THE MONONCHS[1]

(*Mononchus* Bastian 1866)

A GENUS OF FREE-LIVING PREDATORY NEMATODES

CONTRIBUTIONS TO A SCIENCE OF NEMATOLOGY VI

(With 75 illustrations in the text)[2]

By

N. A. Cobb 1917

Introduction

Mononchs are Predaceous

No free-living nematodes have gained more in interest during recent years than those constituting the genus *Mononchus;* this is because the latest discoveries have led to a complete change of view concerning their economic relationships. Careful examination, here recorded, of a large number of specimens belonging to many different species of *Mononchus,* has fully demonstrated the predaceous character of certain common and widely spread soil-inhabiting species—which are found to feed on other small animal organisms, such as protozoa and rotifers, and, most interest-

[1] Reprinted from *Soil Science,* May, 1917, with renumbering of pages and errata, (p. 184).

[2] For the most part the illustrations were prepared under the author's personal supervision by Mr. W. E. Chambers of the Bureau of Plant Industry. Many features set forth in them cannot be seen in the natural object except with the aid of the best immersion lenses skillfully used under favorable conditions. Frequently no further allusion is made to facts thus elucidated. So, too, information contained in the key may not be repeated elsewhere; the key should therefore be consulted in connection with each description. Most of the illustrations are original; when not so, their source is indicated. The species figures are all at the same magnification, so that the reader may judge of the relative sizes of the nemas. Explanatory abbreviations follow.

amp—ampulla
amph—amphid
an—anus
an gl—anal gland
ar dnt—denticular area or rasp
cav som—body cavity
cl int—intestinal cell
cl msc—muscle cell
cl nrv—nerve cell
cl nrv subm—submedian nerve cell
col crd—cardiac collum
crd—cardia
cst ph—pharyngeal rib
cut—cuticle
dct—duct
dct gl cll—duct of one of the caudal glands
dnt—denticules
flx ovr post—flexure of posterior ovary
gl—gland
gl an—anal gland
gl cdl—caudal gland
gl oe—œsophageal gland
grn—granule
gl sal—salivary gland
ing—ingested material
ing nematod—ingested nematode
int—intestine
jnc—junction
lam lb—labial lamina
lb—lips
lum int—lumen of intestine
lum oe—lumen of œsophagus
lum som—body cavity
ms an—anal muscle
msc oe—œsophageal muscle
msc som—body muscle
mur ex—external wall
mur int—intestinal wall
mur ph—pharyngeal wall
mur ut—wall of uterus
ncl—nucleus
ncl cl int—nucleus of intestinal cell
ncl lat—lateral nucleus
ncl ov—nucleus of ovum
nrv—nerve
nrv r—nerver ring
oe—œsophagus
oes lum—œsophageal lumen
on dsl—dorsal tootb
on rtr dsl—retrorse dorsal tooth
on rtr subm—retrorse submedian tooth
on subm dxt—right submedian tooth
on subm snst—left submedian tooth
org—organ
ov—ovum
ov dct—oviduct
ov frt—fertilized egg
ov im—immature egg
p ex—excretory pore
ph str—pharyngeal striae
por—pore
por gl oe—pore of œcophageal gland
ppl—papilla
ppl cdl—caudal papilla
ppl intr—interior papilla
ppl lb—labial papilla
ppl lb extr—exterior labial papilla
ppl subm—submedian papilla
ppl subm sec—secondary submedian papilla
ppl trm—terminal papilla
rcpt sem—seminal receptacle
rct—rectum
reg vnt—ventral field
set—seta
spm—spermatozoa
spn—spinneret
str mur ph—striæ of pharyngeal wall
subcut—subcuticle
sut lb—labial suture
tcg ov—egg shell
trm ovr—blind end of ovary
ut—uterus
vag—vagina
vag msc—vaginal muscle
vlv—vulva

ing of all, on other nemas—and has made it practically certain that all mononchs are predaceous.

Economic Importance. If, as is often the case, the nemas destroyed by the mononchs are nemas injurious to agriculture, then the mononchs are beneficial to man. The first definite instance of this kind was reported in the *Journal of Agricultural Research* in September, 1914: *Mononchus papillatus* was shown to feed upon *Tylenchulus semipenetrans*, the latter a nema infesting the roots of citrus trees. Since that time the writer has observed many similar instances, fourteen of which are recorded herein.

Formerly mononchs were considered harmful to vegetation. The basis of this opinion was twofold: first, they were known to congregate about the roots and between the leaf sheaths of plants, especially succulent plants, in sufficient number to justify the opinion that they would be harmful, provided they were vegetarians; second, vegetable matter was often found in their intestines.

More careful investigation, however, has disclosed other facts incompatible with this opinion that mononchs are harmful to vegetation. The food-habits of mononchs have now been more carefully investigated, as herein recorded, and each species so studied has proved to be carnivorous. The presence of vegetable matter in a mononch's intestine proves to be no very definite criterion of its food habits, appearances to the contrary notwithstanding. A deception has arisen that is now easily explained. The occurrence of vegetable organisms in the intestine of a mononch is merely incidental; in many instances it would be impossible for the mononch to devour its prey without at the same time swallowing vegetable matter. For instance, suppose a mononch to bolt, as one of its victims, a monhystera — a common occurrence. Monhysteras are vegetarians, some of them feeding almost exclusively upon diatoms, others upon other kinds of unicellular algæ. Both on account of their peculiar structure and their bright green color, these diatoms and other algæ are very conspicuous objects in the intestine of the monhystera. Imagine now the appearances presented by the body of an ingested monhystera, swallowed whole, or nearly so, and lying lengthwise in the intestine of a mononch. Under such circumstances, which are entirely normal, the diatoms and other algæ in the intestine of the monhystera may be observed through the colorless tissues

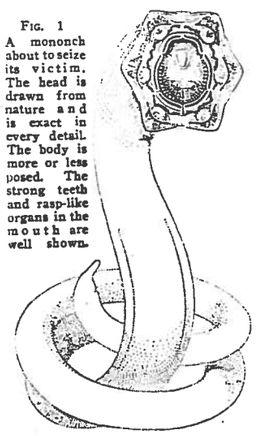


FIG. 1
A mononch about to seize its victim. The head is drawn from nature and is exact in every detail. The body is more or less posed. The strong teeth and rasp-like organs in the mouth are well shown.

of both the mononch and the monhystera, without the body wall of either nema being very plainly visible: it is somewhat as if one looked through the walls of two glass tubes, one within the other, to view comparatively conspicuous objects in the inner tube. Such an observation might easily lead to the conclusion that the mononch had been feeding upon unicellular algæ. The deception is heightened after the body of the monhystera is partially digested, for then all vestiges of the monhystera become practically invisible, and there are left as comparatively conspicuous remains the less readily digested vegetable matter, lying loose in the intestine of the mononch,—the frustules of diatoms for instance, which of course are wholly indigestible. Taking everything into consideration, it is not in the least surprising that hitherto observers have been deceived as to the food habits of mononchs.

As nematologists heretofore have not carefully studied the food habits of mononchs, particular attention was given them in the course of these investigations; but in spite of the care exercised much remains to be discovered. The mouth parts and digestive organs have come in for special study, since it is mainly here that we get clues, faint and puzzling though they be, that help interpret the little we can glimpse of the food habits of these organisms in their natural state. Soil mononchs live in darkness and, as might be expected, behave in a wholly unnatural way when placed in water on a microscope slide and brought in a drowning condition into the blaze of light necessary to a microscopic examination. The difficulties and delays attendant on such a line of research are manifest. Nevertheless, certain fundamental facts have been established; new organs have been discovered and light has been thrown on the true nature and function of organs not hitherto understood. It has seemed best to dwell on the various habits and functions while describing the structures with which they are associated.

As we gain familiarity with the food habits of nemas, it becomes possible on this new basis to make comparative anatomical studies, the results of which may be applied in determining the food habits of newly discovered genera and species.

I

STRUCTURE, FUNCTIONS, AND DISTRIBUTION OF MONONCHS

The mononchs constitute a genus of free-living, predatory nematodes inhabiting soil and fresh water, as well as the above-ground parts of certain plants. The average form and size of a mononch is indicated by the following average formula: $\frac{2.2\ \ 7.4\ \ 25.\ \ '63''\ \ 92.7}{2.1\ \ 2.6\ \ 3.\ \ 3.2\ \ 2.}$ 2.4 mm.*

* This formula, which is now coming into more general use, is simply a decimal method of stating concisely the necessary measurements. The formula is fully explained in the appendix, p. 184.

which corresponds very closely with that of the type species of the genus, *M. truncatus* Bastian, and especially with *M. papillatus* Bastian.

Skin or Cuticle

Striæ. While the skin of these nemas is usually described as smooth and without striations, yet minute transverse striæ are probably always present, though difficult of resolution except in the new species *reversus* and *similis*. Using a good objective of the highest power under favorable conditions, I have almost invariably been able to see these striæ, and as my examinations have embraced the great majority of the known species, it seems probable that any specimen will reveal them if examined with sufficient care. These transverse striæ, all alike on a given specimen, are never sufficiently marked to disturb the plain, even contour of the body. It is rarely possible to

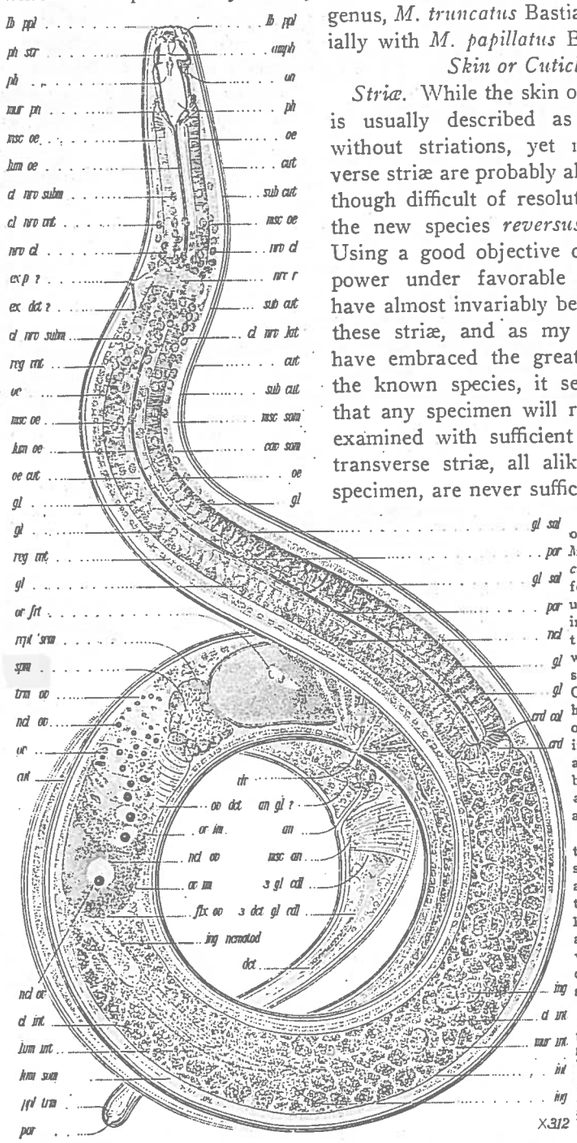


FIG. 2. — Female of a typical mononch, *Mononchus longicaudatus*, a syngonic form. This individual had been feasting on other nemas, the remains of which are shown inside the intestine. Only the anterior half of the sexual organs can be seen in the illustration; an entirely similar branch is hidden on account of the coiled attitude of the body. The lettering of the illustrations is similar throughout and is explained at the bottom of page 129. The anatomy and histology of various newly discovered features are shown:— Œsophageal glands (*gl. sal.*), the pore through which the glands empty into the œsophagus (*por.*), syngonic sperm (*spm.*), formation of polar body (*ov. frt.*), ingested protozoon (*ing.*), etc.

resolve the striæ into components; occasionally, however, they are resolvable into rows of excessively fine dot-like elements, as for instance in *bathybius, reversus* and *incurvus*. Lateral wings to the cuticle are almost unknown, and the striæ are not perceptibly altered on the lateral fields; *papillatus* and *macrostoma* furnish a slight exception to this rule.

Though the muscles of the body wall are relatively powerful, their attachments to the subcuticle are not a conspicuous feature; hence longitudinal striæ due to this cause, though of rather common occurrence, are not very readily observed. There are no longitudinal striations in the cuticle proper. This apparent complete absence of dermal markings often imparts a glassy appearance to living mononchs when examined casually under the microscope, an effect that is heightened by the fact that the colorless body wall is, as a rule, of more than average thickness. Despite their rather thick cuticle, mononchs are very flexible. They coil and uncoil themselves with facility,—a useful gift in a struggle with active prey.

Moulting. From researches on a considerable variety of genera, Maupas concluded that nematodes undergo four moults, and that, correspondingly, the life of each individual is divided into five periods. He examined no mononchs. The accompanying sketch of a portion of the pharynx of a moulting *Monochus brachyuris*, from Arlington, is therefore of interest, as indicating that this specimen had yet to moult three times; and since it was already half-grown (0.8 mm. long) it is fair to presume it had already moulted once, although of course there is no proof of this. The sketch shows four successive dorsal onchi, numbered in chronological order, each the representative of a separate cuticle. The fourth onchus is in a very rudimentary state. This record accords with the observations of Maupas, and indicates the probability that mononchs also moult four times.

FIG. 3.—Head of a moulting mononch, showing successive dorsal teeth, 1, 2, 3, 4.

Strength and Activity. Various features of the cuticle and body-muscles seem to stamp the mononchs as powerful nemas, and when they are taken from their natural haunts and placed in a glass of water for examination, their active serpentine movements fully justify the inference. Though less agile than species belonging to some other genera, they are anything but sluggish. The movements of the anterior extremity are especially striking, a certain suppleness of neck enabling them to dart the head suddenly here or there in almost any direction,—a faculty enabling them with ease to capture their prey, even though it be active.

Nemas Sometimes Float

Distribution by flotation. Ditlevsen notes a very interesting trait of his *Mononchus spectabilis*, namely, that of floating on the surface of water. A number of free-living nemas belonging to other genera are

known to have this faculty, which is due to repulsion between the cuticle and water; de Man found it to exist in the case of *Oncholaimus viscosus*, and the writer has observed it in the case of the larvæ of *Diplogaster aerivora*, although a second larval form of this same species does not exhibit the property, nor do the adults. Ability to float is known also of a number of other species, and, as Ditlevsen's observations show, is not absent in the genus *Mononchus*. Whether flotation plays any part in the economy of such nemas is not known with certainty. Floating on the surface of moving water, nemas would doubtless sometimes be quickly and widely distributed, and it is therefore easily conceivable that flotation has some definite bearing on the life history of species exhibiting it.

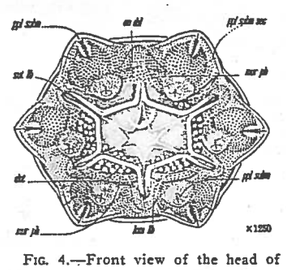


FIG. 4.—Front view of the head of *M. tenuis*. Compare with Fig. 1. Here the lips are nearly closed, but the dorsal tooth and rasps can be seen through the six labial flaps. The two circlets of papillæ are seen to good advantage. The large dorsal tooth shows faintly through the two upper lips.

The surface of a mononch seems almost entirely destitute of setæ and papillæ, if we except those on the lips. Nevertheless, future researches will probably reveal superficial nerve-endings hitherto overlooked. In rare instances a few fairly well-developed setæ occur on the tail, as in the case of *M. sigmaturus;* papillæ also occur sparingly on the tails of the males of various species, and near the vulva on the females of a number of species. No pores are known to occur in the cuticle, except, of course, the spinneret pore, and the pore observed near the nerve-ring and supposed to be the renette pore.

General Form of Body

Neck and Head. The various mononchs are considerably alike in external form. In front the body tapers but little; the neck is nearly always more or less cylindroid, and almost invariably ends in a head not set off from the neck in any way, though there is usually a slight expansion at the lip-region, due to the strong development of the labial papillæ.

Tail and Spinneret. The posterior portion of the body usually tapers from some distance in front of the anus, but in the pre-anal region the diminution is slight and very gradual. The tail may be either simply conoid, or first conoid and then cylindroid, and usually ends in a spinneret, though in about one-fourth of the species the caudal glands and spinneret are absent. When the tail is conoid the spinneret is usually a simple structure, whose existence is indicated mainly by the fact that the terminus is sub-truncate in form, and presents an inconspicuous axial, or sub-dorsal, or sub-ventral pore. This form of spinneret appears to be entirely unarmed, though inconspicuous innervations probably occur.

When the posterior portion of the tail is cylindroid, the terminus is usually almost imperceptibly expanded, and the spinneret is then somewhat differently developed, and is usually armed with obscure, innervated, submedian papillæ or setæ.

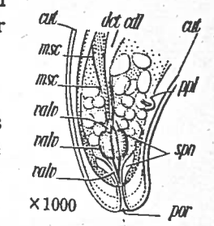


FIG. 5.—Spinneret of *M. lacustris* showing muscle, msc., whose contraction opens the spinneret valve.

Head

Lips. In the view usually obtained the six lips appear to be more or less confluent, and if it were not for their papillæ it would be difficult to count them; but when thrown apart, an attitude in which, however, they are seldom seen, they are more easily counted, since in this attitude the refractive "ceratinous" internal elements of the lips are separated from each other and more readily distinguishable, as shown in figure 1. When closed, these six, broad, flat lips meet together in such a way that the star-shaped mouth opening usually lies in a slightly depressed area on the middle of the front of the head. In some species the inner walls of the lips are strongly "ceratinized," and may be developed into six rather definite, retrorse, subacute points, which, in assaults on other animals, serve as grappling hooks, and act in opposition to the dorsal tooth of the pharynx.

Labial papillæ. Each lip is supplied with at least two, usually more or less conical, innervated papillæ; one on the outer margin and somewhat outward pointing, the other situated about half way between the outer papilla and the centre of the head, and forward-pointing. The front of the head therefore presents two circlets of papillæ, one on its outer margin, and one more closely surrounding the mouth-opening, as shown in figures 1 and 4, and many others. These papillæ may be so flat as to play no conspicuous part in the external conformation of the head, or they may be conical and raised, so as to give to the front of the head a more or less angular contour. The papillæ are slightly mobile, and hence vary somewhat in appearance at different times on the same specimen, a matter depending on the attitude of the lips. Drowned specimens with relaxed lips present a slightly different appearance from those that have been fixed for examination by means of chemicals.

Some of the innervations that frequently occur on the head near the lips may have special functions. Structurally they are sometimes indistinguishable from the subordinate labial papillæ. The species figures show the location of some of these innervations. One pair of them is very near the amphids—the only nerves so far observed to be definitely associated with the amphids. These particular papillæ are so uniform in their occurrence that it seems likely they have a special function, connected with the use of the amphids.

I

Mononchus: Number of Labial Papillæ in the Outer Set

14	10		6	Doubtful: said to be 6	
acutus	bathybius	muscorum var. macrolaimus	brachyuris	dadayi	obtusicaudatus
bracbylaimus	brevicaudatus	obliquus	lacustris	digiturus	parvus
dentatus	consimilis	radiatus	megalaimus	dolichurus	punctatus
gracilicaudatus	denticulatus	reversus	minor	exilis	rex
major	gerlachei	sigmaturus	palustris	fovearum	spectabilis
monhystera	incurvis	subsimilis	sparsus	gymnolaimus	studeri
muscorum	longicaudatus	angustus	teres	index	tenuicaudatus
papillatus	longicollis	trichurus	tunbridgensis	intermedius	tridentatus
rapax	micrurus	vorax		japonicus	truncatus
regius				macrostoma	zschokkei

Comparative morphology of the cephalic papillæ. The outer set of cephalic papillæ is the morphological equivalent of the circlet of cephalic setæ often to be seen on other free-living nemas. In harmony with this fact, the submedian papillæ of this outer set are sometimes two or three in number to each lip, the numerical and morphological factors harmonizing with the law of arrangement of the tactile cephalic setæ of nemas, namely:—when six are present one is found on each of the two lateral lines and one on each of the four submedian lines; when more than six are present the increase occurs first on the submedian lines, the commonest number being ten,—one on each lateral line and two on each of the four submedian lines; when the number is in excess of ten the increase is again more commonly found on the submedian lines. Illustrations of this law of arrangement are seen on the heads of many mononchs. The secondary submedian papillæ of mononchs are sometimes minute and more or less difficult to detect.

Method of Hunting

Senses of Smell and Taste. Obviously mononchs hunt by the aid of some other sense than that of sight, since both they and their prey usually live in subterranean darkness. It is, therefore, exceedingly likely that the nerve endings on the head, terminating in the labial papillæ of the inner row, serve as organs of taste and smell, and that it is by the aid of these senses that they trail their quarry.

Picture these ferocious little mononchs engaged in a ruthless chase in the midst of stygian darkness. We may imagine them taking up the scent of the various small animals upon which they feed, among which almost anything they can lay mouth to seems not to come amiss, and pursuing them with a relentless zeal that knows no limit but repletion. How many acres have their organic balance determined by their millions of prowling mononchs?

Pharynx

The six powerful lips arch together over a large characteristic pharynx, consisting of a rather simple, ellipsoidal or elongated cavity, whose cross-section is more or less irregularly circular, and of which there are two distinct types.

Types of Maw. Teeth. In one type, characteristic of the larger species, there are longitudinal ribs, sometimes simple, sometimes duplex, situated mainly on the median and submedian lines (subgenus *Iotonchus*).[3] When these longitudinal ribs are well-developed there is a tendency for the dorsal tooth or onchus to be farther back, and for the submedian teeth, smaller still, to be located toward the base of the pharynx, and in extreme cases all three teeth may be located actually at the base of the pharynx, or indeed be quite vestigial. The farther back the teeth, the smaller they are, and when located actually at the base of the pharynx they are often exceedingly small.

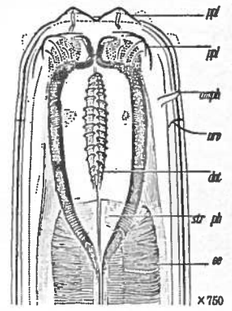


Fig. 6.—Dorsal view of the throat of *M. muscorum*, to show the arrangement of denticles (dnt.) characteristic of the subgenus *Prionchulus*,[4] they constitute a rude "saw." Compare with Fig. 7.

In the other type of pharynx the dorsal tooth is usually strongly developed, and is located midway or farther forward; in which case the wall of the pharynx is strongly reinforced along the dorsal line, while the submedian longitudinal ribs are lacking, or at any rate are faint. However, there often occurs on each of the two ventrally submedian lines in this type of pharynx an onchus of smaller size, located a little farther back than the main onchus; exceptionally these submedian onchi may be nearly as large as the dorsal onchus. In several species the onchi are retrorse (subgenus *Anatonchus*[5]), and when of this character are sometimes more slender, even somewhat digitate.

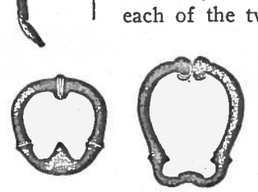


Fig. 7.—Above, profile and front view of the same series of denticles in the throat of *M. muscorum*. Below, two cross-sections of the same specimen, showing end view of the same denticles; at left the section is through the dorsal tooth (sbown black); at right the section is above the tooth. The denticles are shown in the upper part of these two lower figures. The two joints shown in cross-section impart a slight degree of mobility to the pharyngeal walls. Compare with Fig. 6.

Fangs. Denticles. The onchi act as fangs, and are used in conjunction with the powerful lips in seizing and holding the prey. In these maneuvers they are aided by minor pharyngeal structures, prominent among which in some species are two submedian

[3] *Iotonchus*, insignificant tooth; [4] *Prionchulus*, a small saw-tooth; [5] *Anatonchus*, reversed tooth.

areas, armed with minute denticles arranged in transverse rows like the teeth of a rasp (subgenus *Mylonchulus*[6]). While these denticles are usually distributed in two distinct areas, the two sometimes coalesce on the ventral line, so that the denticulated area, or rasp, is continuous and bilaterally symmetrical. As a rule, however, there is a distinct, narrow, ventral interruption, so that the right and left rasps are rather clearly separated from each other. These rasps are widest near the ventral line, and become gradually narrower as they recede, and usually end near the lateral line, or near the dorsally submedian line. On the margins of the rasps the denticles are arranged in distinct rows; elsewhere the arrangement is more or less irregular, though in certain species the arrangement is rather orderly throughout. Each rasp is composed of about six rows of denticles, except in the species *denticulatus*, where the number of rows is about twice (?) as great, and in the new species *sparsus* and *reversus*, where there are only one or two rows. Often at the base of each rasp there is an exceedingly minute submedian onchus.

Method of Attack. When used in conjunction with the strong dorsal tooth and the powerful lips, the rasps are remarkably efficient organs. The mononch glides up to its quarry and makes its onslaught by a quick snap of the head, throwing its jaws suddenly wide open, and grappling its prey by means of the inner armature of the lips. As the jaws close in, the victim's body is jammed against the point of the dorsal tooth, as well as against the rasps, and in this way is at once both punctured by the tooth and lacerated or milled by the rasps. In most cases the onchi seem to be solid bodies, containing no duct through which venom could empty. If any poison is injected into the victim it would seem to be derived from œsophageal glands emptying into the pharynx by some other road. The axial element sometimes seen in the onchus is probably a nerve ending.

Minutiæ of the Wall of the Throat. In general the wall of the pharynx is well developed and strongly refractive, and is usually thickest on the dorsal side where it gives support to the dorsal onchus; often it is very finely transversely striated. In many species this striated appearance seems to be due to a transverse lamination of the pharyngeal wall. The striation, or lamination, may be so pronounced as to give rise to transverse ridges on the interior surface of the pharynx like those of the teeth of a mill-saw file, and no doubt these ridges have somewhat the same function as the rasps just described. The onchi are sometimes seen to be longitudinally striated. The striæ of the pharyngeal walls are most clearly visible during the moulting period. In the original species-figures to follow, what appears merely as shading on the pharyngeal wall is a carefully worked-out chart of the position, number and direction of these laminations.

[6] *Mylonchulus*, a small mill-tooth.

Contour of the Maw. The contour of the pharynx differs somewhat in the various species. If the dorsal onchus is strongly developed, the profile indicates a roughly goblet-shaped or ellipsoidal cavity, and the onchus extends well into the cavity so that its apex lies near the axis of the head, sometimes up front and close to the inner margins of the lips. If, on the other hand, the dorsal onchus is weak, and especially in species

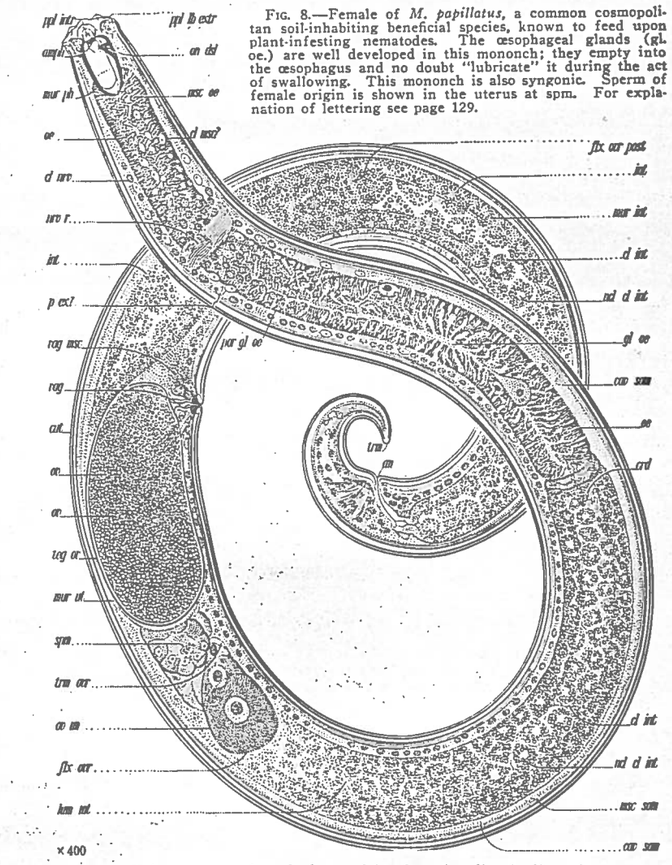


FIG. 8.—Female of *M. papillatus*, a common cosmopolitan soil-inhabiting beneficial species, known to feed upon plant-infesting nematodes. The œsophageal glands (gl. oe.) are well developed in this mononch; they empty into the œsophagus and no doubt "lubricate" it during the act of swallowing. This mononch is also syngonic. Sperm of female origin is shown in the uterus at spm. For explanation of lettering see page 129.

where the wall is not much reinforced by longitudinal ribs, the contour of the pharynx tends to be more or less oblong, so that its floor, lying in the anterior end of the œsophagus, though irregular, is likely to be, on the whole, more nearly flat. Opposite the dorsal onchus there is frequently to be seen a faint transverse seam, most prominent along the ventral side

of the pharynx, indicating a division of the wall into anterior and posterior elements. Sometimes this pharyngeal suture is rather prominent.

Jaw Muscles. The pharyngeal muscles of various species of mononchs have been observed, figured and commented upon by one or two investigators, but only in a vague way. Much remains to be learned concerning them. The following incomplete observations have been made in the course of these investigations.

Under suitable conditions, and especially in some species, long, slender muscles may be seen passing from the lip region backward and outward, so that their proximal attachment is to the body-wall a short distance behind the pharynx. These muscles are the flexor muscles of

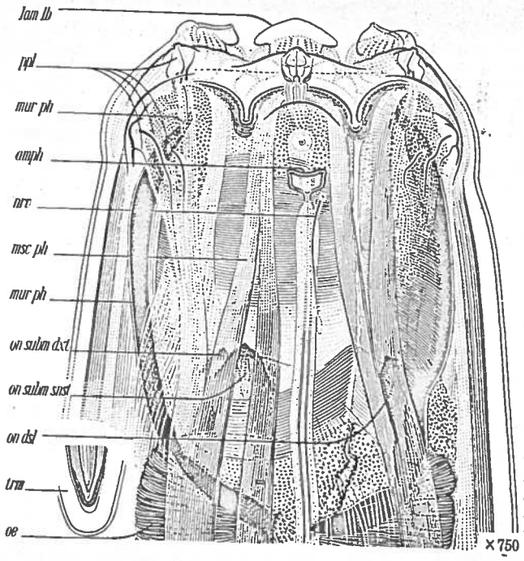


FIG. 9. — Side view of the head of *M. regius*. The lips and their appendages are well shown. The flaps (lam. lb.) are the same organs so well seen in figure 4. The amphid (amph.) extends to the bottom of the pharynx and beyond. The labial muscles (msc.) are so attached as to pull the lips both inward and outward about the stiff external ring as a fulcrum. Traces of this ring are shown arching along the margin of the anterior part of the head. Coming up from the interior of the œsophagus toward the right is seen a light-colored duct; this empties into the pharynx at its base. In this way apparently the secretion of the œsophageal glands has a direct passage to the throat.

the lips. It is certain that each lip, probably each pair of adjacent lips, is connected with a muscle whose function is to pull the lip toward the body axis about a fulcrum near the surface of the head. These muscles, then, shut the mouth. It seems likely that the elasticity of the various parts composing the frame-work of the lips and pharynx may play some part in mastication and deglutition, and act in opposition to some of the muscular elements of the pharynx. The extent to which a mononch can throw its jaws open is shown in the sketch, figure 1, made from a preserved specimen. This act is accomplished by the aid of a second similar set of muscles acting on the outside of the same fulcra. It is unlikely

that the sketch represents the maximum gape, for the effect of chemical fixatives seems to be to lock the jaws tightly rather than leave them agape. When examined alive mononchs are seldom seen to move their mouth parts.

The Mononch and Its Victim

Fate of Victim. So far as I am aware, the struggle of a mononch with its victim has never been witnessed by human eyes. A struggle it must be, for mononchs are sometimes discovered that have gulped down other nemas nearly half as long as themselves. Such a dénoument must be the result of a dramatic conflict. A similar gastronomic exploit on the part of a man would be the gulping down of a string of bologna sausage several feet in length. In one instance in the course of my experience, a mononch was caught with its quarry, another nematode, still gripped in its jaws. Seized by its middle, the victim had been bitten nearly in two. This is a common fate. Sometimes, however, the ingested nema is but little mangled. I imagine the mononch swallows its prey somewhat as the python does, though less deliberately. As the œsophagus seldom occupies over one-fourth of the length of the body, and as the mononch sometimes swallows other nemas nearly half as long as itself, manifestly in such cases one end of the victim's body must reach the mononch's stomach before the other end has disappeared down its throat.

Gluttonous Appetite. While many mononchs bolt their food, it is evident that the food of some among them receives a certain amount of mastication, for the body of the victim is bitten into fragments and swallowed piece-meal. In some cases the degree of mastication may be greater still. Figure 10, for instance, shows the head of a preserved specimen, in the mouth of which lies a portion of the "gizzard" of a rotifer, which has been almost completely denuded of the muscular tissue originally attached to it. It is the thick-lipped species like *M. muscorum* that masticate their food in this way.

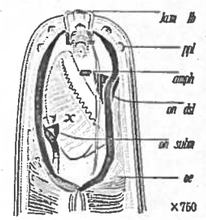


FIG. 10.—Pharynx of a female *M. palustris* with portion of the "gizzard" of a rotifer (x) being masticated.

Œsophagus or Gullet

Lining of the Gullet. Salivary (?) Glands. The œsophagus is more or less cylindroid, a form of œsophagus common in nemas that engorge relatively large objects. The anterior end of the œsophagus, where it receives the base of the pharynx, is usually about one-half to two-thirds as wide as the base of the head, and is occasionally somewhat swollen, so that one may speak with propriety of an obscure pharyngeal bulb. The œsophagus has nearly the same diameter throughout the greater portion of

its length; it may diminish a trifle in the vicinity of the nerve-ring, while in the posterior half it usually expands a trifle, so that finally it is one-half to two-thirds as wide as the corresponding portion of the body. The refractive lining of the œsophagus is strongly developed, and is of such a character that its longitudinal optical section often occupies as much as one-third of the diameter of the whole organ, sometimes one-half, exceptionally even more. The radial musculature of the œsophagus is strongly developed, and usually appears coarser posteriorly than anteriorly.

Œsophageal Glands. In some species, very likely in all, among the interstices of the œsophageal muscles there exist glandular tissues, which empty their secretion into the lumen of the œsophagus through minute pores in the lining, situated from place to place throughout a considerable portion of the length of the organ. Some of these glands appear to empty into the pharynx, but the best developed ones occur in the dorsal section of the œsophagus near the middle.

De Man and Micoletzky mention structures in the wall of the pharynx of *Mononchus,* about the nature of which they seem doubtful, but suggest the possibility that they are pores. My observations lead me to the conclusion that some of the more minute so-called "teeth" or denticles of authors, at the bottom of the pharynx, and even some of those higher up, are in reality elevated pores connected with glandular structures in the anterior part of the œsophagus. These pores appear to me to be the homologues of the pores which I have demonstrated undoubtedly to exist farther back in the œsophagus, and to be the outlets of glands located in the interstices of the radial muscles. See fig. 9.

It is easy to believe that the œsophageal glands are salivary glands, and that they serve the mononchs in gorging down food in somewhat the same way as do the glands of serpents. This surmise is based upon the structure and position of the organs rather than upon definite and extensive physiological experiment; intra vitam stains, however, have shown that the secretions of these glands are alkaline,—evidence supporting the surmise.

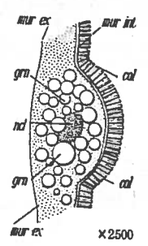


Fig. 11.—Portion of cross section of intestine of *M. longicaudatus* to show columnar structure of the lining of the intestine, *col.*

Intestine

Cardia. There is usually a flattish cardia consisting of 20 to 50 small characteristic cells that stain rather strongly with acid carmine, and manifestly discharge a distinct function. The intestine, which is invariably separated from the œsophagus by a deep and prominent constriction, becomes at once about three-fourths as wide as the body, and is usually made up of cells of such a size that about 8 to 20 are required to build a circumference. These cells contain numerous granules of somewhat variable size, often so arranged

about the large central nucleus as to give rise to a beautifully regular appearance simulating tessellation. As a rule, the columnar lining of the intestine (fig. 11) is not very refractive. Owing to the low visibility of this lining, and the difficulty of seeing through the mass of granules contained in the intestinal cells, the lumen is usually hard to decipher; toward the anus, however, it may become more distinctly visible. Occasionally, the granules are so few or so transparent that the contents of the intestine can be seen with ease, but this is rather exceptional.

Granules. The structure and arrangement of the granules in the intestinal cells of *Mononchus lacustris* may be taken as somewhat typical. The granules of this species are numerous and packed rather closely in the cells, and give rise to a more or less distinct tessellation. Specimens fixed with Flemming solution, and mounted in glycerine jelly, show many of the granules as refractive shells, enclosing a relatively large inner spherical mass, which appears dark or light according to the nature of the focus of the microscope. This structure is characteristic of some of the smallest, as well as some of the largest, granules. These appearances are not uniform throughout the intestine, the shell-like structures being more apparent in the posterior part than elsewhere, and less apparent through the middle portion of the body, where the granules are largest and most abundant.

These intestinal granules play an important role in the economy of the nema—some of them are in fact indispensable intracellular organs. Little as we know about their functions in detail, it is already certain that they have to do not only with the secretion of various digestive fluids, but also with the transformation and storage of the digested matter. The granules in any given cell may be of several kinds, doubtless serving entirely different functions. These facts the author has demonstrated by intra-vitam staining.

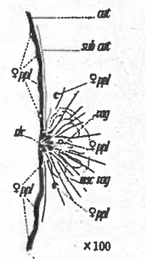


Fig. 12.—Vulva region of *M. major* showing vulvar papillæ, ♀ *ppl.*

Digestion

Food Remnants. The digestive fluids of the mononch must be well fitted for dissolving ceratin, supposedly the main component of nematode cuticle, for the cuticle, as well as most other parts of the ingested victim, disappears completely in the course of digestion. The parts that resist digestion longest are the spicula of male nemas and the oral spears of the spear-bearing sorts. These organs, the spicula and the spear, are composed of relatively thick layers of solid "ceratin," and furthermore are protected from the action of the digestive fluids because of their situation in the interior of the ingested nema, and hence are among the last to be dissolved. Such an undigested remnant, a spear or a spiculum, consti-

tutes one of the most frequent, as well as most reliable, bits of evidence concerning the food-habits of mononchs.

Voracity. Mononchs are voracious. Often the remains of several other nemas are to be seen in the intestine of a single one of them. The writer once had under observation a specimen that had swallowed four large rotifers in quick succession, all tail-end first. The file of rotifers could be clearly seen in the intestine of the mononch. Aquatic mononchs are fond of rotifers. The characteristic "gizzards" of the rotifers, being rather indigestible, are often found in the posterior part of the intestine.

Rectum. From the slightly depressed anus, the lips of which are sometimes rather pronounced, the refractive rectum, usually about as long as the anal body diameter, extends inward and forward, and is separated from the intestine by a distinct constriction. There is no prerectum, though the contrary impression is sometimes created by a constriction caused by a mural commissure (?) some little distance in front of the rectum.

Feces. From the region of the anus relatively powerful transverse muscles pass obliquely backward to the body wall, and find their proximal attachment in the dorsally submedian regions. These anal muscles are more strongly developed in mononchs than in most nemas. A powerful defecating apparatus is needful to such gluttons, since their feces are sometimes bulky, owing, apparently, to the fact that the contents of the intestines of their victims often prove indigestible. Probably this indigestible material is to a considerable extent vegetable in its nature; at any rate, it frequently happens that the feces are bulky, and this fact seems to account for the strong development of the rectum and the anal muscles.

Caudal Glands; Spinneret

The Cement. The caudal glands, when present, are always three in number, and are arranged in a cluster or series opposite to or immediately behind the anus. If the tail is short, the foremost gland is usually dorsal while the two submedian glands are arranged side by side; if the tail is long all three may be arranged tandem. Apparently there are always three separate ducts, one from each gland, each having a separate ampulla; these latter are arranged side by side in a group at the spinneret. Often, however, the spinneret is simple in form and presents ducts that form only indistinct ampullæ. Some idea of the manner and rate of secretion of the caudal glands may be derived from an examination of the adjacent illustration, which shows a spiral mass of the cement substance secreted by them. This spiral mass was coagulated by the fixing fluid in which the specimen met its death.

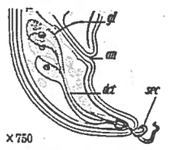


FIG. 13.—Mononch tail showing the three caudal glands, their ducts, the spinneret, and its secretion (*sec.*).

Action of Spinneret. The structure of the spinneret is very similar to that of *Mononchulus,* a related genus whose unusually large spinneret has proven especially favorable for detailed study, and may be described as follows. The three somewhat elongated ampullæ at the ends of the caudal ducts empty into a single sac located in the spinneret. From the front wall of this sac there projects backward into its cavity an elongated element whose free conical distal extremity fits into the outlet of the spinneret, where it acts as a plug or valve. Apparently, this valve must arise through an invagination of the sac during development. The plug is withdrawn by muscles attached to it and to the dorsal body-wall near the end of the tail. A contraction of these muscles elongates the sac containing the caudal secretion and draws the plug away from the aperture of the spinneret, thus allowing the secretion to flow out through the terminal pore. The plug appears to be returned to its position and held there either by the pressure of the secretions in the sac, or by the general internal body pressure exerted on it through the sac. Figure 5 shows the similar spinneret of a mononch.

Use of Spinneret. In any genus consisting of many species most of which have caudal glands, aberrant species usually occur in which these organs are absent. This is true of *Mononchus.* A spinneret would appear to be a particularly useful organ to a predaceous nema, permitting it at will instantly to cement itself to a relatively fixed object, and thus more easily master an active victim; nevertheless, about one-fourth of the mononchs have no trace of such an organ.

The lateral fields are always comparatively well-developed, and are usually one-third to one-fourth as wide as the body. The cells composing them often contain spherical granules not differing greatly in size from those of the intestinal cells. No cuticular pores have ever been seen connecting elements of the lateral fields with the exterior.

Renette

Nothing is known about the structure of the renette—in fact, it is not yet definitely known to exist in mononchs. In most species there is a ventral pore immediately behind the nerve-ring, which bears a close resemblance to the excretory pore of nemas possessing a well-developed renette; but no internal structures have as yet been found to connect with this pore.

Central Nervous System

The nerve-ring surrounds the œsophagus somewhat squarely near the front end of the middle third of the neck. It is usually well developed and easily seen — a distinct refractive collar with groups of nerve cells both in front of it and behind it. Otherwise than this very little is known about the central nervous system of *Mononchus.*

Nerve Commissures. A constriction in the intestine is sometimes observed at a point not far in front of the rectum, say at a distance equaling 3 to 5 body diameters. This constriction is sometimes so pronounced as to cause the posterior portion of the intestine to simulate the pre-rectum of *Dorylaimus*. There is here, however, no true pre-rectum. The constriction seems to be caused by mural commissures surrounding the intestine. The writer can only suggest the possibility of the existence of special nerves at this point, which leave the ventral field, pass slightly backward, then almost immediately become squarely transverse, encircling the intestine until they are very near the dorsal field, where they turn suddenly backward.

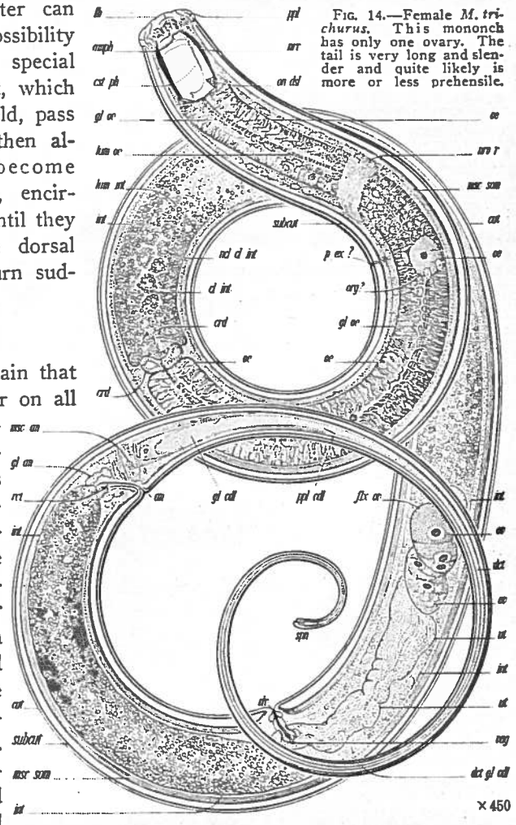


FIG. 14.—Female *M. trichurus*. This mononch has only one ovary. The tail is very long and slender and quite likely is more or less prehensile.

Amphids

If is almost certain that small amphids occur on all mononchs; the writer found them present on three-fourths of the known species. As their general characters have never been adequately described, their form and position are specially noted here, as well as more explicitly in the various illustrations. The external indications of the amphid are always located on the lateral lines somewhere between the base of the lips and a point opposite the middle of the pharynx. The periphery, which in some cases may be unclosed behind, is usually more or less elongated or elliptical in form, its long axis lying transversely on the head. These amphids are seldom more than one-sixth as long as the head is wide, and are usually very difficult of observation. They are most easily detected when viewed dorso-ventrally, and then appear as refractive oblique elements leading from the surface of the head inward and backward through the transparent cuticle, as shown for instance in the cases of *subtenuis* and *regius* (p. 167 and 140). They can seldom be followed more than a short distance inward, and their ultimate internal connections are unknown. A nerve-ending is nearly always to be seen in the cuticle immediately behind each amphid.

No Eyes

Mononchs have no definite organs of vision.

Female Sexual Organs

Organs Mostly Double. Eggs. Ovaries and Ova. From the slightly elevated and rather small vulva, the prominent refractive vagina leads inward at right angles to the ventral surface about one-third the distance across the body. Though comparatively small in size, the vulva is usually easily located on account of the refractive nature of the walls of the vagina. In nine-tenths of the species, the internal female organs are double, and symmetrically reflexed, though in some cases the posterior branch is somewhat smaller than the anterior. In the exceptional species the single ovary is also reflexed (fig. 14). The ovaries occupy relatively less space than is usual in nemas—less than one-fourth of the length of the body. Owing to the comparatively great length of the neck, the vulva is usually located somewhat behind the middle of the body even when the sexual organs are double and symmetrical, and may occur as far back as the junction of the third and final fourths. Each of the two uteri is about twice as long as the body is wide, that is to say, of a size to receive one or two eggs only. These latter are nearly always smooth, thin-shelled, ellipsoidal or elongated in contour, and appear about twice as long as the body is wide, though they are sometimes somewhat shorter, and more rarely longer. Only in a single species are the shells known to be sculptured. The shells are thick in *obliquus*. In all the species examined by the writer, the eggs are deposited before segmentation begins, and this is presumably true of the great majority, if not of all the species. The reflexed ovaries extend one-half to three-fourths the distance back to the vulva and contain a score or so of ova, which near the blind ends are packed in several rows—ova that by increase in size come, each one in turn, to occupy the whole of the width of the organ in its proximal half near the flexure. The ovaries are rather broad, and taper relatively little.

Syngonism. A considerable number of the mononchs are syngonic, and it is probable nearly all of them are so, since the males, if found at all, are nearly always rare. Only on a single occasion, so far as records go, have males been found to be as common as the females. Of most species

the males never have been seen. At a time previous to the development of the vulva the gonads of the female produce minute spermatozoa, which are sent forward and stored in a special portion of the uterus next the proximal end of the ovary. In the only species so far carefully examined in this regard these minute spermatozoa are known to be functional, at least to the extent that they enter the ova, which then proceed to form polar bodies and begin to segment. However, these particular investigations, made by the author and further recorded in figure 2, have been confined to the single species *M. longicaudatus*. Possibly the phenomena are different in other species.

Male Sexual Organs

Spicula. The tail end of the male is invariably like that of the female in general form and size, except that it is more strongly arcuate; it differs however, in some instances, probably in all, in the possession of comparatively well-developed papillæ, and particularly and universally in the existence of a ventral row of 8 to 20 more or less equidistant supplementary organs immediately in front of the anus. The two well-developed arcuate spicula are of equal size, and are always accompanied by two distinct though small accessory pieces, a right and a left. Only exceptionally are the spicula long and slender; usually they are somewhat uniformly arcuate, and appear to be subacute and of somewhat uniform width throughout, at least when viewed in profile, and about one and one-half times as long as the anal body diameter. Usually each is strengthened by a median longitudinal refractive piece. They are never prominently cephalated. The accessory pieces are located some little distance inside the anus, alongside the spicula, which they may appear to cross when viewed in profile. These accessory pieces are usually a little narrower than the spicula, and 2 to 4 times as long as wide. Distally they usually end in two subacute points, often so arranged as to form a small U-shaped figure. When at rest the accessory pieces usually appear as if at about right angles to the axis of the body. They are not cephalated.

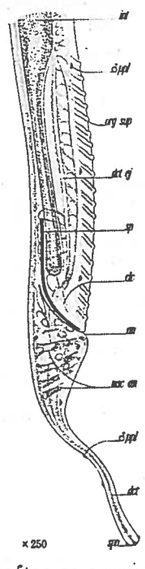


FIG. 15. — Tail end of *M. obtusus* after Bütschli. The spicula in this species are exceptionally long and slender. The male papillæ (ppl.) and supplementary organs are very well shown. The spicula are protrudable and are guided by slender accessory pieces half as long as themselves — also shown.

Supplementary Organs. Sperm. The supplementary organs vary in number up to twenty. The hindmost is located immediately in front of the anus, and may be a little farther removed from its nearest neighbor

than is usually the case in the remainder of the series; thence forward the organs are about equidistant. Usually they are more or less contiguous, though occasionally they are separated by short spaces, especially anteriorly. When most highly developed, each is a convex-conoid, innervated, very minutely papillated or echinulate, more or less protrudable organ, connected with the interior by an oblique, indistinct element along the axis of which a nerve passes inward and forward to join the ventral nerve of the body (v, fig. 16). It would appear that these organs are partly tactile and partly excitatory in function, and act as the complements of the vulvar papillæ of the female. There is no bursa. The series of oblique copulatory muscles is always coextensive with the series of supplementary organs. The rather short testes seem to be invariably two in number and are outstretched in opposite directions. The spermatozoa of males are minute and present a more or less vermiform nucleus.

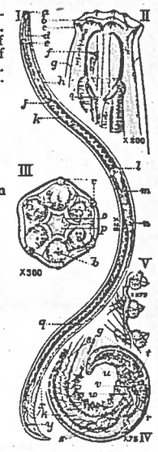


FIG. 16. — *Mononchus major*. I—Side view of male. II — Side view of head of same. III—Front view of head. IV—Side view of tail. V.—Details of male supplementary organs.
a, mouth
b, lip-papilla
c, lip
d, œsophagus
e, nerve-ring
f, pharyngeal tooth
g, innervated papilla of skin
h, œsophagus
i, base of pharynx
j, cardiac collum
k, intestine
l, flexure in testicle
m, blind end of testicle
n, vas deferens
o, lip
p, mouth opening
q, ejaculatory duct
r, spicula
s, ejaculatory duct
t, accessory piece
u, post-anal papillæ
v, spicula
w, ejaculatory duct
x, ventral row male papillæ
y, anus
z, three anal glands

Self-Fertilizing Females; Syngonism

Males Rare. Conjugation of Syngonic Gametes. No trait of mononchs is more interesting than the capacity of the female to reproduce without the intervention of a male—by a peculiar sort of hermaproditism called syngonism. Of most of the species no males are known; in the remaining species, almost without exception the males are very scarce, and only in exceedingly rare cases are they present in anything more than small numbers. Usually hundreds, and even thousands, of specimens may be examined without the discovery of a single male. How then do the females reproduce? The answer is singularly interesting, for, as already explained, the females fertilize their own eggs by means of spermatozoa which they themselves produce in the same gonad. In the mononchs these spermatozoa produced by females are so exceedingly minute that they have hitherto escaped notice (fig. 2). Notwithstanding its small size, the syngonic sperm cell appears to be functional. It enters the egg, expands, and approaches the nucleus of the egg, which meanwhile throws off polar bodies and later proceeds with segmentation. Observations have not yet extended beyond this point, but it seems alto-

gether likely that these minute spermatozoa produced by mononch syngones act in what would be called a normal manner, and as the spermatozoa are known to do in other syngonic nemas in which they are of much larger size, *e. g. Rhabditis.*

Abundance; Distribution

Frequency of Mononchs. Long ago Bütschli declared mononchs to be among the commonest of nemas, an assertion that has been corroborated by all investigators in this field, hardly any of whom have failed to note a number of species, occasionally new ones. Our knowledge of the genus has been augmented in this way by de Man, Micoletzky, Ditlevsen, Steiner, Hofmänner, Menzel, Daday, and the writer, until at the present time about sixty species are known. Doubtless this number will be very largely increased by future researches.

Geographic Distribution. Variety of Habitat. Mononchs are found in all the habitable regions of the world. They inhabit the soils and fresh waters of every clime, occurring even at great depths in lakes and at very high altitudes on mountains. While we have only just begun to learn the details of their geographic distribution, it is already manifest that some species are cosmopolitan. Several species occur both in Europe and in North America, and a few of these same species are known also from Australia. Considering the small number of observations hitherto made along this line, it seems safe to predict that many of the species will be found to be cosmopolitan. Some species adapt themselves to surprisingly varied conditions. *Mononchus longicaudatus,* for instance, is known from the tropics, from temperate regions, and from very cold regions, and inhabits both soil and fresh water. Another species, *Mononchus brachyuris,* is known both from warm springs and from cold Alpine lakes.

Abundance in Arable Soil. Mononchs occur in great numbers in arable soil. On one occasion the writer estimated that at least thirty millions of mononchs per acre were present in the top six inches of a field of maize in New Jersey, and the actual number present may have been much greater. They are regularly present in practically all arable land of a sandy or loamy nature.

The very numerous introductions of living plants into the United States, through the agency of the Office of Seed and Plant Introduction of the Department of Agriculture and other agencies, has brought about simultaneously the introduction of many species of *Mononchus.* Nemas existing in the soil about the roots of introduced plants are often placed under favorable conditions for propagation in this country. It is therefore certain that an unusual variety of mononchs exists in the soils of the United States.

Interplay of Organisms. There are regions where certain nematode diseases of crops are very destructive, while other regions, the climate and soil conditions of which are apparently similar, suffer but little, or at least to a lesser degree, so far as we know. In such cases it is permissible to suppose that the nematodes in the area where the lesser damage is done are held in check by some as yet unknown agent. Is it not possible that the mononchs play some such rôle as this, and that just as certain insects hold other insects in check, so certain nemas hold other nemas in check?

We know relatively little about the life history of most of the mononchs, and as yet very little about the possibility of controlling their growth. One species, *Mononchus longicaudatus,* occurs at certain times in almost inconceivable numbers in the sand of the slow filter beds of the water works of cities. Near the end of the period of use the top layers of the sand in these filter beds sometimes become in reality a huge culture of this species. The observations suggest at least the possibility of cultivating this species on a large scale, should it prove desirable to do so.

The discovery that the genus *Mononchus* is very large and to a considerable extent composed of common and cosmopolitan species that feed upon injurious plant-infesting organisms, suggests so many new lines of research in soil biology as to make it desirable that a clear and connected account of the members of the genus be available to investigators. This need is increased by the fact that the literature is a scattered and fragmentary one, difficult to assemble. To these facts it must be added that most of the new observations herein recorded have been made upon species previously unknown.

II

Genus Mononchus Bastian, 1866

This genus is composed of non-marine, free-living nemas, with naked cuticle and obscure amphids, and having a plain œsophagus preceded by a broad—that is, non-tubular—pharynx, armed with 1 to 3 more or less immobile teeth of which the dorsal is largest, and supplied with 6 powerful papillated lips. Ovaries reflexed, usually two. Testes two, outstretched; spicula two, equal, simple, as are their small accessories; there is a pre-anal ventral row of supplementary organs.

Genera Similar to Mononchus, With Distinguishing Characters

Oncholaimus	Marine; sometimes found in brackish soils. Has cephalic setæ.
Anonchus	Has spiral amphids, and cephalic setæ.
Microlaimus	No thick muscular lips; amphids circular.
Ironus	Pharynx tubular; teeth movable radially.
Nannonchus	Has spiral amphids and cephalic setæ.
Oionchus	Pharynx filled by single tooth, which is really spear-like.
Mononchulus	Quite similar. Has much larger (ventral) spinneret; strongly developed lateral fields; smaller pharynx; female organ single.

Mononchus Bastian, 1866

	Subgenera and Species	
DORSAL TOOTH midway in pharynx or higher, usually massive		
Tooth not opposed by denticles; subg. *MONONCHUS* Cobb; type, *M. truncatus* Bast.; pharynx about 2 to 3 times as long as wide, goblet-shaped or ellipsoidal; wall smooth or transversely striated; spinneret usually present; males of about half the species known; female organs double (except *monhystera*)		
Dorsal tooth faced by 2 ventrally submedian teeth		
Teeth retrorse	(tridentatus de Man 1876)	43
Teeth not retrorse		
Tail conoid, then cylindroid; body 7 mm. long	(rex Cobb 1904)	51
Tail simply conoid; body 3 mm. long or less		
Spinneret and caudal glands absent	exilis n. sp.	1
Spinneret and caudal glands present		
Contour of the head angular; labial papillæ 16	radiatus n. sp	2
Contour of the head rounded; labial papillæ 12		
Pharynx longer than the head is wide	palustris n. sp.	3
Pharynx only as long as the head is wide	teres n. sp.	4
Dorsal tooth not faced by submedian teeth		
Ovary 1; pharynx not much longer than wide	monhystera n. sp.	5
Ovaries 2; pharynx toward twice as long as wide		
Tail simply conoid, 8 per cent or less		
Spinneret none		
Pharynx over half as wide as the head	vorax n. sp.	6
Pharynx not over half as wide as the head		
Length about 1 mm.; tooth midway, small, digitate	parvus de Man 1879	7
Length 1.5 to 2 mm.; tooth beyond midway, massive	papillatus Bastian 1866	8
Spinneret present		
Body 2 mm. long		
Form of the tail regular	intermedius Cobb 1893	9
Form of the tail somewhat irregular	tenuicaudatus Stefanski 1914	10
Body 3 to 4 mm. long		
Tooth midway, amphids a little behind the lips	major Cobb 1893	11
Tooth and amphids at the base of the lips	gerlachei de Man 1904	12
Tail conoid, then cylindroid, about 10 per cent or more		
Œsophagus 15 per cent	fovearum (Dujardin) Bastian '66	13
Œsophagus 22 per cent or more		
Buccal cavity toward 2 times as long as head is wide		
Spinneret armed with 2 very small setæ	megalaimus n. sp.	14
Spinneret not armed with setæ	macrostoma Bastian 1866	15
Buccal cavity only about half as long as head is wide		
Labial papillæ setose	obtusus n. sp.	16
Labial papillæ, at least the outer, not setose		
Pharynx ⅓ as wide as head; body 1.5 mm. long	tunbridgensis Bastian 1866	17
Pharynx ½ as wide as head or more; body 2 to 3 mm.		
Cavity about 2 times long as wide; tooth acute	truncatus Bastian 1866	18
Cavity about 3 times as long as wide; tooth sub-acute		
Inner labial papillæ large; tail sub-conoid	dadayi Micoletzky 1904	19
Inner labial papillæ normal; tail finally cylindric	longicaudatus Cobb 1893	20
Tooth opposed by numerous denticles on opposite wall; Arrangement of the denticles irregular; characters otherwise as in *Mylonchulus*; subg. nov. *SPORONCHULUS*; type *S. dentatus* n. sp.		
The tooth behind midway; spinneret present; anus at 92; 'f	recessus n. sp.	21b
The tooth in front of midway; no spinneret; anus at 96;		
Denticles about 20; pharynx half as wide as the head; 'f	dentatus n. sp.	21a
Denticles about 50; pharynx one-third as wide as the head	decurrens n. sp.	21c
Arrangement of the denticles orderly.		
Denticles along a ventral, longitudinal pharyngeal rib; subg. *PRIONCHULUS* Cobb; type *Pr. muscorum* (Dui.) Bast.; pharynx ellipsoidal, about 2 times long as wide; males of one species known; female organs double; no spinneret	punctatus n. sp.	22
Eggs punctate or echinulate	muscorum (Duiardin) Bast. '66	23
Eggs not punctate or echinulate		
Length 2.5 to 3.4 mm.; vulva at 65 per cent; anus at 94 per cent	longicollis n. sp.	24
Width 3.6 per cent; denticles forward pointing	spectabilis Ditlevsen 1911	25
Width 2.3 per cent; denticles inward pointing		
Length 4 mm.; vulva at 55 per cent; anus at 97 per cent		
Denticles in transverse rows on 2 sometimes confluent, submedian, rasp-like areas, often with 2 very small submedian teeth at their bases; subg. *MYLONCHULUS* Cobb; type *M. minor* Cobb; pharynx goblet shaped, tooth more or less arcuate; smaller species c. which		

the males are unknown (except *tenuis*); female organs double (except *index* and *reversus*); spinneret present (except *similis*)		
Ovary 1; tail rapidly diminished, then digitate		
Vulva behind the ovary; denticles normal	index Cobb 1907	26
Vulva in front of the ovary; denticles few	reversus n. sp.	27
Ovaries 2; tail not digitate (Ex. perhaps *sigmaturus*)		
Dorsal tooth somewhat digitate, relatively small		
Refractive ring about pharynx in front of tooth	obtusicaudatus Daday 1901	28
Refractive ring about pharynx not prominent	brachyuris Bütschli 1873	29
Dorsal tooth massive, not digitate		
Head rounded, denticles in about 12 rows	denticulatus n. sp.	30
Head truncate, denticles in 2 to 6 rows		
Rows of denticles 2	sparsus n. sp.	31
Rows of denticles 4 to 6		
Denticles about 4 rows; spinneret small	micrurus n. sp.	32
Denticles about 6 rows; spinneret larger		
Tail bent ventrally near the middle	incurvus n. sp.	33
Caudal setæ none; tail conoid	sigmaturus n. sp.	34
Caudal setæ (3 pairs) present; tail not conoid		
Tail arcuate or straightish	subtenuis n. sp.	35
Width of adults 2.3 per cent	subsimilis n. sp.	36
Width of adults 2.7 per cent or more		
Caudal glands and spinneret absent	obliquus n. sp.	37
Caudal glands and spinneret present		
Eggs thick shelled		
Eggs thin shelled;		
Buccal striæ faint if any; anus 94 to 96 per cent		
Species aquatic	lacustris Cobb 1915	38
	polonicus Stefanski 1915	39
Species not aquatic	minor Cobb 1893	40
Buccal striæ more pronounced; anus 98 per cent		
Spinneret finally dorsally recurved	brevicaudatus n. sp.	41
Spinneret not dorsally recurved	japonicus n. sp.	42
DORSAL TOOTH and others small, basal or nearly so (Exc. 44)		
Teeth retrorse, small, basal, exceptionally midway; subg. *ANATONCHUS* Cobb; type *A. tridentatus* de Man; large species with roomy elongated pharynx and smallish retrorse teeth; tail long and usually becoming cylindroid; female organs double; males of most of the species known	tridentatus de Man 1876	43
Body 2 to 4 mm.; teeth equal, midway; anus 90 per cent	gracilicaudatus n. sp.	44
Body 5 to 6 mm.; teeth sub-basal; anus 80 to 85 per cent	dolichurus Ditlevsen 1911	45
Submedian teeth equaling the dorsal; body 6 mm.		
Submedian teeth smaller than the dorsal; body 5 mm.		
Teeth not retrorse, small, or even minute; subg. *IOTONCHUS* Cobb; type *I. gymnolaimus* Cobb; large species with roomy elongated pharynx having longitudinal ribs; tail rather long, and often slender; males of more than half the species known; female organs double or single; most species with spinneret		
Ovary single; 1 to 3 rudimentary basal teeth		
Tail digitate; 3 sub-equal vestigial teeth	digiturus Cobb 1893	46
Tail not digitate; 1 dorsal tooth, remainder faint or none		
Posterior extremity setaceous	trichurus n. sp.	47
Posterior extremity slender but not setaceous	(bathybius Micoletzky 1913)	
Pharynx as long as wide; few submedian denticles		
Pharynx about 2 times long as wide; faint submedian teeth	gymnolaimus Cobb 1893	48
Amphid simple; buccal wall thin, transversely striated	consimilis n. sp.	49
Amphid duplex; buccal wall thick, not striated		
Ovaries 2; 1 to 3 small, sub-basal teeth		
Body 4 to 7 mm.; tail finally cylindroid; 3 teeth		
Spinneret present; lips rather plain	rapax n. sp.	50
Length 4 mm.; anus 90 per cent; the 3 teeth subequal	rex Cobb 1904	51
Length 6 to 7 mm.; anus 80 per cent; submedian teeth smaller	regius n. sp.	52
Spinneret none; lips striated lengthwise		
Body 1 to 4 mm.; tail conoid; 1 tooth, sometimes denticles		
Anus at about 86 per cent; tail conoid, or at last subcylindroid	bathybius Micoletzky 1913	53
Lips not set off by constriction; onchi unequal or one	similis Cobb 1893	53c
Onchus with small companions; head rounded	fasciatus n. sp.	53b
Onchus one only, head truncate; pharynx striated		
Lips set off by a deep constriction; onchi three, equal		
Anus at about 94 per cent; tail simply conoid	studeri Steiner 1914	54
Dorsal tooth small, others basal, minute, indefinite	zschokkei Menzel 1913	55
Dorsal tooth distinct		
Buccal cavity half as wide as long; tooth sub-basal	brachylaimus n. sp.	56
Buccal cavity as wide as long; main tooth basal	acutus n. sp.	57
Spinneret present		
Spinneret none		

4. *MYLONCHULUS*

5. *ANATONCHUS*

6. *IOTONCHUS*

1. M. exilis, n. sp. The cylindroid neck ends in a rounded head with a distinctly expanded lip region. The large pyriform pharynx is armed with three subequal teeth. The wider anterior part of the pharynx is two-thirds as wide as the head. The apices of the teeth are midway, the dorsal one being a little the farthest forward. Amphids somewhat behind the lips, but farther forward than the teeth, consisting of somewhat rectangular markings one-fifth as wide as the head, longest in the transverse direction, and with the lateral and front margins plainer than the posterior. Lining of the œsophagus not so prominent as in most mononchs. Intestine greenish, finely granular, obscurely tessellated. Cardia long and plainly to be seen through the flat, colorless pseudo-bulb at the beginning of the intestine. The rectum has a thick lining of highly refractive ceratin, and is a prominent organ one and one-half times as long as the anal body-diameter. Terminus about one-fourth as wide as the base of the tail. The very broad vulva is only slightly elevated. Posterior sexual branch only two-thirds as long as the anterior. On the male there is a row of about 14 equidistant, rather closely approximated ventral ridges in front of the anus, extending forward a distance equal to 3 tail-lengths. These do not bear any prominet papillæ. The body is somewhat thicker in the region of these ridges. Spicula linear, uniformly 5 μ in diameter when seen in profile, the proximal end being in no way distinguished from the rest of the shaft. The accessory pieces appear to rest rather closely against the distal halves of the spicula.

$$\frac{1.8\quad 6.2\quad 27.\quad {}^{\cdot}78^{\cdot}15\quad 98.2}{1.6\quad 1.8\quad 2.\quad 2.3\quad 1.}\ 2.\ \text{mm}$$

$$\frac{1.8\quad 6.\quad 24.\quad 38\quad 98.}{1.6\quad 1.8\quad 2.\quad 2.2\quad 1.2}\ 2.\ \text{mm}$$

Found about the roots of moss, Moss Vale, New South Wales, 1894. Examined in water after fixation with osmic acid.

2. M. radiatus, n. sp. The amphids of this rather small but elegant species are minute and inconspicuous,—about one-eighth as wide as the corresponding part of the head. The granules of the intestine are largest posteriorly, where they are about one-half as wide as the spinneret. The intestine is not tessellated. The tail is markedly arcuate, its spinneret about one-fifth as wide as its base. Anus very slightly raised. Caudal glands rather small, elongated. Sexual organs apparently double and symmetrically reflexed.

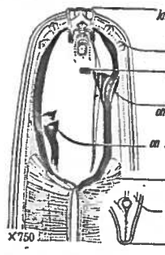
$$\frac{3.3\quad 9.\quad 30.\quad 74^{\gamma}\quad 95.}{2.2\quad 2.8\quad 2.8\quad 2.3\quad 2.2}\rightarrow .8\ \text{mm}$$

17

Description derived from a single young specimen from a cranberry bog in New Jersey, U. S. A. Flemming solution to glycerine. Fig. 17.**

3. M. palustris, n. sp. Intestine 12 to 15 cells in girth, more or less distinctly tessellated. Tail arcuate, its rather conoid spinneret about one-fifth as wide as its base. Caudal glands broad and saccate, their ampullæ occupying most of the posterior half of the tail. The elongated eggs are about twice as long as the body is wide, and occur one at a time in each uterus. The rather small, tapering ovaries contain 8 to 10 ova arranged more or less irregularly.

$$\frac{2.7\quad 8.\quad 30.\quad {}^{\cdot}62^{\cdot}15\quad 97.}{2.\quad 2.3\quad 2.6\quad 2.7\quad 1.9}\rightarrow 1.4\ \text{mm}$$



18

From a white cedar swamp, Jefferson County, Wisconsin, U. S. A. Feeds upon rotifers and probably upon other nematodes, which it appears to masticate (page 443, fig. 10). Sublimate to balsam. Fig. 18.

* This decimal formula for nemas is explained in the appendix.
** The species figures have the same magnification throughout, so that the reader may guage the relative sizes.

4. M. teres, n. sp. This comparatively small, simple form has 2 submedian teeth of equal size. Walls of the intestine with numerous granules of rather uniform size, giving rise to a faint tessellation; the granules such that 2 to 3 would be required to span one of the amphids. Tail rather strongly arcuate, its fairly well developed spinneret about one-fifth as wide as its base. Caudal glands somewhat elongated, their small but rather conspicuous ampullæ nearly filling the posterior fifth of the tail.

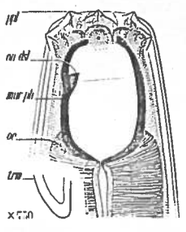
$$\frac{3.9\quad 12.\quad 35.\quad 60^{\gamma}\quad 94.}{3.4\quad 3.8\quad 3.5\quad 3.2\quad 2.7}\rightarrow .8\ \text{mm}$$

19

Description prepared from a single, more or less shrunken specimen, found in the sphagnum of a pot in which blueberry plants were being cultivated. Bears a general resemblance to *papillatus,* but differs in the form of the pharyngeal teeth and of the terminus. Flemming solution to glycerine. Fig. 19.

5. M. monhystera, n. sp. Amphids not seen. Lining of the rectum and of the intestine rather distinct and refractive. Intestine only faintly tessellated, if at all. Tail arcuate, rather blunt, without spinneret. From the rather conspicuous, more or less elevated vulva, the vagina, which is two-thirds as long as the body is wide and tubular, extends obliquely inward and forward. Nothing definite is known with regard to the eggs or the form of the ovary.

$$\frac{3.3\quad 9.7\quad 27.\quad {}^{\cdot}76^{19}\quad 94.}{3.\quad 3.3\quad 3.6\quad 3.2\quad 2.3}\ 1.1\ \text{mm}$$

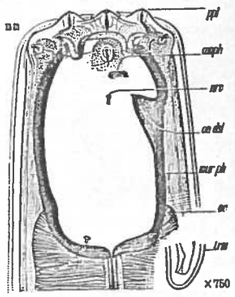


23

Found about the roots of orange trees, Bahia, Brazil. Bears a general resemblance to *M. papillatus,* but has only one ovary. This species is nemativorous. Flemming solution to glycerine. Fig. 20.

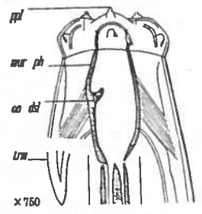
6. M. vorax, n. sp. This voracious species has a large mouth cavity and the œsophagus is therefore at first slightly swollen. Intestine 12 to 20 cells in girth, not tessellated. The terminus of the arcuate tail is about one-seventh as wide as its base. The elongated eggs are about twice as long as the body is wide. Each ovary contains about 30 developing ova, arranged irregularly. Small sperm cells were seen in abundance at the flexure, in a condition indicating that the species is syngonic.

$$\frac{2.7\quad 8.\quad 27.\quad {}^{\cdot}67^{\cdot}22\quad 92.}{2.1\quad 2.3\quad 2.7\quad 2.6\quad 1.6}\ 1.4\ \text{mm}$$



21

Found in soil from a white cedar swamp in Wisconsin, and from a cranberry bog in New Jersey, U. S. A. This is apparently a voracious feeder on other nematodes. Remains of *Dorylaimus* and *Ironus* were seen in the intestine. Resembles *M. macrostoma,* but the tail is conoid and has no spinneret. Sublimate to balsam. Fig. 21.



22

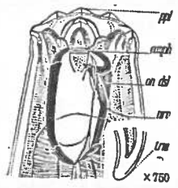
7. M. parvus de Man. De Man mentions the presence of minute teeth at the base of the pharynx, near the beginning of the œsophagus. Lining of the œsophagus well developed. Intestine apparently about 10 to 12 cells in girth, tessellated. Rectum somewhat shorter than the anal body-diameter. Tail arcuate; its terminus only about one-eighth as

$$\frac{3.1\cdot\quad 9.5\quad 29.\quad {}^{\cdot}63^{\cdot}\quad 93.}{3.\quad 3.6\quad 4.7\quad 5.7\quad 3.}\ 1.1\ \text{mm}$$

wide as its base. An egg seen in the uterus measured 100 μ in length. It is not certain that caudal glands are present.

Knowledge of this species rests very largely on the observations of Dr. J. G. de Man, who says that it is an active species, common in sandy soils of the dune districts of Holland. Occurs also in Germany, according to Brakenhoff, whose specimens, however, have the dorsal tooth close to the lips instead of midway as in the type form. Fig 22, previous page (after de Man).

8. M. papillatus Bastian. Glands are present in the segments of the œsophagus, and are most strongly developed in the posterior half. The secretion of the glands in the dorsal segment pours into the lumen of the œsophagus through a minute pore near the middle of the neck, a short distance behind the nerve-ring. Under favorable conditions lenses of the highest power show transverse striæ to be interrupted on the lateral lines, where there are 2 refractive longitudinal striations very close together. What appears to be an ordinary ventral renette pore is found a short distance behind the nerve-ring. The writer's investigations prove this species to be syngonic. The longitudinal ribs of the pharynx, probably 3 in number, are a little more prominently developed than usual. Occasionally a subventral or submedian rib of the pharynx shows traces of most exceedingly fine denticles. Only the most careful examination of favorable specimens shows these denticles. The writer has never observed a denticulated ventral rib like that of *muscorum*, as mentioned by Menzel.



3. 9.3 26. '82·27 93. → 1.1 mm
2.6 3.5 3.8 4.3 2.4

A common, voracious, cosmopolitan, nativorous species. Found in many parts of Europe and of the United States, and also in Hawaii, Australia, South America and Asia. Fig. 23. See also fig. 8.

9. M. intermedius Cobb. Truncate head having 6 lips, each with 2 papillæ. The elongated-oval amphids are half as wide as the base of the lip. The rather long, goblet-shaped pharynx is half as long as the head is wide, and presents a moderate-sized dorsal tooth two-thirds the way from the base to the lips. The intestine, whose commencement is marked by the presence of a pseudo-bulb, shows a rather indistinct tessellation. What appears to be a ventral renette pore occurs just behind the nerve-ring. The lateral fields are one-fourth as wide as the body. Caudal glands are present in the conical, arcuate tail. Spinneret almost pointed. Anus depressed, consequently conspicuous. Vulva conspicuous. The reflexed portions of the ovaries extend one-half way back to the vulva.

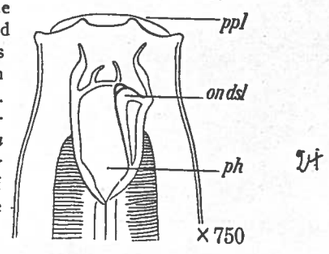
2.5 7.4 24. '81·35 94. → 1.9 mm
2.4 2.4 2.8 3.3 2.4

Found about the roots of sugar cane, Harwood, Clarence River, New South Wales, Australia. Examined in water after fixation with osmic acid vapor.

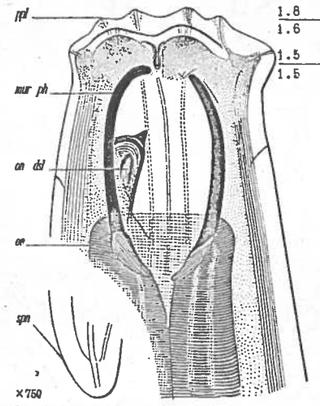
10. M. tenuicaudatus Stefanski. The lips are said to bear 6 large, spheroidal papillæ. A transverse element is said to traverse the wall of the pharynx opposite the apex of the dorsal tooth, and to bear 2 slightly curved projections. The œsophagus is muscular. At first the tail diminishes regularly in diameter, but presents 2 swellings in the posterior part.

? ? 21. '50+' 94. → 2.2 mm
? ? ? 4. ?

Found among algæ, in the Rhone River, Switzerland. This species is said to resemble *M. macrostoma* Bastian in the form of the buccal cavity, but to differ from that species in the details of the structure of the mouth, as well as in the form and length of the tail. Fig. 24, after Stefanski.



11. M. major Cobb. Labial papillæ of the inner row each with 3 (?) nerve-endings. Amphids slightly farther forward than the apex of the dorsal tooth, small. Lateral fields one-fifth as wide as the body. Intestine composed of rather small cells, showing an indistinct tessellation. The eggs are probably less than twice as long as wide. Each of the 12 rather conspicuous, echinulate, mammiform accessory organs is situated on the posterior side of a transverse ceratinous ridge extending one-fourth the distance around the body. The anterior two or three and the posterior one of these organs are smaller than the others. There are 2 pairs of ventrally submedian papillæ, also innervated, on the anterior third of the tail, the posterior pair being near the end of the anterior third, and the other pair half way between that point and the anus. There are other papillæ faintly visible on the dorsal side of the tail and elsewhere (fig. 16). The females of this species also present papillæ near the vulva: 3 small, ventrally submedian papillæ on each side of the body, one opposite the vulva, one a short distance in front of it and another a short distance behind it, and in addition a tandem series of 3 papillæ, both in front of and behind the vulva, on the ventral line. The location and conformation of these papillæ is shown in figure 12. Doubtless the females of other species possess similar papillæ. Fixed with osmic acid; examined in water.



1.8 8. 19. '55·25 95. → 3.4 mm
1.6 2.2 2.6 2.9 1.5

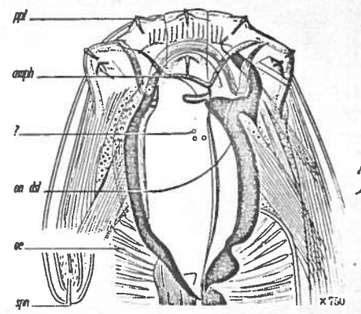
1.5 6.8 19. -M- 95. → 3.4 mm
1.5 2.3 2.9 2.8 2.3

Found about the roots of plants, in damp soil, Moss Vale, New South Wales, Australia. Also about turnips in Tasmania. This species resembles the following. Fig. 25.

12. M. gerlachei de Man. Lateral fields about one-third as wide as the body. In transverse section the buccal cavity, though nearly round, is obscurely three-sided, and shows the existence of 3 small, longitudinal grooves in the wall of the pharynx, presumably so functioning as to increase the elasticity and mobility of the pharyngeal walls. What appears to be a renette pore occurs immediately behind the nerve-ring. Anal muscles are well developed in the female. Spicula arcuate, tapering both ways, about one and one-third times as long as the anal body-diameter, and in their widest part about one-sixth as wide as the corresponding portion of the body. The accessory pieces are about one-third as long as the spicula, relatively small and poorly developed, appearing to be parallel to them when viewed in profile. The

2. 5.2 18. '50·33 92.5 3.7 mm
1.8 ? ? 3.7 2.

2. 5.6 20. -M- 95.5 3.2 mm
1.8 ? ? 3.7 2.3



pre-anal ventral row of supplementary organs is essentially the same as in *major* (fig. 16). According to Steiner's observations the number of supplementary organs in this species may at times be as great as that noted in *major*. Steiner calls attention to the existence of a submedian row of pre-anal papillæ, lying on either side of the ventral row. The tail bears 3 pairs of papillæ, one submedian or subventral pair near the anus; a second subventral pair slightly behind the middle; and a third dorsally submedian pair at the beginning of the final fourth of the tail. In the male the slightly conoid spinneret is one-sixth to one-seventh as wide as the base of the arcuate tail. The proportions are about the same as in the female, although the tail of the female is slightly longer and more slender, and not so strongly arcuate.

Found among fresh water algæ, Cape Van Beneden, Danco Land. It is rather difficult to point out satisfactory differences between this species and *major*. The pharynx of *gerlachei* is relatively smaller and is thicker walled, and its dorsal tooth is slightly farther forward. The number of labial papillæ—sixteen—appears to be the same in each. The amphids are perhaps slightly farther back in *major* than in *gerlachei*. The number of papillæ noted on the tail of the male of *major* is greater than that noted on the tail of *gerlachei*, but so far as the distribution of the dorsal papillæ on the tail of *gerlachei* is concerned, they appear to accord very closely with those of *major*. The two species appear to be closely related. Fig. 26 on the previous page (after de Man).

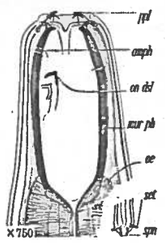
13. **M. fovearum** (Dujardin) Bastian. This is an insufficiently known species and may have to be declared *nomen nudum*. Head a trifle angular. Pharynx angular, "armed with 2 to 3 straight pieces, each (?) with a pronounced tooth in front of the middle." Tail tapering at first but retaining the same diameter through its posterior half, and ending in a sort of spinneret (?). Eggs in single series.

? ? 15. '50' 93. / ? ? ? 3. ? — 2.5 mm

Found at Rennes, France, in a fresh water ditch, along with *Branchipus*, entomostrica, *Euglena* etc. De Man suggests that this species is related to *tridentatus*.

14. **M. megalaimus**, n. sp. Labial papillæ obscure. Amphids obscure, half way between the apex of the dorsal tooth and the anterior extremity. Cardia large and conspicuous, more or less cylindroid, three-fourths as wide as the body. Intestine about 12 cells in girth, more or less distinctly tessellated. At the end of the anterior third the tail is one-fourth as wide as at the anus. Spinneret slightly swollen, with 2 very small digitate setæ.

2.9 '9. 28. '52,38 86. / 1.8 2.6 3.1 3.5 1.7 — 1.5 mm



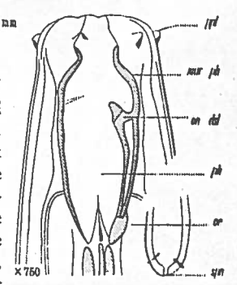
About the roots of plants, in a tamarack swamp, Wisconsin, U. S. A. This mononch is peculiar in the relatively meager development of the labial papillæ and the pharyngeal teeth, and the weakness of the pharyngeal muscles. Flemming solution to glycerine. Fig. 27.

15. **M. macrostoma** Bastian. Inner set of labial papillæ inconspicuous; outer set fairly well developed. The neck tapers but little. The head, however, is rather markedly convex-conoid. De Man describes and figures 2 exceedingly minute submedian teeth at the base of the pharynx. Œsophageal lining strongly developed. Intestine 12 to 15 cells in girth, tessellated. Posterior half or two-thirds of the tail of the female of practically uniform diameter, tapering but very slightly. Spicula arcuate, very slender, about twice as long as the anal body-diameter. Their proximal ends are not cephalated. They are accompanied by 2 accessory pieces, hardly one-third as long, arranged parallel to their distal parts. Supplementary organs, about 20, in the form of innervated papillæ, spread over a distance nearly

equal to the length of the tail, the posterior member of the series being a short distance in front of the anus. There are 3 pairs of somewhat equidistant subventral post-anal papillæ on the anterior part of the tail. There are also lateral papillæ on the tail.

2.7 9. 20. '54'44 89. / 2. ? 2.6 3. 3.2 2. — 2. mm

2.6 ? 25. M 92. / ? ? ? ? ? — 1.9 mm

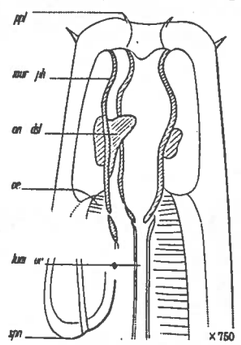


This beautiful, active, rather common species is found in the soils of meadows and marshes in many parts of Europe; it is also aquatic. The writer has followed Dr. de Man's rehabilitation of Bastian's *macrostoma*. Corresponding females which the writer has found at the Arlington Farm, Virginia, U. S. A., indicate the presence of exceedingly fine transverse striæ, and of inconspicuous wings. Amphids obscure, just behind the lips, difficult to see except in dorso-ventral view. The œsophagus receives the basal fourth of the pharynx, and in this region is very slightly swollen. The writer failed to see the minute basal onchi mentioned by de Man. The thin-shelled eggs, which occur in the uteri one at a time, are about one and one-fourth times as long as the body is wide and about half as wide as long, and are apparently deposited before segmentation begins. The writer has no doubt this species is syngonic. A female which had yet to undergo the final moult contained an egg which had its shell completely formed, and was evidently in a state preparatory to segmentation. Flemming solution to glycerine. Fig. 28 (after de Man).

According to Bastian the following differences exist between *macrostoma* and *truncatus; macrostoma* is 50 per cent longer, and is relatively narrower in the ratio of 3.5 to 5.3. *Macrostoma* tapers less in the neck, and has papillæ, while *truncatus* has none. While *macrostoma* is the larger, its pharynx is no longer; the onchus is a little farther forward. The intestine in *macrostoma* is less distinctly tessellated. The posterior part of the œsophagus in *macrostoma* is figured as having an internal expansion. These characters seem to the writer sufficient to separate the two species. It is probable that papillæ on the head of *truncatus* were overlooked by Bastian. This would have been easy, for instance, if the papillæ on *truncatus* are similar to those on *megalaimus*. See figure 27.

16. **M. obtusus**, n. sp. Papillæ setose. The adjacent figure (29) is after Bütschli, whose figures seem to represent a different species from that figured by de Man under the name *macrostoma*, notwithstanding the general resemblances. The proportions of the tail and of the spicula are different in the two forms; the distribution of the papillæ on the tail is also different, and, while the number and position of the pre-anal ventral supplementary organs are about the same, their form as shown by Bütschli is decidedly different from that shown by de Man. In addition, Bütschli's figure shows 3 pairs of pre-anal, ventrally submedian papillæ coextensive with the ventral row. Bütschli's data may therefore, the writer thinks, be taken as establishing this new species. Synonym, *M. truncatus* Bastian of Bütschli.

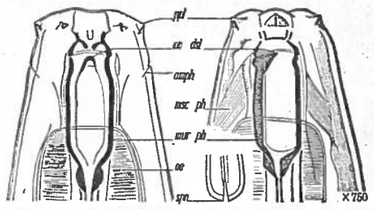
2.4 ? 25. '50+' 87. / 2.5 ? 4.2 ? 3.3 — 1.7 mm



Found in the River Main, Germany; common in mud and in aquaria and among aquatic plants, in moving water not foul. See also fig. 15.

17. M. tunbridgensis Bastian. The Tunbridge mononch is interesting historically as well as intrinsically, for it was an examination of numerous specimens of this aquatic nema that marked the beginning of the classical researches of the well-known English nematologist, H. Charlton Bastian. The upper formula is the average of glycerine specimens from the Arlington Farm, Virginia, U. S. A., while the lower formula is the average of the writer's balsam specimens from Tunbridge Wells, England. As a rule the head is rather suddenly contracted opposite the pharynx, and this is perhaps the best distinguishing mark of the species. Bastian, who had an abundance of specimens, emphasizes this character. The adjacent figures are those of Dr. de Man, and show the pharynx relatively a little narrower than is usual. The tails of the writer's Tunbridge Wells specimens accord rather with Bastian's figure than with his description. As is often the case in other mononchs, the labial papillæ stain more strongly with carmine than do adjacent tissues, so that the lip region as a whole appears strongly colored. Opposite the dorsal tooth there is an exceedingly minute, low, subventral projection. The form of the amphids is not fully determined; they are located nearly opposite the base of the pharyngeal tooth, and have a width one-half to one-third as great as that of the pharyngeal cavity. Near the cardia the œsophageal lining occupies about one-fourth of the optical longitudinal section of the œsophagus. The intestine, which may present a certain amount of tessellation, is about 10 to 12 cells in girth. The anterior two-fifths to one-half of the tail is conoid in such a fashion that at the middle the diameter is about one-sixth as great as at the anus. Thence onward the tail is nearly cylindrical, and ends in a very slightly expanded terminus armed with one or two very inconspicuous papillæ. That a sticky substance often exists on the surface of the terminus of the tail is evident from the accumulation there of minute particles of foreign matter. Caudal glands appear to exist immediately behind the anus, but their nuclei have not been definitely made out as yet. The lateral fields appear to be one-third as wide as the body. Each ovary contains a score or more of developing ova, arranged in several tiers in the distal half of the organ, but single file elsewhere. The somewhat elongated eggs are about one and one-third times as long as the body is wide, and about half as wide as long, and occur in the uteri one at a time.

2.4 8.7 24. '52,20 89. → 1.8 mm
2.1 2.8 3.6 3.7 2.3
2.4 7.8 23. '53,24 90. → 1.3 mm
2. 2.5 2.6 2.7 1.7

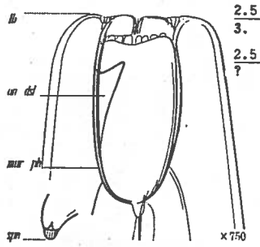


30

This seems to be primarily an aquatic species, though the writer has found it also in soil in the vicinity of rivers and streams. Fig. 30 (after de Man).

18. M. truncatus Bastian. Œsophagus conoid, its lining well developed. Intestine about 12 cells in girth, more or less distinctly tessellated. Lateral fields broad and distinct. It is a question whether to retain this species on the basis of Bastian's original description, or to accept Bütschli's description as a rehabilitation of Bastian's species. It is hardly likely that any species of *Mononchus* is destitute of labial papillæ, and in this respect Bastian's description seems defective. The extreme reduction of the

2.5 ? 25. '50+' 86. → 1.8 mm
3. ? 5. 5.3 3.4
2.5 ? 25. M 92. → 2. mm
? ? ? ? ?



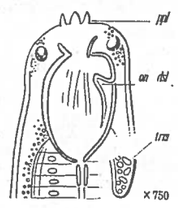
31

labial papillæ so far recorded is shown in *megalaimus*. Bütschli and later authors describe and figure the papillæ of *truncatus* as setose. It seems hardly likely that Bastian would have overlooked setose papillæ such as those figured by Bütschli. In that case Bastian's *truncatus* should be retained as a species, probably having very inconspicuous labial papillæ similar to those of *megalaimus*, while the data given by Bütschli may be taken as establishing a new species, for which the name *obtusus* is proposed. (See No. 16.)

Found in a small pool, among decaying moss and liverwort, England. Fig. 31 (after Bastian).

19. M. dadayi Micoletzky. A striking character of this species, "*M. macrostoma* Bastian var. *armatus* Daday," as described by its author, is the presence of 6 small, tooth-like cuticular spines close around the mouth. No such structures have been seen in other species, and accordingly Micoletzky has proposed for the form the name *dadayi*.

? ? 22. ? 86. → 1.6 mm
? ? ? 4.2 2.8

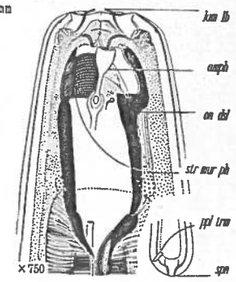


This is a littoral species. The description and drawings rest upon the examination of a single specimen. The original description is very brief and the accompanying illustrations, one of which is here reproduced, are meager sketches of the head and tail ends. A more complete examination of further specimens is desirable. Fig. 32 (after Daday).

32

20. M. longicaudatus Cobb. Opposite the apex of the dorsal tooth there are refractive transverse thickenings of the wall of the pharynx in the ventrally submedian region, and in front of these thickenings there are a few transverse striæ. The lateral fields are two-fifths as wide as the body, and are distinctly to be seen. since they have definite lateral contours, doubtless owing to the thickness of the muscular layer. The lateral fields contain scattered, nearly colorless granules somewhat smaller than those contained in the intestinal cells. In young specimens the vagina is distinctly separated from the uterus by a deep constriction, and the uterus itself is bulbous near this constriction and narrower farther away. *Longicaudatus* is a syngonic species. In the adult and egg-producing specimens the eggs are seldom or never seen more than two at a time, one in each uterus.

3. 6.7 26. '55,23 88. → 2. mm
2. 2.4 3. 3. 2.4

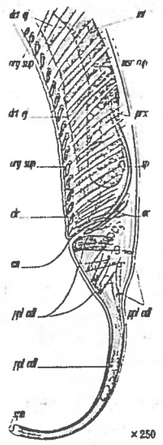


33

A predacious species, feeding upon other nematodes, upon rotifers and protozoa. It is cosmopolitan, and is found in rivers, ditches and pools, as well as in the soils of swamps and meadows. It occurs, sometimes in vast numbers, in the sand of the slow filter beds of the water-works of cities and towns. Flemming solution to glycerine. Fig. 33; also fig. 2, p. 132.

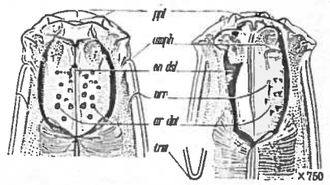
Longicaudatus suffers from an internal disease caused by a fungus having a branched mycelium. The width of the mycelium is about half as great as the thickness of the body wall of the nema, and the septa of the cells are separated from each other by a distance equal to the diameter of the body. There are two other diseases affecting this nema, one of microbe origin, the other of fungous origin; they appear, however, to be confined to the cuticle. One consists of short-styled, elongated-ellipsoidal elements on the surface of the body extending outward at right angles. These have been seen on the tail end. The microbe growth appears as a coating, sometimes of considerable thickness, and occurs on various parts of the body. It has been seen

at both extremities. The adjacent figure (34) depicts the tail end of a male found in Hawaii about the roots of sugar-cane. The general resemblance to the male assigned by Bütschli to *M. truncatus* Bastian is very striking, yet the differences in detail are also pronounced. The number of supplementary organs is 16 instead of about 20, and the organs themselves relatively shorter and more plump. The spicula and their accessory pieces have the same general proportions and size. The tail also has the same form and proportions, but the terminal portion is more slender in the Hawaiian specimen, and the distribution of the papillæ thereon is decidedly different, as will be seen by comparing figures 15 and 34. Male mononchs are so rare that the amount of variation that may exist in a given species is a nearly unknown quantity, so that it is not exactly easy to make intelligent comparisons between the males in these two cases. The Hawaiian male is supposed to be the male of *M. longicaudatus,* the only one that has ever been seen. It is interesting to note that when the spicula become long and slender the accessory pieces also become long and slender, but maintain their general form and are bifurcated at the distal end. Fig. 33 (on the previous page) and fig. 34. It is a curious fact that this, the only male of *M. longicaudatus* ever seen among the many thousands examined, should have come from soil, since *longicaudatus* is much less common in soil than in water.



21a. M. dentatus, n. sp. This representative of a new subgenus is especially interesting as a guide to speculation concerning the relationship of *Mononchus* to other genera. The scattered denticles are paralleled in certain marine nemas. The arcuate tail is conoid from the raised anus. The rather blunt terminus is about one-fourth as wide as the base of the tail. There is a pair of ventrally submedian, innervated papillæ a little in front of the middle of the tail. The amphid is sometimes more elongated than shown in the illustrations.

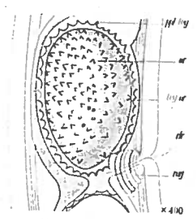
3.	9.	27.	'62,14	95.	1.1 mm
2.6	2.8	3.3	3.3	1.9	

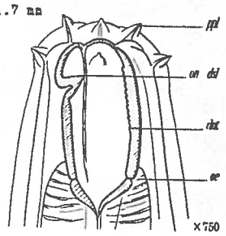


Description of a young female, from roots of orange trees, Bahia, Brazil. Fig. 35. For 21b, *M. recessus,* and 21c, *M. decurrens,* see Appendix, p. 184.

22. M. punctatus, n. sp. This species is proposed for the reception of the specimen described by Brakenhoff under the name *M. papillatus* Bastian, which appears to differ from any mononch hitherto described in that the shells of the eggs are echinulate. It is placed in the subgenus *Prionchulus,* though with some doubt, principally because both the description and the figure of Brakenhoff show the presence of denticles on the ventral rib of the pharynx. The author says: "Hier findet sich nämlich eine, in der Mitte (und an den 2 Seiten) fein gezähnelte Leiste. Diese

2.6	?	25.	'85,26	93.	1.7 mm
2.2	?	?	3.5	?	

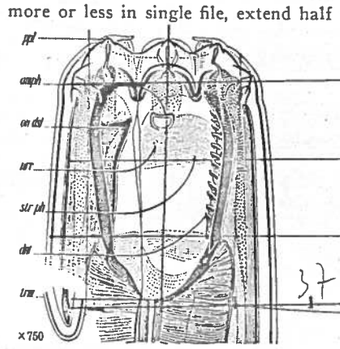




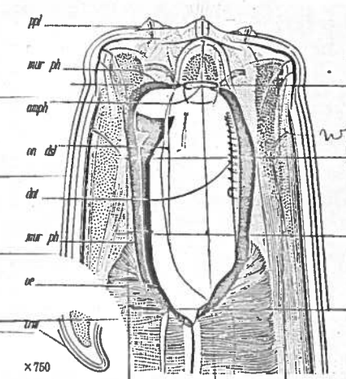
Zähnelung erstreckt sich über eine etwa 0.016 mm. lange Strecke und beginnt distalwärts etwa in der Höhe der Spitze des dorsalen Zahns." The ellipsoidal eggs occur in the uteri one at a time, are about as long as the body is wide, and two-thirds as wide as long.

Found among the roots of *Alopecurus denticulatus,* as well as aquatic habitats, in the bottom of ditches and lakes in Germany. Fig. 36 and 36a (after Brakenhoff).

23. M. muscorum (Dujardin) Bastian. The oldest, and one of the best known species. Intestine tessellated. Tail conoid and arcuate. The reflexed ovaries, each containing about a dozen ova arranged more or less in single file, extend half way back to the projecting vulva. The eggs are one and one-half times as long as the body is wide and three-fourths as wide as long. The anterior sexual organ is somewhat the larger. Fig. 37, left.



2.	9.	24.	'65,32	94.	2.5-3. mm
2.1	2.7	3.2	3.6	1.6	

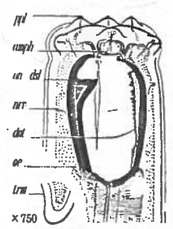


2.3	7.4	24.	'60,25	92.	1.9 mm
2.	3.2	3.7	4.4	2.5	

This is a beautiful and rather common cosmopolitan species, occurring in swamps, marshes, meadows and moorlands. It has been found in various parts of Europe and is not uncommon in the United States. It was first found by Dujardin in the Jardin des Plantes, Paris, where it still thrives; the writer recently found it about the roots of some heather imported thence. It feeds on smaller animal organisms, among them other nematodes. The following is a variety:

M. muscorum (Dujardin) Bastian *macrolaimus,* n. var. Besides differing slightly in proportions from the type form of the species, the variety has a somewhat larger pharynx, with smaller denticles on the ventral rib. The submedian papillæ of the outer sets are apparently double instead of triple, though at some distance behind the outer submedian papillæ there is a special submedian innervation. Most of these minor differences are set forth in figures 36 and 37.

Found in *Cladonia rangiferina,* tamarack swamp, Wisconsin, U. S. A. Fig. 38, right.

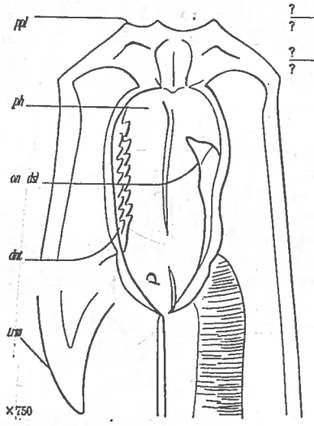


24. M. longicollis, n. sp. A species resembling *M. muscorum,* but which differs in the proportions of the various parts and in the conformation of the pharynx, the denticles of which are irregular and inward pointing. Submedian papillæ of the outer row double, instead of triple as in *muscorum.* Amphids relatively

3.1	10.	27.	Y	93.	1.2 mm
2.2	2.4	2.3	2.1	1.2	

larger than in *muscorum*. Striæ very difficult of resolution. Found about the roots of pitcher-plants and tamarack, in a swamp, Wisconsin, U. S. A. The difference between this and *muscorum* may not be very important. Both are nemativorous. Flemming mixture to glycerine. Fig 39 (at bottom previous page).

25. M. spectabilis Ditlevsen. The muscular œsophagus encompasses the proximal third of the pharynx, and has a conspicuous lining. The uteri may contain from 2 to 4 eggs, usually 2. The acute conical tail is strongly arcuate. The male is a little more slender than the female, and increases in size from a point where the supplementary organs commence, in such a way that the body assumes a maximum circumference near the anus. The copulatory muscles are strongly developed, and the numerous, prominent, supplementary organs appear to have a subventral position, forming two longitudinal rows, between which is a groove. Fourteen of these supplementary organs are figured by Ditlevsen—manifestly not the whole series. The arcuate spicula, which have a strengthening piece in their distal halves, are about one and one-half times as long as the anal body-diameter. Their proximal ends are not cephalated. At the widest part, toward the proximal end, they are about one-fifth to one-sixth as wide as the body; thence toward the distal end they taper gently. The obscurely bifurcated accessory pieces, which in profile view appear to cross the spicula, are of the usual form, and are about one-third as long as the spicula, and about one-third to one-fourth as wide as long. Their distal extremities lie somewhat in front of the tips of the spicula and toward the ventral side of the body. The elongated eggs are nearly one and one-half times as long as the body is wide, and less than half as wide as long.



? ? 20. '55' 96.8 → 4. mm
? ? ? ? ?

? ? 20. M ? → 3.6 mm
? ? ? ? ?

Numerous specimens, the males as numerous as the females, found at Hellerup, near Oresund, Denmark. This species exhibits the phenomenon of flotation. Ditlevsen says: "If some material (meadow soil) is spread in a flat glass cup and water is poured over it, the mononchs will mount rapidly and be lying on the surface dry and shining." Fig. 40 (after Ditlevsen).

26. M. index Cobb. No striæ seen. The neck diminishes opposite the base of the pharynx to form a rather cylindrical, truncated head which is slightly expanded as the head, are indicated by transverse markings, bent backward at each end, and located opposite the middle of the dorsal tooth. Denticles in about five rows, the outer rows more distinct. Pharynx half as wide as the head, and about three times as deep as wide. Œsophagus more or less conoid, with a massive lining occupying about one fourth of the optical section. Cardia pointed. Intestine few cells in girth; rather obscurely tessellated. Rectum half as long as the anal body-diameter. Longitudinal fields are visible throughout most of the length, and are about two-fifths as wide as the body. The diameter of the body increases somewhat just in front of the anus, and then diminishes suddenly at the anus, so that the beginning of the tail is very considerably less in diameter than the portion of the body immediately in front of the anus.

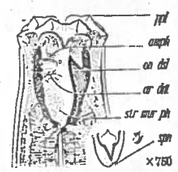
2.1 8.8 30. '69[15] 95.6 → .9 mm
2.4 3.2 3.5 3.6 2.

The diameter of the cylindrical portion of the tail is about one-fourth that of the body at the anus. Caudal glands 3, egg-shaped, opposite the anus. Spinneret slightly apiculate and apparently unarmed. The eggs are evidently of large size. A single egg, not yet passed on to the uterus, was four-fifths to five-sixths as wide as the body, and about three times as long as wide.

Common about the roots of sugar cane on various plantations on the island of Hawaii. Flemming solution to glycerine.

27. M. reversus, n. sp. This very interesting abnormal form possesses striæ that appear resolvable into rows of dots. Intestine about 6 cells in girth, faintly tessellated. Tail more or less cylindroid in the posterior half, its terminus one-fourth to one-fifth as wide as its base. Lateral fields two-fifths as wide as the body. The eggs are of relatively large size, since an ovum not yet passed on to the uterus is 5 to 6 times as long as the body is wide. It is therefore likely that the eggs occur in the uterus only one at a time. The relatively broad ovary tapers but little; it contains about a dozen developing ova.

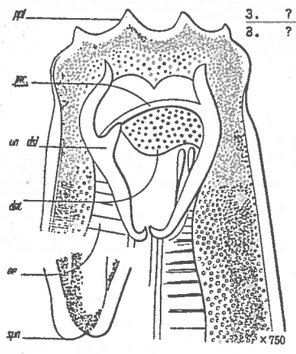
2. 9.4 26. 40·[17] 96. → 1.1 mm
2.2 2.3 2.7 3.4 2.



Rio Janiero, Brazil, about the roots of *Platonia insignis Mart.* In general this species resembles *incurvus* and *minor,* but is readily distinguishable by the form of the sexual organ, and by the sparseness of the pharyngeal denticles, only a few of which are to be seen. When the female sexual organs reduce to one, this remaining one usually extends forward from the vulva. Here the reverse is the case; hence the specific name. Flemming solution to glycerine. Fig. 41.

28. M. obtusicaudatus Daday. Tail conoid, slightly arcuate; toward the end rather suddenly diminished in size. The spinneret well marked.

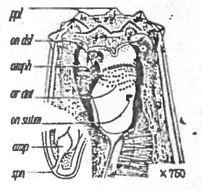
3. ? 28. '67' 95.3 → 1.9 mm
8. ? ? 4.7 ?



Found at Berlinhaven, Island of Salao, New Guinea, in fresh water. It seems probable from Daday's description that there are 3 teeth in the pharynx, 1 dorsal and 2 smaller submedian ones just at the base of the rasps. Probably the junction between the posterior and anterior elements of the pharyngeal walls is unusually prominent; this would account for the "bogige leiste" mentioned in the original description and shown in the original figure along the anterior margin of the rasp. Fig. 42 (after Daday). Assuming Daday's drawing to be more or less conventionalized, this species might be regarded as identical with *minor.*

29. M. brachyuris Bütschli. Amphids appear as transverse slits opposite the onchus. Lining of the œsophagus strongly developed. Cardia plainly to be seen. Intestine tessellated. Rectum half as long as the anal body-diameter. Caudal glands more or less saccate, opposite the somewhat raised anus. Tail somewhat arcuate. Spinneret pore a little to the dorsal side of the middle of the terminus. The vulva is a conspicuous feature, owing to the thickness of the walls of the vagina, which is one-half as long as the body-diameter. Series of

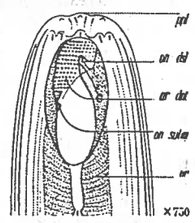
2.2 8. 28. '62·[18] 98. → 1.2-2. mm
2.4 2.9 3.6 3.9 2.2



male supplementary organs, according to de Man, about 12, mammiform and apparently protrudable except the two anterior and the posterior, which are more or less rudimentary. Series about twice as long as the tail.

A cosmopolitan species. In Florida, the writer found this species feeding on the larvæ of *Heterodera radicicola*, an extremely serious root pest. Fig. 43, bottom p. 467.

30. M. denticulatus, n. sp. Onchus opposed by two small subventral onchi farther back, the left a little farther forward than the right.



Found in the Zambezi River, South Africa, among fresh water algæ. The peculiar form of the head and pharynx, and the unusually large number of denticles are the prominent characters of this species. Only a single mutilated specimen has been seen by Dr. Micoletzky. As it is unlikely that the large number of denticles shown in the original figures can be due to moulting phenomena, it would seem that this form differs distinctly from all others. Fig. 44 (after Micoletzky). As neither Micoletzky's text nor figure suggests moulting, the numerous rows of denticles are assumed to be normal.

31. M. sparsus, n. sp. Each rasp consisting of but 2 rows of denticles. The tail diminishes suddenly in size behind the elevated anus, and tapers somewhat in the posterior three-fourths. The terminus is about one-fourth as wide as the base of the tail. The caudal glands (?) lie opposite the rectum.

2.9 12. 32. 54Y 94. → .5 mm
3.4 4.3 4.2 3.8 2.7

Found in sphagnum from greenhouses, Department of Agriculture, Washington, D. C., U. S. A. Flemming solution to glycerine. Fig. 45.

32. M. micrurus, n. sp. This odd form appears to have no submedian onchi. Rasps of only about four rows of denticles. Amphids not seen. Lining of the œsophagus well-developed, occupying three-fifths of the optical longitudinal section.

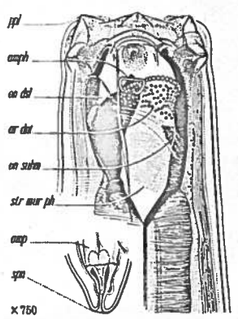
3. 12. 33. Y 98. → .8 mm
2.7 3.4 3.7 3. 2.2

Intestine about 5 cells in girth, not tessellated, or only faintly so. Tail very short and strongly arcuate or bent. Spinneret about one-fifth as wide as the base of the tail. Rectum somewhat shorter than the anal body-diameter; longer than the tail. Caudal glands not clearly seen, probably opposite the rectum. Ampullæ of the caudal glands not very strongly developed.

Described from young specimens found about Litchi roots, Fukien, China. Resembles *brevicaudatus*. Characterized by the extremely small and very strongly arcuate tail. The spinneret is sometimes turned nearly at right angles to the axis of the tail. Flemming solution to glycerine. Fig. 46.

33. M. incurvus, n. sp. Striæ resolvable with difficulty and into rows of dots. Dorsal onchus opposed by 2 inconspicuous, ventrally submedian onchi of smaller size opposite its base. The lining of the œsophagus is a prominent feature, occupying about two-thirds of the apparent width of the œsophagus. Intestine 12 to 15 cells in girth, not tessellated, its granules numerous and fine. Caudal glands 3, broadly saccate, opposite the anus, their ampullæ long and filling the posterior part of the tail.

2. 7.4 28. 63.21 96.2 → 1.4 mm
2.1 2.5 2.9 3.2 2.1

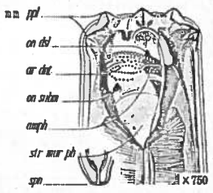


There is a flattish cardia. Anus raised. Longitudinal fields two-fifths to one-third as wide as the body. From the more or less elevated vulva the vagina leads inward at right angles to the ventral surface one-third the distance across the body. The eggs are one and one-half times as long as the body is wide, and occur one at a time in each uterus. The ovaries contain about a dozen developing ova.

Sandy soil in a cranberry bog, Arlington Farm, Virginia, U. S. A. Also on the margin of the spring that gives rise to Salt River, Jamaica. Flemming solution to glycerine. Fig. 47 (at bottom of previous page).

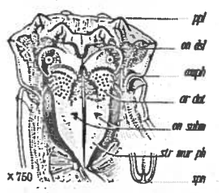
34. M. sigmaturus, n. sp. Two very inconspicuous submedian onchi are found opposite the base of the dorsal onchus, just at the base of the rasps. Intestine 10 cells in girth, comparatively distinctly tessellated. The rectum is about as long as the anal body-diameter, and is somewhat sigmoid. The anus is very distinctly visible on account of its contour, and on account of the refractive nature of the lining of the rectum. What appears to be a renette pore exists immediately behind the nerve-ring. The distinct lateral fields are about one-fourth as wide as the body, and are characterized by the presence in them of scattered granules much smaller in size than those of the intestine. The posterior part of the tail is somewhat digitate, and the whole is slightly sigmoid. From the anus the tail tapers rapidly to near the middle, so that if the posterior half were lacking the tail would be rounded. The diameter of the tail at the middle is about one-third as great as at the base. From the middle onward the tail for a short distance is of uniform diameter, and then tapers rather rapidly in the posterior fourth to a rounded or subtruncated spinneret. Small, somewhat finger-shaped setæ are found on the tail; one dorsally sublateral pair, a trifle in front of the anus; another dorsally sublateral pair near the middle of the tail but located on the more bulky part; finally, a third ventrally sublateral pair a little in front of the digitoid part of the tail. The caudal glands are opposite the rectum. The eggs are about two and one-half times as long as the body is wide. The tapering ovaries contain 10 to 12 developing ova, arranged irregularly.

2.3 12. 30. 64.14 96.3 → 1.2 mm
2.4 3.2 3.3 3.5 2.4



Found in various parts of the United States and Mexico. Resembles *minor and brachyuris,* from which it may be distinguished by the form and structure of the tail. Flemming solution to glycerine. Fig. 48.

35. M. subtenuis, n. sp. Wall and dorsal tooth of the pharynx rather strongly developed. When the lips are closed the pharynx is hardly half as wide as long. Dorsal tooth slightly arcuate, its point located close to the base of the lips. The submedian teeth are easily confused with the denticles. Lining of the œsophagus well developed, occupying one-fourth of the longitudinal optical section. There is a small conoid cardia. Intestine probably about 6 cells in girth, not definitely tessellated. Anus raised and conspicuous, the anterior lip somewhat massive and overhanging. The arcuate, conoid tail ends in a spinneret one-fifth to one-sixth as wide as its base. The ovaries, of which the posterior is somewhat the smaller, appear to contain about a dozen ova. Inconspicuous papillæ appear on the ventral side of the female near the vulva. Two were noted behind the vulva and one or more in

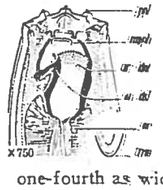


1.5 5.6 28. 72.22 97. → 1.9 mm
1.4 1.7 2.1 2.3 1.3

1.5 6.2 25. 42 97. → 1.8 mm
1.6 1.8 2.1 2.2 1.8

front of it. The tail of the male is somewhat like that of the female but diminishes very suddenly behind the anus. Five pairs of innervated papillæ have been seen on the tail of the male, two of them, however, exceedingly inconspicuous and easily overlooked: Of the three more conspicuous, one ventrally submedian pair is located a short distance behind the anus; a second dorsally sublateral pair occurs a little behind the middle of the tail, and a third subventral pair occurs a short distance in front of the spinneret. Of the two more inconspicuous pairs, one is nearer the spinneret than that just mentioned, and the other, lateral, and slightly behind the middle of the tail. The arcuate spicula are about one and one-fourth times as long as the anal body-diameter. At their widest part, near the middle, they are about one-fifth to one-sixth as wide as the corresponding part of the body and thence taper in both directions; they are not cephalated. The distal ends are obscurely two-pronged. The obscurely bifurcated accessory pieces are of typical form and size, about one-third as long as the spicula and about one-fourth as wide as long. Fourteen rather closely approximated, equidistant supplementary organs occur in front of the anus, occupying a distance about three times as great as the length of the tail. Internally the organs seem to be short, broad tubes of slightly varying diameter; these are probably slightly protrudable. The protrudable portion is not hispid as is the case in *M. major;*—on the contrary, it appears to be smooth. The anterior one and the posterior three of these organs are not so well developed as the others, that near the anus being reduced to a mere innervation; the distance between this latter and its nearest neighbor is about twice as great as between any other adjacent members of the series. These organs give to the ventral contour a crenate or serrate appearance. The anal muscles are prominently developed. The ejaculatory duct is often filled with elongated spermatozoa, somewhat resembling those of *Dorylaimus,* and similar in form to those figured by Dr. de Man for *M. gerlachei.* Each one may be one-fourth as long as the body is wide, or thereabouts. There are two outstretched testes. The blind end of the anterior is about as far behind the base of the neck as the latter is behind the anterior extremity. The blind end of the posterior seems to lie about twice as far in front of the foremost supplementary organ as this latter is in front of the anus. The spicula have a median stiffening piece, and their proximal ends lie toward the dorsal side of the body.

Found about the roots of plants on the Arlington Farm, Virginia, U. S. A. Resembles *M. minor,* but in the proportions of the pharynx there are notable differences. The walls are here thicker; the amphids are larger and farther back; the lips and onchus are strongly developed, so that when the pharynx is closed the cavity appears smaller than in *minor.* Opposite the anterior supplementary organ there is a fibrous ring, probably nervous. A similar structure has been noted in other species. There probably exist at this point in the body special nerve commissures. Flemming solution to glycerine. Fig. 49 (near bottom of previous page).



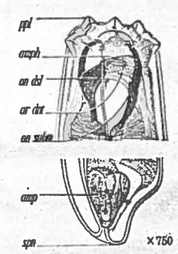
36. M. subsimilis, n. sp. Striæ of the cuticle more or less easy of resolution. Lining of the œsophagus strongly developed, occupying three-fifths of the longitudinal optical section. Anus slightly elevated, especially the anterior lip. The scattered granules in the cells of the intestine are small, but variable in size, and do not give rise to tessellation. The more or less arcuate tail is conoid to the blunt terminus, which is about one-fourth as wide as the base of the tail. A ventrally sublateral innervated papilla occurs on each side near the middle of the tail. There are no caudal glands. Description derived from a single young female.

3. 10. 34. Y 98. / 3.1 3.8 4. 3.8 2.6 → .8 mm

About the roots of banana plants imported from Paris, France. Resembles *brachyuris* and *minor,* but differs in having no spinneret. The dorsal onchus is set farther back in the pharynx than in either of those species, and there are no traces of submedian teeth. The rasps also are less strongly developed. Flemming solution to glycerine. Fig. 50 (at bottom of previous page).

37. M. obliquus, n. sp. Two small, ventrally submedian onchi present, opposite the base of the dorsal onchus. Œsophagus at first a little swollen; its lining well developed, and occupying one-fourth of the optical longitudinal section. Intestine about 8 cells in girth, as a rule not distinctly tessellated. The conoid tail is slightly arcuate, and obliquely truncate at the spinneret, which is about one-third as wide as the base of the tail. The three caudal glands are located opposite the rectum, which ends externally in a slightly elevated anus. The ampullæ of the caudal glands are well developed, and occupy the posterior two-thirds of the tail. Though the vulva is more or less continuous with the ventral surface, it is conspicuous on account of the refractive nature of the walls of the vagina. The elongated thick-shelled eggs are two and one-half times as long as the body is wide, and appear to be deposited before segmentation begins. The ovaries contain about a dozen developing ova, arranged partly single file, partly irregularly. A pair of ventrally submedian innervated papillæ were noted near the middle of the tail of the female.

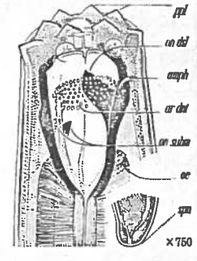
2.6 9. 31. ‹63› 98. / 2.6 3.4 3.4 4.1 2.4 → 1.4 mm



From soil from Germany, along with specimens of *Heterodera schachtii.* Resembles *brachyuris,* from which it seems easily distinguishable by the large thick-shelled eggs. Flemming solution to glycerine. The habitat led to the suspicion that it was feeding on *H. schachtii,* but the writer was unable to establish the fact from the few specimens available for examination. Fig. 51.

38. M. lacustris Cobb. The amphids have the form of "slits," 3 to 4 times as long as wide, and are placed at the base of the lips nearly opposite the apex of the dorsal onchus. They are about one-sixth as wide as the corresponding portion of the head. Intestine from 15 to 20 cells in girth, the cells closely packed with granules of variable size in such a manner as to give rise to a close and obscure tessellation. The well developed lateral fields are one-third as wide as the body. The anus is slightly raised. The lining of the rectum is distinctly refractive. The tail is ventrally arcuate, and ends in a blunt spinneret one-fourth as wide as its base, containing a well developed, internally ceratinized spinneret. The three caudal glands are arranged tandem in the anterior half of the tail, the foremost being opposite the rectum. The spinneret appears to have a needle-shaped valve. A pair of ventrally submedian innervated papillæ has been noted a little in front of the spinneret on the female. The eggs, which appear to occur one at a time in the uteri, are about one and one-third times as long as the body is wide and four-fifths to five-sixths as wide as the body.

2.7 8. 28. ‹63› 98. / 2.5 3.2 3.9 4.2 2.3 → 1.1 mm

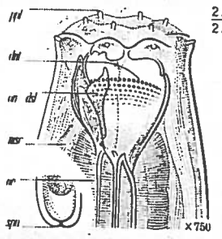


Found in fresh water lakes, Michigan, U. S. A.; about the roots of ferns, Panama Canal Zone; and in the Silver Springs, Florida. Resembles *M. brachyuris* Bütschli, from which it differs in the form of the tail and spinneret. *M. polonicus* Stefanski seems to closely resemble this species. Sublimate to balsam. Fig. 52.

39. M. polonicus Stefanski. Two minute teeth are found at the base of the buccal cavity. The conoid tail is somewhat arcuate from the raised anus, and ends in a truncated spinneret one-fourth as wide as its base. The three caudal glands are located in a tandem series in the anterior third of the tail.

Description derived from young specimens found in vegetable detritus in the Czarna River, Poland. Said by its author to resemble the next species, No. 40.

40. M. minor Cobb. There are 2 minute, submedian onchi, easily overlooked. Amphids, only one-sixth as wide as the corresponding portion of the head, are

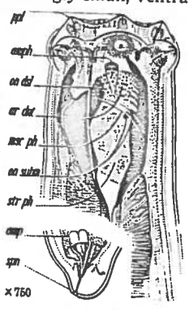


2.3 7.5 26. ‘60’19 96.7
2.4 2.5 2.9 3.4 2.1 → 1.1 mm

present opposite the apex of the dorsal tooth, and consist of arcuate, refractive markings having their convex side toward the lips. They appear to be about one-fourth as wide as the corresponding portion of the head. There are excessively minute striæ or dentations of the inner surface of the margins of the lips; these structures are so fine that they might easily escape observation—much finer than the rasp-like teeth of the pharynx. The lining of the œsophagus occupies nearly one-third of the optical longitudinal section. The cells of the intestine contain small, somewhat uniform, rather evenly distributed granules. The anus is slightly raised, the anterior lip being a little more pronounced than the posterior. The conoid tail is rather strongly arcuate, or even more or less bent near the middle. The comparatively well developed spinneret is one-third as wide as the base of the tail, and possesses a valve similar to that found in *Mononchulus*. The caudal glands are located opposite to, or a little behind the rectum. The lateral fields are two-fifths as wide as the body.

This is a cosmopolitan species, found in tropical and temperate regions. It closely resembles *M. brachyuris* of Bütschli, but is smaller and differs somewhat both in the structure of the tail and in that of the pharynx. Osmic acid to water. Fig. 53.

41. M. brevicaudatus, n. sp. Walls of the pharynx unusually thick. Two exceedingly small, ventrally submedian onchi, opposite the middle of the dorsal onchus.



2.7 9.3 32. ‘89’18 98.
2.2 2.7 3.1 3.4 2.2 → 1.5 mm

Lining of the œsophagus prominent, occupying one-third of the optical section. Intestine 6 to 8 cells in girth, faintly tessellated. Contour of the tail like that of the head of a duck whose beak is very short; from the anus onward having roughly an equilateral contour. Spinneret more elaborate than usual. The ceratinized walls of the vagina are plainly visible. The elongated eggs are two to two and one-half times as long as the body is wide. The ovaries taper but little. About a dozen females have been examined. No males have been seen. Sperm has been seen at the flexure in the ovaries. The species is probably syngonic.

Found about the roots of plants in a cranberry bog, New Jersey, U. S. A. Resembles *micrurus* and *brachyuris* in its general form, but differs in the details of the pharynx and in those of the tail. The species is nemativorous, and also feeds upon rotifers. Sublimate to balsam. Fig. 54, in which, as in many of the original illustrations used in this chapter, what at first sight appear to be merely lines used as shading, are in reality carefully charted striæ or laminations of the wall of the pharynx.

42. M. japonicus, n. sp. The head is not set off in any marked fashion. Amphids present in the form of elliptical markings nearly opposite the apex of the single dorsal tooth; the length of their long axes, which are placed transversely on the head, is probably about one-sixth as great as that of the diameter of the head. The capacious pharynx is somewhat deeper than the head is wide; the anterior portion has a diameter more than half as great as that of the corresponding portion of the head, while the posterior portion has a diameter about two-fifths as great as that of the base of the head. The single, highly refractive dorsal tooth has its apex somewhat in front of the middle of the pharynx. The rasps consist of 5 to 6 rows of teeth, forming a group whose width is about one-fifth as great as the depth of the pharynx. The wall of the pharynx is strongly developed, and is very finely transversely striated in the posterior part. The lining of the œsophagus is an exceedingly distinct feature throughout its length, and appears to occupy about one-fourth of the optical longitudinal section. There is a small cardia. Intestine, about 8 cells in girth, very obscurely tessellated. The short, blunt, arcuate conoid tail is truncated at the terminus, which has a diameter about one-fourth as great as that of the base. The lateral fields are about one-third as wide as the body, and are composed of 2 rows of cells containing relatively large nuclei.

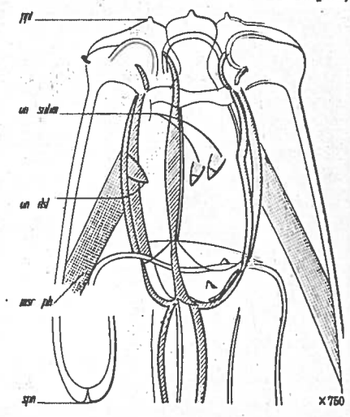
2.1 8.9 30. ‘87’ 98.
2.4 2.8 2.9 2.7 2. → 1.2 mm

This species rather closely resembles a number of others, and it is by no means certain that it is not identical with some one of them, perhaps consituting a variety. Curiously enough, it was found in Mississippi Bay, Yokohama, Japan. Sublimate to balsam.

43. M. tridentatus de Man. At the base of the pharynx are 2 minute denticles. Amphids unknown. Pharynx more or less triquetrous, with three well developed,

2. 6.5 22. ‘82’26 89.
2.1 2.6 3. 3.1 1.9 → 3.2 mm

2. 6.5 22. M 91.
2.1 2.6 3. 3.1 2. → 2.7 mm

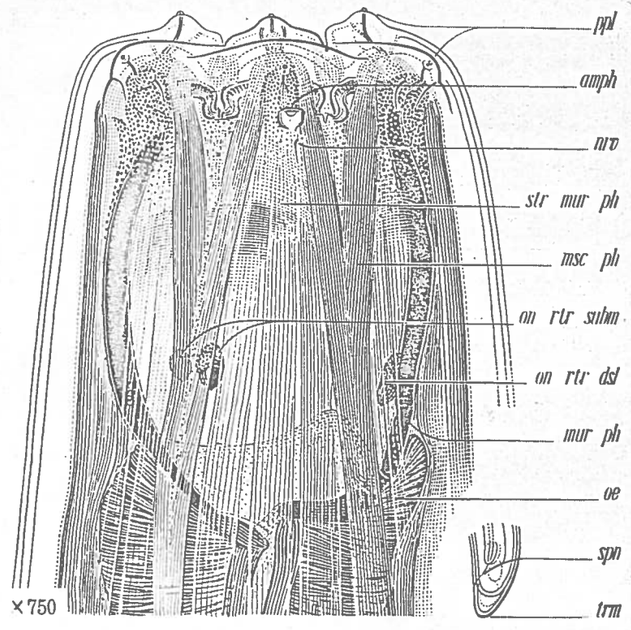


double, longitudinal ribs reaching from end to end. Œsophagus at first slightly swollen. Intestine distinctly tessellated. The arcuate tail is conoid to the terminus, which is about one-sixth as wide as the base of the tail. Each of the slender, arcuate spicula is cephalated by contraction and is supplied throughout its length with a median stiffening piece, and is crossed near its distal extremity on the outside by one of the rather broad, two-pointed accessory pieces, which are one-half as long as the spicula. Supplementary organs 15 to 17, apparently conical, 2 to 3 times as far apart anteriorly as posteriorly, where they are nearly contiguous. The posterior member of the series, the whole of which is about one and one-half times as long as the tail, is somewhat smaller than the other members, and is located a short distance in front of the anus. On the tail itself are a number of papillæ, dorsal as well as ventral; 2 pairs on the anterior half, ventral, and 2 pairs on the posterior half, dorsal. It remains uncertain whether there is a spinneret and caudal glands.

This striking species seems to be widespread in Europe in moist soil, and is rather common. Fig. 55 (after de Man).

44. M. gracilicaudatus n. sp. Intestine about 12 cells in girth. The anterior fifth of the tail is arcuate conoid in such fashion that at the beginning of the second fifth the diameter is about one-third to one-fourth as great as at the anus. Thence onward the tail tapers very gradually through the middle third, the posterior portion being cylindroid and somewhat narrower than the spicula. These latter are uniformly arcuate, and about one and one-fourth times as long as the anal body-diameter. At their widest part, toward the proximal end, they are about one-fifth as wide as the corresponding part of the body. They taper gently in each direction, and are not cephalated. The small accessory pieces are of typical form, only about one-fourth as long as the spicula. The series of 19 contiguous supplementary organs is twice as long as the spicula, or equals 3 body diameters. Anteriorly the organs are somewhat larger and also somewhat farther apart. The conical exterior portion of each organ seems to be more or less protrudable. These organs

1.4	4.8	21.	M38	85.	→ 5.1 mm
1.8	1.6	1.8	1.8	1.8	



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are similar in form to those of *major*, though they are not echinulate. The anal and post-anal muscles are strongly developed. The anal muscles are found throughout the bulkier portion of the tail. The protruding muscles of the spicula extend backward in the tail to near the point where the tail diminishes rapidly in diameter, and there join the ventral part of the caudal wall. The post-anal papillæ are confined largely to the more massive anterior fifth of the tail. On each side there is a ventrally submedian row about as long as the spicula, consisting of 4 to 5 members. Coextensive with them is a ventral row of 3 to 4 papillæ. A little distance behind these, where the tail begins to be smaller, there are 2 dorsally submedian

innervated papillæ of smaller size. The supplementary organs are plainly innervated and the nerves can be traced through the cuticle and through the body musculature, and seem to be connected with internal more or less ellipsoidal cells whose nature remains unknown. The spinneret is very inconspicuous. The nature of the caudal glands remains uncertain.

Found in marshy ground, Arlington Farm, Virginia, U. S. A., about the roots of *Impatiens,* in black, clayey soil, with mud. Resembles *M. dolichurus* to a certain extent. It is regrettable that only a few specimens have been available for examination, as it is a species well adapted to throw light on various features of mononch anatomy. Fig. 56 (on the previous page).

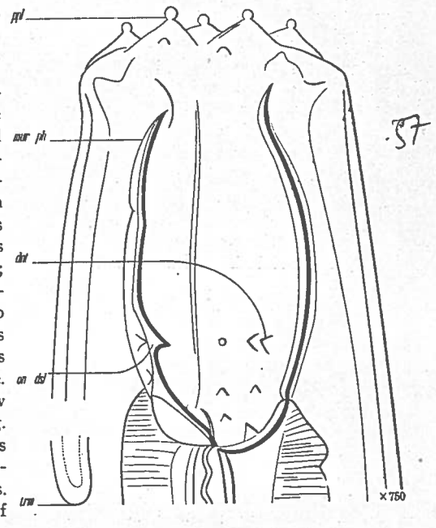
Examination of the pharyngeal muscles of this species leads to a partial understanding of the mechanics of the lips. The muscles which move the lips are long and slender, and pass from the lips backward along the surface of the pharyngeal capsule. They join the body wall some distance behind the pharynx. There are 2 separate groups of muscles, extensors and flexors. Of the 6 extensors 2 are shown in the illustration; these are furcated opposite the middle of the pharynx, one half of each going to the lateral lip; the other half to a submedian lip. The joined fulcra of the 6 lips form a framework encircling the head. The extensors pass outside this framework. The flexor muscles are less clearly shown, but are manifestly better developed. A group of 3 is shown lying between the 2 extensors. They appear as faint bands outside the pharynx passing forward, and beyond doubt are attached to the lips inside the ring of fulcra. The musculature of the lips is shown in the illustration and is further explained on page 140 in connection with the general description of the head.

45. M. dolichurus Ditlevsen. Neck tapering but little. Pharynx probably prismatic, and in transverse section somewhat triangular. About 7 denticles about the base, or near the base, of the pharynx. The arcuate tail tapers to the terminus, which is about one-eighth as wide as the base. The author mentions

?	?	25.	'80'	78.	4. mm
?	?	?	2.5	1.8	

the presence of 3 or 4 inconspicuously developed lobes at the base of the œsophagus, and it would appear from his figures that a spinneret and caudal glands are present, the latter forming a tandem series near the anus. Menzel finds in the pharynx of Swiss specimens of this species 3 teeth of equal size; that is to say, the ventrally submedian teeth are equal in size to the dorsal tooth. His specimens are 4½ to 5½ mm. long, and this probably represents the adult size.

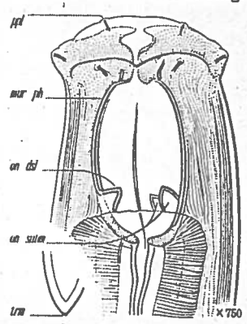
Found in moist soil and meadow land, Jutland; Switzerland. Fig. 57 (after Ditlevsen). Menzel shows the papillæ as much less conspicuous, and without the spherical tips. The original material consisted of but a single immature female.



57

46. M. digiturus Cobb. Amphids occur opposite the anterior part of the pharynx. What appears to be a renette pore occurs just behind the nerve-ring. The anal region is somewhat raised. Behind the anus the tail diminishes rapidly in diameter, so that at the end of the anterior fourth it is about three-fifths as wide as at the anus. Thence, for some distance it is cylindrical, but becomes somewhat abruptly convex-conoid in the posterior fifth and ends in a rather narrow, inconspicuous spinneret. The lining of the œsophagus is a conspicuous feature. Intestine not tessellated. The longitudinal ribs of the inner wall of the pharynx are rather conspicuous features, and extend from end to end of the pharynx.

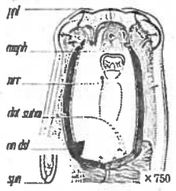
3.3 8. 26. '70[12] 92. → 1.4 mm
2.8 3. 3.4 3.4 2.3



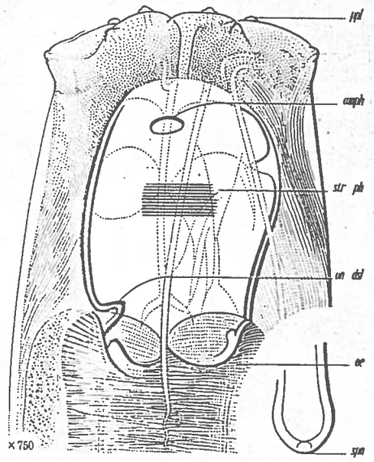
Found about the roots of banana plants, Fiji. Fig. 58.

47. M. trichurus, n. sp. This outstanding form has an œsophagus that is slightly swollen where it receives the pharynx. The lining of the œsophagus is prominent, occupying three-fifths of the optical section. Longitudinal fields one-fourth as wide as the body. Characters well set forth in fig. 14, p. 146.

2.6 .7. 21. '52[11] 69. → 1.2 mm
2.3 2.4 2.8 2.9 1.6



Found about the roots of orange trees, Bahia, Brazil. Bears considerable resemblance to *M. gymnolaimus.* It appears possible from these investigations that the tropical mononchs, when more fully known, will prove especially interesting. Nearly all the more striking species here recorded are from the tropics. The warm soils of the tropical regions teem with nematodes, many of them no doubt, especialy adapted to the peculiar conditions found there. The predatory mononchs in such soils will naturally enough have responded in structure not only to the climatic conditions, but also to the form and habits of their quarry. Fig. 59 (just above).



48. M. gymnolaimus Cobb. The more or less triquetrous pharynx is strongly three-ribbed. Cardia of such a nature as to give rise to a double constriction in the cardiac region. Intestine about 12 cells in girth. What appears to be a renette pore occurs immediately behind the nerve-ring. The lateral fields are about one-fifth as wide as the body. The tail tapers regularly to near the terminus; it is, however, cylindroid for a short distance in front of the spinneret. Vulva not prominent. The uterus is as long as the reflexed portion of the ovary, which

2.6 6.6 24. '67[15] 86. → 2.9 mm
2.2 2.3 2.7 2.5 1.6

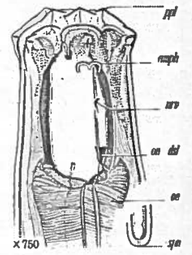
reaches two-fifths the way back to the vulva. The ova are for the most part arranged single file.

This nativorous species will probably prove cosmopolitan. About roots of banana, Fiji; of *Platonia insignis,* Rio Janeiro, Brazil; roots of various plants, Arlington Farm, Virginia, U. S. A. Fig. 60 (on the previous page).

49. M. consimilis, n. sp. Amphids, unlike those of *gymnolaimus,* apparently duplex, located a little behind the base of the lips; one-fourth as wide as the corresponding portion of the head. Wall of the pharynx strongly developed.

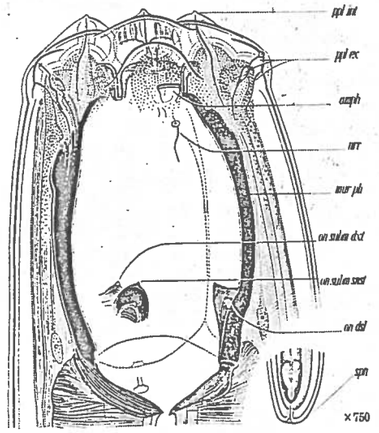
Rather closely resembles *M. gymnolaimus,* but has the walls of the pharynx much more strongly ceratinized, and is of much smaller size. The pharynx is relatively 50 per cent longer. The spinneret is not swollen as in *gymnolaimus.* Description and figures derived from a single, immature female specimen from about the roots of *Platonia insignis* Mart., Brazil. The figure of *gymnolaimus* shows, on the ventral side, near the front of the pharynx, an inward projection, probably representing the optical section of the junction of elements in the pharyngeal wall. No such appearance was observed in *consimilis.* Fig. 61.

3.2 9.1 26. 68[1] 88. → 1.1 mm
2.4 2.7 2.7 2.4 2.1



50. M. rapax, n. sp. Intestine about 12 to 20 cells in girth, faintly tessellated. The female organs are probably double and symmetrical. The conoid tail tapers somewhat in front of the anus to a plain, symmetrical, unarmed spinneret about one-sixth as wide as its base. One and one-half tail-lengths in front of the anus there is a constriction in the intestine, which appears to be due to the presence in that region of commissures, as if, possibly, nerves encircled the intestine at that part.

2.5 8.5 21. 61. 90. → 3.7 mm
2. 2.2 2.6 2.6 1.7



Found about the roots of plants, Arlington Farm, Virginia, U. S. A. Nativorous. Only young females have been seen. As its name, *rapax,* indicates, this species is a rapacious one, swallowing other nemas whole, even when half as long as itself. Fig. 62.

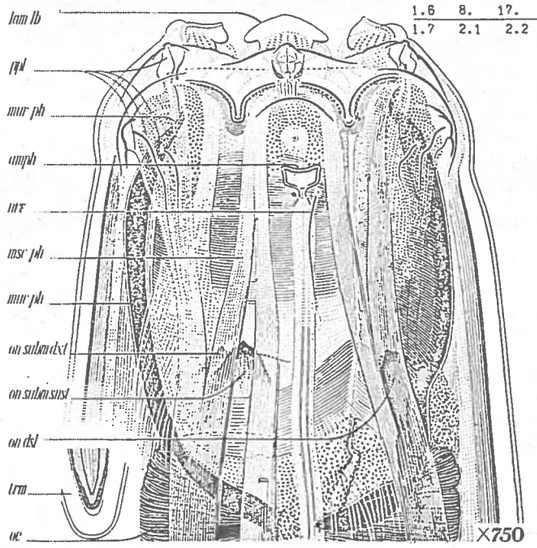
51. M. rex Cobb. This "king" of the mononchs has low, broad, inconspicuous labial papillæ that do not interfere materially with the rounded contour of the front of the head. The lips are bulky and powerful. No amphids have been seen. The pharynx is armed with very powerful muscles. The intestine is tessellated. The lateral fields are one-fifth as wide as the body. The conoid tail tapers more rapidly at first, being nearly cylindroid in the posterior two-thirds, where it is about one-eighth as wide as at the anus. The spinneret, which is slightly expanded, bears two ventrally submedian papillæ, after the manner of *longicaudatus,* but slightly larger

2. 6. 20. '58[37] 81. → 6.5-7. mm
1.6 1.7 2. 2.2 1.4

2. 5.5 20. N[50] 86. → 6.5-7. mm
1.5 1.9 2.1 2.3 1.5

in proportion. Three caudal glands are present. Each uterus is capable of carrying one and possibly two eggs at a time. These are about one and one-fourth times as long as the body is wide, and half as wide as long. The tail of the male tapers more rapidly at first than that of his mate. Supplementary organs 17, prominent, closely approximated, equidistant, occupying a space equal to one and one-half times the length of the tail. The spicula are about twice as long as the anal body-diameter.

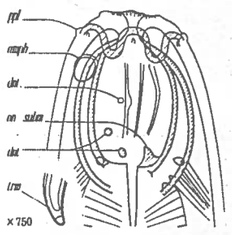
Found at depths of from about 200 to 1200 feet in Lakes Manapouri and Wakatipu, New Zealand.



52. M. regius, n. sp. Amphids relatively small, connected with a narrow, internal, apparently tubular element passing backward past the base of the pharynx. Pharyngeal muscles strongly developed, extending backward from the base of the lips to the body wall behind the pharynx. Each of the six lips with a flat, flap-like outer accessory part, which is longitudinally striated at the base. Onchi subequal, the dorsal slightly the stronger. Found about the roots of plants, Arlington Farm, Virginia, U. S. A. Fig. 63.

53. M. bathybius Micoletzky. In the figure the onchus labeled "submedian" is really a subdorsal onchus. In addition to this subdorsal onchus there are still others, probably 2 to 3 pairs, which in profile view have a double contour. It remains uncertain whether the other markings seen on the wall of the pharynx are projections or pores.

4.9 10. 30. 63Y 67. .8 mm
3.3 3.6 3.9 3.4 2.5

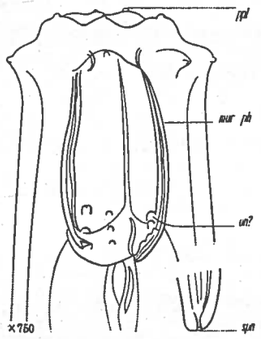


The author considers this species to be related to *M. gerlachei* de Man, the lip region and vestibule of the two species being similar. However, the armature of the pharynx in the two species is quite different.

Found in mud at a depth of about 300 feet in the Atter Lake, Austria. The description and figures rest upon the examination of a single immature specimen, and it is probable that the examination of further specimens will improve our knowledge of this interesting form. Fig. 64 (after Micoletzky). For 53b, *M. fasciatus,* n. sp., and 53c, *M. similis* Cobb, see Appendix, p. 184.

54. M. studeri Steiner. Wall of the pharynx presenting 5 longitudinal ribs, four of them in 2 pairs, the fifth single. At the base of the pharynx numerous small denticles, arranged in rows of from three to four. Œsophagus powerful.

2.8? ? 26. 87. 94. 2. mm
? ? ? 3.4 ?
2.8? ? 27. N 95.4 2. mm
? ? ? 3.2 1.8

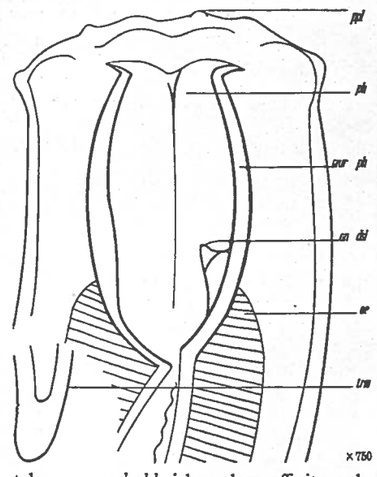


A little in front of the posterior end of the œsophagus there are 3 powerful teeth which, according to Steiner, "are similar to those seen in *Mononchus dolichurus.*" Tail of the male arcuate, conoid to the spinneret, which is about one-fourth as wide as the base. The three caudal glands form a tandem series in the anterior half of the tail. The slightly arcuate spicula in their widest part are about one-sixth as wide as the corresponding portion of the body. They taper slightly at either end, and are about one and one-third times as long as the anal body-diameter. They are not cephalated. The accessory pieces appear to be of the usual character. The twelve short, tubular, equidistant supplementary organs, occupying a space equal to twice the length of the tail, do not interfere materially with the ventral contour. The internal tubular parts are about as long as the spicula are wide. Distance from the anus to the posterior supplementary organ is nearly twice as great as the distance between the adjacent organs. Two pairs of post-anal papillæ were noted.

Found on the island of Ufenau in the Zürich Lake, under moss. Fig. 65 (after Steiner).

55. M. zschokkei Menzel. This species, one male to each three to four females, is found in various parts of the Austrian and Swiss Alps. Neck and œsophagus

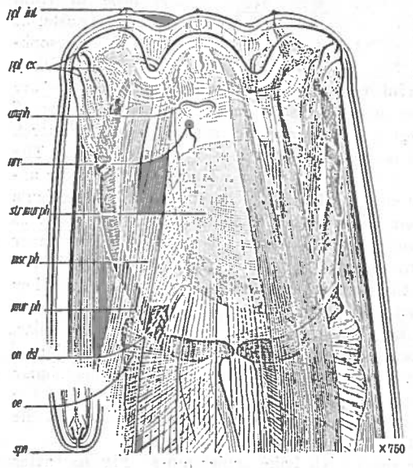
3.? ? 25. ‘66’ 95. 2.2–3.2 mm
? ? ? 3.4 2.1
? ? 25. N 96. 2.4–3.5 mm
? ? ? 3.6 2.4



tapering but little. Small denticles often occur at the base of the pharyngeal cavity. Uterus capable of containing one or two eggs. The blunted terminus of the conoid arcuate tail is about one-eighth as wide as the base. The slightly arcuate spicula are rather slender, each, however, having a stiffening piece in its distal half. Accessory pieces as figured by de Man for his *M. brachyuris* Bütschli. Beginning near the anus the 21 projecting, obliquely conical, equidistant, contiguous supplementary organs, each as high as wide, occupy a space 3 times as long as the tail.

Found in the high Swiss Alps. Fig. 67, after Menzel, who considers that of all the European mononchs at present known, *zschokkei* has close affinity only with *M. parvus* de Man, from which it differs in the position of the onchus and the relative abundance of males.

56. M. brachylaimus, n. sp. There are two exceedingly minute, almost invisible, apparently rudimentary, ventrally submedian, conical, forward-pointing toothlets at the base of the pharynx. These are not shown in the illustration. Three slightly



2.4 7. 21. 65^{14} 94. → 3.2 mm
2.4 2.4 2.8 3. 1.9

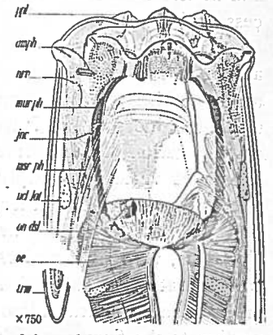
2.3 7.4 19. $-M-^{42}$ 94. → 3.5 mm
2.2 2.3 2.5 2.5 2.

arcuate, duplex, longitudinal ribs strengthen the walls of the pharynx and reach from end to end, one being dorsal, the other two ventrally submedian. Amphids difficult to see. Œsophagus at first slightly expanded. The œsophageal lining is not so prominent as in many other species; its optical section finds expression in 3 or 4 parallel lines, occupying about one-fourth of the longitudinal optical section. There is an inconspicuous, flattish cardia. Intestine about 8 to 12 cells in girth, faintly tessellated. The tail is conoid to the plain, unarmed conoid terminus. The base of the spinneret is about one-fifth as wide as the base of the tail. The clavate caudal glands form a close tandem in the anterior third of the tail. The anus has rather conspicuous, with well developed, though not protruding lips. There is a pair of innervated lateral papillæ near the middle of the tail of the female. Both in front of and behind the vulva, especially behind, there are inconspicuous papillæ, occupying a distance equal to twice to thrice the length of the body-diameter. The two equal, arcuate, rather slender spicula are one and one-half times as long as the anal body-diameter, and are of nearly uniform size throughout the greater part of their length. However, beginning near the slightly truncated tips they taper slightly in the distal sixth. The proximal ends are also narrowed slightly and lie well toward the dorsal side of the body, at any rate when the body is incurved. The two accessory pieces, each about two-thirds as wide as the spicula, are located opposite the distal portions of these latter. When seen in profile they appear to lie nearly at right angles to the body axis, and seem to cross the distal parts of the spicula. They are about two to three times as long as wide, and their distal extremities are diminished and bifurcated, the two prongs of the fork forming a U-shaped figure. When at rest these accessory pieces, as usual, are well inside the anus, in fact appear as if lying immediately under the lateral fields. In front of the anus there is a uniform series of about 16 equidistant, closely approximated, innervated supplementary organs, occupying a distance about equal to the length of the tail. When the tail end of the body is incurved, each organ appears on the ventral contour as a flattish cone, at the apex of which is a nerve ending, which from this point extends inward and forward.

Brown, sandy soil, Arlington Farm, Virginia, U. S. A. This nativorous mononch is distinguished from all others by the relative broadness of the pharynx, and by the position and size of the basal onchi. Especially well adapted to show the structure of the lip muscles and other organs of the head. Fig. 67.

57. M. acutus, n. sp. Œsophagus bulbous at first, the swelling being prolate. Intestine about 10 cells in girth. The arcuate conoid tail is practically acute. There is a pair of sublateral, innervated papillæ near the beginning of the posterior third of the tail. Anus not raised. Fig. 68.

2.6 7.5 22. 45. 94. → 2.1 mm
2.7 3.2 3.3 3.4 2.6



Found about the roots of rhubarb in loose, brown, sandy soil, Arlington Farm, Virginia, U. S. A. Nativorous. One specimen was observed which had swallowed another mononch. This is one of the most instructive forms. It is desirable that the more minute structural details of nemas be very carefully investigated with a view to increasing our knowledge of their comparative anatomy. The different parts of the digestive organs of nemas, small as they are, are as profoundly modified in harmony with the nature of the food as those of higher animals. The digestion of starch requires a different organic mechanism from that for digesting meat. The nemas have specialized to a high degree in the matter of food, and their digestive organs are correspondingly diversified.

Nemas and Soil Fertility

No one with a grain of imagination can engage in such studies as the foregoing without sooner or later asking himself questions of a general nature concerning the biology of the soil, for he gradually comes to see how almost infinitely numerous and varied are the organisms inhabiting it; a population in which the nemas are but an element. The answers to these questions will lead to a new view of soil fertility.

The revolution wrought by Liebig's ideas concerning the chemistry of the soil spent itself only to show us that, grand as it was, it was little more than an overture. Subtler forces and more intricate relationships than any indicated in these earlier conceptions must be considered. We now see, or are beginning to see, that the value of manure and of the rotation of crops is to be explained not simply on the basis of the exhaustion of certain elements in the soil, but also, and probably in some instances mainly, on the basis of an opposite process, an accumulation of certain organisms and substances in the soil. Who knows but that the existence of annuals may be due in some measure to this latter fact? May not these elaborate provisions for the distribution of the seeds of annuals be in some measure a means of escaping these accumulated hostile forces in the soil?

After all the word Agriculture is more or less of a misnomer. We cultivate, not so much the field, as plants. What we are really after is sunshine, for we are lost unless we can convert our infinitesimal part of the energy of this nearest star into food, clothing and shelter. This we do by utilizing the life forces of certain plants and animals, and these are not so few as we dreamed in our older philosophy, for none of our "domesticated organisms" can any longer be considered by itself. Every

such organism is reared in the midst of a host of other organisms, visible and invisible, and often it is these others that determine agricultural success or failure.

The soil is the habitation of a vast community of beings with all the attributes of other huge agglomerations of living things having varying needs, instincts and aspirations; and it is just as inappropriate to look upon it as inorganic as it would be to look upon a great city as merely an agglomeration of hills, streets and houses. Here in the soil are beings in enormous variety; multiplying, growing, dying; competing, fighting, cooperating one with another, with an activity almost if not quite defying the imagination, and we need what may be called soil biologists or geobiologists, who shall understand, as far as possible, this interplay of life forces that gives us food, fiber and fuel. To a considerable degree our progress in agricultural knowledge in the not distant future will be in proportion to the firmness with which we lay hold of and act on this idea.

Summary

1. The genus *Mononchus* is composed of scores, possibly hundreds, of species, divisible into distinct subgenera. The number of known species is hereby more than doubled.

2. The genus is of world-wide distribution, and many of the species are cosmopolitan. Mononchs occur in all kinds of arable soil, sometimes in hundreds of millions per acre.

3. Most mononchs, probably all, are strictly carnivorous. They feed on a variety of living microzoa, prominent among which are other nemas.

4. Injurious nemas are devoured by mononchs, and it is desirable that this trait of mononchs be carefully investigated with a view to utilizing it, if possible, in diminishing the enormous crop losses due to plant infesting nemas—losses amounting to many millions of dollars annually.

5. The lips are moved by long muscles, connecting proximally with the body wall behind the pharynx. These muscles lie along the outer surface of the pharyngeal capsule and act in such a way as to pull the lips inward and outward radially about a series of fulcra existing in a framework encircling the head along the margin of the pharynx. The lips are the mechanical complements of the dorsal tooth and denticles. While most mononchs bolt their food, some give it a certain degree of mastication. The appetite is sometimes voracious.

6. Many mononchs, probably most, are hermaphroditic, even to the degree of syngonism. In the typical case investigated the minute sperm cells of female origin are functional.

7. Well developed glands, salivary in character, occur in the mononch œsophagus, and empty directly into its lumen, and both indirectly and directly into the mouth cavity.

8. What appears to be an excretory pore of the usual type seems universal near the nerve ring.

9. The outer labial papillæ are the homologues of the ordinary cephalic setæ of other nemas, and are therefore most probably tactile in function. This leaves it probable that the inner papillæ are devoted to the senses of taste and smell.

10. Amphids are always present in the form of small lateral more or less elliptical structures near the lips, and are connected with internal elements extending inward and backward.

11. A functional spinneret is present in a majority of the species.

12. The cuticle is always finely transversely striated.

13. Mononchs probably moult four times.

Bibliography

(1) Annett, Dutton, and Elliott.
1901. Report of the Malaria Expedition to Nigeria, Part 2. Liverpool School of Trop. Med., p. 1-92.

(2) Bastian, H. C.
1866. Monograph on the Anguillulidae. *In* Trans. Linn. Soc. London, v. 25, p. 73-184, 6 pl.

(3) Brakenhoff, H.
1914. Nematodenfauna des Nordwest-deut. Flachlandes. *In* Abhandl. Naturw. Ver. Bremen, Bd. 22, p. 267-311, 3 pl.

(4) Bütschli, O.
1873. Beiträge zur Kenntnis der freilebenden Nematoden. *In* Nova Acta Acad. Leopold.-Carol., Bd. 36, p. 1-124, 11 pl.

(5) Bütschli, O.
1876. Freilebenden Nematoden und die Gattung *Chaetonotus*. *In* Ztschr. Wiss. Zool., Bd. 26, p. 363-413, 4 pl.

(6) Cobb, M. V.
1915. Nematodes of the Michigan Lakes. *In* Trans. Amer. Micros. Soc., v. 34, p. 20-47.

(7) Cobb, N. A.
1888. Beiträge zur Anatomie und Ontogonie der Nematoden. *In* Jenaischen Ztschr. Naturw., Bd. 23, p. 41-76, pl. 3.

(8) Cobb, N. A.
1890. A nematode formula. *In* Agr. Gaz. N. S. Wales, v. 1, p. 131-136.

(9) Cobb, N. A.
1893 Plant diseases and their remedies; sugar cane. *In* Agr. Gaz. N. S. Wales, v. 4, p. 808-833, 16 fig.

(10) Cobb, N. A.
1893. Plant diseases and their remedies; sugar cane. Separate Ed. for Queensland Govt., p. 31-56, 16 fig.

(11) Cobb, N. A.
1893. Nematodes, mostly Australian and Fijian. Macleay Memorial Vol., Dept. Agr. N. S. Wales, Misc. Pub. No. 13, p. 3-59, 7 pl., 10 fig.

(12) Cobb, N. A.
1904. Free-living fresh-water New Zealand nematodes. *In* Proc. Cambridge Phil. Soc., London, p. 363-374, 4 fig.

(13) Cobb, N. A.
1907. Fungus maladies of the sugar cane. Hawaiian Sugar Planters' Exp. Sta., Div. Path. and Physiol. Bul. 5, p. 163-196, 4 fig.
(14) Cobb, N. A.
1913. Notes on *Mononchus* and *Tylenchulus*. *In* Jour. Wash. Acad. Sci., v. 3, p. 287-88, 2 fig.
(15) Cobb, N. A.
1914. Nematodes and their relationships. *In* U. S. Dept. Agr. Yearbook, p. 457-490, 19 fig.
(16) Daday, J.
1897. Die freilebenden Süsswasser. Nematoden Ungarns. *In* Zool. Jahrb., Abt. System. Geogr. u. Biol. Thiere, Bd. 10, p. 91-134, 4 pl.
(17) Daday, J.
1901. Mikroskopische Süsswasserthiere aus Deutsch-Neu-Guinea. *In* Természet. Füzetek, Bd. 24-25, p. 1-56, 3 pl.
(18) Daday, J.
1908. Adatok német-kelet Afrika Mikrofauna. *In* Math és Természet. Értesitõ, Bd. 26, p. 1-57, 27 fig.
(19) Daday, J.
1910. Fresh-Water Nematodes of German East Africa. *In* Zoologica, v. 23.
(20) de Man, J. G.
1876. Onderzoekingen over vrij levende Nematoden. *In* Tijdschr. Nederland. Dierk. Ver., Deel 2, p. 78-196, 11 pl.
(21) de Man, J. G.
1880. Die einheimischen Nematoden. *In* Tijdschr. Nederland. Dierk. Ver., Deel 5, p. 1-104.
(22) de Man, J. G.
1884. Die Nematoden der niederländischen Fauna. 206 p. 34 pl. Leiden.
(23) de Man, J. G.
1885. Helminthologische Beiträge. *In* Tijdschr. Nederland. Dierk. Ver., Ser. 2, Deel 1, p. 1-10, 3 pl.
(24) de Man, J. G.
1904. Nématodes Libres. *In* Résultats du Voyage du S. Y. Belgica, Expédition Antarctique Belge, 1897-99, Zoologie. 51., 11 pl. Anvers.
(25) de Man, J. G.
1906. Nématodes de l'Ile de Walcheren. *In* Ann. Soc. Roy. Zool. Malacol. Belg., p. 156-174, 17 fig.
(26) de Man, J. G.
1907. Nématodes libres de la Seine. *In* Ann. Biol. Lacustre, t. 2, p. 9-29, 3 pl.
(27) de Man, J. G.
1912. Helminthologische Beiträge. *In* Zool. Jahrb., Sup. 15, Bd. 1, p. 439-464, 2 pl.
(28) Ditlevsen, H.
1911. Danish free-living nematodes. *In* Vidensk. Meddel. Naturhist. Forening, Bd. 63, Heft 1, p. 213-256, 5 pl.
(29) Dujardin, F.
1845. Histoire Naturelle des Helminthes. 654 p., 12 pl. Paris.
(30) Hofmänner, B.
1913. Freilebenden Nematoden. *In* Zool. Anz., Bd. 42, p. 413-418, 4 fig.
(31) Hofmänner, B.
1913. Nématodes libres du Lac Leman. *In* Rev. Suisse Zool., t. 21, no. 16, p. 589-658, 2 pl.

(32) Hofmänner, B., and Menzel, R.
1915. Freilenbenden Nematoden aus der Schweiz. *In* Rev. Suisse Zool., t. 23, p. 109-243, 3 pl.
(33) Jägerskiöld, L. A.
1909. Freilenbende Süsswassernematoden. *In* Süsswasserfauna Deutschlands, (Brauer), Jena, Heft 15, p. 1-46, 65 fig.
(34) Klausener, C.
1908. Fauna eines hochgelegen Alpensees. *In* Internat. Rev. Hydrobiol., Bd. 1, p. 142-152, 1 pl.
(35) Marcinowski, Kati.
1909. Parasitisch Nematoden. *In* Arb. K. Biol Anst. Land. u. Forstw. Bd. 7, Heft 1, p. 1-192, 1 pl., 76 fig.
(36) Menzel, R.
1912. Freilebande Nematoden, Umgebung von Triest. *In* Rev. Suisse Zool., t. 20, p. 536-542, 2 fig.
(37) Menzel, R.
1913. *Mononchus zschokkei* n. sp. *In* Zool. Anz., Bd. 42, p. 408-413, 4 fig.
(38) Menzel, R.
1914. Mikroskopische Landfauna der Schweiz Hochalpen. *In* Arch. Naturgesch., Abt. A, Heft 3, p. 1-98, 1 pl., 16 fig.
(39) Micoletzky, H.
1912. Fauna einiger Seen Salzburgs. *In* Zool. Jahrb., Abt. System., Géogr. u. Biol. Thiere, Bd. 33, p. 421-444.
(40) Micoletzky, H.
1913. Nematoden der Ostalpen. *In* Sitzber. K. Akad. Wiss. (Vienna), Math. Naturw. Kl., Bd. 122, Heft 4, p. 543-548.
(41) Micoletzky, H.
1914 Nematoden der Ostalpen. *In* Zool. Jahrb., Abt. System., Geogr. u. Biol. Thiere, Bd. 36, p. 331-546, 10 pl., 1 fig.
(42) Micoletzky, H.
1915. Fresh-water nematodes of South Africa. *In* Ergeb. Bot. Forsch. Reise Deut. Ostafrika.
(43) Oerley, L.
1880. Monographie der Anguilluliden. *In* Természet. Füzetek, Bd. 4, Heft 1-2, p. 1-165, 7 pl.
(44) Plotnikoff, B.
1901. Nematoda, Oligochaeta, und Hirudinea. *In* Ber. Biol. Süsswasser-Stat. K. Naturf. Gesell., St. Petersburg, Bd. 1, p. 244-251, 2 fig.
(45) Stefanski, W.
1914. Nématodes du Bassin du Léman. Thése de l'Université de Genève.
(46) Stefanski, W.
1915. Nématodes de Pologne. *In* Zool. Anz., Bd. 45, p. 346-349, 6 fig.
(47) Steiner, G.
1913. Freilebenden Nematoden aus der Schweiz. *In* Arch. Hydrobiol. Planktonk., Bd. 9, p. 259-276, 29 fig.
(48) Steiner, G.
1916. Freilebenden Nematoden. *In* Zool. Anz., Bd. 46, p. 336-368, 11 fig.
(49) Steiner, G.
1916. Freilebenden Nematoden von Nowaja-Semlja. *In* Zool. Anz., Bd. 47.
(50) Zschokke, F.
1900. Die Tierwelt der Hochgebirgsseen. *In* Nouveau Mém. Soc. Helvetique Sci. Nat., t. 37, p. 1-400, 8 pl.