THESIS

PRESENTED TO THE FACULTY OF SCIENCE

OF THE UNIVERSITY OF EDINBURGH,

BY

J. D. F. GILCHRIST, M.A., B.Sc. (EDIN.),

FOR

THE DEGREE OF DOCTOR OF SCIENCE.

THE DEVELOPMENT OF SOUTH AFRICAN FISHES.

(PARTS I AND II.)

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PART I.

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J. D. F. GILCHRIST, M.A., B.Sc., Ph.D.,

Government Biologist to the Colony of the Cape of Good Hope.

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 disappeared 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 pigmen In some larvae a few of the ends of the branching cells wer 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.]

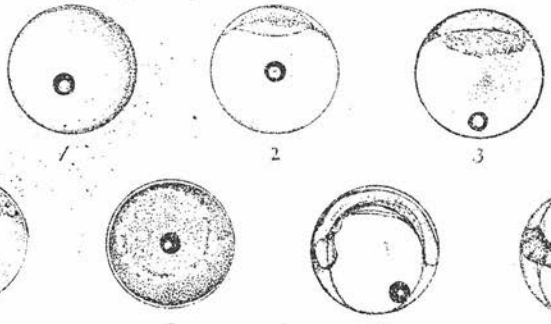
Oil Globule.		Diameter of Egg.	Diameter of Oil Globule.	Occurrence.	Remarks.	Position of Oil Globule.	Position of Rectum.	Notochord.	Pigment.	Species.
Present.	One	1.7	.2	Pelagic	Large perivitteline space	Postero ventral	Posterior	Unicolumnar	Very little	Species III.
		1.44	.29	„	Largest egg including 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.*
		.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 VII1.
	...	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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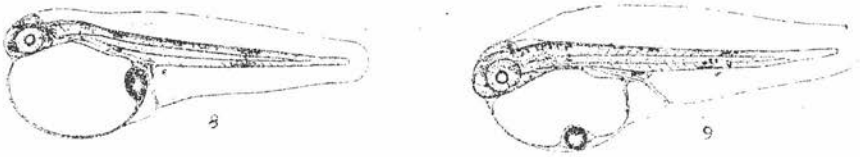
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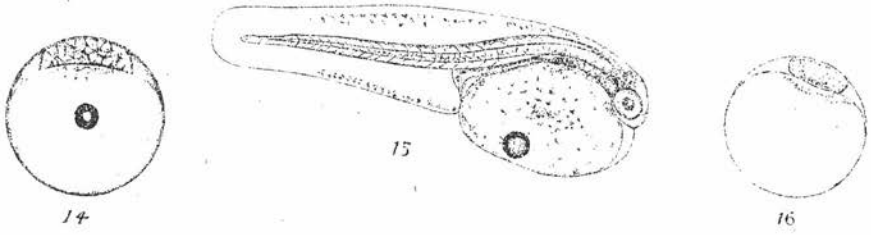
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Plate II.

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).

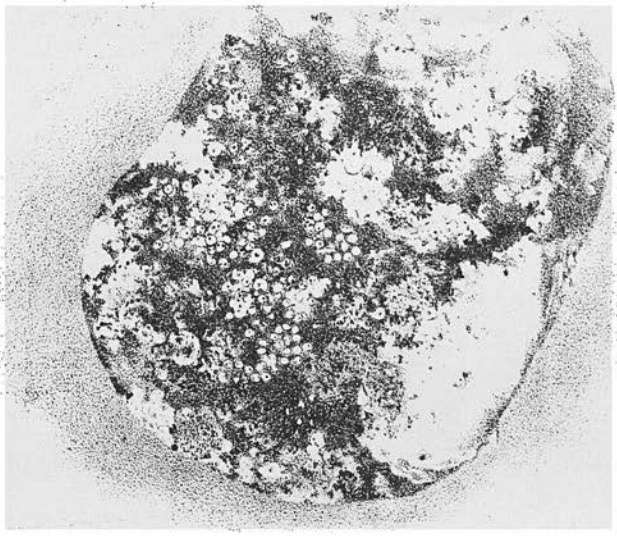
„ 19. Group of eggs containing embryos, from photo by reflected light. (The eggs are in situ on the stone.)

„ 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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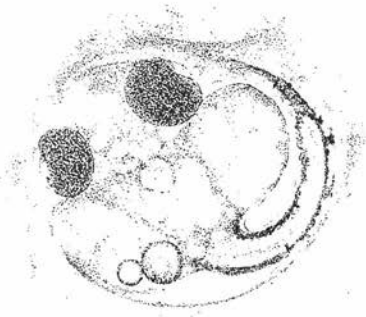

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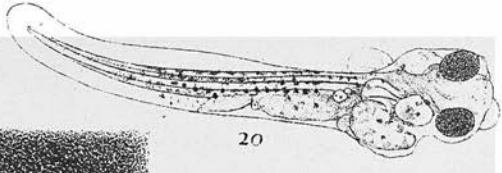

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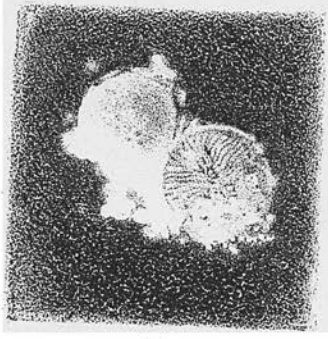

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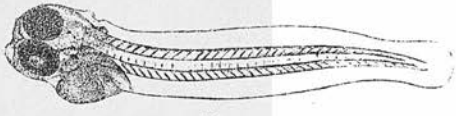

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Cape Times, Lith.

Plate III.

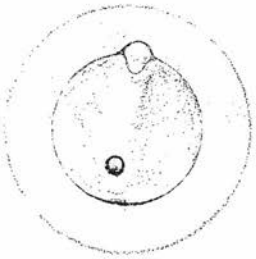
Fig. 23 and 24. Two stages of egg of Species III.

„ 25. Newly-hatched larva of Species III.

„ 26. „ „ „ IV.

„ 27. „ „ „ V.

„ 28. „ „ VI.



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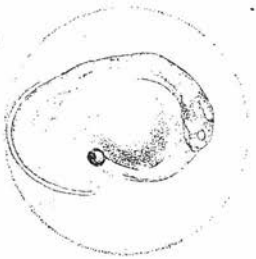

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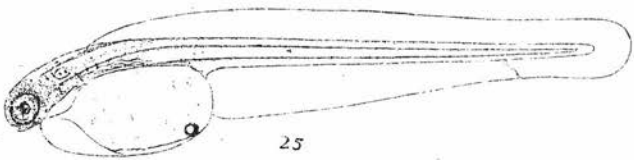

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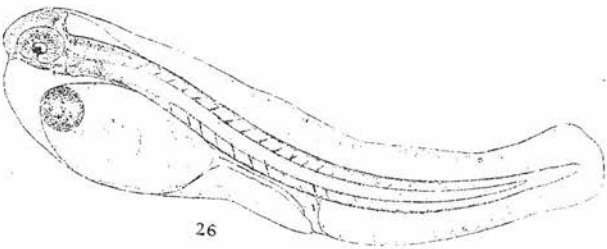

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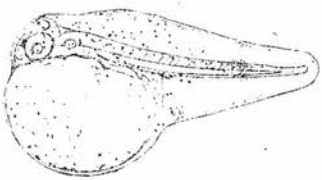

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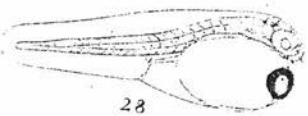

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Cape Times, Lith.

Plate IV.

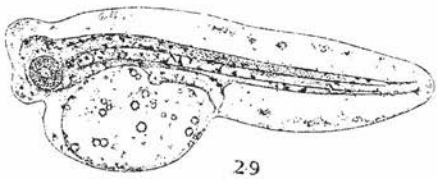
Fig. 29. Newly-hatched larva of Species VII.

„ 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.



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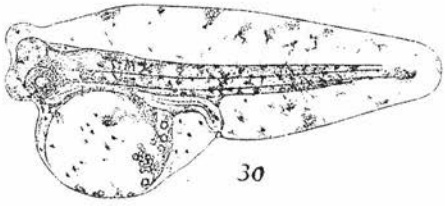

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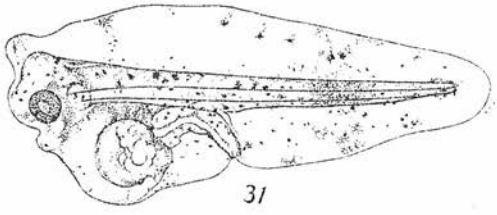

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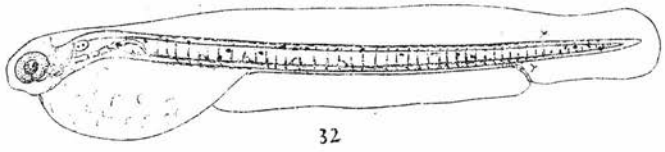

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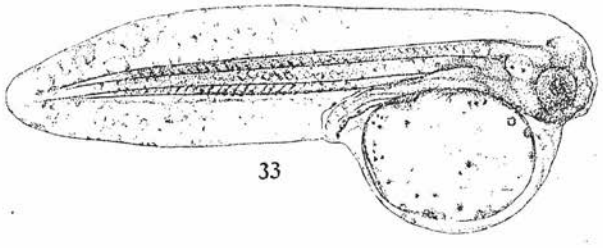

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THE DEVELOPMENT

OF

SOUTH AFRICAN FISHES.

PART II.

BY

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The following observations on the development of South African fishes are in continuation of those published at an earlier date (*Marine Investigations in South Africa*, Vol. II., page 181).

The material was procured by the Government steamer, chiefly while engaged in deep waters off Cape Point, and in occasional tow nettings in False Bay. Whenever possible the eggs were brought in alive, and their development observed. Many eggs and larvae were simply preserved in formalin, and an attempt was made to sort these out into what might be considered to belong to different species. In most cases, however, this turned out to be unsatisfactory, and to avoid confusion the observations made are held in reserve until living specimens can be procured. A few well-characterised eggs, however, are described from preserved specimens.

In Part I. of these observations the egg of a fish named provisionally "Species I." was described, along with the larva hatched from it. It is one of two kinds of eggs that were found attached to shells and stones. This now appears to be the egg of a species of fish known to fishermen as "Klip-zuiger," or "Sucker-fish," a name applied to fish having a well-developed sucker, by means of which they can adhere firmly to rocks, etc. They are small and of no commercial value, so that whatever injury may be done to the egg by nets or trawls is not likely to have any direct effect on the fishing industry. This identification was made possible by the finding of several young fish in

different stages of development in a tow-net attached to the beam trawl in about 20 fathoms in False Bay, off the Roman Rock, 13th October, 1898.

The smallest of these closely resembled the larvae of Species I., and the largest showed the widely separated ventrals with adhesive apparatus between them and the short dorsal fin situated on the tail, characteristic of the family Gobiesocidae. The others represented intermediate stages.

The only member of this family recorded from the Cape is *Chorisochismus dentex*, but as the posterior half of the ventral disc in these young forms has a free margin, they cannot be regarded as belonging to this fish, and they are not sufficiently far advanced to allow of more than a reference to the family with certainty. They have a gill cover free from the isthmus, and therefore do not belong to a species (apparently new) of *Lepadogaster* recently found in False Bay. In view of the characteristic oval eggs of this last-named genus,* a number of eggs were re-examined. In Part I. they were described as about one millimetre in diameter. A number of measurements show that none of them are perfectly circular, though some are very nearly so, one being 1·06 × ·98 mm., while others varied from about this to 1·37 × ·97. In most of these eggs there was also one oil globule from ·17 to ·3 mm., and the space between the eggs was less than in the case of those at first examined. In the fresh egg there was no evidence of a filamentous fringe round the basal part of the egg capsule, though some preserved in formalin showed radial striae on an irregular border.

The identification of the other demersal egg found (Species II.) has not yet been possible, but several specimens were again procured in dredging on rough ground in False Bay in the month of November. That they belong to a fish of small dimensions seems probable, as they have been on more than one occasion found inside an empty barnacle shell, the opening of which was small. Plate V, fig. 34, represents such a shell, (natural size) with one side cut away to show the blue eggs attached to its inner surface. Fig. 35 represents one of the eggs enlarged to show the numerous oil globules which occur towards one side of the egg.

In the following account, the various species dealt with are arranged according to the number of the oil globules and diameter of the eggs, as this artificial arrangement has proved very convenient. For this reason also a key (p. 150) to the eggs and larvae similar to that given in Part I., has been drawn up, including not only the species here dealt with, but those already mentioned in Part I. The items taken from the first table are printed in italics for convenient reference.

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* See Holt, Trans. R. Dublin Soc., S. II., IV., 1891.

The following species are dealt with here :—

(a) Species with One Oil Globule.

SPECIES XI.

Arnoglossus capensis, Blgr.

A single egg was procured by tow-net in Buffel's Bay, on the 14th November, 1903. It measured ·79 mm. in diameter, and had a single oil globule ·11 mm. in diameter. The embryo was fairly advanced, being about half the circumference of the egg. There was then no colouring matter on egg or embryo, but on the following day, when the embryo was about three-quarters the circumference of the egg, a faint reddish tinge could be seen, and this, when examined with a higher power, proved to be a number of small pigment cells scattered over the body from head to tail.

Hatching took place on the following day, and the larva showed several distinctive features (*vide* Plate V, fig. 36). The colouring matter, a bright brick red, was arranged in the following manner: Patches on snout, crown, orbit, otocyst, middle of the margin of dorsal fin, along the superior margin of body to near the tail, in the middle of the body, yolk (most marked behind oil globule), between yolk and rectum, and on inferior margin of the body. The most distinct were the patches above and below the body and extending on to dorsal and ventral fins. These were situated between the yolk and the extremity of the tail, but nearer the former.

Other characteristic features of the larva were the tuberculate appearance of the dorsal and ventral fins and their margins. Slight markings, apparently of the same nature, appeared on the posterior region of the yolk, the substance of which was homogeneous. The oil globule, which was situated posteriorly, had a purplish tinge on its periphery. The rectum was anterior. The notochord was mostly unicolumnar.

The relatively small size of the egg and the characteristics of the larva agree, on the whole, so well with the description and figure of *Arnoglossus** that I have little hesitation in provisionally identifying the parent as *Arnoglossus capensis*, Blgr., a flat fish recently described from False Bay.†

On 24th November, 1903, an egg was procured in False Bay ·7 mm. in diameter and having seven small oil globules in a group and about six branching cells on the yolk near embryo. On the 27th this produced a larva apparently identical with the above. The seven oil globules had fused into one, ·11 mm. in diameter. The larva was 2·8 mm. in length, had a few black spots on body and some black branching cells on yolk (not observed in the first specimen). The oil globule had a yellowish tinge, and the general colouring of the body and fins was the same as in the first specimen, with the same general arrangement. The fins were tuberculate in the same way.

SPECIES XII.

On several occasions fish eggs were procured in False Bay in the month of November, having a diameter of ·89 mm. with an oil globule of ·15 mm. This agrees so closely with the eggs of *Chrysophrys globiceps* (*vide Marine Investigations in South*

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* See Holt: Recherches sur la Reproduction des Poissons osseaux, Ann. Mus. d'Hist. Nat. de Marseille Zoologie, Tome V., 1899.

† The Flat Fishes of Cape Colony, by G. A. Boulenger, F.R.S., "Marine Investigations in South Africa," Vol. I.

Africa, Vol. II, p. 187) that they were at first supposed to belong to this fish. The larvae also were very similar in form, but were invariably devoid of all colouring matter. As the eggs were procured in abundance on several occasions, and in no case did the larvae show any trace of pigment, it seems advisable for the present to regard it as belonging to a different species.

Pagrus laniarius, C. and V. (Panga)

Although this fish occurs in abundance in the trawl, it is somewhat remarkable that only two ripe females and no ripe males have been as yet found among the many hundreds examined. These two specimens were procured on the 9th and 16th March, 1903, about 7 miles off Cape Infanta. The eggs (in formalin) measured ·93 to 1·02 mm. in diameter, and the old globule ·19 mm.

A number of ripe eggs of this fish were procured (6th June, 1904) by one of the Kalk Bay fishermen, who now show considerable interest in these investigations. They were larger than the above, being from 1·06 to 1·1 mm., with an oil globule of ·2 mm.

Macrurus fasciatus, Günth.

Many specimens of *Macrurus fasciatus* have on several occasions been procured in trawling in about 100 fathoms, but of these there was only one perfectly ripe female. This was on the 28th October, 14 miles off Cape Point, when 684 specimens were brought up in the trawl. None of these were ripe males, and the eggs could not therefore be fertilized.

The eggs (Pl. VI, fig. 37) when procured from the female were clear, homogeneous, and floated freely on the surface of the water in which they were placed. They were of a fairly uniform size, ranging from 1·15 to 1·06 mm. in diameter, the oil globule, which was yellow or red in colour, being from ·29 to ·27 mm. The vitelline membrane was thick (about ·02 mm.), and marked in a very distinctive manner. In some cases the markings appeared to be separate dots only, but these were seen in many to be connected by fine hyaline lines, so as to form polygonal markings on the surface of the egg. The dots themselves appeared on a side view to be small connecting pillars between the outer and inner surface of the vitelline membrane (fig. 38).

During the time the "Pieter Faure" was engaged in deep-water work off Cape Point none of the surface tow-nettings contained any eggs at all corresponding to these, but on four

occasions one or two eggs procured in the tow-net attached to the beam-trawl exhibited all the characteristics described above. The polygonal markings were very distinct, as well as the connecting columns. One egg contained an embryo fairly well advanced, and this, when dissected out, showed many black branching cells over the body from head to tail. The rectum was apparently anterior.

The eggs were procured at the following times and places:—

(1) August 20th, 1903. Cape Point, N. 81° E., 32 miles, 460 fathoms. One procured. Refer. No. 17385.
(2) August 27th, 1903. Cape Point, N.E. by E. $\frac{3}{4}$ E., 8 miles, 91 fathoms. One procured. Refer. No. 17555.
(3) September 27th, 1903. Cape Point, N.E. $\frac{1}{4}$ N., 46 miles, 760 fathoms. One procured. Refer. No. 18134.
(4) September 27th, 1903. Cape Point, N.E. $\frac{1}{2}$ N., 47 miles, 700-1,000 fathoms. Two procured. Refer. No. 18097.
*(5) July 8th, 1903. Cape Point, N.E. by E., 36 miles, 650-700 fathoms. One procured. Refer. No. 16799.

On these occasions a moderately fine net was used on the surface, while a coarse net and a moderately fine net were attached to the beam of the shrimp trawl, the eggs being found *only in the last.*

The measurements of these eggs were as follows:—

(1) Diameter of egg, 1·15 mm.; of oil globule, ·3 mm.
(2) " " " " " " " "
(3) " " 1·21 " " " ·25 " (contained embryo).
(4) " " 1·07 " " " ·3 mm. (contained embryo).

The manner in which they were procured seems, on the whole, to point to the fact that their natural place of occurrence is at or near the bottom of the sea. As against this supposition, however, we have to bear in mind that the eggs when procured from the ripe female floated, and that the bottom net was not a closing one. Neither of these considerations are conclusive however, as the fish from which the eggs were procured had been brought up from a depth at which there must have been great pressure, and the eggs under these new conditions of diminished pressure might float. Again, as against the second objection we have to consider that on none of the four occasions on which the eggs were procured were any found in the surface tow-net, which was in use at the same time. The question can only be satisfactorily settled by the use of a closing net.

* Contained 20-30 Small Oil Globules, but otherwise like the others.

Macrurus parallelus, Günth.

Of 145 samples of this fish procured on the 17th September, from 310-560 fathoms, 39 miles off Cape Point, one ripe female was found. On all other occasions when this fish was procured none proved to be ripe. The eggs were clear, not vesiculated, and floated freely at the surface of the water in which they were placed.

They vary from 1·32 to 1·3 mm. in diameter, the single oil globule measuring from ·31 to ·26 mm. The surface of the egg shows the same polygonal markings, with pillars at the angles, observed in the case of *M. fasciatus*, but it is readily distinguished by its larger size.

None of these eggs were found in tow-nettings.

SPECIES XIII.

On the 9th July, 1903, a few eggs were procured in a surface tow-net, Cape Point, N.E. by E., 36 miles. They measured 1·7 mm. in diameter, and had a single oil globule of ·33 mm. The yolk was vesiculated.

These produced transparent colourless larva, difficult to see even in a tube of clear water. They were about 4·67 mm. in length. The notochord was multicolumnar, the rectum posterior, and oil globule posterior. The yolk had well-marked vesiculations. The newly-hatched larva had a very marked downward curvature of the body anteriorly. The dorsal and anal fin were comparatively low, and the former commenced behind the middle of the yolk (Plate VII, fig. 43).

SPECIES XIV.

Seven eggs were found in a surface tow-netting taken on the 9th July, 1903, Cape Point, bearing N. by E., 36 miles. They were all 1·7 mm. in diameter, and had a single oil globule of ·38 mm. The yolk was vesiculated. The more advanced showed a well-developed embryo, with dark pigment cells. On the 12th, all the eggs had sunk to the bottom of the jar, and on the following day some had hatched out (temp. 60°·5 Fahr.).

The larva proved to be very elongate (6·7 mm.) and provided with characteristic black tufts, which did not disappear in formalin after being kept for some months. This characteristic

may be useful for identification purposes. There was no yellow pigment present, and the black pigment (Plate VII, fig. 41) was arranged as follows: Branching cells on snout, crown, behind eye, over part of yolk sac and the body adjacent to it; dense tufts, three above and two below the body posterior to the rectum. The oil globule was covered by a network of black cells. The notochord was multicolumnar and the anus anterior.

SPECIES XV.

Eight ova were procured in a surface tow-net on the 2nd July, 1903, Cape Point, bearing N.E. by E., 38 miles. They were 1·87 mm. in diameter, with an oil globule from ·38 to ·42 mm. They contained embryos fairly advanced, with tail slightly free, and were about half the circumference of the egg. The yolk was transparent and homogeneous, except for some clear dots over its surface, which may not however be constant. The embryo at this stage showed the following pigment patches of a greenish yellow colour: a patch behind each eye, a fainter tract along each side of the body, on the caudal region and oil globule. On the 26th, all the eggs had sunk to the bottom of the jar. They lived till the 31st, but were not in a healthy condition, and did not hatch out. Another lot, about 60 in number, was procured on the 17th September, Cape Point, bearing N.E. (approx.) 40 miles, and hatched out satisfactorily. The larva (Plate VII, fig. 42) is long (4·8 mm.), the rectum anterior, and the notochord multicolumnar. The pigment is arranged as follows: Yellow patches round eyes, on hinder part of yolk sac and oil globule, yellow tufts above and below body and extending on to fins. The arrangement of these tufts varied somewhat in the different larvae. The following were constant: One above the body a little behind the rectum, one below body about as far again behind it, another between the second and the end of the tail, and two at the end of the body. The variation occurred in the addition of another yellow tuft, sometimes above and sometimes below the body, near the third above mentioned. The eggs were procured in surface tow nettings as follows:—

Ref. No.	Locality.	No. Procured.	Date.
17161	Cape Point, N.E. by E. 38 miles.	8	July 23rd, 1903.
17230	Cape Point, E. ½ N. 25 miles.	5	July 30th, 1903.
18053	Cape Point, N.E. approx. 40 miles	60	Sept. 17th, 1903.
17414	Cape Point, E. ½ N. 34½ miles.	4	Aug. 20th, 1903.

SPECIES XVI.

This species is very distinctly characterised by having a thick envelope of a clear gelatinous substance, with polygonal facets on its surface. This substance is apparently homogeneous, and is transparent, so that the egg proper appears as a dark sphere surrounded by a sort of halo, having however occasionally a few dark spots outside its periphery. When viewed by transmitted light (Plate VI, fig. 39), the surface is seen to be divided up into polygonal markings, usually six-sided. When viewed from the side near the periphery of the egg, the sides of the polygonal facets were seen to be curved and raised into ridges having a smooth, sharp, and clearly-defined edge. This becomes very evident when the egg is removed from the water and viewed as an opaque object (fig. 40).

The total diameter, including envelope, varies from 1·91 to 1·7 mm., the egg proper from 1 to 1·06 mm. A single oil globule is present, varying from ·25 to ·21 mm. in diameter, and is usually greenish in colour, but sometimes clear and colourless.

Some of the eggs showed the early stages of embryos, but none far enough advanced to show any specific characteristic. All were examined and measured in 2 per cent. formalin.

The eggs were procured as follows:—

Ref. No.	No. Procured.	Locality.	Means of Capture.	Depth.	Date.
17555	18	Cape Point, N.E. by E. ¾ E. 8 miles.	Moderately fine net on beam.	380-2	Aug. 27th, 1903.
17863	4	Cape Point, N. 50° E. 34½ miles.	Coarse net on beam.	380-475	Sept. 11th, 1903.
17838	85	Cape Point, E. ½ N. 20 miles.	Moderately fine net on surface.	—	" "

NOTE.—Compare somewhat similar eggs described by Hensen and Raffaele.

(b) Species with Several Oil Globules.

Stromateus microchirus, Bonap.

A ripe male and female of this fish were procured in Mossel Bay, 19th February, 1903. Fertilized eggs were secured and kept till hatching took place, 34 hours later. No facilities for microscopic examination were available, and the following notes are from material preserved in formalin.

The eggs vary from ·81 to ·85 mm. in diameter. There are several oil globules, one to five of which are of a dark colour,

with indefinite outline, the others being smaller globules of the normal appearance. The former seem to be oil globules with dark pigment cells, as they could be dissolved, leaving branching pigment cells. The substance of other globules entirely disappeared in dissolving. The larger globule generally occupied a posterior or ventral position in the yolk.

The larva (Plate VII, fig. 44) at the time of hatching is short and stumpy, being about $1\frac{1}{2}$ millimetres from snout to tail and about one-half this in greatest depth. The posterior border of the yolk is near the middle of the total length.

(c) Species with Many Oil Globules.

Syngnathus acus, Linn.

A male of this fish was found in False Bay on the 7th August. In the pouch were rows of eggs of a yellowish red colour. They measured about 1·24 mm. in diameter, and contained many small oil globules, varying considerably in size.

SPECIES XVII.

A single egg (Plate VIII, fig. 45) was procured on 24th November, in False Bay, in a surface tow-netting, and measured 1·57 mm. in diameter. It contained many small oil globules, which occurred in groups and singly throughout its substance. On the following day the embryo was a little less than half the circumference of the egg and showed very characteristic pigment, quite visible to the naked eye as an orange red patch on the lower side of the floating egg. This was seen under the microscope to be a mass of pigment cells, dark red by transmitted light and light orange by reflected light. The whole embryo was covered by this pigment, which extended on to the yolk, gradually becoming fainter till only some scattered branching cells appeared on the surface of the yolk furthest from the embryo. These were of a dark and fainter colour.

Hatching took place on the 27th November.

In the larva the rectum is anterior and the notochord appeared to be multicolumnar, though this could not be made out with certainty owing to the presence of the colouring matter.

Cataetyx messieri, Günth.

On the 27th August, 1903, a large specimen of *Cataetyx messieri, Günth.*, was found, Cape Point, bearing N. 80° E., 32 miles. The depth was 460 fathoms with a bottom of green mud. It was relatively large for a deep sea fish, being about 2 feet in length, and much larger than the type and only specimen hitherto found. The latter, obtained by the "Challenger" in Messier Straits, was 8 inches in length. A conspicuous feature in this fish not seen in the smaller and probably immature "Challenger" specimen was an anal depression covered by a flap, on the inner side of which was situated a papilla, the whole being apparently a copulatory organ of some kind.

A little later, on the 17th September, Cape Point N.E., 40 miles (approx.), in 560-700 fathoms, bottom green mud, we were fortunate in procuring another specimen about the same size, but a female. The ovaries were distended with ova, which were readily discharged on applying a little pressure. They were of a warm reddish colour, which at once suggested the peculiar red characteristic of many deep sea animals, and which has been seen several times in the groups of the Alcyonaria, Nudibranchs and Crustacea in deep waters in this same region. The egg (Pl. VIII, fig. 46) contained many small oil globules, some of a bright red colour, others more of an amber tint, which was also the colour of a single relatively large oil globule which was present in each egg. In some of them when fresh a small patch of what appeared to be protoplasmic matter was observed alongside of this large globule, and this was more apparent when the colouring matter in course of time became quite bleached out by the light, but there was no indication of segmentation or embryos in any of the several hundred eggs examined. The two large ovaries were each about 115 mm. in length and 35 mm. in diameter. They were enclosed in a tough capsule fully distended with ova of the same bright colour as those which had been pressed out. The ova were produced from a series of transverse leaf-like expansions hanging from the roof of the cavity, their free margins extending nearly to its floor. They were closely packed in between these expansions and filled the remaining space under them where they were more loosely packed. From a rough calculation, there must have been over 30,000 in each ovary. It appeared at first that as the eggs were evidently so well developed and flowed so readily from the fish on pressure, they were the ordinary unfertilised eggs found in most fishes, only that they had the colouring and other characteristics of some demersal eggs. A more careful search, however, amongst the ova revealed eight larvae in a fairly advanced stage of development. They were not very difficult to see, though enveloped in a mass of eggs, as the black pigment

of the eyes formed a marked contrast. One was found in the right ovary and the others in the left, and they all occurred on the peripheral region of the mass of eggs on its ventral aspect. They were entirely removed from the ova-producing lamellæ, and had no connection with these or with the walls of the ovary. The eggs in their immediate neighbourhood were embedded in a sort of mucous substance, which coagulated in formalin, and which contained scattered throughout it isolated oil globules. In nearly every case the larvae were found coiled up in a peculiar manner, with a strong flexure near the middle of the body and another in the same direction towards the end of the tail. In one instance, in breaking up the mass of eggs surrounding an embryo, that is carefully detaching eggs and embryo from the surrounding mucous, there was an escape of numerous oil globules, which were also found in the open mouth and throat of the embryo, though none of the eggs or larvae seemed injured. In another case (Pl. xi., fig. 58) the embryo was coiled round a white substance, which at first seemed to be a mass of mucous and oil globules, except that it had numerous black pigment spots. Further examination showed that one end of this mass was enveloped in the mouth of the larva, and this on being withdrawn (Fig. 58a) appeared to be the tail of another and smaller larva. On some of the surrounding mucous being removed this proved to be the case. Fig. 58 represents the whole *in situ* after the tail had been withdrawn from the mouth. The rest of the body of the smaller embryo was coiled up in the form of a figure 8, the abdominal and head region being somewhat broken up.

The largest larva was found lying on the floor of the ovarian wall, that is between the mass of eggs and the tough capsule, and quite free from ova and mucous. It was 10 mm. in length. The pectorals were well developed, and a few rudimentary rays appeared in them, and in the dorsal fin at its commencement over the head (see Pl. XI, fig. 57). The body and fins were covered with black branching cells. These were most marked in the head region, being somewhat more sparsely scattered on the body. They formed a border to the dorsal fin and a less marked one to the anal; a group of pigment cells occurred near the posterior extremity above and below the caudal portion of the body. The dorsal fin commenced well forward on the crown of the head (in the adult it is much further back), and continues backwards as a fairly wide border. The ventral fin behind the vent was also well developed, and there was a slight pre-anal fin. The vent was approximately medium, but somewhat nearer the head than the tail, much more so than in the adult. The rectum was well developed, and the intestine was continued forward, and after making one or two coils over a large liver could be traced to the œsophagus. The notochord appeared to be multicolumnar. There were four well-developed branchial arches and a clavicle.

I hope to make out more details by sectioning the material, which seems sufficiently well preserved for this purpose.

This is not the first time that evidence has been secured that some deep sea fishes are viviparous. Several species have been found with anal papillae, presumably male sexual organs, and Alcock has definitely established the fact in his important discovery of embryos in the eggs of *Saccogaster*. He has also suggested that the embryos may, when hatched out, procure in some way means of subsistence from the surrounding ova. The present case of comparatively large larvae, which from their size and development have apparently existed some considerable time in the ovarian sac after hatching, is a further step in the solution of the problem, and the fact that in those advanced larvae the yolk sac was completely absorbed, the intestinal tract was fairly well developed, and oil globules were found in their mouth and œsophagus, seems to indicate some confirmation of Alcock's hypothesis, and, further, that there is no special organ for absorption of these eggs, but that nourishment is taken in by the mouth. Before finding the small larva in the coils of another of much larger size, apparently in the act of devouring it, I was inclined to believe that the egg capsule, though tough, was in some way broken down, allowing the contents to escape. This case, however, seems to indicate that the larger larvae live on the smaller or those just hatched, the scattered oil globules found being tnose from the ruptured yolk sac of the younger larvæ. This is quite in keeping with the fact of there being so few larvae in proportion to the number of the eggs, and it would be easy to construct a probable life history of an embryo from the time of hatching to birth should it be one of the few that only can survive to that period.

(d) Species with No Oil Globules.

SPECIES XVIII.

On the 14th November, 1903, seven eggs, characterised by their small size (·76-·72 mm.) were procured in a surface tow-net in False Bay. No oil globules were present. There were embryos in each, fairly well developed, being a little over half the circumference of the egg. Distinct black dots occurred along the body, but no yellow pigment, either on embryo or yolk. Küppffer's vesicle was present at this stage. The embryos hatched out on the following day. There were a few black dots along the back of the body, and faint yellow pigment over the body, fins, and yolk. Clear dots occurred abundantly on fins, especially towards their margin. The notochord was unicolumnar, the rectum anterior, and the total length 1·74 mm. Fig. 47 is a drawing

representing this larva on the day following (the 16th), and fig 48 (from photograph) on the 18th, when the pigment appeared somewhat differently arranged, viz., a diffused yellow (in which the individual pigment cells were indistinct) occurring on head and body to a point half-way between the rectum and the end of the tail. Here the yellow pigment expanded into a band, traversing the dorsal and ventral fins. Yellow pigment also occurred on the anterior part of the yolk and on the rectum down to anus. Black branching cells appeared extending from the margin of the body above and below into the adjacent fins.

An egg, which seems to be the same, was found in a surface tow-net on the 17th September, 25 miles off Cape Point. It was about ·76 mm. in diameter, and had no oil globule.

Agriopus spinifer, Smith.

Some time ago the eggs of Agriopus were procured (*vide Marine Investigations*, Vol. II., p. 189), but fertilization was not effected. More recently a ripe male and female were found in the same haul, and fertilized eggs were secured (Buffel's Bay, 25th November, 1903). The eggs varied from 1·83 to 1·74 mm. in diameter.* Seven hours after fertilization the germinal disc showed about 30 to 40 cells, and on the following morning, or 24 hours after fertilization, the blastopore was about three-quarters over the egg (Plate IX, fig. 49). The corrugated appearance noted in the unfertilized eggs formerly preserved were readily seen at this and all subsequent stages, and seems to be a characteristic of the egg. Development seemed to be proceeding quite normally, and on the 27th the length of the embryo was about half the circumference of the egg, at which stage faint branching pigment cells of a dark colour began to appear all over the yolk. On the following day the embryo had increased in length, and the heart, otocyst, and rudiments of the pectoral fin were evident. On the 29th, however, all the embryos were found to be dead or dying. One was dissected out, and is represented in fig. 50. Dark branching pigment cells occurred over the yolk, along the head and body, and on the pectoral fin. The notochord was multicolumnar and the rectum anterior.

SPECIES XIX.

On one or two occasions a few opaque spheres were found in tow-nettings preserved in formalin. They were of a dull white colour, minutely vesiculated, but without any signs of oil globule or embryos, and there was therefore some doubt as to their being

* As there was some doubt as to the maturity of the eggs in the first case these dimensions are substituted in the key on page 152 for those first given.

fish-eggs. About half a dozen of these were found, however, in a fresh surface tow-netting, on the 11th September, 1903, from about 34½ miles off Cape Point (Cape Point bearing N. 50° E.). They measured from 1·87 to 1·72 mm. in diameter, and some contained an embryo a little less than half the circumference of the egg. Yellow pigment spots could be seen on the embryo from head to tail. Unfortunately, these did not hatch out, in spite of special care. Similar eggs were again procured on the 27th September, 46 miles off Cape Point, but they again did not survive till hatching.

Some time afterwards living larvae were procured in a surface tow-net 13 miles off Cape Point, on the 30th October, 1903, with the yolk opaque and vesiculated as in the above eggs, but without any trace of pigment on the embryo. The yolk was drawn out and somewhat rectangular in shape, and the rectum was anterior. The total length was 2·04 mm.

Scombresox saurus, Walb.

The diameter of 12 eggs varied from 2·76 to 2·1 mm. There was no oil globule, and the yolk was clear and not vesiculate. All showed a sprinkling of minute dark dots over the surface. The eggs seem to be of a particularly hardy nature, as, although some sank to the bottom of the jar owing probably to the collection of particles on them, and frequently became coated with a white substance apparently of fungoid growth, yet after clearing with a camel's hair brush they floated fairly well, and ultimately developed as the others. One procured on the 11th September, Cape Point bearing N. 50° E., distant 34½ miles, showed the embryo fairly well developed, but the tail not free. On the 16th, the embryo was further advanced, being about one-half the circumference of the egg and with the tail partially free. There was little colour in the embryo, there being only a few dark dots scattered sparsely over the body and a few stellate (mostly 3-rayed) pigment spots on the surface of the yolk, immediately adjacent to the body of the embryo, as shown in Plate X, fig. 53 (from an egg preserved in formalin). At this stage an active circulation, a characteristic feature of this pelagic egg, appeared. The heart beat 112 in a minute. A single afferent vessel could be perceived running along the ventral surface of the egg. The course of this vessel was in a straight line from the caudal region to the heart. By focussing deeper for the lower side of the egg till the dark spots on embryo and yolk become visible, the following efferent vessels become visible: One on each side, starting from the region of the rudiments of the pectoral fin and proceeding at right angles to the body over the yolk till about half-way to the periphery, when they each turn abruptly to the head region and return on either

side to the heart. Another efferent vessel may be seen, though less distinctly, proceeding along the body to the caudal region, where it apparently joins the afferent vessel first mentioned. On the day following, the pectoral fins were very distinctly visible behind the lateral efferent vessels, and the day after that the circulating system was much more developed, the whole surface of the yolk showing a network of vessels through which the blood corpuscles could be seen coursing rapidly.

The embryo remained without much further change for fourteen days. About two days before hatching a change was noted in the pigment. The orbits become of a dark blue and a group of cells of the same colour appears on the body near the pectoral fins, which at this stage are about half the length of the head. In addition to this, small blue specks appear along the whole length of the body. Very little movement is observed in the embryo before hatching, with the exception of the free pectoral fin (that not appressed against the egg capsule), which is in almost constant motion. In the only case in which the actual hatching was observed there was no rupture of the shell, but a sort of scaling-off of part of the capsule. At the time of hatching, the embryo was about one and a quarter the circumference of the egg.

The newly-hatched larva (Plate X, fig. 54) is as much characterised by the presence of distinctive colouring as it had been previously by its absence. With the exception of the yolk and fins, it is of a deep blue, which on examination with a low power may be resolved into dark blue stellate cells, closely packed on the dorsal aspect, but separated on the ventral region in front of the rectum and on a small part of the yolk adjacent to the body (that part which at an early stage was characterised by the presence of black stellate cells). The mouth is well developed and the lower jaw protrudes slightly beyond the upper. The embryonic ventral fins are well developed; that anterior to the anus slightly overlaps the posterior one. The dorsal is not so deep and begins further back, about half-way between the tip of the snout and the end of the caudal rays. The rectum is median, being about half-way between the posterior margin of the yolk and the end of the body.

The larva is long (one measured 8·5 mm.), and swims with a rather slow undulation of the whole body.

After hatching, the absorption of the yolk proceeds at a rapid rate, and three days later it has disappeared (Plate X, fig. 55). A marked change has meanwhile occurred in the pigment. It becomes differentiated into a dark blue band along the back, extending on the side for about a third of the depth of the body. The remainder of the body below this is of a silvery colour, tinged with blue. At this stage, the rays of the caudal which were present in the egg stage are more marked, but none have as yet appeared in the other vertical fins.

One larva survived for a few days longer, the chief change being the more definite demarcation of the blue band of pigment along the dorsal aspect, the appearance of rays in the dorsal and anal fins, and the more marked protrusion of the lower jaw (Plate X, fig. 56).

The behaviour of this larva, as observed on the animal when in the jar of water, differed considerably from that of other larvae reared. It appeared to seek its food entirely from the surface of the water, and kept up a ceaseless movement, the tail being well submerged, while the mouth-part skimmed along the surface. Small copepods were put into the water, but received no attention; whereas small pieces of bread put on the surface were again and again visited, the larva making repeated darts, perhaps at the minute forms which collected round the floating particles.

There is little doubt that this fish is *Scombresox saurus*, specimens of which in various stages of growth were found in the tow-nets about the same time and place. These varied from about 2 mm. longer than the form reared from the egg, but similar to it in every other respect, to forms about 70 mm. in length, and adults have frequently been found.* (I am aware that Haeckel, Kölliker, and Ryder have stated that the eggs of *Scombresox* are provided with long filaments, but not having access to all the literature at present I can only refer to them now.)

The eggs were procured at the following localities, and on the dates mentioned:—

Ref. No.	No. Procured.	Locality.	Date.
17,703	1	Cape Point, N. 81° E. 32 miles ...	Sept. 9th, 1903
17,835	2	Cape Point, N. 64° E. 37 miles ...	Sept. 10th, 1903
17,161	1	Cape Point, N.E. by E. 38 miles ...	July 23rd, 1903
18,021	12	Cape Point (approx.), N.E. ¾ N. 39 miles	Sept. 17th, 1903
17,078	1	Cape Point, N.E. by E. 34 miles ...	July 21st, 1903
17,888	1	Cape Point, N. 49° E. 38 miles ...	Sept. 11th, 1903
16,798	1	Cape Point, N.E. by E. 36 miles ...	July 8th, 1903
17,861	1	Cape Point, N. 50° E. 34½ miles ...	Sept. 11th, 1903
17,838	1	Cape Point, E. ½ N. 20 miles ...	Sept. 11th, 1903
16,735	1	Cape Point Lighthouse, N.E. 28 miles	June 24th, 1903
16,732	2	Cape Point, N.E. by E. ¼ E. 38½ miles	June 23rd, 1903
16,734	5	Cape Point Lighthouse, N.E. 32 miles	June 24th, 1903
16,733	5	Cape Point Lighthouse, N.E. 32 miles	June 24th, 1903
17,928	2	Cape Point by D. R., N.E. ¾ E. 40 miles	Sept. 15th, 1903
16,860A	1	Cape Point, N.E. by E. 36 miles ...	July 9th, 1903
17,861	1	Cape Point, N. 50° E. 34½ miles ...	Sept. 11th, 1903
17,108	1	Cape Point, E.N.E. 36½ miles ...	July 22nd, 1903
17,969	5	Cape Point, N.E. (approx.) 39 miles ...	Sept. 16th, 1903
17,730	5	Cape Point, E. ¾ N. 38 miles ...	Sept. 9th, 1903
18,048	10	Cape Point (approx.) N.E. 40 miles ...	Sept. 17th, 1903

* Mr. G. A. Boulenger, F.R.S., has been good enough to confirm this identification.

SPECIES XX.

On several occasions an egg was procured of comparatively large size and with a large perivitelline space. It ranged from 2·97 to 2·64 mm., the perivitelline space being a little over one-fifth of this total diameter. Only the yolk of the egg is visible in the water to the naked eye, so that they may readily be mistaken for much smaller eggs. The yolk was characterised in nearly all cases by vesiculations, showing on its surface as polygonal honeycomb-like markings.

Development was comparatively slow. Some eggs which were procured on August 20th, with embryos about half the circumference of the yolk, hatched out on the 28th.

The embryo appears round the yolk as a series of globular-looking myotomes. Shortly afterwards, with the growth of the embryo, the yolk is drawn out into a lenticular-shaped mass, touching the outer envelope at its ends. The movements of the embryo were somewhat peculiar. After a long period of rest, it would suddenly make a spasmodic wriggle, which often completely reversed its position in the longitudinal direction.

The larva when hatched out proved to be well characterised. There was an entire absence of pigment; the yolk was drawn out so that it extended over more than half the total length of the animal. The anus was situated midway between the yolk and the extremity of the tail, and the notochord was multi-columnar (Plate IX, fig. 51).

The eggs were procured at some distance off Cape Point, as follows:—Cape Point, N. 50° E., 34½ miles—by townet at surface; and Cape Point, E. ½ N., 34½ miles—by townet at surface.

In specimens preserved in formalin, the perivitelline space sometimes becomes opaque and the yolk disintegrated, but the eggs are readily recognised.

SPECIES XXI.

This egg is readily recognised on account of its large size (4·2—4 mm.). It has a clear and glassy appearance in the water. Under a low power of the microscope it is translucent, and showed a number of polygonal markings. No oil globule is present.

Development was remarkably slow. One procured on the 20th August, and showing no trace of an embryo, showed the first traces of the embryo on the 24th. On the 28th, the embryo was less than quarter the circumference of the egg. The egg did not float; perhaps, however, on account of small particles of foreign matter adhering to it. On the 4th September the

embryo was about three-quarters the circumference of the egg, and showed occasional movements. On the 8th it was well developed. As a more advanced embryo had died at this stage and this one seemed to be feeble, it was removed from the egg, and the following characteristics observed (Plate IX, fig. 52): there was little colouring matter, only a few black branching cells being observed on head region and over yolk. The rectum was median (somewhat nearer the yolk than the end of the tail). The dorsal fin was low, and the tail came to a point without any caudal expansion. The ventral fin was deeper than the dorsal and the notochord was multicolumnar. The most characteristic feature was a low triangular prominence on the dorsal aspect over the centre of the yolk.

On three occasions the eggs were procured alive, but the larvae did not on any of these hatch out naturally.

The eggs were procured as follows:—

Ref. No.	No. Procured.	Locality.	Date.
17,724	1	Cape Point, E. ¾ N. 38 miles ...	Sept. 9th, 1903.
16,890	2	Cape Point, N.E. by E. ¼ E. 40 miles...	July 14th, 1903.
17,754	1	Cape Point, E. by N. 35 miles ...	Sept. 9th, 1903.
16,690	1	Cape Point Lighthouse, E.N.E. 30 miles	June 22nd, 1903.
17,761	3	Cape Point, N.E. by E. 38 miles ...	July 23rd, 1903.
17,078	1	Cape Point, N.E. by E. 34 miles ...	July 21st, 1903.
16,980	1	Cape Point, N.E. by E. 36 miles ...	July 15th, 1903.
16,826	1	Cape Point, N.E. by E. ¾ E. 38½ miles	July 8th, 1903.
16,798	1	Cape Point, N.E. by E. 36 miles ...	„ „
17,284	1	Cape Point, E. ¾ N. 46 miles (D. R.) ...	Aug. 18th, 1903.
18,048	1	Cape Point (approx.), N.E. 40 miles ...	Sept. 17th, 1903.

Egg.					Larva.				
Oil Globule.	Diameter of Egg.	Diameter of Oil Globule.	Pelagic (P) or Demersal (D)	Remarks.	Position of Oil Globule.	Position of Rectum.	Notochord.	Pigment, &c.	Species.
	·79	·11	P	Smallest egg with 1 oil globule	Posterior	Anterior	Unicolumnar	Red pigment on body, fins and yolk	Species XI. (Arnoglossus capensis ?)
	·81 (?)	*·16 (?)*	*P*	...	*Anterior*	*Anterior*	*Multicolumnar*	*Slight*	*Species VI.*
	·88—·82	*·19*	*P*	...	*Posterior*	„	„	*Moderate, on body*	*Chrysophrys gibbiceps*
	·88	*·16*	*P*	...	*Ventral*	„	„	*Slight*	*Pagellus mormyrus*
	·89	·15	P	...	Posterior	Anterior	Multicolumnar	None	Species XII.
	·89—·85	*·17*	*P*	...	*Posterior*	*Anterior*	*Multicolumnar*	*Moderate, on body*	*Chrysophrys globiceps*
	·91—·82	*·2*	*P*	*About 10% have two oil globules*	„	„	„	(?)	*Sciæna aquila*
	1·1—·93	·19—·2	P	...	...	...	...	...	Pagrus laniarius
One ...	1·15—1·06	·27—·29	P ?	Polygonal markings	...	Anterior ?	...	Black branching cells from head to tail (in formalin)	Macrurus fasciatus
	1·21—1·07	*·23*	*P*	*Yolk early pigmented*	*Ventral*	*Anterior*	*Multicolumnar*	*On body and fins*	*Trigla Kumu*
	1·32—1·3	·31—·26	P ?	Polygonal markings	...	...	...	...	Macrurus parallelus
	1·44	*·29*	*P*	...	*Anterior*	*Median*	(?)	*Abundant on body and fins*	*Species IV.*
	1·7	*·2*	*P*	*Large perivitelline space*	*Postero-ventral*	*Posterior*	*Unicolumnar*	*Very little*	*Species III.*
	1·7	·33	P	Yolk vesiculate	Posterior	Posterior	Multicolumnar	No pigment, anterior curvature	Species XIII.
	1·7	·38	P	„ „	„	Anterior	„	Black tufts on fins	Species XIV.
	1·87	·42—·38	P	Clear dots on surface (constant ?)	„	„	„	Yellow tufts on fins	Species XV.
	1·91—1·7	·25—·21	P	Gelatinous envelope	...	...	...	...	Species XVI.

KEY TO EGGS AND LARVÆ OF SOME SOUTH AFRICAN FISHES.—*Continued.*

Egg.					Larva.				
Oil Globule.	Diameter of Egg.	Diameter of Oil Globule.	Pelagic (P) or Demersal (D)	Remarks.	Position of Oil Globule.	Position of Rectum.	Notochord	Pigment, &c.	Species.
Several	·85— ·81	...	P	...	...	Anterior	...	...	Stromateus microchirus
Several	·81— ·72	·15— ·04	P	*From 1 (rare) to 12 oil globules*	...	,,	...	Yellow pigment abundant on all parts except extremity of tail	*Synaptura pectoralis*
Many ...	1	...	D	*Not pigmented.*	...	*Anterior*	Multicolumnar	*Abundant, on body*	*Species I.* (Gobiesocidæ)
Many ...	1	...	D	*Dark blue in colour*	...	,,	*Multicolumnar*	*Very little*	*Species II.*
Many ...	1·24	...	In pouch of male	Yellowish red	...	...	...	...	Syngnathus acus.
Many ...	1·32	...	P	...	...	Anterior	Multicolumnar	Embryo and yolk with branching yellow pigment cells protuberance over head	*Species VII.*
Many ...	1·57	...	P	Red pigment appears early on embryo	...	,,	,, (?)	Abundant red pigment	Species XVII.
Many ...	1·7	Largest ·72	Viviparous	Deep red	...	Median	,, ,,	Black (in formalin)	Cataetyx messieri.
Many ...	1·78	...	P	Embryo and yolk sac with branching yellow cells	...	Anterior	*Multicolumnar*	*On all parts*	*Species X.*

KEY TO EGGS AND LARVÆ OF SOME SOUTH AFRICAN FISHES.—*Continued.*

Egg.					Larva.				
Oil Globule.	Diameter of Egg.	Diameter of Oil Globule.	Pelagic (P) or Demersal (D)	Remarks.	Position of Oil Globule.	Position of Rectum.	Notochord.	Pigment, &c.	Species.
	·76— ·72	...	P	Smallest egg	...	Anterior	Unicolumnar	Faint yellow on all parts	Species XVIII.
	·98	...	*P*	...	...	*Anterior*	*Multicolumnar*	*Dense on yolk and larva*	*Species* I.
	1·02— ·91	...	*P*	...	...	...	...	...	*Achirus capensis*
	1·06	...	*P*	Vesiculated	...	*Posterior*	*Unicolumnar*	*A few black spots on body*	*Species VIII.*
	1·83—1·74	...	P	Markings on vitelline membrane	...	Anterior	Multicolumnar	...	Agriopus spinifer
Absent	1·87—1·72	...	P	White, opaque	...	(?)	(?)	Yellow spots on embryo	Species XIX.
	2	...	(?)	*In a cluster*	...	...	...	...	*Species IX.*
	2·76—2·1	...	P	Minute dots over surface, vitelline circulation	...	Median	(?)	Blue on head & body	Scombresox saurus.
	2·97—2·64	...	P	Large perivitelline space, vesiculated yolk	...	,,	Multicolumnar	No pigment, elongate yolk	Species XX.
	4·2 —4	...	P	...	...	,,	,,	Dorsal prominence	Species XXI.

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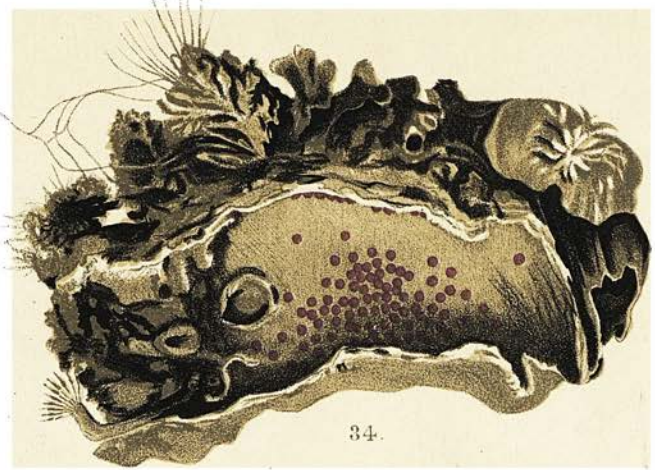
PLATES AND EXPLANATIONS OF PLATES.



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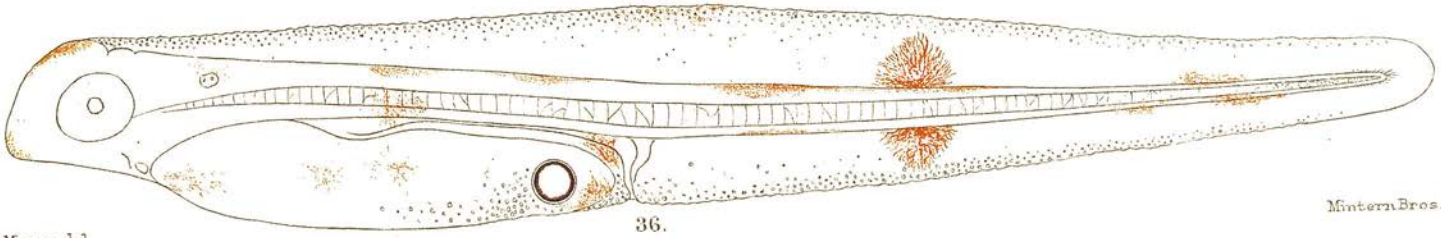


36.

P.McManus del.

Mintern Bros. lith.

Plate V.

Fig. 34. Dead barnacle shell laid open to show blue eggs of Species II. (nat. size.)

„ 35. Single egg of Species II. enlarged and showing numerous oil globules.

„ 36. Larva (newly hatched) of Species XI. (*Arnoglossus capensis*, Blgr.) Nat. size 2·59 mm.

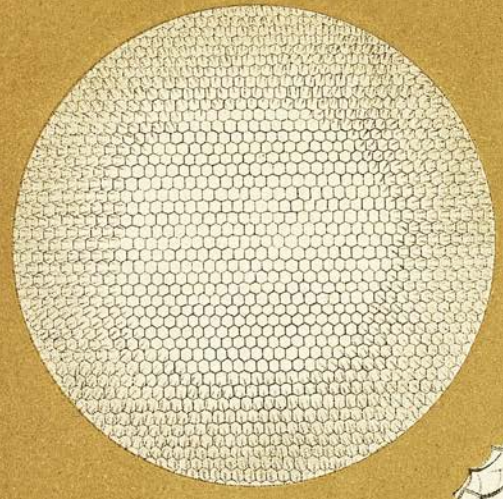
Plate VI.

Fig. 37. Egg of *Macrurus fasciatus*. Nat. size, 1·1 mm.

„ 38. Side view of part of egg capsule of *Macrurus fasciatus*, showing polygonal markings and pillars.

„ 39. Egg of Species XVI. by transmitted light. Nat. size, 1·8 mm.

„ 40. „ „ „ by reflected light. „ „ „



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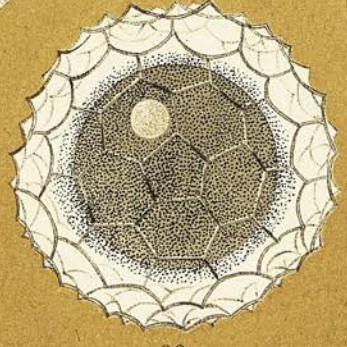

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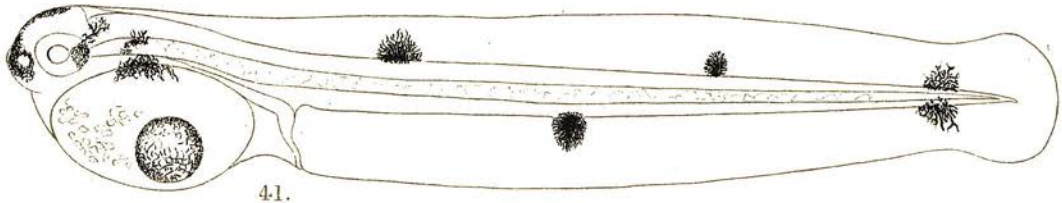

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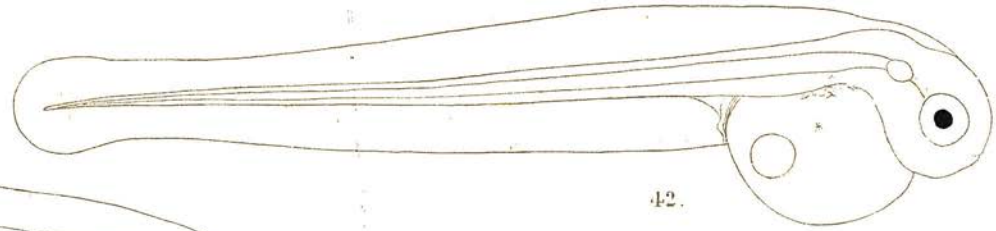

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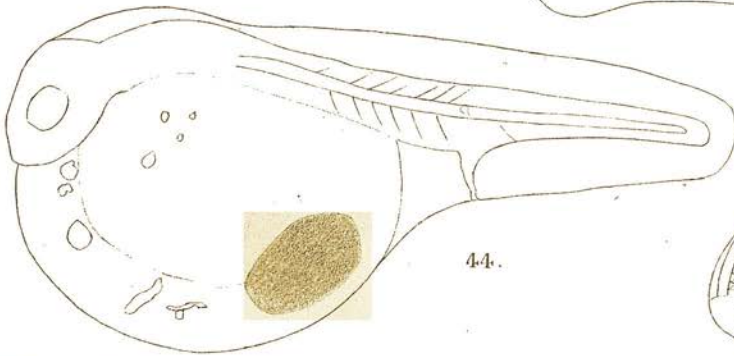

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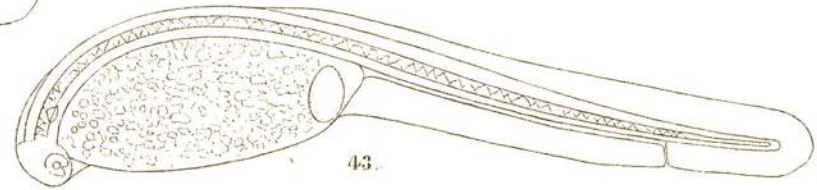

43.

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Mintern Bros lith.

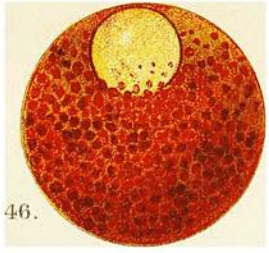
Plate VIII.

Fig. 45. Egg of Species XVII. Nat. size, 1·57 mm.

„ 46. „ „ *Calactyx messieri*, Gunth. Nat. size, 1·7 mm.

„ 47. Larva (newly hatched) of Species XVIII. Nat. size, 1·74 mm.

„ 48. „ „ „ „ One day older.



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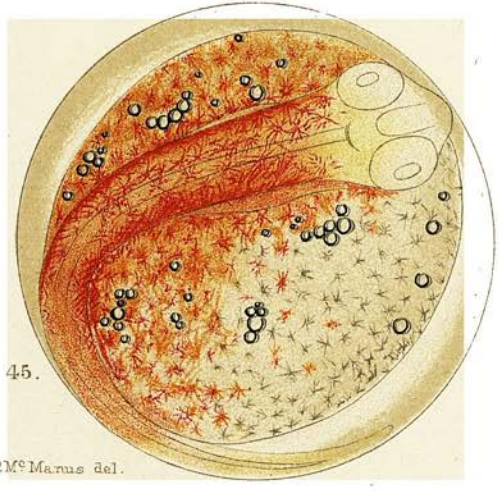

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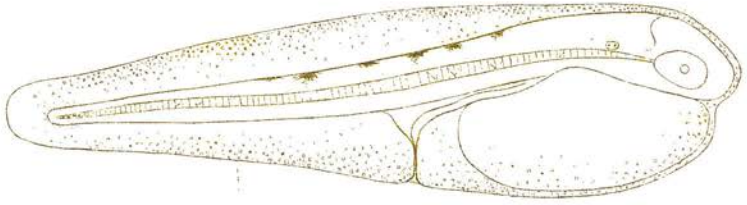

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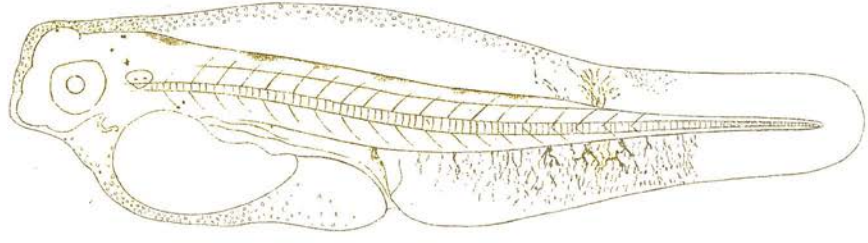


48.

Mintern Bros. lith.

Plate VIII.

Fig. 45. Egg of Species XVII. Nat. size, 1·57 mm.

„ 46. „ „ *Catatelyx messieri*, Gunth. Nat. size, 1·7 mm.

„ 47. Larva (newly hatched) of Species XVIII. Nat. size, 1·74 mm.

„ 48. „ „ „ „ One day older.

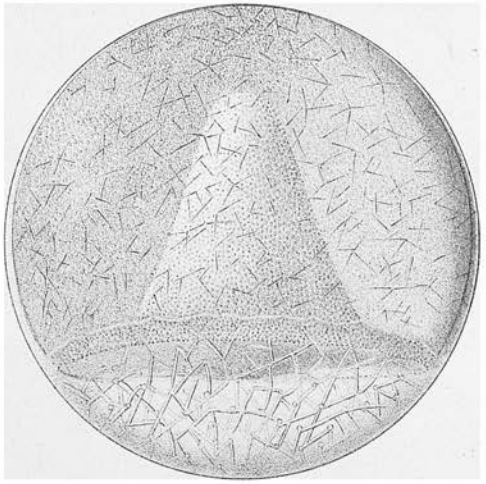
Plate IX.

Fig. 49. Egg of *Agriopus spinifer*, 24 hours after fertilization. Nat. size, 1·8 mm.

„ 50. Larva of *Agriopus spinifer* taken from egg 4 days after fertilization.

„ 51. „ (newly hatched) of Species XX. Nat. size, 6·9 mm.

„ 52. „ of Species XXI. taken from an egg about 19 days after fertilization.



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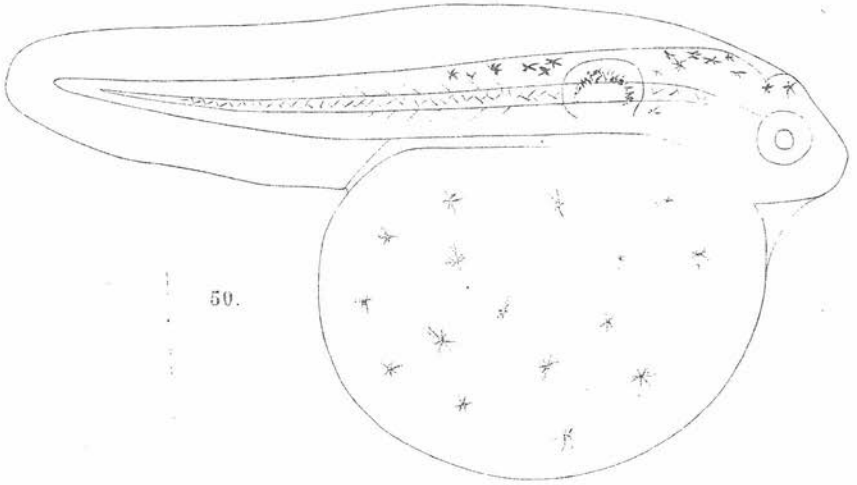

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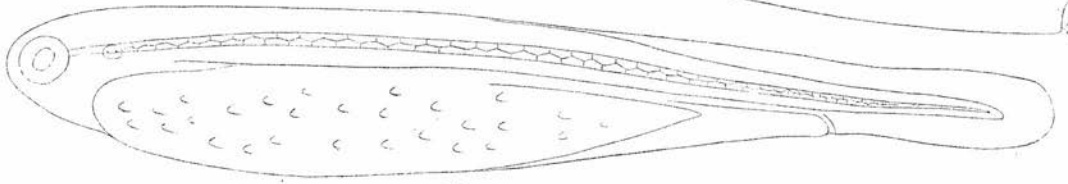

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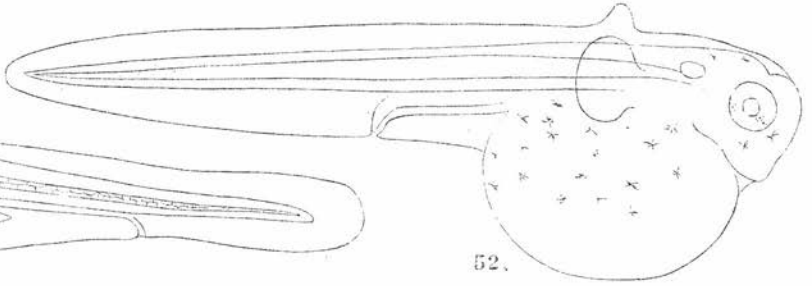

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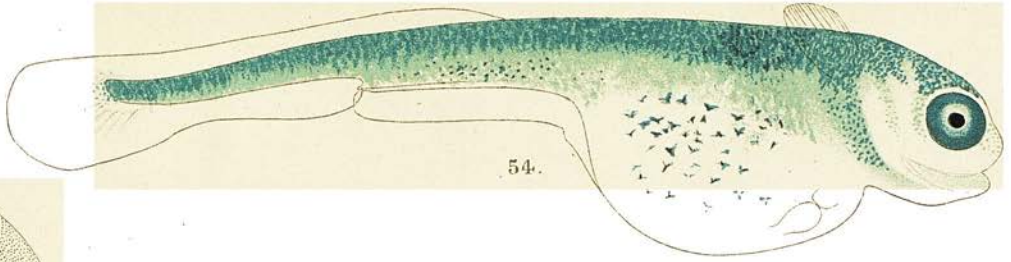

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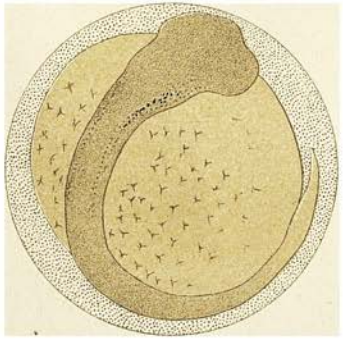

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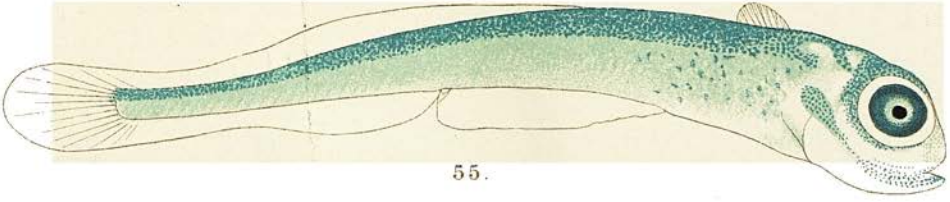

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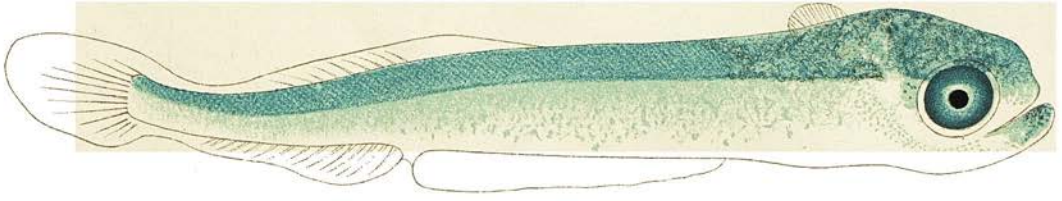

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Plate X.

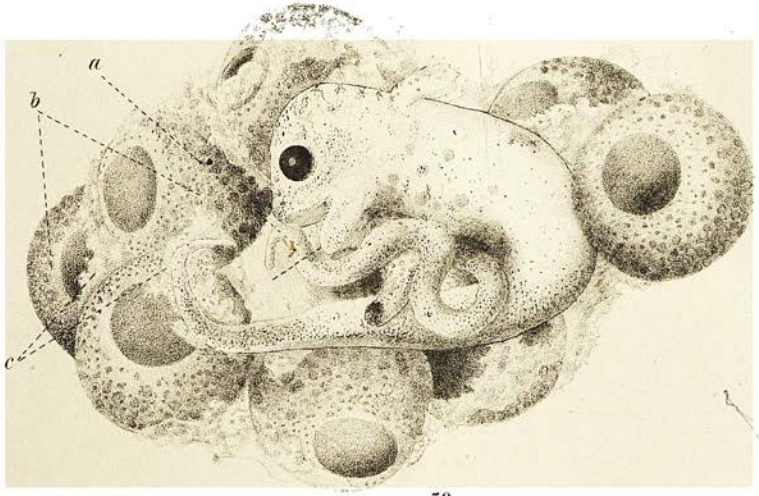
Fig. 53. Egg of *Scombresox saurus*, Walb. Nat. size, 2·6 mm.

„ 54. Larva (newly hatched) of the same. Nat. size, 8·5 mm.

„ 55. „ (three days after hatching) of the same.

„ 56. „ (about six days after hatching) of the same.

57.



58.

P. McManus del.

Mintern Bros. lith.