ; depth, 9 fms.). About 100 hatched out from 3 p.m. to 7 p.m. of the same day, but died shortly afterwards.

About 300 eggs were firmly fixed to the inside of a dead barnacle shell. They were about 1 mm. in diameter, and the adhesive membrane of one egg was slightly continuous with those surrounding it (Pl. II, fig. 21). They appeared as vivid dark blue specks about the size of a pin's head. In some the eyes could be discerned without a lens. Some eggs were not wholly blue and opaque, and showed on one side numerous oil globules occupying less than a half of the whole sphere. In others the blue yolk mass occupied one half the sphere, and the two large eyes, each a little under ¼ the diameter of the egg, lay in the other half with a clear yellow space between and on each side of them, but posteriorly they touched the blue yolk. A conspicuous feature was the heart of a reddish brown colour situated in a notch in the margin of the blue yolk between the eyes. In all the photographs taken an arborescent series of vessels was revealed radiating from the heart through the yolk. Nothing of this could be discovered in viewing the yolk through the microscope, and that it appeared in the photograph was probably due to the less actinic character of the yellow light from the blood. The circulation of the blood could be seen very distinctly at the margin of the hemisphere to the left of the embryo. It was very active, and the heart beat 104 to the minute.

The newly hatched larva (Pl. II, fig. 22) is very lively, much more so than that of Sp. I. The yolk is comparatively small, its anterior end being behind the posterior margin of the eye. Five branchial arches and the mandible of the lower jaw were well developed ;

notochord multicolumnar. The long body is somewhat dark, and a few small black stellate cells appear on its ventral margin near the end of the tail. In the abdominal region the remains of the blue yolk occupy only about half the abdominal cavity, the rest being filled up with the well developed intestine. Above the intestinal mass is a tract of very dark blue pigment. There is a large transparent pectoral fin extending upwards beyond the dorsal margin of the body by about $\frac{1}{2}$ its length.* The beginning of the dorsal* is situated behind the otocyst, being separated from it by a space about equal to its diameter. The otocyst is very close to the eye.

The absence of pigment readily distinguishes it from Species I, and a reference to the figures will show marked differences in other respects, as for instance the anterior position of the anus.

SPECIES III.

(PELAGIC.)

About half-a-dozen unknown pelagic eggs were procured on the 20th November, 1902, in a surface tow net in False Bay. They were very large (1·7 mm. in diameter), due chiefly to the size of the perivitteline space, which was in breadth about $\frac{1}{3}$ the diameter of the yolk. The margin of the egg had a vivid green tint. One oil globule was present, relatively small, being only ·2 mm. in diameter. The embryo shows a series of small black stellate spots along the body from head to tail. There are no pigment spots yellow by reflected light. The upper part of the yolk next the embryo has a number of fine circular lines throughout its substance. (Plate III., figs. 23 and 24.)

Some were hatched out on the following day. The larva can be distinguished from others by the very elongated body (4·1 mm.). Its movements are also characteristic. Instead of the sharp wriggle of the tail there is a comparatively slow undulation of the whole body. Though there are no yellow pigment spots, by reflected light a golden tinge is apparent on the upper margin of the body in the region of the otocyst, and on the posterior margin of the yolk. There are minute black dots on the upper part of the head, and these extend backwards along the dorsal region of the body to about the vertical from the middle of the yolk, where also the dorsal fin commences A few other dark spots occur here and there on the body. The oil globule is slightly in front of the posterior angle of the yolk. The notochord is unicolumnar and the anus is situated in the posterior third of the body. (Pl. III. fig. 25).

* Not brought out clearly in photograph (Fig. 22).

SPECIES IV.

(PELAGIC.)

On one occasion an egg 1·44 mm. in diameter, and with a single oil globule ·29 mm. in diameter, was found in tow nettings in False Bay in December. The larva (Plate III, fig. 26) hatched out on the following day, and proved to be well marked as regards colouring. There was a dense network of yellow pigment along the borders of dorsal and ventral fin, and a few yellow pigment cells on the oil globule which occupied an anterior position. Isolated stellate black spots occurred on the oil globule above the head and behind it for a short distance; a series of isolated stellate black spots occurred on the ventral side of the body from otocyst to rectum, and about half a dozen on the posterior inferior margin of the yolk sac. The yolk had a vesicu ated appearance. The anus was considerably behind the yolk in the posterior half of the total length of the body.

About the same time another egg, 1·48 mm. in diameter, with an oil globule ·29 mm. in diameter was found, and produced a similar embryo.

SPECIES V.

(PELAGIC.)

Several eggs were procured in tow-nettings on the 16th December, 1902, from False Bay, having a diameter of ·98 mm. and possessing no oil globule. Yolk and embryo were covered with many yellow pigment cells. They hatched out into larvae (Pl. III, fig. 27) which were readily distinguished in the water by their short form and large yolk sac, and by characteristic movement, viz., a rapid vibration of the extremity of the tail with very little apparent movement of the anterior parts. They have also macroscopically a slightly cloudy appearance. The larva was 1·6 mm. in length, and the yolk sac very nearly half this. The anus was situated close to the yolk sac, and is thus near the vertical from the centre of the body.

The body, head, yolk sac and vertical fins are covered by yellow finely branching pigment cells, the bodies of which are small and bead like. An exception to this is the posterior third of the caudal region, which is destitute of any pigment. In some larvae a few of the ends of the branching cells were black, and in others a few black spots appeared on the body.

Though the usual dark oil globule was absent, about half-a-dozen very faint clear oily looking bodies were seen indistinctly in the yolk. There was no trace of a pectoral fin visible. The growth of the pectoral may be very rapid, as a very similar larva recently hatched from an unknown egg had the pectorals well developed. It is possible also that this larva may be the same, only hatched out at a later stage of development.

SPECIES VI.

(PELAGIC.)

An unknown larva, apparently newly hatched, was procured in a tow netting on the 12th December, 1902, in False Bay, 5 fathoms from the surface. It was 2·1 mm. in length, and possessed a single oil globule ·16 mm. in diameter and situated anteriorly. The yolk sac was rather long and oval. Along the dorsal region of the body were small black stellate pigment spots. Yellow spots, very faint, giving only a yellow tinge to the body occurred from posterior of the yolk sac towards the caudal extremity where no pigment occurs. A yellow patch occurred before and one behind the head. The oil globule is covered with yellow network of pigment. It is probable that this larva was from an egg ·81 mm. in diameter, though I have some slight doubt as to this, on account of the presence of other unknown eggs. (Pl. III, fig. 28).

SPECIES VII.

(PELAGIC.)

An egg 1·32 mm. in diameter, and containing many small oil globules, was found in a tow-netting from False Bay on the 16th December, 1902. Hatching occurred the following day. The larva, including yolk sac, is covered with yellow branching pigment cells from snout to tail. A few black spots occur on the top of the head and on the mid region of body. The notochord is multicolumnar. The oil globules are scattered throughout yolk. There are about 50 of them, and they vary from ·01 to ·06 mm. in diameter. The pigment cells on dorsal and anal fins have a tufted appearance. In addition to these distinctive features the larva has a very characteristic protrusion over the head region. This, however, seems to vary, as larvae otherwise similar had this feature in a less marked degree. Pl. IV, fig. 29, is from a photograph of this larva. Another larva, very similar in appearance, but with the oil globules situated in a cluster posteriorly may belong to the same species (fig. 30); Fig. 31 is a later stage of the latter.

SPECIES VIII.

(PELAGIC.)

An egg 1·06 mm. in diameter containing no oil globules was found in a tow-netting from False Bay in December. It produced a long (4·5 mm.) larva of a clear hyaline appearance with no yellow spots and only a few (20) black ones, sometimes with branchings. These occurred on the top of the head and scattered without order at considerable distances from each other along the body to the caudal extremity; also one on dorsal and anal fin behind the rectum. The yolk had a clear sacculated appearance. The notochord was unicolumnar. (Pl. IV., fig. 32.) The distance between the anus and the posterior extremity was contained 5 times in the total length of the body, so that its position is markedly posterior.

The pectoral fins were slightly developed.

SPECIES IX.

(PELAGIC.)

A cluster of fish eggs containing embryos was procured in the shrimp trawl on the 2nd April, 1902, 47 miles North West of Lion's Head, from 175 fathoms.

The eggs were spherical, 2 mm. in diameter, and were securely agglutinated together at their points of contact in a small bunch, perhaps a fragment of a larger mass torn from the bottom or captured in the ascent of the trawl in mid water or surface. No opportunity was afforded of ascertaining to what kind of larva they belonged. They were preserved in formalin and the measurements are from these preserved specimens.

SPECIES X.

(PELAGIC.)

A large egg 1·78 mm. in diameter, and possessing many small oil globules, was found in a tow-netting in December in False Bay. It contained an embryo and yolk sac, both

covered with a network of branching yellow cells. The pectoral fins were distinctly visible at this stage (a day before hatching).

The newly hatched larva proved to be well marked, being readily distinguished from all others on account of its large size (4·1 mm.) and uniform pale greenish yellow colouring, which was absent only from the extremity of the tail. Examined with a low power the colouring matter is found to consist of branching black and yellow cells mixed indiscriminately.

The position also of the heart is different from that in all other larvae examined, being situated anteriorly in the space in front of the yolk sac and immediately under the posterior half of the eye. The notochord is multicolumnar.

About three days later a marked change was observed, the colour had completely disappeared from the median fins, and the body became opaque and of a dark green colour. The posterior extremity presented a bifurcate appearance macroscopically, due to the absence of the pigment in this region, and this may be a useful diagnostic character. Instead of swimming about freely in the water like the other larvae observed, this larva kept at the bottom of the jar, head downwards, the tail keeping up a constant and rapid vibration.

[PUBLISHED 6TH JULY, 1903.]

Oil Globule.	Diameter of Egg.	Diameter of Oil Globule.	Occurrence.	Remarks.	Position of Oil Globule.	Position of Rectum.	Notochord.	Pigment.	Species.
Present.	1.7	.2	Pelagic	Large perivitteline space	Postero ventral	Posterior	Unicolumnar	Very little	Species III.
	1.44	.29	,,	Largest egg including yolk	Anterior	Median	(?)	Abundant on body and fins	,, IV.
	1.21—1.07	.23	,,	Yolk early pigmented	Ventral	Anterior	Multicolumnar	,,	*Trigla kumu.*
	.91— .82	.2	,,	About 10 % have 2 oil globules	Posterior	,,	,,	(?)	*Sciæna aquila.*
One	.89— .85	.17	,,	...	,,	,,	,,	Moderate, on body	*Chrysophrys globiceps.*
	.89— .83	.2	,,	...	,,	,,	,,	Little, on body	*Dentex argyrozona.*
	.88	.16	,,	...	Ventral	,,	,,	Slight	*Pagellus mormyrus.*
	.88— .82	.19	,,	...	Posterior	,,	,,	Moderate, on body	*Chrysophrys gibbiceps.*
	.81 (?)	.16 (?)	,,	...	Anterior	,,	,,	Slight	Species VI.
Few ...	.81— .72	.15—.04	,,	From 1 (rare) to 12 oil globules	...	...	...	...	*Synaptura pectoralis.*
Many	1.78	...	,,	...	...	...	Multicolumnar	On all parts	Species X.
	1.32	...	,,	...	...	...	...	...	,, VII.
	1	...	Demersal	Not pigmented	...	Anterior	...	Abundant, on body	,, I.
	1	...	,,	Dark blue in colour	...	,,	Multicolumnar	Very little	,, II.
Absent. ...	2	...	(?)	In a cluster	...	...	...	...	,, IX.
...	1.7 —1.53	...	Pelagic	...	...	...	...	...	*Agriopus torvus.*
...	1.06	...	,,	...	...	Posterior	Unicolumnar	A few spots on body	Species VIII.
...	1.02— .91	...	,,	...	...	...	...	...	*Achirus capensis.*
	.98	...	,,	...	...	Anterior	Multicolumnar	Dense on yolk and larva	Species V.

EXPLANATION OF PLATES.

(All the figures have been drawn on stone from micro-photographs, and are magnified about 20 times, with the exception of Figs. 18, 19, 21 and 17, which last is natural size.)

Plate I.

Fig. 1. Unfertilized egg of *Chrysophrys globiceps* (White Stumpnose).

„ 2. Another showing formation of germinal disc.

„ 3. Fertilised egg showing germinal disc divided into about 32 parts.

„ 4. Later stage showing spreading out of germinal disc, side view.

„ 5. The same, ventral view.

„ 6 and 7. Side and ventral view of developing embryo.

„ 8. Newly-hatched larva of White Stumpnose.

„ 9. Larva two days later.

„ 10. Larva six days later.

„ 11. Fertilized egg of *Chrysophrys gibbiceps* (Red Stumpnose).

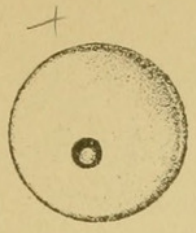
„ 12. Later stage showing embryo.

„ 13. Newly-hatched larva of Red Stumpnose.

„ 14. Fertilized egg of *Trigla kumu* (Red Gurnard).

„ 15. Newly-hatched larva of Red Gurnard.

„ 16. Egg of *Achirus capensis*.



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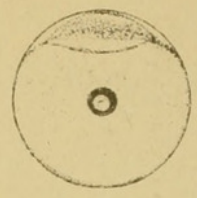

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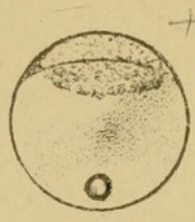

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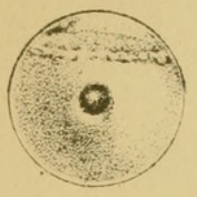

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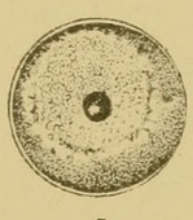

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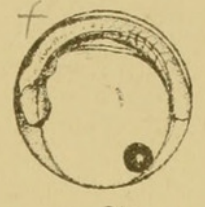

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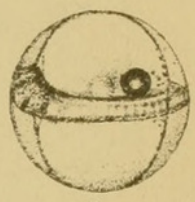

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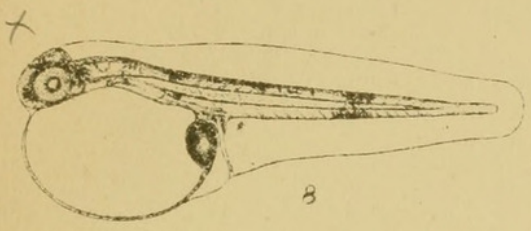

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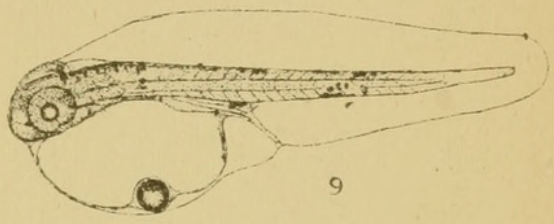

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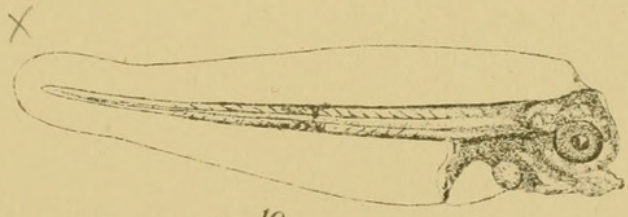

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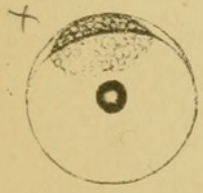

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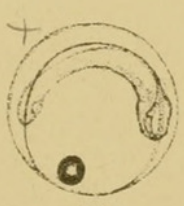

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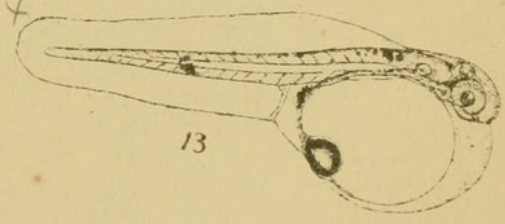

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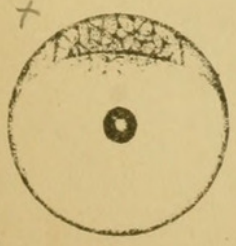

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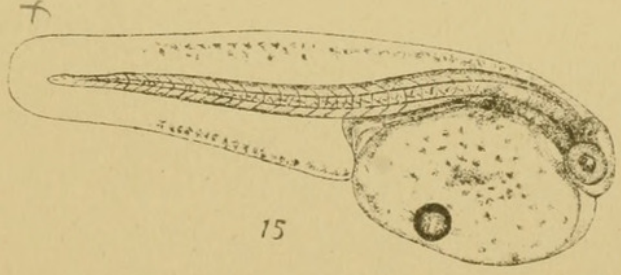

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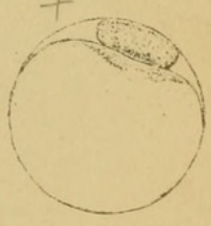

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Plate II.

Fig. 17. Stone on which have been deposited eggs of a fish (Species I.) (Nat. size.)

„ 18. Detached egg containing embryo, from photo by transmitted light (× 40).

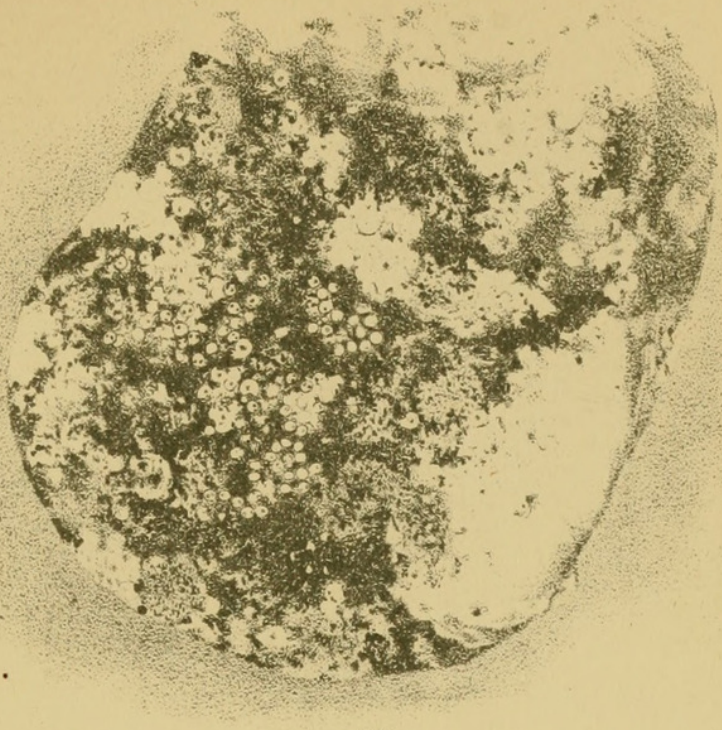
„ 19. Group of eggs containing embryos, from photo by reflected light. (The eggs are in situ on the stone.)

„ 20. Newly-hatched larva of Species I.

„ 21. Two eggs of Species II. detached from shell of barnacle and photographed by reflected light (× 15).

„ 22. Newly-hatched larva of Species II.

(Note.—The origin of the dorsal fin is not sufficiently indicated in drawing.)



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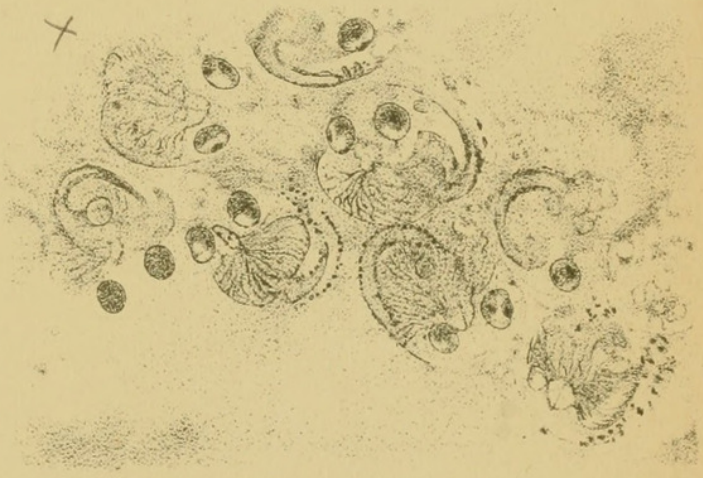

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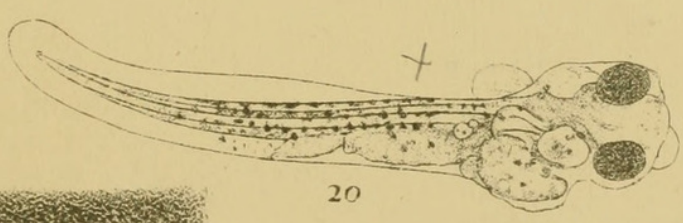

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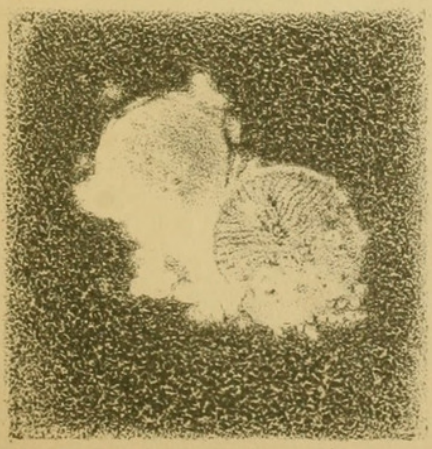

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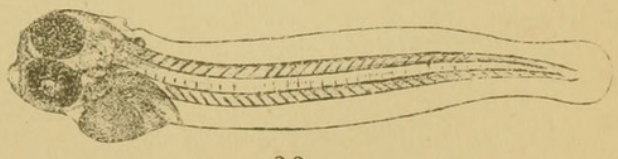

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Plate III.

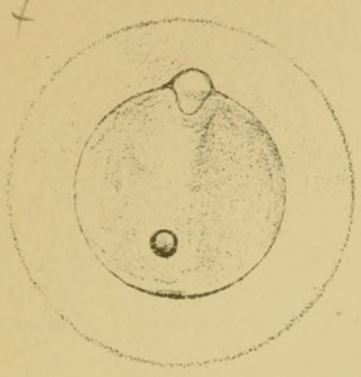
Fig. 23 and 24. Two stages of egg of Species III.

„ 25. Newly-hatched larva of Species III.

„ 26. „ „ „ IV.

„ 27. „ „ „ V.

„ 28. „ „ VI.



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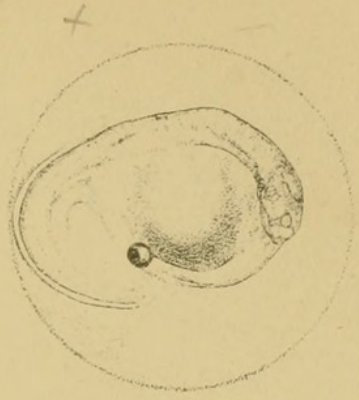
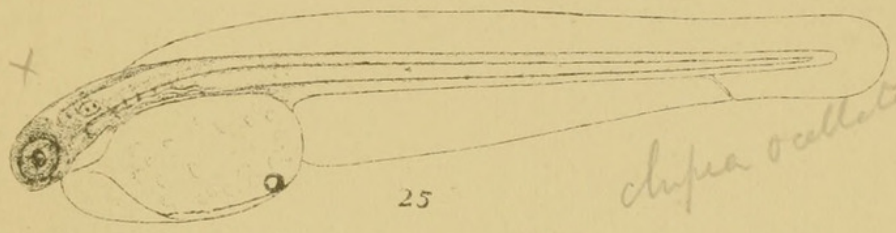


1·7 mm

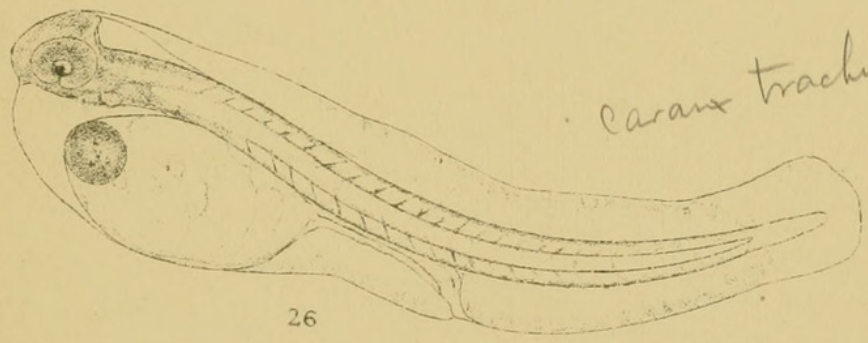
24



4·1 mm

clupea ocellata.

25



. carax trachurus .

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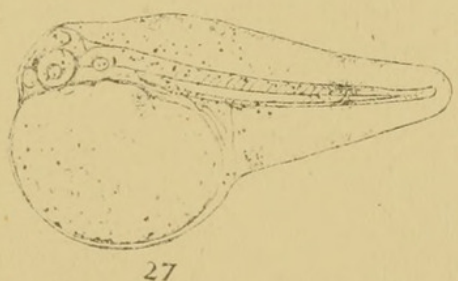

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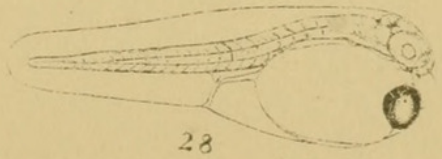


2·1

28

Plate IV.

Fig. 29. Newly-hatched larva of Species VII.

„ 30. Larva very similar to Species VII.

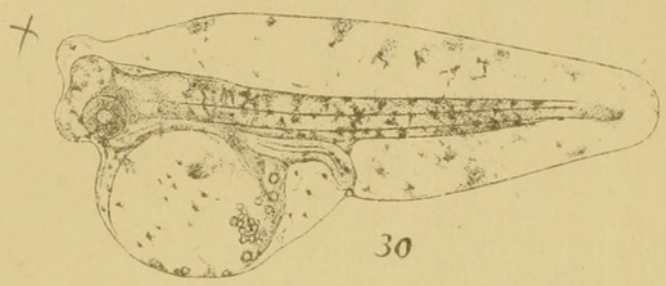
„ 31. Later stage of larva represented in fig. 30.

„ 32. Newly-hatched larva of Species VIII.

„ 33. „ „ „ X.

Solea? vid Raffaele Tav fig 5

29



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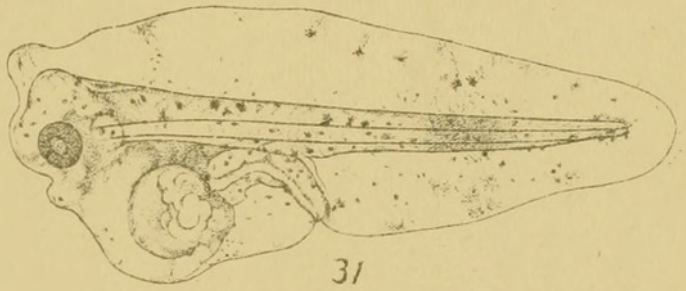

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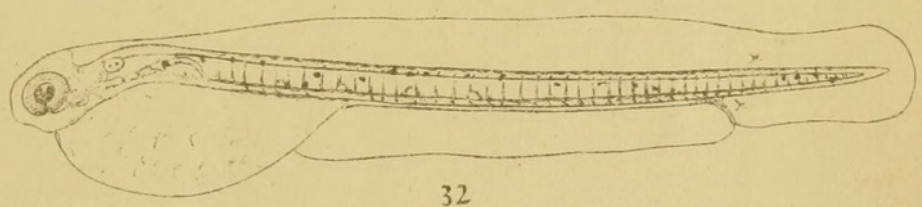
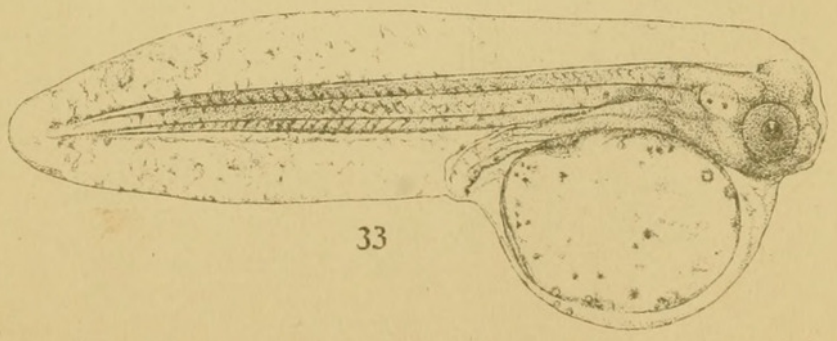


4·5 m

×2

32



4·1

×2

33