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Nematode worms found attacking sugar-cane

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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 Soltwedel has been pointed out by one writer as a probable cause of the cane disease known as Sereh. The measurements of this worm, as given by Dr. Krüger, are $\frac{2\cdot6 \quad ? \quad ? \quad M \quad 95\cdot}{1\cdot5 \quad ? \quad ? \quad 2\cdot9 \quad 2\cdot4}$ 1·78 mm. and $\frac{2\cdot1 \quad ? \quad ? \quad -86\cdot60 \quad 95\cdot}{2\cdot \quad ? \quad ? \quad 2\cdot4 \quad 1\cdot9}$ 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 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.

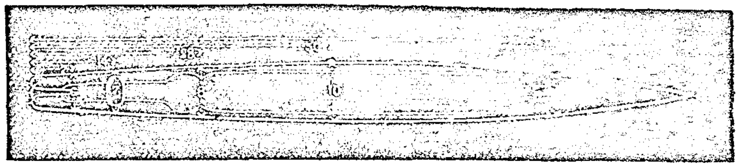


Fig. 29.—Diagram in explanation of the descriptive formula used for Nematode worms; 6, 7, 8, 10, 6 are the transverse measurements, while 7, 14, 28, 50, 88 are the corresponding longitudinal measurements. The formula in this case is:—

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

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 pharanx, 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.

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 are, as a rule, much larger than *Tylenchi* or *Aphlenchi*, 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

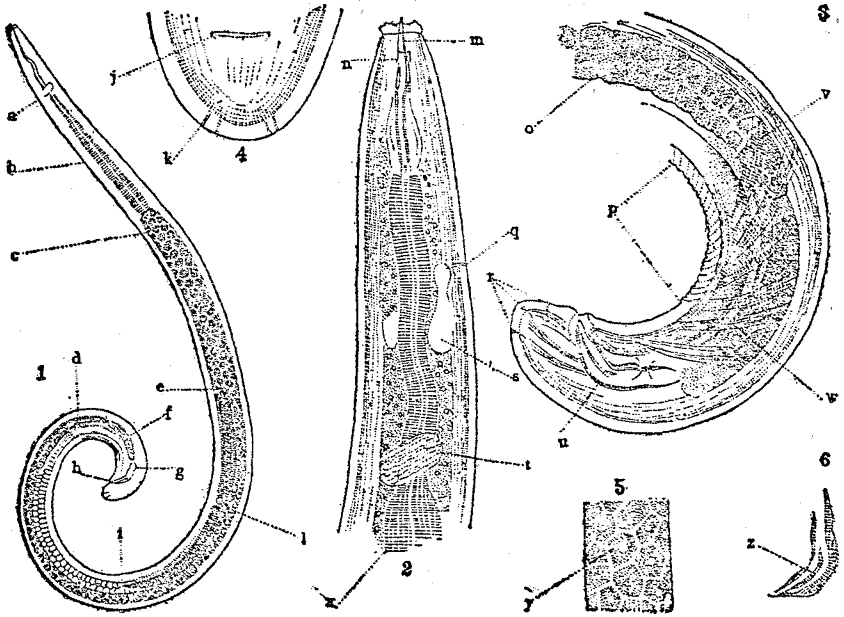


Fig. 30.—Anatomical details of *Dorylaimus perfectus*; 1, male worm magnified; 2, head and anterior part of the neck of the same worm more highly magnified; 3, tail end of same worm more highly magnified; 4, posterior end, ventral view; 5, a portion of the intestine; 6, spiculum.

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

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. $\frac{\cdot 5 \quad 14\cdot \quad 28\cdot \quad `68\cdot'^{25} \quad 95\cdot 7}{1\cdot 5 \quad 3\cdot 8 \quad 4\cdot 1 \quad 4\cdot \quad 2\cdot 3}$ ·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. $\frac{\cdot 6 \quad 6\cdot \quad 24\cdot \quad `54\cdot'^{30} \quad 98\cdot 7}{2\cdot 1 \quad 3\cdot \quad 3\cdot 3 \quad 3\cdot 5 \quad 2\cdot 1}$ 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. $\frac{\cdot 8 \quad 12\cdot \quad 25\cdot \quad `48\cdot'^{25} \quad 82\cdot}{1\cdot 3 \quad 3\cdot \quad 3\cdot 4 \quad 3\cdot \quad 2\cdot 1}$ ·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.

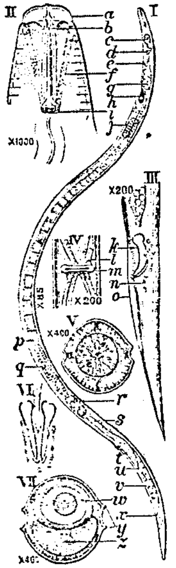
1. *Brachynema obtusa*, n.sp. $\frac{3\cdot 3 \quad 10\cdot \quad 25\cdot \quad Y \quad 98\cdot}{3\cdot 8 \quad 7\cdot 3 \quad 7\cdot 8 \quad 8\cdot 7 \quad 4\cdot 3}$ ·6 mm. The foregoing formula is only approximate and represents the measurements taken from two young worms of this new and interesting 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: Virgin 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 pharyngial 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 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.



a, lip-region.
b, tip of spear.
c, median sucking-bulb.
d, nerve-ring.
e, excretory pore.
f, muscles for moving the spear forward.
g, posterior œsophageal swelling.
h, excretory gland.
i, hind end of spear.
j, loop in ovary.
k, right spiculum or penis.
l, muscles for opening the vulva.
m, the vulva.
n, glandular (?) bodies.
o, bursa.
p, hind end of ovary.
q, uterus containing spermatozoa and one segmenting egg at *r*.
r, segmenting egg.
s, vagina.
t, the vulva or female sexual opening.
u, blind end of posterior rudimentary ovary.
v, intestine, showing its cellular structure.
w, cross-section of an egg.
x, anus.
y, wings of the cuticle.
z, cross-section of the intestine.

Fig. 31.—Side view of the devastating eel-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 (*w*) and the intestine (*z*).

1. *Tylenchus setiferus*, n. sp. $\frac{2{\cdot}5}{1{\cdot}7}\ \frac{10\cdot}{2\cdot}\ \frac{15\cdot}{2{\cdot}3}\ \frac{47\cdot}{2{\cdot}4}\ \frac{85\cdot}{2{\cdot}6}$ ·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, 1·5 μ 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 2· μ 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 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.

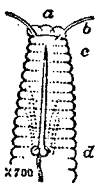


Fig. 32.—Head of *Tylenchus setifera*; *a*, mouth and lips; *b*, ciphalic setæ; *c*, stands opposite the tip of the spear; *d*, stands opposite the base of the spear.

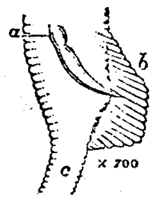


Fig. 33.—Anal region of *Tylenchus setifera*; *a*, proximal end of the right-hand spiculum; *b*, bursa (right-hand flap); *c*, beginning of the tail.

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

2. *Tylenchus emarginatus*, n. sp. $\frac{4\cdot}{2\cdot2}\;\frac{12\cdot}{3\cdot}\;\frac{21\cdot}{3\cdot4}\;\frac{-\mathrm{M}}{3\cdot53.}\;\frac{77\cdot}{}$ ·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 papillæ, 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 μ x 16 μ, 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.

$\frac{3\cdot3}{2\cdot3}\;\frac{10\cdot}{3\cdot}\;\frac{16\cdot}{3.5}\;\frac{-\overset{45}{65\cdot}}{3\cdot2}\;\frac{78\cdot}{2\cdot}$ ·68 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 dihystera*, n. sp. $\frac{2\cdot3}{3\cdot7}\;\frac{11\cdot}{2\cdot6}\;\frac{17\cdot}{2\cdot9}\;\frac{-\overset{70}{57}-}{3\cdot7}\;\frac{97\cdot5}{2\cdot3}$ ·55mm. 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 (2 μ) 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 setæ. 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 28 μ, and the breadth of its shaft 2 μ. The prolate median bulb measured 16 μ x 10 μ, 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. $\frac{2\cdot7}{1\cdot8}\;\frac{14\cdot}{3\cdot}\;\frac{22\cdot}{3\cdot}\;\frac{\mathrm{M}}{3\cdot}\;\frac{75\cdot}{2\cdot4}$ ·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 setæ on the head. Only the anterior third of the neck was convex-conoid. The head was almost truncate. Neither lips nor papillæ 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.

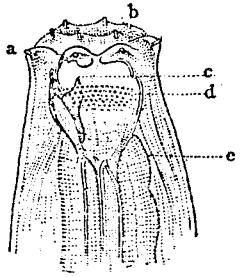
5. *Tylenchus uniformis*, n. sp. $\frac{1\cdot8}{1\cdot9}\;\frac{?}{?}\;\frac{?}{?}\;\frac{-\overset{45}{45\cdot}-}{2\cdot5}\;\frac{88\cdot}{2\cdot2}$ ·63 mm. The transverse striæ of the cuticle were so inconspicuous as to be resolvable only with good lenses of high power. There were no hairs or cephalic setæ. 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. $\frac{1\cdot8}{1\cdot2}\;\frac{10\cdot}{2\cdot5}\;\frac{18\cdot}{2\cdot6}\;\frac{-M}{2\cdot7}\;\frac{90\cdot}{1\cdot8}$ ·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 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.



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.

1. *Mononchus intermedius*, n. sp. $\frac{2\cdot5}{2\cdot4}\;\frac{7\cdot4}{2\cdot4}\;\frac{24\cdot}{2\cdot8}\;\frac{{}^{\cdot}61\cdot^{35}}{3\cdot3}\;\frac{94\cdot}{24}$ 1·93 mm. As in all other known species of *Mononchus*, the cuticle was devoid both of hairs and striations. The cylindroid 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 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

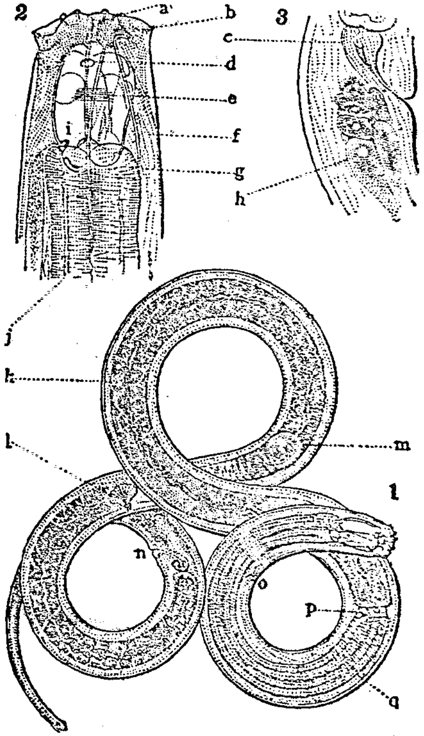
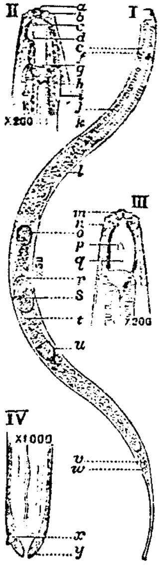


Fig. 35.—Anatomical details of *Mononchus gymnolaimus*: 1, female worm; 2, head of the same more highly magnified; 3, anal region.

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, acesophgus.

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



a, mouth.
b, labial papilla.
c, lateral organ.
d, dorsal tooth.
e, excretory pore.
f, nerve-ring.
g, pharynx.
h, pharyngeal muscles.
i, *j*, œsophagus.
k, cardiac region.
l, intestine.
m, labial papilla.
n, lateral organ.
o, ovum.
p, dorsal tooth.
q, pharynx.
r, egg with shell.
s, vulva.
t, blind end of posterior ovary.
u, bend in ovary.
v, anus.
w, three caudal glands.
x, one of two papillæ on the end of tail.
y, outlet for caudal glands.

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.

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

2. *Mononchus similis*, n. sp. $\frac{3\cdot3 \quad 8\cdot \quad 24\cdot \quad \overset{22}{`58\cdot'} \quad 86.}{3\cdot \quad 3\cdot5 \quad 4\cdot1 \quad 4\cdot5 \quad 2\cdot4}$ 1·83 mm. As usual the skin was without hairs or markings of any kind. The cylindroid 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 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. $\frac{1\cdot6 \quad 7\cdot5 \quad 16\cdot \quad 50\cdot \quad 64\cdot}{1\cdot7 \quad 2\cdot4 \quad 2\cdot7 \quad 3\cdot \quad 1\cdot7}$ ·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 sub-cephalic 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

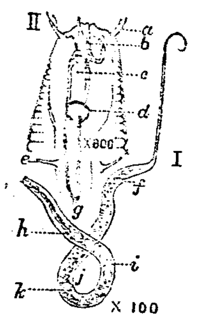


Fig. 37.—*Neonchus longicauda*: I, a female worm; II, head of the same worm more highly magnified; *a*, cephalic setæ; *b*, tooth or rudimentary spear; *c*, pharynx; *d*, lateral organ; *e*, sub-cephalic seta; *f*, anus; *g*, base of the pharynx; *h*, posterior swelling of the œsophagus; *i*, intestine;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