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Nematode worms found attacking sugar-cane

(Uit: Plant diseases and their remedies)

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III. NEMATODE WORMS FOUND ATTACKING SUGAR-CANE.

A good deal has been said and written about the possibility or probability of nematodes being the cause of certain diseases occurring in the sugar-cane of Java. The *Tylenchus sacchari* of Solwedel has been pointed out by one writer as a probable cause of the cane disease known as Serah. The measurements of this worm, as given by Dr. Krüger, are $\frac{26}{15}$ $\frac{9}{7}$ $\frac{2}{4}$ $\frac{2}{2.9}$ $\frac{95}{2.2}$ mm. and $\frac{21}{2}$ $\frac{7}{2}$ $\frac{7}{2.4}$ $\frac{56.00}{1.9}$ $\frac{95}{1.04}$ mm. The worm has distinct lips and a well-developed spear. The tail of the female is conoid to the blunt terminus; that of the male is more pointed, and is supplied with a bursa which extends a short

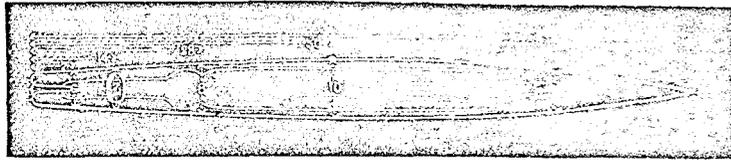


Fig. 29.—Diagram in explanation of the descriptive formula used for Nematode worms; 6, 7, 8, 10, 6 are the transverse measurements, while 7, 14, 28, 50, 88 are the corresponding longitudinal measurements. The formula in this case is:—

$$\frac{7 \cdot 14 \cdot 28 \cdot 50 \cdot 88}{6 \cdot 7 \cdot 8 \cdot 10 \cdot 6}$$

The unit of measurement is the hundredth part of the length of the worm, whatever that may be. The measurements become, therefore, percentages of the length. The measurements are taken with the animal viewed in profile; the first is taken at the base of the pharynx, the second at the nerve ring, the third at the cardiac constriction, the fourth at the vulva in females and at the middle (M) in males, the fifth at the anus.

distance in front of and behind the anus, and when the worm is viewed in profile extends beyond the ventral contour. The spicula, as figured by Dr. Krüger, are acute and cuneiform, and do not exceed the anal body-diameter in length.

In view of the above facts, it was thought best to inquire what nematode worms are to be found in cane-fields on the Clarence River, more especially about the roots of the sugar-cane. Inasmuch as the mere presence of a given species among the roots of cane, would be no proof that it was injurious to, or in any way specially connected with, the cane, specimens of soil from about healthy cane were examined, as well as from about diseased cane. Specimens of soil from cultivated fields under other crops than cane and specimens of virgin soil were also examined. In this way it was possible to come to definite conclusions. The result showed conclusively that most of the species of nematode worms found about the roots of diseased cane-plants occur also equally abundantly about those of healthy cane. Most of the species found in cane-fields occurred in other fields not under cane, and many were found about the roots of native plants in virgin soil.

The following are the descriptions of these worms, arranged under the genera to which they belong. There are in all thirty species, belonging to fourteen genera, of which three are new. Nearly all the species are sorts never hitherto described, only four of them being already known.

1. Dorylaimus.

The genus *Dorylaimus* comprises many worms found in the soil and on the surface of land plants. They derive their food from rootlets and other parts of plants. Their method of feeding is similar to that of the worms composing the genera *Tylenchus* and *Aphelenchus*. They first pierce the tissue of the plant with a spear or sting contained in the pharynx or throat, and which they have the power to thrust forth at will. From the wound thus made they suck up the juices of the plant. These worms differ materially from *Tylenchus*, however, not only in habit but in structure. Many species of *Tylenchus* are parasitic. But thus far no *Dorylaimus* has been shown to be a parasite. They appear always to inhabit the soil and to attack the roots from the outside. In harmony with this mode of life they

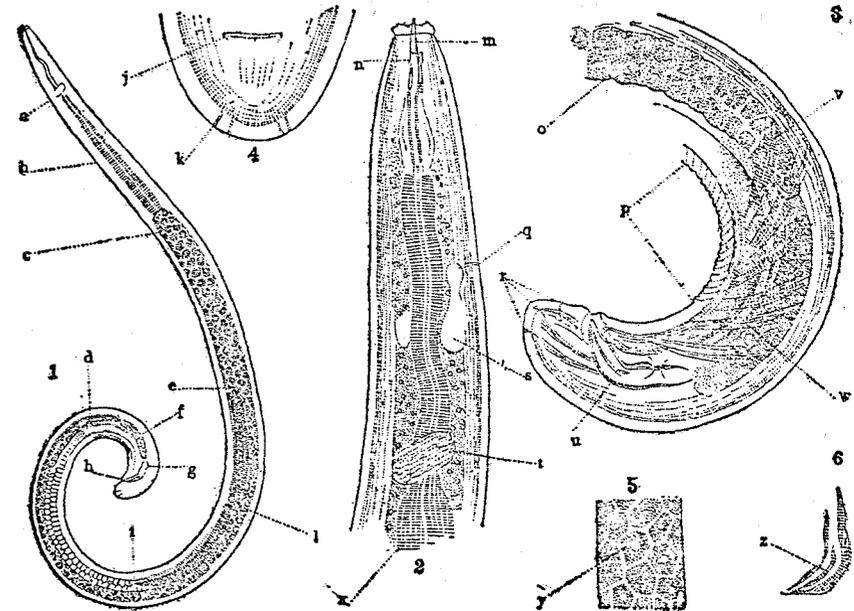


Fig. 30.—Anatomical details of *Dorylaimus perfectus*; 1, male worm magnified; 2, head and anterior part of the neck of the same worm more highly magnified; 3, tail end of same worm more highly magnified; 4, posterior end, ventral view; 5, a portion of the intestine; 6, spiculum.

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|------------------------------------|---------------------------|-------------------------------|
| a, nerve-ring. | j, anus. | s, gland. |
| b, œsophagus. | k, papilla. | t, nerve-ring. |
| c, intestine. | l, junction of testicles. | u, left spiculum. |
| d, intestine. | m, spear. | v, oblique copulatory muscle. |
| e, blind end of anterior testicle. | n, spear-guide. | w, oblique copulatory muscle. |
| f, pre-rectum. | o, intestine. | x, œsophagus. |
| g, spiculum. | p, papilla. | y, tessellation of intestine. |
| h, anus. | q, outlet of gland. | z, spiculum. |
| i, blind end posterior testicle. | r, papilla. | |

are, as a rule, much larger than *Tylenchi* or *Aphelenchi*, some of the larger species being above half an inch long. They are never gregarious. The reader will easily familiarise himself with the form and structure of these worms by consulting the accompanying illustrations. The points that serve to distinguish this genus from other similar ones are, the form of the spear

or sting, the form of the œsophagus, and the presence in front of the rectum of a modification of the intestine, to which I have given the name of pre-rectum. The base of the spear has no bulbous swellings. The œsophagus is narrow in its anterior part, but near the middle it expands and becomes henceforth large and muscular. There are no sucking bulbs.

1. *Dorylaimus minutus*, n. sp. $\frac{5}{1.5}$ $\frac{14}{3.5}$ $\frac{28}{4.1}$ $\frac{58}{4}$ $\frac{97}{2.3}$.34 mm. Cuticle devoid of hairs, likewise of striæ. The conoid neck ends in a rather rounded head, destitute of setæ, but bearing six lips, each with two papillæ. The lip-region it set off from the head by a constriction. Neither eyes nor lateral organs were seen. The spear is rather weak, and its guiding ring but faintly to be seen. In its anterior part the œsophagus is one third as wide as the corresponding part of the neck; a little behind the middle, however, it rather suddenly becomes two-thirds as wide as the neck. The lining of the œsophagus is thick, and in optical section is plainly to be seen. The beginning of the intestine is obvious, rather on account of the change of structure and colour than because the cardiac constriction is distinct. The cardia is flat and inconspicuous. The intestine is thick-walled and two-thirds as wide as the body; its component cells are large, and the lumen consequently narrow and somewhat zigzag. The rectum is equal in length to the anal body-diameter. No pre-rectum was discernible. The lateral fields were one fourth as wide as the body. The nerve-ring encircles the œsophagus somewhat obliquely. The bluntly conoid tail is only twenty micromillimetres long, and contains no caudal glands. The anus is inconspicuous. The vagina is half as long as the body is wide. The size and shape of the eggs remain unknown. The posterior ovary is smaller than the anterior; the reflexed part of each extends two thirds the distance back to the vulva.

Habitat: About the roots of sugar-cane, Harwood, Clarence River, New South Wales, Australia.

2. *Dorylaimus subsimilis*, n. sp. $\frac{6}{1.1}$ $\frac{6}{3}$ $\frac{21}{3.3}$ $\frac{54}{3.5}$ $\frac{98.7}{2.1}$ 2 mm. Neck conoid, especially anteriorly, where it is also somewhat convex. The lip region is set off by a distinct constriction, and is one fourth as wide as the base of the neck. Lips six, low, confluent, each with two papillæ as usual; here, however, rather inconspicuous. No eyes. Spear well developed; its guiding ring distinctly to be seen. Posterior part of the œsophagus two-thirds as wide as the corresponding part of the neck, the expansion taking place gradually near the end of the anterior third; the lining distinctly to be seen. Cardiac collum shallow, though distinct. Intestine three fourths as wide as the body, dark. Rectum equal in length to the anal body diameter. Pre-rectum over twice as long as the rectum. Longitudinal fields one fifth as wide as the body. Nerve-ring encircling the œsophagus at a slight angle. Tail hemispherical-conoid; anus distinct; caudal glands absent; terminus blunt or rounded. Vagina conspicuous, and the position of the vulva therefore easily made out. Reflexed ovaries reaching back to the vulva.

Habitat: About the roots of sugar-cane, Harwood, Clarence River, New South Wales, Australia.

3. *Dorylaimus pusillus*, n.sp. $\frac{8}{1.3}$ $\frac{12}{3}$ $\frac{25}{3.4}$ $\frac{43}{3}$ $\frac{82}{2.1}$.9 mm. No markings were seen on the cuticle of this species, and the skin was, as usual in this genus, destitute of hair. The conoid neck was surmounted by a truncate head, bearing six small lips, each with the usual two papillæ. No

lateral organs were seen, and there were no eyes. The spear was well developed, being one third as wide as the lip region. The anterior three fifths of the œsophagus was only one third as wide as the corresponding part of the neck, but the remainder was twice as wide, the change in width taking place rather abruptly. The lining of the œsophagus appeared as a distinct double line. Though the cardiac collum was shallow it was distinctly to be seen. The olive-coloured intestine was two thirds as wide as the body, being granular and rather thin-walled. A large and conoid cardia projected into the cardiac cavity. The rectum was twice as long as the anal body-diameter, being of the same length as the pre-rectum. The tail tapered rapidly in the anterior third, thence onward it was narrow and ended in a fine point. There were no caudal glands. The vulva was always easily found on account of the prominence of the transparent chitinous vagina, two-thirds as wide as the body. The reflexed ovaries reached one-half to two thirds the way back to the vulva.

Habitat: Roots of sugar-cane, Harwood, Clarence River, New South Wales, Australia; also among roots of moss, Maclean, on the same river.

2. *Brachynema*, new genus.

All that is at present known concerning this genus is comprised in the following description of the first discovered and only known species.

1. *Brachynema obtusa*, n.sp. $\frac{3.3}{3.8}$ $\frac{10}{7.3}$ $\frac{25}{7.3}$ $\frac{Y}{8.7}$ $\frac{98}{4.3}$.6 mm. The foregoing formula is only approximate and represents the measurements taken from two young worms of this new and interesting genus. The cuticle seemed destitute of striæ. The conoid neck, which seemed endowed with a considerable power to expand and contract in length, terminated in a rounded head containing a spear 24 μ long and resembling that found in the pharynx of *Tylenchus*. Six stump-like setæ occurred on the margin of the head. There appeared to be six lips, and there were six papillæ immediately round the mouth-opening. Circular lateral organs were located on the sides of the head at a distance from the base of the spear equal to the length of that organ. There were no eyes. The bulbous swelling forming the base of the stout spear was oblique, the dorsal side being the larger and longer. There were three ox-bow shaped guides to the spear, each one third as long as the spear itself. The spear was contained in a muscular elongated ellipsoidal swelling three times as long as the spear and half as wide as the head, in this respect somewhat resembling that of *Onyx*. From the pharyngeal swelling the tubular portion of the œsophagus, which is one fourth as wide as the neck, leads backward to the posterior muscular swelling which also resembles that of the genus *Onyx*, being one fourth as long as the neck and two thirds as wide. The coarsely granular intestine is two-thirds as wide as the body. The rectum was one and one half times as long as the anal body-diameter, and was preceded by a pre-rectum twice as long as itself. This part of the anatomy closely resembled that of *Dorylaimus*. The lateral fields were one fourth as wide as the body. The ventral excretory pore was located half-way between the nerve-ring and the cardia. There were no glands in the conoid-hemispherical tail: the terminus was rounded. I believe the vulva will be found to be central and the female sexual organs double and symmetrical.

Habitat: Virginia soil from the hills opposite Harwood, Clarence River, New South Wales, Australia. This genus combines some of the characteristics of *Tylenchus*, *Onyx*, and *Dorylaimus*.

3. Tylenchus.

A description of this genus has appeared previously in these pages, and we therefore have only to quote the same here and refer the reader to the adjacent illustrations, which convey a very good idea of the anatomy.

Transparent striated round worms, in most cases devoid of bristles or setæ, varying in length from one-third of a millimetre to three and a half millimetres, attacking the tissues of plants, or more rarely animals, by means of a pharyngeal spear and sucking apparatus of the following construction:—A three-bulbed spear, capable of being thrust forth and withdrawn by appropriate muscles, is connected with a powerful median œsophageal

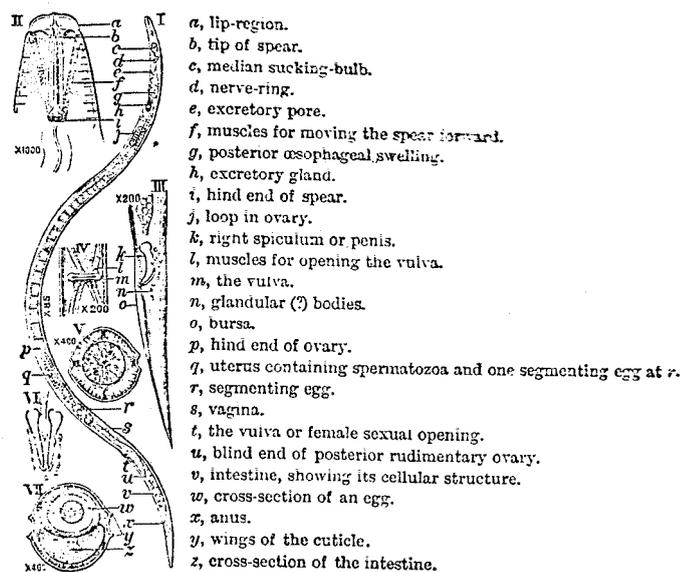


Fig. 31.—Side view of the devastating cel-worm, *Tylenchus devastatrix*. I, a female worm; II, head of the same worm more highly magnified; III, tail of a male; IV, view from below of the female sexual opening; V, cross-section of the worm, passing through the sucking-bulb; VI, front view of the penes and their accessory parts; VII, cross-section through the middle of a female, showing how the body-cavity is filled completely by the ovary (*u*) and the intestine (*z*).

sucking-bulb by means of a tube whose lining is more chitinous than is usual in other Nematode genera; the medium bulb is connected with a smaller posterior bulb of much weaker construction by means of a shorter and weaker tube, which passes through the oblique nerve-ring, situated just behind the median bulb. The posterior bulb may become rudimentary, but probably never quite disappears. Lateral organs as well as visual organs are unknown in the genus. The female sexual apparatus is usually single and asymmetrical, being in that case usually straight and directed forward, and often presenting a rudimentary posterior branch, but may be double and symmetrical. In the former case the vulva is behind the middle; in the latter case it is central. The male possesses two equal slightly arcuate spicula, and in most species a more or less well-developed bursa.

1. *Tylenchus setiferus*, n. sp. $\frac{2.5}{1.7}$ $\frac{10}{2}$ $\frac{15}{2.3}$ $\frac{47}{2.4}$ $\frac{55}{2.6}$.7 mm. This remarkable *Tylenchus*, of which only a few males were seen, stands in great contrast with other members of this genus. The head is armed with four prominent setæ, and the bursa is of a peculiar form. The thickish cuticle is transparent, and marked with plain transverse striæ, 1.5μ apart on the head. These are present in the outer layers of the skin as well as the inner, and the contour of the worm, as seen under the microscope, is in consequence crenate. The conoid neck terminates in a truncate head, bearing four curved and spreading submedian setæ, each about as long as the head is wide. The exact nature and form of these organs is shown in the accompanying sketch. Six spherical lips, each 2μ high, surmount the head, and form a lip region, which is set off from the head by a slight constriction. It remained uncertain whether each lip bore a papilla. There were no eye-spots, and no lateral organs were seen. A well-developed spear, eighteen micromillimetres long, and having three bulbs at its base, each two micromillimetres in diameter, is contained in the head. The anterior part of the œsophagus is a narrow tube of glistening chitine. The median sucking-bulb, which is situated a spear-length from the three bulbs described above, is ellipsoidal in shape. Behind the sucking-bulb the œsophageal tube becomes wider, namely, one fifth as wide as the neck; half way from the median bulb to the cardia it suddenly becomes one third as wide as the neck. The

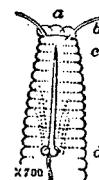


Fig. 32.—Head of *Tylenchus setiferus*; *a*, mouth and lips; *b*, ciphalic setæ; *c*, stands opposite the tip of the spear; *d*, stands opposite the base of the spear.



Fig. 33.—Anal region of *Tylenchus setiferus*; *a*, proximal end of the right-hand spiculum; *b*, bursa (right-hand flap); *c*, beginning of the tail.

cardiac collum is distinct, and behind it the intestine becomes at once two-thirds as wide as the body. The ventral excretory pore is situated just opposite the oblique nerve-ring, which is so broad that its posterior border is situated half way between the median bulb and the cardia. The base of the tail diminishes suddenly in diameter, becoming almost at once only half as wide as at the raised anus; thenceforth it is conical. There are no caudal glands. The bursa, when seen in profile, has the form of a trapezium; its ventral margin is parallel to the body axis; its posterior margin is almost perpendicular to its ventral margin, while its anterior margin slopes forward much as usual. The two equal, elongated, arcuate, acute spicula are one and a half times as long as the anal body diameter. The spicula are supplied with accessory pieces one third as long as they themselves are. The blind end of the testicle is situated as far behind the cardia as the latter is behind the mouth.

Habitat.—This worm was found in soil from the hills opposite Harwood, Clarence River, New South Wales, Australia.

2. *Tylenchus emarginatus*, n. sp. $\frac{4}{2.2}$ $\frac{12}{3}$ $\frac{21}{3.4}$ $\frac{-M}{3.55}$ $\frac{77}{6}$ mm. A characteristic feature of this species is the form of the bursa of the male. It forms with its posterior margin a re-entrant angle at the point where it joins the body. Consequently when the worm is viewed in profile, the tail presents a rather peculiar appearance. The striations of the cuticle are resolvable with high powers. The neck is of the usual conoid form, and is surmounted by a head six micromillimetres wide at the lips, and twelve micromillimetres wide opposite the base of the spear. The indistinct lips are three micromillimetres high. No papillae, lateral organs or eyes were seen. The spear is twenty micromillimetres long, and is slender but well developed, and has a base composed of three distinct bulbs, each one micromillimetre in diameter. The prolate median sucking-bulb is situated at a distance behind the spear, equal to the length of the latter organ. Just behind this bulb the œsophageal tube is one fifth as wide as the neck, but gradually expands until it finally becomes one half as wide as the body. The ventral excretory pore is situated just behind the nerve-ring. The latter is twenty micromillimetres behind the median bulb. The tail is conical from the inconspicuous anus, and is pointed at the terminus. There are no caudal glands. The distance of the inconspicuous vulva from the anus is equal to two thirds the length of the tail. The eggs measure $56 \mu \times 16 \mu$, that is, are two thirds as wide as the body, and from three to four times as long as wide; they apparently become segmented while yet in the uterus. The ovary extends forward to near the base of the neck. The tail of the male resembles that of his mate in form, but is supplied with a bursa three to four times as long as the anal body-diameter, so situated as to be nearly symmetrical with respect to the anus (though, as above mentioned, it has a re-entrant angle behind the anus), and then continuing for a short distance further on the tail.

$\frac{3.3}{2.3}$ $\frac{10}{3}$ $\frac{16}{3.5}$ $\frac{-65}{3.2}$ $\frac{78}{2}$ mm. is the formula for the female, which closely resembles the male in form. The uterus contained only one or two eggs at a time.

Habitat.—Soil, hills opposite Harwood, Clarence River, New South Wales, Australia.

3. *Tylenchus dihystra*, n. sp. $\frac{2.3}{3.7}$ $\frac{11}{2.6}$ $\frac{17}{2.9}$ $\frac{-57}{3.7}$ $\frac{97.5}{2.3}$ mm. The number of species of *Tylenchus* the females of which possess two ovaries is comparatively few. This species is, therefore, of interest, as adding to that number, and serving to give aid in characterising the group. The coarse, plain, striations of the cuticle (2μ) are easily resolvable with lenses of moderate power. The neck is convex-conoid anteriorly; on account of the indistinctness of the cardiac collum the length is not easily made out. The rounded head bears no setae. The lip region is hemispherical, but it was impossible to make out the number and nature of the lips. Neither lateral organs nor eyes were seen. The three bulbs forming the base of the spear were conspicuous, the three together measuring six micromillimetres in width, occupying, consequently, one fourth the width of the corresponding part of the neck. The spear of one specimen was measured, its length being found to be 28μ , and the breadth of its shaft 2μ . The prolate median bulb measured $16 \mu \times 10 \mu$, and was two thirds as wide as the neck. The nature of the posterior part of the œsophagus was difficult to make out. The intestine began as far behind the ventral excretory pore as the medium sucking-bulb was in front of it. In size it was two thirds as wide as the body, and in structure coarsely and irregularly granular. The rectum equalled the anal body-diameter in length. The excretory pore

was situated behind the median bulb, at a distance varying from one to two times the length of that organ. The wings occupied a space equal to one third the width of the body, and presented longitudinal lines separated by a distance equal to one seventh the width of the body. The nerve-ring encircled the œsophagus just behind the sucking bulb. The ventral contour of the conoid tail was continuous with that of the belly, there being no bend or curve as on the dorsal side. The anus was inconspicuous. There were no caudal glands. The vulva was depressed and conspicuous, and led into a vagina, one half to two thirds as long as the body was wide, and also conspicuous. The anterior outstretched ovary reached forward nearly to the cardiac region, and the similar posterior ovary extended backward nearly to the anus. The eggs were as long as the body was wide, and two-thirds as wide as long, and were segmented while still in the uterus. Male unknown.

Habitat.—Roots of sugar-cane, Harwood, Clarence River, New South Wales, Australia.

4. *Tylenchus minutus*, n. sp. Female unknown. $\frac{2.7}{1.8}$ $\frac{14}{3}$ $\frac{22}{3}$ $\frac{-M}{3}$ $\frac{75}{2.4}$ mm. The markings on the skin of this tiny worm, if present at all, were so small as to escape observation with a good immersion lens. There were no hairs on the body or setae on the head. Only the anterior third of the neck was convex-conoid. The head was almost truncate. Neither lips nor papillae were distinctly seen. There were no eyes, likewise no lateral organs. The spear, though minute, was perfect in form, having three bulbs at its base; its length was somewhat greater than the width of the head measured opposite its base. The ellipsoidal median sucking-bulb was half as wide as the neck, and was situated at the termination of the anterior two fifths of the neck. The tube leading from the bulb was at first only one fourth as wide as the neck, but in the posterior fifth of the neck was swollen to twice that width. As is usual in *Tylenchus*, the cardiac collum was indistinct. The intestine was half as wide as the body and coarsely granular. The ventral excretory pore was situated half way between the sucking-bulb and the intestine. The oblique nerve-ring encircled the œsophagus at a distance behind the sucking-bulb equal to the length of that organ. The tail was conical from the slightly-elevated anus, and was not supplied with a spinneret or with glands. The bursa extended along the tail a distance equal to three times the anal body-diameter and along the body in front of the anus a distance half as great as on the tail, and was in every way small and inconspicuous, its contour when seen in profile not reaching to the ventral contour of the worm. The two equal linear slightly arcuate spicula were fully twice as long as the anal body-diameter; their proximal ends were not contrasted in any way with the shafts. The very inconspicuous accessory pieces were half as long as the spicula, close and parallel to which they were situated.

Habitat.—Roots of sugar-cane, Harwood, Clarence River, New South Wales, Australia.

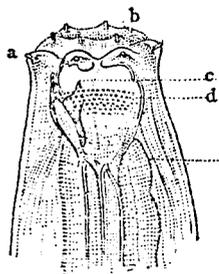
5. *Tylenchus uniformis*, n. sp. $\frac{1.8}{1.0}$ $\frac{?}{?}$ $\frac{?}{?}$ $\frac{-45}{2.5}$ $\frac{88}{2.2}$ mm. The transverse striæ of the cuticle were so inconspicuous as to be resolvable only with good lenses of high power. There were no hairs or cephalic setae. The lips were indistinct and the lip region was not, as is often the case in this genus, set off by a constriction. There were no eyes. The slender spear was one and a half times as long as the head was wide. The anterior part of the œsophagus was about half as wide as the corresponding part of the neck; the median bulb, which was located at the beginning of the

second third of the œsophagus was a mere slight expansion two fifths to one half as wide as that part of the neck; the tube connecting it with the expanded posterior fourth of the œsophagus was one fourth as wide as the neck; at its posterior extremity the œsophagus was half as wide as the base of the neck. The intestine was half as wide as the body, and displayed numerous large refracting granules. The rectum appeared to be equal to the anal body-diameter in length. The ventral excretory gland appeared to be located alongside the posterior swelling of the œsophagus; the ventral pore, its outlet, was situated just behind the nerve-ring, *i.e.*, in advance of the swelling just mentioned. The oblique nerve-ring encircled the œsophageal tube at the beginning of its fourth fifth. There were no glands in the tail, which was conical from the inconspicuous anus. The depressed vulva was easily to be seen. The posterior branch of the sexual organs was rudimentary, and extended only half way to the anus. The blind end of the anterior branch lay as far behind the cardia as the nerve-ring was in front of it. $\frac{1.3}{1.2} - \frac{10}{2.5} - \frac{18}{2.6} - \frac{M}{2.7} - \frac{90}{1.8} = 64$ mm. The tail of the male resembled that of his mate in form, but the anus was elevated and easily seen. No papillæ were seen. The bursa extended along the anterior fourth of the tail and equally far in front of the anus; it was so narrow as not to show beyond the ventral contour of the body when the worm was viewed in profile, and was, therefore, quite inconspicuous. The two equal elongated cuneiform spicula were twice as long as the anal body-diameter, and were arcuate in the distal two thirds, the proximal third being enlarged. The very inconspicuous accessory pieces were one fourth as long as the spicula, to which they were very close. The testicle extended forward to a point as far behind the cardia as the mouth was in front of it.

Habitat.—Found in soil about the roots of sugar-cane, Harwood, Clarence River, New South Wales, Australia.

4. Mononchus.

This genus includes at present nearly twenty species, none of which are parasitic. All feed on the roots or other tissues of plants. I have reason to believe they at times do considerable damage, more particularly to tender



a, papilla of the outer row.
b, papilla of the inner row.
c, dorsal tooth.
d, rasp-like teeth on inner wall of the pharynx.
e, beginning of the œsophagus.

Fig. 34.—Head of *Mononchus digitatus*, highly magnified.

seedlings. I have washed as many as three hundred of these worms from a single bunch of celery. The anatomy of a typical female is well shown in the adjacent wood-cut. The males are rare, and comparatively little is known about them.

1. *Mononchus intermedius*, n. sp. $\frac{2.5}{2.4} - \frac{7.1}{2.4} - \frac{24}{2.8} - \frac{61^{33}}{3.3} - \frac{94}{24} = 1.93$ mm. As in all other known species of *Mononchus*, the cuticle was devoid both of hairs and striations. The cylindrical neck terminated in a truncate head without setæ, but bearing six lips each with two papillæ as usual. Elongated oval markings placed transversely on the head just behind the base of the lips

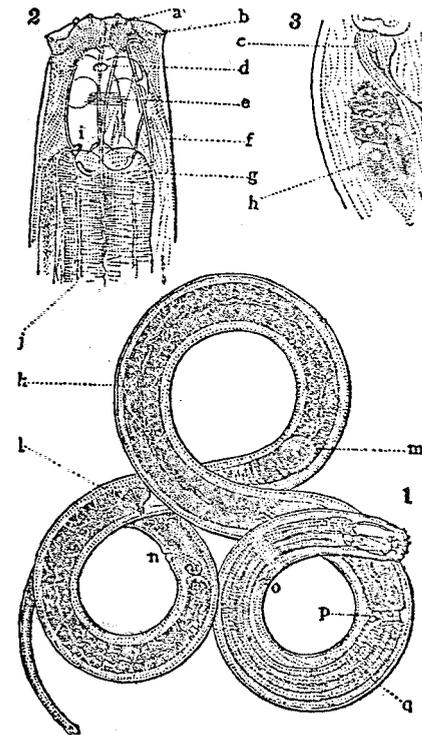


Fig. 35.—Anatomical details of *Mononchus gymnotaimus*: 1, female worm; 2, head of the same more highly magnified; 3, anal region.

a, papilla of the inner row.
b, papilla of the outer row.
c, rectum.
d, lateral organ.
e, striation of inner wall of pharynx.
f, pharyngeal muscles.
g, beginning of œsophagus.
h, caudal glands.
i, dorsal tooth.
j, œsophagus.
k, intestine.
l, vagina.
m, flexure in ovary.
n, anus.
o, excretory pore (?).
p, cardiac constriction or collum.
q, œsophagus.

served to represent the lateral organs; these were half as wide as the base of the nearest lip. This species agrees with all others of the genus in having no eyes. The pharynx was long and goblet-shaped, being half as long as the head is wide, and bearing a moderate-sized dorsal tooth two thirds the way from the base to the lips. In the neighbourhood of the nerve-ring the œsophagus is only half as wide as the neck, but near the pharynx it is

somewhat wider, and again posteriorly it becomes three fifths as wide as the body. The posterior part of the œsophagus appears to be coarser in structure than the anterior half; in all parts the lining appeared as three distinct double lines. The olive-coloured intestine, which was separated from the œsophagus by a distinct constriction, was three fourths as wide as

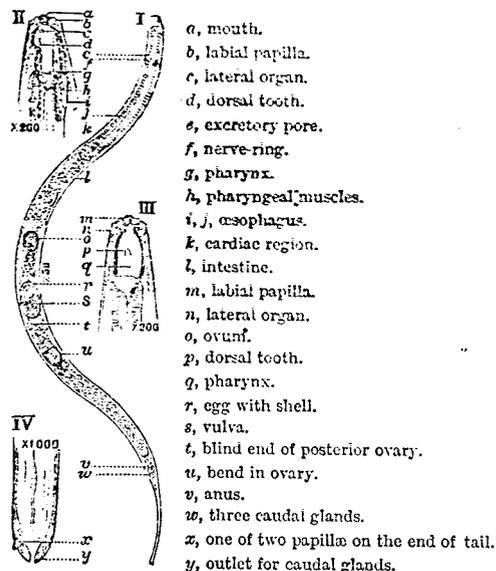


Fig. 36.—I, female *Mononchus longicaudatus*; II, side view of head of same worm; III, ventral view of head of same worm; IV, end of tail of same worm.

vagina half as long as the body was wide. The reflexed portion of the ovaries extended half-way back to the vulva.

Habitat.—About roots of sugar-cane, Harwood, Clarence River, New South Wales, Australia.

2. *Mononchus similis*, n. sp. $\frac{3.3}{3.7}$ $\frac{8}{3.5}$ $\frac{24}{4.1}$ $\frac{58^{23}}{4.5}$ $\frac{86}{2.4}$ 1.53 mm. As usual the skin was without hairs or markings of any kind. The cylindrical neck ended in a truncate head without setæ, but with the usual two rows of labial papillæ. The lateral organs were not seen unless they be represented by transverse slits near the base of the outside lateral papillæ. The pharynx was three fifths as wide as the head, and nearly one and one half times as long as wide, and contained a single small dorsal tooth at the base. In form the pharynx was triquetrous, and ribbed longitudinally, and had the middle half of the lateral walls covered with teeth like those of a file. The œsophagus was anteriorly one half, but posteriorly two thirds, as wide as the neck, and had a coarsely-radiated structure; its lining appeared as a triple line when seen in optical section. Cardiac collum shallow but distinct, pseudo-bulb faint. The olive-coloured intestine was three fourths as wide as the body, and the granules contained in its cells were so arranged as to give rise to a tessellation; this made it easy to count the cells, the result showing that it took about fifteen of them to build the circumference. The rectum was three fourths as long as

the body, and rather indistinctly tessellated; its commencement was marked by the presence of a pseudo-bulb, this appearance being brought about by the transparent nature of the walls in the cardiac region. The intestine ended in a rectum whose length equalled that of the anal body-diameter. The ventral excretory pore, or what appeared to be such, was located just behind the nerve-ring. The lateral fields were one-fourth as wide as the body. The nerve-ring encircled the œsophagus squarely as is always the case in this genus. Caudal glands were present in the conical and arcuate tail, which ended in an inconspicuous and almost pointed spinneret. The anus was depressed and conspicuous. The conspicuous vulva led into a

the anal body-diameter. A ventral pore, presumably the outlet of the ventral gland, occurred just behind the nerve-ring. As usual in *Mononchus*, the nerve-ring encircled the œsophagus rather squarely. The tail was arcuate and conoid from the conspicuous depressed anus, and ended in a blunt spinneret one eighth to one sixth as wide as the base. The spermatozoa were arranged in a ball in the uterus. The ovaries reached half-way back to the vulva.

Habitat.—Roots of sugar-cane, Harwood, Clarence River, New South Wales, Australia.

5. *Neonchus*, new genus.

1. *Neonchus longicauda*, n. sp. $\frac{16}{1.7}$ $\frac{75}{2.4}$ $\frac{16}{2.7}$ $\frac{50}{3}$ $\frac{64}{1.7}$ 7 mm. It is possible that this worm stands in a position between *Mononchus* and the spear-bearing genera. Only two rather immature females having been seen, it is not possible to make positive statements with regard to affinities. The skin bears a few hairs, and is marked by transverse striæ resolvable with high powers. With lenses of the highest power, each striation is resolvable into a row of dots. A rounded head surmounts the conoid neck. Ten spreading setæ, each two fifths as long as the head is wide, are arranged in the usual manner on the margin of the head. Four submedian subcephalic setæ, a trifle longer than those on the margin of the head, are found half-way between the lateral organs and the base of the pharynx. Small knob-like papillæ occur on the front of the head. The lateral organs resemble those of *Plectus*, being unclosed circumferences one fourth as wide as the head, situated opposite the middle of the pharynx. There are no eyes. The prismoid pharynx is about one fifth as long as the neck, and one seventh as wide, and is strongly lined with chitine. The dorsal wall is prolonged into a tooth or spear, and this organ seems to have guides somewhat after the manner of *Onyx*. *Neonchus* shows another resemblance to *Onyx* in the formation of the œsophagus, which is at first tubular, and only one-third as long as the corresponding part of the neck, but expands in the posterior fourth to form an elongated swelling two-thirds as wide as the base of the neck. Where the œsophagus receives the pharynx, it is also somewhat enlarged. The lining of the œsophagus appears as a single distinct line when seen in optical section. The cardiac collum is deep and very distinct. The irregularly granular intestine becomes at once three fourths as wide as the body. The rather small, shallow cardia can be distinctly seen. The rectum equals the anal body-diameter in length, or somewhat exceeds it. The nature of the ventral gland, and of the lateral fields, remains unknown. The nerve-ring surrounds the œsophagus almost squarely a trifle in front of the middle of the neck. The conoid tail tapers more rapidly near

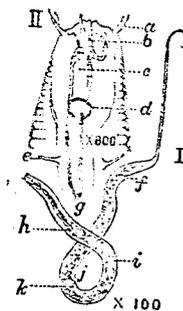


Fig. 37.—*Neonchus longicauda*: I, a female worm; II, head of the same worm more highly magnified; a, cephalic setæ; b, tooth or rudimentary spear; c, pharynx; d, lateral organ; e, subcephalic setæ; f, anus; g, base of the pharynx; h, posterior swelling of the œsophagus; i, intestine; j, vulva; k, either spermatozoa or immature ova.

the anus than elsewhere. The depressed anus is distinctly to be seen. There are no caudal glands. Possibly the tail is prehensile. The terminus is one sixteenth as wide as the base of the tail. I saw only immature females, and can only surmise that their sexual organs are double and symmetrical, and not reflexed (—♀—).

Habitat.—Soil about the roots of sugar-cane, Harwood, Clarence River, New South Wales, Australia. Also about the roots of moss near Maclean, on the same river.

6. Chromadora.

1. *Chromadora minima*, Cobb. $\frac{2.8}{2.5} \frac{?}{?} \frac{17}{3.0} \frac{45}{4.4} \frac{87}{2.8} = 51$ mm. The transverse striae are resolvable, with high powers, into rows of dots. The hairs on the body, if any be present, must be very inconspicuous. The neck was conoid, more especially in the anterior part. The head was somewhat truncate, and bore at least six small, rather forward-pointing setae, perhaps one sixth as long as the head was wide. The rather transparent lips bore papillae, probably twelve. The lateral organs were placed just behind the base of the pharynx; the right was a left-handed spiral of two

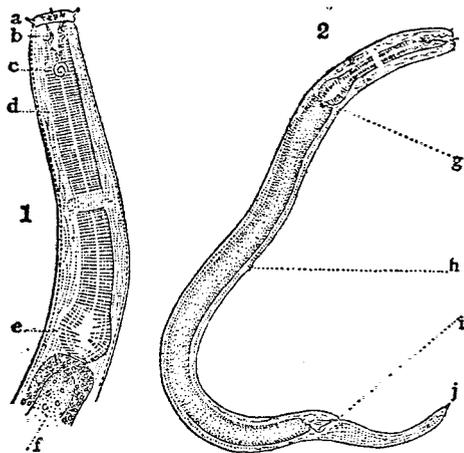


Fig. 38.—*Chromadora minima*, magnified.

a, one of the cephalic setae.
b, pharynx.
c, spiral lateral organ.

d, œsophagus.
e, posterior œsophageal bulb.
g, cardiac collum,

h, vulva.
i, anus.
j, spinneret

and a fourth turns, and the left was a similar right-handed spiral. The worm has no eye-spots. The anterior part of the pharynx was cyathiform, and presented the usual twelve chitinous ribs; the posterior part appeared sigmoid when seen in profile. The tooth was exactly like that of the Fiji worm (*C. minima*). The œsophagus was about half as wide as the neck, though where it received the pharynx it was somewhat larger; at the posterior extremity it enlarged to form a prolate bulb four fifths as wide as the base of the neck, and containing an elongated internal chitinous arrangement. The lining of the œsophagus was plainly visible, and appeared as two slightly sinuous lines. The rather thick-walled intestine was two

thirds as wide as the body, and was separated from the œsophagus by a distinct constriction; it ended in a rectum of the same length as the anal body-diameter. A ventral gland lay just behind the cardiac constriction, but all its parts were difficult to make out; the location of the pore, its outlet, was a little behind the ring, the ampulla being roundish. The tail was conoid from the rather conspicuous anus, and ended in an apiculate spinneret one fourth as wide as the body at the anus. The conspicuous shining vulva was slightly depressed. The two ovaries were outstretched (—♀—), the eggs being three times as long as the body was wide, and only about half as wide as long. The female is shown in the adjacent figures.

Habitat.—Soil about the roots of sugar-cane, Harwood, Clarence River, New South Wales, Australia. Found previously (1891) in Fiji, about the roots of banana plants. The Fiji worms were immature, and in consequence the descriptions imperfect. I have observed this worm also at Moss Vale, New South Wales.

7. Chaolaimus, new genus.

1. *Chaolaimus pellucidus*; n. sp. $\frac{4}{2} \frac{11}{4} \frac{23}{4.1} \frac{53}{4.7} \frac{95}{3.1} = 64$ mm. At first sight this worm has the appearance of a *Tylenchus*. It does not, however, belong to that genus, but, in all probability, to a new genus. Only one specimen was seen, and that an immature moulting female, so that many important parts of the anatomy remain unknown. The cuticle appears to be without striae, as none were seen with a $\frac{1}{8}$ homogenous immersion lens. There were no hairs on the body. Posteriorly the neck is cylindrical, though the anterior third is convex-conoid, and ends in a truncate head, bearing six papilla-like setae on the margin of the head. The lips, if they be present, must be very flat and inconspicuous. Neither eyes nor lateral organs were seen. The pharynx was difficult to understand. The posterior half was simple enough, merely cylindrical and one fifth as wide as the head, and having two chitinous thickenings like knobs at the base; this part was strongly lined with chitine. The anterior half of the pharynx was composed of numerous pieces of chitine arranged irregularly as if they were the fragments

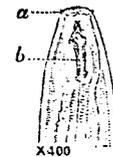


Fig. 39.—Head of *Chaolaimus pellucidus*.

of broken pharyngeal lining. The whole pharynx was enclosed in what appeared like an ellipsoidal bladder, twice as long as wide, and three fourths as wide as the head. All these observations are made of uncertain value because of the worm being in process of moulting the skin, and with it, of course, the pharyngeal lining. The cardiac collum was indistinct. The intestine was three fourths as wide as the body, and presented irregular granules. The ventral excretory pore was situated somewhat behind the nerve-ring, or, more accurately, at the end of the second third of the neck. The blunt tail was convex-conoid from the conspicuous depressed anus. The vulva was inconspicuous. The sexual organ appeared to be single, to extend forward (♀), and the reflexed part to extend back past the vulva, half-way to the anus. The only egg seen was twice as long as the body was wide, and one fourth as wide as long.

Habitat.—Roots of sugar-cane, Harwood, Clarence River, New South Wales, Australia.

8. Monhyстера.

So far as known the worms classed under this head are harmless to man. They inhabit the soil and the sea, and appear to feed upon microscopic organisms. A good idea of the anatomy will be gained by consulting the accompanying figures and those of the first species described below.

1. *Monhyстера rustica*, Bütschli. $\frac{2}{2.5}$ $\frac{11}{3.5}$ $\frac{18}{4.2}$ $\frac{60}{4.5}$ $\frac{70}{2.9}$.5 mm. The cuticle is marked by striae, resolvable with immersion lenses. A few hairs, about one eighth as long as the body is wide, are found here and there. The nearly cylindrical neck terminates in a truncate head, bearing near its margin ten spreading setae, arising opposite the base of the pharynx, each about one fourth as long as the head is wide, one of each submedian pair being somewhat shorter than its mate. There are six indistinct papillae inside the row of setae. The circular lateral organs are one fourth as wide as the neck, and are placed at a distance from the anterior extremity equal to three or four times the depth of the simple, somewhat cup-shaped pharynx. This latter is one third as wide as the head, and leads into a cylindrical oesophagus nearly two thirds as wide as the neck, and presents a very slight expansion in front of the distinct cardiac constriction. For some distance behind the pharynx the oesophagus is very transparent. The lining of the oesophagus when seen in optical section is more or less sinuous. At the

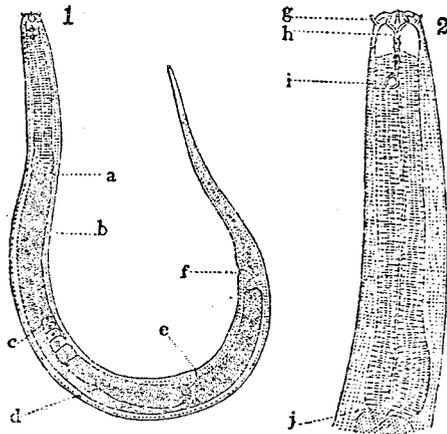


Fig. 40.—*Monhyстера rustica*, magnified. 1, Female worm; 2, head and neck of the same worm more highly magnified; a, cardiac collum; b, intestine; c, blind end of ovary; d, egg; e, vulva; f, anus; g, one of the cephalic setae; h, base of the pharynx; i, lateral organ; j, cardiac collum.

beginning, opposite the cardia, the intestine is somewhat transparent, giving rise at first to the impression that some gland-like organ is present here, but careful examination serves to dispel the deception. The intestine is two-thirds as wide as the body, and is composed of cells indistinctly to be seen on account of the multitude of granules with which they are filled. The transparent rectum is conoid, and its length is equal to that of the anal

body-diameter. Nothing was learned concerning either the ventral excretory organs or the lateral fields. The nerve-ring is situated near the middle of the neck, and encircles the oesophagus somewhat squarely. The tail is conoid to the swollen terminus, where it is one sixth as wide as at the base. There are caudal glands and a spinneret. The vulva is depressed. The eggs are twice as long as the body is wide, and one fourth as wide as long, and are probably deposited before segmentation begins.

Habitat.—About roots of moss, Maclean, Clarence River, New South Wales, Australia. This now well-known species is found also in Fiji. I am able here to add considerably to a knowledge of its anatomy.

2. *Monhyстера insignis*, n. sp. $\frac{1.3}{2.5}$ $\frac{10}{3}$ $\frac{22}{3.2}$ $\frac{75}{3.6}$ $\frac{85}{2.9}$.55 mm. The transverse striae were so fine as to be barely resolvable with a good one twelfth inch homogenous lens. A few hairs were scattered here and there on the worm; these were one fourth as long as the body was wide. The nearly cylindrical neck terminated in a truncate head bearing twelve spreading setae, each about half as long as the head was wide, though the members of the submedian pairs were not quite equal in length; these setae were attached just behind the transparent lips, of which there appeared to be three. Each of the six papillae found on the lips bore a minute bristle. The circular lateral organs were one fifth as wide as the head, and were located at a distance from the anterior extremity equal to twice the width of the head. There were no eyes. The pharynx consisted of an oblate mouth cavity one half as wide as the head, followed by a narrower conoid part; the length of the whole was equal to the width of the head. The width of the nearly cylindrical oesophagus was half as great as that of the neck; its lining appeared as a single distinct line. The granular intestine, which was two thirds as wide as the body, was separated from the oesophagus by a deep and distinct constriction, and ended in a transparent rectum nearly twice as long as the anal body-diameter. The tail, which was conoid from the depressed anus, contained caudal glands, and ended in a blunt apiculate spinneret one third as wide as the body at the anus.

Habitat.—Found about the roots of sugar-cane, Harwood, Clarence River, New South Wales, Australia.

3. *Monhyстера pratensis*, n. sp. $\frac{8}{2}$ $\frac{10}{2.9}$ $\frac{22}{3.3}$ $\frac{60}{3.8}$ $\frac{85}{2.3}$ 1 mm. The transverse striae of the cuticle are resolvable with high powers. The hairs, which occur throughout the length of the worm, are easily seen, as they are one fourth as long as the body is wide. The neck was cylindrical and the head truncate. The ten cephalic setae were about half as long as the head was wide, and were arranged in the usual manner, the submedian being sub-equal. The lip-region was transparent, and its details difficult to determine. If any papillae were present they must have been very inconspicuous. The circular lateral organs were one fourth as wide as the head, and were located at a distance from the anterior extremity equal to the width of the head. There were no eyes. The cylindrical oesophagus, which, though pretty uniformly three fifths as wide as the neck, was slightly swollen posteriorly, was separated from the intestine by a deep and distinct constriction. The lining of the oesophagus when seen in optical section appeared as a distinct single line. The transparent finely granular intestine was three fourths as wide as the body, and presented no signs of tessellation. The rectum somewhat exceeded the anal body-diameter in length. The nerve-ring was a trifle oblique. The tail was conical from the conspicuous depressed anus to the blunt spinneret, which was one eighth as wide as the base of the tail. The

alva was elevated and conspicuous. The single egg seen in the uterus was rectangular, being as long as the body was wide, and four fifths as wide as long; it was unsegmented. The spermatozoa were one half as wide as the uterus. The ovary appeared to extend about half-way to the cardia.

Habitat.—Found in soil about the roots of sugar-cane, Harwood, Clarence River, New South Wales, Australia.

4. *Monhystera Australis*, n. sp. $\frac{1.1}{2.4} \frac{10}{3} \frac{91}{3.2} \frac{50}{2.5} \frac{55}{2.1}$.55 mm. The information I have concerning the anatomy of this species is very meagre. The most striking feature is the nearness of the vulva to the anus. The cephalic setæ are well developed. The lip region is transparent, and encloses an oblate cavity half as wide as the head. I am uncertain about the location and size of the lateral organs; they were probably circles one fourth as wide as the neck, located at a distance from the anterior extremity equal to one and one half times the width of the head. The anterior part of the œsophagus was three fifths as wide as the neck; posteriorly, however, it became two thirds as wide as the neck. The dark-coloured intestine was three fourths as wide as the body, and was marked off from the œsophagus by a distinct constriction; its cells were easily made out on account of the transparency of the walls. The conoid rectum considerably exceeded the anal body-diameter in length. The body diminished more rapidly in size from the vulva backward. From the conspicuous elevated anus the tail was conoid to the somewhat conical and apiculate spinneret.

Habitat.—Soil from hills opposite Harwood, on the Clarence River, New South Wales, Australia.

9. Alaimus.

1. *Alaimus minor*, n. sp. $\frac{.5}{1} \frac{14}{2.5} \frac{33}{2.9} \frac{40}{2.9} \frac{96}{1.1}$.64 mm. The formula represents pretty much all that was discovered concerning this new species. The œsophagus was pretty uniformly one half to two thirds as wide as the neck. The sexual organ appeared to be single, and to extend backward; it remained uncertain whether it was reflexed. I am not positive about the length of the tail as expressed in the formula. Tail conoid.

Habitat.—Soil from hills opposite Harwood, Clarence River, New South Wales, Australia.

10. Bastiana.

1. *Bastiana Australis*, n. sp. $\frac{?}{6} \frac{?}{?} \frac{23}{1.5} \frac{M}{1.6} \frac{85}{1.5}$.95 mm. Female unknown. The neck was cylindrical posteriorly, but the anterior half was conoid. The rounded head bore the usual number of setæ, each of these being about as long as the head was wide. The œsophagus was of about the same shape as the neck, being from one third to one half as wide. The cardiac collum was distinct. The intestine was three fourths as wide as the body. The tail was conoid. The linear arcuate acute spicula were one and one-half times as long as the anal body-diameter. I think there were two testicles (—M—). The row of ventral accessory organs extended forward to the middle of the neck; the distance separating these organs one from another was about equal to half the width of the body.

Habitat.—Virgin soil from hills opposite Harwood, Clarence River, New South Wales, Australia.

11. Cephalonema, new genus.

1. *Cephalonema longicauda*, n. sp. This peculiar worm belongs to a new and very distinct genus. I have thus far seen two species—the present, on the Clarence River, and a second at Moss Vale, N.S.W. Both were, however, immature, so that much remains to be learned about the nature of the sexual organs. Nor is this all; for though I have been able to give in the accompanying figure a good idea of the form of the head and pharynx I can offer no explanation of the uses of the various organs or structures I have pictured. The worms at first sight appear to belong to *Dorylaimus*, another genus of free-living nematodes, but a short examination is sufficient to dispel this illusion. Two specimens of the present species gave the following measurements: $\frac{?}{?} \frac{18}{?} \frac{75}{?} \frac{44}{1.5}$ mm. and $\frac{4.8}{1.7} \frac{9.6}{1.8} \frac{20}{1.9} \frac{76}{1.9} \frac{1.1}{1.3}$ mm. Both were young, and as yet showed no traces of sexual organs. The body

wall was thick, like that of various species of *Dorylaimus*. No markings were seen on the cuticle. The neck was sub-cylindrical, and was capped by a somewhat rounded head set off by a distinct constriction. There were four very short submedian setæ, and these were the only hairs seen on the worm. The somewhat hemispherical lip region was evidently composed of six connate lips, bearing twelve papillæ, arranged in two rows somewhat like those on the head of *Dorylaimus*. I saw no lateral organs, and there were certainly no eyes. The long and narrow pharynx measured from one sixth to one fourth as wide as the head, and reached half-way to the nerve-ring, and contained near the lips an organ that resembles the thumb-shaped tooth sometimes seen in the anterior part of the pharynx of *Diplogaster*. In the anterior part the œsophagus was one half as wide as the neck; in the posterior third, however, it was widened after the manner of the œsophagus in *Dorylaimus* and *Onyx*. When seen in optical section the lining of the œsophagus appeared as a single line. The irregularly granular intestine was separated from the œsophagus by a rather indistinct constriction, and was narrower than the œsophagus, being only half as wide as the body. The rectum was equal in length to the anal body-diameter; there was no pre-rectum, as in *Dorylaimus*. The nerve-ring, which was two thirds as wide as the neck, encircled the œsophagus obliquely. The tail was conical from the slightly-depressed anus. There were no caudal glands, and the terminus was hair-fine.

Habitat.—Found about the roots of sugar-cane, Harwood, Clarence River, New South Wales, Australia.



Fig. 41.—Head of *Cephalonema longicauda*; a, labial papillæ; b, one of the four submedian cephalic setæ; c, horny processes in the mouth, of unknown significance; d, long tubular pharynx.

12. *Plectus*.

The nematodes belonging to this genus are harmless to crops. They are found both in the soil and on the surface of plants, and are never parasitic. They appear to feed upon microscopic organisms. They are active little worms, having the power to retain life after having been preserved for many years in a dry state. The characteristic features of the genus are unmistakable, and no one will ever, having once carefully examined a specimen, be at a loss to recognise similar worms in future. The long two-chambered pharynx, the œsophagus with a single well developed cardiac bulb, and the well developed spinneret are among the most striking features of the anatomy.

1. *Plectus parietinus*, Bastian. $\frac{7.8}{3.9} \frac{?}{?} \frac{22}{5.6} \frac{50}{6.9} \frac{80}{31}$ 1.13. This worm, of which only two females were seen, is probably the *parietinus* of Bastian.

2. *Plectus minimus*, n. sp. $\frac{?}{3.3} \frac{15}{3.6} \frac{30}{3.5} \frac{50}{2.2} \frac{90}{.33}$ mm. Although we are not in possession of very full details with regard to the anatomy of this species, there will, I think, be no difficulty in recognizing the species in future. The small size, the long neck and tail, and comparative slenderness are all striking characteristics. The pharynx was of the same form as that characteristic of the genus *Plectus*, and appeared to occupy two fifths of the space between the anterior extremity and the nerve-ring. The œsophagus was about half as wide as the neck, and ended in an elongated ellipsoidal bulb (three fourths as wide as the base of the neck), containing a distinct valve and connected with the intestine by a tubular cardia as long as the bulb itself. The intestine was about two thirds as wide as the body, and ended in a rectum one and one-half times as long as the anal body-diameter. The body diminished in size rapidly in the neighbourhood of the anus, the tail being conoid to the apiculate spinneret, which was one third as wide as that portion of the body nearest the anus. The single mature egg was four times as long as the body was wide, and from five to six times as long as wide; it was still unicellular, segmentation not having yet begun. The form of the sexual organs remains undetermined.

Habitat.—Soil from hills opposite Harwood, Clarence River, New South Wales, Australia.

3. *Plectus pusillus*, n. sp. $\frac{7.6}{2.9} \frac{17}{3.3} \frac{29}{3.9} \frac{52}{4.5} \frac{25}{2.6}$.43 mm. The plain transverse striæ were visible only with high powers of the microscope. No hairs were seen on the body. Posteriorly the neck was cylindroid, but in the anterior fourth it was convex-conoid. The truncate head bore four spreading setæ attached a little behind the base of the lips, each one fourth as long as the head was wide. There were six lips, as is usual in *Plectus*, and each of the six bore a papilla. The lateral organs were unclosed circumferences one fourth as wide as the head, located opposite the middle of the anterior half of the pharynx. This latter was two-chambered, the two chambers being of equal length; the anterior one was prismoid, one-fourth as wide as the head, and not expanded near the lips, while the posterior one was enclosed in a tube resembling the succeeding part of the œsophagus in size and appearance. There were no eyes. The anterior half of the œsophagus was two thirds as wide as the neck, but narrowed in the neighbourhood of the nerve-ring to one third as wide as the corresponding part of the neck. The cardiac bulb forming the posterior extremity of the œsophagus was broadly fusiform, and two thirds as wide as the base of the neck; it contained a distinct valve in front of its middle point, and was

connected with the intestine by an almost tubular cardia, extending into the cardiac cavity a distance equal to one fifth the length of the bulb. When seen in optical section the lining of the cardia appeared as a single distinct straight line. Corresponding with the nature of the cardia, the cardiac collum was very unusually broad and distinct. The intestine was three fourths as wide as the body, and, though granular, showed no traces of tessellation. The ventral gland lies in front of the cardia, and the pore, its outlet is located just behind the somewhat oblique nerve-ring. This latter is twice as broad as the œsophagus at the point encircled. The tail is conoid from the inconspicuous anus, and ends in a rounded apiculate spinneret one third as wide as the body at the anus. The vulva is elevated, and comparatively conspicuous. The thin-shelled eggs are more than twice as long as the body is wide, and are about one third as wide as long.

Habitat.—Soil about the roots of moss, Maclean, Clarence River, New South Wales, Australia.

4. *Plectus intermedius*, n. sp. $\frac{7.2}{3.2} \frac{13}{3.5} \frac{21}{4.2} \frac{50}{4.4} \frac{87}{2.8}$ 1. mm. The striæ of the cuticle are resolvable with moderate powers of the microscope. Very short hairs occur on the body. The conoid neck is surmounted by a rather rounded head. Four submedian, widely spreading setæ, each one fifth as long as the head is wide, occur at the base of the lips. These latter are six in number, are small, inconspicuous and hemispherical, and bear very inconspicuous papillæ. The lateral organs are unclosed circumferences, one seventh as wide as the head, and are located as far behind the cephalic setæ as the latter are behind the anterior extremity. There are no eyes. The entire pharynx is three tenths as long as the neck, its anterior chamber being half as long as the posterior. Near the mouth the anterior chamber is nearly half as wide as the head, but soon becomes narrower. The posterior part of the pharynx resembles the succeeding part of the œsophagus, but is easily distinguished by the presence in it of three arcuate expansions of the lining, which together form an arrangement having a fusiform contour. The tube of the œsophagus is about half as wide as the neck, and ends in pyriform or ellipsoidal bulb, two thirds as wide as the body, and containing a very distinct valvular apparatus half as wide as the bulb itself. The lining of the œsophagus, when seen in optical section, appears as a single line. The thin-walled and colourless intestine, which is marked off from the œsophagus by a deep and distinct constriction, is two thirds as wide as the body. Its cells contain small granules, not having any apparent definite arrangement. There is a very distinct cardia, half as long as the bulb, so large as to nearly fill the cardiac cavity. The rectum was somewhat longer than the anal body-diameter. The ventral excretory pore was located nearly opposite the nerve-ring. This latter encircled the œsophagus squarely. The conoid tail tapered from in front of the inconspicuous anus to the rounded apiculate spinneret, one fourth as wide as that portion of the body near the anus. The rather inconspicuous vulva was a depressed transverse slit, one third as long as the body was wide, and led into a vagina one half as long as the body was wide. The dark and conical thin-shelled eggs were from once and one half to twice as long as the body diameter, and from one third to two thirds as long as wide. The reflexed ovaries reached three fourths the distance back to the vulva. Near the blind ends of the ovaries the ova were arranged in several rows—not single file.

Habitat.—About the roots of sugar-cane, Harwood, Clarence River, New South Wales, Australia.

Plectus cephalatus (Abb 1893)

5. *Plectus cephalatus*, n.sp. $\frac{9}{5.4}$ $\frac{14}{6.3}$ $\frac{24}{7.3}$ $\frac{40}{8.3}$ $\frac{57}{8.3}$ 4 mm. This active and interesting little species adds another to the little group of *Plecti* having expansions of the cuticula in the neighbourhood of the head. These expansions, as well as all the rest of the cuticula, are marked with plain transverse striae resolvable with high powers. The hairs on the body are few, but they are conspicuous. The neck is conoid, and the head truncate. There are four submedian, forward-pointing, cephalic setae, each two thirds as long as the head is wide: these are situated on the margin of the head. The expanded lip region is composed of six prominent lips, each of which seems to bear a papilla. The lateral organs are unclosed circumferences, one third as wide as the head, exclusive of the cuticular expansions: regarded as spirals, the left is a right-handed spiral, and the right a left-handed spiral.

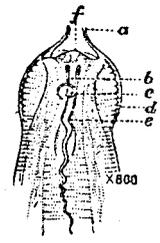


Fig. 42.—Head of *Plectus cephalatus*. a, four processes of the cuticular expansion d which pass forward and surround the mouth; b, anterior pharyngeal chamber; c, spiral lateral organ; d, expansion of the cuticle on the head; e, base of the anterior pharyngeal chamber.

There are no eyes. The two-chambered pharynx extends half-way to the nerve-ring, the anterior prismoid chamber, which is almost twice as long as the posterior, being one fourth as wide as the head; the posterior chamber is of the form usual in *Plectus*, and resembles the succeeding part of the oesophagus. At first the oesophagus is half as wide as the corresponding part of the neck, but it diminishes in its posterior part to one fourth as wide as the base of the neck, though it finally expands into a pyriform bulb, which includes the conspicuous cardia and is one half as wide as the neck. The lining of the oesophagus is plainly to be seen. The rather thick-walled intestine is three fourths as wide as the body, and is lined with chitine. The cardia, as indicated above, is very long and large. The rectum equals the anal body-diameter in length. The ventral excretory pore is situated just behind the nerve-ring. The two wings of the cuticula are separated by a distance equal to one ninth of the width of the body. The nerve-ring encircles the oesophagus pretty squarely. The tail is concave-conoid from the inconspicuous anus, and ends in an apiculate spinneret, one fourth as wide as the anal body-diameter is long. The vulva is rather conspicuous. The eggs are one and one half times as long as the body is wide, and two thirds as wide as long, and appear to be deposited before segmentation begins. The reflexed ovaries reach one half to two thirds the distance back to the vulva.

Habitat.—Found about the roots of moss near Maclean, Clarence River, New South Wales, Australia.

13. *Cephalobus*.

Some of the species of this genus have latterly come to be regarded with suspicion by those who pay particular attention to the diseases of plants. They are found to be in some cases parasitic or quasi-parasitic, and to occur in myriads, more especially in diseased parts. It remains, however, to be proved that they are the real offenders in such cases. From the structure of the mouth parts, one would expect the food to be such as to require little or

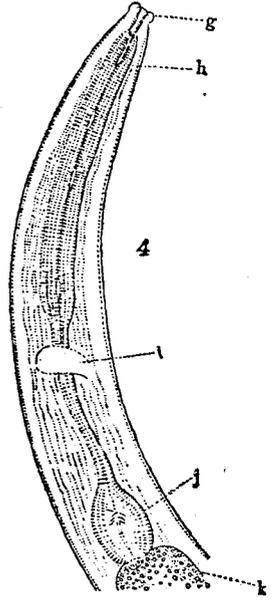


Fig. 43.—Head and neck of *Cephalobus*, magnified. g, lips; h, base of the pharynx; i, nerve-ring; j, posterior sucking-bulb; k, intestine.

no mastication, resembling as they do those of the genus *Rhabditis*. Many species of *Rhabditis* live for the most part on fouling matter, which has been reduced to a liquid or semi-liquid state by the action of fungi and microbes. It may be that this is true of most *Cephalobi*, and that where they have been found in such numbers in diseased parts of plants, they have been preceded by other organisms, which are the primary cause of the disease. The reader will be assisted to understand the nature of the mouth-parts and oesophagus by consulting the accompanying cut, showing the head and neck of a species found among the sheaths of diseased banana plants from Fiji.

1. *Cephalobus multicinctus*, n.sp. $\frac{2.1}{2.3}$ $\frac{17}{4.1}$ $\frac{27}{4.5}$ $\frac{42}{4.7}$ $\frac{50}{5.3}$ 56 mm. The plain transverse striae were easily resolvable with quarter-inch objectives, the distance between two successive striae measuring two micromillimetres. There were no hairs on the body. The neck was convex-conoid anteriorly, and ended in a truncate head, devoid of setae. The three inconspicuous lips were armed with

papilla. Curved markings, somewhat hook-shaped, or like an unclosed figure six, and located on the sides of the head at a distance from the anterior extremity equal to the length of the posterior oesophageal bulb, seemed to represent the lateral organs. The shape of the pharynx is well shown in the adjacent wood-cut. The anterior two thirds of the oesophagus was about

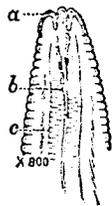


Fig. 44.—Head of *Cephalobus multicinctus*. *a*, the lips; *b*, base of the pharynx; *c*, oesophagus.

half as wide as the corresponding part of the neck. The junction of this part of the oesophagus, with the succeeding tubular part, was distinctly marked. There was no median swelling. About half-way down this anterior part of the oesophagus a sort of joint is indistinctly to be seen. The narrow tubular part of the oesophagus is only one fifth as wide as the neck, but expands at last to join the ellipsoidal cardiac bulb, which is two thirds as wide as the body. The intestine, which is separated from the oesophagus by a distinct constriction, was nearly three fourths as wide as the body, and presented a distinct lumen or channel. A small cardia projects into the large and conspicuous, thin-walled cardiac cavity. The rectum was twice as long as the anal body-diameter. The ventral excretory pore was located opposite the nerve-ring. This latter encircled the oesophagus a trifle obliquely, and was as wide as the anterior half of the oesophagus. The wings of the cuticle appeared as three longitudinal lines when seen under the microscope, the distance between the two outer lines being equal to one seventh the width of the body. The tail was conical from the inconspicuous anus, and contained no glands and had no spinneret. The vulva was inconspicuous—only slightly raised. There was but one ovary, and this extended first forward half way to the cardia, and then backward to a point equally far behind the vulva, where it was again reflexed and extended forward, and ended near the vulva. The ova were arranged single file. The eggs were as long as the body was wide, or a little longer, and nearly half as wide as long; they were segmented while still in the uterus.

Habitat.—About roots of sugar-cane, Harwood, Clarence River, New South Wales, Australia.

14. *Rhabditis*.

This genus is one of great interest from a purely scientific point of view, but is of no great economic importance. It combines with many features of the free-living nematodes, a number of those of the sorts found parasitic in animals. The anatomy of a typical species is shown in the following illustrations:—

1. *Rhabditis simplex*, n. sp. $\frac{3.3}{3} \frac{15}{5.4} \frac{24}{6.2} \frac{73}{5.6} \frac{88}{2.7}$ 66 mm. This formula is derived from the measurements of two rather immature females. The cuticle was transversely striated. Neck conoid; head truncate; cephalic setæ wanting; lips six, well developed, each with a papilla; eyes lacking; pharynx prismoid, one fourth as wide as that part of the neck opposite its base, a trifle wider just at the lips; anterior part of the oesophagus about half as wide as the corresponding part of the neck; median

bulb an almost imperceptible swelling, located a trifle in front of the middle of the neck; tube connecting the median swelling with the posterior bulb one sixth as wide as the corresponding part of the neck; posterior bulb, ellipsoidal, half as wide as the base of the neck, and containing a distinct valve; intestine three fourths as wide as the body, its cells distinct, its lining thick, and its channel apparently sinuous; rectum more than twice as long as the anal body-diameter; excretory pore just behind the nerve-ring; nerve-ring oblique; tail conical; caudal glands absent; vulva conspicuous though not elevated; vagina conspicuous.

Habitat.—Virgin soil, hills opposite Harwood, Clarence River, New South Wales, Australia.

2. *R. minutus*, n. sp. $\frac{3.7}{3.1} \frac{20}{5.1} \frac{33}{5.2} \frac{M}{5.4} \frac{93}{4} \frac{93}{4}$ 3 mm. Female unknown.

The cuticle of this tiny worm is traversed by transverse striæ resolvable only with high powers. Like other species of *Rhabditis*, the body is quite destitute of hairs. The neck is conoid, but becomes convex near the head, which is rather truncate, and bears no setæ, and only very inconspicuous papillæ—probably three. Neither lateral organs nor eyes were seen. The prismoid pharynx is one-fourth as wide as the anterior part of the neck, and is furnished near the lips with small separate pieces of chitine. The anterior part of the oesophagus is half as wide as the corresponding part of the neck, and ends in an elongated-ellipsoidal median bulb two-thirds as wide as the middle of the neck, where it is situated. The tube that leads onward from the median bulb is considerably narrower than the anterior part of the oesophagus, but expands finally to form an ellipsoidal bulb three-fourths as wide as the body. The valvular apparatus in this posterior bulb is distinctly to be seen. The intestine is three-fourths as wide as the body, its thin walls being

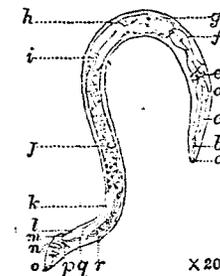


Fig. 45.—Male of *Rhabditis minutus*. *a*, lips; *b*, pharynx; *c*, oesophagus; *d*, median bulb; *e*, cardiac bulb; *f*, intestine; *g*, testicle; *h*, flexure in testicle; *i*, blind end of testicle; *j*, spermatozoa; *k*, ejaculatory duct; *l*, papilla; *m*, rib of bursa; *n*, ribs of bursa; *o*, ribs of bursa; *p*, accessory piece; *q*, left-hand spiculum; *r*, intestine.

lined with chitine. The cardia is very rudimentary, and the cavity behind it large and conspicuous. The ventral excretory pore is situated just behind the nerve-ring, which is as wide as the part of the oesophagus it obliquely encircles. The wings on the sides of the body are separated by a distance equal to one-eighth of the width of the body. The ventrally arcuate tail is conical from the elevated anus, and is completely enveloped by the bursa which springs from a point half as far in front of the anus as the middle of the tail is behind it. The terminus is pointed, and there are no caudal glands. The ribs of the bursa may be thus described:—There are eight pairs in all—two in front of the anus and very inconspicuous, four conspicuous long and slender ones on the anterior half of the tail, and three on the posterior third of the tail, less conspicuous. The two equal, brownish, linear, slightly arcuate spicula are axial in position, their proximal ends being inconspicuous. In length they are one and one half times greater than the anal body-diameter. The accessory pieces are half as long as the spicula;

instead of being placed parallel to the spicula they are placed nearly perpendicular to them. The testicle is so reflexed near its free extremity that the blind end lies as far behind the cardia as the latter is behind the mouth, the reflexed part being one-third as long as the neck. Most of these particulars are well illustrated in the adjacent figure.

Habitat.—Roots of sugar-cane, Harwood, Clarence River, New South Wales, Australia.

3. *R. filiformis* (?). Bütschli $\frac{2.8}{2.4}$ $\frac{14}{3.8}$ $\frac{19}{4.1}$ $\frac{43}{4.3}$ $\frac{71}{5}$. 5 to 6 mm. This species is the same as that found in Fiji, and appears to be identical with that described by Professor Bütschli, under the name of *filiformis*. The following is a quotation from the description of this species as it stands in the *Macleay Memorial Volume*:—Cuticle plainly but finely transversely

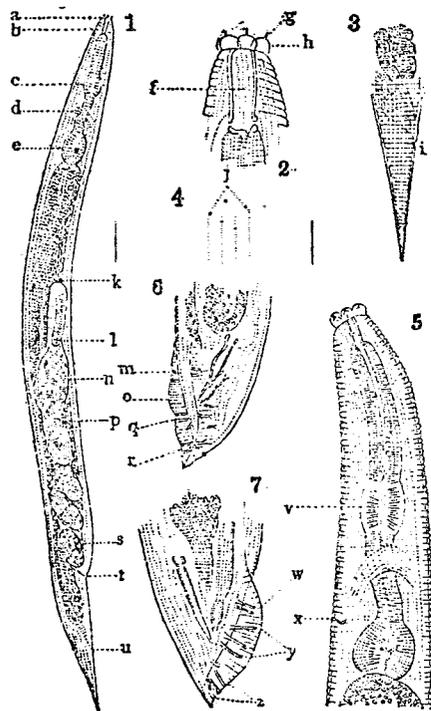


Fig. 46.—*Rhabditis filiformis*: 1, female worm magnified; 2, head of the same worm more highly magnified; 3, tail of the same worm; 4, figure to show relative width of body and lateral wings; 5, head and neck; 6, tail-end of a male; and 7, another view of the same

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|----------------------------|-----------------------------------|------------------------------------|
| a, lips and papillæ | j, wings of cuticle. | s, segmented egg. |
| b, pharynx. | k, flexure in ovary. | t, vulva. |
| c, median œsophageal bulb. | l, blind end of ovary. | u, anus. |
| d, nerve-ring. | m, bursal ribs of anterior group. | v, median bulb. |
| e, posterior bulb. | n, spermatozoa. | w, ribs of anterior group. |
| f, pharynx. | o, bursa. | x, excretory pore. |
| g, papilla on lip. | p, egg. | y, bursal ribs of median group. |
| h, lip. | q, bursal ribs of median group. | z, bursal ribs of posterior group. |
| i, anus. | r, ribs of posterior group. | |

striated; neck nearly cylindrical to behind the pharynx, then convex-conoid to the mouth, which is one-fourth as wide as the base of the neck; lip

region half as wide as the prolate cardiac bulb; only traces of lips; no setæ or papillæ on the head; œsophagus in the anterior half fusiform and about half as wide as the neck, thence narrowing gradually to a tube one-fifth as wide as the neck; cardiac sucking bulb one-half as wide as the neck; cardiac collum distinct, the constriction deep; intestine thick-walled, four-fifths as wide as the body, with a thick transparent lining; cardia small, the cavity large; rectum narrow, nearly twice as long as the anal body-diameter, separated from the intestine by a distinct constriction; ventral excretory pore somewhat behind the middle of the neck (12.5%); wings of the cuticle nearly as far apart as the opposite sides of the pharynx; tail conoid from the distinct anus, its terminus hair-fine; near the anus two lateral glands which empty through lateral pores at the beginning of the second sixth of the tail; vulva depressed; vagina very short; reflexed ovaries reaching half-way back to the vulva; eggs as long as the body is wide and two-thirds as wide as long.

Habitat.—Soil about roots of moss, &c., near Maclean, Clarence River, New South Wales, Australia.

The foregoing descriptions, comprise all that was learned about the nematode worms to be found on, or in, or about the roots of sugar-cane on the Clarence River. The conclusions to be drawn from my observations are briefly these: 1. Nematodes are abundant in the soil about the roots of cane both in healthy and diseased fields on the Clarence River. 2. They are not more abundant in badly diseased fields than elsewhere. 3. Most of the thirty species seen occur also in fields where no cane is growing, and many of them in virgin soil far removed from plantations. 4. While fully half the species seen are more or less injurious to plants, no species was seen in sufficient numbers to do a serious amount of damage, and not a single species was seen that appeared to be parasitic.

It is thought best to publish the descriptions, however, notwithstanding the negative results, and this for several reasons. They serve to show the detailed manner in which the investigations were conducted throughout, and serve to render it probable that Australian sugar-cane growers have little to fear from these baneful animals. They constitute furthermore, a considerable contribution to a scientific knowledge of a group of animals which includes many of the worst parasites known.