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III.—On the Ova of Gobius

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was said by Drury and Fabricius to come from Barbadoes, a locality which the recent acquisition of some fine specimens to the British Museum collection proves to have been quite correct. M. Thomson, however, in redescribing the species under the name *Phryneta melanoptera*, ignored the fact that his specimen was ticketed Grenada, and assigned to the species the vague locality "Africa merid." M. René Oberthür, in whose possession Thomson's collection now is, has, at my request, compared Thomson's type of *melanoptera* with Drury's figure and description of *verrucosa*, and has assured me that the two species are undoubtedly identical. The species has not, so far as I know, been recorded from Africa, except, inaccurately, in the case just cited. Its presence in the Antilles can only be explained on the assumption that it was at one time transported from Africa.

In Mr. Fry's collection I have seen specimens from Trinidad and Barbadoes.

III.—On the Ova of *Gobius*. By ERNEST W. L. HOLT,
St. Andrews Marine Laboratory.

[Plate II.]

ON the 13th May, 1890, a dead shell of *Lutraria elliptica* was kindly given to me by Miss Traill, of St. Andrews, who had found it the previous day cast ashore on the West Sands, and whilst removing the sand with boiling water had detected certain foreign bodies adhering to it. This lady subsequently gave me two shells of *Solen siliqua*, collected on the same occasion, with similar bodies attached.

On examining the shell of *Lutraria*, the two valves of which were still united by the ligament, it was found that the inner surface of the left valve was entirely covered, save for a narrow margin, by a number of little whitish bodies.

The valves of both the razor-shells were widely open, and on the inner surface of the valves in each specimen a sub-circular patch of similar bodies (about 2 inches in diameter) occurred.

The whitish bodies, on being submitted to the microscope, proved to be the ova of some Teleostean, and, from certain peculiarities of structure, are conjectured to be those of a goby, probably *Gobius minutus*, by Professor M'Intosh, who has kindly asked me to undertake their description.

The egg is elongated, its long diameter varying from 1·14

to 1.2 millim. The contour is somewhat pyriform and the narrow end (having a diameter from .42 to .48 millim.) is blunt and almost truncated. The larger end, on which the egg rests, is from .68 to .74 millim. at its greatest width and tapers rapidly below that point to a small facet or pedicle of attachment.

As seen in Pl. II. fig. 3, the shape of the egg is subject to slight variation. Of the egg-contents it is difficult to speak with certainty, as the treatment received may well have induced some changes.

In those which appeared to be the best preserved the perivitelline space is large and is principally in the lower region of the egg. The yolk is bean-shaped, and the embryo, which is somewhat advanced though without free caudal growth, lies in the long axis of the egg. Yolk and embryo together have a long and short diameter of about .91 and .37 millim. respectively. Both are of course opaque, but it is possible to make out what appear to be very numerous oil-globules of various sizes, occurring all over the yolk and apparently forming the bulk of that structure.

The zona radiata is very thin, showing under a high power the usual closely-set minute dots or punctures.

The apparatus for the attachment of the egg is the most remarkable feature. From the facet or pedicle of attachment (fig. 1, *p*) springs a hyaline structure, which spreads outward in the form of an umbrella. Under a high power this structure is seen to be pierced by alternate concentric rows of diamond-shaped or ovoid apertures (fig. 1, *sp*), which increase in size the further they lie from the pedicle, whilst, on the contrary, the proximal interstitial hyaline matter is more massive than that surrounding the more remote rows of apertures. Three or four such rows of apertures can be made out, beyond which the structure is continued in the form of a fringe of long and tapering threads, which adhere to the shell and to the threads of the adjacent ova (fig. 1, *fil.*). The ova, though very closely packed together (fig. 2), do not adhere to each other or to anything except by means of this tissue.

From the nature of the apertures the whole structure has the appearance of being composed of a number of threads, radiating from the pedicle and so arranged as to cross each other frequently in the proximal part of their course. But the closest examination under a high power (Zeiss D, Oc. 2) fails to support this appearance. The interstitial matter between the proximal rows of apertures is entirely homogeneous and cannot be resolved into fibres either in stained or unstained specimens; but between the larger distal aper-

tures one can frequently make out a division into two strands, which do not as a rule cross each other, but seem to be merely apposed.

Filaments or processes are known to occur on the eggs of many Teleosteans. They were found by Hoffmann* in *Gobius minutus*, *niger*, and other species, *Heliasis chromis*, *Belone*, and *Blennius*. Eigenmann, in his recent excellent memoir "On the Egg-membranes and Micropyle of some Osseous Fishes" †, very clearly describes the development of the filaments in *Fundulus*. In this form they are developed all over the surface of the egg, whereas in our ova the process of attachment is confined to what is presumably the micropylar region. In *Fundulus* the filaments, originally arising internal to the granulosa, are shown to pass through and, in further development, to lie external to it, being "bent in a more or less regular manner first to one side and then to another," and "usually follow the margins of the granulosa cells," to which they are "correspondingly curved."

Eigenmann also notices rivet-shaped processes on the eggs of *Pygosteus*, and from certain phenomena noticed in his preparations suggests that "they are from the beginning adhesive." He describes a layer external to the zona in all eggs on which processes are found. Whether such a layer exists here I cannot say, nor can I speak with accuracy as to the relation of the attachment process to the zona.

But it seems possible that filaments may be developed in this form as in *Fundulus* and *Pygosteus* (though confined to a restricted area), and penetrating the granulosa in due course, so as to lie along the margins of the granulosa-cells, and "being from the beginning adhesive," may have set up with each other intimate relationships, resulting in the formation, by the adhesion and ultimate fusion of their proximal elements, of such a structure as is actually found in the extruded ova before us. The distal parts of the filaments, not coming into contact with each other, and thus remaining independent, may perhaps have extended over a considerable part of the granulosa, and the whole pedicle of attachment is probably everted on extrusion of the egg in the same manner as the outer membrane of the zona in *Osmerus*, described by Buchholz and Cunningham.

Eigenmann speaks of his "rivet-shaped processes" in *Pygosteus* as taking a much deeper stain than the membrane (external to the zona) in which they are set. Treated with

* Hoffmann, "Zur Ontogenie der Knochenfische," Verhandl. d. Kon. Ak. v. Wetenschappen, Amst. Deel xxi. 1881, p. 19.

† Bull. Mus. Comp. Zool. vol. xix. no. 2.

picro-carminic the pedicle of attachment in our ova takes the carminic stain very deeply, whilst the zona (and external membrane if present) is quite unaffected by it.

This seems to induce the belief that the process of attachment is similar in nature to filaments of an external membrane rather than representing an everted membrane as in *Osmerus*.

Turning to the question of the parent fish, Professor M'Intosh has kindly given me a drawing of the eggs of *Gobius niger* from the Channel Islands, which will be seen to present some points of resemblance to those under discussion. Both are considerably elongated and both possess filamentous processes at their lower ends. In *G. niger*, however, the meshwork is less distinct than in ours and the eggs are fixed in rows by the interlacing of their filaments. In both forms the perivitelline space would appear to be large*.

Of the nature of the yolk in Professor Prince's specimens or in *Gobius niger* I am unable to speak. The yolk in our eggs, however, presents great likeness to that of a larval form common in this bay and long since identified by Professor M'Intosh with a species of goby. Two species are common here, viz. *G. Ruthensparri* and *G. minutus*. In the Seventh Annual Report of the Scotch Fishery Board Professor M'Intosh, writing "On the Pelagic Fauna of the Bay of St. Andrews during the months of 1888," mentions young gobies (chiefly *G. minutus*) as occurring in some numbers in the net in July and August, ranging in size from 3.5 to 11 millim. Their occurrence much earlier (at stages too young for diagnosis of species according to our present knowledge of this genus) is frequent, but their ova have never been found here, probably because other forms have occupied attention. A few larval forms appeared this year in April and May, of one of which I append a figure (fig. 6). Larval gobies are readily distinguished by the characteristic pigmentation and very early appearance of a conspicuous air-bladder. The specimen figured measured 3.57 millim. The anus is slightly anterior to median, the pectorals are large and fan-

* Professor Prince, writing to me from Valentia under date May 25, 1890, describes some eggs that had just been found, during the cruise under the auspices of the Royal Dublin Society, in the pools about the Begginish Islands. In shape they strongly resemble those of *G. niger*, and they are placed side by side on end, as in our form. From a rough sketch the perivitelline space appears very large; the length is about $\frac{1}{16}$ inch. Professor Prince is developing these eggs, and will no doubt be able to throw some light on to their species. Judging from the fact that a female *G. Ruthensparri* was taken in the same pool, he thinks it probable that they belong to that species.

shaped, the embryonic dorsal fin commences opposite the pectoral girdle. Embryonic fin-rays occur in the slightly spathulate embryonic caudal fin. There is a considerable preanal fin. The notochord is unicolumnar, and the hyoidean and mandibular apparatus well developed. The eye is greenish yellow. Black stellate chromatophores occur below the anterior end of the notochord, extending back as far as the air-bladder. Yellow pigment occurs amongst them. The air-bladder is greenish, with black dendritic pigment scattered over it. Above the anus and halfway between that point and the air-bladder occur two large masses of gamboge-yellow pigment (reddish brown by transmitted light), over each of which extends a large black dendritic chromatophore. Small black chromatophores extend along the ventral edge of the anterior two thirds of the abdomen and along the ventral edge of the postanal region to a point a little short of the caudal extremity. Halfway between the anus and the caudal extremity is another large yellow patch, overlaid by dendritic black pigment on the ventral region, and a similar but smaller dorsal patch lies just above it. No pigment occurs on the embryonic fins. The yolk is considerably reduced. It is darkish and appears to consist almost entirely of small oil-globules.

It is to be regretted that the information given by British authors as to the breeding of the Gobies is rather vague. Day ('British Fishes') gives June as the breeding time of *G. niger* and *G. minutus*, and May or June as that of *G. paganellus*. He also mentions, on the authority of a correspondent, that *G. Ruthensparri* attaches its eggs to the inside of an empty valve of *Mya arenaria*, but does not describe the egg or the method of attachment.

From the same authority it appears that the late Mr. Roberts, of the Scarborough Museum, had frequently bred this species in confinement.

Parnell ('Fishes of the Forth') mentions that *G. niger* and *G. gracilis* (*Parnelli*) spawn in June.

Couch ('British Fishes,' ii. p. 154) found a black Goby with enlarged ooe in February, and very young ones which appeared to belong to the same species in the autumn. Beyond this I can find no information.

Note.—Since making the foregoing remarks two females of *Gobius minutus* were brought to the Laboratory from the estuary of the Eden *, the contents of whose ovaries leave no doubt but that this is the parent species.

* May 27, 1890.

I regret that great pressure of time* prevents me (as with the extruded ova) at present from making more than a superficial examination of them; but I hope at a future date to treat the subject in a manner more worthy of it. Meanwhile, however, in the light of my previous remarks a few notes may be of interest.

The two specimens (the stomachs of which were full of the *Cypris*-larvæ of *Balanus*) measure respectively 2 and $3\frac{1}{4}$ inches, and the ovaries, which are by no means ripe, are nearly in the same condition in both. The largest ova measure from .6 to .71 millim. in long diameter; they are ovoidal, with one end much broader than the other.

Numerous oil-globules can be made out, distributed in an irregular manner amongst the granular yolk-matter. The thin zona is visible by careful focusing adhering closely to the yolk, and having outside it another layer in which minute dots, presumably nuclei, are present—in fresh unstained specimens under a high power. This layer, the granulosa, is in its turn covered by the process of attachment (which is exactly similar to that of the extruded ova), a fact which justifies the supposition that the latter was everted at extrusion, as is the outer membrane in *Osmerus*.

The micropyle, a minute funnel-shaped depression, can be made out in favourable unstained specimens, where it is not hidden by the ruptured follicular epithelium. It lies at the broad end of the egg, and the process of attachment stretches out on all sides. The meshwork of the latter ceases at the broadest part of the egg, and the filaments continuous with it pass upwards side by side almost to the opposite (narrow) end of the egg, but do not actually meet there.

In fresh specimens treated with picro-carmin the process of attachment takes the carmine stain more rapidly than any other part, the granulosa taking it slowly, if at all. In smaller eggs, *i. e.* half the size of the foregoing, the process of attachment is not seen, but minute, deeply staining dots are visible at the broad end of the egg, and probably represent its earliest appearance. The larger stained eggs show an intimate connexion between the process and the zona for a short distance around the micropyle, being the area which afterwards becomes the pedicle. The apertures are comparatively more elongated in this region, with finer interstitial matter (closely applied to the zona), which suddenly thickens at the margin of the pedicle. I could detect no layer between the zona and

* [Mr. Holt left within a few hours for the trawling expedition on the west coast of Ireland.—W. C. M.]

the granulosa, nor, I think, is this possible without the aid of the microtome.

EXPLANATION OF PLATE II.

Fig. 1. Process of attachment of ovum attributed to *Gobius minutus*; the filaments are mostly curtailed. *fil*=filament; *p*=pedicle of attachment; *sp*=apertures in process of attachment; *z. r.*=zona radiata. (Zeiss D, Oc. 4.)

Fig. 2. Group of ova *in situ*. $\times 3$.

Fig. 3. Detached ova highly magnified. *a. p.*=process of attachment; *e*=embryo; *y*=yolk.

Figs. 4, 5. Ova of *Gobius niger* from glycerine-preparations, enlarged under lens.

Fig. 6. Larval *Gobius* of 14th May, 1890; length 3.57 millim. *a. b.*=air-bladder; *h*=heart; *n*=notochord; *y*=yolk. Magnified.

IV.—Notes on *Radiolaria* from the Lower Palæozoic Rocks (Llandeilo-Caradoc) of the South of Scotland. By GEORGE JENNINGS HINDE, Ph.D.

[Plates III. & IV.]

THE *Radiolaria* described in this paper are contained in specimens of chert collected from several different localities in the Southern Uplands of Scotland, and sent to me for examination by the Geological Survey of Scotland through B. N. Peach, Esq., F.G.S. From the most promising pieces of this chert a number of microscopic sections have been prepared, and from these the forms have been studied. I may premise that the occurrence of these minute organisms in this chert was first announced by my friend Prof. H. Alleyne Nicholson, M.D.*, of Aberdeen; but the specimens which he examined did not show the structure sufficiently well to allow of positive determination as to their real nature.

The chert containing the *Radiolaria* occurs in beds and intercalated nodular masses in a portion of the well-known series of Ordovician or Lower-Silurian strata forming the Southern Uplands of Scotland; and it is more particularly developed in the counties of Lanarkshire, Peeblesshire, and Edinburghshire. Mr. B. N. Peach†, who has lately been resurveying the district, informs me that he has traced a defi-

* Trans. Edinb. Geol. Soc. vol. vi. pt. i. p. 56 (1890).

† A full description by Mr. Peach of the geological and stratigraphical relations of these rocks will appear in a forthcoming Geological Survey Memoir on Sheet 16.