Lee Kenneth Ernest 1927-

STUDIES ON THE SYSTEMATICS AND ANATOMY
OF NEW ZEALAND EARTHWORMS

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INTRODUCTION

The study of New Zealand earthworms has been extensive, but has been confined principally to the systematics of the group. Only one family of the Oligochaeta, the Megascolecidae, is represented in the endemic fauna, but within this family, over eighty species, belonging to seventeen genera, have been recorded and described. Apart from the Megascolecidae, certain species, lumbricids, world-wide in their distribution, are present and are regarded as having been introduced through the agency of man.

The family Megascolecidae is confined almost entirely to the Southern hemisphere, and the southern regions of the Northern hemisphere, and within these regions, the greatest number of species occur in New Zealand, South America, South Africa, and Australia. When the distribution of the Megascolecidae became known, in the late nineteenth century, its sporadic nature evoked a great deal of interest among zoo-geographers, since earthworms, being terrestrial, and unable to tolerate immersion in salt water, form an ideal basis for the consideration of dispersal problems among terrestrial animals as a whole. The interest thus aroused in the Megascolecidae led to much work on the group in New Zealand. Michaelsen (1913 (b)) accounts for the predominance of the Megascolecidae in the southern continental areas by postulating that originally the family had a wide distribution in the northern and southern continents, and that other

families (e.g. the Glossoscolecidae), evolved more recently in the northern continents, have gradually superseded the Megascolecidae in all but the most remote regions of their original area of distribution. Matthew (1915) came to a similar conclusion in regard to the origin of present southern faunas in the course of his work on the distribution and evolution of the Mammalia. Evidence in favour of Michaelsen's conclusions can also be derived from the distribution of slugs, spiders, Collembola, Coleoptera, littoral Echinoderms, Polychaeta and Brachiopoda in the southern land masses.

The way in which the Megascolecidae, or in fact any endemic earthworms, became established in New Zealand has been a matter for conjecture, due to the geographical isolation of New Zealand, and the intolerance of earthworms for salt water. Hooker (1853), in an attempt to explain the affinities of the New Zealand flora with other southern floras, postulated the existence of former land bridges connecting the southern continents and New Zealand with the Antartic continent at some time when the Antarctic continent had a temperate climate. The theory was enthusiastically supported by Beddard and Benham to explain the problem of distribution of the terrestrial Oligochaeta, but was discounted by Michaelsen and later by Stephenson. A controversy on the subject continued for many years, and no final conclusion was ever reached.

The distribution of earthworms within New Zealand has never been studied in detail, since most of the species

which have been described were collected from isolated localities in the South Island, and its neighbouring small islands, and little was hitherto known of the fauna of the North Island. In this thesis, sixteen new species are recorded and described from the North Island, and it is now possible to give some account of the affinities of the Oligochaete faunas of the North and South Islands, at least in regard to some of the more common genera. The dominant element in the New Zealand Megascolecidae is the Sectio Neodrilacea, of the sub-family Acanthodrilinae. The Sectio Neodrilacea comprises the three genera Maoridrilus, Neodrilus and Plagiochaeta, together with the genus Neochaeta which is described for the first time in this thesis. All four genera are confined to New Zealand. All but two of the fourteen species of Maoridrilus described by previous workers were collected from scattered localities throughout the South Island and its neighbouring small islands, and the other two were collected, one from Plimmerton, and the other from Auckland, in the North Island. No species have been recorded from the northern and central districts of the North Island, except M. mauiensis, Benham, (1905), from Auckland, and it would seem that the centre of dispersal of the genus must have been in the South Island, and the species which are now found in the North Island must have become established not long before the two islands became finally separated. One species of Neodrilus, N. monocystis, has been recorded by Beddard (1887) but the locality from which it was collected is not mentioned. It can be

assumed that it was collected in the vicinity of Dunedin, since Benham (1898) mentions having found the species under logs in the Dunedin district. Four new species of Neodrilus are described in this thesis, all collected in the southern region of the North Island. It is not possible, from such scanty data, to give a definite opinion as to the distribution of the genus, but it would not be unreasonable to assume that its distribution is similar to that of Maoridrilus. Plagiochaeta is known from only two species, P. sylvestris, (Hutton, 1876) and P. lineatus, (Hutton 1876), both from the Dunedin district in the South Island, and Neochaeta is also known from only two species, both collected in the North Island, so it is not possible to draw any conclusions from the known distribution of these two genera.

The endemic earthworms of New Zealand are confined almost entirely to the leaf-mould of the rain forest floors, and are rarely found in cultivated land. This marked and common habitat-preference is broken only in the case of Neodrilus agilis, which thrives in cultivated land. Pickford (1937) found that among the Acanthodriline earthworms of South Africa this same habitat-preference was equally marked. There is also, among New Zealand earthworms, commonly a marked division into top-soil and sub-soil species within the same area, e.g. in the Wellington district, the dominant top-soil forms are Maoridrilus and Neodrilus, while the dominant sub-soil species is Octochaetus multiporus, Benham, (1899). In cultivated soils, the introduced European species Allolobophora caliginosa and Lumbricus rubellus have a very wide distribution, while Eisenia foetida is commonly found

in decaying vegetable matter in cultivated areas.

This ^{paper}thesis deals only with endemic earthworms, and is principally a contribution to the knowledge of the systematics of the group, and accordingly the development of practical systematic keys is attempted. In addition, some account of the anatomy of the endemic earthworms is attempted. In the systematic section, twenty species, belonging to six genera, are considered, and of these, sixteen species are from the North Island, and the other four from the South Island. In addition to the descriptions of the species, keys are given to the sub-families of the Megascolecidae, and to the genera, and where possible the species of the genera, occurring in New Zealand. The key to the sub-families of the Megascolecidae is that of Jackson (1931), and those to the genera and species are original, and are presented for the first time. In the section on microscopic anatomy, Neodrilus agilis, n.sp., is studied. The reason for the selection of this species is that Neodrilus is a genus peculiar to New Zealand, and has been derived from the Acanthodriline stock in New Zealand. It is a form typical of the Neodrilaceae, which is the dominant group in the New Zealand earthworm fauna, and although it is markedly distinct from the Lumbricidae, it shows striking similarities in its anatomy to Lumbricus. This similarity in the anatomy of genera which show such a diversity of macroscopic structure indicates that the Order Oligochaeta is a very compact group.

It has not been possible, in the time available, to make a detailed study of the ecology and behaviour of

New Zealand earthworms, but observations on any unusual ecological factor or behaviour pattern which were observed are included in the descriptions of the individual species concerned.

No claim is made to a complete coverage of the systematics of North Island earthworms, and much work remains to be done before a comprehensive account of the fauna can be undertaken.

The range of material studied has been due to access to the collections of the Dominion Museum, made available by Dr. R.A. Falla, Director of the Museum, and to the invaluable advice and many helpful suggestions given throughout the work connected with this thesis by Prof. Sir William Benham, of Dunedin.

HISTORICAL SURVEY

The first record of an earthworm from New Zealand is contained in a description of Megasolex antarctica, by Baird in 1867. The description is short, and insufficient to be of any use in the recognition of the species.

Hutton was the next worker to contribute to the knowledge of the group in New Zealand. In his "Earthworms of New Zealand in the Otago Museum" (1876), he described four new species of Lumbricus, (L. annulatus, L. levis, L. campestris, and L. uliginosus), and two new species of Megascolex, (M. sylvestris and M. lineatus). These worms were subsequently re-examined by Benham (1898), who found that Hutton's L. annulatus was Eisenia foetida, his L. levis was an undetermined species of Octochaetus, with a specimen of Allolobophora caliginosa, his L. campestris was Neodrilus monocystis, together with a specimen of Lumbricus rubellus, his L. uliginosus was Maoridrilus uliginosus, and his species of Megascolex were placed by Benham in the genus Plagiochaeta, (Benham, 1892). Hutton also published a "Catalogue of Worms of New Zealand", in two parts (1878, 1879), in which he listed all the species of earthworms which he knew to occur in New Zealand.

The systematic examination of the New Zealand earthworm fauna has been carried out principally by Beddard and Benham, and to a lesser extent by the German zoologists Michaelsen and Ude. These four workers have between them described over eighty species, belonging to seventeen genera,

of indigenous earthworms. Beddard's papers may be found in the Proceedings of the Zoological Society, London, Proceedings of the Royal Physical Society, Edinburgh, and the Quarterly Journal of Microscopic Science. The majority of Benham's papers are in the Transactions of the New Zealand Institute, and the Transactions of the Royal Society of New Zealand, with a few in the Quarterly Journal of Microscopic Science, and the Proceedings of the Zoological Society, London. Much of Michaelsen's work was published in "Das Tierreich", and the remainder of Michaelsen's and all of Ude's work has been published in various German journals.

Two genera of the sub-family Acanthodrilinae, Acanthodrilus and Microscolex, have figured prominently in discussions on the origin and relationships of southern faunas.

Acanthodrilus occurs in New Zealand, South America, South Africa, and sporadically in Mexico, Central America, Madagascar, and New Caledonia. Michaelsen (1903, 1913 (a), 1913 (b)) considered that this distribution could be explained by the postulation of a former wide distribution of the genus in the Northern continental areas, the genus spreading southwards, and subsequently being eliminated by later evolved genera, finally becoming restricted to the southern hemisphere. Michaelsen's explanation is in agreement with the findings of Matthew (1915) on the distribution of the Mammalia.

Microscolex occurs in South America, the Falkland Islands, South Georgia, Kerguelen, Marion Island, Cape Colony, Crozet Islands, Campbell Island, Auckland and Antipodes

Islands, and Macquarie Island.

Beddard (1895, 1895(a)) first proposed the adoption of Hooker's theory of former land connections between South America and the Antarctic Islands, by way of an Antarctic continent, to explain the distribution of Microscollex. Michaelsen opposed Beddard's views on the grounds that the genus could have achieved its present distribution by the transport of cocoons by birds and floating masses of seaweed. Benham opposed Michaelsen's argument on the grounds that masses of seaweed would be torn to pieces by the heavy surf on the shores of the Antarctic Islands, and that there is no proof that the cocoons of Microscollex can withstand long immersion in seawater. Michaelsen (1907) discounted Benham's argument concerning the action of the surf, and claimed that some of the species of Microscollex, unlike other earthworms, are euryhaline, and that the present distribution of the genus consequently presents no problem. It must be remembered that the present earthworm fauna of the Antarctic Islands must have been established in its entirety since the close of the last glacial epoch, that is, since the commencement of the Pleistocene, and if land bridges are to be postulated to explain the distribution, they must have disappeared very rapidly, within comparatively recent times. On the other hand, it must also be remembered that soundings taken in the Antarctic region show that there are submarine ridges, at a depth of less than 2,000 fathoms, joining most of the Antarctic Islands, and linking up with the Antarctic continent. Belief in the former linking of

the Southern land masses is not now generally held, and the argument has been dropped.

In recent years, Benham's papers have been the only contributions to knowledge of the New Zealand earthworm fauna, and it is regrettable that no one else has taken any interest in this large group since the work of Michaelsen, Beddard and Ude came to an end.

MATERIALS AND METHODS

The material used in this thesis was collected over a period of two years, from localities covering the southern and central districts of the North Island of New Zealand. Most of the specimens were obtained from leaf-mould in native rain forests. Leaf-mould was collected in bags, and returned to the laboratory, where the large specimens were extruded by hand, and the small specimens extracted by placing the leaf-mould in a Berleze funnel, and collecting the worms in a dish of alcohol.

The systematic descriptions are based on the external features of the specimens, and the internal anatomy as seen in a dissection from the dorsal aspect.

For the section on the microscopic anatomy of Neodrilus agilis, specimens were collected from Karori, Wellington, and cross-sections, 4 microns thick, were cut with a Reichert rotary microtome. The sections were stained with Ehrlich's haematoxylin, and counter-stained with Congo Red.

Many specimens were collected by interested persons, and their assistance is acknowledged in the systematic section.

SYSTEMATICS

Seventeen genera, containing over eighty species of indigenous earthworms, have been recorded from New Zealand and the neighbouring islands. All the genera belong to the Fam. Megascolecidae, the characters of which are given below.

9 Fam. Megascolecidae. "Chaetae sigmoid, simply pointed, either lumbricine or perichaetine in arrangement. Clitellum beginning with, or in front of XV. One pair of male pores, usually either on XVII or XVIII, seldom on XIX. Female pores paired, or a single median pore, with few exceptions on XIV. An oesophageal gizzard usually present. Two pairs of testes, in X and XI, or one pair in X or XI. One or two pairs of prestates; prestates rarely absent. One pair of ovaries in XIII." (Stephenson, 1930).

The Fam. Megascolecidae is divided into seven sub-families, of which only three, the Acanthodrilinae, the Megascolecinae, and the Octochaetinae are represented in New Zealand.

The work of Benham, Beddard, Michaelsen and Ude has led to an extensive knowledge of the earthworms of the South Island, but knowledge of those of the North Island is very limited. Of the twenty species described in this thesis, sixteen are North Island forms, none of which has previously been described.

Below are keys to the sub-families of the Megascolecidae, and to the New Zealand genera of the sub-families Acanthodrilinae, Megascolecinae, and Octochaetinae.

The classification followed is that of Michaelson
(1900) as set out by Stephenson (1930).

- a1 One pair of calciferous glands or oesophageal pouches
in IX, sometimes united ventrally..

.....Sub-Fam. Ocnero-drilinae

- a2 Calciferous glands not, or not only in IX.

- b1 Two or three gizzards anterior to testes.

- c1 Micronephric.

.....Sub-Fam. Trigastrinae.

- c2 Meganephric

.....Sub-Fam. Diplocardiinae.

- b2 One or no gizzards anterior to the testes.

- d1 Spermathecal pores posterior to VIII/IX,
or united with female pores

.....Sub-Fam. Eudrilinae

- d2 Spermathecal pores on or anterior to
VIII/IX, or lacking.

- e1 Vas deferens opens into spermiducal
gland, except when the latter is
lacking.

.....Sub-Fam. Megascolecinae.

- e2 Vas deferens and spermiducal gland
entirely separated or at most opening
close to each other

- f1 Micronephric

.....Sub-Fam. Octochaetinae

- f2 Meganephric.

.....Sub-Fam. Acanthodrilinae

Give source

Sub-Fam. Acanthodrilinae.

The sub-family Acanthodrilinae is divided into two Sectiones, the Sectio Acanthodrilacea, distinguished by having the nephridiopores in a single series on each side of the body, and the Sectio Neodrilacea, distinguished by having the nephridiopores more or less alternating between a position anterior to the dorsal and anterior to the ventral chaetal bundles in successive segments. The Sectio-Neodrilacea is peculiar to New Zealand, and only three genera, Maoridrilus, Plagiochaeta and Neodrilus have hitherto been described. One new genus, Neochaeta, is described in this thesis, and is included in the key to the genera of the Neodrilacea given below. The Sectio Acanthodrilacea is represented by five genera, Microscolex, Rhododrilus, Acanthodrilus, Dinodriloides, and Perieodrilus, in New Zealand, and a key to these genera is also given below.

KEY TO THE N.Z. GENERA OF THE ACANTHODRILACEA

a1 Chaetae 8 per segment.

b1 Gizzard vestigial or absent Microscolex

b2 Gizzard well developed

c1 One pair of prostatic

pores on XVII Rhododrilus

c2 Two pairs of prostatic

pores on XVII and XIX Acanthodrilus

a2 Chaetae 12 per segment Dinodriloides

a3 Chaetae more than 12 per segment Perieodrilus

a1 Chaetae 8 per segment.

b1 One pair of prostatic pores on XVII ... Neodrilus

b2 Two pairs of prostatic pores, on XVII and XIX.

..... Maoridrillus

a2 Chaetae more than 8 segment.

c1 One pair of prostatic pores on XVII.

..... Neochaeta (n.
g.)

c2 Two pairs of prostatic pores, on XVII

and XIX Plagiochaeta

Sub-Fam. Megascolecinae. This sub-family is represented in the New Zealand region by the six genera Pontodrilus, Megascolides, Notoscolex, Diporochoaeta, Pheretima and Megascolex. A key to these six genera is given below.

KEY TO THE N.Z. GENERA OF THE MEGASCOLECINAE

a1 Chaetae 8 per segment.

b1 Gizzard vestigial or absent Pontodrilus

b2 Gizzard developed in the region of

V or VI.

c1 Prostates tubular, with simple

unbranched canal Megascolides

c2 Prostates with branched system

of ducts Notoscolex

a2 Chaetae more than eight per segment.

d1 Meganephridial Diporochoaeta

d2 Micronephridial.

e1 Gizzard single, between

7/8 and 10/11 Pheretima

e2 Gizzard single, in V,

VI, or VII Megascolex

Sub-Fam. Octochaetinae.

This sub-family is represented in the New Zealand region by the three genera Octochaetus (Subgenus OCTOCHAETUS), Dinodrilus and Conicodrilus. A key to these genera is given below.

KEY TO THE N.Z. GENERA OF THE OCTOCHAETINAE

a1 Chaetae 8 per segment Octochaetus

a2 Chaetae 12 per segment.

b1 Calciferous glands in the region of XIV-XVI

..... Dinodrilus

b2 Calciferous glands in XVIII.

..... Conicodrilus

THE SYSTEMATIC CHARACTERS OF THE GENERA AND SPECIES
OF THE MEGASCOLECIDAE

Many, if not all, earthworms are specifically identifiable on sight by the experienced student, but the general features of size, colour, habit etc. which permit the ready separation of one species from another are most difficult of description, and accordingly systematists rely on a mass of minute description, from which one or a few morphological features are selected as having high generic and specific value. The selection of such features, which often differ from genus to genus, makes the systematics of the Oligochaetes rather difficult at the start. As soon as an acquaintance is made with a genus after minute dissection, it is not long before the genus and its species become recognisable at sight. An account is here given of the morphological features which have been found to be reliable systematic characters, and of the variation of some other characters to which systematic importance has sometimes been attached.

Generic Characters.

The genera of the Megascolecidae are distinguished from one another by the following features:-

(1) Number and arrangement of the chaetae on the segments. There are two fundamental arrangements:-

a. Lumbricine - as found in Maoridrillus, where there are four pairs of chaetae on each segment - a dorso-lateral and a ventro-lateral pair on each side. This is the commonest arrangement, and from it, in many genera, has

been derived the other arrangement.

b. Perichaetine - as found in Plagiochaeta, where there is a large number of chaetae, or pairs of chaetae, evenly spaced around each segment.

The lumbricine arrangement of the chaetae is invariable, but in the genera with a perichaetine arrangement of the chaetae, there may be variations between individual species in the number of chaetae, or pairs of chaetae, on each segment. In such cases, the number of chaetae per segment is often a valuable specific character.

(2) Nephridia - The usual condition is the meganephridial condition, in which there is, in each segment, a pair of large nephridial tubules opening to the exterior by a pair of small pores. From the meganephridial condition, in many genera, has been derived the micronephridial condition, as seen in Octochaetus, where there is a large number of very small nephridial tubules, not opening to the exterior, in each segment. A condition intermediate between the meganephridial and the micronephridial conditions is seen in some genera, e.g. Megascolides, in which there are micronephridia in every segment, but in some of the most posterior segments, meganephridia are present in association with them.

(3) Arrangement of the Nephridiopores - In nearly all the meganephridial genera of the Megascolecidae, the nephridiopores are in a single series on each side of the body, but in the four genera comprising the Neodrilacea, and in some species of Perionyx, the nephridiopores alternate more or less regularly between a dorso-lateral and a ventro-

lateral position in successive segments.

(4) Male Genital Apparatus - The number and positions of the prostatic pores and the associated male pores are used to distinguish genera. The more general arrangement is the "acanthodriline", in which there are two pairs of prostatic pores, on XVII and XIX, and a single pair of male pores on XVIII (as in Acanthodrilus). The "acanthodriline" arrangement is considered to be the primitive condition, and from it the other two arrangements are derived. The other two arrangements are:-

(a) Microscolecine, in which the posterior pair of prostates and their pores disappear, and the male pores may, or may not unite with the prostatic pores on XVII (e.g. Neodrilus).

(b) Balantine, in which the anterior pair of prostates and their pores disappear, and the male pores and prostatic pores unite on XVIII (e.g. the South African genus Udeina).

These arrangements may undergo variations, and the importance attached to such variations is not standardised. Benham (1909) distinguished the genus Leptodrilus for two species which resembled Rhododrilus, except that the prostatic pores opened on XVI, instead of on XVII or XVIII, but Stephenson does not consider a similar modification in some species of Notoscolex to be of sufficient importance to justify the establishment of a new genus.

(5) The presence or absence of the gizzard. The vestigial nature of the gizzard in some genera, and its development in others is a valuable generic character, e.g.,

the two genera Microscolex and Rhododrilus are distinguished by the vestigial nature of the gizzard in the former, and its greater development in the latter.

Specific Characters.

The similarities of species within the genera of the Megascolecidae are often extremely close, and it is commonly necessary to make use of small differences in internal anatomy to differentiate between closely allied species.

The number and form of the spermathecae, and their diverticula are useful and reliable specific characters. A great diversity is often found within a genus, but within a species, the constancy of form, particularly of the diverticula, is a character of great systematic importance.

Another constant and reliable specific character is the form of the penial chaetae, which are present in nearly all the New Zealand Megascolecidae. Pickford (1937) found the form of the penial chaetae of great systematic value in the Acanthodriline earthworms of South Africa.

In some cases, the number of testes is a useful specific character, e.g. in Diporochaeta chathamensis, Benham (1900(a)) and D. obtusa, there is only one pair of testes, in XI, in contrast to the more general two pairs, in X and XI, found in this genus.

Pickford (1937) made use of the nature of the junction between the nephridial tubule and the nephridial vesicle to divide the species of some genera into groups.

The characters discussed above are useful, and

have been found to be reliable. Other characters, whose reliability is more doubtful, have been used for the distinction of some species. Beddard (1892) distinguished his two species Octochaetus multiporus and O. thomasi by their difference in size, the former species being very large, and the latter rather smaller, although he gave no measurements of O. thomasi for comparison with O. multiporus. Beddard's species were founded on a small number of specimens, and it is doubtful whether the distinction between the two can be upheld, since within a single species a great variation of size is frequently found, e.g. I have found mature specimens of Neodrillus agilis to vary between 51 mm. and 86 mm. in length, and if Beddard's species are to be upheld, it would be difficult, if not impossible, to distinguish a small specimen of Octochaetus multiporus from a large specimen of Octochaetus thomasi.

Benham (1905) made use of the number and position of the tubercula pubertatis to distinguish Dinodrillodes annectens, Benham, (1905) from D. beddardi, Benham (1904). It is doubtful whether a distinction of the two species based on this character can be upheld, since in Microscolex aucklandicus, (Benham, 1902), Microscolex huttoni, Benham (1900(2)), and Rhododrillus besti, Benham (1904(2)), the same author records a great deal of variation in the number and position of the tubercula pubertatis, and I have observed similar variations in Neodrillus agilis. It would seem that the number and position of these structures must be carefully observed in many specimens, before a species

can be founded on a character which is so prone to variation in other genera and species.

The differentiation of species among earthworms is, and must remain, a difficult task, because they form a very compact group, and display very little variation of anatomy, even between apparently widely divergent species.

ABBREVIATIONS USED IN PLATES I-XX

C.G.	=	cerebral ganglion
CH.	=	chaeta
CL.	=	clitellum
C.M.	=	copulatory muscles
D.B.V.	=	dorsal blood vessel
DIV.	=	diverticulum of the spermatheca
D.P.	=	dorsal pore
F.P.	=	female pore
G.	=	gizzard
H.	=	heart
INT.	=	intestine
M.	=	mouth
M.P.	=	male pore
N.	=	nephridium
N.P.	=	nephridiopore
O.	=	ovary
OE.	=	oesophagus
OE.GL.	=	oesophageal gland
O.F.	=	ovarian funnel
P.	=	prostate
PAP.	=	prostatic papilla
P.CH.	=	penial chaeta
P.D.	=	prostatic duct
PERI.	=	peristomeum
PH.	=	pharynx

P.P.	=	prostatic pore
PR.	=	prostomium
S.	=	septum
SAC.	=	sac containing the penial chaetae.
SAL.GL.	=	salivary gland
SP.	=	spermatheca
SP.D.	=	spermathecal duct
SP.P.	=	spermathecal pore
T.	=	testis
T.F.	=	testicular funnel
T.PUB.	=	tuberculum pubertatis
V.B.V.	=	ventral blood vessel
V.S.	=	vesicula seminalis.

THE GENUS RHODODRILUS

Fam. Megascolecidae
Sub-Fam. Acanthodrilinae
Sectio Acanthodrilacea
Genus Rhododrilus, Beddard, 1889.

"Chaetae eight per segment. Nephridiopores in a single series on each side. Male pores on XVIII or XVII, or in furrow 17/18; one pair of prostatic pores on XVII. Spermathecal pores one to four pairs, the last pair in furrow 8/9. Gizzard well developed. Two pairs of free testes and funnels, in X and XI.

"Distribution: New Zealand (North and South Islands), Campbell Island, Auckland Islands, Chatham Island, Kermadec Islands, Snares Island, Little Barrier Island; one species in Queensland, Australia." (Stephenson, 1930).

The genus Rhododrilus is distinguished from the genus Microscolex Rosa, by the fact that Rhododrilus has a gizzard, while the gizzard of Microscolex is vestigial or is absent. Both the genera show the microscolecine reduction of the reproductive organs, i.e., there is only one pair of prostates, opening to the exterior on XVII, as opposed to the more general acanthodriline organisation of the reproductive system, in which there are two pairs of prostates, opening to the exterior on XVII and XIX. In 1905, Michaelsen united the two genera under the name of Microscolex, but in 1907, the two genera were separated again by the same author, under their original names, in consequence of the importance now attached to the presence in some and the absence in others, of the gizzard. The species described below presents a

problem, in that the gizzard, though quite definite, is of small size, and has thin, though muscular walls. The gizzard cannot, in my opinion be considered as vestigial, so I have placed the species in the genus Rhododrilus. The fact that the specimens were obtained from within the known distribution area of Rhododrilus, and outside that of Microscolex, would also seem to indicate that the species belongs to Rhododrilus, and not to Microscolex.

Rhododrilus fuscus n. sp.

Plate 1

Of this species, I have only one mature specimen, collected by A.J. Healy, from Taumatotara, Kawhia, on 5/12/47, and several immature specimens, also from Kawhia. The mature specimen is very dark brown dorsally, and light brown ventrally, with a small yellowish spot surrounding each chaeta. It is 33 mm. in length, with 75 segments, and 3.5 mm. in diameter, terminating bluntly at mouth and anus. The clitellum is buff, and covers the segments XIV-XVI, and half of XVII, completely surrounding XIV, and elsewhere covering only the dorsal and lateral aspects of the segments.

The prostomium is tanylobous. The chaetae commence on II, and are eight per segment, arranged in pairs, a ventral and a dorso-lateral pair on each side of each segment. The chaetae of the dorso-lateral pair are much more widely spaced than those of the ventral pair. On segment XXI, the arrangement of the chaetae is as follows:-

ab = 1 mm.; bc = 1.5 mm.; cd = 1.5 mm.;

aa = 1.25 mm.; dd = 2 mm.

A single pair of spermathecal pores occurs at VIII/IX, in line with chaeta b.

There is a pair of female pores on XIV, appearing as small slits, slightly anterior and lateral to chaeta a.

The prostatic pores are a pair of small apertures on XVII, situated on very prominent white papillae, and in line with chaeta b. The chaetae a and b are absent on XVII, and penial chaetae are visible, protruding close to the prostatic pores. A shallow longitudinal groove passes back from each prostatic pore, onto XVIII, terminating at the male pore on each side. The male pore is situated in a small white area, close to the anterior margin of XVIII, and anterior to the pair of chaetae ab.

Dorsal pores commence at IV/V, and are present in each intersegmental groove posterior to this. Nephridiopores commence on II, and are in a single series on each side of the body, in line with the chaeta c.

On a superficial examination, this species could easily be taken as a species of Neodrilus, its gross form being very like that of N. polycystis, but a closer examination shows that it lacks the alternation of position of the nephridiopores characteristic of Neodrilus.

Internal Anatomy

Alimentary Canal: The pharynx is large and muscular, and occupies the first five segments. Its dorsal surface is

covered with small salivary glands. There is a small gizzard with thin muscular walls in VI, and the oesophagus extends from VII to XVIII, without any oesophageal glands. The intestine commences in XIX and has a typhlosole.

Vascular System: The dorsal blood vessel is unpaired in the first five segments, but becomes paired at V/VI, and the two vessels remain distinct throughout the rest of the length of the animal. There are four pairs of hearts in X, XI, XII, and XIII, those of XIII being extremely dilated.

Reproductive System: There are two pairs of large lobate testes in X and XI close to the mid-ventral line, and a pair of small lobulate ovaries in XIII, also close to the mid-ventral line. Three pairs of racemose vesiculae seminales are present in X, XI, and XII, extending around the lateral walls of the oesophagus, and meeting in the mid-ventral line above the dorsal blood vessel.

A single pair of spermathecae occurs in IX. Each is a large irregular ovoidal sac, opening to the exterior at VIII/IX. There are two diverticula on each spermatheca, a small, medial, trilobulate diverticulum, and a lateral, polylobulate diverticulum of much larger size, curved around the outside of the spermathecal sac.

The prostates are large coiled tubular structures, arising from a short muscular duct in XVII, and following an extremely convoluted course, within XVII and XVIII, this latter segment being greatly distended to accommodate the

prostates. The left prostate is confined to XVII and XVIII but the right doubles back again from XVIII, and passes through the septum XVIII/XIX, to terminate in XIX. Penial chaetae are absent, but copulatory muscles, as in Octochaetus, occur in XVI and XVII, running from the dorso-lateral aspect of the body wall to the mid-ventral line close to the prostatic ducts.

The nephridia are paired, and simply coiled, and the duct terminates in a large clear vesicle.

PLATE I

FIG. 1.

FIG. 4.

FIG. 5.

FIG. 2.

FIG. 3.

PLATE 1RHODODRILIUS FUSCUS N.SP.

- Fig. 1. Dorsal aspect, first six segments.
- Fig. 2. Ventral aspect, first twenty-three segments.
- Fig. 3. Dissection from the dorsal aspect.
- Fig. 4. Right spermatheca, antero-medial aspect.
- Fig. 5. Left prostate, medial aspect.
-

THE GENUS NEODRILUS

Fam. Megascolecidae
Sub-Fam. Acanthodrilinae
Sectio Neodrilacea
Genus Neodrilus, Beddard, 1887.

"Chaetae eight per segment. Nephridiopores more or less regularly alternate in position on each side, in line with the ventral and lateral chaetae. Male pores on XVIII; prostatic pores one pair on XVII. Spermathecal pores one pair in the furrow 7/8. Oesophageal gizzard present. Testes two pairs, free, in X and XI. Prostates one pair; penial chaetae present.

Distribution: New Zealand.

The genus seems to have been derived from the genus Maoridrilus by the supervention of the microscolecine genital apparatus." (Stephenson, 1930). 9

The genus was previously known from one species, N. monocystis, first described by Beddard (1887), and confirmed and redescribed by Benham (1892).

In my collection there are four new species of the genus, N. rosae, N. agilis, N. polycystis, and N. karoriensis, all collected in the vicinity of Wellington. They are all small worms, and were collected from leaf-mould in native rain forests, with the exception of N. agilis, which occurs in cultivated ground at Kaporī, Wellington. N. agilis and N. polycystis are both extremely active forms, and lash violently when touched.

The five species now known fall into three groups, according to the number of calciferous glands occurring on the oesophagus. The first group contains only N. monocystis, which has no calciferous glands. The second group contains only N. rosae, which has one pair of calciferous glands in XIV. In the other three species, N. agilis, N. polycystis and N. karoriensis, there are two pairs of calciferous glands in XIV and XV. These last three species may be distinguished by the number, form and position of the diverticula of the spermathecae. In N. agilis there is a group of diverticula clustered around the duct of the spermatheca, and the whole spermatheca is contained in VIII, whereas in N. polycystis and N. karoriensis, the spermathecae lie in VIII, but their diverticula project forward through the septum 7/8 into VII. These last two species may be distinguished by the fact that N. polycystis has a cluster of small diverticula in VII, while N. karoriensis has only one diverticulum, of large size, in VII.

(Variation in Neodrillus:)

The following account is based on observations on twenty-nine specimens of N. agilis, collected from Karori, Wellington, in cultivated ground on 9/7/48.

(Variation of External Features:)

Only mature specimens were examined for variation. In these, the size range was from 51 mm. to 86 mm. The number of segments does not vary directly as the length, the least

observed being 95 in a worm of 69 mm. length, and the most 123 in a worm of 86 mm. length. The average length was 73 mm., and the average number of segments 114.

The spermathecal pores showed no variation in number or position, there being a pair at 7/8, in all cases except one, where the right pore was absent, but in its place was a large scar showing that an injury had occurred.

The prostatic pores showed no variation in number or position, there being a single pair on XVII, except in one case where the left prostatic pore was absent. This anomaly occurred in the specimen which possessed only a single spermathecal pore, but there was no sign of injury in the vicinity of the prostates.

The tubercula pubertatis varied considerably in number and position. In one specimen the tubercula were completely absent. In the other specimens, tubercula occurred on one or more of the segments XIV, XV, and XVIII. Normally they occur in pairs. In nineteen specimens a pair occurred on XIV, and in two of these an additional small pair occurred on XVIII. In four specimens, a single tuberculum occurred on XIV, on the left in two cases, and on the right in the other two cases; in all four of these, a pair was also present on XV. In the other five specimens, there was only a single pair on XV.

The positions of the nephridiopores showed a considerable variation in the specimens examined. Normally in the Neodrilacea, the nephridiopores show a more or less

regular alternation in successive segments, between a dorsal and a ventral position, both the pores in each segment being either dorsal or ventral, as the case may be. The nephridiopores in all the species of Neodrillus commence on II, and in the anterior region, they are all dorsal. In N. agilis, the most anterior ventral pore varied in position in the specimens, between VIII and XI, and thereafter there was an alternation of positions. However, in eleven of the specimens, the alternation was irregular, in that on each segment the pore of one side was dorsal, while that of the other side was ventral, and the alternation of position of the pores was shown separately on each side of the body.

Variations of Internal Anatomy:

The spermathecae showed no variation in the form of the sac or the diverticula, and except in one case, both spermathecae were contained entirely in VIII. In the one exceptional case, the right spermathecal sac was in IX, and a long duct led from the sac, through the septum VIII/IX into VIII. The diverticula formed a cluster around the duct close to its termination at VII/VIII, as is normal in the species. The left spermatheca of this specimen was contained in VIII, as is usual.

In one other specimen the right spermatheca was completely absent, but there was a white scar on the body wall, showing that an injury had occurred, and the spermatheca must have been excised.

The prostates showed irregularities which make them quite useless as specific characters. In one specimen, mentioned above as having only one prostatic pore, the left prostate was absent. In the other specimens, the prostates showed a considerable variation in size. They extended through one to five segments in different specimens, and in eleven specimens there was a difference in extent between the left and the right prostates of the same specimen. In three specimens, one prostate crossed over the top of the gut, and extended back on the other side beside the opposite prostate. A similar condition was found in N. karoriensis (q.v.). The other internal organs displayed no variation in the specimens that I examined.

It seems then, that in the genus Neodrillus, the form and position of the spermathecae and of their diverticula are specific characters of value, but that all the other characters discussed above must only be used after the consideration of a series of specimens.

Distribution of Neodrillus:

Neither Beddard nor Benham mentions the locality from which their specimens of N. monocystis were collected, but the four species which I have described are confined to the Southern portion of the North Island, in the vicinity of Wellington.

KEY TO THE SPECIES OF NEODRILUS

a1 Calciferous glands absent.

..... N. monocystis.

a2 Calciferous glands one pair in XIV.

..... N. rosae.

a3 Calciferous glands two pairs in XIV and XV.

b1 Diverticula of the spermatheca small and numerous, in VIII.

..... N. agilis

b2 Diverticula of the spermatheca projecting forward through the septum VII/VIII, into VII.

.....

c1 A group of small spermathecal diverticula in VII.

..... N. polycystis.

c2 A single large diverticulum of the spermatheca in VII.

..... N. karoriensis.

Neodrillus rosae n. sp.

Plate II.

Of this species I have only one specimen, collected by R.K. Dell from leaf mould near the summit of the Rimutaka Range on 14/6/47. The specimen is 57 mm. in length, with 122 segments, its diameter for the greater part of its length being 3.5 mm., tapering gradually to the mouth and anus. It is light pink in colour dorsally, paler ventrally, with a pale buff clitellum covering XIV-XIX, and half XIII, developed only dorsally and laterally.

The prostomium is tanylobous. The chaetae commence on II, and are lumbricine in arrangement. On segment XXX:-

ab=cd= 1 mm.; aa= 1.5 mm.; bc= 2 mm.; dd= 2 mm.

A pair of spermathecal pores occurs at VII/VIII, in line with the chaeta b.

The female pores are a single pair on XIV, just anterior to chaeta b.

A single pair of prostatic pores occurs on XVII, each pore on a prominent white papilla in line with the chaetae ab. A groove runs longitudinally across each papilla and is continued back onto XVIII, terminating at the male pore of each side. The male pore has prominent tumid lips, and lies in line with, and slightly anterior to the chaetae ab on XVIII. There are three tubercula pubertatis, one on each side of the segments XIII, XIV, and XV, each taking the form of a narrow raised white strip running laterally across the ventral surface of the segment, from chaeta b of one side to chaeta b of the other side.

The nephridiopores commence on II, where they are anterior to the chaeta d. On segments III-IX they are anterior to chaeta c. The first ventral pair occurs on X, where the pores are anterior to chaeta b, and posterior to this segment there is a regular alternation between a dorsal and a ventral position, as is characteristic of the Neodrilacea.

Internal Anatomy

Alimentary Canal: The pharynx occupies segments I-IV, and is very muscular. There is a small gizzard in VI, and a narrow oesophagus commences in VII, and runs back to XVI, bearing a prominent pair of calciferous glands in XIV. The intestine commences in XVII, is thin walled and has a typhlosole.

Vascular System: The dorsal blood vessel is unpaired, throughout the length of the animal, and bears four pairs of dilated hearts in segments X, XI, XII and XIII, those of XIII being extremely dilated.

Reproductive System: Two pairs of free lobate testes occur in X and XI, and a single pair of lobate ovaries in XIII. Both the testes and the ovaries are close to the ventral mid-line.

A single pair of spermathecae is present in VIII, and each takes the form of a large ovoidal sac, with a smaller anterior diverticulum opening into the short spermathecal duct close to its external aperture, and the whole structure

is confined to segment VIII. The surface of the diverticulum is striated. Two pairs of large racemose vesiculae seminales surround the oesophagus in segments XI and XII. There is a single pair of convoluted tubular prostates extending through segments XVII-XIX, and terminating blindly in XIX. Each prestate opens by a muscular duct in XVII. Penial chaetae are present in a transparent sac lying under the prostatic duct.

PLATE II

FIG. 4.

FIG. 1.

FIG. 5.

FIG. 6. S. XVIII-XIX

FIG. 2.

FIG. 3.

PLATE IINEODRIIUS ROSAE N.SP.

- Fig. 1. Dorsal aspect, first six segments.
- Fig. 2. Ventral aspect, first twenty-one segments.
- Fig. 3. Dissection from the dorsal aspect.
- Fig. 4. Right spermatheca, medial aspect.
- Fig. 5. Left prostate, medial aspect.
- Fig. 6a. Penial chaeta.
- 6b. Normal chaeta.
-

Neodrilus agilis n. sp.

Plate III.

I have a large number of specimens of this slender, greenish-grey worm, collected from Karori, Wellington. It is extremely active and agile in its movements, and when mildly stimulated displays a rapid sideways thrashing of its body. This is in contrast to most worms, which, when mildly stimulated, withdraw slowly from the source of stimulation. N. polycystis shows a similar, but not so marked, sensitivity to mild stimulation.

The specimen described is 51 mm. in length, with 118 segments, and 3 mm. in diameter, tapering gradually to mouth and anus. The clitellum is olive green, and covers segments XIII to XIX, dorsally and laterally.

The prestomium is tanylobous. The chaetae are lumbricine in arrangement, and commence on II. The arrangement on segment XXV is:-

ab = cd = 0.5 mm.; aa = 1.5 mm.; bc = 2 mm.}

dd = 1.5 mm.

A pair of spermathecal pores occurs at VII/VIII, in line with chaeta a.

There is a single pair of female pores on XIV, anterior and slightly lateral to chaeta b.

The prostatic pores are a single pair on XVII, each on a raised papilla in line with the chaetae ab, which are absent on this segment. The male pores are on XVIII, directly in line with the prostatic pores, and just anterior to the chaetae ab. There is a pair of prominent tubercula

pubertatis on the ventro-lateral surface of XIV, and a much smaller pair in the corresponding position on XVIII.

The nephridiopores commence on II, where they are anterior to the chaeta d. The pores on III-IX are anterior to chaeta c, and the first ventral pair occurs on X, where they are anterior to chaeta b. Posterior to X, there is a regular alternation between the dorsal and the ventral positions in successive segments.

Internal Anatomy

Alimentary Canal: The pharynx occupies segments I-IV, and has salivary glands attached to its posterior region, and extending back into segment V. There is a small gizzard in VI. The oesophagus runs through the segments VII-XVI, and bears calciferous glands in XIV and XV. The intestine commences in XVII, and has a typhlosole, which spirals slowly around the circumference of the intestine in the course of its length.

Vascular System: The dorsal blood vessel is unpaired, and the blood, which is red in life, turns green on coagulation, and imparts an olive green colour to the blood vessels. There are four pairs of dilated hearts in segments X, XI, XII, and XIII.

Reproductive System: The testes are polylobate structures, situated close to the ventral mid-line in X and XI, and the ovaries are similar structures also close to the ventral

mid-line, in XIII.

There is one pair of spermathecae, situated in VIII, each spermatheca consisting of a large ovoidal sac, with a wide curved duct leading to the exterior at VII/VIII. A cluster of small diverticula occurs around the distal extremity of the duct. In one specimen which I have examined, there is a remarkable assymetry of the spermathecae. The left one is as described above, but the right spermatheca in this case consists of a sac in IX, with a long wide duct -passing through the septum VIII/IX into VIII, and opening to the exterior at VII/VIII. The diverticula of the right spermatheca are normal. I have not observed any other assymetry of the spermathecae in N. agilis.

There is a single pair of prostates, each commencing in XVII, and taking the form of a convoluted tube, extending back to XXI, where it terminates. The prostates are closely applied to the lateral aspects of the intestine. A small sac containing penial chaetae is closely applied to the medial aspect of each prostate in XVII.

Nephridia: The nephridia commence in II, and their ducts terminate at small vesicles, which alternate in position, corresponding to the alternation of the external peres. The nephridia are light green in colour.

PLATE III

PLATE III

NEODRILUS AGILIS N.SP.

- Fig. 1. Dorsal aspect, first six segments.
- Fig. 2. Ventral aspect, first twenty segments.
- Fig. 3. Dissection from the dorsal aspect.
- Fig. 4a. Right spermatheca, medial aspect.
- 4b. Left spermatheca, lateral aspect.
- Fig. 5. Right prostate, medial aspect.
- Fig. 6a. Penial chaeta.
- 6b. Normal chaeta.
-

Abnormal Reduction of the Reproductive Organs in
Neodrillus agilis:

Plate IIIA, figs, 1, 2.

In a specimen of *N. agilis* collected by B.M. Bary at Karori, Wellington on 30/6/48, there was an irregularity of the reproductive organs not previously recorded.

Only one spermathecal pore, the left, was present, occupying the usual position, in the groove VII/VIII, and anterior to the chaetae ab. It appeared that the whole region surrounding the right spermathecal pore had been excised, since a white scar extended across the ventro-lateral surface, from the middle of VII to the posterior border of VIII, and the chaeta b was absent from both VII and VIII on the right side.

Only one prostatic pore, the right, was present, although there was no external sign of injury in the region where the left prostatic pore is normally situated.

Internally, the anatomy was normal, except that the right spermatheca and the left prostate were completely absent.

It seems likely that the right spermatheca was accidentally excised, but the absence of the left prostate cannot be explained in this way, since there is no sign of a scar, and such a large structure as a prostate, extending as it does through several segments, could not be completely excised without leaving a large scar, and considerably distorting the whole internal anatomy of the specimen in this region. There cannot be any connection between the

excision of the spermatheca and the failure of the prostate to develop, since they seem to develop simultaneously, judging from immature specimens which I have examined. I consider that it is simply an isolated anomalous asymmetry of the prostates, and that it is probably due to some accident in the embryological development of the specimen.

PLATE IIIA

FIG. 1.

FIG. 2.

PLATE IIIANEODRILIUS AGILIS

Fig. 1. Ventral aspect, first twenty segments.

Fig. 2. Dissection from the dorsal aspect.

Neodrilus polycystis n. sp.

Plate IV.

This is a small reddish-brown worm, rather square in cross-section, which is fairly common in the Rimutaka and Southern Tararua Ranges.

The description is based on a specimen collected by P. Gardner from leaf-mould at Tauherenikau, in the Tararua Ranges, on 17/4/48. It is 44 mm. long, with 81 segments, and 4.5 mm. in diameter.

The prostomium is tanylobous. The clitellum is buff in colour, and covers segments XIV-XVIII, and part of XIX, dorsally and laterally. The chaetae are lumbricine in arrangement, and commence on II. Each chaeta arises from the centre of a pale yellowish spot, giving the species a distinctive appearance, since it appears as though there are eight yellowish lines passing longitudinally along the length of the animal. The posterior end of the specimen has been amputated at some time, and on some of the regenerated segments, the arrangement of the chaetae has been considerably upset. On the first regenerated segment, the right dorsal pair of chaetae is displaced laterally, and an additional pair is present between the left dorsal and ventral pairs, making five pairs in all on this segment. On the second regenerated segment, an additional pair of chaetae is present between the right dorsal and ventral pairs, making five pairs again. On the fourth regenerated segment, there are four pairs of chaetae in the normal positions, but an additional pair occurs, situated close together, between the individual chaetae of the right ventral

pair. On the other regenerated segments, the chaetal arrangement is normal. The arrangement of the chaetae on segment XXI is as follows:-

ab = cd = 1 mm.; aa = 2 mm.; bc = 2.5 mm.; dd = 2 mm.

A single pair of spermathecal pores occurs at VII/VIII, in line with chaeta b.

There is a single pair of female pores, anterior and slightly medial to chaeta b on XIV.

A single pair of prostatic pores occurs on XVII, each on the apex of a prominent white papilla, in line with the chaetae ab. A longitudinal groove passes across each papilla, but is not continued back onto XVIII, as is usually the case in this genus. The ventral chaetae are absent on XVII. A pair of male pores is present on XVIII, close to the anterior border of the segment, and directly behind the prostatic pores.

Tubercula pubertatis occur in the form of a white upraised band, running laterally across the ventral surface of each of the segments XIV and XX. There are also smaller tubercula on the ventral surfaces of XVI and XVIII, each divided into definite left and right halves.

The nephridiopores commence on II, where they are anterior to chaeta d. On III to VIII, they are anterior to chaeta c. The first ventral pair of pores occurs on IX, and there is then a regular alternation between the dorsal and the ventral positions on the subsequent segments, as is found in all the other Needrilacea.

Internal Anatomy

Alimentary Canal: The pharynx is large and muscular, and occupies the first four segments. Salivary glands occur on the posterior dorsal aspect of the pharynx, and extend back into V. There is a small gizzard in VI. The oesophagus extends from VII to XVII, and bears two pairs of calciferous glands, in XIV and XV. The intestine commences in XVIII, and has a typhlosole.

Vascular System: The dorsal blood vessel is unpaired in the first thirteen segments, but splits into two at the septum XIII/XIV, and for the remainder of the length of the body, the vessel is paired in each segment, but the two vessels fuse together at each septum. There are four pairs of dilated hearts in segments X, XI, XII, and XIII.

Reproductive System: There are two pairs of testes in X and XI, and a pair of ovaries in XIII. Both testes and ovaries are of polylobate form, and are situated close to the mid-ventral line.

Two pairs of racemose vesiculae seminales occur in XI and XII, surrounding the oesophagus laterally and dorsally. There is a single pair of spermathecae in VIII. Each consists of a large spheroidal sac lying in VIII, with a short duct leading to the exterior at VII/VIII. There is a cluster of small spermathecal diverticula attached to the duct, and projecting forward through the septum VII/VIII into VII.

The prestates are a single pair, wholly confined to

XVII. Each is a very large, simply coiled, tubular structure, opening by a muscular duct to the exterior. Anterior to the duct of the prostate, and lying close beside it, is a small sac containing the penial chaetae.

Remarks: This species is, like N. agilis, extremely active, and moves with a rapid undulating motion across the ground, when disturbed.

PLATE IV

FIG. 6

PLATE IVNEODRILUS POLYCYSTIS N. SP.

- Fig. 1. Dorsal aspect, first six segments.
- Fig. 2. Ventral aspect, first twenty-one segments.
- Fig. 3. Dissection from the dorsal aspect.
- Fig. 4. Right spermatheca, medial aspect.
- Fig. 5. Left prostate, medial aspect.
- Fig. 6a. Penial chaeta
- 6b. Normal chaeta.
-

Neodrillus kareriensis n. sp.

Plate V.

I have only one specimen of this species, collected by Dr J.T. Salmon from leaf-mould in Fort Hill bush, Kareri, on 22/1/47. The colour, in spirit, is sienna brown, with a buff clitellum covering XIV to XIX dorsally and laterally.

The dimensions of the specimen cannot be accurately determined since the posterior region is contorted, but it is about 30 mm. in length, with 119 segments, and the diameter for the greater part of the length of the body, is 2.5 mm.

The prostomium is tanylobous. The chaetae commence on II, and are lumbricine in arrangement. On segment XXV, the arrangement is as follows:-

ab = cd = 0.5 mm.; aa = 1.5 mm.; bc = 1.75 mm.;

dd = 1.5 mm.

A pair of transverse, slit-like spermathecal pores occurs at VII/VIII in line with chaeta b.

There is a pair of female pores on XIV, each pore occupying the centre of a small white area, just anterior to chaeta b.

The single pair of prostatic pores occupies the apices of a pair of prominent white papillae on XVII. The chaetae a and b are absent from XVII, but the pores are in line with the chaetae a and b of the adjacent segments. A groove runs longitudinally across each papilla, and is continued back onto XVIII, terminating at the male pore on each side, in line with, and slightly anterior to the pair of chaetae ab. The male pores have prominent tumid lips.

There are four tubercula pubertatis in the form of prominent transverse white ridges, on the ventral surfaces of the segments XII, XIII, XIV, and XV, extending from chaeta a of one side to chaeta a of the other side on each of the segments.

The first pair of nephridiopores is on II, anterior to chaeta d on each side. On segments III - IX, they are anterior to chaeta c. On X, they are anterior to b, on XI, to c, and a regular alternation of position follows for the remainder of the segments.

Internal Anatomy

Alimentary Canal: The pharynx is large and muscular, and occupies the first four segments. A large gizzard with very thick muscular walls extends through V and VI. This is in contrast to the other species of the genus, in which the gizzard is small, and is always confined to one segment, either V or VI. The oesophagus extends from VII to XVII, and has two pairs of calciferous glands in XIV and XV. The intestine commences in XVIII, and has a typhlosole.

Vascular System: An unpaired dorsal blood vessel passes from the pharynx, posteriorly along the dorsal mid-line, and four pairs of hearts occur in X, XI, XII, and XIII.

Reproductive System: There are two pairs of free polylobate testes in X and XI, close to the ventral mid-line, and a pair of polylobate ovaries in the corresponding position

in XIII.

A single pair of spermathecae is situated in VIII, each with a diverticulum passing through septum VII/VIII, into VII. The spermathecal sac is large and irregular and has a narrow duct opening to the exterior. The diverticulum is spherical, about one third the size of the sac, and its surface is covered with small upraised pustules. It opens into the spermathecal duct close to its distal end.

A pair of convoluted, tubular prostates commences in XVII, and passes back through the subsequent segments, closely applied to the lateral aspects of the intestine. The left prostate passes through segments XVII and XVIII, into XIX, where it terminates. The right prostate passes through XVII, into XVIII, and then bends forward again into XVII, where it passes across the top of the oesophagus onto the left side, and then continues forward through XVII and XVI, into XV, terminating beside the left calciferous gland of that segment. A similar distortion of the prostates is seen in some specimens of N. agilis. (q.v.)

There are three pairs of large racemose vesiculae seminales, in segments X, XI, and XII, surrounding the oesophagus laterally and dorsally in those segments.

PLATE V

FIG. 1.

FIG. 4.

FIG. 5.

FIG. 6.

FIG. 2.

FIG. 3.

PLATE VNEODRILUS KARORIENSIS N. SP.

- Fig. 1. Dorsal aspect, first six segments.
- Fig. 2. Ventral aspect, first twenty segments.
- Fig. 3. Dissection from the dorsal aspect.
- Fig. 4. Right spermatheca, medial aspect.
- Fig. 5. Left prostate, medial aspect.
- Fig. 6a. Penial chaeta.
- 6b. Normal chaeta.
-

THE GENUS MAORIDRILUS

Fam. Megascolecidae

Sub-Fam. Acanthodrilinae

Sectio Neodrilacea

Genus Maoridrilus, Michaelsen, 1899.

"Chaetae eight per segment. Nephridiopores on each side more or less regularly in line alternately with the ventral and lateral chaetal bundles. Male pores on XVIII; prostatic pores on XVII and XIX. Spermathecal pores in furrows 7/8 and 8/9. Testes and funnels two pairs, free, in X and XI. Two pairs of prostates.

Distribution: New Zealand, including Stephen and D'Urville Islands." (Stephenson, 1930.)

Fourteen species of the genus have been previously described, and it appears that this is New Zealand's commonest, and probably oldest genus of earthworm. Of the fourteen species so far described, only two, M. mauensis, Benham, 1904, and M. intermedius, Michaelsen, 1924, were collected from the North Island. M. mauensis was collected from Auckland, and M. intermedius at Plimmerton. Eleven species are described below, and among these there are four species from the South Island, M. uliginosus, (Hutton), 1876, M. thomsoni, Benham, 1918, M. rosae, Beddard, 1892, and M. nelsoni, n. sp., and seven new species from the North Island, namely, M. ruber, M. gracilis, M. pallidus, M. attenuatus, M. minor, M. gravis, and M. montana. All seven of these species are from the Southern region of the North Island.

The genus seems to be confined entirely to virgin soils, and not to invade cultivated areas. This is, of course, characteristic of most of the native earthworms of New Zealand.

It is not possible to construct a key to all the known species of Maeridrilus, since in some of the early descriptions of species, the characters on which identification has been based do not lend themselves to the construction of a practicable key.

The eleven species of the genus dealt with in this thesis may be distinguished into three groups according to the number of calciferous glands occurring on the oesophagus. In M. montana, calciferous glands are absent. In M. minor, M. ruber, M. attenuatus, M. thomsoni, M. pallidus, and M. gravus, there are two pairs of calciferous glands, and in M. rosae, M. uliginosus, M. nelsoni, and M. gracilis, there are three pairs of calciferous glands. Of those having two pairs of calciferous glands, M. gravus has the gizzard in V, and all the others have the gizzard in VI. Those having the gizzard in VI may be distinguished from one another by the nature of the diverticula of their spermathecae, and the form of their penial chaetae, as set out in the key given below. The species having three pairs of calciferous glands may be distinguished from one another by the nature and the position of the diverticula of their spermathecae, as is also set out in the key.

A KEY TO THE SPECIES OF MAORIDRILUS *

- a1 No oesophageal glands M. montana
- a2 Two pairs of oesophageal glands.
 - b1 Gizzard in V. M. gravis
 - b2 Gizzard in VI.
 - c1 Spermatheca small and spherical,
lacking diverticulum M. minor
 - c2 Spermatheca with small posterior diver-
ticulum, lacking anterior diverticulum.
..... M. ruber.
 - c3 Spermatheca with anterior diverticulum,
not projecting into preceding segment.
..... M. attenuatus
 - c4 Spermatheca with anterior diverticulum,
projecting through the septum into
the preceding segment
 - d1 Penial chaetae short and simply
pointed. M. thomsoni
 - d2 Penial chaetae long and slender,
with spatulate tip M. pallidus
- a3 Three pairs of oesophageal glands.
 - e1 Spermatheca with anterior diverticulum,
not projecting into preceding segment.
..... M. rosae
 - e2 Spermatheca with anterior diverticulum,
projecting through septum into
preceding segment.

* Only the species handled in the course of this thesis are included in this key.

- f1 Diverticulum of spermatheca
small and rounded M. uliginosus
- f2 Diverticulum of spermatheca
elongate and curved M. nelsoni
- f3 Diverticulum of spermatheca
round and flattened from
side to side M. gracilis

List of Species not included in the Key above:

- ✓ M. plumbeus, (Beddard), 1895.
(Syn. Acanthodrilus plumbeus, Beddard, 1895.
Maoridrilus plumbeus, (Beddard), Michaelsen, 1900)
- ✓ M. dissimilis, (Beddard), 1885 (a).
Syn. Acanthodrilus dissimilis, Beddard, 1885 (a).
Maoridrilus dissimilis, (Beddard) Michaelsen, 1899.
- ✓ M. parkeri, (Beddard), 1895).
Syn. Acanthodrilus parkeri, Beddard, 1895.
Maoridrilus parkeri, (Beddard) - Michaelsen, 1900.
- ✓ M. tetragonus, Michaelsen, 1899.
- ✓ M. smithi, (Beddard), 1893.
Syn. Acanthodrilus smithi, Beddard, 1893.
Maoridrilus smithi, (Beddard) - Michaelsen, 1900.
- ✓ M. michaelseni, Ude, 1905.
- ✓ M. purus, Ude, 1905.
- M. modestus, Ude, 1905.
- ✓ M. mauiensis, Benham, 1905 (a).
- ✓ M. megacystis, Benham, 1918.
- ✓ M. intermedius, Michaelsen, 1924.

Maoridrillus uliginosus, (Hutton), 1876. Plate VI.
 (Syn. Lumbricus uliginosus, Hutton, 1876.
Acanthodrillus novae-zealandiae, Beddard, 1885.
Acanthodrillus uliginosus, (Hutton) - Benham, 1898.
Maoridrillus uliginosus, (Hutton) - Michaelsen, 1900.)

A single specimen of this large pink worm was collected by W.H. Dawbin from leaf-mould in the Cobb River Valley, Nelson.

It is 130 mm. long, with 113 segments, rather rectangular in cross-section, with the diameter varying between 9 and 10 mm. throughout its length.

The prostomium is tanylobous. The chaetae commence on II, and are lumbricine in arrangement. The pairs of chaetae are situated on the angles of the segments, when the body is seen in cross-section. On XXIV, the arrangement of the chaetae is as follows:-

ab = cd = 0.5 mm.; aa = 4 mm.; bc = 6 mm.; dd = 6 mm.

The ventral chaetae of XVII and XIX are absent, but there are penial chaetae projecting from beside the prostatic pores on these segments. The penial chaetae are long and slender, curved, and flattened distally.

The clitellum is slightly darker in colour than the rest of the body, and covers the segments XIV-XX, dorsally and laterally.

Two pairs of spermathecal pores occur, at VII/VIII and VIII/IX, lateral to the line of the chaeta b.

There is a single pair of female pores on XIV, anterior and slightly medial to chaeta a on each side.

There are two pairs of prostatic pores, on XVII and

XIX, not situated on prominent papillae, but in line with the chaetae ab of the adjacent segments. The two pores on each side are joined by a longitudinal groove, which passes between the chaetae a and b on XVIII, and the male pores occur in these grooves between the chaetae a and b on XVIII.

Six tubercula pubertatis occur, in the form of wide, upraised white bands on the ventral surfaces of XV, XVI, XX, XXI, XXII and XXIII, each extending from chaeta a of one side to chaeta a of the other side.

Internal Anatomy

The septa VIII/IX, IX/X, X/XI, XI/XII, and XII/XIII are thickened and muscular.

Alimentary Canal: A large muscular pharynx occupies the first five segments. There is a large thick-walled gizzard in VI. The oesophagus extends from VII to XVII, and bears three pairs of calciferous glands, in XIV, XV, and XVI. The intestine commences in XVIII.

Vascular System: The dorsal blood-vessel is paired, but the two vessels fuse at each septum. The vessels break down into a plexus of small vessels on the pharynx. Four pairs of hearts occur in X, XI, XII and XIII, and they originate from an unpaired supra-intestinal vessel, lying beneath the dorsal blood vessel.

Reproductive System: There are two pairs of polylobate

testes, in X and XI, and a pair of polylobate ovaries in XIII. The testes and ovaries are situated close to the ventral mid-line in their respective segments.

Two pairs of spermathecae occur in VIII and IX, each consisting of a large ovoid sac with a diverticulum projecting through the septum into the preceding segment, the whole structure opening by a short muscular duct to the exterior. The diverticulum is a round structure, with its surface raised up in small rounded pustules.

There are two pairs of coiled tubular prostates in XVII and XIX, each confined to one segment, and opening by a narrow muscular duct to the exterior. Penial chaetae are present, in a small transparent sac, lying beneath each prostatic duct.

PLATE VI

FIG. 1

FIG. 4

FIG. 5

FIG. 2.

FIG. 6

FIG. 3

PLATE VIRI
MAODRILUS ULIGINOSUS
A

- Fig. 1. Dorsal aspect, first six segments.
- Fig. 2. Ventral aspect, first twenty-seven segments.
- Fig. 3. Dissection from the dorsal aspect.
- Fig. 4. Left anterior spermatheca, medial aspect.
- Fig. 5. Left anterior prostate, medial aspect.
- Fig. 6a. Penial chaeta
- 6b. Normal chaeta.
-

Maoridrillus thomsoni, Benham, 1918.

Plate VII.

A specimen of this species was collected by D.E. Hurley from leaf-mould at Kahikitea Bay, Marlborough Sounds, on 4/4/48.

The specimen is 101 mm. long, with 176 segments, rather rectangular in cross-section, with a diameter of 4-5 mm. throughout its length.

The chaetae are lumbricine in arrangement, the pairs of chaetae occurring laterally and ventro-laterally on the segments. On XXIII, the arrangement of the chaetae is as follows:-

ab = cd = 0.5 mm.; aa = 2 mm.; bc = 2 mm.; dd = 5 mm.
The prostomium is tanylobous.

Two pairs of spermathecal pores occur at VII/VIII, and VIII/IX, in line with the chaetae ab.

There is a pair of female pores on XIV, anterior and slightly lateral to chaeta b on each side.

There are two pairs of prostatic pores, one pair on each of the segments XVII and XIX, in line with the chaetae ab. Each pore is situated on the apex of a prominent white papilla, and the two pores of each side are joined by a longitudinal groove, which passes between the chaetae a and b on XVIII. The male pores are situated in these grooves, between the chaetae a and b on XVIII.

Nephridiopores commence on II. Those of II-IX are lateral in position, and anterior to chaeta c. Those of X are ventro-lateral, and anterior to chaeta b. Posterior to

X there is a regular alternation between the lateral and the ventro-lateral positions on successive segments.

There are two tubercula pubertatis, each in the form of a wide, white band, extending from chaeta a of one side to chaeta a of the other side, on the segments XVI and XX.

Internal Anatomy

Alimentary Canal: A large muscular pharynx, covered dorsally by salivary glands, occupies I-V. A long, thick-walled, muscular gizzard lies in VI. The oesophagus extends from VII-XVII, and bears two pairs of calciferous glands in XV and XVI. The intestine commences in XVIII.

Vascular System: An unpaired dorsal blood vessel runs throughout the length of the body, breaking down into a plexus of fine vessels on the pharynx, and bearing five pairs of dilated hearts, in IX, X, XI, XII and XIII.

Reproductive System: There are two pairs of testes, in X and XI, and a pair of ovaries in XIII. Both testes and ovaries lie close to the ventral mid-line in their respective segments.

Two pairs of spermatheca occur, in VIII and IX.

Each consists of an elongate sac, opening by a short muscular duct to the exterior, with a diverticulum projecting into the preceding segment, and opening into the spermathecal duct. The surface of the diverticulum is upraised in rounded pustules, giving it the appearance of a blackberry.

There are two pairs of coiled, tubular prostates, in XVII and XIX, each confined to one segment. Penial chaetae are present in a transparent sac, lying close to the duct of each prostate. A muscle arises from each of these sacs in XVII, and passes dorsally, the two muscles having a common insertion on the mid-dorsal aspect of the anterior septum of XVII. There are two pairs of large lobate vesiculae seminales in XI and XII.

Remarks: I have placed this specimen in the species thomsoni, since it shows so many of the characters set out in Benham's description of this species. It does not, however, show a rectangular hollow between the prostatic pores, but since a hollow of this nature is often produced in a poorly preserved specimen, by contraction of the body-wall, and Benham noted that his description is based on a very poorly preserved specimen, I feel that I am justified in placing the worm in this species, since it differs perceptibly only in this one feature.

PLATE VII

FIG. 4

FIG. 2

FIG. 6

FIG. 3

PLATE VIIMAORIDRILUS THOMSONI

- Fig. 1. Dorsal aspect, first six segments.
- Fig. 2. Ventral aspect, first twenty-two segments.
- Fig. 3. Dissection from the dorsal aspect.
- Fig. 4. Right anterior spermatheca, medial aspect.
- Fig. 5. Right anterior prostate, medial aspect.
- Fig. 6a. Penial chaeta.
- 6b. Normal chaeta.
-

Maoridrillus rosae (Beddard), 1892.

Plate VIII.

(Syn. Acanthodrillus rosae, Beddard, 1892.

Maoridrillus rosae, (Beddard) - Michaelsen, 1900).

Three specimens of M. rosae (Beddard) were collected by D.E. Hurley, from leaf-mould at Kahikitea Bay, Marlborough Sounds, on 4/4/48.

The specimen on which the description is based is 121 mm. long, with 168 segments, and 7-8 mm. in diameter throughout its length. The clitellum covers XIV-XIX, and part of XX, and is developed only dorsally.

The prostomium is tanylobous. The chaetae commence on II, and are lumbricine in arrangement. On segment XXIII, the arrangement is as follows:-

ab = cd = 0.5 mm.; aa = 3.25 mm.; bc = 5.5. mm.;
dd = 6.5 mm.

There are two pairs of spermathecal pores, at VII/VIII and VIII/IX, in line with the chaetae ab.

A pair of female pores occurs on XIV, anterior to chaeta b of each side.

There are two pairs of prostatic pores, situated on the apices of raised papillae on XVII and XIX, in line with the chaetae ab. A longitudinal groove joins the two pores of each side, and passes between the chaetae a and b of XVIII. The male pore of each side occurs in the groove, between the chaetae a and b on XVIII. The ventral chaetae of XVII and XIX are absent.

Tubercula pubertatis are present on XIV, XV, and XVI, in the form of a transverse ridge extending from chaeta

a of one side to chaeta a of the other side on each segment.

Nephridiopores commence on II. Those of II-IX are dorso-lateral, and anterior to chaeta c. On X, they are ventral, and anterior to chaeta b. Posterior to this there is a regular alternation between the dorso-lateral and the ventral positions.

Internal Anatomy

Alimentary Canal: The pharynx is large and muscular, and occupies the first five segments. An elongate, thick-walled gizzard occurs in VI. The oesophagus extends from VII to XVII, and bears ^{two} ~~three~~ pairs of calciferous glands, in ~~XIII~~, XIV and XV. The intestine commences in XVIII.

Vascular System: The dorsal blood vessel is paired, but the two vessels fuse together at each septum. There are four pairs of dilated hearts, in X, XI, XII and XIII.

Reproductive System: There are two pairs of lobate testes in X and XI, and a pair of lobate ovaries in XIII. Both testes and ovaries are close to the ventral mid-line in their respective segments.

Two pairs of spermathecae occur, in VIII and IX. Each consists of an elongate ovoid sac, with a diverticulum projecting forward from the short muscular duct which leads to the exterior, the whole structure confined to one segment. The wall of the diverticulum is lobulated.

Two pairs of large coiled prostates occur, in XVII and XIX, each prostate having, close to its anterior border, an elongate sac. There are two pairs of large racemose vesiculae seminales, surrounding the oesophagus, in XI and XII.

PLATE VIII

FIG. 4.

FIG. 5.

FIG. 6.

FIG. 2.

FIG. 3.

PLATE VIIIMAORIDRILUS ROSAE

- Fig. 1. Dorsal aspect, first six segments.
- Fig. 2. Ventral aspect, first twenty-one segments.
- Fig. 3. Dissection from the dorsal aspect.
- Fig. 4. Right anterior spermatheca, medial aspect.
- Fig. 5. Left anterior prostate, medial aspect.
- Fig. 6a. Penial chaeta.
- 6b. Normal chaeta.
-

Maoridrillus nelsoni n. sp.

Plate IX.

A single specimen of this species was collected by W.H. Dawbin in the Cobb River Valley, Nelson.

The specimen is contorted, and it is impossible to accurately determine its length. It is about 120 mm. in length, with 169 segments, and the diameter is 4.5-5 mm. throughout its length.

The prostomium is tanylobous. The clitellum covers XIV-XIX, dorsally and laterally, and overlaps slightly onto the dorsal surface of XIII and XX.

The chaetae commence on II, and are lumbricine in arrangement, the individuals of each pair being close together, and the pairs widely spaced, occupying dorso-lateral and ventro-lateral positions on the segments. On segment XXIII the arrangement of the chaetae is as follows:-

ab = cd = 0.5 mm.; aa = 2.5 mm.; bc = 5 mm.; dd = 4 mm.

There are two pairs of slit-like spermathecal pores at VII/VIII and VIII/IX, in line with chaeta a.

A single pair of female pores occurs on XIV, anterior to the chaeta a.

Two pairs of prostatic pores occur, on XVII and XIX, situated on small papillae, situated on the sides of a rectangular trough, which is continuous across XVII, XVIII and XIX. This trough may be due to contraction of the body-wall, since the specimen was preserved in formalin. The two prostatic pores of each side are joined by a longitudinal groove, which runs along a ridge, and passes between the

chaetae a and b on XVIII. The male pores occur in these grooves, between the chaetae a and b, on XVIII.

Nephridiopores commence on II, anterior to chaeta c. The first two pairs are dorsal, the third pair is ventral, and anterior to the chaeta b, and a regular alternation between the two positions follows for the remainder of the segments.

Internal Anatomy

Alimentary Canal: A strong muscular pharynx occupies the first five segments. A thick-walled gizzard lies in VI. The oesophagus extends from VII to XVII, and there are three pairs of calciferous glands in XIV, XV and XVI. The intestine commences in XVIII. In its posterior region, the intestine shows a peculiarity, in that its lining is thrown into longitudinal folds, and this region may be distinguished as a definite rectum.

Vascular System: The dorsal blood vessel is unpaired posterior to the septum V/VI, but at this septum it splits into two, and the two vessels thus formed break down into a plexus of small vessels on the pharynx. There are six pairs of hearts, in the segments VIII to XIII.

Reproductive System: There are two pairs of lobate testes in X and XI, and a pair of lobate ovaries in XIII. Both testes and ovaries are close to the ventral mid-line in their respective segments.

Two pairs of spermathecae occur, in VIII and IX.

Each is a bilobulate sac, opening by a short muscular duct to the exterior, with a diverticulum extending forward through the septum into the preceding segment. The diverticulum is elongate and curved, and its distal extremity is covered with rounded pustules.

There are two pairs of convoluted tubular prostates, in XVII and XIX, each confined to one segment. Penial chaetae are present, in an elongate transparent sac, lying close to each prostatic duct. There are two pairs of large racemose vesiculae seminales, surrounding the oesophagus in XI and XII.

PLATE IX

FIG. 4.

FIG. 1.

FIG. 5.

FIG. 6.

FIG. 2.

FIG. 7.

1 CM.

1 MM.

PLATE IXMAORIDRILUS NELSONI N.SP.

- Fig. 1. Dorsal aspect, first six segments.
- Fig. 2. Ventral aspect, first twenty-one segments.
- Fig. 3. Dissection from the dorsal aspect.
- Fig. 4. Left anterior spermatheca, medial aspect.
- Fig. 5. Left anterior prostate, medial aspect.
- Fig. 6. Intestinal lining posterior region.
- Fig. 7a. Penial chaeta.
- 7b. Normal chaeta.
-

Macridrilus ruber, n. sp.

Plate X.

I have five specimens of this large red worm, two collected from Stokes Valley, by R.R. Forster, two from Waikanae by R.R. Forster, and one from Wilton's Bush, Wellington, by D.E. Hurley.

The description below is based on the specimen collected at Wilton's Bush, Wellington, which is 124.5 mm. long, with 149 segments, and 5-6 mm. in diameter throughout its length. The clitellum is slightly darker in colour than the rest of the body, and covers XIV-XX, dorsally and laterally.

The prostomium is tanylobous. The chaetae commence on II, and are lumbricine in arrangement. The posterior segments are rectangular in cross-section, and the pairs of chaetae occupy the corners of the segments. On XXIII, the arrangement of the chaetae is as follows:-

ab = cd = 0.5 mm.; aa = 2 mm.; bc = 3.5 mm.; dd = 3.5 mm.

Two pairs of spermathecal pores occur, at VII/VIII and VIII/IX, in line with the chaetae ab.

There is a single pair of female pores on XIV, anterior to chaeta b on each side.

Two pairs of prostatic pores are situated on the apices of small raised papillae on XVII and XIX. The two pores of each side are joined by a longitudinal groove, which passes between the chaetae a and b on XVIII. A pair of male pores occurs in these grooves on XVIII, between the chaetae a and b.

The nephridiopores commence on II. Those of II-IX are dorso-lateral, and anterior to chaeta c. Those of X are ventro-lateral, and anterior to chaeta b, and posterior to this, there is a regular alternation between the dorso-lateral and the ventro-lateral positions.

Internal Anatomy

Alimentary Canal: There is a small muscular pharynx, occupying the first five segments. Salivary glands cover its dorsal surface. An elongate, thick-walled gizzard lies in VI. The oesophagus extends from VII-XVII, and has two pairs of calciferous glands in XV and XVI. The intestine commences in XVIII.

Vascular System: The dorsal blood vessel is unpaired throughout, and there are four pairs of hearts, in X, XI, XII and XIII.

Reproductive System: There are two pairs of spermathecae, in VIII and IX, each consisting of a large ovoidal sac, with a small posterior diverticulum, opening to the exterior by a muscular duct. The diverticulum lies close to the sac, and has an irregular surface. The prostates are convoluted tubular structures, a pair in each of XVII and XIX. An elongate transparent sac containing penial chaetae lies under each prostate. The penial chaetae are long, slender, S-shaped spines, sharply recurved and pointed distally.

Two pairs of large, racemose, vesiculae seminales surround the oesophagus in XI and XII, and there is a smaller pair in XIV. The presence of vesiculae seminales in XIV is unusual, and their function obscure, since they are so far removed from the testes.

PLATE X

FIG. 4.

FIG. 1.

SP. D.

FIG. 5.

FIG. 2.

FIG. 6.

1 MM

FIG. 3.

PLATE XMAORIDRILUS RUBER N.SP.

- Fig. 1. Dorsal aspect, first six segments.
- Fig. 2. Ventral aspect, first twenty-three segments.
- Fig. 3. Dissection from the dorsal aspect.
- Fig. 4. Left anterior spermatheca, medial aspect.
- Fig. 5. Left anterior prostate, medial aspect.
- Fig. 6. Penial chaeta.
-

Maoridrillus gracilis, n. sp.

Plate XI.

A single specimen of this species was collected by I. McNuer from Sphagnum moss in a peat bog, at Wallaceville, near Wellington, on 4/3/48.

It is an elongate, iridescent, brown worm, 290 mm. long, with 233 segments, and a diameter of 5-6 mm. throughout its length.

The prostomium is tanylobous. The chaetae commence on II, and are lumbricine in arrangement, the individuals of the pairs being closely approximated, and the pairs widely spaced. On XXIII, the arrangement is as follows:-

ab = cd = 0.5 mm.; aa = 2.5 mm.; bc = 2.5 mm.;
dd = 2.5 mm.

A swollen clitellum, light brown in colour, surrounds XIII-XVI, and part of XII.

There are tubercula pubertatis on X and XV, in the form of a pair of raised white patches, placed one on each side of the ventral mid-line on each of these segments.

Two pairs of spermathecal pores occur at VII/VIII and VIII/IX, in line with chaeta a. The pores are surrounded by very prominent white lips.

There is a pair of very small female pores on XIV, just anterior to chaeta b.

Two pairs of prostatic pores occur, on the apices of small, rounded papillae, in line with the chaetae ab, on XVII and XIX. A longitudinal groove joins the two prostatic

pores of each side, and passes between the chaetae a and b on XVIII. The male pores occur in these grooves, on XVIII, between the chaetae a and b.

The nephridiopores are not visible externally.

Internal Anatomy

The septa IX/X, X/XI, XI/XII, XII/XIII and XIII/XIV are thickened and muscular.

Alimentary Canal: A narrow, muscular pharynx occupies the first four segments, and extends into V, where it is surrounded by diffuse salivary glands. There is an elongate thick-walled gizzard in VI. The oesophagus extends from VII-XVII, and has three pairs of calciferous glands in XIV, XV and XVI. The intestine commences in XVIII.

Vascular System: The dorsal blood vessel is unpaired in the posterior region, but is paired anterior to XVI/XVII, although the two vessels fuse at each septum anterior to XVI/XVII.

Reproductive System: There are two pairs of lobate testes in X and XI, and a single pair of lobate ovaries in XIII. Both testes and ovaries are close to the ventral mid-line in their respective segments.

Two pairs of spermathecae occur, in VIII and IX. Each spermatheca consists of a large ovoidal sac, opening

by a short muscular duct to the exterior, with a diverticulum lying in the preceding segment, and opening into the spermathecal duct. The diverticulum is round and flattened from side to side, in a mushroom-like shape, and its surface is covered with small rounded papules.

There are two pairs of coiled, tubular prostates, in XVII and XIX, each confined to one segment. Penial chaetae are present, in a transparent sac, lying anterior to each prostatic duct. The penial chaetae are elongate and slender, with a curved distal end, and a sharp point.

Nephridia: The nephridia commence in II. Those of II-IX open to the exterior dorso-laterally, those of X open ventro-laterally, and posterior to X there is a fairly regular alternation between the two positions, in successive segments.

PLATE XI

FIG. 1.

FIG. 4.

FIG. 5.

FIG. 6.

FIG. 2.

FIG. 3.

FIG. 7.

PLATE XIMAORIDRILUS GRACILIS N.SP.

- Fig. 1. Dorsal aspect, first five segments.
- Fig. 2. Ventral aspect, first twenty-two segments.
- Fig. 3. Dissection from the dorsal aspect.
- Fig. 4. Right posterior spermatheca, medial aspect.
- Fig. 5. Left anterior prostate, medial aspect.
- Fig. 6. Portion of the body wall, to show the
arrangement of the nephridiopores.
- Fig. 7. Penial chaeta.
-

Maoridrillus pallidus n. sp.

Plate XII.

Two specimens of this fairly large, pink worm were collected by R.R. Forster from leaf-mould at Levin on 6/6/48.

The specimen on which the description below is based is 70 mm. long, with 89 segments, 3 mm. in diameter for the greater part of its length, and terminating bluntly at the mouth and at the anus, which is a vertical slit.

The prostomium is tanylobous. The chaetae are lumbricine in arrangement and commence on II. The arrangement of the chaetae on XXIV is as follows:-

~~chaetae = 15.5 mm., chaetae = 15.5 mm., chaetae = 15.5 mm.;~~

dd = 2 mm.

The ventral chaetae are absent on XVII and XIX, where the prostatic pores occur.

The clitellum is slightly darker in colour than the rest of the body, and covers XIII-XIX, dorsally and laterally, and overlaps slightly onto the dorsal surface of XX.

There are two pairs of spermathecal pores at VII/VIII and VIII/IX, in line with the chaeta a.

A pair of female pores occurs on XIV, anterior to the chaetae ab.

There are two pairs of prostatic pores on XVII and XIX, on the apices of small rounded papillae, in line with the chaeta b. There is a depression of the ventral body-wall on each of these segments, between the prostatic pores.

A longitudinal groove joins the two pores of each side, passing between the chaetae a and b of XVIII. The male pores occur in these grooves, between the chaetae a and b on XVIII.

Nephridiopores commence on II. Those of II are dorsal, and immediately behind the grooves of the prostomium. Those of III-X are dorso-lateral and anterior to chaeta c, those of XI, ventro-lateral and anterior to chaeta b, and posterior to XI there is a regular alternation between the dorso-lateral and the ventro-lateral positions.

Internal Anatomy

Septa IX/X, X/XI, XI/XII, XII/XIII, XIII/XIV and XIV/XV are muscular and thickened.

Alimentary Canal: A large, muscular pharynx, covered dorsally by salivary glands, occupies the first five segments. There is an elongate, thick-walled gizzard in VI. The oesophagus extends from VII to XVIII, and there are two pairs of calciferous glands in XIV and XV. The intestine commences in XIX, and lacks a typhlosole.

Vascular System: The dorsal blood vessel is unpaired throughout. There are four pairs of dilated hearts in segments X, XI, XII and XIII.

Reproductive System: There are two pairs of small lobate testes in X and XI, close to the ventral mid-line. A single pair of ovaries occurs in XIII. The ovaries are peculiar

in form, each consisting of a cluster of small laminae, arising from the anterior septum of the segment, close to the ventral mid-line.

There are two pairs of spermathecae, in VIII and IX, each consisting of an elongate sac, with slightly folded walls, opening by a short, narrow duct to the exterior, and a diverticulum, arising from the spermathecal duct, and projecting forward through the septum into the preceding segment. The surface of the diverticulum is lobulated.

There are two pairs of extremely coiled prostates, in XVII and XIX, each opening by a narrow muscular duct to the exterior. Penial chaetae are present, in an elongate transparent sac, lying close to the duct of each prostate. The penial chaetae are elongate and slender, sharply curved distally, and having a spatulate tip. Two pairs of racemose vesiculae seminales occur, surrounding the oesophagus in XI and XII.

PLATE XII

FIG. 1.

FIG. 4.

FIG. 5.

FIG. 6.

FIG. 2.

FIG. 3.

PLATE XIIMAORIDRILUS PALLIDUS N.SP.

- Fig. 1. Dorsal aspect, first six segments.
- Fig. 2. Ventral aspect, first twenty-one segments.
- Fig. 3. Dissection from the dorsal aspect.
- Fig. 4. Right posterior spermatheca, medial aspect.
- Fig. 5. Left anterior prostate, medial aspect.
- Fig. 6a. Penial chaeta.
- 6b. Tip of penial chaeta, showing its spatulate form.
- 6c. Normal chaeta.
-

Maoridrillus attenuatus n. sp.

Plate XIII.

Two specimens of this worm were collected from leaf-mould, at Matahiwi, near Masterton, on 30/3/48. They are light pink in colour, with a red clitellum, developed dorsally and laterally over XIV-XIX, and half of XIII and XX.

The specimen on which the description is based is 98 mm. long, with 241 segments, and a diameter of 5 mm.

The prostomium is tanylobous. The chaetae commence on II, and are lumbricine in arrangement. On XXIII, the arrangement of the chaetae is as follows:-

ab = cd = 0.5 mm.; aa = 2 mm.; bc = 3.25 mm.;
dd = 3.25 mm.

There are two pairs of spermathecal pores, at VII/VIII and VIII/IX, in line with the chaetae ab.

A single pair of female pores occurs on XIV, anterior and slightly lateral to chaeta b on each side.

Two pairs of prostatic pores are situated on the apices of paired white papillae, in line with the chaetae ab, on XVII and XIX. A longitudinal groove with tumid borders joins the two prostatic pores of each side, passing between the chaetae a and b of XVIII. The male pores are situated in these grooves, between the chaetae a and b, on XVIII.

Nephridiopores commence on II. Those of II-X are dorso-lateral, anterior to chaeta c. Those of XI are ventro-lateral, anterior to chaeta b, and posterior to XI there is a regular alternation between the dorso-lateral and

the ventro-lateral positions in successive segments.

Dorsal pores commence at X/XI, and occur in each intersegmental groove posterior to this.

Internal Anatomy

Alimentary Canal: The pharynx occupies the first five segments and its dorsal surface is covered with a diffuse mass of salivary glands. A large, muscular gizzard lies in VI. The oesophagus extends from VII to XVII, and has two pairs of calciferous glands in XV and XVI. The intestine commences in XVIII.

Vascular System: The dorsal blood vessel is unpaired throughout, and there are four pairs of dilated hearts in X, XI, XII and XIII.

Reproductive System: There are two pairs of testes, in X and XI, and a pair of ovaries in XIII. Both the testes and the ovaries lie close to the ventral mid-line in their respective segments.

Two pairs of spermathecae occur, in VIII and IX. Each is a small, elongate sac, with a small, rounded diverticulum projecting forward from it, the whole structure contained within one segment, and opening to the exterior by a narrow muscular duct.

The prostates are two pairs of coiled, tubular structures, occurring in XVII and XIX, each prostate confined

to one segment. Beside each prostatic duct is a short transparent sac, containing the penial chaetae. The penial chaetae are elongate and slender, curved in an S-shape, and have a sharp point. There are two pairs of small, racemose vesiculae seminales, in XI and XII, surrounding the lateral aspects of the oesophagus.

PLATE XIII

FIG. 1.

FIG. 4.

FIG. 5.

FIG. 2.

FIG. 6.

FIG. 3.

PLATE XIIIMAORIDRILUS ATTENUATUS N.SP.

- Fig. 1. Dorsal aspect, first six segments.
- Fig. 2. Ventral aspect, first twenty-four segments.
- Fig. 3. Dissection from the dorsal aspect.
- Fig. 4. Right posterior spermatheca, medial aspect.
- Fig. 5. Left anterior prostate, medial aspect.
- Fig. 6a. Penial chaeta.
- 6b. Normal chaeta.
-

Several specimens of this small, slender, brown worm were collected by Dr J.T. Salmon among moss and lichens, at Mt. Ross, in the Southern Wairarapa, on 5/4/47.

The specimen on which the description is based is 27 mm. in length, with 104 segments, and a diameter of 1.5 mm. for the greater part of its length, tapering gradually to the anus. The clitellum is light brown in colour, and completely surrounds XIV-XIX, and part of XIII.

The prostomium is tanylobous. The chaetae are lumbricine in arrangement, and commence on II. The ventral chaetae are absent on XVII and XIX, where the prostatic pores occur. On segment XXIV, the arrangement of the chaetae is as follows:-

ab = cd = 0.5 mm.; aa = 1 mm.; bc = 1.25 mm. dd = 1 mm.

There are two pairs of spermathecal pores, at VII/VIII and VIII/IX, in line with chaeta a on each side.

A single pair of female pores occurs on XIV, anterior and slightly medial to chaeta b on each side.

Two pairs of prostatic pores are situated on the apices of prominent white papillae, on XVII and XIX, in line with the chaetae ab. A groove with prominent tumid lips, continuous with the papillae of the prostates, joins the two prostatic pores of each side, and passes between the chaetae a and b of XVIII. The male pores occur in these grooves, between the chaetae a and b on XVIII.

The nephridiopores commence on II. Those of II-IX are dorsal and anterior to chaeta c, those of X ventral, and anterior to chaeta b. Posterior to X, there is a regular alternation between the dorsal and the ventral positions.

Internal Anatomy

Alimentary Canal: A large muscular pharynx occupies the first four segments. A narrow, thick-walled gizzard lies in VI. The oesophagus extends from VII-XVI, and has two pairs of calciferous glands, in XV and XVI. The intestine commences in XVIII, and lacks a typhlosole.

Vascular System. The dorsal blood vessel is unpaired throughout, and bears four pairs of dilated hearts in X, XI, XII, and XIII.

Reproductive System: There are two pairs of polylobate testes, in X and XI, and a single pair of ovaries in XIII. Both the testes and the ovaries are close to the ventral mid-line in their respective segments.

There are two pairs of spermathecae, in VIII and IX. Each is a very small spherical sac, lacking diverticula, and opening to the exterior by a short muscular duct.

There are two pairs of tubular, simply coiled prostates, in XVII and XIX. A small transparent sac, containing the penial chaetae, lies close to each prostatic duct. The penial chaetae are elongate, and sharply recurved

distally, with a sharp point. There are two pairs of lobulate vesiculae seminales, surrounding the oesophagus in XI and XII.

PLATE XIV

FIG. 4.

PLATE XIVMAORIDRILUS MINOR N.SP.

- Fig. 1. Dorsal aspect, first six segments.
- Fig. 2. Ventral aspect, first twenty segments.
- Fig. 3. Dissection from the dorsal aspect.
- Fig. 4. Right posterior spermatheca, medial aspect.
- Fig. 5. Right anterior prostate, medial aspect.
- Fig. 6a. Penial chaeta.
- 6b. Normal chaeta.
-

Maoridrillus gravus n. sp.

Plate XV.

Five specimens of this grey worm were collected from leaf-mould and moss, at Mt. Ross, in the Southern Wairarapa, by R.R. Forster, on 5/4/47.

The specimen on which the description is based is 51 mm. in length, with 102 segments, and 3 mm. in diameter at the mid-body, tapering gradually to the mouth and anus. The clitellum is buff in colour, completely surrounding segments XII-XIX.

The chaetae commence on II, and are eight per segment, arranged in pairs, a dorso-lateral and a ventro-lateral pair on each side of each segment. The individual chaetae of the dorso-lateral pairs are more widely spaced than those of the ventro-lateral pairs. On XXIV, the arrangement of the chaetae is as follows:-

ab = 1 mm.; cd = 1.5 mm.; aa = 1 mm.; bc = 1.5 mm.;
dd = 1.5 mm.

The prostomium is tanylobous.

Two pairs of spermathecal pores occur at VII/VIII and VIII/IX in line with the chaeta b.

There is a single pair of female pores, in the form of small transverse slits, anterior and slightly lateral to chaeta a on XIV.

There are two pairs of prostatic pores, on XVII and XIX, each pore situated in the centre of a small pale area, in line with the chaeta a. The two prostatic pores of each side are joined by a longitudinal groove, passing

between the chaetae a and b of XVIII, very close to chaeta a. The male pores occur in these grooves, close to the chaeta a, on XVIII. The chaetae a and b are absent on XVII and XIX.

The nephridiopores commence on II. Those of II-XI are dorso-lateral, and anterior to chaeta c. Those of XII are ventro-lateral and anterior to chaeta b, and posterior to this segment, there is an alterationⁿ between the dorso-lateral and the ventro-lateral positions, but the alternation is not regular.

Internal Anatomy

Alimentary Canal: A large muscular pharynx occupies the first four segments. A large muscular gizzard, with thick walls lies in V. The oesophagus extends from VI-XVI, and has two pairs of calciferous glands, in XIV and XV, those of XV being much larger than those of XIV. The intestine commences in XVII, and lacks a typhlosole.

Vascular System: The dorsal blood vessel is unpaired in the first twelve segments, but becomes paired at the septum IX/X. Posterior to this septum, the two vessels remain distinct in each segment, but fuse together at each septum. There are four pairs of dilated hearts in X, XI, XII and XIII, the last pair being much more dilated than the other three pairs.

Reproductive System: There are two pairs of polylobate testes, in X and XI, and a single pair of small bilobed ovaries in XIII. Both the testes and the ovaries are close to the

ventral mid-line in their respective segments.

Two pairs of spermathecae occur, in VIII and IX, each a small ovoidal sac, without diverticula, opening to the exterior by a short muscular duct.

There are two pairs of small tubular prostates, in XVII and XIX, each confined to one segment. Penial chaetae are present, in a small transparent sac, lying close to each prostatic duct. The penial chaetae are long and slightly curved, bending sharply near the distal extremity, and terminating in a sharp point. There are two pairs of small, lobulate, vesiculae seminales, surrounding the lateral walls of the oesophagus, in XI and XII.

PLATE XV

FIG. 1.

FIG. 4.

FIG. 5.

FIG. 6.

FIG. 2.

FIG. 3.

PLATE XVMAORIDRILUS GRAVUS N. SP.

- Fig. 1. Dorsal aspect, first six segments.
- Fig. 2. Ventral aspect, first twenty segments.
- Fig. 3. Dissection from the dorsal aspect.
- Fig. 4. Right posterior spermatheca, medial aspect.
- Fig. 5. Right anterior prostate, medial aspect.
- Fig. 6a. Penial chaeta.
- 6b. Normal chaeta.
-

Maoridrillus montana n. sp.

Plate XVI.

Two specimens of this very large earthworm were sent me by Prof. W.B. Benham, of Dunedin, who obtained them from the Tararua Ranges, in the Wellington Province, at an elevation of 5,000 feet, and who suggested in manuscript that if they belonged to a new species it might be called M. montana.

The description is based on the smaller of the two specimens, which is 350 mm. in length, with 214 segments, and 15 mm. in diameter throughout the greater part of its length. It has a greatly swollen clitellum, having a maximum diameter of 23.5 mm.

The prostomium is tanylobous. The chaetae commence on II, and are lumbricine in arrangement. On segment XXIV, the arrangement is as follows:-

ab = cd = 1.5 mm.; aa = 8.5 mm.; bc = 8.5 mm.; dd = 10 mm.

The clitellum is developed dorsally and laterally over XII-XXI, extending slightly onto the dorsal surface of XI.

There are two pairs of large, slit-like spermathecal pores, with tumid lips, at VII/VIII and VIII/IX, in line with the chaeta b.

A pair of slit-like female pores occurs on XIV, slightly anterior and lateral to chaeta a on each side.

There are two pairs of prostatic pores, on XVII and XIX, each on a prominent papilla in line with chaeta b. The two prostatic pores of each side are joined by a

longitudinal groove, which passes between the chaetae a and b of XVIII. The male pores occur in these grooves, on XVIII, between the chaetae a and b.

The nephridiopores commence on II. Those of II-X are dorso-lateral, and anterior to chaeta c, those of XI, ventro-lateral, and anterior to chaeta b, and posterior to XI there is a regular alternation between the dorso-lateral and the ventro-lateral positions.

Internal Anatomy

The septa IX/X, X/XI, XI/XII, XII/XIII, and XIII/XIV are thickened and muscular.

Alimentary Canal: A large, muscular pharynx occupies the first five segments. There is a large, thick-walled gizzard lying in VII and VIII. The oesophagus extends from IX-XIII, and lacks oesophageal glands. The intestine commences in XIV, and lacks a typhlosole.

Vascular System: The dorsal blood vessel is unpaired in the first four segments, but becomes paired at IV/V.

Posterior to this, the vessels remain distinct in each segment, but fuse at each septum. There are four pairs of dilated hearts, in X, XI, XII and XIII.

Reproductive System: There are two pairs of polylobate testes, in X and XI, and a single pair of ovaries in XIII. Both the testes and the ovaries lie close to the ventral mid-line in their respective segments.

Two pairs of spermathecae occur, in VIII and IX. Each is a large spherical sac, with a small diverticulum, divided into several lobes, opening into the short spermathecal duct anteriorly.

There are two pairs of coiled, tubular prostates, in XVII and XIX. Penial chaetae are present, in a long transparent sac, lying beside the duct of each prostate. The penial chaetae are elongate and slender, swollen distally, and terminate in a sharp point. Two pairs of lobulate vesiculae seminales surround the oesophagus, in XI and XII.

The size range of the genus Maoridrilus is remarkable. One of the specimens of M. montana, sent me by Prof. Benham is 700 mm. in length, and has a maximum diameter of 40 mm., while M. minor is 27 mm. in length, and has a maximum diameter of 1.5 mm.

PLATE XVI

FIG. 4.

FIG. 1.

FIG. 5.

FIG. 6.

FIG. 2.

FIG. 3.

PLATE XVIMAORIDRILUS MONTANA N. SP.

- Fig. 1. Dorsal aspect, first six segments.
- Fig. 2. Ventral aspect, first twenty-four segments.
- Fig. 3. Dissection from the dorsal aspect.
- Fig. 4. Left posterior spermatheca, medial aspect.
- Fig. 5. Right anterior prostate, medial aspect.
- Fig. 6a. Penial chaeta.
- 6b. Normal chaeta.
-

THE GENUS NEOCHAETA

Fam. Megascolecidae
Sub-Fam. Acanthodrilinae
Sectio Neodrilacea
Genus Neochaeta n.g.

Chaetae numerous (more than eight) per segment. Nephridiopores on each side more or less regularly alternating in position. Male pores on XVIII. Prostatic pores one pair on XVII. Spermathecal pores one pair at VIII/IX. Gizzard absent. Testes two pairs in X and XI. Prostates a single pair, penial chaetae present.

Distribution: New Zealand, North Island.

Two species.

The genus could have been derived from the known genera of the Neodrilacea in one of two ways. Either it could have been derived from Neodrilus by multiplication of the chaetae, in the same way as Plagiochaeta has probably arisen from Maoridrilus, or it could have been derived from Plagiochaeta by the supervention of the microsclecine genital apparatus, in the same way as Neodrilus has probably been derived from Maoridrilus.

The two species described below show a great deal of similarity, although the localities from which they were collected are very widely separated. The similarity is so great, that there must have been, and may still be, a continuous distribution of the genus throughout the Southern

and Central districts of the North Island, but until further specimens are collected the true distribution must remain in doubt.

KEY TO THE SPECIES OF NEOCHAETA

- a1 Anterior diverticulum present on spermatheca.
Groove joining male and prostatic pores on each
side.
..... N. forsteri
- a2 Very small posterior diverticulum on the
spermatheca. Groove joining male and prostatic
pores absent.
..... N. salmoni.

Neochaeta forsteri n. sp.

Plate XVII.

Seven specimens of this species were collected by R. Forster from leaf-mould at Mt. Ross, in the southern Wairarapa district on 5/4/47. It is a small brown worm, darker anteriorly than posteriorly, with a row of yellowish spots, encircling each segment. A pair of very small chaetae arises from each spot.

The specimen on which the description is based is 22 mm. long, with 65 segments, and has an almost uniform diameter of 2.5 mm. The clitellum covers XIII-XVIII, and completely surrounds these segments, except for a small area on the ventral surface of XVII and XVIII, where the prostatic pores and the male pores are situated.

The chaetae commence on II. There are eighteen pairs on each segment, each pair arising from the centre of one of the yellowish spots mentioned above, and the individual chaetae of each pair are very close together (0.2 mm.). The pairs of chaetae are evenly spaced around each segment, except that the dorsal and ventral spaces are about twice as wide as the spaces between the other pairs of chaetae.

The spermathecal pores are very small slit-like apertures at VIII/IX, close to the median ventral line, and in line with the ventral-most pair of chaetae.

A pair of female pores occurs on XIV, close together, and in line with the ventral-most pair of chaetae of each side.

There is a single pair of transverse, slit-like prostatic pores on XVII, lying in line with the ventral-most

pairs of chaetae on the adjacent segments, these pairs of chaetae being absent on XVII. A shallow groove runs back from each prostatic pore onto XVIII, terminating at the male pore on each side, close to the anterior margin of XVIII.

The nephridiopores commence on II. Those of II-V are dorso-lateral, anterior to the third-from-dorsal pair of chaetae on each side. Those of VI are ventro-lateral, anterior to the third-from-ventral pair of chaetae on each side. Posterior to this, there is an alternation of dorso-lateral and ventro-lateral positions, as in the other Neodrilacea.

Internal Anatomy

Alimentary Canal: There is a small rounded pharynx occupying the first four segments. There is no gizzard. The oesophagus extends from V-XIV, and there are no oesophageal glands. The intestine commences in XV, and has a shallow groove-like typhlosole.

Vascular System; The dorsal blood vessel is unpaired throughout. There are only two pairs of hearts, in XI and XII, the latter pair more dilated than the former.

Reproductive System: Two pairs of free, polylobate testes occur in X and XI, and a single pair of polylobate ovaries in XIII. Both testes and ovaries are close to the mid-ventral line in their respective segments.

There is a single pair of spermathecae in IX, each a small elongate sac, with a short duct leading to the exterior at VIII/IX. A small pyriform diverticulum is joined by a short narrow duct to the spermathecal duct, and projects forward through the septum VIII/IX, into VIII.

A pair of short, uncoiled, tubular prostates occurs in XVII, each opening to the exterior by a short muscular duct. A sac containing elongate penial chaetae lies close to the anterior aspect of each prostate. Two pairs of racemose vesiculae seminales surround the lateral aspects of the oesophagus in XI and XII.

PLATE XVII

FIG. 1.

FIG. 4.

FIG. 5.

FIG. 2.

FIG. 6.

FIG. 3.

PLATE XVIINEOCHAETA FORSTERI N. SP.

- Fig. 1. Dorsal aspect, first six segments.
- Fig. 2. Ventral aspect, first twenty-one segments.
- Fig. 3. Dissection from the dorsal aspect.
- Fig. 4. Right spermatheca, medial aspect.
- Fig. 5. Right prostate, medial aspect.
- Fig. 6. Penial chaeta.
-

Neochaeta salmoni n. sp.

Plate XVIII.

Of this species I have three specimens collected by Dr J.T. Salmon from leaf-mould near the Desert Road, Central North Island, on 24/3/48. It is a small worm, similar in gross form to the genotype (N. forsteri), but darker brown in colour.

This description is based on a specimen 15 mm. in length, with 61 segments, with an almost uniform diameter of 2 mm.

The prostomium is tanylobous. The clitellum is buff in colour, covering segments XIII-XVII, and part of XVIII, completely encircling these segments, except for a small area on the mid-ventral aspect of XVII and XVIII, where the prostatic pores and the male pores occur.

The chaetae are perichaetine in arrangement, and occur in eighteen pairs, closely spaced around each segment, nine evenly spaced pairs on each side, with a slightly greater space separating the dorsal-most and the ventral-most pairs of the two sides.

There is a single pair of spermathecal pores, close to the ventral mid-line at VIII/IX, and anterior to the ventral-most pair of chaetae of each side.

A single pair of prostatic pores is present on XVII. They are situated on the apices of a pair of very small papillae, and the pores themselves are very small. This is in contrast to N. forsteri, where there are no papillae, and the pores are large. The male pores are

a small pair, on the anterior border of XVIII, in line with the prostatic pores, and just anterior to the ventral-most pair of chaetae. There are no grooves joining the prostatic and male pores, such as are present in N. forsteri.

Nephridiopores commence on II. On II, the pores are anterior to the seventh pair of chaetae from the mid-ventral line. On segments III-VI, they are anterior to the fifth pair, on VII, to the third pair, and thereafter there is a regular alternation between positions anterior to the fifth and the third pairs.

There is a single tuberculum pubertatis, in the form of a lateral ridge on the posterior ventral aspect of IX.

Internal Anatomy

Alimentary Canal: A large muscular pharynx occupies I-IV. There is no gizzard. The oesophagus extends from V-XVI, and lacks oesophageal glands. The intestine commences in XVII, and has a typhlosole.

Vascular System: The dorsal blood vessel is single throughout, and as in N. forsteri, there are only two pairs of hearts, in XI and XII. The hearts in XII are extremely dilated.

Reproductive System: There are two pairs of large, free, polylobate testes in X and XI, and a single pair of lobate ovaries in XIII. Both the testes and the ovaries are close to the ventral mid-line.

Two pairs of small, racemose vesiculae seminales are present, in XI and XII.

A single pair of spermathecae is present in IX. Each is a small elongate sac, wholly confined to IX, and lacking an anterior diverticulum as in N. forsteri. In N. salmoni, there is a small posterior diverticulum of the spermatheca, arising from the point where the spermathecal sac opens into the duct.

There is a single pair of small, tubular prostates in XVII, with small penial chaetae in a sac beside the duct of each prostate.

N. salmoni is very similar to N. forsteri, but can be distinguished externally by the presence of small prostatic papillae, and the absence of a groove joining the prostatic and male pores on each side, and internally by the absence of an anterior diverticulum and the presence of a small posterior diverticulum of the spermatheca.

PLATE XVIII

PLATE XVIIINEOCHAETA SALMONI N. SP.

- Fig. 1. Dorsal aspect, first six segments.
- Fig. 2. Ventral aspect, first twenty segments.
- Fig. 3. Dissection from the dorsal aspect.
- Fig. 4. Right spermatheca, medial aspect.
- Fig. 5. Right prostate, medial aspect.
- Fig. 6a. Penial chaeta.
- 6b. Normal chaeta.
-

THE GENUS MEGASCOLIDES

Fam. Megascolecidae
Sub-Fam. Megascolecinae
Genus Megascolides, McCoy, 1878.

"Chaetae eight per segment. Spermathecal pores one to five pairs, the last in furrow 7/8 or 8/9 or on segment IX. One gizzard in the region of segments V and VI. Micronephridial at least in the anterior region of the body, often throughout. Prostates tubular, with simple unbranched canal." (Stephenson, 1930).

The occurrence of the genus Megascolides in New Zealand has been the source of much discussion. Benham (1904) established the genus Tokea for eight species of earthworms from the North Island of New Zealand, which showed characters intermediate between those of Notoscolex and Megascolides. Michaelsen (1907) merged Tokea with Notoscolex, on the grounds that Tokea has a branched system of canals in the prostate, but Benham (1939) pointed out that this is not so. Stephenson (1923) agreed with Michaelsen, but in 1930 he refers on p. 658 to the edibility of Tokea (Megascolides), while on p. 837, he writes "Tokea must now go into Notoscolex." Notoscolex is distinguished from Megascolides by the lack of branching of the canal in the prostate in the latter genus, and Benham (1939) on these grounds says that Tokea is probably to be regarded as a sub-genus of Megascolides. In accordance with Benham, I have placed the species described below in Megascolides.

Megascolides benhami n. sp.

Plate XIX.

Of this species, I have only one specimen, collected by A.J. Healy from leaf-mould at Raglan, on 13/12/47. The spirit preserved specimen is red in colour, paler ventrally than dorsally, with a purplish clitellum, completely encircling segments XIV-XVI, and half of the segments XIII and XVII. It is 65 mm. in length, with 70 segments, and a diameter of 4 mm.

The prostomium is tanylobous. The chaetae commence on II, are eight per segment and are approximately equally spaced around the segments. On segment XXI, the arrangement is as follows:-

aa = 1.5 mm.; ab = 1.5 mm.; bc = 2 mm.; cd = 1.75 mm.;
dd = 2 mm.

The spermathecal pores are not visible externally.

A pair of small female pores occurs on XIV, very close together, in a small median depressed area, close to the anterior ventral margin of the segment.

The male pores occur on XVIII, in shallow depressions with tumid borders, slightly lateral to the line of chaeta a, which is absent on this segment.

Tubercula pubertatis are present in the form of a pair of small white papillae in each of the intersegmental grooves XVII/XVIII and XVIII/XIX, in line with the chaeta a of each side.

Nephridiopores are absent throughout the length of the body.

Internal Anatomy

The septa VII/VIII, VIII/IX, IX/X, X/XI, XI/XII, XII/XIII, XIII/XIV and XIV/XV are much thickened and muscular.

Alimentary Canal: The pharynx is large and extremely muscular, and occupies the first four segments. A well-developed, strongly muscular gizzard is present in V and VI. The oesophagus extends from VII to XV, and has no oesophageal glands throughout its length. The intestine commences in XVI, and lacks a typhlosole.

Vascular System: The dorsal blood vessel is of wide diameter, and is unpaired throughout. Four pairs of hearts are present, in segments IX, X, XI, and XII. There are no hearts in XIII, an unusual character in the Megascolecidae.

Reproductive System: There are two pairs of free, polylobate testes in X and XI. A single pair of small lobulate ovaries is present in XIII. The testes and ovaries lie close to the ventral mid-line in their respective segments.

Four pairs of vesiculae seminales occur, in IX, X, XI, and XII. Those of IX are small spherical masses of racemose tissue, lying close behind the spermathecae of that segment, while the other three pairs are large racemose organs occupying all the available space in their segments, and meeting in the dorsal mid-line.

There are three pairs of spermathecae, in VII,

VIII, and IX. Each is a horn-shaped, thin-walled sac, opening by a narrow duct to the exterior. A very small, tubular diverticulum opens into the duct close to its distal extremity.

The prostates are elongate, unbranched, tubular structures, lying close to the ventral mid-line, beneath the intestine. They are of unequal extent, the left prostate commencing in XVIII, and passing straight back to XXII, where it turns ventrally, to pass under the intestine, between the sub-intestinal blood vessel and the nerve cord, and terminate in XXII, slightly to the right of the ventral mid-line, while the right prostate commences in XVIII, passes straight back to XXI, and there turns dorsally, to terminate close against the lateral wall of the intestine in that segment. This arrangement of the prostates is similar to that described by Benham in Tokea esculenta (1904), where the left prostate also passes under the intestine between the sub-intestinal blood vessel and the ventral nerve cord.

Micronephridia are present in every segment except the first, and they take the form of a band of small slender tubules, close to the anterior margin of each segment. In the last ten segments of the body, meganephridia are present together with the micronephridia. Close examination of a meganephridium shows that it differs markedly from the meganephridia of other earthworms. The whole structure is compact and flattened, and is contained in a gelatinous capsule. The vesicle is large and sub-spherical, and has

no opening to the exterior. The nephridial tubule leading from the vesicle is thrown into four loops, the first of small size, and the last two large, the tubule in the course of these latter two loops passing from side to side across the full width of the vesicle. A nephridial funnel is present, but does not, as is the case in other earthworms, open into the next most anterior segment. Instead, it lies close to the posterior surface of the vesicle, within the capsule surrounding the whole nephridium. It seems hardly likely that a nephridium could function as such under these circumstances, and the organs are probably functionless in this species.

PLATE XIX

FIG. 1.

FIG. 4.

FIG. 5.

FIG. 2.

FIG. 6.

FIG. 3.

PLATE XIXMEGASCOLIDES BENHAMI N. SP.

- Fig. 1. Dorsal aspect, first six segments.
- Fig. 2. Ventral aspect, first twenty-two segments.
- Fig. 3. Dissection from the dorsal aspect.
- Fig. 4. Right posterior spermatheca, medial aspect.
- Fig. 5. Right meganephridium from segment LXII, medial aspect.
- Fig. 6. Normal chaeta.
-

THE GENUS DIPOROCHAETA

Fam. Megascolecidae
Sub-Fam. Megascolecinae
Genus Diporochaeta, Beddard, 1890.

"Chaetae at least in the middle and hinder parts of the body, numerous (more than eight) per segment. Spermathecal pores two to five pairs, the last in furrow 8/9. One gizzard in the region of segments IV - VI, seldom vestigial. Purely meganephridial. Prostates tubular, with a simple unbranched duct.

Distribution: Australia (Victoria and Tasmania, Queensland); New Zealand, Chatham Islands; South India.

Forty-seven species." (Stephenson, 1930).

Four species of the genus have previously been described from the New Zealand region, namely, D. Intermedia, Beddard, 1890, D. chathamensis, Benham, 1900(a), D. shakespeari, Benham, 1905, and D. gigantea, Benham, 1905. One new species, D. obtusa, is described below. It shows very close affinities with D. chathamensis, Benham, and also closely resembles the Australian species D. maplestoni, Spencer, and D. walhallae, Spencer. The differences between D. obtusa and these three species are set out below:-

	<u>D. obtusa</u>	<u>D. chatham-</u> <u>ensis</u>	<u>D. maple-</u> <u>stoni</u>	<u>D. walhal-</u> <u>lae</u>
No. of chaetae per segment.	18	16	14	20-24
No. of sperma- thecae	3 pairs	3 pairs	2 pairs	5 pairs
Spermathecal diverticulum.	present	absent	absent	absent
Number of testes	1 pair	1 pair	1 pair	2 pairs

KEY TO THE NEW ZEALAND SPECIES OF DIPOROCHAETA

a1 Two pairs of spermathecae.

b1 Oesophagus dilated in XI, XII, and XIII.

..... D. shakespearei.

b2 Oesophagus dilated in XII and XIII.

..... D. gigantea.

a2 Three pairs of spermathecae.

c1 Spermathecae without diverticula.

..... D. chathamensis.

c2 Spermathecae with diverticula.

..... D. obtusa

a3 Four pairs of spermathecae.

..... D. intermedia.

Diporochaeta obtusa n. sp.

Plate XX.

This species is very common in the central districts of the North Island of New Zealand, extending in its distribution from the East to the West coast of the Island. The specimen on which the description below is based was collected by P. Culliford, from leaf-mould in mixed forest near Norsewood, Hawkes Bay, on 27/1/48. It is a small worm, 21 mm. in length, with 65 segments. The diameter is 1.5 mm., and the body terminates bluntly at the mouth and anus.

The prostomium is tanylobous. The chaetae commence on II, are eighteen per segment, and perichaetine in arrangement. The chaetae are evenly spaced around the body, except that the ventral gap is slightly greater than any other.

The clitellum covers only segments XIV-XVI, and is continuous right around these segments.

Dorsal pores are obvious, commencing at IV/V, and occurring in each intersegmental groove posterior to this.

Three pairs of spermathecal pores occur at VI/VII, VII/VIII, and VIII/IX, in line with chaeta b. A pair of small, round, white markings occur close together in the mid-ventral line, on the anterior margin of IX, in close association with the spermathecal pores, and a single similar marking is present on VIII, on the right, and on VII, on the left.

A pair of female pores occurs on XIV, slightly anterior to chaeta a.

There is a very prominent pair of white papillae on XVIII, between the chaetae a and b on each side, and on the apices of these pores the common male and prostatic pores open.

Tubercula pubertatis occur on XVII, XVIII, and XIX. Those of XVII and XIX take the form of a pair of small papillae, posterior to chaetae a and b on XVII, and anterior to those chaetae on XIX. Those of XVIII are large medial transverse bands on the anterior and posterior margins of the segment, extending from the line of chaeta a of one side to the same line on the other side, and there are also, on this segment, a pair of small papillae on the anterior margin of the segment, immediately anterior to the chaeta c of each side.

The nephridiopores are lateral, and occur in a single series on each side, in line with the chaeta e.

Internal Anatomy

Alimentary Canal: The pharynx occupies I to V, is not very muscular, and is covered dorsally by salivary glands. A small gizzard occurs in VI. The oesophagus extends from VII-XVI, and has three pairs of calciferous glands in XIII, XIV, and XV. The intestine commences in XVIII, and lacks a typhlosole.

Vascular System: The dorsal blood vessel is unpaired throughout. There are three pairs of hearts in X, XI, and XII, those of XII being extremely dilated.

Reproductive System: There is one pair of free, polylobate testes in XI, close to the mid-ventral line, and a single pair of ovaries in XIII, also close to the mid-ventral line.

Only one pair of vesiculae seminales occurs, in XII. There is a diffuse mass of sperms lying loose in XI, the same as is recorded by Benham in D. chathamensis.

There are three pairs of spermathecae, in the segments VII, VIII, and IX. Each consists of a lobulated sac opening by a narrow duct to the exterior, with a small smooth-walled diverticulum lying close to the medial aspect of the sac, and opening into the spermathecal duct.

One pair of prostates occurs, and these organs are of enormous size. Each is a wide convoluted tubular structure, extending through the six segments XVIII-XXIII, closely applied to the lateral wall of the gut, and opening to the exterior by a thin muscular duct in XVIII. There are no penial chaetae.

The nephridia are compact structures, in a single series on each side.

This species shows a great likeness to D. chathamensis, Benham, 1900(a). The presence of only one pair of testes and funnels, the absence of vesiculae seminales in XI, and their replacement by a mass of loose sperms, the possession of three pairs of spermathecae, the dumb-bell shaped papillae

of the male and prostatic pores on XVIII, and the form of the tubercula pubertatis at XVII/XVIII and XVIII/XIX, are all characters shared with D. chathamensis, but D. obtusa differs in the possession of only three pairs of oesophageal glands instead of four pairs, the presence of a small diverticulum on each spermatheca, three pairs of hearts instead of two, and the extremely convoluted nature of the prostates.

Distribution: Apart from the specimen described above, which was collected at Norsewood, in Hawkes Bay, specimens have been collected from the vicinities of Waikouru, in the central North Island, Lake Waikaremoana, in the North-eastern region of the North Island, from the Awakino Valley, on the West Coast in the Taranaki District, and from Kawhia and Raglan in the Waikato. Such a wide distribution is remarkable for an earthworm, particularly since the species is confined to leaf-mould, and the Eastern and Western localities in which the species has been found are separated by a large area of desert country, covered over by an extensive volcanic dust shower. It may be, however, that the area now covered by the volcanic dust was originally an area of extensive forests which have been destroyed by the dust shower in comparatively recent times, and that D. obtusa achieved its very wide distribution prior to this event.

PLATE XX

PLATE XX

DIPOROCHAETA OBTUSA N. SP.

- Fig. 1. Dorsal aspect, first six segments.
- Fig. 2. Ventral aspect, first twenty-one segments.
- Fig. 3. Dissection from the dorsal aspect.
- Fig. 4. Left posterior spermatheca, medial aspect.
- Fig. 5. Normal chaeta.
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THE MICROSCOPIC ANATOMY OF NEODRILUS AGILE

The Body Wall:

Plate XXI, figs. 1-4.

The body wall shows the layers typical of the higher Oligochaeta, and there is a striking similarity to the body wall of Lumbricus terrestris. There is an outer epidermis, one cell thick, with a thin overlying cuticle, beneath the epidermis a thin layer of circular muscles, and internal to the circular muscle layer, a thick layer of longitudinal muscle fibres. (Fig. 1.).

Cuticle: (fig. 2.) The cuticle, is a thin, structureless, translucent layer, approximately 2 microns in thickness, overlying and protecting the epidermal cells. The surface of the cuticle is irregularly folded when seen in a cross-section of the body. There do not seem to be any pores in the cuticle corresponding to the positions of the gland cells in the epidermis.

Epidermis: (fig. 2.) The epidermis is little different from that of Lumbricus terrestris, as described by Cerfontaine (1890). Three types of cells can be distinguished in the epidermis:-

(i) Supporting cells - These are columnar in form, with granular cytoplasm, as in Lumbricus, but their nuclei are basal, unlike those of Lumbricus, where they are situated at about half the height of the cells.

(ii) Basal cells - These are small, rounded cells,

with granular cytoplasm, and a large central nucleus, situated below the supporting cells.

(iii) Mucous Gland Cells - These are elongate columnar cells, with granular cytoplasm, and a basal nucleus. A distended vesicle, containing darkly-staining granules, occurs in each of the gland cells, immediately beneath the cuticle. The degree of distension of the vesicle varies with the stage of secretion of the gland cell.

A very thin basement membrane (about one micron in thickness) bounds the epidermis internally.

The Muscles of the Body Wall: (fig. 3.)

Two layers of muscle fibres occur under the basement membrane of the epidermis. There is an outer layer of circular muscle fibres, closely packed, with scattered ovoidal nuclei. The circular muscle layer is bounded internally by a thin sheet of connective tissue, and between this connective tissue layer and the peritoneum is a thick layer of longitudinal muscles. The fibres of both the muscle layers are arranged in the same way as they are in Lumbricus terrestris. The fibres of the longitudinal layer, in cross-section, are flat and leaf-like, and arranged in a feather-like pattern on a two layered lamella of connective tissue. The fibres are not set at an angle of 45 degrees to the lamella, as they are in Lumbricus terrestris, but are set at an angle of approximately 90 degrees. Blood vessels occur in some cases, running between the two sheets of the lamella.

The muscles of the chaetae (fig. 4.) are distinguishable into two distinct groups, the protractors, and the retractors. The protractors take their origin from the lateral aspects of each chaeta, and radiate out from there, some of them merging into the circular muscle layer of the body-wall, and others running beside the shaft of the chaeta, and terminating near the basement membrane of the epidermis, close to the pore through which the chaeta projects to the exterior.

There is a single retractor muscle to each pair of chaetae, attached near the base of the shaft of the chaeta, and passing through the coelom, to an attachment near the base of the other chaeta of the pair.

The whole chaeta and its protractor muscles are enclosed in a thick sheath of connective tissue.

PLATE XXI

Fig. 1. Cross-section of the body wall, showing the epidermis and muscle layers.

Fig. 2. Detail of the epidermis.

Fig. 3. Detail of the muscle layers of the body wall, as seen in cross-section.

Fig. 4. Cross-section of the body wall, showing a chaeta with its musculature.

BC. = basal cell; BM. = basement membrane;
BV. = blood vessel; C. = cuticle; CC. = columnar cell;
CH. = chaeta; CM. = circular muscle layer; CMF. = circular muscle fibre; CT. = connective tissue; EP. = epidermis;
GC. = gland cell; LA. = lamina; LM. = longitudinal muscle layer; LMF. = longitudinal muscle fibre; MP. = protractor muscle; MR. = retractor muscle; N. = nucleus; NBC. = nucleus of basal cell; NCC. = nucleus of columnar cell; P. = peritoneum.

PLATE XXI

FIG. 2.

FIG. 3.

FIG. 1.

FIG. 4.

The Alimentary Canal:

Plates XXII, XXIII.

The Pharynx.- (Pl. XXII, figs. 1-3).

The apparent great mass of the pharynx is due to a thick dorsal layer of salivary glands, with extrinsic muscle fibres, running through this layer, and inserted on the walls of the pharynx. (fig. 1).

In cross-section, the pharynx is X-shaped, the lumen being extended dorso-laterally on each side, into an elongate flattened diverticulum. The cells lining the dorsal diverticula are heavily granular, elongate, columnar, ciliated cells (fig. 2). Their boundaries are indistinct, and there appears to be a layer of small basal cells beneath the columnar cells. Groups of intracellular fibrillae, as described by Mayer (1913) in the Lumbricidae, originate close to the basement membrane of the epithelium, and pass towards the surface, to terminate close to the row of heavily-staining basal granules which underlie the close set cilia. The epithelium lining the lumen of the pharynx consists of lightly granular, non vacuolated, non-ciliated columnar cells, situated on a basement membrane. There is a layer of muscle fibres external to the basement membrane.

The Gizzard: (Pl. XXII, figs. 4, 5).

In cross-section, the gizzard is oval in form, flattened dorso-ventrally, and surrounded by a thick investing layer of circular muscle fibres (fig. 4).

The epithelium lining the gizzard is slightly irregular in outline, and consists of a layer of heavily

granular, elongate, non-vacuolated columnar cells, with small basal cells scattered between the columnar cells. (fig. 5.). The cells of the epithelium rest on an acellular basement membrane, and external to the basement membrane is a thick coat of circular muscle fibres, bounded externally by the syncytial peritoneum.

The Oesophagus: (Pl. XXII, figs. 6, 7).

The oesophagus of N. agilis is an elongate tubular structure, bearing two pairs of calciferous glands, in the form of lateral dilatations in XIV and XV.

In cross-section, it is oval in form, laterally flattened, and consists of an oesophageal epithelium, surrounded by a thin muscular layer, the whole structure enclosed in an investment of peritoneum. (fig. 6).

The epithelium consists of lightly granular, non-vacuolated, columnar cells, with basal cells scattered beneath the columnar cells. (fig. 7.). Immediately external to the epithelium is a thin layer of circular muscle fibres, and external to the circular muscle coat is a single layer of longitudinal muscle fibres. The oesophagus and its muscle layers are surrounded and enclosed by a thick sheath of connective tissue, continuous with the peritoneum. There is no sign of chloragogen granules in the syncytial tissue surrounding the oesophagus.

Oesophageal Glands: (Pl. XXIII, figs. 1, 2).

In segments XIV and XV, the oesophagus is swollen laterally, forming paired calciferous glands in each of

these segments.

In cross-section, the oesophageal glands are seen to consist of a thin epithelial layer, thrown into numerous longitudinal lamellae, laterally and dorsally, bounded by a strong fibrous syncytial sheath. (fig. 1.) Between the epithelium and the sheath is a large blood sinus, which follows the convolutions of the epithelium. In Pheretima hawayana, Stephenson and Prashad (1919) found that the epithelium was thrown into folds, but the folds in that case were transverse, not longitudinal as they are in N. agilis. The epithelium of the oesophageal glands in N. agilis (fig. 2) is composed of short columnar cells, heavily granular in the basal region, and showing a gradation in the intensity of the granulation, to a light granulation in the upper regions of the cells. Scattered among the columnar cells of the epithelium are gland cells, each with a large clear vacuole. The sheath surrounding the oesophageal glands is packed with chloragogen granules.

The Intestine: (Pl. XXIII, figs. 3, 4).

The intestine of N. agilis commences in segment XVII. It is wide and thin walled, and is constricted at each septum throughout its length. The typhlosome spirals slowly around the intestine in the course of its length.

In cross-section, the intestine is seen to consist of a ciliated epithelial layer, and an outer layer of chloragogen tissue, with an irregular blood sinus lying between the two layers, and extending right round the

circumference. (fig. 3.). A blood sinus of this nature has also been recorded from Pheretima juloides, by Hertling (1923).

The epithelium of the intestine (fig. 4) is ciliated, and consists of heavily granular, columnar cells, with small basal cells scattered between them. A row of deeply staining basal granules lies beneath the close set cilia of the columnar cells. No gland cells are visible in the intestinal epithelium.

The chloragogen tissue (fig. 4) is syncytial, unlike that of Lumbricus, and other genera which have been investigated, where the chloragogen tissue consists of elongate columnar cells. Stephenson (1930) states that in the Megascolecidae, the chloragogen cells do not enter into the formation of the groove which constitutes the typhlosole, but in N. agilis the chloragogen tissue is bent down into the groove with the other layers of the intestinal wall.

PLATE XXII

FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

FIG. 6.

FIG. 5.

FIG. 7.

PLATE XXII

- Fig. 1. Cross-section of pharynx.
Fig. 2. Epithelium of dorsal diverticulum of pharynx.
Fig. 3. Epithelium of lumen of pharynx.
Fig. 4. Cross-section of gizzard.
Fig. 5. Epithelium of gizzard.
Fig. 6. Cross-section of oesophagus.
Fig. 7. Epithelium of oesophagus.

BC. = basal cell; BG. = basal granules;
C. = cilia; CC. = columnar cells; CMF. = circular
muscle fibre; CT. = connective tissue; DIV. = diverticulum
of the pharynx; FB. = intra-cellular fibrillae; GC. = gland
cell; L. = lumen; LMF. = longitudinal muscle fibre;
MF. = muscle fibre; NBC = nucleus of basal cell;
NCC. = nucleus of columnar cell; P. = peritoneum.

PLATE XXIII

FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

PLATE XXIII

- Fig. 1. Cross-section of oesophagus in region of calciferous gland.
- Fig. 2. Epithelium of calciferous gland.
- Fig. 3. Cross-section of intestine.
- Fig. 4. Intestinal wall and epithelium.

BC. = basal cell; BG. = basal granules;
BS. = blood sinus; C. = cilia; CC. = columnar cell;
CHL.N. = nuclei of chloragogen tissue; CHLT. = chloragogen
tissue; GC. = gland cell; GR. = chloragogen granules;
L. = lumen; LA. = lamina of oesophageal gland;
NCC. = nucleus of columnar cell; TYPH. = typhlosole.

The SpermathecaPlate XXIV, figs
1-4.

There is a pair of spermathecae in VIII, each consisting of a large sac, with a duct leading to the exterior at VII/VIII. A group of small diverticula is clustered around the duct.

In cross-section, the spermatheca is seen to be completely engloved in a thick sheath of encircling muscle fibres, the sheath being particularly thickened in the region of the spermathecal duct. (fig. 1).

The epithelial lining of the spermathecal sac rests on the circular muscle fibres (fig. 2), and three types of cells are distinguishable in the epithelium of the sac:-

(i) Columnar cells, with basal nuclei, and a granular cytoplasm, showing a decreasing gradient of intensity of granulation from their bases upwards.

(ii) Vacuolated columnar cells, similar in form to the columnar cells, but each having an elongate vacuole, close to its free surface.

(iii) Small basal cells with heavily granular cytoplasm, and a central nucleus, lying beneath the columnar cells.

In Eisenia rosea, Szuts (1920) describes the epithelium of the spermathecal sac as being of simple columnar cells, with basal nuclei, and a layer of small rodlets on the free border of the cells. There are no such rodlets in N. agilis.

The spermathecal sac of N. agilis does not contain spermatozoa, but in some of the sections, a mucus-like

substance can be seen in the lumen of the sac. Grove (1925) found a similar substance in the spermathecal sac of Lumbricus terrestris, and suggested that it may be utilised for the nutrition of the sperm-cells while they are lodged in the spermatheca.

The epithelial lining of the diverticula of the spermatheca forms a mesh of alveoli within each diverticulum (fig. 3.). The cells of the epithelium are similar to those of the epithelium lining the spermathecal sac, but the columnar cells are shorter. Sperm cells are stored in the alveoli of the diverticulum, grouped together in straight lines, the individual cells lying side by side, or arranged in balls, with the heads of the spermatozoa pointing inwards, and the tails outwards. In Didymogaster sylvaticus, Brennan (1900) states that the epithelium of the spermathecal diverticulum is ridged, and the sperm cells are stored between the ridges.

The diverticula are enclosed in a muscular sheath, continuous with that surrounding the spermathecal sac and duct.

The epithelium of the spermathecal duct consists of simple, elongate, columnar cells, with ovoidal basal nuclei, resting on a very thick layer of muscle fibres. There are no irregularities in the epithelial lining of the duct, as have been recorded in other earthworms (e.g. glandular tubes in Dichogaster beddardi, recorded by Horst (1895), and small chambers opening into the duct, as recorded by Stephenson (1925) in Pheretima pingi.)

PLATE XXIV

- Fig. 1. Vertical section through the right spermatheca, to show the spermathecal sac, diverticula, and duct.
- Fig. 2. Epithelium of spermathecal sac.
- Fig. 3. Cross-section of a spermathecal diverticulum, to show the epithelium of the alveoli.
- Fig. 4. Longitudinal section of the spermathecal duct, to show the epithelial lining.

ALV. = alveolus; BC. = basal cell;

CC. = columnar cell; CM. = circular muscles; D. = spermathecal duct; DIV. = diverticulum of spermatheca; EP. = epithelium of spermathecal sac; L. = lumen; NCC. = nucleus of columnar cell; SAC. = spermathecal sac; SH. = sheath; SPCC. = sperm cells; VCC. = vacuolated columnar cell.

PLATE XXIV

FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

The Prostates:

Plate XXV, figs. 1, 2.

There is a single pair of prostates in Neodrilus agilis, each arising from a muscular duct in XVII, and varying in size in different individuals.

In cross-section, the prostate is seen to be a tubular structure, bounded externally by a thin connective tissue sheath, and comprised of elongate, loosely packed cells, arranged radially around a central lumen (fig. 1.). Small blood vessels occur, close to the external sheath.

Four types of cells can be distinguished, arranged around the lumen of the gland:

(i) Gland cells.- These are elongate cells, extending from the lumen out towards the sheath of the gland, but not in contact basally with the sheath. Masses of deeply-staining granules are contained in these cells, and the nucleus generally seems to be absent, although in some cases, a small spherical nucleus is visible at the base of the cell. The cytoplasm of the gland cells is lightly granular.

(ii) Cells similar in form to the gland cells, but containing no granules. These may be stages in the formation of gland cells.

(iii) Elongate, narrow, columnar cells, abutting on the connective tissue sheath of the gland, and extending inwards toward the lumen of the gland. The cytoplasm of these cells is heavily granular, and their nuclei are basal. They are probably supporting cells.

(iv) Small basal cells, lying between the supporting

cells, against the connective tissue sheath. Their cytoplasm is heavily granular, and they have small spherical nuclei, with a prominent, darkly staining nucleolus. Their function is probably to replace the gland cells after the secretion of the gland cells has been expended.

The structure of the prostate in Neodrilus agilis is closely analogous to that of Eutyphoeus waltoni, a Megascolecid earthworm, the prostates of which were described by Stephenson and Haru Ram (1919). These authors record occasional strands of muscle fibres running through the prostates in Eutyphoeus waltoni, and this is the only point of difference from Neodrilus agilis, in which muscle fibres are not visible.

Stephenson (1930) states that the cells of the gland in Eutyphoeus waltoni appear to break down to form the secretion, and it would seem, from the absence of nuclei in most of the gland cells, that this is also the case in Neodrilus agilis.

The prostatic duct (fig. 2.) has a simple columnar epithelial lining when seen in cross section, and is surrounded by a very thick layer of encircling muscle fibres, bounded externally by a thin connective tissue sheath, with small scattered nuclei. The lumen of the duct is Y-shaped in cross-section.

PLATE XXV

FIG. 1.

FIG. 2.

PLATE XXV

Fig. 1. Cross-section of the prostate, to show the arrangement of the cells around the lumen of the gland.

Fig. 2. Cross-section of the prostatic duct.

B.C. = basal cell; BV. = blood vessel;
EP. = epithelium; GC. = gland cell; GR. = secretory
granules of gland cell; L. = lumen of prostate;
MF. = muscle fibres; NBC. = nucleus of basal cell;
NGC. = nucleus of gland cell; SC. = supporting cell;
SH. = sheath.

DISCUSSION

The endemic earthworm fauna of New Zealand forms a compact unit, all the known species falling within the three sub-families Acanthodrilinae, Megascolecinae, and Octochaetinae, of the family Megascolecidae. In this thesis, twenty species have been recorded and described, but they present no problem in regard to the status of the individual species in the general scheme of classification, since all, with the exception of the two species of the new genus Neochaeta, belong to genera which are well known in the New Zealand region. Neochaeta could have been derived from the genus Plagiochaeta, by a reduction to the micro-scolecine condition of the genital apparatus, in the same way as Neodrilus has probably been derived from Maoridrilus, or from the genus Neodrilus by a multiplication in the number of chaetae, in the same way as Plagiochaeta has probably been derived from Maoridrilus. Neochaeta, so far as is known, is confined to the North Island, and Plagiochaeta to the South Island, and since Neodrilus is found in the same area as Neochaeta, it is reasonable to assume that Neochaeta was derived from Neodrilus.

The New Zealand earthworm fauna, despite its compact nature, shows remarkably close affinities to the faunas of widely separated countries. The Acanthodrilinae are found in New Zealand, New Caledonia, Australia, Subantarctic Islands, Madagascar, South Africa, Cape Verde Islands, Cameroons, southern South America, Central America,

Mexico and Cuba. The distribution of the genus Microscolex, which is an Acanthodriline, was used as evidence in favour of the possible migrations of animals through an Antarctic continent, but the presence of Acanthodrilines in New Caledonia and Australia points to a possible pathway of migration through the Indo-Malayan archipelago. The latter explanation of the origin of the New Zealand fauna is again suggested by the distribution of the genus Octochaetus, of the sub-family Octochaetinae. There are twenty species of Octochaetus in India, and four in New Zealand, and the genus has not been recorded elsewhere. The distribution of this genus puzzled Michaelsen, because if it had achieved its distribution by way of land bridges, there must, at some time, have been a land bridge between India and New Zealand, which did not pass through Australia. It may be however, that the genus previously occurred in Australia, and has become extinct in that region. Whether this is so or not, a land bridge, to be suitable for the distribution of earthworms, must be of considerable duration, and Octochaetus, according to Michaelsen's interpretation of the phylogeny of the Megascolecidae, being a comparatively recently evolved genus, must have achieved its distribution in comparatively recent geological times. If a land bridge between India and New Zealand is postulated to explain the distribution of the genus, then other terrestrial animals could have crossed it equally well, and there is then no reason why the Mammalia could not have reached New Zealand.

Michaelson concluded that the genus Octochaetus had arisen independently in the two regions, and established two sub-genera, Octochaetus in New Zealand, and Octochaetoides in India. The only morphological evidence that Michaelson could offer to justify the division of the genus into these two sub-genera was that the calciferous glands of the Indian species are slightly larger in size than those of the New Zealand species. A division into sub-genera on such slender evidence cannot be justified, and Michaelson's interpretation of the present distribution of the genus, though possible, can hardly be considered likely. The distribution of the Megascolecinae also gives strong support to the concept of a northern as opposed to a southern origin of the New Zealand earthworms. The Megascolecinae, according to Michaelson, arose in Queensland, and are found now throughout the Australian and Indian regions, in Malaya, the Phillipines, China, Japan, and Polynesia, with a few species in North America. The genus Diporochaeta makes an excellent basis for argument. This genus took its origin in Australia (Benham, 1900(a)), and it is now found in the eastern states of Australia, in New Zealand, the Chatham Islands, and Southern India. Michaelson derives the genus from Plutellus, which has a similar distribution, and it seems obvious that if land bridges are to be invoked to explain the present distribution of both these genera, such land bridges must have joined New Zealand to northern rather than southern land masses. The evidence for a northern origin of the

endemic earthworm fauna of New Zealand, taken from the present distribution of the Octochaetinae and the Megascolecidae, and to a lesser extent from the Acanthodrilinae, greatly outweighs the evidence of a southern origin of the fauna provided by the Acanthodrilinae.

The microscopic anatomy of Neodrilus agilis, which has been discussed in this thesis, shows a striking similarity to that of the common European earthworms.

The body wall of N. agilis is almost identical in structure with that of Lumbricus, the only noticeable difference being that the longitudinal muscle fibres are not set obliquely, but are at right-angles to the lamella to which they are attached. It would be expected that the muscle layers of the body wall of N. agilis would be quite different from those of Lumbricus, since N. agilis is an extremely active species and is capable of throwing itself into the air, if lightly stimulated, by a spasmodic lateral thrashing of the body, while Lumbricus only displays such violent movement when badly injured.

The structure of the alimentary canal shows few unusual features, being similar in most respects to that of Lumbricus, and in other respects to that of other genera of the Megascolecidae which have been studied in detail. The only feature which is worthy of note is the syncytial nature of the chloragogen tissue, a feature which has not previously been recorded from other earthworms. Normally, the chloragogen tissue consists of a single layer of elongate cylindrical cells, lying in the coelom, and attached by

a narrow basal portion to the wall of the intestine (e.g. in the Lumbricidae), but in N. agilis, the chloragogen tissue takes the form of an irregular syncytial layer, with scattered nuclei, surrounding the intestine.

The spermathecae of N. agilis differ from those of the Lumbricidae in having diverticula, in which the sperm cells are stored after copulation, the spermathecal sac not being used for this purpose. However, there is apparently a similarity in function of the epithelium lining the spermathecal sac in the two groups, since in some sections of the spermatheca of N. agilis, a mass of mucus-like material is visible inside the sac, and Grove (1925) noted the same fact in the spermathecal sac of Lumbricus terrestris. The diverticula of the spermathecae in N. agilis are similar in structure to those of other Megascolecidae which have been studied in detail.

The prostates of N. agilis are tubular in form. Among the Megascolecidae, there are two fundamental types of prostates, the tubular type, and the lobular type. The tubular type, as found in N. agilis, consists of a simple, coiled, bent, or undulating tube, with a single central lumen, and a single duct, opening to the exterior, and continuous with the lumen of the gland, while the lobular type, as found in Pheretima, consists of a mass of lobules, each with a small ductule, all the ductules opening into a common duct before discharging to the exterior. The prostate of N. agilis is no different from those of other Megascolecidae with tubular prostates, which have been

studied in detail.

The great similarity of anatomy among the Megascolecidae, and the similarity of their anatomy to that of other widely different groups of earthworms, is an indication that earthworms form a natural group of great homogeneity.

The importance of earthworms in relation to the fertility of the soil is a subject of great importance, and one of which little is known. That there is a direct correlation between the fertility of pasture lands and the density of population of earthworms is undoubted, but it has never been established with certainty whether the greater population density is due to the greater fertility of the soil, or whether the greater population density of earthworms is a contributing factor in an increase in the fertility of the soil. Nothing is known of the activities and possible importance of endemic earthworms in the leaf-mould of the New Zealand rain forests, or of the reasons for the failure of endemic earthworms to establish themselves in cultivated soils. Smith (1893) mentions the failure of the endemic earthworms to maintain themselves in the soil once it is brought under cultivation, but offers no explanation of the fact.

New Zealand has a rich, but compact, earthworm fauna, and although much work has been done, much still remains to be done before a satisfactory account of its composition, affinities, and possible economic importance in relation to the fertility of the soil in native rain

forests can be presented.

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