

NOTES ON AUSTRALIAN EARTHWORMS.

PART I.

BY J. J. FLETCHER, M.A., B.Sc.

(Plates VIII. and IX.)

In his well-known work on "Vegetable Mould and Earthworms," Mr. Darwin, probably influenced by the recollections of his travels over the Hawkesbury sandstone country during a very hot and dry month (January 1836), says that, until he was informed by Mr. Krefft to the contrary, he should scarcely have thought earthworms would be common in New South Wales with its dry climate. Mr. Krefft's information was, however, of a general nature, and from the character of the castings sent by him to Mr. Darwin, probably referred only to the worms found in the neighbourhood of Sydney. Having myself collected specimens of five new, and one undescribed species of earthworms from two localities, both oases of rich volcanic soil in the Hawkesbury sandstone formation, and having heard from gentlemen who have actually seen specimens, of the existence of large worms in the Hunter and Manning River districts, it seems safe, considering how many rich tracts of similar country are yet unsearched, to hazard the conjecture that, when the earthworms of this colony have been systematically collected and described, it will be found, at any rate in the coastal districts where the soil is good, that they are by no means scarce, and, as regards both individuals and species, will compare favourably in point of numbers with earthworms in other parts of the world. As there are several new worms from Queensland in the Macleay Museum, and as both Dr. Ramsay and Mr. Masters have noticed large worms in several districts of the same colony, a similar statement may be made concerning both it and, probably, the coastal districts of more or less of the whole continent, wherever there is good soil. The alluvial

flats in some inland districts are not destitute of worms as I shall mention later, but with respect to the extensive plains of the interior where the rainfall is small, the case may be different, and I should be glad to receive information on the subject.

Up to the present time only three species of earthworms have been described from Australia, with a fourth (*Lumbricus orthostichon*, Schmarda) from Tasmania. This last was originally described as from New Zealand, but this locality, on the authority of Captain Hutton, is incorrect. Two of the described species (*Lumbricus Novæ-Hollandiæ*, Kinberg, and *Digaster lumbricoides*, Perrier) are from New South Wales, the third (*Megascolides australis*, McCoy) being from Gippsland, Victoria. At present I have met with only one of these species.

From gardens, grass paddocks, uncultivated lands, and old quarries in Sydney or its suburbs I have obtained specimens of four or five species of worms. Of these, one is without doubt Kinberg's species; a second seems to be a European introduced species (*Lumbricus olidus*, Hoffmeister); a third is a small perichæte worm which appears to be closely allied to, if not of the same species as, much larger worms found at Burrawang, and of which a variety occurs at Mount Wilson; a fourth, of which I have found only three immature specimens all devoid of a clitellum, has two gizzards, and appears to belong to Perrier's genus *Digaster*, but is different from the species described by him from Port Macquarie; while a possible fifth species, known to me so far only from the Elizabeth Bay garden, is at present un-identified. I did not find the first of these, which seems to inhabit comparatively poor soil, either at Burrawang or Mt. Wilson, but it is evidently a wide-spread species in this colony as, through the kindness of two of our members, Messrs. J. R. Garland and A. G. Hamilton, I have received specimens of it from Wagga Wagga, and from Guntawang near Mudgee, and I have found it myself on the banks of the Turon River, about five miles from Capertee; thus showing that the alluvial flats of some inland districts are not destitute of worms.

Some or all of these worms cast on the surface abundantly during and just after wet weather especially in spring and in autumn. At such times also worms may frequently be found on the surface under logs and stones without the trouble of digging for them ; such situations, because they retain moisture longer, are favourite resorts for them, and accumulations of castings may often be found under large logs, when none are to be seen elsewhere. Last March after heavy rain I dug up a number of worms (*L. Novæ-Hollandiæ*), many of which were snugly coiled up in little chambers at the bottoms of their burrows, and this is doubtless the usual way in which they exist during dry periods. Like their European congeners, as mentioned by Mr. Darwin, after heavy rains many worms of this species may be noticed crawling about aimlessly or lying dead, on the garden paths or even on the pavements in the suburbs. This was very noticeable during the early part of this month (June).

For prolific hunting-grounds for worms, the neighbourhood of Sydney will not compare with the rich volcanic soil of Burrawang and of Mount Wilson. These two localities with Sydney form the angular points of a triangle, of which the two sides meeting at the metropolis are each about 50 miles long, as measured on the map, while the third is somewhat longer.

Burrawang township is situated on the coach road from Moss Vale to Kiama, at a distance of 10 miles from the railway. The elevation above sea-level is about the same as that of Moss Vale, namely 2200 feet. The district varies from undulating to hilly, many of the hills being still capped with basaltic boulders. It is well watered with perennial creeks, and has an average annual rainfall probably not less than that of Moss Vale (49 inches). The rich soil is due to the decomposition of a sheet of lava which, the Government Geologist kindly informs me, probably emanated from somewhere near what is now Bowral, and over-spread more or less of the Hawkesbury sandstone formation of the district. The great depth of the rich red or chocolate-coloured soil may be noticed in the road-cuttings, and I have been told that in some places near Robertson it is as great as 25 feet. In one poor

paddock on the farm where I procured my specimens, a sand pit shows about 6 feet of soil resting upon sand. The sandstone is not everywhere covered, for about half-a-mile from this farm it crops out in precipitous cliffs, and a little further off there is an uncovered tract of about 100 acres, the stunted vegetation of which both as regards its general appearance and the species of plants, presents a striking contrast to the surroundings, and instantly calls to mind the neighbourhood of Sydney. Elsewhere the large size of the Eucalypts, the abundance of tree-ferns, and the large tracts of thick Sassafras brush, much of which however is now being cleared, testify to the richness and fertility of the soil.

In this locality I have obtained examples of four new, and one undescribed species of earthworms. One of these (*Didymogaster silvaticus*) seems to be restricted to the Sassafras brush, where it is to be found in and under rotten logs, on the substance of which it feeds. From information kindly given me by Mr. C. S. Wilkinson I have since found this worm under similar circumstances in Sassafras Gully near Springwood on the Blue Mountains. The first specimens of this species which I saw were shewn to me some two years since by Mr. Haswell, to whom they were given by the Hon. James Norton. It seems to be a common worm in the brush country, as there are specimens of it in the Macleay Museum from Jervis Bay, and from an unknown locality, possibly Springwood, from which place also I believe Mr. Norton's examples came. I did not find it at Mt. Wilson though it probably occurs there.

The other four species all live together in the more open country timbered with Eucalypts, though they may also inhabit the rich soil of the brushes. As yet I have collected only in a few paddocks on one farm, so that it is quite likely that other worms remain to be discovered in the district, which is occupied by dairy farms, agriculture not being carried on to any great extent.

During three of my visits to Burrawang I have been able to follow the plough, and one could not in any other way get such

a good idea of the abundance of these worms. On one occasion when the length of the furrows was about 80 yards I walked behind the plough and counted all the worms I could see either in the furrows or sticking out of the overturned clods, and I found that for a number of furrows the average number of worms visible under these circumstances was about 50 per furrow. Allowing a foot for the width of soil turned over for each fresh furrow, these would give nearly 10,000 worms to the acre. This is a small estimate compared with that given by Hensen for European worms, namely 53,767 per acre (1), and quite insignificant compared with two given by Urquhart for New Zealand worms, namely 348,840 and 784,080 per acre (2). But while Hensen's estimate is for worms found in gardens, in which situations he believes they are twice as numerous as in cornfields, and Urquhart's are for worms living in pasture land, which in one case had been 17 years in grass, my estimate is for worms in virgin soil, for the land to which I refer was not cleared during my earlier visits, and it was being ploughed for the first time on the occasion to which I refer. Moreover, my estimate is obviously below the mark for several reasons. In the first place the plough did not turn up the soil to a depth exceeding six inches if so great, and there were probably some worms below this level; and secondly if the clods had been broken up and carefully examined more worms would have been found. Hensen takes one gram (15.4 grains) as his standard of weight of a single worm, and Urquhart gives 6 grains as the average weight of his specimens, but that of the Burrawang worms would, I think, exceed the first of these weights, the largest worms, which however are least numerous, of which I have one specimen measuring 30 inches and a still larger one measuring 42 inches, probably weighing over 4oz. Allowing therefore for the large size of the worms and for the requirements of additional space on this account, it may

(1) Quoted by Darwin, *loc. cit.* p. 159.

(2) "On the Habits of Earthworms in N.Z." Trans. and Proc. of the N.Z. Inst. Vol. XVI, 1883, p. 269.

fairly be conceded that, for virgin soil, Burrawang is well provided with earthworms, though of course it is possible that the particular spot referred to may have been an unusually favourable one. Doubtless, as is the case elsewhere, the occupation of the land by man will lead to an increase in the number of worms, but, as it is quite exceptional in most country districts for farmers to manure the ground, the increase may be slow. A few miles off at Robertson I went to look at a piece of land which was being ploughed, and which the ploughman told me had been cropped twice, once with corn and once with potatoes, and though I found the same species of worms, I find on referring to my notebook that they did not strike me as being more numerous than I had seen elsewhere (1).

I have mentioned that the worms of these four species live together, by which is meant that in the same furrow, or even in a few yards of it, or by digging up a few square feet of soil in a good spot, one may obtain specimens of all four

(1) As the abundance of worms either at Burrawang or Mt. Wilson at the present time is not altogether, if at all attributable to the advent of man, since in both localities they may be found in undoubtedly virgin soil, the following facts are interesting by way of comparison. In "Nature" for 1884 (Vol. XXIX. pp. 213 and 406) will be found two letters in which the writers say, that earthworms do not exist in the prairies of the Canadian North-West, and in the United States in those of Kansas, nor in the Indian Territory, Idaho, and Washington Territory, possibly in some of these places, as the writers suppose, on account of the prevalence of intense cold, and of prairie fires, or because the soil is more or less alkaline. On p. 503 in a third letter, an American writer commenting on the first, says:—"It is well-known to settlers on virgin soils in this country that in the first tillage of the ground they will see no earthworms. This is equally the case whether they settle upon prairie land which has been swept annually by fires, or upon wood land which has been cleared for cultivation, and which has never been burned over. . . . But, until settlement and tillage by man there is no trace of earthworms even in those most favourable localities called "beaver meadows." At first they are found about the stable-yard, then in portions of ground enriched by stable manure, garden or meadow, till at length they may be found in all soils, either those cultivated or those pastured by domesticated animals. . . . The frontier settlers in Mukoka in the Canadian Dominion. . . . tell me that until a place has been inhabited for five years it is useless to search for the earthworm." According to this writer it would appear to be introduced worms which eventually become so numerous.

kinds in different stages of growth. The largest of these (*Notoscolex grandis*) though not so gigantic as certain worms found in Brazil, in Ceylon, or at the Cape, nor as the Gippsland worm of which Professor McCoy measured an example 70 inches long when held up, is still a large worm, one example among my spirit specimens measuring 42 inches, and being of proportionate thickness. The other three, one of which is a perichæte worm—that it has a more or less complete circle of bristles round each segment—are smaller, but still fair-sized worms; their dimensions and characters will be given in the systematic part of this paper.

At Mt. Wilson as I shall mention presently, the abundance of worm castings on the surface is very striking, but at Burrawang, strange to say, the worms do not, as far I can discover, cast on the surface. This statement may be qualified to the extent, that on a part of the farm, where the soil is so poor that a brickyard was opened for a time, after heavy rain small worms may be seen under stones and logs, beside which one may occasionally find a small quantity of their castings. But in the best paddocks such as I have seen ploughed, I have never been able to find the castings on the surface, nor under any circumstances have I ever found the castings of the big worms above ground, though I have searched carefully over a piece of land before ploughing, and yet in the course of an hour have seen the same ground teeming with worms only a few inches below the surface. I have been to Burrawang twice in midsummer, twice in midwinter, and once in early spring, yet my experiences have always been the same as regards the general absence of surface castings. On the occasion of my first visit not knowing where to look for them, and seeing no indications on the surface, I did not get to know that worms were found there, until I questioned the men about the place. But though the worms do not cast above ground their castings are abundant enough in their burrows, and very often the clods turned over by the plough are simply riddled with castings up to within a few inches of the surface. The best opportunity of examining these, however, is furnished by the earth round the roots of fallen trees. Many of the large Eucalypts on

the farm have been "ringbarked" for some years, and from time to time especially during high winds after rain, some of those on sloping ground fall, and their numerous, long, spreading roots tear up large quantities—often several cwt—of the soil compacted round them, so as to present the appearance, when seen from below, of large discs sometimes six or eight feet in diameter. Here the burrows of worms of all sizes, most of them completely plugged with cylindrical castings, may be found running in all directions, some of them nearly horizontal. Such places are evidently favourite spots with the worms, and they probably habitually live in them, or they perhaps specially resort to them for breeding purposes, or during dry periods. Generally if such trees have not been down so long that the earth has become dry, one may count upon finding two or three big worms by digging away the soil; and it is in this way that I have obtained many of my best examples. (1) Still I have never been able to find surface castings about the bases of the standing trees, nor have I found that the burrows open on the surface in such situations. If, as I suppose, the worms come to the surface only exceptionally or not at all, it may at first sight appear difficult to understand under what circumstances copulation takes place. Nevertheless as D'Udekem (2) says of *Lumbricus communis* var. *cyaneus*, "cette variété paraît sortir plus difficilement de la terre, que les autres; l'accouplement paraît se faire sous terre," it is possible that a similar state of things obtains with the worms in question.

The burrows run perpendicularly, or more or less obliquely, and are sometimes even somewhat devious, as one may see by tracing the course of a worm; so that on one occasion in trying to dig out of its burrow a very large specimen, which I saw for an instant and then lost sight of, I unintentionally cut off a considerable piece of both ends with one stroke of the spade. The surface of

(1) I do not know at present whether the worms live in this way about the roots of living trees; possibly such situations would be too dry for them on account of the absorption of moisture by the roots.

(2) Mém. Acad. Roy. de Belgique, 1863.

the burrows in firm soil is perfectly clean and apparently without any special lining, and never in any case have I observed extraneous matter such as leaves, which might have been dragged in from the exterior. The plough generally cuts off a few inches of the tails of the big worms or lifts the earth right off them, but with the smaller worms one may find as many examples with the anterior end uppermost as not.

On page 110 of Darwin's book will be found an account of the depths—3 to 8 feet—to which European worms burrow. In our dry climate it might be expected that worms, at any rate in dry seasons, would extend their burrows to even greater depths, and possibly it may be so. At Burrawang I do not think the worms usually burrow to as deep as 6 or 8 feet, though I have only one piece of negative evidence to offer in support of this opinion. Before my later visits a road leading to an adjacent farm had been partially made, and the crown had been taken off the top of a small rise for a width of perhaps 10 yards, and to a depth in the deepest part of about 3 feet. During my last visit the road was approaching completion, and two men were deepening the cutting to a depth of four or five feet more. I made several visits to the cutting, and saw some tons of earth excavated, yet I could not find a single worm nor see any castings. Either the worms had all been removed in the preliminary excavation, or the soil just there was devoid of worms. The traffic over the road was too insignificant to cause worms beneath the surface any discomfort, and in the paddock on the other side of the fence not more than 50 yards distant I had seen the plough turn them up in abundance, so that it is difficult to believe that this particular patch of very deep and good soil was destitute of worms, and it seems plausible to suppose that they were removed in the first instance. On questioning one of the men he told me that the worms were not found in the sub-soil, but whether his experience was limited to this particular instance I do not know.

During my last visit several inches of rain fell in three days, and though on a road in one paddock I saw a few small worms and

noticed tracks, it had not dislodged any worms from the ground which I saw ploughed the day after it cleared up (1). Neither do I think it was entirely owing to the rain that the worms were so close to the surface on this occasion, as on each of my three visits during ploughing the result has been the same, as regards the abundance of worms and their proximity to the surface. In Europe the worms are obliged in winter to burrow deep to avoid the cold, but at Burrawang, though cold, from its greater elevation, compared with Sydney, the fine sunny days which prevail during frosty weather probably prevent the worms from suffering discomfort from the cold. In summer time there is no ploughing going on, but one can always obtain worms by digging in suitable ground without going very deep, though probably at this season the worms are not quite so close to the surface as the winter ploughing shows them to be then.

The perichæte worm, when handled, wriggles and squirms in a very lively fashion; and when placed on the ground it soon burrows out of sight. Two of the other worms are less lively than this one, while the big ones are remarkably sluggish and passive. The day after ploughing if the birds have not found them out, specimens of these three may be found dead on the ploughed ground apparently without having made any efforts to burrow into the ground again. On one occasion having brought from the field more worms than I required I put two on the ground in the garden where they were lying dead next day. When the worms are held in the hand for a minute

(1) Of very large worms, from 4 to 6 feet long, from South Africa, originally described and figured by Rapp, and recently re-examined by Beddard, the latter says:—"These monstrous worms appear to be fairly abundant in the neighbourhood of Port Elizabeth and other parts of the Cape Colony, but are only rarely seen; they do not seem to move about at night like our British worms; only heavy and prolonged rains drive them to the surface from their underground burrows; on such occasions, as I am informed by a correspondent, which only take place a few times a year, the ground is covered by hundreds of these creatures slowly crawling about in all directions; as a general rule they do not return into the earth after the rain has ceased, but remain above ground, and are shortly killed by the sun." (*Nature*, Vol. XXX., p. 571. October, 1884.)

or two, the milky perivisceral fluid wells out of the dorsal pores in considerable quantities. When put alive into spirit it comes out in jets, which are rendered visible by the coagulating effect of the spirit. Occasionally when an extended worm is touched unexpectedly the perivisceral fluid is squirted out in jets, but this is most noticeable in the brush worm, which does it almost habitually when irritated. This may perhaps serve some defensive purpose, but it seems to be due rather to the sudden contraction of the body, and this view seems likely because the body-wall of the brush worm is more than usually thick and muscular, and the animal is capable of contracting its body into a remarkably small compass. Professor McCoy says that the Gippsland giant worms are brittle, that when alive they emit an odour resembling that of creosote, and that fowls will not eat them even when chopped up. The Burrawang worms will stand a considerable amount of hauling without damage, they are quite free from any offensive smell, and poultry eat them greedily.

The other locality, Mt. Wilson, is about 3,400 feet above sea-level. Except for the spur which the road follows, it is entirely surrounded by a labyrinth of gullies, and the country round is of a very barren and rocky description (1). The Government Geologist says of it:—"At Mount Wilson near the Great Western Railway, an intrusive mass of dense augitic basalt containing crystals of oligoclase has burst through the Coal Measures and Hawkesbury sandstones and flowed out and covered the latter. Wherever patches of this trap rock occur the soil resulting from the decomposition supports a most luxuriant growth of vegetation, including tree-ferns and splendid timber trees of Eucalypti. These patches of dense vegetable growth amidst the rugged Blue Mountains are in striking contrast with the stunted timber and scrub seen almost everywhere upon the sandstone formation." (2)

(1) A general account of Mt. Wilson will be found in Mr. Trebeck's paper, *ante* p. 491; also from the pen of Mr. Du Faur on p. 58 of the "Railway Guide of N. S. W."

(2) Notes on the Geology of N.S.W., p. 62. By C. S. Wilkinson, F.G.S., F.L.S.

Here worms, judging by the abundance of the castings, are individually as numerous as at Burrawang. As there was no ploughing going on, I was dependent on digging for a supply of specimens, which I found on subsequent examination to belong to three species. One of these is a perichæte worm at present not known to me from any other locality, and which I have named *Perichaeta Coxii*, after Mr. J. D. Cox, from whom I first heard of the existence of earthworms at Mount Wilson, and to whose kindness and hospitality I owe the opportunity of collecting specimens there. This seems to be the most abundant worm at Mount Wilson, and is to be found not only in the soil on the top of the mount, but also in the gullies about the base of it considerably below the level of the basaltic capping, wherever the soil washed down from the high ground, and mixed with the decaying vegetable matter, forms a rich compost. The second is also a perichæte worm of which I obtained only a few specimens, which appear to be a variety of a species (*P. australis*), which I found more abundantly at Burrawang, and of which stunted specimens are to be met with in the poor soil about Sydney. Of the third species I obtained only a single, young specimen, also a perichæte worm, which differs from the others, among other things, in having four pairs of spermathecæ instead of two. The only other Australian worms with a like number of spermathecæ that I know of, are in the Macleay Museum, and came from Queensland, and have not yet been described. (1) I therefore postpone the consideration of the third Mt. Wilson species until I can obtain a further supply of specimens. I heard of larger worms than any I obtained, and these perhaps may also be new.

Surface castings abound every where, in the open, under and at the sides of prostrate logs, at the base of walls of rock, and under overhanging ledges, and this both on the summit of the mount

(1) Since the above was in type I have found two specimens of a small perichæte worm with four pairs of spermathecæ, at Seven Hills near Parramatta.

and in the gullies. Nothing could be more striking than the difference between Burrawang and Mt. Wilson in this respect.

The castings form rugged, convoluted masses plainly indicating their origin, often several inches above the ground, but too irregular and not standing sufficiently erect to deserve the epithet of "tower-like," and they give one the idea of having been ejected in so soft a condition as to have sunk down instead of forming "towers;" otherwise they are very similar to the castings represented in Figs. 2 and 3 in Darwin's book. The night of my arrival it began to rain heavily; after the rain the worms were casting freely, the fresh castings being of a semi-fluid consistency, so that from the absence of tower-like castings it may be that they usually cast only during and just after wet weather. As noted by Mr. Darwin in the case of other worms, the castings cohere with considerable tenacity on drying, and after heavy rain the old ones were only partially disintegrated thereby. In several places where logs had been burnt, the castings beneath and at the sides of them had been baked, but beyond a change of colour they were still perfectly recognisable as old castings. The worms must materially aid in the work of denudation, because there is not much level ground, and many of the slopes, on which castings may be found, are tolerably steep, so that eventually much of the soil brought to the surface by the worms must be washed down into the gullies.

Since earthworms are so abundant at Mt. Wilson it is not improbable that they are equally so in the soil of Mts. Tomah and Hay, which are not many miles distant, and which, as I understand, are similarly capped with basaltic rocks. If so, the comparison of the worms from these three spots may be of great interest, because practically these mountains have been completely isolated for ages, since the innumerable ravines and gullies which surround them may not unreasonably be supposed to form insuperable barriers to the passage of worms from one to the other, and the surrounding country is of such a barren and rocky character as to support few, if any, worms. On the other hand it

may be that the volcanic outbursts at all three spots were contemporaneous, and that subsequently all three localities were stocked under similar circumstances, and from the same source, and were afterwards isolated by denudation, so that the worms having lived under very similar conditions may not be very different. (1)

I do not know for certain whether the rich soil of the Burrawang district forms a completely isolated tract, though on the map this appears to be the case, or whether it does not merge into that of Illawarra, and this again into some other ; (2) but that of Mount Wilson certainly does. As the worms I have described seem more or less restricted to these fertile spots, which must have been stocked in the first instance from the then surrounding areas, possibly the existing worms are simply the well-grown and robust descendants of ancestors which long enjoyed a generous diet, and the surviving remnants of a once more widely spread worm-population whose limits have since been narrowed by the work of denudation, as much of the superficial area of the Blue Mountains, except perhaps in some of the gullies, is probably destitute of earthworms at the present time.

(1) Similar remarks are applicable to Mt. King George. Speaking of this neighbourhood Strzelecki says :—“Between these ranges lie yawning chasms, deep winding gorges, and frightful precipices. Narrow, gloomy, and profound, these stupendous rents in the bosom of the earth are inclosed between gigantic walls of a sandstone rock, sometimes receding from, sometimes frightfully overhanging the dark bed of the ravine, and its black silent eddies, or its foaming torrents of water. Everywhere the descent into the deep recess is full of danger, and the issue almost impracticable. The writer of these pages, engulfed in the course of his researches, in the endless labyrinth of almost subterranean gullies of Mt. Hay and the River Grose, was not able to extricate himself and his men until after days of incessant fatigue, danger, and starvation.” (Phys. Desc. of N.S.W. and Van Diemen's Land, p. 57.)

(2) On the Geological Sketch Map accompanying Mr. Wilkinson's “Notes on the Geology of N.S.W.,” no large extent of volcanic rocks is shewn in this neighbourhood, but several *perfectly isolated* patches are marked as lying between the Railway and the coast. These, however, as regards their extent and limits, are probably only represented diagrammatically, the map being on too small a scale to allow of its being otherwise. I cannot identify any connection between Burrawang and either of the patches figured.

While Mr. Darwin has exhaustively treated the subject of the habits of European worms, so little is known from actual observation of the habits of any exotic earthworms in their native haunts, that I have, in the foregoing part of this paper, quoted rather copiously from my notes. In what follows my object is simply to describe intelligibly the worms I have collected, to do which it is necessary to take note of at least the more prominent anatomical characters; but for various reasons I have had to postpone the consideration of the details of the structure and arrangement of the segmental organs, of the salivary and intestinal (calciferous) glands, of the typhlosole, and of the nervous and vascular systems, as also of the situation of the nephridiopores, and of the relations of the vasa deferentia to the prostates in most cases. The parasites, which in various stages infest many, if not all, of these worms are also worth investigating. Too often those who have worked at the anatomy of foreign earthworms have had to be content with scanty supplies of badly preserved material. Having now obtained a general idea of some of our earthworms, I purpose endeavouring to make the most of my good fortune, by re-examining them and any others I can get, in detail from a morphological point of view, and with the help of section-cutting. As almost the whole of the material I have had for examination has been in spirit for more or less lengthy periods and was, with the exception of the Mt. Wilson worms which were obtained early in January, collected in winter when the worms are sexually inactive, I purpose collecting fresh supplies with a view to special preparation.

The rich districts of Illawarra, of the Hunter, the Manning, the Richmond, the Clarence, and others of our coastal rivers as well as other parts of the colony, will doubtless yield, when systematically searched, a rich harvest of earthworms, a knowledge of which and of their geographical distribution cannot fail to be of great interest from several points of view. As my time and opportunities for collecting material are limited, I appeal to members of this Society resident in favourable localities, for information of any description, or for specimens either put straight

into good methyated spirit, or packed with due allowance of space in a tin box or wide bottle with a small amount of earth and plenty of damp moss.

Perrier (1) has divided earthworms into three groups, viz. *Lumbricini anteclitellini*, *L. intracitellini*, and *L. postcitellini*, according as the male pores are situated in front of, within, or behind, the clitellum or girdle. It is interesting to find that there are Australian representatives of all three groups. Too little is known of Australian earthworms to attempt to generalise at present, but there are one or two points that may be noticed. The occurrence of the genus *Lumbricus* in Australia is interesting, because at present it is not known from Asia or the East Indies, though it occurs in N. and S. America, and at the Cape. On the other hand, there are indications that the genus *Perichaeta*, which may be said to have its head-quarters in Asia and the East Indies, is well represented in Australia, while it is represented at present by a single species in S. America. Again the genus *Acanthodrilus* occurs both in New Caledonia and New Zealand, yet so far it has not been met with in Australia; this however, may be simply due to want of more careful search. Intracitellian worms were first described by Perrier from S. America; subsequently several Asiatic genera were added to this group. The Australian intracitellian worms described in this paper have no particular affinity with any of the described genera.

Among the points of interest presented by the worms which I have examined, the following is perhaps most noteworthy, though possibly some allowance must be made for the sexual inactivity of some of them: in all of them the vasa deferentia are quite independent of the testes (or seminal reservoirs in *L. Novæ-Hollandiæ*), and (except in the last named species) the two pairs of testes are either in consecutive segments (XI and XII), or two segments intervene between these, which are then in IX and XII, but in both cases the two pairs of "ciliated rosettes" or vas deferens

(1) Nouv. Arch. du Mus. Paris, Tom. VIII, 1872, p. 43.

funnels are in segments x and xi. A similar condition has been described by Perrier as occurring in *Pontodrilus* and others, and by Beddard in *Acanthodrilus*.

In the following list the three described species are included.

A. ANTECLITELLIAN WORMS.

1. LUMBRICUS NOVÆ-HOLLANDIÆ, Kinberg.

Lumbricus Novæ-Hollandiæ, Annulata nova, Ofversigt af Kongl. Vet. Akad. Forhand. Stockholm, 1866, p. 95.

As there appears to be no copy of Kinberg's paper in the colony, and in neither of the abstracts available are the specific characters of the worm mentioned, all I can learn about it is, that Kinberg did describe a species of *Lumbricus* from Sydney. Professors Perrier and Lankester, however, both speak of Kinberg's descriptions as being insufficient being founded wholly on external characters, (1) the former writer also stating that Kinberg was unable to identify the male pores in the Australian *Lumbricus*; hence a fuller description of it is both desirable and necessary.

The commonest species of earthworm about Sydney is a *Lumbricus* (or *Allobophora* of Eisen), and it appears to be widely distributed in this colony, for I have received specimens of it from Picton, from Wagga Wagga, and from Guntawang near Mudjee, and I have found it on the banks of the Turon River near Capertee, and at Seven Hills near Parramatta (2). There can be, I think, little doubt that this is the species to which the examples examined by Kinberg, belong, because I have not been able to meet with any other worms referable to this genus except from the Hon. W. Macleay's garden at Elizabeth Bay, one of the oldest-established gardens in Australia, and to which plants have been brought from many parts of the world. In this and in a neighbouring garden

(1) Perrier loc. cit. p. 33, and Lankester Phil. Trans. Vol. 163, p. 265.

(2) Since the above was in type I have received specimens of this worm from Bowning near Yass, kindly sent to me by Mr. J. Mitchell.

originally part of it, there flourish apparently three *anteclitellian* worms, of which one is without doubt the European *L. olidus* introduced, a second is the worm alluded to above as being in all probability *L. Novæ-Hollandiæ*, from which the third differs in colour, and in the number of segments comprised by the clitellum, but seemingly not in other important points. I do not know at present what this last worm really is, but as its habitat is so restricted it may be left out of account for the present.

Large specimens of the worm which, from its abundance and wide distribution, it seems reasonable to suppose is *L. Novæ-Hollandiæ*, from Sydney gardens consist of from 130 to 150 segments, and are from about 115 to 145 mm. long when moderately contracted. Such worms are larger than any I have seen from any other locality. Colour varying from slate to light or dark brown above, usually darkest in front of clitellum, whitish below. Young specimens are redder and bleach white in spirits, whereas the larger ones retain their colour. Body cylindrical, flattened ventrally, tapering anteriorly, flattened posteriorly. Prostomium pear-shaped, with a median longitudinal groove inferiorly, embedded in the buccal segment for less than half the width of the latter. After about the fifth, the segments are tri-annulate.

Clitellum well-developed, comprising at least eight segments, from XXVII to XXXIV, but sometimes involving also portions of XXVI and XXXV; incomplete on the ventral surface of segments XXVII to XXIX, but more or less complete on the remaining portion, the outlines of the segments being usually quite obscured. Immature worms may be found with a rudimentary clitellum, commencing as ventral and infero-lateral thickenings of segments XXX to XXXIV, there being also two isolated thickened masses on segments XXXI and XXXIII just dorsad of the main thickening on each side. Later stages shew a complete clitellum for segments XXX to XXXIV, and finally in sexually mature worms all but the ventral surface of the three or three and a-half preceding segments is added.

Male pores slit-like, on segment xv, in the middle of the segment and between the second and third rows of setæ on each side; in

mature specimens the pores have thick and tumid lips, the swellings often extending on to the two segments adjacent to xv. Female pores on xiv, in a line with the setæ and dorsad of those of the second rows. Apertures of spermathecæ between segments ix and x, and x and xi, in a line with the interval between the two outermost rows of setæ on each side. Dorsal pores intersegmental, present throughout after the 8th segment.

Ventral surface of segments ix-xi swollen, probably functioning as adhesive organs.

Setæ in eight longitudinal rows forming four pairs; the inner pairs ventral, the outer lateral and placed just where the change of colour takes place. Setæ simple, *f*-shaped with a very slight enlargement near the middle; wanting on the first and last segments, present on the clitellum.

The alimentary canal presents no remarkable deviations from the *Lumbricus* type. The buccal cavity leads into a muscular pharynx extending as far back as segment v; this is followed by the long œsophagus which opens into the crop lying in segments xv and xvi; the large muscular gizzard occupies the next two segments, after which comes the large sacculated intestine which continues throughout the rest of the body. From segments vi to ix the œsophageal walls are thin, the contents showing through them, but in segment x and the two immediately following it, the walls become thicker, more glandular, and very vascular. In segment x the œsophagus gives off a pair of lateral diverticula, hollow vascular pouches with projecting rugæ, which, on slitting up the canal are seen to communicate with it by a pair of apertures. The diverticula in segment x are always conspicuous; but in segments xi and xii there are apparently no distinct pouches, though the œsophagus being constricted at the mesenteries the intermediate portions of it in these segments externally appear swollen, while internally the portion in xi presents a number of very vascular, thick lamellæ, that in xii being much less modified. These are the calciferous glands; from this portion of the intestine, crystalline particles may be obtained, many of which effervesce on the addition of acid, those

which do not being probably silicious grains of sand taken in with the food. In segments XIII and XIV the œsophageal walls are less glandular and thick. The septum between the two gizzard segments is usually wanting.

The supra-intestinal blood-vessel and the dorsal surface of the alimentary canal from the pharynx backwards but more conspicuously in the intestinal region, are coated, just as in European species, with the brownish-yellow issue formerly termed hepatic.

Of the male organs I am able at present to give only a preliminary and unsatisfactory account, as I have had for dissection only winter worms whose organs are in a functionally inactive condition; and it will be necessary for their complete understanding to dissect a more perfect series of animals in various stages of growth, than I have yet been able to do. The condition than I have met with in well-grown worms with fully developed clitella is as follows. In the 11th and 12th segments, when a worm is opened from the dorsal aspect, there are visible two pairs of conspicuous white masses lying above the intestine, those of each pair touching in the median line. But in addition to these, there are two other pairs of bodies of very similar appearance and structure, but of very much smaller size; so that in these worms, in the condition met with with, the vesiculæ seminales, or seminal reservoirs are of a fourfold character. The anterior pair of these lie in segment IX, and are attached to the anterior face of the mesentery between segments IX and X; the transverse "hearts" in this segment lie between them and the intestine, and the segmental organs lie in front of them. The second pair occupy a similar position in the 10th segment. The bodies of both pairs are quite separate from each other, smooth, somewhat flat or cylindrical, and not divided into lobes. The bodies in segments XI and XII are very much larger, slightly bi- or tri-lobed, with the surface not smooth but rather somewhat lobulate, and those of each pair apparently quite independent of each other, and attached by a stalk to the posterior faces of the mesenteries between segments X and XI, and

XI and XII respectively, slightly above, and to one side of the intestine, then arching over the latter they touch in the median dorsal line. Each pair, of which the posterior are sometimes the larger, lie in their own segment. Under the microscope portions of all these four pairs of bodies shewed in my specimens an abundance of various stages of parasites—Gregarines and *Anguillula*-like Nematoids—with a small quantity of spermatozoa in various stages of development.

Smaller worms from Wagga Wagga, Guntawang, and Sydney, but with well developed clitella show the same arrangement in a more marked degree, the two bodies of each pair in segments XI and XII, attached to the mesenteries a little above and to one side of, the intestine, being relatively so much smaller as to show at a glance their complete independence of each other, and of the “ciliated rosettes.” The two anterior pairs were about as usual. Two worms with only rudimentary clitella shewed no perceptible difference. All these worms also were collected in winter; what changes may take place in the disposition of these organs when the worms are sexually active, I hope to find out in the ensuing spring, from the examination of a series of animals. The arrangement I have described is remarkable, and different from that of *Lumbricus agricola* and other European species, which have two pairs of seminal reservoirs in segments X and XI, those of the anterior pair bilobed and the posterior pair unilobed (1), the two pairs originating in immature worms as six small vascular outgrowths of three of the septa, arranged in three pairs, of which the two anterior pairs coalesce to form the bilobed mass met with in mature worms.

The two pairs of “ciliated rosettes”—or anterior dilated extremities of the vasa deferentia,—lie on the floor of segments X and XI, just in front of the posterior mesenteries of these segments. The first pair of “rosettes” thus lie below, and in the same segment as the second pair of bodies above-mentioned, and,

(1) Bloomfield, Q. J. M. S. 1880.

are as it seems to me, quite independent of them ; the second pair occupy a similar position in the following segment, and are also independent of the white masses in the same segment. Below the posterior white masses in segment XII, on the floor of the segment on either side, and close to the anterior mesentery is a small white body which on examination will be found to be a few coils of the vasa deferentia just before these pass through the mesentery between segments XI and XII to join the " ciliated rosettes " on the other side of it. The ducts from the four ciliated rosettes unite in segment XII and continue as the two vasa deferentia to open by the male pores on segment xv.

Attached to the posterior faces of the mesenteries between ix and x, x and xi, corresponding nearly with the position of the ovaries in XIII are two pairs of small but noticeable bodies consisting of masses, of cells which may be, and probably are the true testes. In European *Lumbrics* the true testes, occupy a similar position, and are invisible in sexually mature worms, being enclosed within the seminal reservoirs. In these worms also the " ciliated rosettes " are enclosed by the seminal reservoirs. In our *Lumbricus* in the condition I have met with them, they are free, as Perrier has described them to be in *L. americanus*, and in *L. Victoris*.

The female organs are much more like those in European species, and consist of, a pair of small pear-shaped ovaries attached low down to the anterior mesentery of segment XIII on either side of the nerve cord ; a pair of oviducts commencing in segment XIII with dilated funnels having plicated margins, and, piercing the septum between segments XIII and XIV, opening to the exterior by the oviducal pores on the ventral surface of XIV ; and two pairs of spermathecæ, small, globular, shortly stalked sacs, which, partially underlying the mesenteries between ix and x, and x and xi lie just within segments x and xi, and open to the exterior as previously mentioned. The spermathecæ of the winter specimens examined by me contained no spermatozoa.

The nervous and vascular systems call for no particular mention ; there are seven pairs of transverse hearts in segments vi to XII, joining the supra- and sub-intestinal trunks.

The segmental organs are conspicuous, and consist of coiled, glandular, ciliated tubes of the usual *Lumbricus* type, and similarly disposed, namely a pair in each of the segments excepting a few of the most anterior ones. The external apertures of these organs are not discernible in the specimens I have examined, but in specimens of a worm from Mr. Macleay's garden differing from those described in colour and in the number of segments comprised by the clitellum, they are easily seen as a row of pores on each side, on the anterior margins of the segments, just dorsad of the second row of bristles on each side.

Hab. Sydney, Seven Hills near Parramatta, Picton, Wagga Wagga, Guntawang near Mudgee, Turon River near Capertee (2700 ft. above sea level), N. S. W.

Obs. This worm seems to prefer poor and medium soils. I have never found it either at Burrawang or Mt. Wilson, nor do I know whether it is found in any of the other colonies. The specimens from Wagga were from gardens, about drains, tanks, and damp places in paddocks; the Guntawang specimens were collected over a large extent of country, both from cultivated and from virgin soil, and from clayey flats on the banks of the Cudgegong River.

Of the two other anteclitellian worms which also occur in the Elizabeth Bay gardens, one has the characters of the European *L. olidus* as follows:—Prostomium pear-shaped, extending back on the buccal segment for about half its width, number of segments about 80, the lateral and dorsal portions of the middle of each segment a dark red, the anterior and posterior margins being yellowish or white, ventral surface white, clitellum of about six segments from xxv to xxx or xxxii, lighter in colour than the other portions of the body, male pores on xv, setæ in eight rows of four pairs. This worm is very partial to manure heaps, and emits an unpleasant foetid odour. Mr. Masters informs me that birds will not knowingly touch it, and that, if by first feeding some tame curlews in his gardens with ordinary worms he beguiles them into taking one the foetid worms, it is instantly rejected with evident disgust. The

other *anteclitellian* worm has about the same dimensions as large examples of *L. Novæ-Hollandiæ*, but is of a pale flesh-colour, and has a saddle-shaped clitellum of about six segments from XXIX to XXXV, sometimes taking in about half of XXVIII and XXXVI, and incomplete below.

B. INTRACLITELLIAN WORMS.

NOTOSCOLEX, n. g.

Intracitellian worms with clitellum comprising some or all of segments XIII-XXIII; male pores two, on segment XVIII, on papillæ in a line with the intervals between the inner couples of setæ; oviducal pores on XIV; setæ in eight longitudinal rows.

2. NOTOSCOLEX CAMDENENSIS, n. sp.

(Plate VIII, Figs. 1-5.)

A good spirit specimen (somewhat contracted) gave the following measurements.—Length 148 mm.; breadth (greatest) 9 mm.; length of pre-clitellar region 19 mm.; length of clitellum 15 mm.; number of segments about 220. This is a very good example of average good specimens. Such a worm when living and crawling will extend itself to 18 in. or 2 ft. Of two specimens measuring 102 mm. and 107 mm. respectively, and comprising each about 200 segments, neither shewed any trace of a clitellum. When alive these worms are of a uniform pale flesh-colour, except that, the integument being very thin, the internal organs shew through it and locally modify the ground colour.

The anterior portion of the body from somite XIII forward is cylindrical, tapering slightly anteriorly. Behind this, except in the caudal region, the body is perceptibly flatter in spirit specimens, but more nearly cylindrical when alive, and its breadth very gradually diminishes posteriorly; the last half-dozen somites more circular and rapidly decreasing in size; mouth and anus terminal.

Prostomium small, flattened from above downwards, wide as compared with its thickness, in spirit specimens hardly projecting beyond the buccal somite, marked inferiorly with one median and

two lateral longitudinal grooves, with sometimes a second faint outer groove on each side; when everted the anterior extremity more convex, the grooves then curving upwards to the dorsal aspect, producing a ribbed appearance; the buccal segment only slightly notched, the prostomium extending back on it only for a about $\frac{1}{3}$ of its width.

Most of the segments from IV-XIII are wider than in any other part of the body; the fourth segment is faintly bi-annulate; the next nine are each divided by a well-marked groove into two principal annuli of which in segments VII to XIII the posterior ones are subdivided into two secondary annuli, and in segments IX-XIII the anterior annuli are similarly but not so completely subdivided; slight variations may be met with. Behind the clitellum the segments are narrower, and are either bi-annulate, or shew two grooves, one in front of, and one behind the setæ.

Clitellum thick and glandular, comprising ten segments from XIV to XXIII, but occasionally not taking in quite the whole of the first or last of these, complete except for a narrow portion on the median ventral line between the inner rows of setæ, but even here the surface of some of the anterior segments is slightly modified but never so much so as to obliterate the inter-segmental grooves as is the case on the rest of it. My specimens were collected in winter; when the worms are breeding probably the clitellum is even better developed.

Setæ simple, *f*-shaped with a slight enlargement nearly in the middle, on papillæ, arranged in eight longitudinal rows, of which the four inner rows are ventral in position and form two couples, one on either side of, and rather close to the median ventral line: the four outer rows form two couples and are lateral or ventro-lateral in position. The rows of setæ of each of the two outer couples are further apart from each other than are those of the inner ones; all the rows are plainly visible without a lens. Segments after the first setigerous.

Male pores two, situated on two slight papillæ probably more conspicuous in the breeding season, in a line with the intervals

between the setæ of the two inner couples ; the latter wanting on somite XVIII which bears the pores. In immature specimens also the two inner couples of setæ on this somite are wanting, and the ventral surface in the region of the male pores is thickened somewhat on each side of the median line. The apertures of the oviducts are on somite XIV, one on either side of and rather close to the median line, just behind the annular groove, in front of a line joining the setæ, and slightly ventrad of those of the two innermost rows. Spermathecal apertures between somites VII and VIII, and VIII and IX, their inner margins just about in a line with the innermost rows of setæ on each side. Dorsal pores intersegmental, commencing after somite VIII and continuing throughout. Most of the mesenteries of segments VI to XIV are enormously thick and muscular, and there are strong interseptal ligaments.

The mouth leads into a buccal cavity, and this into the pharynx, which for the size of the worm is short reaching back to somite IV. The dorsal wall of the pharynx is especially thick and muscular. Following the pharynx is a piece of œsophagus which after somite V enters the large gizzard ; the anterior division of this is thin-walled and hemispherical in shape, and perhaps may function as a crop ; the posterior division is cylindrical, but tapering posteriorly, thick-walled and muscular. The whole of this structure lies between the two mesenteries of somite VI, but in the spirit specimens dissected, it pushed back the mesenteries between somites VI and VII, and VII and VIII, so as to lie in the first two and partly in the latter somite, the mesenteries mentioned closely over-lying one another and the gizzard. This is followed by the small intestine which in each of somites XIV to XVI is provided with a pair of kidney-shaped intestinal (calciferous) glands. (Figs. 1 and 2.) Each of the six reniform, stalked pouches is grooved transversely on its dorsal surface, a branch from the dorsal vessel running in the groove, and is attached to the intestine by a duct arising almost from the hilus. Their inner portions almost touch over the intestine, the dorsal vessel running below and between them ; a more detailed account

of the structure of these glands is postponed for the present. In somite XVII the intestine is still thin-walled and narrow, and in somite XVIII it dilates suddenly into a large intestine, which for a short distance in the first and last portions of its course is straight, sacculated, and constricted at the mesenteries, narrowing gradually towards the anus; the intermediate portion when distended and the worm is contracted appears to be of increased calibre, being closely coiled in a corkscrew fashion. The intestine is unprovided with cæca in any part of its course, and spirit specimens do not show the yellow so-called hepatic tissue present in *Lumbricus*.

Of generative organs there are firstly two pairs of minutely lobulated or racemose, solid, white bodies which are in all probability the true testes. One pair is in somite XI the other in XII, of which the posterior pair is the larger. The testes are attached by stalks and by ligaments to the posterior faces of the mesenteries between somites X and XI, and XI and XII, slightly above, and at each side of the intestine. The testis of each pair is separate from its fellow, merely touching, above and below, and arching round the intestine, so that when the worm is opened from above they are seen to overlies it. Secondly there are two vasa deferentia, which bifurcate in somite XIII, the four branches commencing anteriorly with complex, "ciliated rosettes," which receive the spermatozoa. The anterior pair of these lie just in front of the mesentery between somites X and XI, and therefore in somite X, while the posterior pair occupy a corresponding position in somite XI. That is to say the ciliated anterior dilatations of the vasa deferentia lie in the segments anterior to those containing the testes from which they receive the spermatozoa. A similar peculiar arrangement obtains in certain other earthworms, of which a case has recently been described by Beddard (1) in a species of *Acanthodrilus* from New Zealand; and it, or a variation of it, appears to be quite a common arrangement in Australian worms. Thirdly in somite XVIII is a pair of prostates, lobulated, small for the size of the worm, each with a short straight

(1) P.Z.S., 1885, p. 824.

duct which is doubtless joined by the distal portion of the vas deferens on each side, but owing probably to the condition of the worms I have never been able to trace the exact connection between them; the common ducts open on the exterior of somite XVIII as previously mentioned. I have seen no trace of any penial setæ.

The female portion of the generative organs comprises a pair of ovaries, a pair of oviducts, and two pairs of spermathecæ. The ovaries are to be found without any difficulty on each side of the nerve-cord, attached low down to the posterior surface of the mesentery between somites XII and XIII, and lying therefore in somite XIII. The oviducts commence by ciliated funnels on the anterior face of the mesentery between XIII and XIV, situated opposite the ovaries, and, passing through the mesentery, are continued as two short tubes which open to the exterior on the ventral surface of segment XIV. Of the spermathecæ there is a pair in each of somites VIII and IX. Each spermatheca is a long, narrow sac, the distal portion cylindrical when distended, insensibly diminishing towards the proximal portion which appears like a long duct, often bent like a hoop, on which, at some distance from the aperture, is a rudimentary cæcum, small, broad, with its summit marked with four little elevations so as to appear serrate in outline; the cæcum projects backwards. The spermathecæ often, if not usually, are folded inwards across the floor of the somite, one overlying the other, beneath the sub-intestinal vessel. They open anteriorly to the exterior by apertures of which one pair is between somites VII and VIII, and the other between VIII and IX.

The vascular system presents two principal trunks, one supra-intestinal and the other sub-intestinal. Transverse branches pass from these trunks to the adjacent organs. They are connected by eight pairs of "hearts" in somites VI to XIII. There appears to be no subneural vessel.

Segmental organs of the type met with in *Lumbricus* are absent. Attached to the coelomic wall are small tufts of glandular tubes, most conspicuous in some of the anterior segments.

The nervous system calls at present for no special comment.

Hab. The rich soil of Burrawang in the county of Camden, N.S.W.; at present I know of no other locality.

3. NOTOSCOLEX GRANDIS, n. sp.

(Plate VIII, Fig. 6.)

In its external characters, leaving out of consideration the clitellum and the setæ, this worm looks at first sight very like a large edition of *N. Camdenensis*, the anterior segments being more completely divided and subdivided into annuli. These big worms are much less numerous, and in winter are so often devoid of a clitellum, that, before I had dissected any of them, I used to wonder whether they were not simply the aged and patriarchal forms of the preceding species, which had ceased to breed, but I found on dissection that the reproductive organs, though the testes are small both relatively and absolutely for the size of the worm, were not correspondingly atrophied. Though allied they are correctly referable to different species, the characteristic points of difference between them apart from the size, having to do with the clitellum, the setæ, the alimentary canal, the spermathecæ, and the more marked annulation of the most anterior segments.

It is somewhat difficult to extract these large worms from the ground without injury to them, hence some of my largest examples are in a fragmentary condition. A whole specimen preserved in good spirit measures—length 76 c.m., breadth 11 mm., length of preclitellar region 36 mm., length of clitellum 20 mm. Three softer specimens preserved in weaker spirit are less contracted, and measure from 76 to 106 c.m., (30 to 42 inches.)

The body is cylindrical, tapering very slightly anteriorly, more so posteriorly, both extremities rather obtuse. The prostomium small, flat, hardly projecting beyond the buccal segment, marked anteriorly and inferiorly with about five or more longitudinal grooves, not embedded in the buccal ring. Mouth and anus terminal. The segments are widest (some of them as from

about VI to X 4 mm.), and most annulate in the region of about the anterior thirteen, where except for about the first five, the mesenteries are enormously thick and muscular: hence when excessively contracted this region is olive-shaped, and thicker than elsewhere. At first on account of the numerous zontic markings the first fifteen or sixteen segments are somewhat difficult to count from external observation only. All these segments, except the first, are divided into two well-marked primary annuli; after the third segment they are further sub-divided into four secondary annuli; IX and the next few segments may shew slight traces of a further subdivision of the posterior annuli; still further back the segments shew less distinctly four annuli, but there are slight variations in different specimens.

The male pores are situated on two papillæ on segment XVIII, the papillæ dove-tailing in between the ends of two transverse, parallel, glandular ridges, one on the anterior ventral margin of XVIII, and the other in a similar position on XIX, but both extending some way on to the adjacent segments; usually there is a depression between the ridges, but sometimes this is absent, and the papillæ may more or less completely fuse with one or both ridges so as to give rise to a more or less complete glandular patch. One specimen 26 cm. long shows no ridges, and the pores are indistinct. In others these ridges appear to be the only trace of a clitellum, but in reality they are something superadded to it.

It is easy enough at Burrawang in winter time when my specimens were collected, to find worms of three species with well-developed clitella, and it is very exceptional to find adult specimens of them without this structure. It was therefore puzzling to find so many of the largest worms apparently without any clitellum except the ridges I have mentioned; but as Professor McCoy had described something similar in the Gippsland worm, I thought at the time that possibly the worms belonged to the same genus, as I had not then been able to investigate the matter. Having now gone carefully over the whole of my material I have found four specimens collected by myself, which shew an undoubted clitellum, still better shewn

in two specimens collected for me in the spring. These specimens have a clitellum of six, or six and a-half segments, commencing with segment XIV or the posterior part of XIII, up to and including XIX. This region is differently coloured, has its surface modified, but the glandular development not so thick in all cases as to obscure the lines of demarcation between the segments, though in one specimen the clitellum is perfectly complete all round and so thick that it does do so. The ridges and pores are situated on the posterior ventral portion of the clitellum. (Fig. 6.) In these worms it appears then that when not actively breeding the clitellum is usually absent. The male pores being on segment XVIII, this species also is intraclitellian, and cannot be referred to McCoy's genus *Megascolides* as at present defined.

As in the other species the first four mesenteries are incomplete, while most of those from segments VI to XIII are excessively thick and strong, with strong interseptal ligaments; in worms at all contracted, they overlies one another like saucers, and nothing is seen in dissections of the contents of the anterior segments, until they are put aside. The presence of a few enormously thickened anterior mesenteries like these, prevails in all the other worms I have examined, except in our *Lumbricus*, and in *Didymogaster*, in both of which it is much less noticeable. A similar arrangement has been described in other worms, and, as Perrier suggests, it is probably of assistance to them in burrowing, especially where the ground is hard.

The setæ are quite inconspicuous even with a lens after removal of the cuticle, and I have not yet satisfactorily made out their arrangement, but from what I have seen I believe there are eight rows arranged as in the preceding species.

The male pores, as already mentioned, are on XVIII; the two pairs of spermathecal apertures are between segments VII and VIII, and VIII and IX; the two oviducal apertures are on XIV, one on either side of and rather close to median line, and not very conspicuous. The dorsal pores are intersegmental, and commence after about the 8th or 9th segment. Nephridiopores not discernible.

The alimentary canal is very similar to that of the previous species but with the following points of difference: the crop lies in segment v instead of vi, and the reniform stalked, intestinal glands in segments xiv to xvi are wanting, the portions of the canal in these segments being only thick-walled and swollen, glandular, vascular, but without diverticula; the large intestine begins in xvii.

The generative organs are also very similar: two pairs of racemose testes in segments xi and xii, attached to the anterior mesenteries, the only noticeable thing about them being that they were even absolutely somewhat the smaller in this species; two pairs of vas deferens funnels in segments x and xi, leading into a main vas deferens on either side which doubtless joins the prostatic duct of the same side, but in my specimens their relations could not be determined; two pairs of spermathecæ in segments viii and ix, opening anteriorly, elongate, narrow, almost cylindrical sacs (about 7 mm. long and $1\frac{1}{2}$ mm. wide), the diameter nearly uniform so that the duct is short, a protuberance or rudimentary cæcum given off anteriorly close to proximal end, the proximal portions not coiled, the sacs not folded inwards; a pair of ovaries in xiii; and two oviducts, having the same relations as in the smaller worm.

The vascular and nervous systems have not presented any conspicuous deviations from the smaller worms. Small tufts of glandular tubes coating the cœlomic wall, more conspicuously in the anterior region of the body, are probably the segmental organs.

Hab.—Burrawang, N.S.W.

4. DIDYMOGASTER SYLVATICUS, g. et sp. n.

(Plate IX, fig. 7 and 8.)

The worms thus designated when their form and general appearance, their habits, and certain structural characters are considered, differ so markedly from any other known Australian worms, as to necessitate, in my opinion, the creation of a new genus for their

reception. These worms in respect of having the male pores on segment XVIII, and in possessing eight rows of setæ and two gizzards, make some approach to Perrier's *Digaster*, but while the latter genus is *postclitellian*, the worms under consideration are *intracitellian*. The more important generic characters, as far as one can judge from the consideration of a single species, are:—Clitellum of about five segments from XIII or XIV to XVIII; male pores on XVIII; female pores on XIV; eight rows of setæ; two gizzards.

This is the worm previously alluded to as usually living in and under rotten logs in the sassafras brush at Burrawang and at Springwood. It appears to thrive on a diet of rotten wood, though of course it at times must live in the earth before it gets into the rotten logs, and Mr. Wilkinson informs me that on one occasion he saw a number of them beneath an uprooted clump of ferns.

Colour when alive dark red almost plum-colour, lighter below; some spirit specimens retain the colour fairly well, others change to a bluish-grey. The segments of the clitellar region usually lighter, and of a purple hue. The integument is very thick, so that none of the vessels or organs show through it. Contracted spirit specimens are short, flat, and thick, and a transverse section of the body, except that it is flattened ventrally, would be elliptical in outline; the first few anterior and the last few posterior segments are more circular. Large specimens have a length of from 70 to 80 mm., a breadth of 10-12 mm., and a thickness of 8 to 9 mm., and comprise from 100 to 120 segments. The body is widest a little way behind the clitellum, tapering anteriorly and more gradually posteriorly. When alive and extended the body is more cylindrical and more tapering. When alive and very strongly contracted the body becomes of nearly uniform girth and obtusely rounded at both ends.

Prostomium small, rounded; buccal segment very slightly excavated, only for about $\frac{1}{3}$, or even less of its width.

The segments are very distinct, there being in some specimens but little indication of division into annuli; after about the 7th

in others the segments are bi-annulate, and further back they may be even tri-annulate. In all my adult specimens (collected in winter) the only trace of the clitellum is the distinctly brighter colour and the slightly modified surface of segments XIV to XVIII, and sometimes of XIII except the ventral portion, but there is no thick glandular development, nor are the lines of demarcation between the segments at all obscured. Such examples have the papillæ and male pores conspicuous. Small immature worms are wholly without any trace of such modifications, and the papillæ and pores are scarcely noticeable. Three specimens in the Macleay Museum though somewhat bleached, shew five segments, XIV to XVIII, still further specialised so as to leave no doubt of the existence of a well developed clitellum during the breeding season; and in one of them the inter-segmental boundaries are all but obliterated, and the clitellum is complete all round except for the ventral portion of XVIII. In these specimens also XIII is slightly modified but is well marked off from the other segments. The slit-like male pores open on two conspicuous papillæ on XVIII, situated laterally on the anterior half of the ventral portion of the segment, the anterior basal portions of the papillæ extending slightly on to the preceding segment.

The setæ in some specimens are quite inconspicuous: but usually they are easily discernible in eight longitudinal rows, of which the inner three on each side are ventral and straight, while the outermost row on each side is lateral, and in all the specimens I have seen, sinuous. The second and third, and third and fourth about the same distance apart, and a little further distant than the first and second rows; the two innermost rows are about 3 mm. apart. The setæ are simple *f*-shaped. The setigerous segments commence with the second.

The dorsal pores commence after segment v, and at first occur regularly; further back, however, they may be present only between every two or even three, segments.

The two oviducal pores are situated on segment XIV, one on each side of, and rather close to the median line; they are about

1.5 mm. apart while the male pores are about 4 mm. apart. The three pairs of spermathecal pores are peculiarly placed. There is a pair of spermathecæ in each of segments VII, VIII and IX: these open posteriorly on segments IX, X and XI respectively; that is to say, each spermatheca opens on the second segment after the one in which it is placed. The pores are slit-like, not inter-segmental but situated well within the anterior margins, or even just in front of the middle of their respective segments, and in a line with the intervals between the second and third rows of setæ. Nephridiopores not recognisable.

The mesenteries from segment XV forward are thicker than those which follow, but relatively are nothing like so thick as in the other worms.

The alimentary canal presents a muscular pharynx occupying about segments II to IV, a short œsophagus in segment V, which is followed by two globular gizzards, one in each of segments VI and VII; a narrow portion follows of which that in segments VIII and IX is thin-walled, but in segments X to XVI its walls become thick-walled, glandular, and vascular. The part in segment X is swollen and globular, less marked in XI to XIII, but there are no diverticula; in XIV there is a long piece thrown into a half-coil to the right so that the dorsal vessel crosses it transversely, a half coil to the left in XV, and another to the right in XVI. In XVII the walls are thinner, and the calibre of the canal suddenly increases, but for two-thirds of its course the noticeable breadth arises not from its being a broad sacculated canal, but because the thin-walled intestine, which is really of less diameter than at first sight appears, is coiled like a corkscrew, there being in contracted worms a half coil in each segment right and left alternately. For the remaining third it is straight and forms a rectum, which gradually decreases in breadth.

The male generative organs comprise two pairs of testes in segments IX and XII; two vasa deferentia which branch in segment XII and the anterior ciliated portions of which lie free in segments X and XI; and a pair of small prostates in segment

xviii. The testes are smooth white bodies, which superiorly are drawn out into digitate processes tapering to fine points. The posterior testes are attached partly to the ventral wall, and partly to the posterior face of the mesentery between xi and xii. The anterior ones, the basal portions of which lie just behind the posterior spermathecæ, are attached partly to the ventral wall, and partly to the anterior face of the mesentery between ix and x; they are smaller and further apart than are those of the posterior pair. The anterior portions of the vasa deferentia are very much plicated. The prostates are flattened, almost completely divided transversely into two portions. The prostatic ducts are no doubt joined by the vasa deferentia, as is usual, but in none of the specimens dissected by me have I been able to see the actual connection; the common genital duct is excessively short.

The female organs comprise a pair of ovaries in the usual position in segment xiii; a pair of oviducts commencing in the same segment by ciliated funnels and opening on the ventral surface of the succeeding segment; and three pairs of somewhat rounded or pyriform spermathecæ, a pair in each of segments vii to ix, and of which the posterior pair are sometimes the larger. Each spermatheca has a small pyriform cæcum placed anteriorly and inferiorly, so as to be quite hidden until the spermatheca is turned back. The spermathecæ appear to be only very shortly pedunculated, but the ducts are really longer than at first sight appears, as they run for some distance in the body wall, and open to the exterior two segments behind those which contain the spermathecæ to which they belong.

The vascular system presents a supra-intestinal trunk which throughout its course is more or less completely double, the two constituent portions being confluent at, and for a short distance on either side of each of the septa, and which in segments vii to xiii is connected with the supra-nervian trunk by pairs of hearts, of which the last three or four pairs are especially large. Some of the "hearts" arise in part from a secondary longitudinal

vessel which is noticeable in some of the segments commencing with x: of these peculiarities I reserve a fuller description until I have been able to make a further examination of them. There are the usual transverse branches from the main trunks to the intestine, &c. The double condition of the supra-intestinal trunk is not unlike what Beddard has met with in two species of *Acanthodrilus* from New Zealand.

The segmental organs are quite inconspicuous; probably the little glandular tufts attached to the coelomic wall are these organs, but to make out their structure and relations requires more careful study than I have yet been able to give them. I have never been able to see any nephridiopores.

In each of the four segments v to ix or thereabouts is a pair of peculiar bodies, one lying on either side of the œsophagus, and both richly supplied with vessels; of the structure and relations of these I must also postpone the consideration.

Hab.—Burrawang, Springwood, Jervis Bay, N. S. W.

C. *POSTCLITELLIAN* WORMS.

DIGASTER, Perrier.

This genus comprises *postclitellian* worms with two gizzards and eight rows of setæ. Only one species has been described.

5. DIGASTER LUMBRICOIDES, Perrier.

Nouv. Arch. du Mus. Paris, VIII, 1872, p. 94, pl. i, fig. 24, pl. iv, figs. 64 and 65.

This species of which I have not yet seen examples, is characterised by the possession of two gizzards,—one in segment v the other in vii—eight rows of setæ, a clitellum of three segments (xiv-xvi), male pores on xviii, two pairs of pear-shaped spermathecæ in segments viii and ix, two pairs of racemose testes in x and xi, a pair of flattened prostates.

Perrier says of this worm that it is difficult at first sight not to confound it with an ordinary *Lumbricus*, whence the specific

name, but his description of this species, probably from the indifferent material at his disposal is not so full and complete as that of most of the others in his most valuable paper. Moreover the description in the text differs somewhat from that in the explanation of the plate. Hence a further knowledge of this species is desirable.

Hab.—Port Macquarie, New Holland. (*Perrier.*)

Obs.—At Marrickville, near Sydney, under the same stone, I found three worms which are probably referable to Perrier's genus. They were all about the same size, 120 mm. long and 4 mm. broad (spirit specimens), but were evidently immature as not one of them shows the slightest trace of clitellum. On dissecting one of them I found it possessed two gizzards, one in v and one in vi, and it may possibly belong to this genus, though if so it differs in some respects from Perrier's species; but in the hope of obtaining fully developed specimens, I shall postpone a further account of it for the present.

PERICHÆTA, Schmarda.

This genus was founded by Schmarda for worms characterised by the possession of a complete circle or ring of setæ on each of the setigerous somites. The researches of Perrier and others have shewn that this, as *the* generic character of these forms, is insufficient. I have not been able to see several of Perrier's papers, but the amended characters of the genus as given by Beddard (1) are as follows: "setæ generally arranged in a continuous row round the middle of each segment; clitellum occupying 2, 3, or 4 segments (14-17). Male generative apertures paired, and situated upon 18th segment of the body, which is always *behind* the clitellum; genital papillæ occasionally developed in neighbouring segments. Female generative aperture single, and within the clitellum upon the 14th segment. Two pairs of testes, more or less solid and compact, in segments 11 and 12; terminal portion of vas deferens on either side connected with the duct of a large

(1) Ann. Mag. Nat. Hist. Vol. XIII, (5), May 1884, p. 401.

prostate gland. Copulatory pouches varying in number from two to four pairs, and provided each with a variously shaped supplementary pouch or pouches. Intestine with a cæcum on either side in 26th segment "

No species of this genus has hitherto been described from Australia I believe, though in his description of *Megascolides*, Professor M'Coy incidentally mentions the occurrence of a perichæte worm in Gippsland, which he calls *P. Gippslandica*, but of which I have been unable to find any published description. Two new species are recorded in this paper, and in addition in the Macleay Museum there are specimens of at least two worms from Queensland, different from these, and probably differing from each other, which have uninterrupted rings of setæ.

6. PERICHÆTA AUSTRALIS, n. sp.

(Plate IX, figs. 9-11.)

A large Burrawang spirit specimen consisting of about 140 segments gave the following measurements: Length 144 mm.; breadth 9 mm.; length of preclitellar region 19 mm. A Mt. Wilson specimen has about the same dimensions. Body cylindrical, perceptibly constricted at the clitellum, region anterior to this olive-shaped; the last nine or ten somites decrease in circumference rapidly and successively. Colour from reddish to greenish brown above, very iridescent, much lighter below; old worms are much darker in colour than young ones, which are redder. The dorsal vessel shews conspicuously through the skin in the median dorsal line. Prostomium pyriform, with a longitudinal groove inferiorly, extends on to the buccal segment for about two-thirds of its width.

Clitellum distinct, comprising three somites—xiv to xvi; complete all round, not usually so thick as to obliterate entirely the intersegmental grooves; setæ and dorsal pores present on the clitellar segments.

Setæ simple, generally *f*-shaped, though from the region in front of clitellum they are straighter, thicker, with the projecting portion transversely striated: arranged on a transverse ridge in the middle

of each segment, but not forming complete circles, these being interrupted in the median ventral and dorsal lines. These interruptions, of which the ventral is the more marked, are such as would be caused by the absence of one or two setæ from a complete circle, that is to say they are about two or more times the width of the interval between two of the setæ: they are usually more marked in the anterior part of the body: posteriorly the dorsal interruption often appears to be rather apparent than real by reason of there being no median dorsal row of setæ, and it is rendered more noticeable by the dorsal vessel showing through the integument of the interval between the first dorsal setæ on either side. The number of setæ per segment varies somewhat in different parts of the body, and also apparently according to the size of the specimen. In front of the clitellum there are 20 setæ to a segment; just behind it 28; and in the caudal region 32 or 34: or there may be 20, 32 and 36. Two specimens from Mt. Wilson gave 16, 30, and 34. The first, and the last few segments not setigerous.

Male pores two, each on a conspicuous mammillary elevation on segment XVIII, just in front of the line of setæ of this segment, corresponding with the interval between the second and third rows of setæ on each side; no setæ apparent on that part of the segment between the papillæ. The pores themselves open on teat-like papillæ situated on basal eminences, like a mammary gland with its teat: no traces of penial setæ such as Beddard has described in *P. armata*. The apertures of the oviducts are two minute pores, one on each side of, and close to the median line, just in front of the line of the setæ. There are two pairs of spermathecal apertures, between somites VII and VIII, and VIII and IX; they are in a line with about the sixth row of setæ on each side. (In Mt. Wilson specimens they almost correspond with the interval between the first and second rows on each side, but are nearer to the former). Dorsal pores intersegmental, present throughout after the fifth segment.

The buccal cavity leads into a muscular pharynx extending as far back as the 5th somite; the short œsophagus leads to the gizzard

in somite VI ; after which follows the thin-walled small intestine, which in segments X to XII is provided with three pairs of intestinal glands, vascular pouches without stalks, not grooved dorsally. In somite XVI the large intestine commences, and continues as a wide, straight, sacculated tube throughout the rest of the body. It gives off no cæca in the 26th segment such as commonly occur in most species of this genus, nor in any other part of its course. Its walls are more or less coated externally with a layer of small yellowish masses in spirit specimens, which may perhaps be of a similar character to the so-called hepatic tissue of *Lumbricus*, though it does not also coat the dorsal vessel. There is no conspicuous typhlosole ; I have not yet been able to cut sections.

Of testes there is a pair in each of segments IX and XII, that is to say two segments intervene between those which contain them. Each testis is a long, racemose, white body attached below and to the mesentery, broadest at its base, and tapering to a point, the distal portion being folded under : thus shortened those of each pair touch in the median line above the intestine. The testes of the posterior pair are the larger. Those of the anterior pair are attached below and to the anterior face of the mesentery between segments IX and X, their basal portions being just behind the two posterior spermathecæ. The posterior testes are attached below and to the posterior face of the mesentery between somites XI and XII. In each of the two intervening somites—X and XI—lies a pair of complexly plicated “ciliated rosettes.” These lie on the ventral wall, on each side of the nerve cord, and just in front of the mesenteries separating somites X and XI, and XI and XII. They are large and conspicuous, but owing to their being squeezed through the contraction of the worms, and to being long in spirit, they are somewhat distorted, and it is difficult to make out their exact shape. The branches of the vas deferentia leading from these bodies join on each side in segment XII, and the two vasa then continue backwards on each side of the nerve cord to join the prostatic ducts rather close to their origins, and at the ends of the outer legs of the U-shaped bends. Very frequently on opening

a worm two white flocculent masses are seen filling the whole upper portions of somites x and xi, quite obscuring what lies below. At first sight they look like two additional pairs of testes. Under the microscope they are seen to be masses of spermatozoa which have been probably dehisced into these segments from the two pairs of testes in somites ix and xii, and have been coagulated by the spirit. The masses do not seem to be enclosed in any membrane, and as soon as they are touched they break up into fragments. The ciliated anterior portions of the vasa deferentia crammed with spermatozoa lie below these masses, the intestinal glands and the hearts lying above or partly in front of them, but they are free. Hence in this species there appear to be no vesiculæ seminales, the functions of such being here performed by the segmental cavities. The prostates, of which there is a pair lying in somites xviii and xix, one on each side, are flattened, white bodies, transversely divided into lobes. The two prostatic ducts arise from the inner side of the anterior ends, and, after a very short distance, are joined by the distal portions of the vasa deferentia; the common ducts, which are U-shaped with the bends turned forward and lying in somite xvii, increase in calibre, especially in the proximal portions, and may possibly function as penes, but I have not been able to find any penial setæ. In the one Mt. Wilson specimen dissected the U-shaped portions of the common ducts were turned backwards and the bends lay in xix. The two ovaries are large, flattened, situated in segment xiii, attached low down to the posterior face of the mesentery between somites xii and xiii. The oviducts commence by plicated funnels in xiii, situated opposite the ovaries, and open on the ventral surface of the next segment by two apertures instead of one, as is usual in other species of this genus. There are two pairs of spermathecæ,—a pair in each of segments viii and ix—and they open anteriorly. They are pear-shaped or rounded when distended, with short stalks, each of them having a cæcum as long as, but much narrower than itself, which lies in front of it, and opens into the duct near its orifice; the free extremity of each cæcum dilated.

The supra- and sub-intestinal vascular trunks are joined in segments VI to XII by seven pairs of hearts, of which the last three pairs are largest, but in this species also there are some peculiarities about these organs which require further examination. Some of the anterior segments shew masses of glandular tufts which may be the segmental organs. The further consideration of these organs also is postponed. No nephridiopores discernible.

Hab.—Burrawang, Mt. Wilson (?), Sydney, N.S.W.

Obs.—Notwithstanding the presence of two oviducal apertures instead of a single one, and the absence of intestinal cæca, these worms possess so many important characters in common with other species of the genus *Perichaeta*, that I have included them in it. A better knowledge of the Mt. Wilson worms may necessitate the making of a new and separate species for them, for, though they agree fairly well on the whole with Burrawang specimens, they still present several points of difference, as in the position of the spermathecal apertures, and of the bend of the genital duct, and possibly in other respects. As I have had only two specimens from Mt. Wilson, and only one of them for dissection, I prefer to consider them as a variety of the species, until I can study them more fully.

Sydney specimens are smaller and have fewer setæ, (one example 55 mm. long had about 24 setæ per segment) but have the same general characters in regard to the clitellum and internal organs. From Seven Hills, beyond Parramatta, I have recently obtained two worms similar in size and general appearance to Sydney specimens but differing among other respects in having four pairs of spermathecæ, some of which have excessively long cæca. I hope shortly to procure better examples of this worm, which may be the same as the third worm from Mt. Wilson, previously mentioned.

7. *PERICHAETA COXII*, n. sp.

The commonest worm at Mount Wilson is, when looked at from above, in colour and general appearance, apart from the clitellum,

more like *N. Camdenensis* than a perichæte worm, though a closer examination shews that it is provided with from 16 to 20 or more rows of setæ, which dorso-laterally are arranged somewhat irregularly. Nevertheless, from the consideration of its general characters, at any rate provisionally, it is here included in the genus *Perichæta*. The largest (spirit) specimen obtained measures 190 mm. in length, with a breadth of about 9 mm. in front and 7 mm. further back, but other specimens of nearly the same length are much less in diameter. Body cylindrical, often in spirit specimens contracted just in front of clitellum where the mesenteries are thin, and the intestine of small calibre; diameter greatest in the region in front of this where the mesenteries are thick; flattened somewhat ventrally, tapering very gradually posteriorly; the circumference of the last few segments decreases rapidly and successively, and the anus is situated either on a central eminence, or in the centre of a disc, according to the state of contraction.

Prostomium somewhat flattened, marked anteriorly and inferiorly with irregular grooves; extending back on the buccal segment for about $\frac{1}{2}$ its width.

The segments of the posterior portion of the body are either free from zontic markings, or, like those in the middle region have two, one in front of and one behind the ridge which carries the setæ. In the anterior region the number of annuli into which some of the segments are divided is rather difficult to make out at first sight. Segments II to IV are bi-annulate; after these they are either tri-annulate—the setæ being on the middle annulus, or in addition, as from about VII to XIII, the anterior and posterior annuli may again be less completely sub-divided, each into two, giving five annuli to a segment altogether. Many setæ are wanting in this region.

The clitellum comprises 4 or $4\frac{1}{2}$ segments from XIV to XVII, or in addition the posterior half of XIII. It varies in the extent in to which it is developed, being sometimes very thick and complete all round, or incomplete on the ventral surface of about the last segment. A good-sized specimen 140 mm. long shews no trace

of it. The male pores are on segment XVIII; their position is determinable on a first examination only by dissection, as there are three or four pairs of pores of accessory glands lying immediately in front of them, and three pairs just behind them, and there is but little in the appearance of any one pair of them to distinguish them particularly as the male pores. Of these accessory gland pores, which are just external to or about in line with the second rows of setæ on each side, the first pair are on XVI, the second and third pairs on XVII, and a pair on XVIII just in front of and external to the male pores, and on each of the three segments following it; sometimes there are even eight pairs of pores; and frequently there is one pore more on one side than on the other. The ventral portions of the annuli carrying the pores are slightly thickened, the pores being situated on slight elevations of these ("copulatory papillæ"). They are the apertures of glandular pouches whose bases are seen, when the worm is dissected, as successive pairs of hemispherical eminences situated on either side of the nerve cord, and beneath the prostates. Two specimens without clitella showed none.

The apertures of the oviducts are on XIV as in *P. australis*, but not quite so close to each other. The apertures of the spermathecae are just behind the grooves between VII and VIII, and VIII and IX, and on the anterior margins of the two latter segments, just dorsad of the line of the innermost rows of setæ. Nephridiopores are quite indistinguishable in my specimens.

The setæ are simple *f*-shaped and in no way remarkable, though their arrangement is somewhat peculiar. Those of each segment are situated on a median ridge, not however so conspicuous as is usual in perichæte worms, nor do they form complete circles. The setæ are less conspicuous on the preclitellar segments. Behind these there is a median ventral region about 2 mm. wide in an ordinary specimen, devoid of setæ, and bounded on either side by a straight longitudinal row of them. External to each of these rows and at a distance of about 1 mm. from them is a parallel row. After these the remaining rows of which there are about 16 altogether, cease to preserve any regularity, becoming sinuous

and with numerous gaps, so that the setæ on a segment are frequently at irregular intervals, and vary slightly in number on the various segments. The median dorsal region is devoid of setæ, and the rows of setæ which bound it are irregular and sinuous. The setæ do not regularly alternate from segment to segment. In the caudal region the rows are more numerous (about 30 in a large worm), and more regular but not perfectly so, and the dorsal and ventral interruptions are narrower but noticeable. The segments after the first are setigerous throughout. In front of the clitellum the setæ are fewer per segment, less conspicuous, and very irregular; the first two ventral rows on either side being the only regular ones.

Dorsal pores intersegmental, occur throughout after about the 13th segment. The mesenteries of segments VI to XIII are very thick and muscular, the first two and the last two of these less thick than the others, and are braced together by interseptal ligaments.

The muscular pharynx extends back to about III; the large gizzard the anterior portion of which is hemispherical, thin-walled and crop-like apparently lies in segments V, VI, and part of VII, but it is bounded posteriorly by the mesentery between V and VI, which is quite thin, and which behind is pushed backwards by the large gizzard; the small intestine continues as far as segment XVI, when it suddenly dilates and continues as the large sacculated intestine throughout the rest of the body, and is unprovided with cæca in any part of its course. The small intestine is provided with no less than six pairs of pouch-like diverticula—calciferous glands—a pair in each of segments VIII to XIII, and of which sometimes the last three pairs are the largest; they lie just in front of the mesenteries intervening between the segments containing them and the succeeding ones; they are not dorsally grooved as in *Notoscolex*; in slitting open this part of the intestine, the internal surface of it and of the glandular pouches is red, very vascular, and provided with rugæ; the apertures of the pouches are distinct; calcareous particles were not noticed.

Of generative organs there are firstly two pairs of testes, a pair in each of segments XI and XII. Each testis is a white, racemose body, independent of its fellow, those of each pair being attached to the anterior mesenteries of the segments in which they lie. Both pairs are of about the same size: they overlies the intestine, those of each pair touching in the median line. The anterior ciliated funnel-shaped portions of the vasa deferentia lie on either side of the nerve cord in segments X and XI, just in front of the mesentery which bounds each of these segments posteriorly. I have not been able yet to make out the posterior portions of the vasa deferentia, nor under what circumstances they join the prostatic ducts. The prostates are two long (7 mm.), and wide (4 mm.), flattened, lobulated bodies extending over about nine segments from XVIII or XIX to XXVIII, lying on either side of the intestine. The prostatic duct comes off from the anterior inner end of the gland, and is very long and much coiled. The prostates in this species are much larger, and the ducts longer and more coiled than in any other that I have examined. The two ovaries are in the usual position in segment XIII. The oviducts commence opposite these, and open to the exterior in the next segment. There are four spermathecæ, a pair in each of segments VIII and IX, opening anteriorly; they are pear-shaped with a rather long duct, which gives off a short and rudimentary cæcum, wider than high. The spermathecæ were distended with fully developed spermatozoa. The vascular system presents a dorsal trunk which is single, and in segments VI to XIII is connected with the sub-intestinal trunk by seven pairs of transverse "hearts," of which those in the last three or four of the segments containing the vascular intestinal pouches are the largest. The usual branches pass to the intestine, and anteriorly vessels are given off to the gizzard and pharynx, but the details require further examination. The segmental organs consist of tufted glandular masses, which are large, stalked, and dendriform in some of the most anterior segments, but smaller and inconspicuous elsewhere. A detailed account of these will be given later.

Hab.—Mt. Wilson only at present.

8. CRYPTODRILUS RUSTICUS, g. et sp. n.

One of the Burrawang worms is *postclitellian*, has eight rows of setæ arranged in a peculiar manner, has three or four pairs of accessory gland pores, two pairs in front of, and the others behind the male pores which are on segment XVIII, and one gizzard. It cannot therefore be referred to either of the genera *Acanthodrilus* or *Digaster*, and seems to belong to a new genus.

The best examples I have (spirit specimens) are about 190 mm. long ; 6 to 7 mm. broad ; have a clitellum about 8 mm. long ; the length of preclitellar region short, only 13-15 mm. ; and consist of about 250 somites. Among a number of Burrawang worms specimens (spirit) of this species attract one's attention by the very short preclitellar region as compared both with the clitellum and with the length of the body.

The body is cylindrical, rather obtuse at both extremities (in contracted spirit specimens). The prostomium is small, somewhat flattened, and in some specimens irregularly grooved anteriorly and inferiorly ; embedded in the buccal segment for about $\frac{1}{2}$ of its width. The anterior thirteen segments very distinct, widest from about VI-X, some of them faintly bi-annulate, or tri-annulate as they are further back. The clitellum which comprises about $4\frac{1}{2}$ segments, extends from the posterior half of XIII up to and including XVII, is thick, glandular, and well developed ; is complete all round except sometimes on the posterior ventral portion of about the last segment of it. On this is situated the anterior pair of accessory gland pores, which are not at first sight readily distinguishable by their appearance from the male pores. Sometimes all the pairs of pores are situated on little elliptical flat-topped eminences ("copulatory papillæ") in the enlargements of as many somewhat dumb-bell-shaped depressions, the outlines or rims of which are raised and tumid, of which the second one is on XVIII, and the others on the junctions of the two preceding and succeeding segments respectively. The first of these dumb-bell-shaped areas

is partly on the last clitellar segment but involves the preceding segment, and just behind it is a little ridge carrying the setæ of the segment. The second is on the first post-clitellar segment (XVIII), carries a pair of pores and the male pores, and extends rather far back so that it partially involves the anterior portion of XIX. The last is on the junction of XIX and XX and involves both; or if there is a fourth it is on the junction of XX and XXI. One specimen had only the two anterior pairs of pores. Sometimes the portion representing the handle of the dumb-bell is wanting, and then the pores are situated in elliptical depressions or pits, which are a little longer (transversely) than the intervals between the inner rows of setæ and nearly correspond with them. The rows of setæ are visible on the clitellar segments.

The setæ are simple, *f*-shaped, arranged in eight rows, not in pairs, of which four rows are ventral, two lateral, and two dorsal. The innermost rows on each side are about 3 mm. apart, and are about in a line with the inner side of the heads of the dumb-bell-shaped areas. The second rows on each side are about 1 mm. from the first rows. Dorsad of each of these at a distance of about 3 mm. (measured as in the other case with compasses), is the third row on each side. Dorsad again of each of these and at a distance of about 2 mm. is the outermost row on each side, so that these are quite dorsal in position, and measured across the back, are about 4 mm. apart, that is only about 1 mm. further apart than are the two innermost ventral rows from each other.

The two pairs of spermathecal apertures are inter-segmental, between VII and VIII, and VIII and IX, the pores of the anterior pair a little closer together, and ventrad of the innermost rows of setæ. There is a slit-like depression on XIV, on which probably the oviducts open. Male pores slit-like, not very conspicuous, situated on XVIII not on prominent papillæ. Nephridiopores not discernible. Dorsal pores throughout after about segment XIII, intersegmental.

Most of the mesenteries of segments VII to XIII are very thick and muscular, those of V, VI, XII, and XV less so, but in the case of the last two thicker than those which follow.

The alimentary canal comprises a short muscular pharynx, a short œsophagus, a large muscular gizzard in v, which pushes back the mesentery behind it so as to lie partly in vi; the small intestine extends from vi to xvii, has no special vascular pouches, but especially in xiii or xiv to xvi presents globular swellings with thick vascular walls, internally provided with longitudinal rugæ; the sacculated large intestine commences in xviii, continues to the end of the body, and is unprovided with cæca.

The genitalia include, two pairs of small racemose testes in segments ix and xii; the posterior pair the larger, lying on each side of the intestine and attached to the posterior face of the mesentery between xi and xii; those of the anterior pair further apart, just behind the posterior spermathecæ, attached partly to the anterior face of the mesentery between ix and x; two vasa deferentia opening anteriorly with two pairs of ciliated rosettes lying free in x and xi, just in front of the posterior mesenteries of these segments; a pair of prostates in xviii and part of xix, lobulated, with a short thick prostatic duct arising from the smaller lobe, not coiled, gradually increasing in calibre; two pairs of spermathecæ in segments viii and ix, more or less pyriform, opening anteriorly by a short duct from which arise two or sometimes three short and rudimentary cæca; a pair of ovaries in xiii in the usual position; a pair of oviducts in xiv, passing through the mesentery between xiii and xiv opening anteriorly into the former by ciliated expanded mouths. I have been unable to determine under what circumstances the vasa deferentia join the prostatic ducts. The accessory glands appear as two or more white elevations lying on either side of the nerve cord, with the free portion of the prostate lying between them.

Segments vii to xii contain transverse hearts, the relations of which require further investigation.

The segmental organs consist of dendriform masses or tufts of glandular cæcal tubes. They are most conspicuous in the anterior segments as far back as about xviii, after which they are much less conspicuous. They are most noticeable along a line about 2 mm.

on each side of the nerve cord, and are very large in the first five segments. Probably owing to excessive contraction in my specimens their apertures are not visible on the exterior.

Hab.—Burrawang, N. S. W.

D. WORMS "INCERTÆ SEDIS."

9. MEGASCOLIDES AUSTRALIS, M'Coy.

Megascolides australis, M'Coy, Prod. Zool. of Vict. Decade I, 1878, p. 21, pl. 7.

The worms of this species are chiefly characterised as follows:—Body of from 350 to 500 segments, about 2 feet long when contracted and about 6 feet long when extended, setæ difficult to see, arranged in eight longitudinal rows of four pairs, clitellum incomplete, consisting of three short ventral bands between the 32nd, 33rd, and 34th segments, position of male and female genital pores undetermined.

From these characters it would appear as if these worms might be anteclitellian, but though this is a point which can only be settled by dissection, I venture to express the opinion that on further examination they will probably be found to be intracitellian, and that the clitellum may be better developed in the breeding season.

Hab.—Gippsland, Victoria (*McCoy*).

In conclusion I have to thank several gentlemen for their kindness and help, or for specimens, among whom I am particularly indebted to my late colleague, Mr. R. T. Baker, for the first specimens of *Notoscolex grandis* I obtained, and for his kindness in making a number of careful drawings of various worms; to Mr. J. D. Cox for the opportunity of visiting Mt. Wilson; to Messrs. Garland, Hamilton, and Mitchell for specimens of *Lumbricus Novæ-Hollandiæ* from their respective localities; to Mr. Masters for the best specimens of *L. olidus* that I have seen; and to Mr. Haswell for the loan of several important papers, which I should otherwise have been unable to see.

EXPLANATION OF PLATES.

LIST OF REFERENCES.

<i>ph.</i>	pharynx	<i>t.</i>	testis,
<i>æ.</i>	oesophagus	<i>pr.</i>	prostrate
<i>g.</i>	gizzard	<i>v.d.</i>	vas deferens
<i>i.</i>	intestine	<i>c.r.</i>	ciliated rosette
<i>i.g.</i>	intestinal (calciferous) glands	<i>g.d.</i>	genital duct
<i>cl.</i>	clitellum	<i>sp.a.</i>	aperture of spermatheca
<i>sp.</i>	spermatheca	<i>m.p.</i>	male pores
<i>c.</i>	cæcum of spermatheca		

The numbers on the left of the figures indicate segments.

Plate VIII.

- Fig. 1.—Anterior portion of the body of *Notoscolex Camdenensis* opened from the back, to shew the general relation of the alimentary canal, and a portion of the genitalia. Portions of some of the thick mesenteries are indicated, but the first four being incomplete should not have been shewn, this region being occupied by the pharyngeal muscles.
- Fig. 2.—A pair of the kidney-shaped intestinal (calciferous) glands seen from the front.
- Fig. 3.—A mesentery with a pair of testes attached to it.
- Fig. 4.—A pair of spermathecæ displaced, and turned outwards.
- Fig. 5.—Spermathecæ folded inwards in the natural position.
- Fig. 6.—Anterior portion of *N. grandis*, seen from below, to shew the clitellum, ridges, and male pores. In this specimen the papillæ on which the pores open, are fused with the posterior ridge.

Plate IX.

- Fig. 7.—Anterior portion of the body of *Didymogaster silvaticus*, seen from below. The position of the spermathecal pores on IX, X, and XI; of the oviducal apertures on XIV; of the male pores on XVIII; and of the setæ on some of the segments, is indicated.
- Fig. 8.—Dissection of the anterior portion of the body from above, to shew the alimentary canal and part of the genitalia. The vas deferens is represented diagrammatically on one side, its exact relation with the prostrate being undeterminable in my specimens. (Twice the natural size.)
- Fig. 9.—Dissection of portion of the anterior part of the body of *Perichaeta australis*, to shew the arrangement of part of the genitalia. The left anterior testis, and the right posterior spermatheca have been omitted; and the cæca of the spermathecæ are turned forwards. *Note.*—As the testes are really attached to the thick mesenteries which are here omitted, it is difficult to represent them as they really are.
- Fig. 10.—Spermatheca with its cæcum. (Enlarged.)
- Fig. 11.—Prostate with the genital duct. (Enlarged.)



Fletcher, J. J. 1886. "Notes on Australian earthworms. Part I." *Proceedings of the Linnean Society of New South Wales* 1, 523–574.

View This Item Online: <https://www.biodiversitylibrary.org/item/30467>

Permalink: <https://www.biodiversitylibrary.org/partpdf/39359>

Holding Institution

MBLWHOI Library

Sponsored by

MBLWHOI Library

Copyright & Reuse

Copyright Status: NOT_IN_COPYRIGHT

This document was created from content at the **Biodiversity Heritage Library**, the world's largest open access digital library for biodiversity literature and archives. Visit BHL at <https://www.biodiversitylibrary.org>.