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EDITORIAL NOTE.

THE accompanying Paper by Mr. Whitelegge was published on the 19th April, 1890, as a Report to the Commissioners of Fisheries of New South Wales, and is again issued as Part II. of the "Records of the Australian Museum." The Trustees having given their permission, at the request of the President of the Commissioners, Mr. Whitelegge was specially deputed to investigate the so-called Oyster disease, and spent some time in the neighbourhood of Newcastle prosecuting his researches, which were continued and completed at the Australian Museum.

R. ETHERIDGE, JUNR.,
ACTING CURATOR.

REPORT ON THE WORM DISEASE AFFECTING THE OYSTERS ON THE COAST OF NEW SOUTH WALES.

By Thomas Whitelegge,

Fellow of the Royal Microscopical Society; Zoologist, Australian Museum.

At the request of the members of the Fisheries Commission, I, by permission of the Trustees of the Australian Museum, recently paid a visit to Newcastle with a view to inquire into the so-called oyster disease, which is caused by the presence of a small marine worm, identified by Prof. Haswell, of the Sydney University, as *Polydora (Lucodore) ciliata* (Johnston). On my arrival at Newcastle I was taken over the various oyster beds by Mr. Curan, the local Inspector of Fisheries, who did everything in his power to assist me. I am also indebted to Messrs. Gibbons and Anderson, two of the principal oyster lessees, for their kindness in providing me with boats and dredges.

The Infected Area.

Although the worm is very generally distributed, having been met with in various situations, from about half-tide line to moderately deep water, still the principal home of the worm appears to be on the mud flats about low-water mark. The oysters from this region were invariably infected with the worm, particularly those which lay loose on the surface or partially buried in the mud. Whilst those oysters which were fixed to some solid substance, and elevated ever so little above the surface of the mud were comparatively free from the pest.

During my stay I examined about fourteen oyster beds, which I need not particularize, suffice it to say that the worst are the bare mud-flats and the artificial beds in deep water. The latter are composed of oysters collected on the banks of the river, and probably the majority were obtained from the mangrove flats, as they would be more easily gathered, inasmuch as they are not, in that locality, fixed to any solid substance. From an examination of a very large series of these oysters, I am convinced that they were infested with the worm before their removal, as the evidence of disease was in nearly all cases deep-seated and below the lines of growth made after being laid down. The natural beds —only a short distance from the artificial ones—are fairly free from disease; and, further, they appear to overcome the worm when attacked, quickly enclosing it with a thick layer of shelly matter before it has time to establish itself. From what I ascertained of the habits of the worm, it appears that a large amount of mud is necessary to its existence, and that the more muddy the place, the better the worm thrives; such being the case, it is reasonable to suppose that those oysters which are fixed on some solid body, and somewhat above the surface of the mud, will have a better chance of escaping the ravages of the worm, than those which are partially buried in mud or lying loose on the surface. I conclude, therefore, that if some loose material, such as stones, old shells, &c, was placed on the mud-flats for the spat to set upon, removing it from direct contact with the mud, that the prevalence of the worm would be considerably diminished. In the absence of such material, the worms have no other alternative but to fix on the oysters as a place of refuge.

Symptoms of the Disease.

Oysters which are badly infested with worms may be detected at a glance by their thick rounded outline, and the absence of thin sharp edges. Moreover, by looking along the anterior margins of the valves, the entrances to the worm tubes will, on close inspection, be readily seen; those openings furthest removed from the edges of the shell having a *keyhole-like outline*, whilst those on the actual margins are *semicircular*. In the majority of cases the worms are found on the anterior margins of both the upper and lower valves, and frequently on the posterior margins, but rarely on other parts. On opening the diseased oyster, the valves will be seen to possess a series of blister-like structures, which are very variable in shape and extent, usually they are more evident on the lower valve than on the upper. On pressing the surface of these blisters with the point of a knife, it readily yields, and underneath will be seen a quantity of light brown mud in which the worms are embedded. Each worm has its own collection of mud, and from it a membranous tube often extends a short distance beyond the edge of the shell. The tube is invariably curved, but it is usually curved in such a way that the entrance and the outlet are in close proximity to each other, the inlet and outlet being often inclosed by the thin layer of shell deposited by the oyster. When viewed in section the opening of the tube is semicircular, the older part of the shell forming the base, and the newer layer the half-circle; or there are two openings, each consisting of three-fourths of a circle, with a space connecting them together, and bounded above and below by linear layers of shell. On removing the thin shelly matter it will be seen that the inner surface retains all the inequalities of the mud over which it was deposited, and forms a sort of mould of the inclosed mud, and rarely exhibits any distinct groove except near the edge. The older parts of the valves upon which the worm rests, exhibit grooves of certain depths, varying according to the length of time the worm has been in the shell. The grooves are deepest near the edges, and gradually get shallower inwards. During my observations I found about twenty examples in which very young worms had just entered the shells, and in all these cases, the worms were surrounded by large patches of mud, and a thin membranous covering deposited by the oyster. On the removal of this mud, the surface of the old shell was quite smooth, without any trace of a groove—a lens when applied to the spot failing to show any erosion. The only means by which the place occupied by the worm could be detected was by the presence of the edges of the thin membrane formed by the oyster. The above mentioned facts have an important bearing on the question as to how the worm gets into the shell, which is a much simpler process than has hitherto been supposed, inasmuch that it does not entail any far-fetched theories about the worm boring into the shell, with the assistance of an acid secretion from the body, or mechanically by means of its bristles. My opinion is that the worm does not bore into the substance of the shell at all in the strict sense of the word.

How the Worms effect an entrance into the Oysters.

Before entering into details it will be necessary to take into consideration the habits of the young worm, which will, when fully stated, show that the boring theory is out of the question; and, further, that sections of the shell, if carefully examined, furnish sufficient evidence to show that all the appearances presented may be accounted for without supposing that the worm deliberately drills an opening into the solid shell. On the third day after my arrival at Newcastle, I found several clusters of ova, which I concluded were those of the *Polydora ciliata*. They were found on the sides of the membranous tubes of the worm, in little transparent sacs, each cluster somewhat less in diameter than the body of the worm, and each sac containing between 50 and 60 eggs. I placed some of these egg-sacs in a test tube and kept them for six days, during which time most of the eggs hatched out. On examining a cluster under the microscope, I observed the newly hatched larvæ swimming about in the egg-bag, and by means of a dissecting needle, I ruptured the wall and allowed them to escape. They swim very rapidly by means of the oral and anal wreaths of ciliæ and the tufts of long stiff setæ, which they only used occasionally. They appear to jump or skip when the bristles are brought into play, and are consequently very difficult to follow under the microscope. At birth the body is about twice as long as broad, and consists of six segments. The antennæ are represented by small rounded lobes, the eyes are four in number, two near the mesial line, and two a little further forward and widely separated. On each side of the body there are a series of bristles, on the first segment there are about 9 on each side, on the remaining segments the bristles diminish in size and number posteriorly.

The early stages of this worm have been dealt with by A. Agassiz in the Annals & Magazine of Natural History, Vol. XIX., ser. 3, 1867, page 203, the figures given representing larvæ from about five days old and upwards. In the course of his remarks he refers to a work by Claparède (Beobachtungun) which is not obtainable in Sydney, and states that his examples were considerably more advanced than those figured by Claparède, "having already lost, if ever they possessed them, the bunches of ringed bristles so characteristic of the younger stages of many Annelids." I may say that the only bristles seen by me were the lateral tufts already mentioned. For the first six days the larvæ swim about vigorously, after which they begin to settle down, and appear to be in search of some suitable place to commence life in earnest. At this stage it is very difficult to transfer them from one vessel to another by means of the dipping tube, from the fact that the moment they feel the current of water, they suddenly fix themselves on the sides of the tube, and no amount of shaking will move them. They hold on to the glass by the head with leech-like tenacity, whilst the rest of the body moves up and down with the water. The only way to get them on to a glass slide is to wait until they settle down to the bottom of the tube. This peculiar habit of being able to fix on an object suddenly, when caught in a current of water, is a very important factor in enabling the worm to select any spot it chooses for its abode. If the place first chosen is not convenient, it can move to another more favourably situated, even in the face of a strong current of water.

In the early part of this report I mentioned the fact that the attacks of the worm are usually confined to the anterior and posterior margins. The reason for this is obvious. The main current of water drawn in by the oyster enters at the anterior margin, and passes out at the posterior margin. It is evident that if the worms possess the power of selecting their future place of abode, those which fix on the anterior margin will benefit by being situated in the inflowing current, which is a means of supplying them with food; and those fixing on the posterior margin will also be similarly benefited, only in a lesser degree.

From what I have seen of the habits of the young worm in its free swimming state, and also of those already mentioned as having just settled down, I am of opinion that the young worm simply swims into the open oyster, and fixes itself by its head on the margin of the shell. If the position is suitable it immediately begins to construct a tube and collect a large quantity of mud. It may possibly be guided to the most favourable spot by the current of water drawn in by the oyster. If so, then we have the explanation why it is that the anterior margin is more often infested than any other part of the shell. The worms appear to have the power of collecting a large quantity of mud in a very short time. Some which I kept in confinement in moderately clear water added fully one-quarter of an inch to the length of their tubes in about an hour, and I have frequently removed the projecting tubes at night, and in the morning they had been repaired and projected beyond the edges of the shell fully half an inch; so that a vigorous young worm on entering an oyster can soon accumulate a large quantity of mud, which is immediately covered over by the oyster with a thin layer of shelly matter, and if the oyster is healthy, the deposit is laid down quickly, confining the worm with its patch of mud to a very small space. On the other hand, if the oyster is unhealthy and already infested, the shelly deposition is slower and the worm collects a large patch of mud before the layer is solidified. Hence it is that the size of these accumulations of mud get larger as the worms increase and the oyster gets weaker. In some very severe cases the whole of the lower valves were covered with freshly collected mud, and the oysters were reduced to a mere skin, and utterly incapable of secreting any shelly matter. The effect of these blister-like structures, which increase in number and size as the disease progresses, is to practically fill up the whole of the lower valve and to bulge out the upper, so that there is no room left for the oyster.

In all cases the recently collected mud is of a light brown colour, and was found to be the work of young worms varying in length from one-eighth to half an inch, the patches of mud on the larger examples varying from one to one and a half inch in length, by one-half to three-quarters of an inch wide. In most of the examples mentioned the surface of the mud was covered by a thin pliable membrane. The mud surrounding the adult worm is usually more compact and darker in tint, often inclining to slate colour; whilst the mud which the worms have left is frequently black. No doubt it is partly due to the decomposition of this black mud that so many oysters die. The parts of the oysters overlying these putrefying patches are always discoloured by yellowish spots.

When the habits of the young worm are considered in connection with the evidence derived from the examination of oysters, in which the worm has just established itself, it points to the conclusion that the larvæ simply swim into the open shell; and there is no evidence of any boring having taken place from without from the fact that the place occupied by the worm is quite smooth, and even in those cases in which the worm is full grown, the surface is often devoid of any grooves. It is only in old-established cases that grooves and tubular openings are found, and there they only exist on the margins as a rule. The above remarks apply to the old or thick parts of the valves; the newer thin deposit over the mud, as before mentioned, merely exhibits the irregularities of the surface over which it was laid whilst in a soft pliable condition, and is usually without any trace of grooves, except near the margin. Even these grooves, when examined with a lens, show a mould of what was beneath, without exhibiting any signs of having been bored. Another feature is the entire cavity occupied by the mud and worm, which cannot be accounted for by the boring theory. If the worm bores into the substance of the shell, how are the blister-like cavities formed? It is not reasonable to suppose that the worm has the power of raising a rigid layer of shelly matter and forming a blister. To do this the layer must be rendered pliable, otherwise there would be evidence of such raising in the shape of cracks, etc. If the blisters are formed by the disintegration of the shell, there ought to be some evidence on the inner surfaces; but there is nothing to show that disintegration had taken place. One surface is comparatively smooth, and the other a perfect mould of the enclosed mud.

Is it not more reasonable to suppose that the upper layer is deposited over the mud whilst in a soft state, simply covering the mud and worms, than to suppose that the worm bores into the shell and then forms the blister? If the blisters were formed by the disintegration of the shell, there ought to be some variation in the thickness of the layer, inasmuch as the disintegration would be unequal, and be most evident immediately over the worm. Such, however, is not the case; the deposited layer is pretty uniform in thickness over each blister.

From an examination of a large number of shells in sections, it appears to me that the cavities when once formed are never enlarged in any perceptible degree. Frequently, when viewed in section, cavities may be seen one above another in tiers, each one distinct, but regulated in form by the one below. These various cavities simply represent the entrance of so many worms into the open shell at different times, each worm in turn being covered over by a thin deposit.

Mr. A. Oliver, in an article in the "Centennial Magazine" for September, 1889, suggests that the death of the oyster takes place from being unable to close the valves on account of the undermining of the attachment of the abductor muscle. I may say that during the whole of my investigations I never met with such a case, a fact which militates against the boring view. I, however, met with many instances in which the muscular spot was considerably lessened, not by its being undermined, but by the encroachment of the worm around the point of muscular attachment and deposits of shelly matter all round, so that the spot, after the removal of the muscle, appeared to be in a deep hole owing to fresh deposits being laid down all around it.

The death of the oyster is brought about chiefly by the decomposition of the mud after the death of the worms; but no doubt the imperfect closing of the valves has its effect. In all cases in which the worms are numerous, the edges of the valves are defective, from the fact that the worms occupy the edge and that the shelly deposits are used in lining the shell. Oysters that are infested with worms are much more sensitive than those which are free from them—at least those which I kept under observation were so. If the vessel containing them was disturbed, the diseased oysters were the first to close and the last to open. This sensitiveness will tend to deprive them of a large quantity of food. In addition there are the worms placed in the current which carries the food to the oyster, and which in bad cases may number from twenty to thirty, each feeding on the food drawn from the supply of the oyster.

During my stay at Newcastle I was much surprised at the absence of the worms from the dead shells; but after keeping some oysters under observation for about six weeks, I began to see the reason for this. The fact is the worm is a sort of commensal and partly parasitic on the oyster, in so far that it only appears to thrive when in the currents of water created by the oyster. If the oyster can succeed in forming sufficient shell to force the entrance of the worm-tube away from the edge, so that the opening is out of the current, the worm appears to leave the shell. I opened some badly infested shells, took out the oysters, and then replaced the valves in the water. In the course of a few days the worms deserted the valves, which to my mind tends to prove that unless they are in such a position as to partake of the food drawn in the current by the oyster, they leave their position and seek some other abode. During my observations I never saw the adult worms attempt to obtain an entrance into a fresh oyster. I selected a young oyster and placed it in a vessel by itself. With it I repeatedly placed a number of adult worms, with a view to determine if they would attack the oyster; but in all cases the worms appeared quite incapable of getting into the shell, and they invariably died within a very short time. They seemed to make no effort to gain an entry into the oyster, although placed near the edge of the shell and often on the surface. They rolled about in a very helpless sort of way, collecting small particles of floculent matter around them for concealment.

Evidence as to Boring, from an examination of the Shell.

One frequent appearance of the interior of the valves tells very forcibly against the boring theory. In many cases the worm occupies an elevated position in the shell, projecting above its surface as much as half an inch. The heap of mud surrounding such worms is covered by a thin layer of shelly matter, and both the entrance and the outlet to the worm-tube stand up at right angles to the oyster-shell valve, so that the worm lives within the shell completely, and the ends of the tube have no connection with the outer water, except when the oyster is open. (See Plate 6, fig. 5). Instances of this kind can only be explained by supposing that the worm and the mud have been enclosed by the shelly matter deposited by the oyster.

There appear to be three well marked stages in the appearance of sections of the shell when viewed from the outside and looking into the ends of the tubes. (See Plate 6, figs. 7, 8, 9.)

In the first stage we have the flattened solid part of the shell upon which the worm rests. Immediately over this is the thin layer formed by the oyster, which forms a semicircular outline (fig. 7). In this stage there are no grooves where the worm is in contact with the shell. In the second stage the basal surface is slightly grooved and the upper layer less of a semicircle, and somewhat flattened (fig. 8). In the third stage the grooves are so sunken in the basal surface that they appear somewhat like a keyhole, and consist of two openings, each forming three-fourths of a circle, with a space connecting them together. It is the appearance presented in the third stage that has led to the idea that the worm bores into the shell. At first sight such openings certainly look as if they had been bored; but if the various stages are carefully examined, with due regard to the time the worm has been in the shell —which may be determined by the colour of the enclosed mud, the size of the worm, the thickness of the shelly deposit, and the condition of the surface upon which the worm rests—the different phases presented may be traced easily, and the only way to get at the facts is to follow up what are evidently the early stages of the disease. In the first place the worm swims into the open shell, and settling down on the surface, near the margin, it at once collects a quantity of mud. The oyster, the moment it feels the presence of a foreign body, begins to deposit a layer of shelly matter, which determines or limits the extent of the muddy patch, according to the rapidity with which it is laid down and solidified. At this stage the worm rests on a smooth surface, and is covered over by a thin layer of shell. The oyster still continues to deposit shelly matter, and the growth at the edge tends to force the opening occupied by the worm further out. 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 surface.

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. If the worm has been long in the shell, the grooves formed are deep, and the longer they remain the deeper they become. When measured from the outside inwards they are longer and more tubular; but this is owing to the fact that the growth or increase in the size of the shell forces the entrances further outwards and upwards, or downwards, as the case may be, according to whether it is the upper or lower valve which is affected. Ultimately the openings have the keyhole-like aspect which look as if they had been bored, but which, if carefully examined, will show that they have passed through the various phases before mentioned, *becoming shallower inwards and ceasing to be grooved at all.* With regard to the worm boring into limestone, shale, &c., mentioned by English writers, I think it is quite possible that a young worm 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. Professor McIntosh, in the Ann. and Mag. of Nat. Hist., vol. 24, ser. 1868, p. 278, speaks of its boring into any shell that is thick enough to be bored.

The Remedy.

There are several ways in which to deal with the worms, with a view to their destruction. Those which I am about to give are the result of direct experiment, and if carried out in a proper manner, will prove effectual. When I returned to Sydney, after my fortnight's sojourn at Newcastle, I brought back a large quantity of diseased oysters. These I experimented on in various ways during a period of two months, having them under observation daily during the whole of that time. Some of the worst cases were placed in fresh water, which had the effect of killing the worms and some of the oysters; the latter were no doubt killed by the putrescent germs developed in the mud after the death of the worms. Others which were kept without water for fourteen days, were afterwards placed in salt water for several days, and in all cases the worms were destroyed, whilst the oysters appeared to be in a healthy condition. Some which were kept in an extempore aquarium for over two months, were cultivated until the whole of the worms had died out. This I attribute to the water supplied, not on account of its being bad, but from the fact that it was moderately clear and free from mud, which seems so essential to the life of the worm.

From the above series of experiments we may conclude that placing the oysters in fresh water for a few days will destroy the worms. But this method has its drawbacks from the difficulty of transporting them over long distances, and could only be used in favourable localities. The most effective as well as the quickest method would be the drying process. The oysters should be removed from the beds, freed from mud by washing, and then placed under a shed or cover of some kind, to protect them from the sun's rays. The oysters should be spread out in thin layers, and occasionally turned over, so as to ensure the thorough drying of the shells externally. The process may be continued for ten days or longer—if the oysters would stand it. They might afterwards be relaid on the beds, if suitable ground exists on which to lay them—that is to say ground having a stony or shelly bottom. If they are laid on a mud surface, they will very soon be infested again. Another method which might be useful would be to remove the oysters into prepared ponds, into which none but moderately clear water is allowed to enter, or place them on a sandy or pebbly beach in such a position that they would be exposed to the sun, and get partially dry between every rise and fall of the tide. No doubt if either course was adopted and continued for some months, the worms already in the oysters would be destroyed. The above mentioned remedies can only be applied to oysters that are loose or attached to small objects, such as shells, &c.

So long as oysters are cultivated on the bare surface of the mud, they will be liable to the attacks of the worm; but if some solid substratum be provided for the spat to fix upon, and so remove them from direct contact with the mud, the oysters will have a chance of escaping the disease.

It would be much to the advantage of men engaged in dredging and of the lessees, if they made themselves familiar with the worm as it exists in the oyster in a living state. This is comparatively an easy matter. All that is required is a small magnifying glass and a vessel containing sea water. If a diseased oyster is put in a shallow basin, the worms may be easily seen projecting out of their tubes, and the pair of feelers playing to and fro in search of food. If a practical knowledge be obtained of the appearance of the diseased oyster and the living worm, then the shells can be examined during any process carried on for the destruction of the worms, and the observer will be able to judge as to the effects of the remedy. If after placing a diseased oyster in water, and after the lapse of some hours the worms are not to be seen protruding their tentacles, it may be safely concluded that they are dead; but to make sure the oyster should be opened carefully, and some of the worms taken out and placed in a saucer of clean sea water, to see if there is any power of movement left in them.

The following is Dr. Johnston's description, as given in the British Museum Catalogue of the British Non-Parasitical Worms, page 205:—

LEUCODORE CILIATUS.

"Worm from 6 to 8 lines long, linear-elongate or slightly tapered to the tail, somewhat quadrangular, of a yellowish or flesh colour, with a dark red line down the middle. Head small, depressed, in the form of a short cylindrical proboscis, encircled with a raised hood or membrane. Mouth edentulous, eyes four, minute, placed in a square at the base of the antennæ, which are more than a fifth of the length of the body, tapered, wrinkled, and clothed along their inferior sides with short cilia. Segments numerous, narrow, distinct, the first four with an inferior papillary cirrus on each side, and a brush of retractile bristles; the fifth with a series of bristles curved like an italic *f*, obtuse, not capable apparently of being protruded like the others, and having rather a more ventral position; the following segments have on each side an obtuse branchial cirrus, originating from the dorsal margin, as long as half of the diameter of the body, held either erect or reflected across the back to meet its fellow on the mesial line; beneath it a small mammillary foot, armed with five or six sharp slightly curved bristles (crotchets?) with a small conical cirrus with a still more ventral position. The branchial cirrus is clothed on its lower aspect with rather long moveable cilia; it becomes very small or entirely disappears on the posterior segments, in which the bristles, on the contrary, appear to be longer and more developed. Bristles simple, unjointed. Anal segment conformed into a circular cup or sucker, in the centre of which the anus opens by a small round aperture. In this worm the cilia, which cover the under side of the branchial processes, are remarkable for their size and length, for they can be seen with a common magnifier fanning the water with equal and rapid beats, and driving the current along their surface. Their analogy with the cilia of Zoophytes is obvious; but here their motion is certainly dependant on the will of the animal, for I have repeatedly seen it begin and stop, and be again renewed after an interval of repose, and again be checked in a manner that could leave no doubt but that the play of the organs was entirely voluntary. The cilia of the antennæ, notwithstanding the larger size of the organs, are less than half the length of those of the branchiæ.

Leucodore ciliatus lives between the seams of slaty rocks, near low-water mark, burrowing in the fine soft mud which lines the fissures. Its motions are slow. When placed in a saucer it keeps itself rolled up in an imperfectly circular manner, lying on its side, and the painful efforts made to change its position, with little or no success, show too plainly that it is not organised to creep about like the *Annelides errantes*, but, on the contrary, that its proper habitat must be a furrow similar to those of the Tubiculous worms, to which in structure it evidently approximates in several particulars."

Dr. Johnston's description is wanting in detail in some respects, and Prof. McIntosh, in the Annals and Magazine of Natural History, vol. 2, series 1868, p. 282, gives a very lengthy description of the tentacles, bristles, hooks and the anal segment, accompanied by a plate, which is reproduced and will be found at the end of this report. As far as I can ascertain, nothing has yet been published in reference to the eggs of the worm, and the following, if new, may be of interest:—The ova appear to be matured in the body of the worm and commence on about the thirtieth segment. Each succeeding segment to about the fiftieth bears a pair of egg-sacs, each of which contains between fifty and sixty eggs. The egg-cases are deposited on the sides of the membranous tubes inhabited by the worm, and remain in this position until the young worms are hatched. (Fig. 10, plate 3). It appears to me that the brood-pouches are formed within the body of the worm, and at the period of deposition the outer cuticle is ruptured, and the egg-sacs fixed on the sides of the tube. Before the eggs are deposited, the body of the worm is plump and of a cream colour, with a central line varying in colour from bright red to a very dark brown. Afterwards the body appears thin and of a chocolate colour, and appears almost like another species. In fact until I carefully examined those which had laid their eggs, I thought there was a second species inhabiting the oysters. The period during which the worms produce ova may be stated to be the months of October, November and December. How far the breeding extends beyond these months I am unable to say; but it probably is within the mark to say that it may extend for a month or six weeks on each side.

The following is a list of the principal writers who have written on the worm and its habits:—

Leucodore ciliatus—Johnston, Magazine of Zoology and Botany, 1838, ii., p. 66, pl. 3, f. 1-6.

" " Dr. T. Williams, Report of the British Association, 1851, p. 208.

" " Dr. Johnston, Catalogue of Non-Parasitical Worms in the British Museum, 1865, p. 205, pl. 18, f. 6.

" " Prof. E. Ray Lankester, Annals and Magazine of Natural History, 1868, vol. 1, ser. 4, p. 233, pl. xi.

" " Prof. W. C. McIntosh, Annals and Magazine of Natural History, vol. 2, ser. 4, 1868, p. 276, pls. xviii. and xix.

Leucodore ciliatus—Prof. T. H. Huxley, The English Illustrated Magazine, No. 1, Oct. 1883, pp. 46 to 55; No. 2, Nov. 1883, pp. 112 to 121.

" " Dr. W. A. Haswell, Centennial Magazine, Sept. 1889, p. 148.

Polydora (Leucodore) ciliata (Johnston)—Alexr. Agassiz, Annals and Magazine of Natural History, vol. xix, ser. 3, 1867, p, 242, pls. v. and vi.

Polydora (Leucodore) ciliata—Dr. W. A. Haswell, Proceedings of the Linnæan Society of New South Wales, vol. x, p. 273.

There are very many other papers bearing on the habits of the worm, amongst which may be mentioned one by Dr. Wright in the Edinburgh New Philosophical Journal, 1857, vol vi, p. 90; another by Mr. Alexander Oliver in the Centennial Magazine for September, 1889, pp. 134 to 148; and some details of the habits of the worm are given by Sir J. Dalyell in his work on the Powers of the Creator Displayed in Creation, 1851, vol. ii, p. 159.

—:o:—

SUPPLEMENTARY NOTE.

SINCE the foregoing was written, I have received a number of oysters through the Department of Fisheries, from the Clarence River, which had been in fresh-water for 13 days, owing to the flood waters spreading over the beds. An examination of these oysters tends to confirm the opinion already expressed in the body of this report.

Out of 200 oysters, 50 were found to have been attacked by the worm, and 25 of these exhibited the early stages of the disease. The area occupied by the worms was of variable extent, but mostly small; the patches of mud being covered by deposits formed by the oysters; 15 out of the 25 specimens were in the membranous stage, and in the rest the deposits were partially calcified. In the whole of the 50 specimens the position occupied by the worms was on the anterior margin of the shell, about midway between the hinge and the ventral edge. On clearing away the patches of mud, which were covered with membrane only, the surface on which the body of the worm rested was found to be perfectly smooth, and without any trace of erosion; whilst in those in which the deposited layers were thick and fully calcified, slight traces of grooves were visible near the margin. In every case the worms were dead, having been killed by the fresh-water. The mud contained in the blister-like cavities had become putrid. and its colour of an inky blackness, and the stench unbearable, In every instance where the mud was only covered by a thin deposit, the oysters were either dead or dying, from the attacks of the putrescent germs developed in the mud; while those in which the deposit was thick appeared to be in a healthy condition.

The worm does not seem to confine itself to the oyster; I have seen it in *Pinna Menkei* and *Pectunculus Dunkeri* from Shoalhaven. It is common in *Chione calophylla*, *Venus laqueata*, and other bivales in Port Jackson. The distribution of the worm appears to be world-wide. It is found in Europe, North America, Australia, and the Philippine Islands. There is also a species described by Schmarda from the Chilian coast of South America, which may prove to be the same.

ADDENDA ET CORRIGENDA.

PAGE	LINE	
8.	1.	Omit "Re-."
8.	1.	For "an" read "a new."
8.		Omit foot-note *
9.	30.	For "44" read "48."
10.	1.	Omit "Re-."
10.	1.	For "an" read "a new."
10.		Omit foot-note.
18.		Foot-note † for "1877" read "1887."
20.	32.	For "milee" read "miles."
23.	33.	For "viverinus" read "viverrinus."
24.	36.	For "Lymnodynastes" read "Limnodynastes."
27.	30.	For "Barwon" read "Barron."
30.	20.	For "nalabatus" read "ualabatus."
30.	42.	For "Scenoæpus" read "Scenopœus."
31.	10.	Omit "Ptilotis" and substitute ,,
31.	17.	For "epioletus" read "epicletus."
31.	17.	For "Agavista" read "Agarista."
31.	36.	For "Gonyodactylus" read "Gonyocephalus."
31.	38.	For "Myxophies" read "Mixophyes."
36.		Omit foot-note.
37.		Omit foot-note.
38.		Omit foot-note.
41.	6.	For "Lucodore" read "Leucodore."
49.	23.	Add "4" after "Ser."
51.	24.	For "moveable" read "movable."
52.	6.	Add "4" after "Ser."
61.	30.	For "macroscopic" read "microscopic."
65.	30.	For "mising" read "mosing."
69.	5.	For "cresentic" read "crescentic."
78.	2.	For "(155)" read "(15·5),"
81.	23.	For "of the total" read "in the total."
81.	23.	For "four-sevenths of" read "four-sevenths in."
81.		Omit "and is" in foot-note.
86.	8.	For "artica" read "arctica."
86.	19.	Add "Herd." after "viridis."
87.	6.	Omit "," before "ovum."
91.	40.	For "subtymppanal" read "subtympanal."
98.	41.	For "mmch" read "much."
99.	18.	For "this" read "thus."
99.	30.	For "percepttble" read "perceptible."
123.	2.	For "Madroporaceæ" read "Madreporaceæ."
123.	8.	For "cænenchyma" read "cœnenchyma."
Pl.	xi.	The figures are reversed.
,,	xxi.	(Explanation) For "Microcystina" read "Microcystis."

Note "DOTICUS PESTILENS: *A correction.*—From a communication kindly forwarded by Mr. F. P. Pascoe, it appears that the genus for which I adopted the MS. name *Metodoticus* (see p. 75), has been described under the name *Doticus* (Ann. Mag. Nat. Hist. ix. p. 27, 1882). The Victorian Apple-pest should, therefore, be known as *Doticus pestilens,* instead of *Metadoticus pestilens,* as at first suggested. A figure of the insect, and some account of its life-history, are contained in Mr. French's recently published 'Handbook of the Destructive Insects of Victoria.'—A. S. O."

EXPLANATION OF PLATE III.

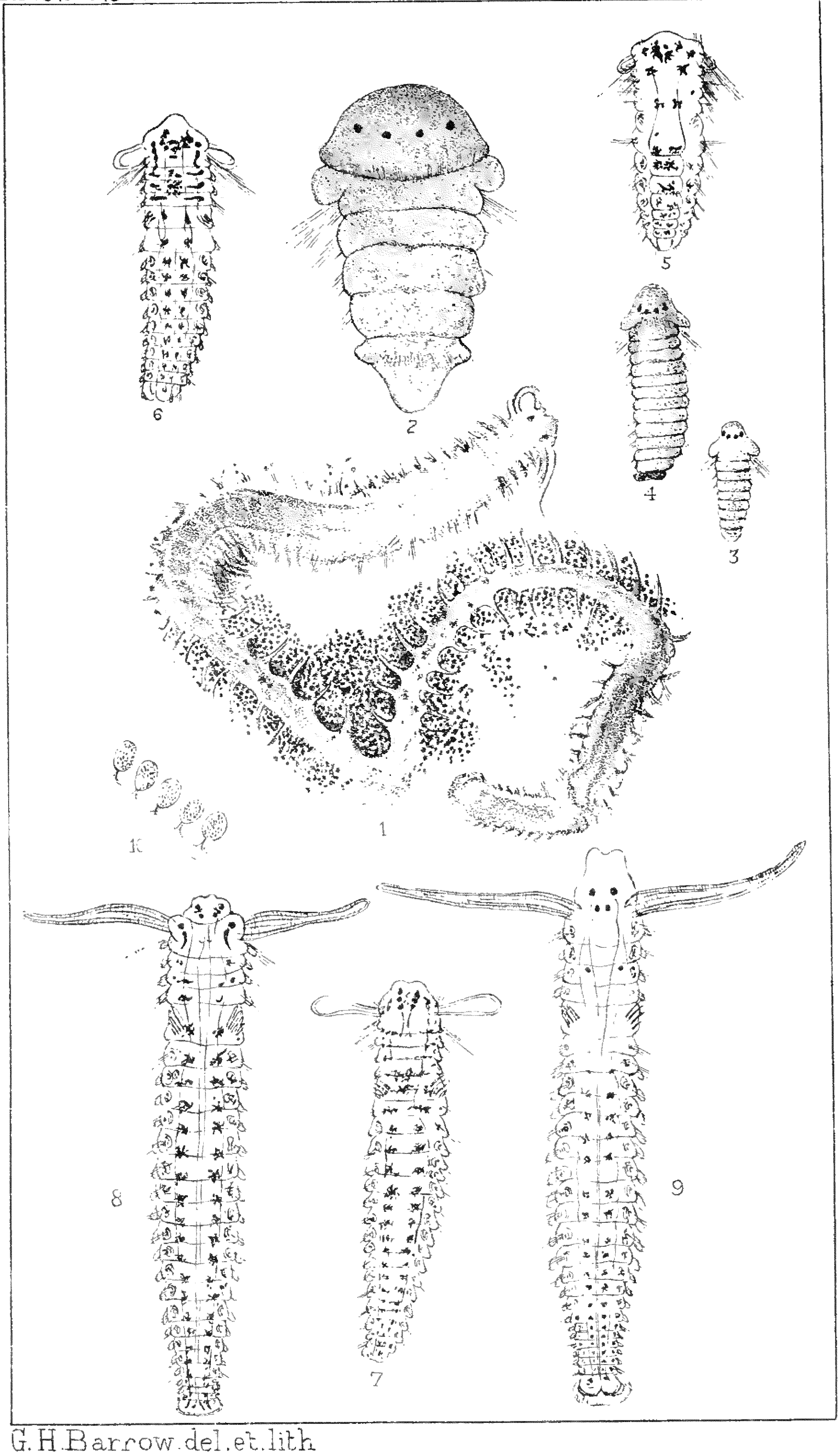
Fig. 1. *Polydora* (*Leucodore*) *ciliata*, with ova, from a photomicrograph, highly magnified. Original.

,, 2. Young larvæ of *Polydora* from a photomicrograph, taken shortly after its escape from the ova-sac, highly magnified. Original.

,, 3 & 4. Older stages, from a photomicrograph, highly magnified. Original.

,, 5 to 9. Somewhat more advanced, after Prof. A. Agassiz.

,, 10. Egg-cases of *Polydora*, attached to the side of the membranous tube, x 7 diameters.



G. H. Barrow. del. et. lith.

EXPLANATION OF PLATE IV.

Fig. 1. Adult worm (*Polydora*) enlarged under a lens.

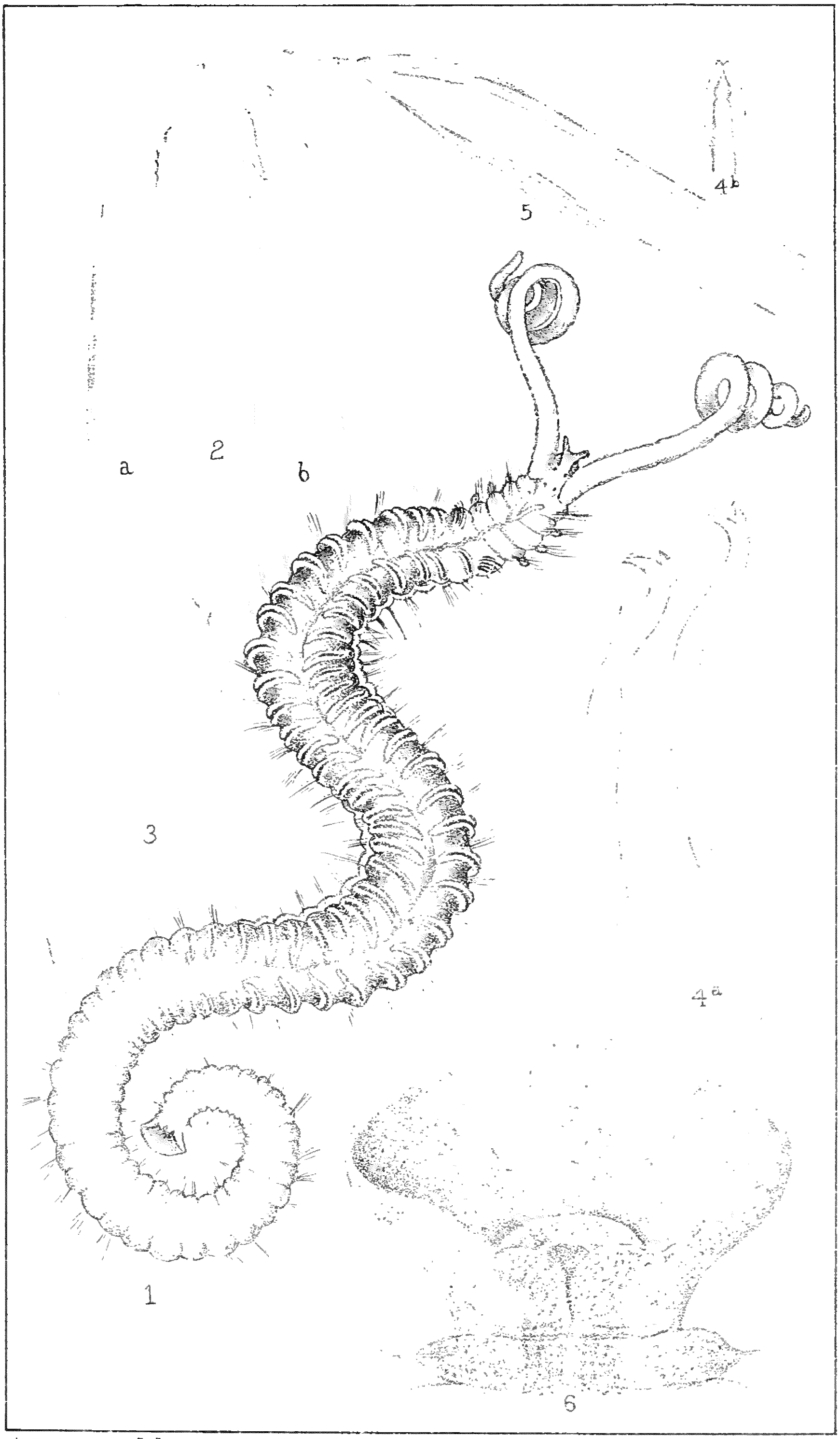
„ 2. Great hooks of the fifth segment of the body; *a*, as usually seen in the separated and perfect organ under pressure; *b*, more complete as obtained in the living animal or in a favourable spirit preparation x 700 diameters.

„ 3. Spear-tipped bristles accompanying the former x 700 diameters.

„ 4. Hooks of the posterior region of the body; *a*, pressed between two glasses; *b*, seen in front, so as to exhibit both wings, x 700 diameters.

„ 5. Front and side view of two of the bristles of the same species, x 700 diameters.

„ 6. Caudal segment and its cup, x 210 diameters. The whole of the figures and explanations after Prof. W. C. McIntosh.



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EXPLANATION OF PLATE V.

Fig. 1. Lower (left) valve of *Ostrea cuculata*; (Born) *d*, dorsal edge, *v*, ventral ditto, *a*, anterior margin, *p*, posterior ditto, showing a large blister with the opening of the worm tube on the anterior margin.

,, 2. Upper (right) valve exhibiting two blisters; the one with a dotted outline near the ventral edge, is covered by a calcified layer; the other is in the membranous stage.

,, 3. Upper valve showing a larger blister, the work of a single worm (right hand figure). The same with the surface of the blister removed showing the position occupied by the worm (left hand figure).

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EXPLANATION OF PLATE VI.

Fig. 1. Transverse section of lower valve, exhibiting a series of cavities formed by the oyster in its attempts to cover over the various patches of mud collected by the worms. The entrances to some of the cavities may be seen on the right hand side of the figure (the anterior margin).

,, 2. Section of upper valve showing two cavities, with the openings also on the anterior margin.

,, 3. Upper valve showing the extent of the mud patch collected by a single worm, and the surface of the mud covered by a thin uncalcified membrane.

,, 4. Tubes erected by *Polydora* at the aperture of its tunnel. The attenuated tentacles are seen protruding from the mouth of one. Enlarged under a lens, after Prof. McIntosh.

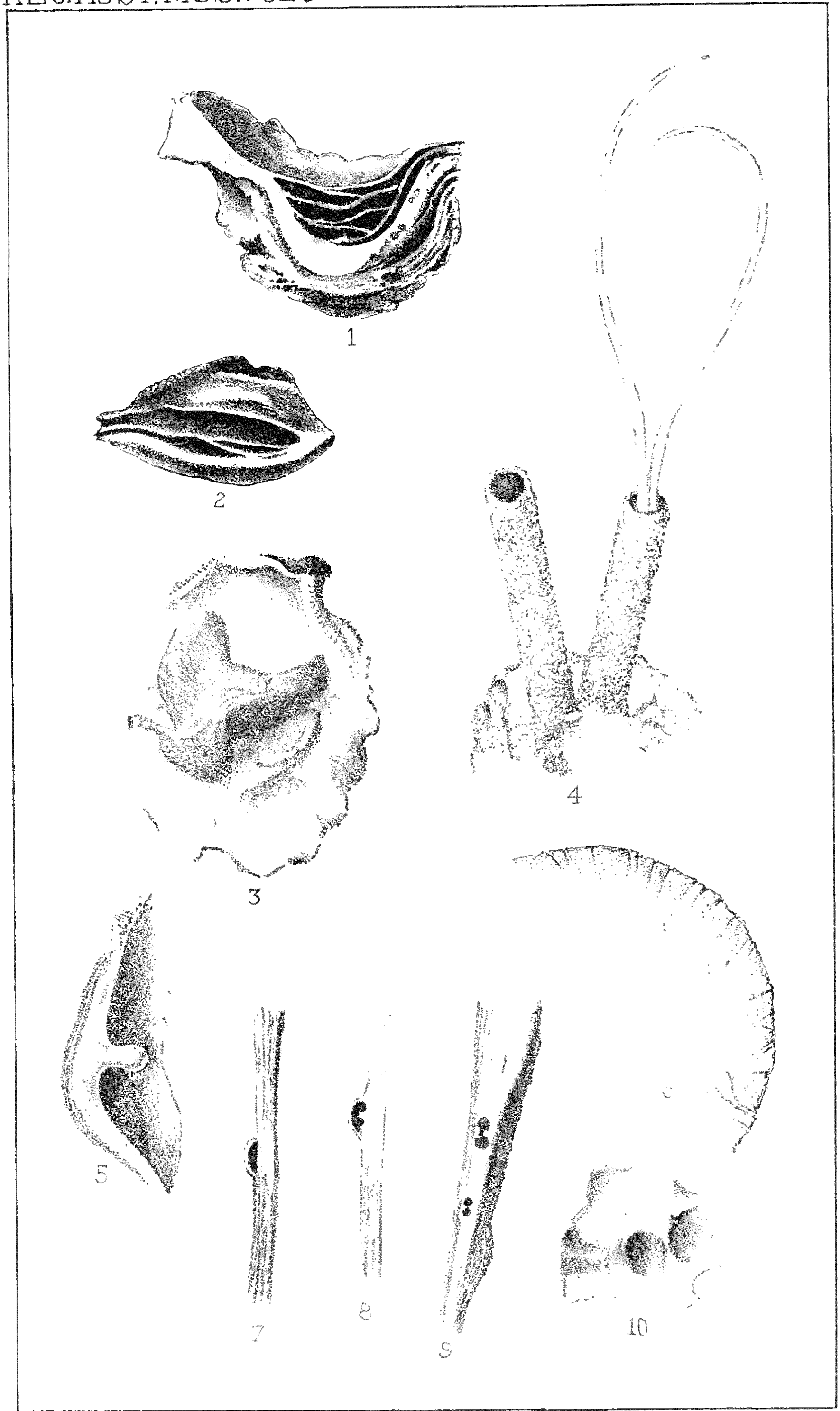
,, 5. Upper valve showing an elevated nodule; near its summit is the tube of the worm projecting at right angles to that of the nodule; the latter is so situated that when the oyster closed its valves there was no communication from without.

,, 6. Edge of an old shell, exhibiting the grooves made by the action of the worms in moving in and out of tubes. The grooves only exist at the margin, and disappear entirely inwards. Slightly enlarged.

,, 7, 8, & 9. Sections of shells showing the openings of the tubes occupied by worms.

Fig. 7, first stage; Fig. 8, second stage; Fig. 9, third stage. Enlarged three times. See page 48

,, 10. Portion of a blister showing the inequalities on the inner surface. See page 46.



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