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Intermediate between *P. leptalina* (= *pisonis*) and *P. pandosia*, but nearest to the latter; the primaries with wider and less deeply incised black external area above; below with five submarginal white spots; in the secondaries below the brown apical spur is carried, as a subcostal band, to the inner margin close to the base, as in *P. leptalina*.

Expanse of wings 47 millim.

Two males, Rio Dagua, Colombia (*W. F. H. Rosenberg*).

In typical *P. kichaha*, from Honduras, the orange macular submarginal stripe on under surface of secondaries appears to be confined to the apex of these wings, which doubtless led Reakirt to compare his type with *P. marana*.

VI.—*Notes from the St. Andrews Marine Laboratory.*—
No. XVI. By Prof. M'INTOSH, M.D., LL.D., F.R.S., &c.

1. On the Ova, Larval, Post-larval, and Young Forms of *Rhombus maximus*, with Remarks on the Adults in Confinement.
 2. On the Ova and Larvæ of *Drepanopsetta platessoides*.
 3. On the Spawning-period of *Agonus cataphractus* and the Vitality of its Ova.
 4. On the Post-larval Stage of *Crystallogobius Nilssonii*.
 5. Note on Injuries to Oysters by Boring Forms.
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1. *On the Ova, Larval, Post-larval, and Young Forms of Rhombus maximus, with Remarks on the Adults in Confinement.*
- No form has been the cause of greater uncertainty in regard to eggs, larval, and post-larval stages than this species. Yet ripe ova were first obtained during the trawling expeditions in July 1884 in a female of 12 lbs. Neither then, nor in 1892, when Mr. Holt found another ripe female on the pontoon at Grimsby, could a male be procured; but the latter naturalist subsequently was more successful, hatched the fertilized ova, and gave the first accurate account * of the larval fishes, though none lived more than a few days after escaping from the egg. Recently Dr. Canu †, who is carrying out fishery investigations for the French government at the Marine Station of Boulogne-sur-Mer, was able to fertilize the eggs and make a brief note of the development. The perseverance

* Journ. Mar. Biol. Assoc. vol. ii. n. s. p. 399.

† Ann. Stat. Aquic. Boulogne, 1893, p. 131.

of Dr. Fulton and the practical skill of Mr. Harald Dannevig at the Dunbar hatchery of the Fishery Board have at length made it possible to give a more complete account of the development of this important fish. It is remarkable that few, if any, eggs of the turbot are found in our inshore waters either at the surface, in mid-water, or at the bottom; indeed, it is one of the ova that has hitherto escaped capture in the tow-nets of the laboratory, closely allied ova having more than once been mistaken for it. This rarity may be due either to its tendency to sink, after a time, to the lower regions of the water, or to the distance of the spawning-grounds from the coast. The ripe season would seem to extend from the beginning of June to the end of July at least, and probably overlapping both periods.

The ripe ovum of the turbot has an average diameter of 1.0287 millim., and the single oil-globule it contains measures 0.21 millim.* On extrusion the healthy ova are perfectly buoyant, floating at the surface of still water or suspended in mid-water. In some instances, however, at Dunbar many of the eggs went to the bottom, probably because changes had occurred by long retention in the ovaries. The capsule (*zona radiata*) is very distinctly wrinkled both in the fertilized and in the unfertilized condition, indeed quite as much as in the lemon-dab. The oil-globule presents no special tint, and retains a nearly uniform diameter in all the specimens, as Mr. Holt has already noticed. When the eggs were in mass the latter observer was of opinion that the oil-globule gave a faint ochreous hue to the whole. Like other forms these ova are sensitive in the early stages and with difficulty bear a journey, especially in warm weather, and it would be well in such cases to delay transmission until the blastopore has closed.

Ova fertilized at 6 A.M. on the 22nd June were in the multicelled condition at 6 P.M., but the disk showed certain peculiarities, the result of the journey by rail from Dunbar to St. Andrews in glass vessels, thick earthenware jars being much better for transport. Thus many of the marginal cells of the disk were much elevated and the nuclei clearly defined as slightly pinkish bodies by transmitted light. Numerous free nuclei were in the periblast. It seemed as if a somewhat abnormal activity, due to external conditions, had ensued, a view the more probable since the entire series perished before next morning.

Another series of ova, fertilized on June 21st at 5 P.M., and

* Wenkebach gives the diameter of the egg as .75 (*vide* Cunningham).

which bore the journey and the heat more satisfactorily, presented at the twenty-fourth hour, viz. about 5 P.M. on the 22nd, the germinal cavity and shield. As the embryo became outlined next day (23rd) a tendency to the formation of numerous large vesicles, at the ordinary site of Kupffer's, as well as extending forward along the body in groups, was a conspicuous feature. How far this condition was due to the vicissitudes the ova had encountered is an open question, but it was pronounced. On the 24th June the embryo was distinctly outlined with optic vesicles, lenses, cardiac thickening, and other features, while the large vesicles above mentioned were fewer. Moreover in some a series of chromatophores were thickly dotted along the trunk and a few over the brain, but no colour was yet visible under a lens, though the embryo was indicated by a distinct opacity.

On the 25th June the ova presented a slightly reddish hue under a lens. It was also interesting to note that the diameter of some of them had increased in the direction of the long axis of the embryo, so that they were ovoid. The head and body were studded with rounded reddish (ruby-red by transmitted light) chromatophores, some, however, being only slightly tinted; they likewise extended over part of the yolk. The protoplasmic investment of the oil-globule had a few black specks. The otcysts were well formed, the lenses distinct, and the heart pulsated feebly at intervals. The tail had extended considerably beyond the yolk, yet one or two vesicles occurred on the site of Kupffer's. The yolk had a streaked granular aspect, probably from the development of minute vesicles on the blastodermic surface. The notochord was multicolumnar.

Next day the pigment-corpuscles had a darker ruby-red, and black chromatophores had also appeared. The pectoral expansions were distinct, the vesicles had vanished from the ventral aspect of the trunk, while the tail was longer and had a few black chromatophores near the tip. The black pigment at the oil-globule had increased. The pulsations of the heart were more regular. The yolk had considerably diminished, and thread-like processes projected here and there from its margin. Only a few red chromatophores existed on the minute vesicular yolk-sac. The black corpuscles seemed to form a band along the margins of the body superiorly and inferiorly.

On the 27th June the colour under a lens was brick-red, from the branching of both red and black chromatophores. The eyes were somewhat darker and the yolk had still further diminished.

Most of the ova hatched about the sixth or seventh day—the same period being mentioned by Mr. Holt—the larva measuring about 2·2 millim. in length or a little more. The increase in the red pigment was characteristic, the body under a lens having a brick-red hue, with blackish chromatophores scattered over the surface. The rounded reddish chromatophores of the embryo were now (in the larva) much branched on the head, trunk, two caudal bars, and the rectal process, and some had appeared around the oil-globule and at the throat, as well as in the cardiac region. The two brownish bars at the tail had a somewhat triangular or bluntly conical form, and extended from the trunk to the border of the marginal fin. A slight patch also occurred in the latter dorsally, about midway between the caudal bar and the head. The reddish pigment at the rectum passed downward to the termination of the gut and abruptly ceased, a pale strand of tissue being continued from it to the edge of the marginal fin. The heart lay somewhat low in the subopercular region, which was deeply pigmented. The finely ramified black chromatophores covered the entire region tinted reddish, so that only the middle of the yolk-sac was translucent, and even on this were a few much-branched red corpuscles. The ventral surface of the yolk-sac, as well as other parts, had numerous black chromatophores. By transmitted light the reddish parts had a fine ruby-red hue. The eyes had a similar colour, a few dark touches also being present. The abundance of pigment obscured the otocysts and their two otoliths. Even at this stage the larval fishes darted about at intervals, after resting on the bottom or float with the yolk-sac uppermost and the tail inferior. In Mr. Holt's examples the oil-globule was ventral in position, but in ours it occupied a more or less posterior position.

After two days the pigment in the eyes had increased and they were slightly iridescent. The black chromatophores over the body were more abundant, while the bars behind the vent were broader, especially the superior, which almost touched the margin of the fin. The mouth was open and the mandible was prominent. The oil-globule adhered to the remnant of the yolk—nearly in the middle of the abdomen, though slightly variable in position—in some having moved upward and backward with the diminishing yolk.

On the 1st of July the larval turbot evinced greater activity, darting through the water at intervals and again resting on the bottom. The increase in the black pigment rendered the body dusky brown. The two posterior bars had spread out, and finely ramified black pigment existed in both. The mid-

dorsal patch now touched the body-line, and it also presented a few black chromatophores. The same brownish hue tinted the marginal ridge over the head and snout. The black pigment rendered both dorsal and ventral surfaces dark when viewed on edge, two long blackish bands occurring dorsally, separated by the brownish area in the mid-dorsal line. The skin was finely dotted with minute vesicles. The eyes had a greenish iridescent lustre. The marginal fin continued as a prominent border over the vertex to the tip of the snout; this fin was still proportionally broad, though the body had lengthened to fully 3.46 millim. No fin-rays were yet visible in the caudal expansion. Movements of the mandible and of the hyoidean apparatus occurred occasionally. The pectoral fins had considerably increased in size and were used in balancing. The clavicular bar was also evident. The oil-globule was seen with difficulty, but in diminished size; it was, with the remnant of the yolk, in some near the lower border of the abdomen. A feature of moment in these larval turbot was their hardihood, for after exposure on a slide in a few drops of water for two hours they became active when transferred to their vessel.

The yolk was entirely absorbed on the 3rd July, that is about the seventh day. The marginal fin over the head had increased in depth and the black and other pigments had ramified outward in all directions at its inner border. The caudal expansion showed faint embryonic rays. Blood-vessels with pale blood were now observed, *e. g.* the sub-intestinal, coursing upward in front of the rectum and passing towards the liver, and the subnotochordal trunk (aorta), which could be traced backward to the inferior line of pigment behind the posterior brown bars.

With the disappearance of the yolk the turbot may be considered to have attained their early post-larval condition, and they swim throughout the water by rapid strokes of the tail and vibrations of the pectorals. In still water they often remain suspended with the head downward; but there can be little doubt that, like the plaice observed by Mr. H. Dannevig, they would luxuriate with their heads directed to the current in the fresh streams of water either in the open sea or in the apparatus at Dunbar. The body of the little fish was dull reddish (more or less ruby-red) by transmitted light, but by reflected light it had a dull ochreous or pale brownish hue and finely marked with black. The outer margins of the two dorsal patches were paler, and the pigment immediately behind the prominent posterior bars was also pale, these lighter touches being very evident during the vigorous move-

ments of the animals. The abdomen was deeply pigmented all over with black. The head and anterior region were conspicuous both from the great depth of the opercular region and the development of pigment on the abdomen, so that the aspect was somewhat like that of a tadpole. The eyes were greenish silvery. The pectorals were large and fan-shaped, with reddish and black pigment at the base, the latter extending outward into the fin as long branching lines, which resembled very much the ramifications of rivers in a map. The angle of the mandible projected prominently downward, as it were enclosing the anterior hyoidean region in a deep furrow. The vent now gave passage to minutely granular matter.

Besides the movements above noted the little turbot occasionally swam at the surface on their sides, skimming along with rapidity and moving the hyoidean region actively. They were quick in observing the movements of the minute crustaceans and other forms in the vessel, and seemed to dart at them for food. No form hitherto observed at St. Andrews appeared to be more hardy or to undergo the vicissitudes of temperature and manipulation with greater impunity. There are grounds, therefore, for expressing the hope that they may yet be reared in great numbers from the post-larval to the adolescent and adult conditions in suitable enclosures.

Larval turbot are seldom caught in the tow-nets, though from a figure * of Prof. Marion's either this or the brill occurs off Marseilles on the 2nd of March. Mr. Holt, again, was fortunate in procuring at the surface of the North Sea a series of post-larval forms ranging from 5.50 to 16.25 millim. In these the snout is short and obtuse and the angle of the mandible acute. The tail is narrow and the belly prominent in the smallest example. The tail becomes deeper and the abdomen less projecting at 7 millim. At 13 millim. the right eye appears above the ridge. One of the most interesting features is the presence of an armature of spines, best marked in specimens 10-15 millim. long, on the head behind the eye, on the articular region of the mandible, and on the opercular region; these persist till they reach 25 millim., and Mr. Holt has even found traces of them in one example of 175 millim.

Off the east coast of Scotland pelagic specimens $1\frac{3}{8}$ to $1\frac{1}{2}$ inch occur in July, and in August they increase in size and take to the bottom. Thus by aid of a net for capturing sand-eels a series ranging from 41 to 62 millim. were taken at the margin of the estuary of the Eden on the 7th September.

* Ann. du Mus. d'Hist. Nat. Marseilles, iv. 1, pl. ii. fig. 20.

The size, however, was variable, for others taken on the 15th reach only $1\frac{3}{4}$ inch. Increasing in size, they were found 3 inches long close inshore on sandy ground by the same net worked from the land by aid of a boat in the middle of December. In February some were 6 inches, but others in April were only $5\frac{1}{4}$, while one on the 23rd May only reached $2\frac{3}{8}$ inches. The last would seem to have been an example from an egg spawned very late or to have been arrested in growth. As a rule they reach 6 or 8 inches in June, while in September many are captured in 3-5 fathoms from $9\frac{1}{8}$ to $9\frac{1}{2}$ inches, the latter apparently representing the growth from the previous spawning-season, or a period of about fifteen months.

Thereafter the turbot seeks the offshore waters, the deeper parts of which form its home and its breeding-grounds.

This large and active fish presents certain difficulties in regard to voluntary spawning in confined areas—as, for instance, in the ponds at Dunbar. Though apparently at home in the pure sea-water, through which they skim with much dexterity and ease, and readily feeding on herrings and sand-eels, they have hitherto refused either to shed milt or ova without artificial aid; so that the experiment is much less successful than with the plaice, which spawns so freely. Moreover, in confinement the turbot is liable to ulceration of the surface on the opercular region of the right side and on each margin of the same surface at the tail. Such injuries are probably due to friction against the bottom or sides of the pond, and even though the bottom is covered with sand the ulcers have a tendency to form.

When, however, the eggs were obtained and duly fertilized no difficulty was found in hatching them, for the Dannevig apparatus at Dunbar causes a constant and equable movement. Thus the tendency to sink, observed by Mr. Holt and others, is counteracted.

The turbot, like other flat fishes in confinement, are prone to a disease which, in common language, may be called "egg-bound,"—that is to say, though they have pure sea-water, a certain space, the presence of males, and abundant food, yet they refuse to shed their ova. This condition, indeed, was specially referred to in the case of the flounder some years ago*. Though the ovaries are largely distended with ripe ova or ova that have been ripe, occlusion of the ducts by spasm or otherwise prevents their issue, and in some instances causes the death of the fish. In the ovaries of the female

* Third Ann. Report Scot. Fish. Board, 1885, p. 62.

turbot at Dunbar degeneration had taken place to a considerable extent on the 7th September. In the centre of the enlarged ovary was a space filled with glairy mucus, containing degenerating ova which had formerly been fully matured. The mucus was mixed with fatty débris and granules, with shrunken egg-capsules. The fishes were evidently getting rid of the eggs of the season, chiefly by disintegration and absorption, while in the walls of the ovary a crop of minute ova were developing in a healthy condition and having a diameter of about $\cdot 0762$ millim. Between the foregoing date and the beginning of April considerable change had taken place in the ovaries; thus, out of five examples only one had many degenerating ova on the ovarian walls, the capsules being wrinkled, collapsed, and opaque, while the contents consisted of minute granules of yolk and oil-globules which by transmitted light had a slightly yellowish colour. In the majority the capsule had ruptured and permitted the contents to escape. The wall of the ovary itself consisted of rugose laminæ, chiefly longitudinal in the elongated posterior region, or slightly oblique anteriorly where trending to the oviduct. These laminæ were covered with developing ova, the largest ranging from $\cdot 2286$ to $\cdot 3810$ millim., thus considerably exceeding in size those of September. The anterior region of the ovary appeared to be somewhat thicker than the posterior and the ova slightly larger; but this may have been accidental. The oviduct was occupied by a mass of degenerating ova. Of the other four, three had a few degenerating ova between the folds of the ovaries and one had got rid of the whole. All showed healthy developing eggs in the ovaries, though the size was less than those of the first-mentioned specimen. Under these artificial circumstances, therefore, the retained ova are got rid of very slowly; but such a condition probably never takes place in the sea. It is, at any rate, clear that the environment of the turbot at Dunbar had been favourable for the development of the ovarian ova and that, initial difficulties being overcome, it may yet be possible to retain the spawning fishes from season to season. When they become accustomed to confinement and find themselves in favourable surroundings the "egg-bound" condition, which is voluntary, may disappear.

2. On the Ova and Larvæ of *Drepanopsetta platessoides*.

During the trawling expeditions of 1884 an egg was frequently found in spring, especially during March and April, which was distinguished from all others by the large size of

the perivitelline space—that is, the space within the transparent capsule or zona in the early stages of the egg. It was mentioned in the report on trawling that these ova were one third larger than the majority of the pelagic eggs, and resembled hydropic ova. The latter condition, however, was only apparent, and they were in all respects healthy, the advanced embryo with its yolk-sac lying in the centre of the transparent capsule. These eggs were widely distributed all along the eastern coast from the south of St. Abb's Head to the Moray Firth, so that they evidently belonged to a common species. Though ripe long-rough dabs were seen in the dead condition in March 1884, and the eggs observed to be pelagic, yet, as this occurred during a violent storm, no opportunity was available of doing more than noting their condition, which, on issuing from the ovary, differs, as will by-and-by be shown, from their subsequent state, and thus the connexion between them and the foregoing was not made out. Every season (viz. in March, April, and May) since that date these eggs have been brought in greater or less numbers to the Marine Laboratory and hatched. A figure of the same egg was also shown me by Mr. J. T. Cunningham in 1885, but he likewise had not ascertained the form to which it belonged, for in 1887* he observes that he had not been able to hatch it and that no similar egg had been obtained from an adult fish. Further remarks on the egg and newly-hatched larva were made in the "Pelagic Fauna of St. Andrews Bay"†; the advanced embryo tending to the upper arch of the egg in floating, and presenting along the sides minute yellowish (chrome) and black chromatophores, which in most cases were still unbranched after hatching. In the "Researches"‡ the same egg was again alluded to, and the early post-larval fish figured. It "presents three distinct yellowish bars behind the vent, another at the latter, and a line along the dorsum of the intestine, besides various touches of the same on the head and elsewhere. Stellate black chromatophores occur along with the yellow, and in the early condition are present on the yolk. The eyes soon assume a silvery aspect. The larval fish is active and comparatively large, resembling in certain respects the plaice. It is probably a pleuronectid."

When surveying the fishing-grounds off the west coast of Ireland with Mr. Green and Prof. Haddon in 1891, Mr. Holt

* Trans. Roy. Soc. Edinb. vol. xxxiii. p. 105, pl. vii. fig. 2.

† Seventh Ann. Report Fishery Board for Scotland, p. 270, pl. iii. figs. 1-3 (1889).

‡ Trans. Roy. Soc. Edinb. vol. xxxv. pt. iii. p. 853, pl. xviii. fig. 2 (Feb. 1890).

found that these eggs pertained to the long-rough dab, and thus their comparative abundance was readily explained. A similar relationship had been suspected at St. Andrews, since the ova of almost all the other pleuronectids except the halibut had been examined. These ova are especially abundant on the fishing-grounds to the east of the Island of May. So far as my experience goes they chiefly abound in March, rarely a few occur in February, and in all probability, though nearly ripe, none are discharged before January. Off the west coast of Ireland Mr. Holt found the adults spawning during the same months, viz. from March to the beginning of May.

It is remarkable that the obscurity surrounding the eggs of so common a fish should have remained so long. In a recent Scandinavian work * nothing more definite than hearsay evidence is afforded, though the statement of the fishermen of Bohuslän that the roe runs in February and that the fish is spent by the month of March is near the truth. Moreover, comparatively small specimens, both male and female, attain maturity.

By the energy of Dr. Fulton, Scientific Superintendent of the Fishery Board for Scotland, a large consignment of living specimens was forwarded to the Laboratory in excellent condition this spring, so that an opportunity was given for a re-examination of the development of this species. The ripe females ranged from 7 to $13\frac{1}{4}$ inches, and all were distinctly distended with the enlarged ovaries. Moreover, as they lay on the dark bottom of the tank the prominent ovarian region of the coloured surface was readily distinguishable as a broad pale pinkish streak. Some of the females were also marked with white touches, generally in pairs over the interspinous regions dorsally and ventrally, very much in the position the dark touches hold in the pelagic post-larval forms. The males, on the other hand, were much smaller, ranging from $5\frac{1}{4}$ to $6\frac{3}{4}$ inches in total length, and presenting little or no distention—a fact due to the minute size of the testes, which are wholly confined to the abdominal cavity, and are only about $\frac{1}{2}$ to $\frac{3}{4}$ of an inch in length in a male of $6\frac{3}{4}$ inches. No larger male occurred in this collection, which consisted of nearly sixty specimens, so that the question may be raised as to the reasons for the limitation of the size of this sex and the small size of the male organs.

Most of the females were very ripe, and a considerable quantity of ova escaped on the slightest pressure and fell in

* 'Scandinavian Fishes,' Fries, Ekström, and Sundevall (2nd edit., 1893).

a mass into the water, and then slowly mixed with it. In the experiments made in the laboratory the smallest trace of milt fertilized every egg in the vessels, which were about a foot across, so that the activity of the sperms was characteristic. The quantity of ripe ova discharged at a given time was quite as large in proportion as in the plaice, in the turbot, and in the flounder. Fishes in which the testes are small, as in the torsk, plaice, long-rough dab, and sole, do not appear to differ much, in regard to the rapidity of issue of the ripe eggs, from those with large testes. The small size of the testes in the horse, compared with the large size of the testes in the porpoise, is another instance of the caution requisite in drawing conclusions on this head. At any rate, in regard to fishes the ascertained facts up to date do not seem to warrant strong statements on the subject. The ripe female sole in Scottish waters discharges a considerable number of eggs, and a large number are also emitted by the ripe lemon-dab. The quantity of ripe eggs which issue from a torsk is about as large in proportion as in a cod, yet the testes of the two differ much in size.

The egg of the long-rough dab, on issuing from the oviduct, is beautifully translucent, and measures from 1.0668 to 1.1430 millim. The *zona radiata* clings somewhat closely to the contained yolk, and is wrinkled all over, quite as much as in the lemon-dab. The perivitelline space is small, and thus differs from the condition as ordinarily seen in the tow-nets. As a rule the yolk, or egg proper, has a diameter of 1.0668 millim., while the capsule has a diameter of 1.1430 millim. When placed in sea-water, and whether fertilized or not, a gradual change takes place in the perivitelline space, so that next morning, that is, in twelve hours, the diameter of the capsule is from 1.7907 to 1.8669, probably by the imbibition of water, as in the case of desiccated eggs, while the diameter of the egg proper in the centre remains nearly the same. This distention removes many of the wrinkles from the surface, but not all, since these were visible in almost every example up to the period of hatching. Many of the eggs had groups of minute fatty granules dotted all over the yolk. Next day (22nd March) at 12.30 considerable progress had been made, the disk being in the multicelled condition, the cells of the blastoderm being often prominent, and at 5.40 P.M. much more finely divided. The minute granules of oil occur over the yolk, beneath the protoplasmic investment, and they appeared to be fewer next day, so that probably they were gradually used up in the process of development. The minutely cellular disk presents an inward curvature at its

edge, which is not quite regular, from the occurrence of minute projecting cells. The disk does not always occupy the centre of the yolk under examination. Occasionally a group of large oleaginous globules lies under the developing disk, not at the uppermost pole of the egg.

On the 24th the embryo was outlined, with the optic enlargements. The blastopore in some was almost closed, and Kupffer's vesicle was represented by a few granules or minute vesicles. The notochord formed a pale streak extending forward to the middle of the trunk, and the margins of the body were faintly indicated.

Next day the blastopore had closed and Kupffer's vesicle was large. Numerous muscle-plates had formed and the notochord could be traced forwards almost to the head. On each side a delicate cellular border stretched backward outside the muscle-plates. The granules had now disappeared from the surface of the yolk.

On the 26th March the embryo resembled Mr. Holt's fig. 58, pl. vii. *, and traces of blackish pigment appeared along the body, best seen by placing white paper beneath the specimens. Besides, there are in some the pale precursors of the pigment-specks, which appear blackish by transmitted light. The notochord was visible throughout, the lenses in some were faintly indicated, and the otocysts appeared as elongated thickenings with a longitudinal slit, as in the green cod †. The heart was also distinct. The zona was thin and readily ruptured, even when the egg was carefully lifted.

The following day the blackish pigment formed dark bands, especially when viewed on a white surface, and the next day a faint yellowish tint was visible under a lens. The tail formed a blunt knob projecting beyond the yolk.

The yellowish hue was more distinct on the 30th March. On the head it was somewhat diffused, as the chromatophores had given off branches. The rows of rounded specks along the sides were only faintly tinted. Both yellow and black pigments were present. The latter (black) were very finely ramose on the dorsum of the snout and on the head, as well as behind the otocysts. Distinct muscular twitchings of the body occurred to-day.

On the 1st April the embryo more than stretched across the egg; but in most the pigment corpuscles remained simple. The heart was minutely papillose internally and trumpet-

* "On the Eggs, Larval and Post-larval Stages of Teleosteans," Trans. Roy. Soc. Dubl. v.

† Twelfth Ann. Report Fishery Board for Scotland, pt. iii. p. 219, pl. ii. fig. 8.

shaped. Slow contractions occurred at intervals. Most of the yolk was absorbed, and the alimentary canal formed a pale band in front. The otocysts sometimes differed in size. The day after, most of the yellow chromatophores in some were ramified, so that the colour was diffuse, but in others the pigment-specks remained circular. A few small black points were mingled amongst the yellow along the sides of the body. At this stage the yolk was quite free from pigment.

A few were hatched on 3rd April, and many next day. It is possible that the conditions as regards still water and low temperature may have considerably delayed hatching. A specimen removed from the capsule on the latter date (4th April) differs in some respects from that figured by Mr. Holt, viz. a larva about half a day old, since the pigment is not definitely marked in his sketch. Moreover, the former presented no embryonic rays in the caudal; indeed, these did not appear for some time. Mr. Holt's specimens therefore were probably more advanced at the period of hatching. No mouth is visible and the œsophagus ends blindly in front. With the exception of those on the head the yellow chromatophores are still rounded, though, as a rule, the pigment is branched at or shortly after hatching. In a lateral view the yellow chromatophores are grouped chiefly at the dorsal and ventral margins of the muscle-plates and on the rectum; the tip of the tail is devoid of them. Besides the yellow, very finely ramose black pigment-corpuscles occur on the head and amongst the yellow along the body, but it is not easily seen after the yellow chromatophores become stellate, and in some specimens it is late in appearing. The upper part of the head is chiefly furnished with black pigment. A change must thus ensue before the pigment is grouped into bars, for it is somewhat general at this stage. The lumen of the gut has not entered the oblique portion of the rectum, and the pre-anal region of the marginal fin is small at this stage. A more advanced condition of the pigment was present in a specimen (also removed from the capsule) on the 5th April. Both yellow and black chromatophores are finely branched. The variability in regard to the development of the pigment is further shown in an example three days later, viz. 8th April, in which the pigment has now been grouped in bars—that is to say, at certain parts the extension of the chromatophores is more pronounced than at others. Thus the head and the region of the body proper have yellowish and black pigment, the latter along the dorsal and ventral edges of the muscle-plates, with a special area at the rectum, and three bars behind the latter, that near the tip of the tail being mostly

black, though a few yellow chromatophores are present. The eyes also have pigment-specks; the caudal shows embryonic rays. The yolk has considerably diminished. The otocysts are still elongated from before backward, but present a double outline from the differentiation of the capsule.

The larvæ daily increased in activity and size, and the five groups of chromatophores became very distinct, viz. one on the body over the middle of the yolk, another at the rectum, two conspicuous bars behind the latter (often broken up into a dorsal and a ventral band), and a small fifth near the tip of the tail. In the more advanced and more active larvæ, with the yolk much diminished, the pigment is more continuous. Those with a large amount of yolk swim with a wriggling movement. By reflected light the colour of these larval forms is greenish yellow, and thus it differs from the chrome-yellow of the younger stage. This change of hue appears to be due to the development of the black pigment amongst the yellow. The increase in the size of the pectorals in a few days became marked, and though usually carried more or less obliquely, they were fan-shaped when viewed from above.

The chief changes till the 20th April were the deepening of the marginal fin both dorsally and ventrally and the extension of the chromatophores (both yellow and black) from the line of the body into the marginal fin at the two conspicuous bars behind the vent, and the appearance of stellate black pigment-corpuscles along the ventral edge of the fin. Stellate black corpuscles also occur on the abdomen, and the eyes are bright silvery. The yellow pigment still forms a line over the medulla and the first part of the cord. The caudal pigment-bar is chiefly of black corpuscles, only two or three yellow being present. The pectoral fins are larger and have rays; the upward slant of the mandible and the reduction of the yolk to a small round ball complete the features at this stage.

3. *On the Spawning-period of Agonus cataphractus and the Vitality of its Ova.*

Parnell gives May as the spawning-period of this species. Couch says nothing more than that the spawning-period is stated to be spring; while Day describes a female, 5 inches long, from Southend, in February, as having its comparatively large eggs nearly ripe. In the "Researches" * it was stated that the females caught in the sprat-nets in the Tay

* *Op. cit.* p. 674.

showed nearly ripe ovarian eggs on the 16th December, and that they had a dull golden colour, while the structure of the zona (capsule) is given. The males at the same time showed well-formed sperms. It is added that the species seems to spawn from January (or perhaps December) to April. In the recently published 'Scandinavian Fishes' the authors observe * that "the males are so rare that neither Krøyer nor Ekström has met with a full-grown example; nor, during late years, has the Royal Museum met with a single example. It is probable that it is only during the spawning-season that they live in so shallow water as to be in any danger from the nets used in shore-fishing. The spawning-season is in spring, in March and April or the beginning of May. We have no information as to the way in which the roe is deposited or the development of the fry." So far as our observations go the males are by no means rare, and they accompany the females into the shallow water, and pass into the estuaries of the Eden and the Tay. The remarks published on the subject have escaped the notice of the authors.

The occurrence of a small mass of ova of this species on 1st October, 1894, considerably extends the spawning-period. It was procured at low water near the pier-rocks at St. Andrews, attached to the root of a tangle. The eggs measured from 1·7526 millim. (·0705 inch) to 1·9050 millim. (·075 inch), showing that the ovarian examples mentioned in the "Researches," as, indeed, had often been observed, were nearly ripe. Each egg at this date (1st October) had a large oil-globule and an advanced embryo. The circulation was in active operation on the 27th November, the exterior of the egg being further coated with many parasites. In January and February 1895 the eggs were frozen, and they remained so nearly a month; yet on the 2nd March some of the embryos were alive, and, though the water could not be changed, as the pumping-apparatus was under repair, were safely hatched. The remarkable hardihood of such eggs is in contrast with the pelagic ova, which, as a rule, would have been killed.

The egg-capsule is very tough, and rebounds from the needle under pressure like a ball of india-rubber. Under a low power the torn edge shows layer upon layer of the secretion. It is thus difficult to extrude a perfect embryo.

The larvæ immediately after hatching closely correspond with that captured in the bay and figured by Prof. Prince †. The body is about 7 millim. long, the tail being somewhat

* 'Scandinavian Fishes,' 2nd edit., 1892, p. 210.

† Trans. Roy. Soc. Edinb. vol. xxxv. pl. xviii. fig. 11.

longer than in the sketch, and has embryonic fin-rays. The head has large silvery eyes, with greenish-yellow pigment behind them, and around and below the widely open mouth. The trunk generally is dotted over with the same greenish-yellow pigment (ochreous by transmitted light), which is also present in streaks on the basal region of the pectoral fins, on the yolk-sac, and on the prominent anal cone. The three yellow dorsal patches in the marginal fin are distinctly separated and generally have the distal border opaque white, the first being small and nearly in a line running upward from the posterior border of the vent, the second about the widest part of the fin, and the third about the posterior region of the same dilatation. Opposite the two latter is a corresponding patch ventrally. A similar touch of yellow occurs at the commencement of the tail. Numerous stellate black pigment-spots are present on the yolk-sac, a few on the pectoral, and a series along the dorsal and ventral margins of the body as far as the third patch of yellow on the marginal fin. One or two occur on the border of the marginal fin and a considerable number in the ventral patch of yellow (second) in the latter, while only a very few are found in the dorsal patch opposite it. Two exist in the ventral touch behind the former and only traces in the dorsal patch opposite. One or two chromatophores also occur ventrally in the patch at the root of the tail. The black pigment would seem to be better developed ventrally than dorsally.

In connexion with the appearance of eggs at this period it may be mentioned that on the 10th October a larval form resembling *Cottus* was captured in the tow-net. In general outline it resembled that figured in the "Researches"* (somewhat younger than in fig. 9, pl. xvi.), with the vessels coursing over the yolk-sac. The oil-globule remained at the anterior part of the yolk-sac. Small specks of black pigment occurred along the sides of the body, one set forming a row near the upper lateral region. No distinct coloration was visible on the pectorals. The eyes were iridescent greenish, like the inner surface of *Halietis*.

Hitherto it has been unusual to get larvæ at this season of the year, so that the deposition of such eggs must have been antedated by some months on this occasion if the interpretation of the nature of the larvæ be correct.

* *Op. cit.*

4. *On the Post-larval Stage of Crystallogobius Nilssonii.*

In a former paper* an unknown elongated post-larval form, with prominent teeth and long pectorals, procured on the 20th July, 1889, was described. A further examination of this young fish, which was only 7 millim. long, shows that in all probability it is the post-larval stage of a male *Crystallogobius Nilssonii*, which at that date had only once been found in Scotland, viz. by Mr. Edward, in a rock-pool at Banff. The very early stage at which the special sexual characters occur in this species is interesting; yet Dr. Day considered that in the young males the head is more pointed, indeed almost as in the females, in which the jaws are short, straight, and toothless. It is clear, however, that such a statement requires amendment, especially the supposition that the teeth ("canines") are only developed as maturity is reached. In the small example from St. Andrews it was the presence of these characteristic teeth and the shape of the mandible that attracted attention, and yet the larval marginal fin was still present. The description given in the Ninth Report may be supplemented by the remark that in the adult male the pectoral fins are remarkable for their "broad (multiradiate) and somewhat lobate form, with their semicircular muscular root and elongated roundish shape. When expanded the pectoral fins are as deep as the body." In life they are boldly speckled with black on a yellowish ground, the latter being brightest inferiorly. The remarkable coloration of these fins in the post-larval stage is an addition to the series in developing Teleosteans. When the eyes of a fresh form are examined from above they are finely iridescent and greenish blue; even when seen laterally they are silvery with a bluish sheen. Since this specimen was captured Mr. Cunningham has procured many adults of both sexes near the Eddystone Lighthouse, while Mr. Holt has been equally successful off the west coast of Ireland and on the east coast of England. It appears to be generally distributed round British shores, though the adults have not yet been secured here. It is sometimes found in as great abundance in Norway as in the south of England. The authors (Fries, Ekström, and Sundevall) of the recently published work on Scandinavian fishes observe that June is approximately the spawning-season of this species, and the development of the post-larval example would appear to point to May or early June as the probable period on our shores.

* Ninth Ann. Report Fishery Board for Scotland, pt. iii. p. 332.

5. Note on Injuries to Oysters by Boring Forms.

It is well known that oysters, amongst other attacks to which they are subject, suffer extensively from the burrowing habits of an annelid (*Polydora*), as well as from the borings of a sponge (*Cliona*). Such have been referred to in the 'Annals' by Dr. Hancock and others, as well as the writer. Both forms chiefly attack the upper (convex) valve, which they by-and-by penetrate, rendering its interior unsightly by dark blotches or excrescences. In the case of the Whitstable "native" this is a serious blemish in the interior of the otherwise pearly white valves, the latter feature having been generally looked upon as the distinguishing characteristic of this favoured oyster. It has sometimes been supposed that such inroads, both of annelid and sponge, are due to the impurity of the water caused, for instance, by the dredgers of the Thames depositing their débris in the proximity of the beds. While the latter is objectionable for various reasons, a glance at the habits of the chief depredators makes it probable that the cause just mentioned has little to do with the attacks. Both annelid and sponge perform the functions of universal destroyers of dead shells, calcareous and other rocks, even in very pure water, inshore and offshore. At Whitstable* the chief enemy is *Polydora*, which propagates in the usual manner by eggs and free-swimming larvæ, the latter occurring in great numbers throughout a considerable part of the year. The purer the water the greater the probability, therefore, that these larvæ will settle on fresh sites and extend the colonies of borers. At the same time *Polydora* is partial to inshore localities in which a considerable amount of mud is present in the currents.

It is not easy to get rid of the annelids after they have tunnelled the shells. Even though every oyster were to be treated in a solution, it is clear that what would kill the annelid would also endanger the oyster. It is satisfactory, however, to know that while the marks on the interior of the valves are unsightly, they do not interfere with the qualities of the oyster as food, nor should they be an objection to the serving of the mollusk in the convex valve, as now obtains in London and elsewhere.

* I have to thank Mr. Sibert Saunders for specimens of these.