L.—*Notes from the Gatty Marine Laboratory, St. Andrews.*—No. XXII. By Prof. M'Intosh, M.D., LL.D., F.R.S., &c.

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1. *On Abnormal Coloration in the Pleuronectids.*

About a dozen adolescent turbot have lately been obtained in the nets for plaice in the Bay showing a deep notch above the head, the dorsal fin terminating in a prominent hook. All these were coloured on both sides. The following may be taken as examples:—

No. 1 was about 9 inches in antero-posterior diameter and 8 inches in transverse diameter. The left eye was normal in position, whilst the right was barely clear of a line drawn from the edge of the dorsal to the tip of the snout. This eye had extensive vision, since in life the dorsal fin, even on the bottom, was below it. Every part of the under surface was as deeply pigmented as the upper. The prickles were, however, considerably less numerous and less prominent than on the left side; but their occurrence lends support to the view that we have to deal with more than the effect of light.

2. A specimen about the same size and having the dorsal fin terminating in the hook-like process above the head, a line from the distal edge of the latter just touching the front of the eye. The pigment was equally developed on both sides, as in the former case, but the prickles were somewhat more numerous and more prominent than in that form.

3. A living example in the tank is somewhat larger than the preceding, viz. about 10 inches, but has precisely the same arrangement of the dorsal fin, which terminates in a hook-like process behind the head. The eyes are in the same position. It is evident from an examination of this example that the dorsal and anal fins are used in the tank, and probably in nature, as partial supports, and in the case of the dorsal fin the right eye (which has passed to the left side) thus has a much wider area of vision than is apparent from a study of spirit-specimens.

4. A male turbot 13½ inches in length and 11 inches in greatest breadth had a deep notch above the head, the tip of

the hook-like process of the dorsal fin extending in front of a line from the anterior edge of the right eye, which was just over (to the left of) the ridge. Both sides were deeply pigmented and a considerable number of prickles existed on the right side.

In a turbot of 22 inches in length and 18 inches across—noticed by Prof. Ewart *—the right eye remained on the right side near the ridge. Both sides of the body were pigmented. The same hook-like malformation of the end of the dorsal fin was present. The intensity of the coloration of the right side would not seem to be greatly altered by the presence of the eye thereon, as in some in which the eye had passed the ridge the colour appears to have been quite as well developed.

In a finely developed sole, 14 inches in length, procured at Portrush, in Ireland, the under (left) surface had a conspicuous reddish tinge along the sides (dorsal and ventral) and here and there extending to the middle line, from the presence of numerous red pigment-corpuscles. The only other pigment on the surface was a dark patch at the base of the tail. The right (upper) surface had the normal pigment.

In a flounder (*Platessa flesus*) $7\frac{1}{4}$ inches long the dorsal fin terminated in a hook which curved forward so as to touch a line from the left eye, which was truly dorsal in position—in fact, it occupied the ridge. The right eye was normal. Both sides were deeply tinted, no distinction (except a small white belt running forward and backward below the left eye to the extent of $\frac{3}{4}$ inch) being visible between them. The prickles on the head, however, were little developed on the left side, though the rough region above the pectorals was present on both sides.

A flounder of $8\frac{1}{2}$ inches, in which the dorsal fin is arrested behind the left eye and terminates in a small point or hook. The left eye is lateral in position, its lower border being on a level with the ventral surface (left). Its range of vision would thus be extensive on the left side, sweeping from the bottom upwards about $\frac{3}{4}$ of a circle, especially when its dorsal fin was on the bottom or when swimming. The left side is as deeply pigmented as the right, even prolonged immersion in spirit for eight or nine years only rendering the left side of the head somewhat less dusky. This flounder was remarkably well nourished for its size, and evidently secured its food readily. The ovaries were far advanced.

In a dab $8\frac{1}{2}$ inches long, with both eyes on the right side and the dorsal fin running evenly forward on the left side of

* Second Report S. F. B., Appendix, p. 80, pl. xiii. (1884).

the eye beyond its middle, both sides of the body were uniformly coloured. The fish was to all appearance normal in its characters, yet no bleaching of the left or ventral side had occurred.

Such an example raises doubts as to whether it is the effect of light or its absence which alone is responsible for the condition in the Pleuronectids. This is further supported by the fact that in metamorphosing young examples the side which is to be pale becomes considerably less pigmented before the fishes swim obliquely or leave their pelagic life. Even when the pelagic stage is greatly prolonged, as, for instance, in the young turbot, by an arrest of the right eye in its progress to the left, so that each side has an eye in a fish about an inch in length, the same feature is noticed. Thus, in the 'Invertebrates and Fishes of St. Andrews' *, fig. 5 (pl. vi.) represents the right side of such a specimen, which has on the whole less pigment than the left side, viz. fig. 6. This feature has often been observed in smaller forms of various Pleuronectids.

Besides, the mere fact that the lateral line in such examples as the dab above mentioned remains unchanged indicates a condition more deeply seated than so simple a cause as the absence or presence of light. This will be again referred to.

A dab about 9 inches in length had the dorsal surface normal, but the posterior half of the left (lower) surface was pigmented like the dorsum throughout. No structural abnormality was present.

Messrs. Cunningham and Macmunn † met with no examples resembling this and the preceding in turbot, brill, flounder, or plaice—that is, a normal outline with pigment on the lower or ventral side.

Various abnormally coloured plaice have recently been procured at St. Andrews both by hook and net.

1. In an example procured 1st February, 1901, measuring about 10¾ inches in length, the dorsal surface had an area of about 3 inches from the tip of the snout backward of the normal colour. The colour-line included half an inch of the anterior border of the anal fin, and trended with a slight convexity backward and then a slope forward to the dorsal edge. The dorsal line of the coloured region was 2½ inches, the ventral about 4. The rest of the dorsal (right) surface was pure white, with the exception of a small isolated patch about the size of a large pea less than half an inch from an incurvation of the dorsal edge of the coloured region. Two small

* 1875.

† Philos. Trans. 1893, B, vol. 184, p. 806.

specks, separated by an inch from each other, also occurred behind this, about $\frac{5}{8}$ inch above the lateral line. From the anterior area a coloured belt proceeded along the edge of the dorsal fin about $1\frac{3}{4}$ inch backwards, and a similar marginal belt occurred on the anal fin for fully 2 inches, the interspinous region in both bearing the pigment. The under surface was entirely white.

2. A second example, procured at the same time and measuring $10\frac{3}{4}$ inches long, had only the dorsal surface of the head and the tail coloured normally. The former coloration extended to about a quarter of an inch behind the eye and the irregular posterior border proceeded obliquely downward to the edge of the operculum. Part of the opercular region was thus white, part coloured, the pigmented region, from the shape of the parts, being rhomboidal and about an inch broad. The coloured part at the tail was about $1\frac{5}{8}$ inch, with an irregular anterior margin. The rest of the dorsum was pure white, with the exception of slight streaks of pigment in the interspinous regions of both dorsal and ventral fins, and two streaks which followed the forks of two pectoral rays. A little more than an inch behind the tips of the pelvic fins a triangular depression running from the anal fin about $\frac{3}{4}$ inch inward marked the site of what appeared to have been an injury, now healed. The pigment on the slightly incurved anal fin was best marked at the site of the injury, which appeared to have occurred during the early adolescent condition. A dimple about a quarter of an inch from the lateral line on the left side of the fish seemed also to be connected with this injury. The under (left) surface was pure white.

3. A plaice 9 inches in length and well nourished. The entire upper surface was pure white, except the head, the pelvic fin, and a few touches on dorsal, anal, and caudal fins. The head, with the exception of the upper part of the operculum (above the base of the pectoral fin), was of the normal dark hue, the pigment of the lower margin of the operculum being boldly separated from the white shoulder behind it. The pigment-line dorsally passed to the right of the termination of the dorsal fin, bounded the eye, and then slanted irregularly to join the opercular pigment. The right pelvic fin was coloured, as also was a small patch of the margin in front of the vent, whilst a touch of pigment occurred on the tip of the pectoral. The dorsal and ventral fins had various slight bands of colour chiefly on the region between the rays. The caudal had a median longitudinal bar and faint pigment-lines on the fin on each side of it (dorsal or right surface). The under surface was entirely white.

A deep notch occurred behind the vent and then a prominent point with the spine followed by the anal fin. A marked hollow, as if from former injury, existed at this region on the left side.

4. A plaice 9½ inches in length, and which was less plump than usual, showed a marked concavity behind the pelvic fins, thus separating the origin of the anal by a larger interval than normal. The upper (right) surface had the ordinary ground-colour, but in addition the whole surface was speckled with boldly marked touches of dark brown pigment, which extended to all the fins and the tail. Moreover, the entire under surface (left) was even more thickly and conspicuously dotted with specks of the same dark brown pigment, which extended to all the fins and tail. The densest groups of these touches occurred over the opercular region and the abdomen. The ground-colour of this surface was white.

5. In a plaice about 12 inches long the dorsal (right) surface was peculiarly mottled. The anterior area corresponding to the head and most of the abdominal region below (to the right of) the pectoral was of the usual dark tint, as also was the tail and a broad irregular patch extending about 3 inches forward, especially on the ventral (right) edge. The rest of the upper surface (with the exception of a patch about 1¼ inch by ¾ inch between the two larger areas and ventrally, that is to the right) was pure white, the fins (dorsal and anal) alone showing a little dark pigment. The under surface was pure white. No structural peculiarity was visible externally.

6. A poorly nourished plaice* about 10 inches in length had the dorsal (right) surface dotted all over with black specks and touches, whilst the ventral (left) surface presented an extraordinary appearance, for it was speckled with dense opaque white areas and small circular patches of white, which invaded likewise the fins and tail. Small black specks also occurred on the head, fins, and here and there over the body. The circular nature of the patches of white and their coalescence to form larger areas would indicate a condition of things not uncommon in certain affections of the skin in which the sympathetic system of nerves is often specially concerned. Such a condition is manifestly due to more than the action of light, which is inadequate to explain the appearances. A consideration of all the circumstances of the pigment in these Pleuronectids therefore points as much to peculiarity of constitution and the influence of the sympathetic system of nerves as to the action of light, however important that may be.

* Mentioned in the Report S. F. B. for 1894 (published 1895), part iii. p. 234.

The coloration of such plaice, moreover, would render them conspicuous to fishes and other forms which preyed on them, just as hawks often strike down white pigeons in a flock of blue. The fact, however, that plaice have the shelter of the sand may have increased the chance of survival. It has also to be remembered that these are only adolescent fishes and that they had yet to encounter many risks before attaining full size in the deeper water beyond St. Andrews Bay.

2. *On the British* Syllidæ.

In Dr. Johnston's Catalogue of the British Museum (1865) seven species frequenting British waters are mentioned, viz.:—*Syllis armillaris*, O. F. Müller; *S. cornuta*, H. Rathke; *S. prolifera* (=*Autolytus prolifera*, O. F. Müller); *S. monoceros*, Dalyell, a species which has articulated cirri and long pencils of swimming (sexual) bristles; *Gattiola spectabilis*, Johnston; *Myrianida pinnigera*, Montagu; and *Ioida macrophthalma*, Johnston (a sexual form of one of the preceding).

Instead of the four or five genera then known there are now at least nine or ten, and the number of species has been increased by a multiple of five. Yet the small size and the difficulty in discriminating the species has probably led to some being overlooked even in the British area, just as in some foreign collections the representatives are wholly absent. The group is one of the most interesting to naturalists from the frequence of schizogamy and epigamy in its members, as well as from the occurrence of phosphorescence. While linear budding is thus common, no British species exhibits the remarkable lateral branching of *Syllis ramosa* of the 'Challenger'* or of the *Trypanosyllis gemmipara* of H. P. Johnson† from Puget Sound, a species in which numerous buds arise from a "proliferating somite" near the posterior extremity.

3. *On the* Syllidæ *of the 'Porcupine' Expeditions.*

In the expedition of 1869 a *Syllis* was dredged at no. 6 (3. 6. 69) which appears to approach most nearly *Syllis armillaris*, O. F. M., though the ventral cirrus is narrower. Its imperfect condition forbids further diagnosis.

* Zoology, vol. xii. p. 198, pls. xxxi. &c.

† Proc. Bost. Soc. Nat. Hist. vol. xxix. no. 18, p. 405, pl. vii. figs. 72–76 (1901).

Ehlersia cornuta, H. Rathke, var. *hystricis*.

Dredged in 92 fathoms on Adventure Bank in the 'Porcupine' expedition of 1870.

The head generally resembles that of *Syllis armillaris*, O. F. M., though the tentacles, like the cirri, seem to be shorter.

The body also agrees with that of *S. armillaris*, the cirri being comparatively short. The foot has dorsally a cirrus of seven to nine joints. Beneath is a short and bluntly conical setigerous region bearing spines and a group of bristles with somewhat slender shafts slightly curved at the tip, which is bevelled. The terminal piece is proportionally long and with a hook at the tip and a minute secondary process beneath. The edge of the terminal piece has a series of spikes. In this small specimen the characters of the bristles are less evident than in the larger, especially the discrimination of the secondary process beneath the terminal hook. The ventral cirrus is elongated, the base somewhat constricted below the enlargement, then tapering to the tip, which extends as far outward as the end of the setigerous region.

This variety differs from the typical form in the shorter dorsal cirrus and in the shorter ventral cirrus, whilst the slenderness of the bristles and the difficulty of diagnosing their bifid nature brings it close to those species with simple tips to the terminal pieces of the bristles which Langerhaus has described *. As the latter author has pointed out, the *Chætosyllis Œrstedi* of Malmgren † seems to be the sexual form (with swimming-bristles) of this species, procured in June at Spitzbergen. Langerhaus also includes the *Syllis sexoculata* of Ehlers ‡ under the same species, and they certainly approach each other very closely, for palpi, cirri, and bristles all correspond.

In the typical *Ehlersia cornuta*, which was dredged in the 'Porcupine' expedition of 1869 off Bundoran, Donegal Bay, in 20–25 fathoms (Stat. 18), the form of the body is more robust, the spikes on the edge of the terminal blade of the bristles better marked, and the minutely bifid tip distinct. The dorsal cirri are stout and the ventral cirri are tongue-shaped, and not long tapered cones as in this form (var. *hystricis*), which approaches *Syllis abyssicola* in this respect.

* Zeitschr. f. w. Zool. Bd. xxxii. p. 538.

† Ann. Polychæt. p. 162.

‡ Borstenw. i. p. 241, pl. x. figs. 5, 7, & 8 (1864).

Ancistrosyllis grœnlandica, M'Intosh.

An incomplete example of this species was dredged in the 'Porcupine' expedition of 1870, east of Cape de Gatte, 6 miles from shore, at a depth of 60–160 fathoms. The specimen to which the fragment pertained was evidently larger than the original one procured in the cruise of H.M.S. 'Valorous' in 1875 *. The dorsal hook is remarkably strong at the curvature towards the tip, and apparently fixes the body very securely to other tissues, such as a tube or sponge. The point of the hook also shows minute rough processes. The shaft of the hook, which is boldly striated, diminishes from the distal curvature downwards to the level of the skin, where the narrowest part is, a dilatation then occurring in the tissues of the foot.

In the inferior division the smooth conical tip of the spine projects beyond the surface, and in this specimen the papillæ on the ventral cirri were very few and difficult to observe.

4. *On Norwegian* Syllidæ *collected by Canon Norman, D.C.L., F.R.S.*

Ehlersia cornuta, H. Rathke, var.

Habitat. Procured by Canon Norman in Finmark.

A fragment of the anterior end of a *Syllis*, the head having long palpi, the tentacles distinctly moniliform and of considerable length. The cirri anteriorly had at least from eighteen to twenty segments, and they continued of this length to the end of the fragment.

The foot presented a slightly tapered dorsal cirrus of eighteen to twenty segments. The conical setigerous region was supported by two spines, the larger with its smoothly conical tip projecting beyond the apex. The bristles were comparatively slender, with shafts of the usual structure and the upper with very long slender terminal pieces which appeared to have a simple tip with a slight hook. Both shaft and tip of the upper bristles were remarkably slender and the latter long; but though the approach of the marginal spikes to the terminal hook caused an appearance which resembled a bifid tip, yet, so far as could be made out, no condition of this kind obtained. The marginal spikes were proportionally large and distinct. The lower bristles had shorter and broader terminal pieces, and a minute secondary

* The distribution of this peculiar form is thus extensive.

process was visible below the terminal hook, though it was by no means distinct.

The ventral cirrus is remarkably elongate in proportion to the size of the foot. It extends considerably beyond the tip of the latter. In shape it is constricted at the base, slightly dilates for some distance, and then diminishes a little toward the tip.

This form therefore differs from the variety procured by the 'Porcupine' in having more numerous articulations in the dorsal cirri, viz. eighteen to twenty, yet Malmgren gives twenty-two to twenty-seven as the typical number. The great length of the ventral cirrus, which extends considerably beyond the tip of the setigerous region, is also noteworthy. The number of the articulations in the dorsal cirri seems to vary much, for in an example from the deep water off St. Andrews Bay they are even more numerous than Malmgren observes. Moreover, the shorter and wider ventral cirrus in such forms also leaves the question open as to whether all can be included under the original species.

5. *On the Boring of* Polydora *in Australian Oysters.*

An interesting Report to the Fisheries Commissioners of New South Wales by Mr. Thomas Whitelegge, Zoologist to the Australian Museum, 'On the Worm Disease affecting the Oysters of New South Wales' *, affords an opportunity of glancing at the effects of this widely distributed genus in colonial waters, more especially as a considerable collection of Australian oysters exists in the University Museum.

Mr. Whitelegge appears to have overlooked the earlier paper by Prof. Haswell †, who examined the oysters from the same beds, viz. Newcastle, Hunter River, and described the blisters formed by the thin layers of nacreous substance over the fine black mud in the valves, and suggests that the extensive destruction of the oyster-shells in Hunter River may be connected with the muddiness of the water produced by increased traffic. Prof. Haswell found two species of *Polydora* in the oyster-shells, one of which is new, viz. *Polydora polybranchia*, the other being *P. ciliata*.

The author (Mr. Whitelegge) carried out his observations at Newcastle (Hunter River), where there are many beds,

* 1890. Kindly forwarded by the Hon. J. H. Want, who has taken great interest in the fisheries of New South Wales.

† 'Jottings from the Biol. Laboratory, Sydney University,' p. 275 (1880).

about fourteen having been examined. He found that *Polydora* chiefly affected those oysters on the surface of or buried in the mud, a feature probably not unconnected with the fact that tubes of mud are fashioned by the annelid at its apertures in the shell. The idea that removal of the shells from mud would lessen the liability to attack may have some basis, since, as mentioned, mud is necessary for the manufacture of the tubes which project beyond the apertures in the shell; but the annelid also makes these tubes of the debris from its borings in aluminous shale. It must not be supposed, however, that the placing of the oysters on a bed of shells will have the effect of freeing them from the annelids, the business of which is to bore into all shells and similar solid bodies. His diagnosis of oysters "badly infested with worms" as having a thick rounded outline and devoid of thin sharp edges will not suit British oysters, such as those from Whitstable, many of which have thin edges, though the shell is honeycombed by the worms. Moreover, in the British oysters the apertures of the tubes occur all over the shell, and the same occurs in certain examples from Australia. He is of opinion that the oysters were infected before removal from the mangrove-flats to the beds, but, as the swarms of pelagic larvæ carry the species everywhere, this is not of much consequence. The view that on the natural beds (on the mangrove-flats) the oysters appear to overcome the worm—that is, the postlarval form—by quickly enclosing it with a thick layer of shelly matter before it has had time to establish itself is more than doubtful. The young annelid may settle on the shell quite out of the reach of any such secretion, just as it does on the limestone, chalk, and shale. The postlarval worm is not different in this respect from the postlarval *Cliona*, the boring sponge, which likewise settles on the oyster irrespective of any shelly secretion, and is even more destructive than *Polydora*. Besides, an examination of the massive pearl-shells from Thursday Island, for which this University Museum is indebted to Mr. James R. Tosh, will show that the postlarval boring mollusks, like the boring sponges, follow similar habits and settle in numbers on the valves irrespective and out of reach of any shelly secretion. *Polydora* is capable of perforating harder shells than those of the oyster, and its ravages are perhaps best seen in massive shells such as those of *Chama*.

The keyhole outline of the tubes "furthest from the edge of the oyster" is probably due to the coalescence of the tubes to form a loop, for the tunnels of *Polydora*, so far as observed, are circular, and thus in marked contrast to the tunnels of

Dodecaceria, another boring annelid, the single tube of which forms a keyhole-outline in transverse section.

The expression that the inlet and outlet of the tube is "often enclosed by the thin layer of shell deposited by the oyster" probably means that, according to the author, the worm stoically keeps its body in the line of its tube whilst the oyster makes a cast of it, a condition of things foreign to experience. It may happen that at the growing edge of the valve the projecting tubes of mud may be fixed by the shelly secretion of the edge of the mantle, but there is no proof that the annelid would thereby be prevented from gaining the exterior—so necessary for its existence.

The author makes much of the mud in which he appears invariably to have found the young *Polydora*, and of "the thin membranous covering thereof secreted by the oyster." He has seen no groove indicative of boring in such cases, and denies, indeed, that the annelid bores at all. Such views, however, cannot be received by zoologists either in regard to *Polydora* or other boring annelids, such as *Dodecaceria* and *Sabella saxicava*, or in regard to the perforations made by *Phoronis*, boring mollusks, and sponges. *Polydora* bores not only in oysters, but in dense shells, such as *Fusus* and *Buccinum*, and over vast areas of the ocean, and is one of the important agents in disintegrating the shells on the sea-bottom. It is true that very little might be visible at first, as the postlarval worm settles on the oyster, but even less would be seen in the case of the postlarval sponge, as it fixes itself to the shell, yet in due time the shell is tunnelled by the one and honeycombed—often with beautiful dendritic patterns—by the other. The idea that the postlarval worm settles inside the valves of the oyster could only apply to the free edge (uncovered by the mantle), and it is traversed by the fact that there is no such secretion to account for the phenomena in the case of a limestone rock or a mass of shale. If the annelid does not bore, how does it make the finely formed tunnels in such rocks and in the thick coating of *Melobesia* (a calcareous alga) which covers many rocks and stones between tide-marks, and in *Balani*? Few traces of mud and no "thin membranous coverings" occur in these instances.

The view that the postlarval worm, with a great capacity for attachment, simply clings by the mouth to the margin of the shell of the open oyster, "constructs a tube, and collects a large quantity of mud," which the oyster surrounds with a shelly secretion, and repeats it when the worm continues its tube, will not fully explain the case. There is no doubt that considerable irritation ensues when, for instance, a *Polydora* makes use of a fissure at the margin of the valve, follows the chink inward, and may even penetrate to the mantle, or when in the course of its boring it perforates the valve. The mud ejected by the vent may thus collect and require investment by the shelly secretion, and cause the so-called blister. A large blister $1\frac{1}{2}$ inch long in a specimen sent by Mr. Want may thus have originated, and it had a double shelf, indicating that, after the first source of irritation had been shut off, a new intrusion had occurred. The tubes which led to this were only sunk in the shell at the extreme margin and for a short distance, the rest of the communication with the interior being between the laminæ, where a chink existed, probably the result of the former irritation. Such a condition is very apt to happen now and then under the varied circumstances affecting thousands of annelids and oysters, and had been described by Prof. Haswell and seen in an example from the same Australian grounds (Newcastle) in 1883. But it must be borne in mind that blisters may arise in shells where no examples of *Polydora* have been or are. Thus in a very fine oyster from Lake Cutgee, near Bermagui, Australia, a large blister was caused by a group of small pebbles, the largest nearly reaching a quarter of an inch and the smallest like a coarse sand-grain. In certain very fine oysters from Whitstable thin blisters occur without apparent cause, and no *Polydoræ* are present. It is possible, therefore, that occasionally *Polydora* may take advantage of a space caused by other sources of irritation than itself, though there is no reason to suppose that it does not now and then also cause by its excreted mud the irritation, especially *Polydora hoplura*, the form found by Dr. D. Carazzi in the Australian oysters. In some examples of this kind it is possible that the annelid found it more convenient to utilize the vacuity in the oyster than send the mud out of the external apertures of its tubes. In the great majority of British shells few collections of mud enclosed by a shelly layer are found, and yet the valves may be riddled by *Polydora ciliata*. The statement in the Report that each worm necessarily has its own collection of mud therefore requires the qualification of species. The collections of mud with the young worms within the valves have not been observed in this country, where *P. hoplura* has not yet been specially noticed. The author discusses the probabilities of the cavities of the blisters being enlarged by the worm, but this has never been supposed by any zoologist. In most instances the tunnels bored by *Polydora ciliata* in shells are cylindrical and quite clean and have no relation to "blisters," and the position is further shown by the boring of the annelid in chalk, limestone, aluminous shale, and sandstone, where there is no possibility of the secretion of a "thin membranous" layer to keep the intruder out. As shown by Dr. Carazzi, the conditions indicated by Mr. Whitelegge pertain for the most part to the action of *Polydora hoplura*.

The notion that boring does not occur because no "grooves" were visible may be equally applied to the boring sponges, *Sipunculi*, *Phoronides*, and other forms. Besides, no grooves are necessary where a chink between the shelly layers permits the annelid to form its tunnels of mud, as indicated in the foregoing paragraph.

The tendency to secrete a nacreous coating to shut off sources of irritation is observed in many mollusks, and is taken advantage of, for instance, by the Chinese in the coating of their josses with the nacreous layer and in the artificial formation of pearls. Blister after blister may thus be formed by different perforations. It is interesting that the boring sponges do not cause the same irritation as the excreted mud of *Polydora*, their minute perforations on the inner wall of the shell being rapidly coated by the shelly secretion; but their great number and persistent character have ultimately a serious effect on the health of the oyster. The decomposition of this excreted mud of *Polydora* is certainly a source of danger to the mollusk.

That the annelids do not thrive unless in living oysters which cause currents, and thus bring the commensals food, is negatived by the fact that vast numbers bore in limestone rocks and shale, where no living mollusks and no favourable currents are. They have, indeed, been kept alive in shale for months 50 miles from the sea. All that can be said on this head is that they are very abundant on living oysters.

It is quite possible that the boring is best carried out when the annelid settles after the pelagic stage. The "helplessness" of the adult when removed from its tube is no proof that it is incapable of boring. Any other adult borer, for example *Dodecaceria* or *Sabella saxicava*, would, when removed from its tube, be equally helpless.

The statement that in certain instances the annelid "lives completely within the shell, and the ends of the tube have no connexion with the outer world except when the oyster is open," is exceptional. As far as observed, a like condition has not been seen in this country nor in one hundred and twenty oysters from fifteen Australian beds, including those from Hunter River (Newcastle) kindly presented to the University in 1883 by the Trustees of the Australian Museum. It might have been supposed that the margin of the mantle would have affected the intruding body by a calcareous secretion.

Mr. Whitelegge gives three figures (6, 7, and 8, pl. iv.) of sections through the tubes of *Polydora*, viz. 7, a single tube (loop at inner end), which he supposes is the first stage in which the worm rests on the flattened solid part of shell, and over which (the quiescent worm) the oyster forms a layer, semicircular in transverse section. In the next stage (fig. 8) the semicircle has become a keyhole, namely, there is a tendency to a double tube; whilst in the third stage (fig. 9) the two tubes are distinctly separated. But the same appearances are found in the borings of the annelids in limestone-rock, chalk, and shale, and are not related to the secretions of the oyster. His first stage is the loop at the end of the tunnel, his second is the commencement of the double tube in an instance where the loop has been very short, whilst his third stage is the distal portion of each tunnel. The latter is a simple circular tube with a loop internally. The appearances figured, therefore, represent certain parts of the tunnel, but the interpretation of their formation differs.

The whole position taken up by the author is lost at the foot of page 8 of the Report, where, after mentioning the entrance of the worm "into the open shell," the collection of mud, and the investment by the layer of shell (how it manages to live after this encystment is not explained), he adds, "the body of the worm, resting on the shell, has by reason of the constant movements in and out a tendency to wear away the shell"; "whether this is accomplished by strictly mechanical means or by a corrosive acid I am unable to say, but the fact remains that it is worn away." There is no doubt the reporter would have arrived sooner at this conclusion if, instead of confining his observations to oysters, especially those having the "blisters" internally, he had studied the action of the worm on limestone and on shale. The observations were evidently made with much care and display great acuteness; but it is difficult at first sight to grasp all the circumstances affecting these complex processes.

Again, the opinion is expressed that when the worm has been long in the shell the "grooves" are deep, and the longer they remain the deeper they become, from the fact that "the growth or increase in the size of the shell forces the entrances further outward and upwards or downwards, as the case may be, according to whether it is the upper or lower valve." It is true many of the tunnels pass from the margin of the valves inwards, but such may be due to the facilities afforded by the numerous chinks and fissures between the thin shelly plates for the early operations of the annelids of this species, as pointed out by Dr. Carazzi. *Polydora*, moreover, bores in univalves, not to allude to rocks and stones, where the tubes could not be affected in this way. Nor will the statement concerning the appearances of the tubes, viz. "becoming shallower inwards and ceasing to be grooved at all," lend much support. The tubes end in a loop, which, in shells that are worn, or when the loop occurs in a "blister" or space, does not show the circular form (in section of the shell) of the distal part of the tube. The circular form, however, is really kept up by the tunnel in the mud or by calcareous sediment in other circumstances, and both of which may be washed away after death. The tube is thus continuous from one aperture to the other, and the annelid can reverse itself therein, the head appearing at either aperture. The exact meaning of this part of the description is difficult to comprehend. If it be that the proximal end or loop of the tube indicates the site occupied by the postlarval worm when it is "shut out" by the oyster, such, as already mentioned, does not accord with previous observations.

It is also necessary to demur to the statement in the Report that it is quite possible that in limestone and shale the annelid "may take possession of a small depression, and as it grows gradually enlarge it by its constant movements in and out, until it has formed its tube in the same. Such tubes may serve for a succession of generations, being still increased in size by each occupant, as is the case with some of our sea-urchins which form holes in the sandstone of Port Jackson. But still there would be an absence of boring in the sense used with reference to this worm." The supposition that the swarm of finely-drilled tunnels on the free edge of a fractured piece of limestone rock or the thick end of *Chama* have thus been formed in fortuitous depressions cannot be accepted. The surface of many of the rocks and stones drilled by *Polydora* and *Dodecaceria* is perfectly smooth, and besides, in not a few instances, the number and regularity of such fortuitous depressions that would be necessary negative it. The author's argument would be equally applicable to the works of *Teredo* and *Limnoria* in timber, and would be equally futile. Further, if oysters from certain Australian beds be examined, tubes of *Serpulæ* will be found in great numbers on the surface, and some of these have been partially enveloped by the shell during growth, so that they require to be picked out. A careful examination of these tubes, for instance, gives no evidence that by the "constant movements in and out" the slightest change has occurred in their diameter. Nor would the same movements alter the diameter or make the tunnels of *Polydora* or *Dodecaceria*. The power of boring is a special attribute of these and other forms which perforate rocks and shells. It might be as appropriately said of *Teredo* and *Xylophaga* (mollusks which perforate wood) that their tunnels are made by "constant movements in and out."

Polydora is an active borer in shells, rocks, and stones, and if it be carefully observed when working in the softer pieces of shale, cloudy jets of the debris are noticed issuing from the apertures of its tubes at intervals, and they form a deposit on the bottom of the vessel. Whether this consists wholly of materials from the excavations in the shale or partly of the contents of the intestine is an open question, but it partakes of the debris of the shale. Dr. Carazzi's supposition that the description given by the writer* might apply to chinks and fissures between the layers of the albuminous shale is unnecessary. The remarks applied to solid and fairly hard portions of the shale, which required to be split to show the tubes of the annelid, just as in the hard calcareous rocks.

Oysters (and other shelly mollusks) are everywhere attacked by *Polydora*, but such can scarcely be termed a disease. The annelid is a commensal in the case of the oyster, and shares with it the muddy food carried by currents within reach of its mouth and tentacles, which are richly ciliated and fitted for conveying particles of various kinds. It settles on the oyster because it possesses a shell wherein it can bore, and because the shell-fish is usually on a site suitable for supplies of food. Some, such as *Polydora ciliata*, do not necessarily interfere with the inner layer of the valves, and thus are in contrast with the boring sponge (*Cliona*), which not only is more destructive to the mass of the shell, but perforates the nacreous (inner) layer by multitudes of minute pores, necessitating a constant secretion from the outer layer of the mantle to close them, and by-and-bye rendering the interior of the valves discoloured, nodulated, and unsightly. At first each minute pore is shut off by a thin circular patch of the secretion, but as the sponge pertinaciously progresses in its work of destruction the valves assume the condition just mentioned. On the other hand, *Polydora hoplura*, a southern species, as shown by Dr. Carazzi, more frequently perforates the valves and causes collections of mud and the formation of blisters as described by Mr. Whitelegge. As Mr. Whitelegge states, the general view is that the presence of *Polydora* on oyster-beds is connected with

* Ann. & Mag. Nat. Hist. ser. 4, 1868, ii. p. 276.

mud; and a considerable number of years ago the Whitstable Oyster Company of the Thames were greatly exercised on this subject, for they were of opinion that the deposition of mud from the dredgers used in the Thames was the cause of the attacks which rendered many of their beautiful oysters unsightly. The *Polydora* (*P. ciliata*) which is found in these is much smaller, as a rule, than that (*P. hoplura*) in the Australian oysters; but if the authorities of New South Wales saw the havoc made of the Whitstable shells, they would derive some satisfaction from the fact that things might be worse than they are in Australian waters. Yet many of the Whitstable oysters, though honeycombed externally by the worm-tunnels, are perfectly sound within, and fit to appear in the most fastidious market. Probably much depends on the vigour of the oyster, as in some cases, instead of the Australian "blisters," the large Whitstable oysters pour out a dense mass of pure white calcareous secretion nearly a quarter of an inch in thickness, thinning off at the edges over an area of $1\frac{1}{4}$ in. square, and thus keep the lively annelids at a distance from the mantle. Of the two commensals, the annelid—British or Australian—is preferable to the sponge, yet it is doubtful if the losses through them are so serious as to endanger the success of oyster-culture either at home or in Australia.

Mr. Whitelegge proposes to kill the boring-worms by immersing the oysters in fresh water for some days, or by placing them in the air (under shelter from the sun) for ten days or longer. It is quite possible that the annelids would thus be killed, and, it may be, some of the oysters. No sooner, however, would the oysters be replaced on any ordinary bed within reach of sea-water than they would be liable to inroads both of the annelids and the sponge, since the larval and postlarval forms of both abound, the former especially for many months. Besides, unless in special enclosed parks, any oysters left on the beds, or the occurrence of old shells, limestone boulders, suitable shale, or even sandstone in the neighbourhood, would re-people the entire area within a brief space.

The perforations of *Polydora* in oysters need not be taken too seriously, since even the best oysters are thus invaded, and yet their quality is undisputed. The condition is so universal that the greatest difficulty would be encountered in stamping it out, and it is doubtful if the result would compensate the labour and expense, even were it practicable. Besides, as already mentioned, the boring-sponge is a more dangerous enemy to the oyster-shell, since it so generally perforates the inner or nacreous layer.

Of the beds represented in the collections procured in 1883, the oysters of the Manning River were comparatively free from *Polydora*, as are those of the Clarence River, Moryna River, Shoalhaven River, Crookhaven River, Richmond River, Clyde River, Camden Haven, Cape Hawke, and Cape Upstart (Queensland) beds. Whether these had been specially selected or were average examples, however, was not indicated. The oysters from Georges River, Hawkesbury River, Newcastle (Hunter River), and comparatively few from Jervis Bay, had larger numbers of *Polydoræ*, but were not by any means seriously affected when contrasted with those in Britain. A few from Auckland, New Zealand, were quite free from this borer. Some of the beds showed the oyster-valves riddled by the boring sponge (*Cliona*), such as Shoalhaven, Hawkesbury, Jervis Bay, Georges River, Clarence River, and Moryna River. A survey of the available specimens here does not show that the oysters from Hunter River are more subject to attacks of *Polydora* than certain other beds; but as these were collected in 1883, the condition may be different now, though such is unlikely. *Polydora* is a ubiquitous form.

No appearance observed in this collection militated against the view that in every instance oyster-culture, under efficient management, could be carried out with much success.

It may be added that various papers have within recent years been published on *Polydora*. In one of these, Prof. Léon Vaillant *, in referring to the action of *Polydora ciliata* on the calcareous rocks at the mouth of the Somme, estimated that there would be from 250,000 to 300,000 of them in a superficial mètre, and he considers them amongst the most persistently destructive forces affecting such shores. This action of *Polydora* had long before been recorded in this country, though it had escaped the notice of Mr. Whitelegge. The most complete revision of the species of the genus inhabiting oysters is that by Dr. D. Carazzi †, of the Museum of Spezia. He concludes his paper with some remarks on the biology of the annelids. As already indicated, he is of opinion that the descriptions of Mr. Whitelegge apply mainly to *Polydora hoplura*, which is partial to the margins of oyster-shells and more frequently passes through the entire shell, irritating the oyster and causing the blister with its attendant mud. Its action on living oysters is thus more grave, as a rule, than that of *P. ciliata*, a species also described as occurring in New South Wales.

* Ann. Sc. Nat. Zoolog. 7e sér. tome xii. p. 44 (1891).

† Mitt. Zool. Stat. Neapel, ii. Bd. 1 Heft, pp. 1–45, Taf. 2 (1893).