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On the Classification of the *Tylenchida*, new order (Nematoda, Phasmidia)

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The nemas commonly known as "tylenchs" have heretofore been assigned to the Order RHABDITIDA which includes those phasmidians possessing an esophagus which is divided into corpus, isthmus and bulbar regions. This classification brought together such divergent groups as the tylenchs, cephalobs and rhabditids which, in many respects, are vastly different from one another.

To one who has observed many thousands of specimens of RHABDITIDA, it has long been evident that the tylenchs are very remotely related to the other groups. There are certain differences in their general and detailed morphology which have been inadequately evaluated in formulating their taxonomy, and too much attention has been given to finding minor similarities and overemphasizing their importance. True, there may have been a common ancestry in remote antiquity but the lines through which the various groups developed have been separated so long that but little semblance remains.

Actions and habits of tylenchs readily separate them from other forms, and one well acquainted with the various groups should easily distinguish them by these points alone. Reactions to stains are most revealing and it generally is a simple matter to separate the tylenchs in a mixed collection by the particular tints of color which they exhibit, showing that their body tissues have distinctive qualities.

The classification here outlined is based upon more than 6,000 specimens representing almost 200 species from 28 genera of Tylenchoidea which have been assembled in the Division of Nematology collection at Salt Lake City, Utah, during the past 30 years. Collections have come in from 24 states, Alaska, and the Hawaiian Islands, with the greatest numbers from Utah, California, Nevada, Idaho and Colorado. Canada, Australia, England, Netherlands, Germany and 11 other foreign countries are represented. But even this wealth of material has many limitations and the outline presented doubtless will be found inadequate within a few decades, because probably not more than 20% of the genera and 5% of the species have been discovered and future workers will be forced to make some alterations and many additions. Suborders and additional superfamilies doubtless will be established as the group is expanded by global collecting. Let us hope that changes will be made on specimens actually in hand and not on theory. The task will not be one for the over-enthusiastic neophyte with just a few collections, but rather one for the experienced nematologist with thousands of specimens on which to base extremely careful work.

The illustrations accompanying the following diagnoses have been prepared just as carefully as was possible. Face views showing arrangements of the amphid apertures and cephalic papillae are necessarily somewhat schematic and frequently

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the prominence of these minute organs is exaggerated. Observations have been made through a 1.5 mm oil immersion objective and 5X and 10X oculars, from which all side lights have been eliminated by means of a heavy cloth screen fitted about the ocular. An observer working at an open table with side lights interfering with his vision would find it impossible to see many of the details shown in these face views. With equipment superior to that used by the writer and exceptionally good eyesight, someone may eventually locate and illustrate the cephalic papillae, deirids and phasmids which the writer has been unable to see on certain species. Improved staining techniques are especially desirable for this critical type of work and future workers should investigate their possibilities.

Generally observations have been made on specimens killed by gradual heat, fixed in formalin-alcohol-acetic acid solution and mounted in glycerin, although some specimens have been observed before killing and fixing while others were stained and mounted in balsam. Face views and cross sections were prepared by cutting off the desired portions with a very slender eye knife and mounting in hard glycerin jelly, a comparatively simple process when once one has mastered the technique.

The purposes of this paper are threefold: 1. To establish the order TYLENCHIDA and outline the general relationships of the free-living and plant parasitic nemas belonging in the superfamily Tylenchoidea. 2. To emend the diagnoses of some of the more common genera of Tylenchoidea. 3. To add new information on the morphology of tylenchs, especially those characters which have been found to be of value in making generic and specific diagnoses.

In the descriptions of species the ratios given are a combination of those used by de Man and Cobb. For α, β, and γ we have substituted a, b, c. These are the ratios, respectively, of body length to body diameter, to length at base of esophagus and to tail length. "V" is the position of the vulva as a percent of body length; superior figures indicate extent of ovary or uterus from vulva as a percent of body length. "T" is the extent of the male gonad anteriad from the anus.

No attempt has been made to cover the families and genera of Aphelenchoidea (Fuchs 1937). Likewise the Tylenchoidea parasites and associates of insects under the families Myenchidae, Pereira, 1931, and Allantonematidae Chitwood and Chitwood, 1937, have been omitted.

Order TYLENCHIDA, new order

Diagnosis.—Nematoda, Phasmidia. Stoma armed with a protrusile spear or stylet (except degenerate males of a few species). Basal portion of esophagus bulbar or lobe-like, without a sclerotized valvular apparatus.

Type superfamily.—Tylenchoidea Chitwood and Chitwood, 1937.

General description.—Cuticle marked by striae which usually are interrupted on the lateral fields by incisures or refractive bands. Deirids and phasmids frequently visible but almost as often very difficult or impossible to see. Excretory pore a conspicuous feature, usually located near the latitude of the nerve ring. Lip region typically with two circlets of papillae, visible only from a face view; one circlet consisting of six closely grouped about the vestibule; the other of eight located farther out on the contour of the lips. However the numbers of these papillae may be greatly reduced in some species or perhaps beyond the limits of the microscope used. Amphid apertures generally high on the lips and visible only from a face view when they are seen as minute refractive orifices (except the slit-like lateral apertures of *Psilenchus*).

Esophagus consisting of a corpus which may, or may not, contain a median bulb with a sclerotized valvular apparatus; a narrow isthmus encircled by the

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nerve ring; and an enlarged basal portion. This basal region may consist of a true bulb enclosing the three esophageal gland nuclei, or the glands may form a lobe and protrude back over the anterior end of the intestine. If a true basal bulb is present, there is also a valvular apparatus (cardia or esophago-intestinal valve) connecting the lumen of the esophagus with the intestine. If the esophageal glands are lobe-like, the junction of the lumen and the intestine is a minute, very obscure, muscular apparatus. The so-called "dorsal gland" may empty into the esophageal lumen near the base of the spear (Tylenchoidea) or into the median bulb (Aphelenchoidea) (Fig. 4, G, H). The two remaining glands empty into the median bulb, as recorded by Cobb (1923a) and Goodey (1929). The arrangement of the three esophageal gland nuclei does not follow any set pattern and they will be observed in greatly varying positions, even in individuals of the same species.

The cells of the simple intestine are generally well filled with refractive granules which obscure the details of the cell nuclei, except when stained and cleared. Preliminary observations through a "Phase" microscope revealed the cell nuclei very satisfactorily and the use of this type of instrument should be explored. It appears probable that the number and arrangement of the intestinal cells and their nuclei will prove to be of taxonomic value. The intestine ends in a distinct rectum leading to a small slit-like anus, except in certain Criconematidae in which the rectum and anus are most obscure, perhaps absent.

Ovaries one or two, outstretched, reflexed or coiled (Heteroderidae), most frequently made up of a single series of developing oögonia, but sometimes consisting of a compound series arranged about a rachis as in *Anguina*. Testis single except in certain forms of *Meloidogyne*.[1] Spicula simple, tapering, curved; resting on a plain trough-like gubernaculum. A telamon present in *Hoplolaimus*. Bursa present in Tylenchoidea except in Heteroderidae, Paratylenchinae, *Eutlyenchus* and *Tylenchulus*. Aphelenchoidea without bursa except in *Aphelenchus* and *Metaphelenchus*. Bursal ribs absent in Tylenchoidea, present in Aphelenchoidea.

Keys to superfamilies and families and subfamilies of Tylenchoidea have been prepared, together with a key to genera of Tylenchidae. For keys to the subfamilies, genera and species of Neotylenchidae the reader is referred to the writer's paper on that group (1941). The genera and species of Criconematinae were covered by Taylor (1936), except for the genus *Cacopaurus* Thorne, (1943) and the recent paper of Loos (1948) on *Hemicycliophora*.

Key to superfamilies of TYLENCHIDA

1. Dorsal esophageal gland emptying into lumen of esophagus near base of spear; bursa present, except in Heteroderidae and Paratylenchinae, and the genera *Eutylenchus* and *Tylenchulus;* bursa not supported by ribs. Tylenchoidea Chitwood and Chitwood, 1937.[2]

   Dorsal esophageal gland emptying into median bulb of esophagus; bursa absent except in *Aphelenchus* and *Metaphelenchus,* in which the bursa is supported by ribs ..... Aphelenchoidea Fuchs, 1937

Key to families of Tylenchoidea

1. Median esophageal bulb greatly enlarged; isthmus and basal bulb reduced; spear strongly developed, except in degenerate males of certain species in which it is greatly reduced or absent. Cuticle generally heavily annulated

[1] Dr. B. G. Chitwood of the Division of Nematology is now engaged in a study of the Heteroderidae and this work will include the reestablishing of the genus *Meloidogyne* Göldi.

[2] Synonyms: Anguillulinoidea Pereira, 1931, in part.
Anguilluloidea Schuurmans—Stekhoven and Teunissen, 1938, in part (Designated as an order by the authors).

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or squamose ..... Criconematidae, new family

Median esophageal bulb small to moderate in size or absent; isthmus narrow, elongated; basal portion of esophagus a distinct bulb, or lobe-like, extending back over anterior end of intestine; cuticle not heavily annulated or squamose 2

2. Valvular median esophageal bulb absent ..... Neotylenchidae, new family

Valvular median esophageal bulb present 3

3. Male tails short rounded; bursa absent; females pyriform or lemon-shaped. Heteroderidae, new family

Male tails conoid or elongated; bursa present, except in *Tylenchulus* and *Eutylenchus;* females typical active nemas, except saccate in *Tylenchulus* and *Nacobbus,* and reniform in *Rotylenchulus* ..... Tylenchidae Filipjev, 1934

Family NEOTYLENCHIDAE, new family

Diagnosis.—Tylenchoidea. Median esophageal bulb absent. Cephalic framework in either six or eight sectors. Basal portion of esophagus variable; joined directly to intestine (*Hexatylus*); an elongated glandular extension (*Deladenus*); short, lobe-like basal extensions (*Neotylenchus*); definite basal bulb with cardia (Neotylenchinae); or bearing a stem-like process extending into the intestine (Paurodontinae).

Obviously, this heterogeneous group is unsatisfactory for many reasons and the writer admits that it is merely a "catchall," established as a matter of taxonomic convenience until more extensive collecting enables future workers to arrange the many divergent forms properly into their respective groups.

Type Subfamily.—Neotylenchinae Thorne, 1941.

Type genus.—Neotylenchus Steiner, 1931.

Family HETERODERIDAE, new family

Diagnosis.—Tylenchoidea. Obligate plant parasites. Males with short, rounded tails. Bursa absent. Females lemon shaped or pyriform, saccate (*Meloidogyne*) or cyst-forming (*Heterodera*).

Type subfamily.—Heteroderinae Filipjev, 1934.

Type genus.—Heterodera Schmidt, 1871.

The advisability of establishing this family may be questioned, but these two genera have such distinctive characteristics that the writer deems it inadvisable to keep them in the Tylenchidae.

Family CRICONEMATIDAE Thorne, 1943

Diagnosis.—Tylenchoidea. Median esophageal bulb greatly developed; isthmus reduced or absent; basal bulb much reduced. Spear strongly developed, except in males of certain species in which it is reduced or absent. Cuticle frequently heavily annulated or squamose. Vulva near posterior end. Ovary single. Posterior uterine branch absent. Bursa present or absent.

Type subfamily.—Criconematinae Taylor, 1936.

Type genus.—Criconema Hofmänner and Menzel, 1914.

The name Criconematidae was first used without a diagnosis by the writer (1943).

Key to subfamilies of Criconematidae

1. Isthmus of esophagus absent or short and broad, cuticle strongly annulated. Criconematinae Taylor, 1936

Isthmus of esophagus short, narrow and distinct, cuticle finely annulated. Paratylenchinae, new subfamily

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Subfamily PARATYLENCHINAE, new subfamily

Diagnosis.—Criconematidae. Cuticle with small annulations. Female body slender, active, (*Paratylenchus*), or obese (*Cacopaurus*). Female spear long, slender. Male spear reduced or absent. Esophagus with a short, distinct isthmus. Ovary single. Male without true bursa but ventrally flattened or concave in anal region so that when seen from a submedian angle there appears to be a narrow, thick bursa.

Type genus.—*Paratylenchus* Micoletzky, 1922.

Key to subfamilies and genera of Tylenchidae

1. Basal portion of esophagus lobe-like, extending back over anterior end of intestine 2
   Basal portion of esophagus forming a distinct bulb.
   Tylenchinae Filipjev, and genera of doubtful position 8
2. Lip region convex-conoid, $\frac{1}{3}$ to $\frac{1}{5}$ as wide as spear length, tails generally shorter than anal body diameter ..... Hoplolaiminae Filipjev 3
   Lip region low, somewhat flattened, $\frac{1}{2}$ to $\frac{3}{8}$ as wide as spear length; tails at least twice as long as anal body diameter, except in *Nacobbus* and *Rotylenchulus* and in these genera the females are saccate or reniform.
   Pratylenchinae new subfamily 5
3. Cuticle of lip region divided into minute plates ..... *Hoplolaimus* Daday, 1905
   Cuticle of lip region marked by plain annules only 4
4. Amphid apertures near oral opening ..... *Rotylenchus* Filipjev, 1934
   Amphid apertures at base of lip region ..... *Helicotylenchus* Steiner, 1945
5. Ovary one 6
   Ovaries two 7
6. Female a typical active nema ..... *Pratylenchus* Filipjev, 1934
   Female saccate with elongated posterior ..... *Nacobbus* Thorne & Allen, 1944
7. Female a typical active nema ..... *Radopholus*, new genus
   Female reniform ..... *Rotylenchulus* Linford and Oliveira, 1940
8. Head armed with setae 9
   Head not armed with setae 10
9. Cuticle with transverse striae only ..... *Eutylenchus* Cobb, 1913
   Cuticle with transverse and longitudinal striae ..... *Atylenchus* Cobb, 1913
10. Body greatly attenuated, a = 150 ..... *Ecphyadophora* deMan, 1921
    Body not greatly attenuated, a = 40 or more 11
11. Base of spear furcate ..... *Chitinotylenchus* Micoletzky, 1922
    Base of spear amalgamated, with or without basal knobs 12
12. Ovaries two 13
    Ovary one 16
13. Spear more than one-half as long as esophagus ..... *Dolichodorus* Cobb, 1914
    Spear not more than one fourth as long as esophagus 14
14. Tails attenuated, amphid apertures slit-like ..... *Psilenchus* deMan, 1921
    Tails conoid or blunt and rounded, amphid apertures pore-like 15
15. Female tails blunt, rounded ..... *Tylenchorhynchus* Cobb, 1913
    Female tails pointed or subacute ..... *Tetylenchus* Filipjev, 1936
16. Female saccate, male without bursa ..... *Tylenchulus* Cobb, 1914A
    Female not saccate, male with bursa 17
17. Female body obese, largely immobile, gonad cells arranged about a rachis. *Anguina* Scopoli, 1777
    Female body slender, active, gonad cells not arranged about a rachis 18

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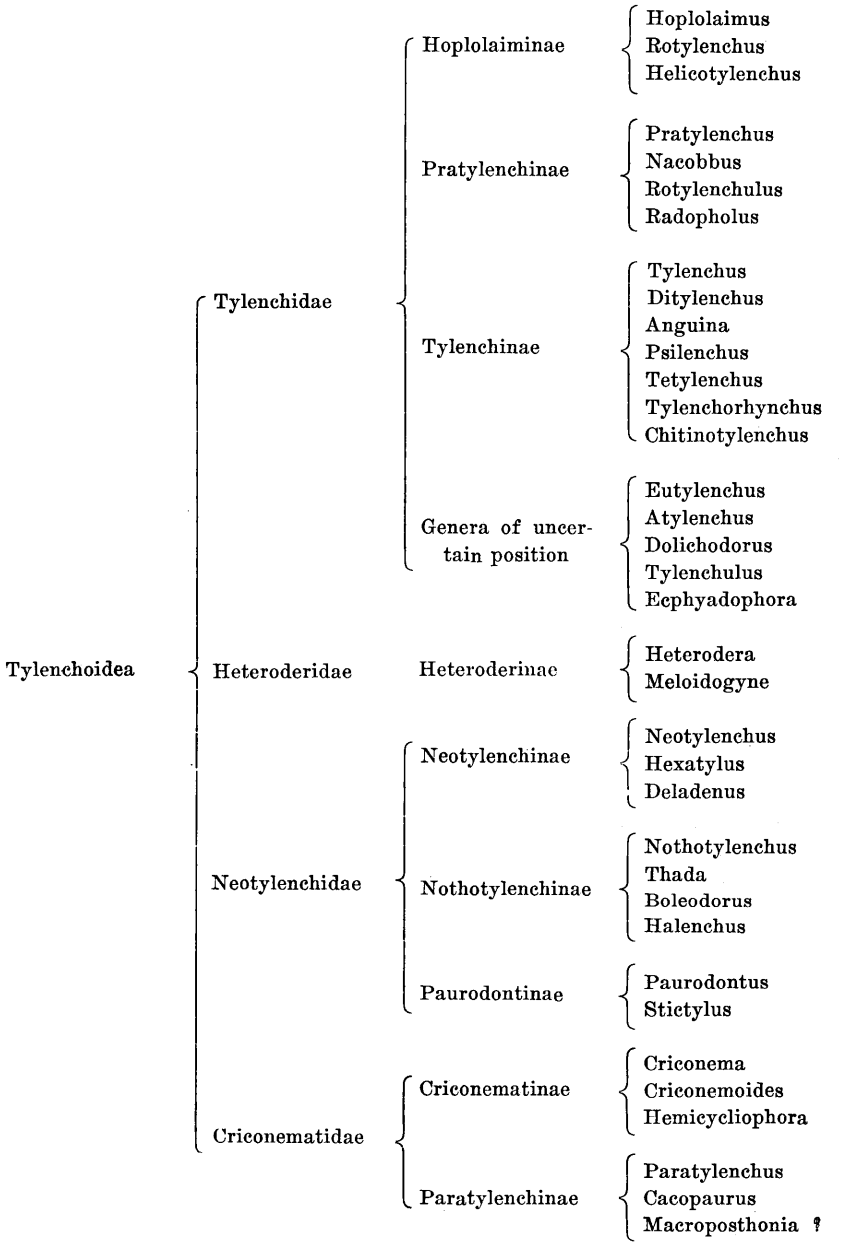
18. Tails greatly elongated, filiform; bursa short, adanal; lip region striated. *Tylenchus* Bastian, 1865

Tails conoid, bursa enveloping one-fourth of tail or more; lip region not striated ..... *Ditylenchus* Filipjev, 1934

Diagrammatic arrangement of the Tylenchoidea



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Subfamily HOPLOLAIMINAE Filipjev, 1934

Diagnosis emended.—Tylenchidae. Cephalic framework heavily sclerotized, frequently yellowish in color. Spear massive with strongly developed knobs, three to five times as long as width of lip region. Basal portion of esophagus lobe-like, extending back over anterior end of intestine. Ovaries two, outstretched. Tails of both sexes usually shorter than anal body diameter. Male tail enveloped by bursa. Phasmids usually opposite, or anterior to, the latitude of the anus.

Cuticle strongly striated. Lateral fields marked by at least four incisures. Neck tapering rapidly to the lip region which may be covered with minute plates (*Hoplolaimus*) or annulated (*Rotylenchus* and *Helicotylenchus*). Median esophageal bulb spheroid with small sclerotized valve. Junction of esophageal lumen and intestine very obscure, usually only a short distance posterior to the isthmus. Intestine packed with coarse granules. Vulva near middle of body. Female terminus hemispherical to convex conoid, sometimes bluntly digitate.

Type genus.—*Hoplolaimus* Daday, 1905.

Genus *Hoplolaimus* von Daday, 1905

Diagnosis emended.—Hoplolaiminae. Lip region set off, cap-like, with cuticle divided into minute blocks by transverse and longitudinal striae. Cephalic framework massive, yellowed. Spear massive, strongly knobbed, with anterior forward pointing processes to which the protrudor muscles are attached. Distal portion of gubernaculum protrusile, cephalated, bearing lateral "titillae."[3] Telamon present but very obscure in most specimens.

Cuticle coarsely annulated, the lateral fields marked by four incisures and frequently with fine transverse striae. Phasmids of the usual type present on *Hoplolaimus uniformis*, while on *H. coronatus* they are very large and located erratically on the lateral fields. Deirids not observed. Ovaries two, outstretched. Testis single, outstretched. Spicula strong, arcuate. Tails shorter than anal body diameter, that of the female hemispheroid to bluntly conoid; while that of the male is ventrally arcuate and enveloped by the bursa.

Type species.—*Hoplolaimus tylenchiformis* Daday, 1905.

Representative species.—*Hoplolaimus uniformis* n. sp.[4]

Daday's description of *Hoplolaimus tylenchiformis* is meagre and his figures are at first glance somewhat misleading. One of these illustrations is here reproduced (Fig. 7L), and obviously was made from a flattened specimen which apparently had been killed with cold fixative, causing the cuticle to shrink, and collapsing the anterior portion of the esophagus and the isthmus until the median bulb and basal gland lobe were forced forward near the spear, greatly shortening the neck. Specimens of *H. coronatus* killed in this manner are in the writer's collection and exhibit a similar condition, which an inexperienced observer might easily illustrate as Daday did.

Hoplolaimus coronatus Cobb, 1923

Cobb (1923) emended the generic diagnosis of *Hoplolaimus* in his description

[3] The term "titillae" is here proposed for these lateral processes on the distal, protrusile end of the gubernaculum of *Hoplolaimus*.

[4] Many nematode genera are based on type specimens which have not been preserved and the original descriptions and figures are meagre and require extensive emendation. In many instances there is little possibility of anyone's ever collecting topotypes (specimens secured in the exact locality in which the type was secured). Therefore, it is proposed that *representative species* be designated for such genera and that these species be described in detail and used as basic material for future comparative work. Designation of *representative species* would, of course, be superseded by an emended description of the type should later workers collect specimens.

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of *H. coronatus* but failed to record certain important details concerning this species:

1. The three esophageal gland nuclei are contained in one large lobe which extends back over the anterior end of the intestine, generally in a dorsal position (Fig. 7I).

2. The "lateral organ" described by Cobb actually was a greatly enlarged phasmid, and one is present on each side of the body; they may be located anywhere between the neck and the tail. On one female observed, the left phasmid was located at a latitude near 16% while the right one was near 85%. On all three males examined, the left phasmids were near the tail (Fig. 7K), while the right ones were far forward between 30% and 50%. This erratic placement of the phasmids is a most unusual and interesting feature of the species.

3. The extrusile gubernaculum is distally cephalated and bears titillae similar to those of *Hoplolaimus uniformis* (Fig. 7K).

Hoplolaimus uniformis, new species
Fig. 1, A–M

♀: 1.4 mm; a = 31; b = 7.1; c = 80–120; V = 32 54 30

♂: 1.4 mm; a = 38; b = 7.5; c = 49; T = 53

Annules of the cuticle vary in width from 3 μ near the base of the neck to about 2 μ near the posterior end of the body. Lateral fields marked by four incisures which occupy a space about one-fourth as wide as the female body near the vulva, while on the male they are about two-fifths as wide as the body. Frequently the lateral fields are marked by obscure extensions of the body striae. Deirids not seen. Phasmids of female generally located somewhat anterior to the latitude of the anus while on the male they usually are about opposite or slightly posterior to the anus. The male phasmids are located close to the terminus of the dorsal incisure of the lateral field, near the base of the bursa (Fig. 1, G, H, J); Fig. 1, J is somewhat schematic because the phasmids both are shown in the same plane as the anus when actually they rarely are directly opposite each other.

Lip region marked by about five annules which are divided into irregular sections which vary greatly in arrangement on the different specimens. These structures are easily observed from a face view but may be overlooked when the head is seen laterally. The face view also reveals a rather complicated 6-pointed cuticular structure about the vestibule which appears to be imbedded in the first annule. The purpose of this structure is problematical unless it serves as an anchor for some of the labial muscles. Arrangement of the amphids and labial papillae are apparently as illustrated (Fig. 1, D) but they are so infinitesimal that accurate observations are difficult. A cross section reveals the basal plate of the cephalic framework as being duplex in the dorsal and ventral sectors.

The esophageal glands of *Hoplolaimus* have been inadequately described in previous works and therefore they are shown here in considerable detail. Young specimens and sometimes males show a rather limited development of the gland lobe which generally lies dorsad in the body (Fig. 1, E), while adult females exhibit great development of the lobes, which are found more laterally and on either the right or left side of the body (Fig. 1, A). The junction of the esophageal lumen and the intestine lies far forward near the nerve ring (Fig. 1, F). Intestine packed with coarse granules which frequently obscure details of the reproductive system.

From the depressed transverse vulva the vagina leads in at right angles and from it the two branches of the reproductive system are outstretched. Unfortunately, the specimens in hand were not in the best of condition and certain details

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of the ovaries may not be exactly as illustrated (Fig. 1, A). Generally the posterior ovary is on the left side of the body. Eggs measure about 30×100 μ.

The testis begins as a cap cell followed by two cells in single file, then becomes a double line of spermatocytes for a distance equal to about four times the body width; when spermatogenesis is completed they become spermatozoa about 4 μ in diameter.

Structures of the male tail are most interesting. The simple, tapering spicula rest on a gubernaculum unlike that seen in any other tylench. The distal end is a knobbed structure with lateral titillae (Fig. 1, J). The telamon lies between the spicula and is very easily overlooked from the usual lateral view (Fig. 1, I). Cross sections through the bursal region show this organ to be much thicker and more strongly developed than is generally supposed (Figs. 1, J, K).

Genus *Rotylenchus* Filipjev, 1934

Diagnosis emendcd.—Hoplolaiminae. Lip region continuous with the neck contour, marked by four to eight transverse striae. Spear three to five times as long as width of lip region, with strongly developed basal knobs. Basal portion of esophagus lobe-like, variable in form and position. Vulva near middle of body. Ovaries outstretched with oöcytes arranged in single file except for a short region of multiplication. Gubernaculum trough-like, sometimes slightly cephalated or recurved, but not bearing lateral titillae like those of *Hoplolaimus*.

Cuticle strongly annulated with lateral fields marked by at least four incisures. Tails generally shorter than anal body diameter; that of the female hemispheroid to bluntly conoid, or sometimes digitate; while that of the male is ventrally arcuate and enveloped by the bursa. Phasmids varying in position, either anterior or posterior to the latitude of the anus. Deirids not observed. Median esophageal bulb spheroid with small refractive valvular apparatus. Intestine generally packed with coarse refractive granules which obscure details of the cellular structure. Spicula of the usual tylenchoid form.

Type species.—*Rotylenchus robustus* (deMan, 1880) Filipjev, 1934.

Filipjev (1934) established the genus *Rotylenchus* and designated the type species as *Rotylenchus robustus* (deMan, 1880), synonym *Tylenchus robustus* deMan, 1880, but gave no diagnostic characters. Later, (1936), he published a key to the genera of Tylenchinae in which the diagnostic characters were listed as follows: Head chitinized, cuticle strongly annulated, spear strong, ovaries paired, esophagus aphelenchoid. The use of "aphelenchoid" was, of course, an error but it appears obvious that he intended to convey the idea that the glands of the basal portion of the esophagus extended back over the anterior end of the intestine. Also, he intended this genus to include forms like the male figured by deMan, 1884, and the female illustrated by Goodey, 1932, because he used these two illustrations in his book on Agricultural Helminthology (1934a). (See also Fig. 121, A, B, p. 214 of Schuurmans-Stekhoven translation, 1941.)

Tylenchus robustus was described by deMan (1876) and his figure, 18a, of the anterior portion of the body shows a specimen which in some respects resembles a *Tylenchorhynchus* with a definite basal esophageal bulb containing two large nuclei. However, the accompanying figure, 18c, illustrates a rounded female tail slightly shorter than the anal body diameter, and unlike that of any known *Tylenchorhynchus*. DeMan's 1880 description was published without figures but in 1884 he published practically the same description and added excellent illustrations. The discrepancies between the 1876 and 1884 illustrations apparently prompted Filipjev to designate the 1880 description as the type of his genus *Rotylenchus*. This confusion can now be explained by examining figures 2 E and F of this paper which

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illustrate basal esophageal lobes lying laterally in the body and extending back over the anterior end of the intestine in a manner which the uninitiated worker might easily interpret as definite basal bulbs.

It is also probable that deMan had a mixture of closely related species of *Rotylenchus*. This conclusion has been reached after comparing specimens kindly sent by Dr. T. Goodey from England and Luxemburg, the latter collected by Dr. M. Simon. Dr. H. Goffart forwarded a specimen from Kitzeberg, Germany, and Dr. J. W. Seinhorst collected others in Holland. There is even a possibility that deMan confused specimens of *Hoplolaimus uniformis* with those of *R. robustus* because the two species closely resemble each other in many respects.

The accompanying female illustration is based on specimens from Luxemburg which, of all those examined, most closely resembled deMan's 1884 figures in the numbers of annules on the lip region and female tail. The few males examined differed from deMan's 1884, Fig. 92b, in the position of the phasmid which he illustrated as being well behind the latitude of the anus, these specimens generally having the phasmid located slightly anterior to the latitude of the anus (Fig. 2, G). However a male of *Rotylenchus erythrinae?* from England possessed a phasmid located almost exactly like that shown by deMan (Fig. 2, I).

Rotylenchus obviously represents a group of closely related species which will require extensive collecting and much careful work before their taxonomy can be presented in a satisfactory manner, because the principal diagnostic characters lie in the total body length, the number of annules on the lip region, and the forms of the tails. Most of the species formerly made synonyms of *R. robustus* doubtless represent valid species but specimens must again be collected and carefully evaluated before accurate diagnoses can be formulated.

The much debated question of the nature of the posterior portion of the esophagus with its three gland nuclei is now clarified. (Fig. 2, D, E, F.) These illustrations show that the basal lobes are most variable in form and position and rarely do two specimens present even similar development. Consequently this portion of the esophagus is of no specific diagnostic value.

Rotylenchus robustus (deMan, 1880) Filipjev, 1934

Synonyms.—Tylenchus robustus deMan, 1876, 1880; *Anguillulina robusta* (deMan, 1876) Goodey, 1932.

Fig. 2, A–H

♀ : 1.0–1.2 mm; a = 28–36; b = 6–8; c = 50–60; $V = {}^{32}\ 54\text{–}62\ {}^{28}$

♂ : 0.8–1.0 mm; a = 25; b = 6.1; c = 40–50; T = 40

Body tapering anteriorly to the narrow pointed lip region which is marked by five annules. Female tail hemispherical to bluntly conoid; male tail bent ventrally, with a broad enveloping bursa. Cuticle marked by coarse annules which are interrupted on the lateral fields by four incisures. Deirids not observed. Female phasmids generally located slightly anterior to the latitude of the anus, but occasionally observed back near the middle of the tail. Male phasmid most frequently located near the latitude of the anus but sometimes it may be back on the tail proper, near the base of the bursa.

FIG. 1. *Hoplolaimus uniformis.* A—Female; ×360. B—Cuticle pattern of lip region; ×1080. C—Cross section of head through basal plate; ×1080. D—Face view; ×2160. E—Esophageal gland region of young female; ×360. F—Right side of gland region shown in A; ×360. G—General structures of posterior portion of male; ×720. H—Cuticle pattern of posterior portion of male; ×720. I—Section through spicula and telamon; *tel.* telamon; ×1080. J—Section through anal region of male showing gubernaculum and phasmids; ×1080. K—Cross section through bursa near terminus; ×1080. L—Cross section through lateral field; ×1080. M—More conoid type of female tail; ×540.

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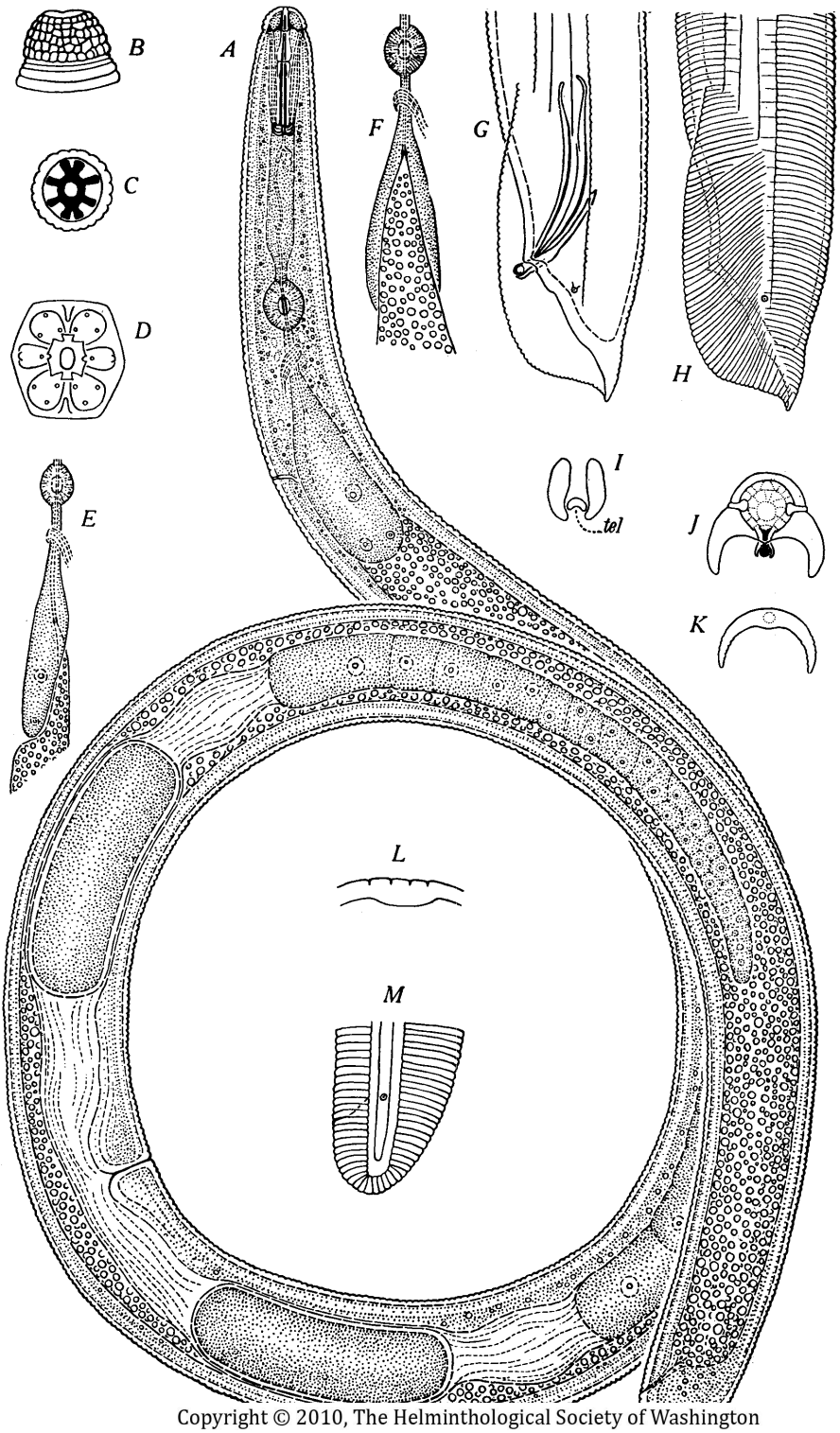

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From a face view the amphid apertures are seen near the outer margin of the lateral lips; and fourteen papillae are visible, although exceedingly minute and difficult of resolution. Cephalic framework heavily sclerotized, sometimes yellowish in color; the basal plate somewhat duplex in the dorsal and ventral sectors. Spear massive with strongly developed basal knobs. Dorsal gland aperture close to base of spear. Median esophageal bulb spheroid with small sclerotized valvular apparatus. Isthmus comparatively short. Basal lobe of esophagus variable in size and position (Fig. 2, D, E, F). Junction of esophageal lumen and intestine very obscure and impossible to determine on many specimens.

Vulvă a broad, depressed, transverse slit. Ovaries outstretched with oöcytes arranged in single file except for a short region of multiplication. Testis single, outstretched. Gubernaculum thin, trough-like, with recurved distal portion.

Diagnosis.—Rotylenchus with the above measurements and general description. Distinctive because of the five annules of the lip region and broad, rounded female tail; and the recurved distal portion of the gubernaculum.

Subfamily PRATYLENCHINAE, new subfamily

Diagnosis.—Tylenchidae. Lip region one-half to three-fifths as wide as spear length, frequently low, flattened. Tails at least twice as long as anal body diameter, except in *Nacobbus* and *Rotylenchulus* and in these two genera the females are saccate or reniform respectively. Bursa enveloping tail. Phasmids located well behind the latitude of the anus. Deirids not observed. Spear strong with well developed knobs. Median esophageal bulb spheroid. Basal portion of esophagus consisting of an elongated lobe extending back over the anterior end of the intestine; greatly variable in form and position, and containing the three large esophageal gland nuclei. Ovaries one or two.

Type genus.—Pratylenchus Filipjev, 1934.

The Pratylenchinae include those rather broad headed plant parasitic nemas which form a very natural group because of the close similarities of the larval stages, and of the structures of the head, spears, esophagi and male tails. However there are divergent characteristics which eventually may necessitate raising the group to family rank and separating off such aberrant genera as *Nacobbus* and *Rotylenchulus* from the more simple forms like *Pratylenchus* and *Radopholus*. The greater number of species of this subfamily appear to come from the warmer climates and extensive collecting in the tropics should reveal many more genera and species.

Genus *Pratylenchus* Filipjev, 1934

Diagnosis emended.—Pratylenchinae possessing a single outstretched ovary and a rudimentary posterior uterine branch. Bursa enveloping entire tail. Phasmids located one-third of the tail length or more, behind the latitude of the anus. Deirids not observed. Esophageal gland nuclei arranged in a single lobe which extends back over the anterior end of the intestine, and varies greatly in size, form and position. Junction of esophageal lumen and intestine obscure, generally about one body-width posterior to the median esophageal bulb. Lip region annulated, set off by a narrowing of the head. Cephalic framework sclerotized, refractive. Spear strong with massive basal knobs. Median bulb of esophagus slightly ovate, half or more the width of the neck. Cephalic basal plate with expanded dorsal and ventral processes.

FIG. 2. A–H *Rotylenchus robustus.* A—Head; ×1320. B—Face view; ×1760. C—Section through cephalic basal plate; ×1760. D—Female; ×440. E—Basal lobe of male esophagus lying laterad in body; ×660. F—Female esophagus with greatly developed basal lobe; ×660. G—Male tail; ×880. H—Female tail; ×880. I—*Rotylenchus erythrinae* ♀. Male tail; ×1320.

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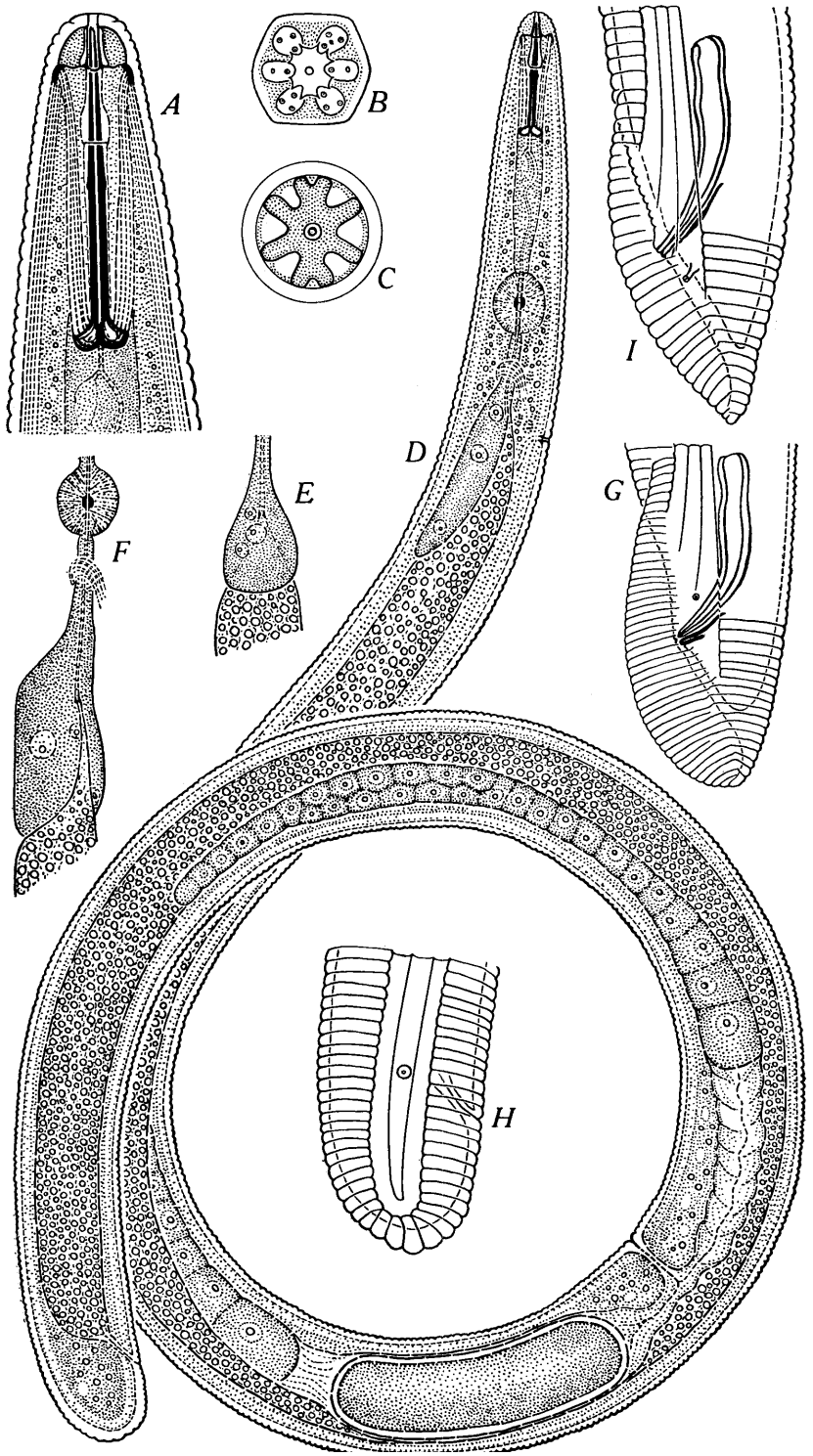

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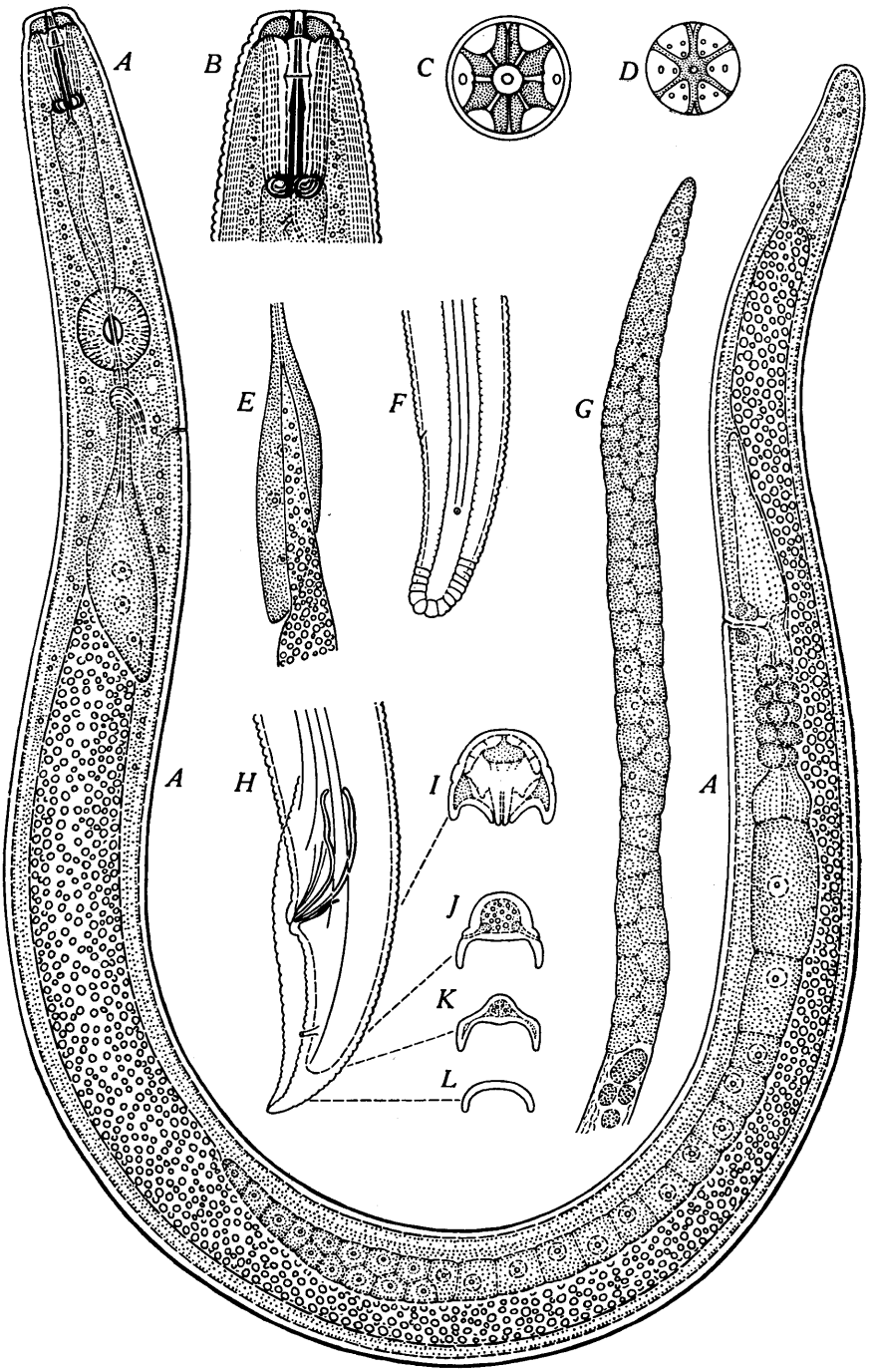

FIG. 3. *Pratylenchus pratensis*. A—Female; ×800. B—Female head; ×1400. C—Cross section through cephalic base plate; ×1600. D—Face view; ×1600. E—Basal portion of esophagus showing connection with anterior end of the intestine; ×800. F—Female tail showing phasmid and lateral field; ×1200. G—

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Type species.—Pratylenchus pratensis (deMan, 1880) Filipjev, 1936.

Pratylenchus is composed of a group of very closely related species which are most difficult to separate, the principal differentiating characters being the form and annulation of the lip region and the tail.

Tylenchus obtusus Bastian, (1865, Figs. 117, 118, 118a) appears to be a *Pratylenchus*. The total length of 0.87 mm is greater than that of any known species of this genus and were it not for this extreme length, this form might well be considered similar, if not identical, to *Pratylenchus pratensis*. If Bastian erred in this measurement, *P. pratensis* might then be a synonym of *P. obtusus*. Unfortunately, it has not been possible to secure collections from the type locality near Broadmoor, Berks., England.

Soltwedel (1888) described *Tylenchus sacchari* from Java and Filipjev, (1936) placed the species in *Pratylenchus*. The form represents what doubtless is a new, undescribed genus among the Pratylenchinae, because of the blunt rounded tail of the male with its adanal bursa, and the anterior location of the excretory pore only slightly behind a point opposite the base of the spear. However, Soltwedel's meagre description and figures are insufficient evidence on which to base a satisfactory diagnosis and the writer leaves the task of emending the species description and erection of a new genus to the fortunate individual again collecting this interesting form.

Pratylenchus pratensis (deMan, 1880) Filipjev, 1936

Synonyms.—Tylenchus pratensis deMan, 1880; *Anguillulina pratensis* (deMan, 1880) Goodey, 1932.

Fig. 3, A–L

♀ : 0.6 mm; a = 22; b = 4.6; c = 21; V = ^{38} 82 ^{3}

♂ : 0.53 mm; a = 22; b = 4.2; c = 20; T = 46

Cuticle marked by distinct transverse striae which average about 1 μ apart. Lateral fields marked by four incisures, the outer ones being slightly crenate. Lip region set off by a narrowing of the head contour and bearing two striae which form three annules. On the female tail the striae extend completely around the terminus (Fig. 3, F). From a face view the six sectors of the lip region are easily visible, the two lateral ones being distinctly wider than the submedian four. Each sector bears a minute papilla located close to the oral disc, and the four submedian lips each have two additional very obscure papillae. The amphid apertures are located near the outer margin of the lip region. The basal plate of the cephalic framework is six-pointed (Fig. 3, C), the dorsal and ventral processes being much wider and somewhat duplex in structure. This wider structure is reflected in the dorsal and ventral cephalic arches (Fig. 3, D). Knobs of the strong spear are almost one-third as wide as the head at that point. Dorsal esophageal gland orifice about 2 μ behind the spear base. Median esophageal bulb slightly ovate with strong refractive valvular apparatus. Esophageal glands forming a large lobe extending well over the anterior end of the intestine in which the three gland nuclei can generally be observed. Usually this lobe lies on the right side of the body. The actual junction of the esophageal lumen and the anterior end of the intestine is very obscure and located about one body-width behind the median bulb (Figs. 3, A, E). Granules of the intestine so dense that details of the intestinal cell structure usually cannot be observed.

Anterior branch of the female reproductive system composed of a cellular ovi-

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Testis; ×800. H—Male tail showing phasmid and lateral field; ×1200. I, J, K, L—Cross sections through anal region, phasmids and posterior parts of tail as indicated; ×1200.

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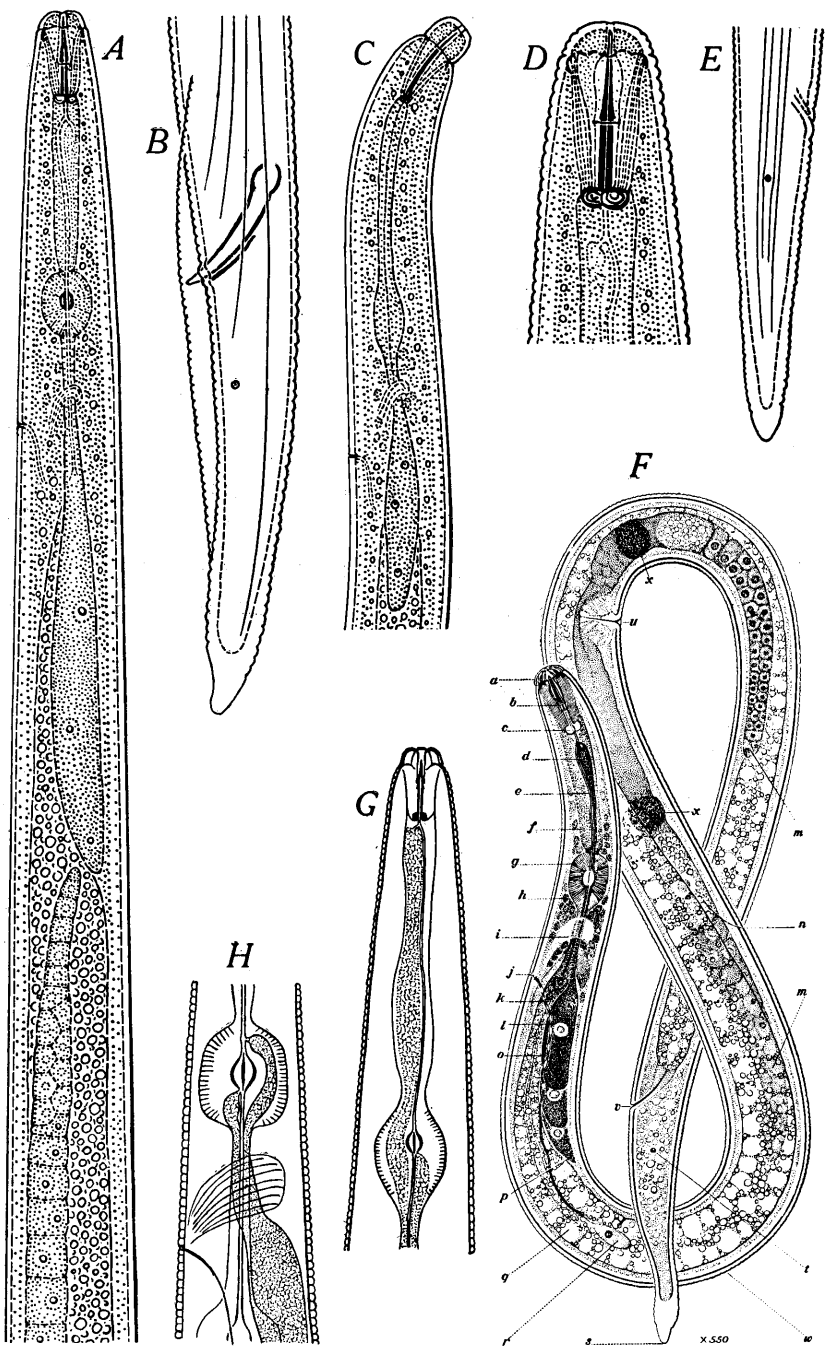

FIG. 4. A–F—*Radopholus similis*. A—Anterior portion of female; ×750. B—Male tail; ×7000. C—Anterior portion of male; ×750. D—Female head; ×1500. E—Female tail; ×750; Originals. F—Young female; ×550: *a*, Lip region; *b*, spear guide; *c*, 3-bulbed spear; *d*, ampulla, salivary gland; *e*, esophageal lumen; *f*, esophagus; *g*, median bulb; *h*, nerve cells; *i*, nerve ring; *j*, excretory

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duct and an outstretched ovary made up of a series of developing oöcytes arranged in single file except for a short region of multiplication near the anterior end. Posterior uterine branch extending one-third to one-half the distance back to the anus.

Female phasmids located near the middle of the tail. Male phasmids near the base of the bursa, four-sevenths of the tail length behind the anus. In cross section, the tail is seen to be flattened ventrally posterior to the anus and the phasmids extend out through this flattened portion but do not enter the bursa proper (Figs. 3, H, J). Cross sections show the bursa to be of surprising thickness (Figs. 3, I, J, K, L). The single outstretched testis is made up of developing spermatocytes most of which are arranged in two rows (Fig. 3, G). Spicula arcuate, hafted, resting upon a simple trough-shaped accessory piece.

Diagnosis.—Pratylenchus with the above measurements and general description, distinctive because of the three annules in the lip region; and the striae extending completely around the terminus of the femal tail.

The above description from specimens kindly collected for the writer by Dr. T. Goodey from a meadow in the vicinity of Sydenham, England, where deMan made his type collection. These individuals so closely resemble the type description that there appears to be no doubt concerning their identity.

Radopholus, new genus

Pratylenchinae. Two ovaries present. Head of female resembling that of *Pratylenchus pratensis*, with low lip region set off by a slight narrowing of the head contour, about half as wide as base of neck. Female spear also very much like that of *P. pratensis*, about twice as long as lip region width with strong basal knobs. Esophageal gland lobe extending back over intestine. Phasmids of both sexes prominent, located well back of the tails. Deirids not observed. Bursa enveloping only about four-fifths of tail. Tails of both sexes elongate-conoid to the rounded or irregular shaped terminus.

Type speices.—Radopholus similis (Cobb, 1893) new combination.

This genus is established to receive those didelphic species which most closely resemble nemas of the genus *Pratylenchus*. One other species is included: *Radopholus oryzae* (v. Breda de Haan, 1902) new comb. Synonyms: *Tylenchus oryzae* v. Breda de Haan, 1902; *Anguillulina oryzae* (v. B. de Haan, 1902) Goodey, 1932; *Rotylenchus oryzae* (v. B. de Haan, 1902) Filipjev and Schuurmans-Stekhoven, 1941. See Goodey, 1936, for emended description and figures. *T. apapillatus* Imamura, 1931, probably is a synonym of this species.

Radopholus similis (Cobb, 1915) new combination

Synonyms.—Tylenchus similis Cobb, 1893; *Tylenchus biformis* Cobb, 1907; *Anguillulina similis* (Cobb, 1893) Goodey, 1932; *Rotylenchus similis* (Cobb, 1893) Filipjev, 1936.

Fig. 4, A–F

♀: 0.65 mm; a = 22; b = 5.9; c = 10; V = 43 54 38

♂: 0.5 mm; a = 29; b = 5.2; c = 8.7; T = 32

Female.—Lip region rounded, marked by three striae, set off by a slight narrowing of the head contour. Cuticle distinctly striated. Lateral fields marked by four incisures, the lateral ones minutely crenate. Deirids not observed. Phasmids a little less than one body-width behind the latitude of the anus. Tail conoid

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pore; *k*. initial intestinal cells; *l*, anterior salivary gland; *m*, end of ovary; *n*, ovum; *o*, renette duct; *p*, posterior salivary gland; *q*, fat granule, intestine; *r*, renette cell ♀; *s*, terminus; *t*, phasmid; *u*, vulva; *v*, anus; *w*, crenate cuticle; *x*, spermatozoa. After Cobb, 1915. G, H—Arrangements of esophageal gland outlets. (G—Tylenchoidea. H—Aphelenchoidea.) After Goodey, 1929.

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to the blunt, rounded terminus. Spear strong with well developed knobs. Median bulb of esophagus subspherical with a small valve slightly anterior to the center. Isthmus about as long as the body-width. Junction of esophageal lumen and intestine very obscure. Basal lobe of esophagus from two to four times as long as the body-width, extending back over the anterior end of the intestine. This lobe usually is in dorsal position, and contains the three gland nuclei. Anterior ovary frequently extending forward to the median bulb of the esophagus. Posterior ovary sometimes reaching into the tail and occasionally reflexed forward one to three body-widths. Oöcytes in single file except for a short region of reproduction. Eggs about twice as long as body diameter.

Male.—Lip region sub-spheroid, unstriated, set off by constriction. Cuticle distinctly annulated. Lateral fields marked by four incisures, ending on the tail as illustrated (Fig. 4, B). Phasmids near base of bursa, about one body-width posterior to the latitude of the anus. Bursa crenate, rising at a point well in front of the spicula and extending two-thirds the length of the tail.

Spear very slender with tiny basal knobs. Esophagus reduced, the median bulb apparently being valveless. Testis outstretched, one-fourth to one-third the body-length. Spicula slightly arcuate, cephalated, distally acute. Gubernaculum thin, trough-like, slightly less than half as long as spicula.

Description and figures from specimens collected from the roots of sugarcane, *Saccharum officinarum,* collected near Honolulu, Hawaii, and kindly forwarded by Dr. M. B. Lindford; and two females from roots of pepper, *Piper nigrum,* East Indies, sent by Dr. T. Goodey. The basal lobe of the esophagus was much more developed in the specimens from pepper (Fig. 4, A) than in those from sugarcane.

Cobb (1915) stated "The lip region also is minutely transversely striated, the number of labial striae being about 8 or 10." This statement does not agree with the writer's observations which revealed only three striae (Fig. 4, D). Cobb's figure of the female (Fig. 4, F) shows the three esophageal gland nuclei in separate lobes, where actually they are in one elongate lobe (Fig. 4, A).

Genus *Tylenchorhynchus* Cobb, 1913

Synonym.—*Bitylenchus* Filipjev, 1934.

Diagnosis emended.—Tylenchinae. Lip region set off by constriction or continuous with head contour. Lateral fields marked by four or six incisures. Phasmids conspicuous, located well behind the anal region. Deirids generally not visible. Spear strong with large basal knobs. Basal bulb of esophagus well developed, connected with the intestine by a large cardia. Vulva near midde of body. Ovaries two, outstretched. Female tail blunt, rounded, usually two or more times as long as anal body diameter. Male tail slightly arcuate, enveloped by the bursa. Spicula and gubernaculum of the usual tylenchoid form.

Type species.—*Tylenchorhynchus dubius* (Bütschli, 1873) Filipjev, 1936.

Tylenchorhynchus dubius (Bütschli, 1873) Filipjev, 1936

Synonyms.—*Tylenchus dubius* Bütschli, 1873; *Tylenchorhynchus cylindricus* Cobb, 1913; *Anguillulina dubia* (Bütschli, 1873) Goodey, 1932.

Fig. 5, A–G

♀: 0.9 mm; a = 33; b = 5.5; c = 22; V = 28 54 31

♂: 0.9 mm; a = 36; b = 5.5; c = 17; T = 54

Lip region set off by a distinct constriction, marked by five annules. Lateral fields one-fourth as wide as body near middle, marked by four incisures. Phasmids prominent on both sexes (Fig. 5, C, F, G). Deirids not observed. From a face view the cephalic papillae are so minute that exact numbers and locations could not

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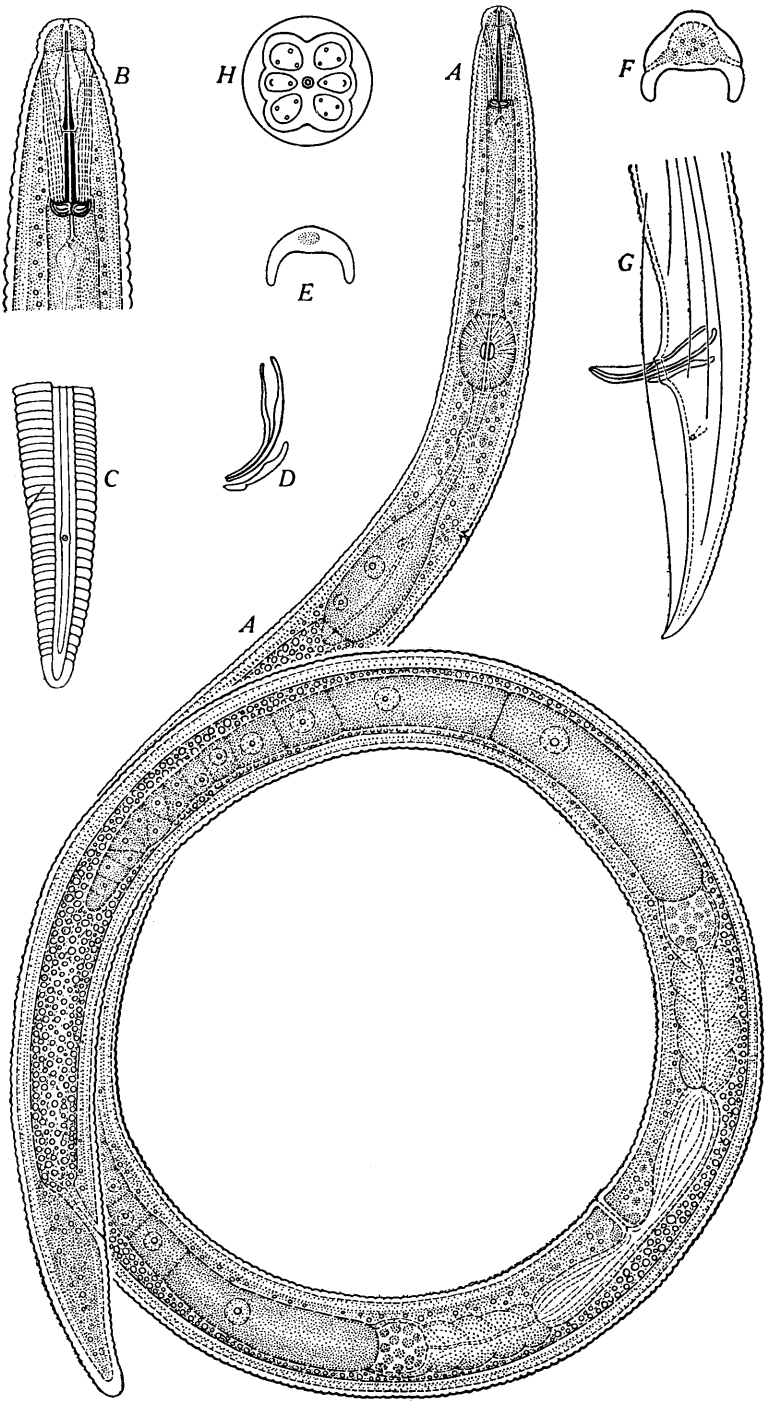

FIG. 5. A–G *Tylenchorhynchus dubius*. A—Female; ×510. B—Head; ×1020. C—Female tail; ×680. D—Spiculum and gubernaculum; ×680. E—Cross section through male tail near terminus; ×680. F—Cross section of male tail through pharyngeal region; ×680. G—Male tail; ×680. H—*Tylenchorhynchus* sp.; face view.

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be determined. However, on a large species of the genus the papillae and amphid apertures were arranged as illustrated (Fig. 5, H). Spear more than three times as long as lip region width, bearing strongly developed basal knobs. Median esophageal bulb slightly ovoid; basal bulb well developed, joined to intestine by a large, conoid cardia. Excretory pore slightly posterior to nerve ring. Vulva near middle of body. Ovaries outstretched, with oögonia arranged in single file. Testis single, outstretched. Spicula of typical tylenchoid form. Gubernaculum trough-like, cephalated. Bursa enveloping tail.

Habitat.—A cosmopolitan species. The form illustrated here was collected near Goshen, Utah, from desert soil. The male phasmids are slightly farther forward than those figured by Bütschli but otherwise the specimens correspond closely to the type.

Genus *Tetylenchus* Filipjev, 1936

Diagnosis emended.—Tylenchidae without sclerotized cephalic framework. Cuticle finely striated. Ovaries two, outstretched. Spear of moderate size, with or without basal knobs. Tails of both sexes tapering to an acute or subacute terminus. Deirids and phasmids present, generally easily visible. Bursa sub-caudal, extending almost to the terminus. Distance from anterior end to valve of median bulb shorter than that from valve to base of esophagus. Esophagus with elongate-ovate median bulb; unusually long slender isthmus, and elongate-pyriform basal bulb containing the usual three gland nuclei. Cardia usually discoid. Spicula tylenchoid; gubernaculum a simple trough-like plate.

Type species.—*Tetylenchus tenuis* (Micoletzky, 1922) Filipjev, 1936.

Representative species.—*Tetylenchus joctus*, new species.

Key to species of Tetylenchus

1. Spear without basal knobs ..... *abulbosus*, n. sp.
   Spear with basal knobs 2
2. ♀ Tail eight times as long as anal body diameter ..... *tenuis* Micoletzky
   ♀ Tail only four or five times as long as anal body diameter 3
3. Spear twice as long as lip region width ..... *joctus*, n. sp.
   Spear one and one-fourth times as long as lip region width ..... *productus*, n. sp.

Tetylenchus joctus, new species

Fig. 6, A–G

♀: 0.7 mm; a = 30; b = 4.5; c = 9.4; V = 31 55 38

♂: 0.6 mm; a = 30; b = 4.5; c = 9.0; T = 70

Cuticle finely striated. Lateral fields marked by six minute incisures. Deirids about opposite base of esophagus. Phasmids of both sexes slightly posterior to middle of tail. Lip region set off by a slight narrowing of the body contour, marked by six fine striae. There is no sclerotized cephalic framework. Spear about 15 μ long, its protrudor muscles attached to refractive elements at the side of the head. From a face view the lip region is seen to be slightly hexagonal. Amphid apertures minute, located close to the oral opening. Four prominent submedian papillae present on the outer contour of the lips; if other papillae were present they were beyond the limits of visibility. Esophagus with elongate-ovate median bulb, long, slender isthmus, and well developed basal bulb containing the usual three esophageal gland nuclei. Cardia discoid. Intestine with scattered fine granules.

FIG. 6. *Tetylenchus joctus.* A—Female; ×750. B—Face view; ×3000. C—Head; ×1500 D—Right side of cardiac region of specimen shown in A; ×750 E—Cuticle pattern of female tail; ×750. F—Cross section through male tail in phasmid region; ×1500. G—Cuticle pattern of male tail; ×750.

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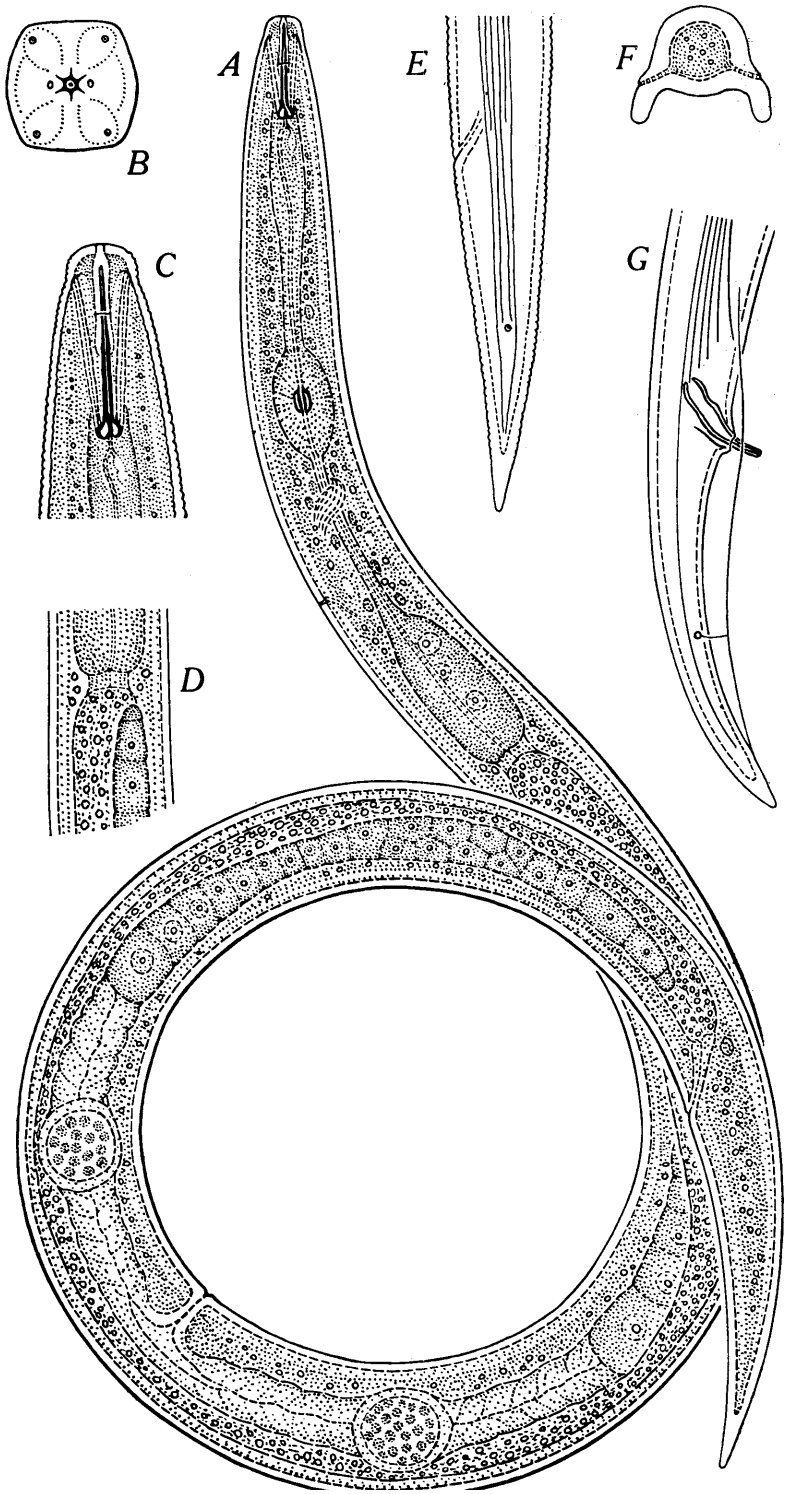

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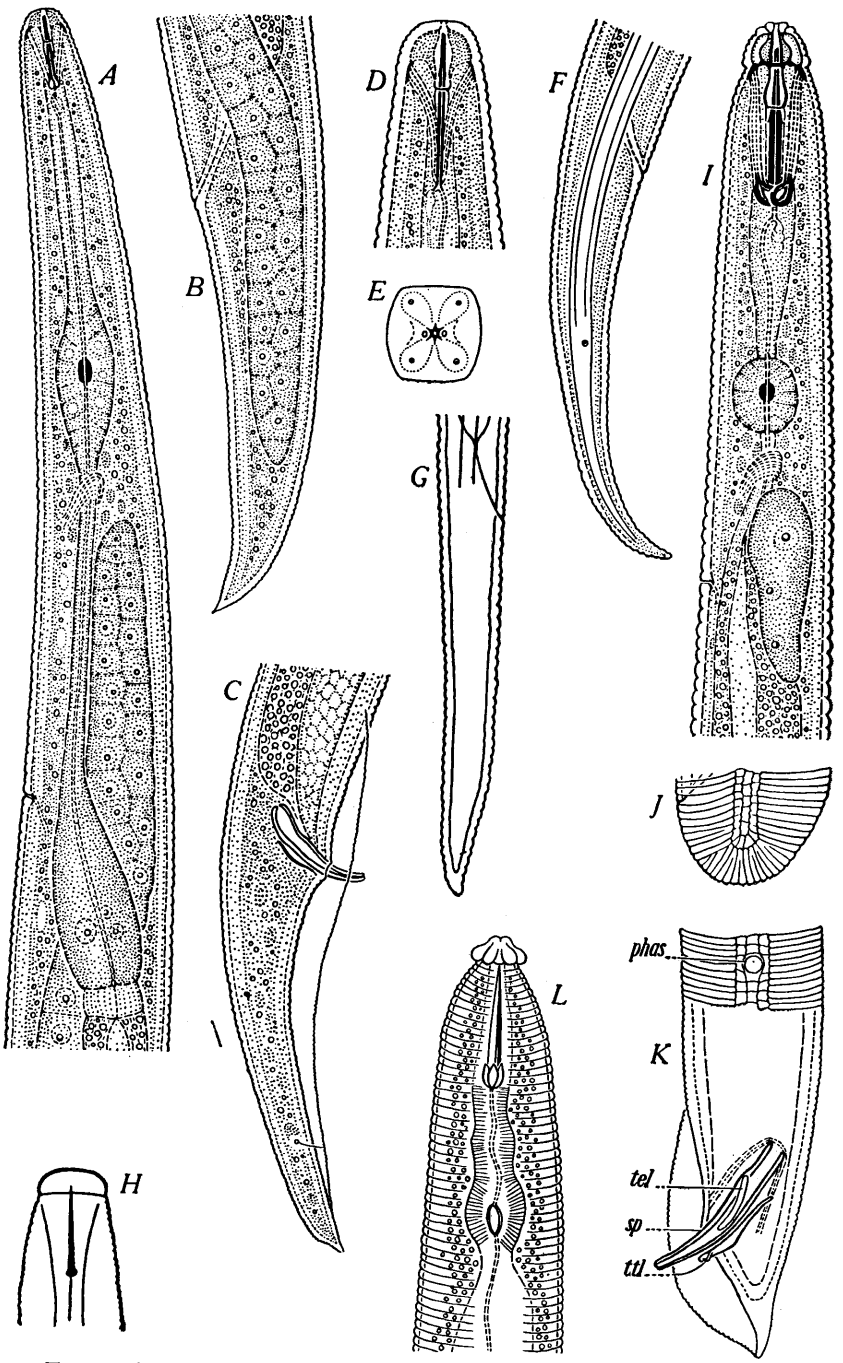

FIG. 7. A–C—*Tetylenchus productus.* A—Anterior portion of body; ×800. B—Female tail; ×800. C—Male tail; ×800. D–F—*Tetylenchus abulbosus.* D—Head; ×1200. E—Face view; ×1600. F—Female tail; ×600. G, H—*Tetylenchus tenuis.* G—Female tail. H—Head. After Micoletzky. I–K—*Hoplolaimus coronatus.* I—Anterior portion of body; ×400. J—Cuticle pattern of female

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Vulva a transverse slit. Anterior ovary extending almost to base of esophagus, posterior reaching almost to rectum. The specimens were not yet gravid, but had they been fully developed and producing eggs the ovaries doubtless would have been even longer. A conspicuous feature in each uterus was the spherical spermatheca. Oöcytes arranged in single file except for the usual short region of multiplication. Spicula tylenchoid, with thin, trough-like gubernaculum. Bursa subcaudal, an accentuated stria extending from the phasmid to the border of the bursa.

Diagnosis.—Tetylenchus with the above measurements and general description. Distinctive because of lip region set off by slight narrowing of body contour; terminus of tail subacute; lateral fields marked by six incisures; phasmids slightly posterior to middle of tail; spear about 15 μ long with small but distinct basal knobs. Spermatheca spherical.

Habitat.—Soil about roots of grass and weeds, Wrangell, Alaska, collected by Miss Jocelyn Tyler, August, 1932. The letters *joc* and *t* from her name are used as a root for the specific designation *joctus.*

Tetylenchus productus, new species
Fig. 7, A–C

♀: 1.2 mm; a = 25; b = 7.1; c = 17; V = 45 53 42

♂: 1.0 mm; a = 33; b = 7.1; c = 14; T = 72

Body tapering both ways from near the middle. Head rounded, the lips not set off in any manner. Terminus acute, sometimes almost mucronate. Lateral fields marked by six incisures that are generally easy to see. Deirids about opposite base of esophagus. Phasmids of female slightly posterior to middle of tail; on male about two-thirds the distance from anus to terminus. Lip region without sclerotized framework, the protrudor muscles of the spear attached to sclerotized elements at the side of the head. From a face view the vestibule is seen to be slightly sclerotized with six minute radiating elements. Amphid apertures very minute, located close to the oral opening. Four submedian cephalic papillae were easily seen but the others were either absent or beyond the limits of visibility. Spear about 12 μ long, slender, with small basal knobs. Median bulb of esophagus elongate with small valvular apparatus. Isthmus long and slender, ending in an elongated bulb with the three gland nuclei grouped more closely together than is usual. Cardiac valvular apparatus about one-third as wide as the body. Intestine with small scattered granules. Vulva a broad, transverse slit. Ovaries a conspicuous feature of the body, the anterior one frequently extending well past the base of the esophagus while the posterior may reach far into the tail. Adjacent to the cap cell the ovary appears to be made up of about four lines of developing oöcytes which may be arranged about a rachis, but this point was not definitely determined. Following this region of multiplication the oöcytes are arranged in the usual single file.

Habitat.—A single collection from hillside soil near mouth of Ogden Canyon, Utah. Three other attempts to find specimens in the same locality have failed.

Tetylenchus abulbosus, new species
Fig. 7, D–F

♀: 1.0–1.4 mm; a = 39; b = 6.6–7.4; c = 10; V = 34 52 30

Lip region rounded, striated, not set off from body contour. Body striae varying from 1 to 2 μ apart. Lateral fields about one-third body width, appearing as

tail; ×400. K—Longitudinal section through male tail showing telamon, *tel,* gubernaculum, *gub.* right spiculum *sp.* and titilla, *ttl.* Upper portion shows cuticle pattern and left phasmid, *phas;* ×400. L—*Hoplolaimus tylenchiformis.* After Daday.

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bright, refractive crenate bands marked by two fine incisures. Deirids about opposite base of esophagus. Phasmids near ventral side of lateral fields. Cephalic framework not visible. Face view shows lip region laterally constricted with amphid apertures located close to oral opening. Spear slender without basal knobs, its protrudor muscles attached to sclerotized elements at sides of head. Distance from anterior end to valve of median bulb equal to two-thirds that from valve to base of esophagus. Esophagus with elongate-ovate median bulb, long slender isthmus and elongate pyriform basal bulb. Cardia disc-like. Intestine with coarse scattered granules. Ovaries outstretched with oöcytes arranged in single file except for a short region of multiplication. Eggs about twice as long as body diameter. Males unknown but females contained spermatozoa, indicating that males do exist.

Diagnosis.—*Tetylenchus* with the above measurements and general description. Distinctive because of the rounded, striated lip region, continuous with body contour. Spear without basal bulbs. Tail arcuate to the small bluntly conoid, subacute terminus. Lateral field a broad refractive crenate band with two obscure incisures. Phasmid located near the ventral border of the lateral field.

Habitat.—A single collection made from soil in a wheat field near Downey, Idaho, by C. W. McBeth, March 7, 1936.

Tetylenchus tenuis (Micoletzky, 1922) Filipjev, 1936

Synonyms.—*Tylenchus tenuis* Micoletzky, 1922; *Anguillulina tenuis* (Micoletzky, 1922) Goodey 1932.

Fig. 7, G, H

♀ : 0.69 mm; a = 47.7; b = 3.8; c = 11.2; ^{24} 52 ^{23}

Body slender, tapering toward both ends. Striae about 1.5 μ apart near middle of body; 0.7 μ toward anterior end. Lateral fields distinct, about one-fourth the body width. Head slightly set off, convex, without papillae. Spear short, weakly knobbed. Esophagus very long with elongated bulbs. Nerve ring and excretory pore two-fifths the distance from anterior end to base of esophagus. Esophagus distinctly set off from intestine. Anus indistinct, rectum longer than anal body diameter. Ovaries paired and symmetrical. Tail bluntly conoid. Male unknown.

Habitat.—Alpine moss, Steiermark, Zirbitzkogel, Austria, at about 1,800 meters elevation.

Genus *Psilenchus* deMan, 1921

Diagnosis emended.—Tylenchidae with prominent striae on both cuticle and subcuticle. Lip region, without a sclerotized frame-work. Amphid apertures elongated, slit-like, conspicuous; located well below the contour of the lip region. Spear elongated, slender, with or without basal knobs; the protrudor muscles attached to lateral sclerotized plates. Outlet of dorsal esophageal gland very close to base of spear. Deirids prominent, located near the latitude of the nerve ring. Phasmids generally easily observed, situated two to five body-widths posterior to the anal region. Lateral fields with incisures or, rarely, consisting of plain refractive bands. Tails of both sexes elongated, filiform; frequently clavate. Distance from anterior end of body to center of median esophageal bulb greater than that from center of bulb to base of esophagus, except in *Psilenchus magnidens* in which these measurements are about equal. Esophagus with distinctly set off pyriform basal bulb. Cardia well developed, discoid to pyriform. Ovaries one to two, outstretched; the developing oöcytes arranged in single file. Testis single with spermatocytes in single file. Spicula tapering, arcuate, cephalated. Gubernaculum thin, trough-like, slightly curved.

Members of this genus are immediately distinguished by the elongated, slit-like amphid apertures; slender, frequently clavate tails of both sexes; prominent

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deirids and phasmids; elongated spears; absence of a sclerotized labial frame-work and by the fact that the distance from the anterior end to the center of the median bulb is equal to, or greater than, the distance from the center of the bulb to the base of the esophagus.

Specimens of *Psilenchus* are found widespread in cultivated and virgin soils of the Western United States but usually in small numbers. The divergent species here presented indicate that eventually the group will merit a family rank.

Key to species of Psilenchus

1. Terminus bulbous or clavate; two ovaries present 2
   Terminus filiform, one ovary present 4
2. Lip region plain, not striated 3
   Lip region distinctly striated ..... *striatus*, n. sp.
3. Spear with small basal knobs ..... *clavicaudatus* Micol.
   Spear without basal knobs ..... *hilarulus* deMan
4. Spear plain without basal knobs ..... *magnidens*, n. sp.
   Spear with distinct basal knobs 5
5. Spear straight, knobs symmetrical ..... *gracilis*, n. sp.
   Spear curved, knobs asymmetrical ..... *aberrans*, n. sp.

Psilenchus hilarulus deMan, 1921
Fig. 8, A–G

♀ : 1.1–1.5 mm; a = 33–38; b = 6.5–7.1; c = 8.0–8.5; V = ^{32} 47 ^{32}
♂ : 1.0–1.2 mm; a = 32–36; b = 6.0–6.8; c = 6.0–6.6; T = 42

Cuticle marked by striae which average about 1 μ apart near the head, slightly less on the body proper and generally much finer on the tail, although occasionally specimens occur on which the caudal striae are variable in width and sometimes extend completely to the terminus as described by deMan for his type specimens. Lateral fields marked by four incisures except near the head and on the tail where they are reduced to two. Deirids prominent, opposite the nerve ring. Phasmids easily seen two or three body widths posterior to the anus. The elongated tails taper to the terminus which varies from cylindrical to clavate. (Fig. 8, G.) Amphid apertures elongate, slit-like, located below contour of lips. From a face view the lateral sectors of the head are observed to be widened to make room for these broad amphids. Three papillae were observed on each of the four submedian head sectors but none was seen on the lateral ones. The slender spear is devoid of basal knobs, the protrudor muscles being attached to the walls of the posterior portion. The dorsal esophageal gland opens into the lumen of the esophagus at the base of the spear. Median bulb ovate with conspicuous valvular apparatus; posterior bulb pyriform with the usual three gland nuclei. Excretory pore opposite the nerve ring. Cardia conoid, submerged in the anterior end of the intestine. Lumen of intestine narrow with distinct walls. Intestinal granules of variable size, usually densely packed.

Vulva a transverse slit. Ovaries paired, outstretched. Spicula curved, tapering, cephalated, resting on a plain, thin, trough-like gubernaculum. Bursa crenate, rising near a point about opposite the proximal ends of the spicula and extending past the anus a distance equal to about twice the anal body diameter. Male phasmids located near the posterior ends of the bursa.

This species is readily distinguished among the didelphic forms by the unstriated lip region and slender, knobless spear.

Habitat.—Type specimens described by deMan from moist soil on bank of River Mark near Breda, Netherlands. A rather rare inhabitant of virgin and culti-

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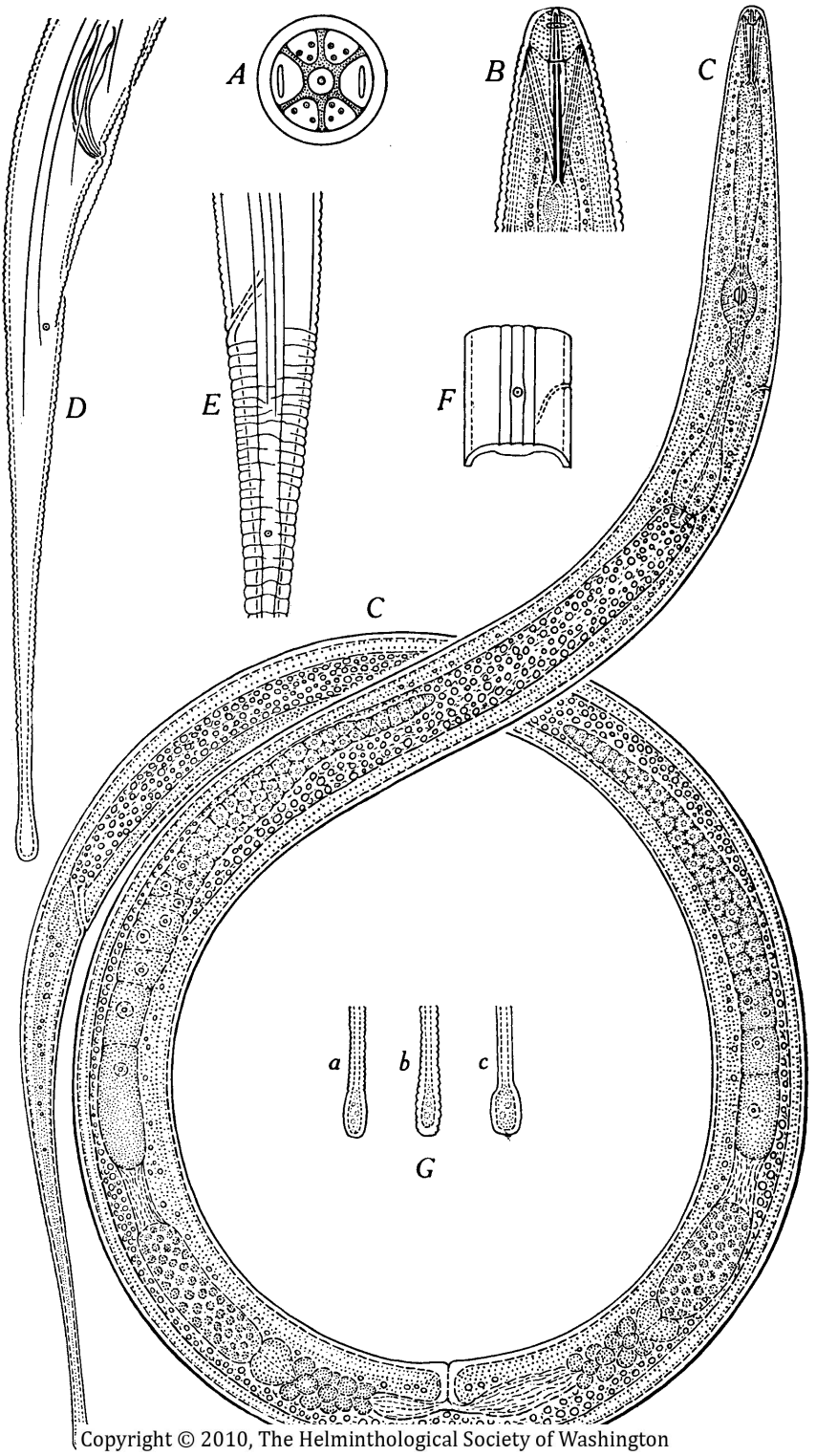

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vated soils from numerous points in Utah; sugar beet field, Fort Collins, and alfalfa field, Grand Junction, Colorado; potato field, Aberdeen, Idaho; and cotton fields near Bard and Arvin, California. Also collected near Reno, Nevada, by Dr. Merlin W. Allen.

Psilenchus striatus, new species

Fig. 9, D, E

♀: 1.6 mm; a = 35; b = 7.6; c = 14, V = 28 50 28

Lip region striated, continuous with head contour. Body assuming an open "C" form when killed by gradual heat. Lateral fields consisting of plain, refractive bands, about one-third as wide as body. Deirids conspicuous, located about opposite nerve ring. Phasmids easily observed about two anal body-diameters posterior to anus. Tail elongate clavate to the rounded terminus. Spear, 23 μ long, slender, without basal knobs, the anterior end somewhat expanded with a prominent aperture. Distance from anterior end to valve of median bulb much longer than from valve to intestine, the proportions being about 6: 4. Intestinal cells filled with coarse refractive granules. Vulva a broad depressed slit from which the symmetrical ovaries are outstretched. Anus a depressed transverse slit. Male unknown.

Diagnosis.—Psilenchus with the above general description and measurements. Immediately distinguished by the body length, annulated lip region, slender knobless spear with expanded aperture, plain band-like lateral fields and open "C" posture when killed by gradual heat.

Habitat.—One female from soil about roots of walnut trees, Santa Clara, California.

Psilenchus clavicaudatus (Micoletzky, 1922), new combination

Synonyms.—Tylenchus clavicaudatus Micoletzky, 1922; *Anguillulina clavicaudata* (Micoletzky, 1922) Goodey, 1932; *Tetylenchus clavicaudatus* (Micoletzky, 1922) Filipjev, 1936.

Fig. 9, L

♀: 1.23 mm; a = 37; b = 10; c = 9.3; V = 26 52.5 26

Head one-fifth as wide as maximum body width; lip region without sclerotized framework; annules 0.8–1.2 μ wide on body, 2.5–4.0 μ on tail; lateral fields one-seventh as wide as body; spear long, one-sixth the neck length, slightly knobbed at base; intestine with large granules in anterior portion; ovaries paired, symmetrical, outstretched, tail slender with very characteristic clavate terminus.

Habitat.—Pasture land, Bukowina, Czernowitz—Stadt, Austria.

Except for the slightly knobbed spear, this species appears to closely resemble *Psilenchus hilarulus.*

Psilenchus magnidens, new species

Fig. 9, A–C

♀: 0.9 mm; a = 36; b = 6.6; c = 5.6; V = 38 66

Body assuming an almost straight position when killed by gradual heat; lateral fields, deirids and phasmids more difficult to see than they usually are in *Psilenchus;* amphid apertures located near base of lips, about half as long as head width; spear with a broad lumen, without basal knobs and sometimes slightly bent in anterior portion. Distance from anterior end to valve of median esophageal bulb about equal to that from valve to base of esophagus; cardia large, discoid.

FIG. 8. *Psilenchus hilarulus.* A—Face view; ×2600. B—Head; ×1300. C—Female; ×440. D—Male tail; ×660. E—Cuticle pattern of female tail; ×660. F—Deirid region. G—Variations in female terminus: a—Bard, California; b—Reno, Nevada; c—Lewiston, Utah.

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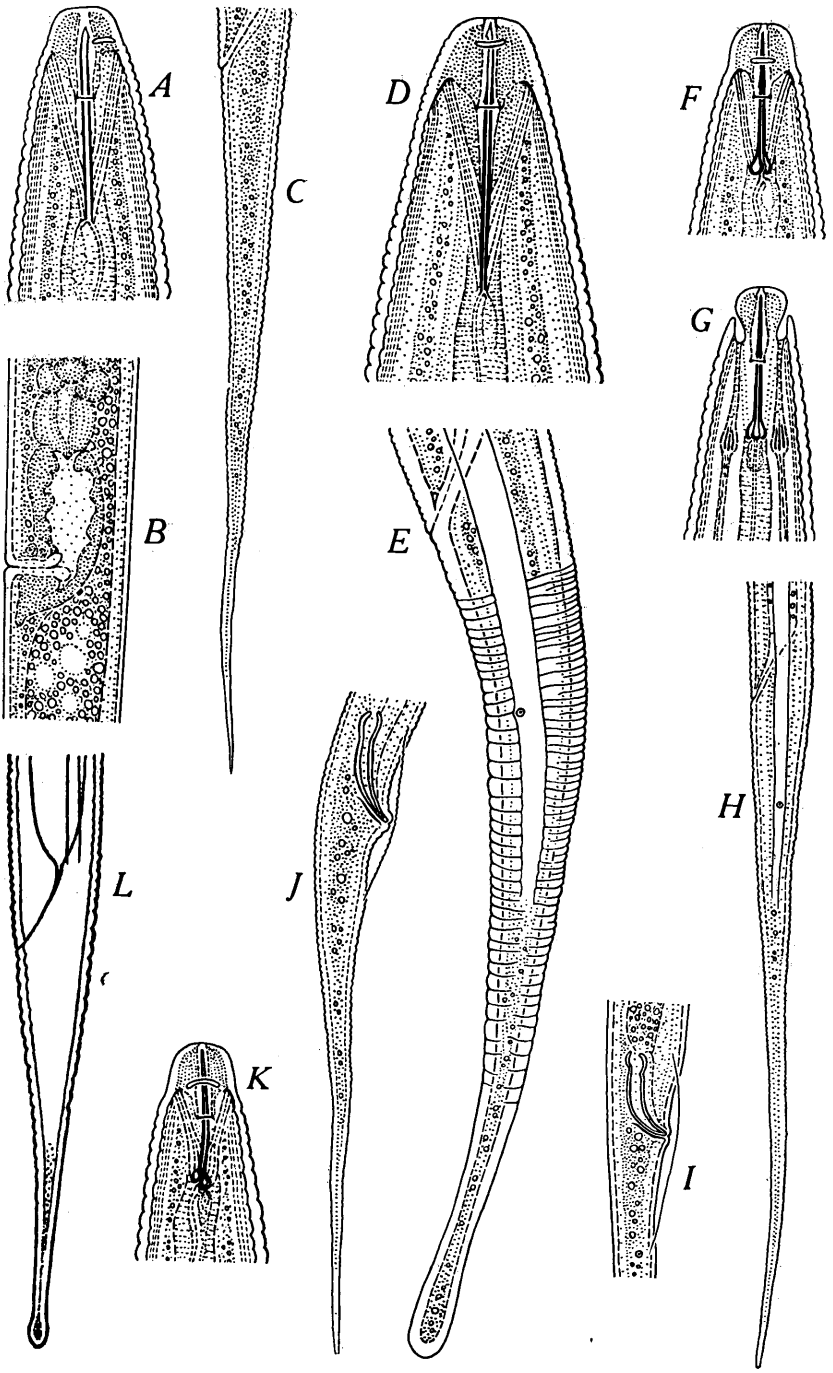

FIG. 9. A–C—*Psilenchus magnidens.* A—Head; ×1500. B—Vulvar region; ×750. C—Female tail; ×750. D, E—*Psilenchus striatus.* D—Head; ×1500. E—Female tail; ×750. F–I—*Psilenchus gracilis.* F—Head in lateral view; ×1500. G—Head in dorso-ventral view; ×1500. H—Female tail; ×750. I—Bursa region of male; ×750. J, K—*Psilenchus aberrans.* J—Male tail; ×750. K—Head; ×1500.

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Ovary extending forward nearly to base of esophagus; an egg was about four times as long as body width. Vulva a depressed transverse slit; posterior uterine branch about half as long as body width. Tail tapering uniformly to the acute terminus. Male unknown and a gravid female contained no spermatozoa, therefore males probably are rare or do not occur.

Diagnosis.—*Psilenchus* with the above general description. Immediately distinguished by the broad lumen of the knobless spear.

Habitat.—Alfalfa field near Holladay, a suburb of Salt Lake City, Utah. Also collected from potato field near Reno, Nevada, by M. W. Allen. A young female from soil collected by J. A. Pinchard, State College, Miss., belongs to this, or a closely related, species.

Psilenchus gracilis, new species
Fig. 9, F–I

♀: 0.65 mm; a = 35; b = 6.2; c = 4.8; $V = {}^{34}\ 63$
♂: 0.62 mm; a = 33; b = 6; c = 6; T = 40

Body assuming a rather straight position when killed by gradual heat. Cuticle marked by the usual distinct striae which are rather uniformly spaced throughout the body, except near the terminus where they become excessively fine and gradually disappear. Lateral fields about one-fourth as wide as the body, appearing as plain bands with only occasionally minute traces of the usual two middle incisures. Deirids and excretory pore about opposite the nerve ring. Phasmids located two or three anal body diameters posterior to the anus. Amphid apertures about half as wide as the head and located at the base of the rounded lip region. Spear very slender with an exceedingly narrow lumen and bearing well developed basal knobs. Median bulb of esophagus ovate with indistinct valve; basal bulb elongate-pyriform. Cardia large, discoid to hemispherical. Distance from anterior end to valve of median bulb only slightly greater than that from valve to base of esophagus.

Vulva a broad depressed slit from which the vagina leads in at right angles. Posterior uterine branch about half as long as body width. Spicula cephalated, curved; gubernaculum, thin, flat, slightly curved.

Diagnosis.—*Psilenchus* with the above general description. Distinctive because of the straight, well knobbed spear; slender tapering tail which is longer than the vulva-anus distance; plain, band-like lateral fields; and rather straight posture of the body when killed by gradual heat.

Habitat.—Cultivated fields near Midvale, Utah. 2♀, 1♂

Psilenchus aberrans, new species
Fig. 9, J, K

♀: 0.66 mm; a = 36; b = 6.0; c = 7.6; $V = {}^{42}\ 66$
♂: 0.61 mm; a = 32; b = 6.4; c = 7.1; T = 43

Body assuming an open "C" form when killed by gradual heat. Cuticle marked by the usual transverse striae which become excessively fine toward the terminus. Lateral fields about one-third as wide as body with two fine, but distinct, incisures visible the larger part of their length. Excretory pore and deirids about opposite the nerve ring. Phasmids two or three anal-body diameters posterior to the anus. Lip region unstriated. Amphid apertures almost half as wide as head, located near base of lip region. Spear slender, with very fine lumen; slightly bent ventrically in its posterior third. Dorsal knob of spear larger than the submedian and extending somewhat farther back. Median esophageal bulb ovate with obscure valve; posterior bulb elongate-pyriform. Cardia discoid to hemispherical. Vulva a depressed slit from which the vagina extends in at right angles to the

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body axis. Ovary outstretched. Posterior uterine branch rudimentary, less than half as long as the body width. Spicula arcuate, cephalated; resting on a thin, flat, slightly curved gubernaculum. Bursa rising about opposite proximal ends of spicula and extending back somewhat more than one anal body diameter past the elevated anus. Terminus minutely rounded.

Diagnosis.—*Psilenchus* with the above measurements and general description. Distinctive because of the slightly curved, asymmetrically knobbed spear, open "C" form of body when killed by gradual heat; and vulva-anus distance greater than tail length.

Habitat.—Sugar beet fields near Fort Collins and Wellington, Colorado, and alfalfa field near Holladay, a suburb of Salt Lake City, Utah.

Genus *Tylenchus* Bastian, 1865

Diagnosis emended.—Tylenchinae. Tails filiform. Lip region striated. Vulva well behind middle of body. Anterior ovary outstretched. Posterior uterine branch short, rudimentary. Bursa short, adanal. Developing oöcytes and spermatocytes usually arranged in single file. Deirids generally prominent, located near the latitude of the conspicuous excretory pore. Phasmids not observed.

Cuticle striated, lateral fields marked by incisures. No sclerotized cephalic framework present. Spear well developed with basal knobs; the protrudor muscles anchored to the cephalic walls. Median esophageal bulb ovate with refractive valvular apparatus. Isthmus long, slender, ending in a somewhat pyriform basal bulb containing the usual three nuclei. Cardia present. Intestinal cells usually packed with coarse granules which obscure details of the cell nuclei.

Type species.—*Tylenchus davainii* Bastian, 1865.

Tylenchus davainii Bastian, 1865

Synonym.—*Anguillulina davainii* (Bastian, 1865) Goodey, 1932.

Fig. 10, A–G

♀: 1.0–1.3 mm; a = 25–35; b = 6–7.5; c = 5.5–7.2; $V = {}^{36}\ 65\ {}^{2}$

♂: 0.9–1.1 m; a = 37: b = 5.5; c = 6; T = 46

Tails elongated, filiform, ventrally bent. Cuticle strongly striated. Lateral fields with crenate borders, marked by two incisures. Deirids prominent, located near the latitude of the sclerotized excretory pore. Phasmids not observed, either absent or beyond the limits of visibility. Lip region striated, set off by a slight narrowing of the body contour. Spear strongly knobbed with protrudor muscles attached to the walls of the head. From a face view the amphids were observed to be located near the margin of the lateral lips, and a single papilla was seen on each of the four submedian lips. Median esophageal bulb ovate with refractive valve. Isthmus slender, ending in a somewhat pyriform bulb which contains the usual three gland nuclei. Cardia conoid. Anterior cells of intestine hyaline, but the remainder of the cells are packed with coarse dark granules.

Vulva a depressed slit. Anterior ovary outstretched with oöcytes usually arranged in single file. Posterior uterine branch rudimentary, shorter than the body diameter. Spicula of the usual tylenchoid type. Gubernaculum thickened near the middle. Bursa crenate, about three times as long as the anal body diameter. Testis single, outstretched, with spermatocytes arranged in single file.

Description derived from specimens collected in Ogden Canyon, Utah. A widely distributed species from valley and mountain soil of the western states.

Genus *Ditylenchus* Filipjev, 1934

Diagnosis emended.—Tylenchinae. Ovary single. Rudimentary posterior

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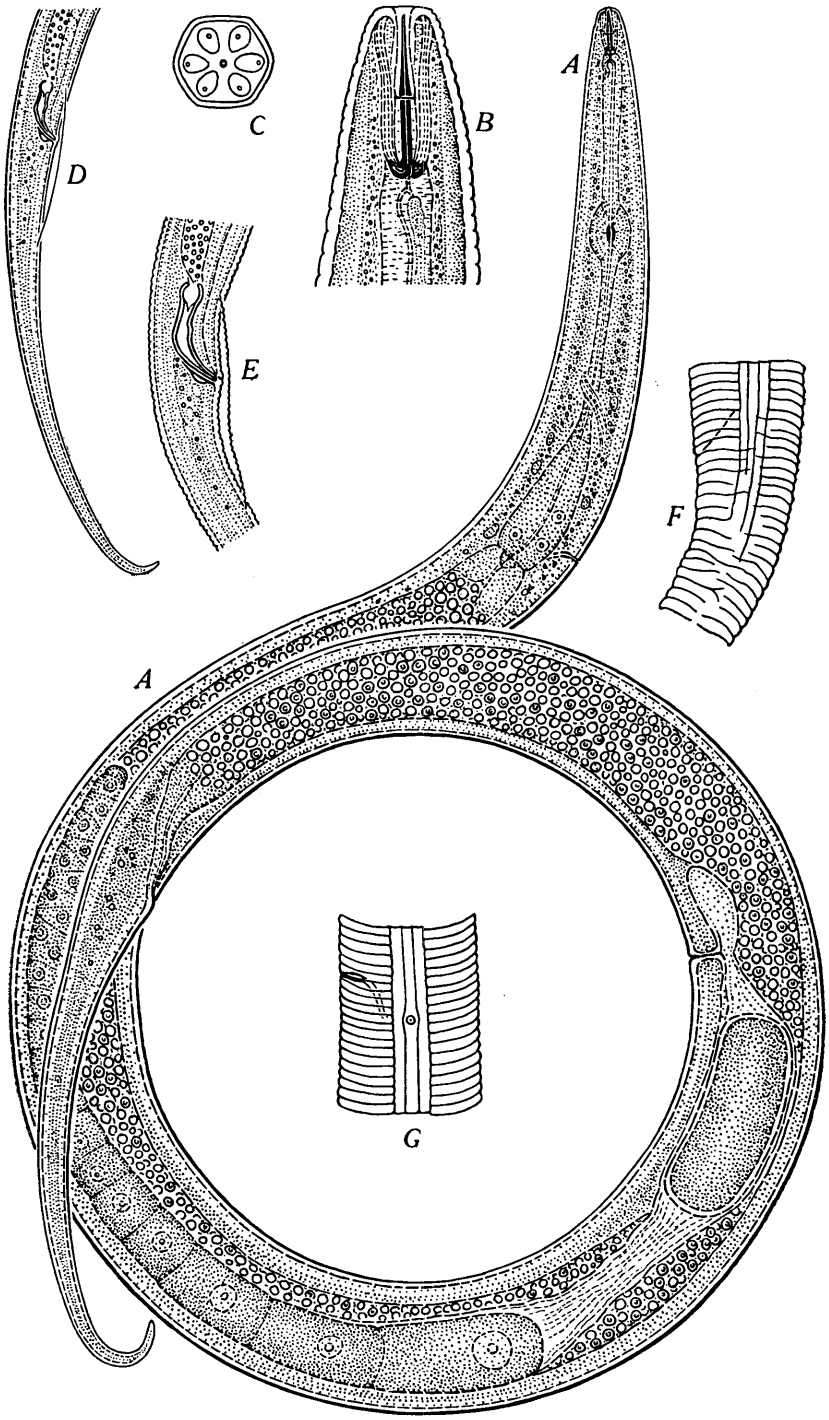

FIG. 10. *Tylenchus davainii*. A—Female; ×400. B—Head; ×1200. C—Face view; ×1600. D—Male tail; ×400. E—Bursa region; ×800. F—Cuticle pattern of female anal region. G—Cuticle pattern of deirid region.

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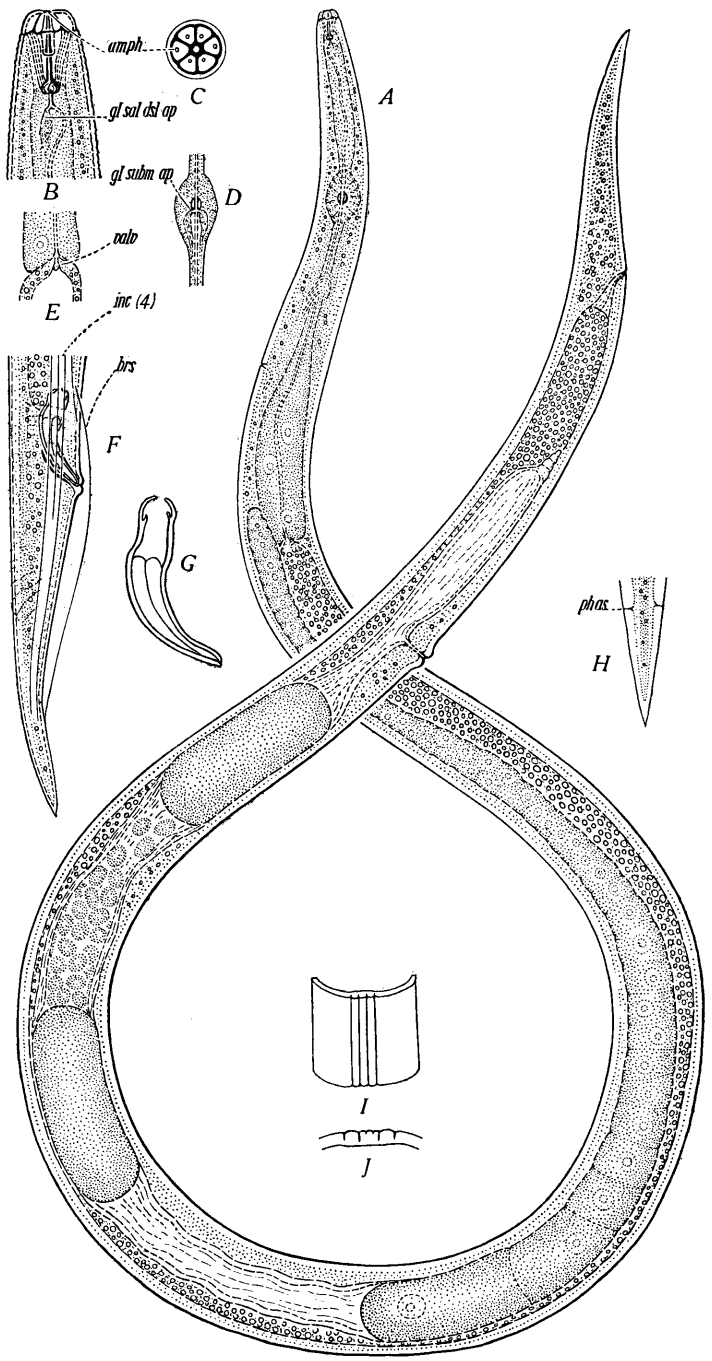

FIG. 11. *Ditylenchus dipsaci.* A—Adult female; ×330. B—Head of female; *amph,* amphid; *gl sal dsl ap,* aperture of dorsal salivary gland; ×1000. C—Face view showing arrangement of amphids and 4 labial papillae; *amph,* amphid; ×1000. D—Dorsal view of median esophageal bulb; *gl subm ap,* apertures of sub-

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uterine branch present. Lip region plain, not annulated. Gonad cells in one or two lines, not arranged about a rachis. Lateral fields marked by four or six incisures. Basal portion of esophagus a distinct bulb, occasionally with a short lobe extending back over anterior end of intestine. Deirids small but usually visible. Phasmids exceedingly minute if visible at all. Bursa enveloping one-fourth to three-fourths of the tail. Tails elongate-conoid to an acute or subacute terminus.

Type species.—*Ditylenchus dipsaci* (Kühn, 1857) Filipjev, 1936.

Ditylenchus dipsaci (Kühn) Filipjev, 1936

Synonyms.—See Thorne, 1945.

Fig. 11, A–J

♀: 1.0–1.3 mm; a = 36–40; b = 6.5–7.1; c = 14–18; $V = {}^{60-70}\ 80\ {}^{7}$

♂: 1.0–1.3 mm; a = 37–41; b = 6.5–7.3; c = 11.5–14.5; T = 65–72

Body marked by transverse striae about 1 μ apart which are easily visible under the oil immersion at any point on the body. Lateral field marked by four incisures; cross sections of the body from certain favorable specimens show the center element is marked by two minute incisures which may indicate that an ancestor once possessed six (Fig. 11, J). Deirids usually visible near base of neck. Phasmids exceedingly obscure and visible only from a dorsal or ventral view on favorable specimens. Amphid apertures located on the apices of the lateral lips where they appear as minute refractive dots which are best seen from a face view (Fig. 11, B, C). Spear with strongly developed knobs from which protrudor muscles lead to the well-sclerotized labial framework. Basal bulb of esophagus with the usual three prominent gland nuclei. Anterior end of intestine extending into the base of esophagus where it joins the lumen with a very small muscular valvular apparatus.

The outstretched ovary sometimes reaches as far as the median bulb of the esophagus but more generally ends near the basal bulb; rarely reflexed. The developing oöcytes largely lie in tandem and develop into eggs which are from 2 to 3 times as long as the body width. The rudimentary posterior uterine branch extends about half-way back to the anus. Vulva-anus distance equal to from $1\frac{3}{4}$ to $2\frac{1}{4}$ times the length of the tail. Terminus always acute

Testis outstretched with spermatocytes arranged in single file except in a short region of growth. From a perfectly lateral view the spicula exhibit a sclerotized pattern that apparently is characteristic of the species, but the proper angle of observance is so difficult to obtain on the various specimens that this pattern rarely is of taxonomic help (Fig. 11, G). Bursa well developed, rising about opposite the proximal ends of the spicula and extending about three-fourths the length of the tail. Lateral incisures forming a pattern similar to that illustrated (Fig. 11, F).

Diagnosis emended.—Obligate plant-parasitic *Ditylenchus* with the above measurements and general description. Lateral field marked by four incisures; base of esophagus extending but slightly over the anterior end of the intestine; gonads outstretched, their cells lying in tandem. Eggs two to three times as long as the body diameter. Spicula with characteristic pattern as figured. Terminus acute.

Type host.—*Dipsacus fullonum*, fuller's teasel.

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median esophageal glands; × 500. E—Junction of intestine and esophageal lumen; *valv*, muscular valvular apparatus in anterior end of intestine; × 500. F—Posterior portion of male; *inc*, 4 incisures of lateral field; *brs*. bursa; × 500. G—Spiculum; × 1000. H—Terminus; *phas*, phasmid (much exaggerated); × 500. I—Section of cuticle at mid-body showing 4 incisures; × 330. J—Cross section of lateral field (note the 2 minute incisures in the central element); × 1000.

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Genus *Anguina Scopoli*, 1777[5]

Diagnosis emended.—Tylenchinae. Robust, stout species with female body generally arcuate or spiral in form. Cuticle marked by fine striae which frequently are visible only on the neck and lip region. Lateral fields appearing as plain bands or as bands bearing four or more minute incisures. Deirids and phasmids not observed. Lip region distinctly set off with amphid apertures appearing as minute refractive elements at the apices of the lateral lips. Six minute papillae surround the oral opening with four submedian ones located on the outer margins of the submedial lips. Spear small with well developed basal knobs. Median bulb of esophagus with distinct valvular apparatus; basal bulb made up of glandular tissues which frequently may become greatly swollen and irregular in form. Ovary extending forward, generally with one or two flexures. Oöcytes in multiple series, arranged about a rachis. Posterior uterine branch rudimentary. Spicula joined together, arcuate, without definite cephalation, the blades generally as wide, or wider than the haft. Gubernaculum trough-like, slightly curved. Testis with spermatocytes developing in multiple rows about a rachis. Bursa enveloping tail or nearly so. Typical parasites of the seeds and stems of plants.

Anguina is distinguished from *Ditylenchus* by the caudal bursa, multiple rows of oöcytes and spermatocytes arranged about the rachis, more robust, amalgamated, wider spicula, and by the distended, almost immobile bodies of the females.

Anguina tritici (Steinbuch, 1799) Filipjev, 1936
Fig. 12, A–J

♀: 3.8 mm; a = 20; b = 13; c = 31; V = 83 91 [3]

♂: 2.4 mm; a = 25; b = 9; c = 30; T = 80

Obligate plant parasite with obese body; that of the female being spiral in form and largely immobile, while the male generally is more active. Striae usually visible only on the neck region. Lateral fields indistinct, consisting of narrow bands marked by numerous minute incisures. Spear greatly reduced with small basal knobs. Esophagus of gravid female frequently with grossly developed glandular structures as shown (Fig. 12, A). Between the nerve ring and the basal bulb is a secondary "storage" gland, set off from the bulb by a definite constriction, in which the dorsal gland secretions apparently collect until it may become greatly distended; or the secretions may be used and the gland reduced to a small ovate swelling. Cardia small, often obscure. Ovary greatly developed with one or two flexures, the oöcytes arranged about a rachis. In cross section the ovary appears as pulpy cellular tissue surrounded by a relatively thin layer of developing oöcytes (Fig. 12, J). A spherical spermatheca lies adjacent to the outlet of the ovary, and the posterior uterine branch also serves as a spermatheca. Several eggs may be present at one time in the oviduct, each about as long as the vulva body width.

Testis with one or two flexures, the spermatocytes arranged about a rachis. Spicula broad, short, amalgamated; the only instance of amalgamation observed in the Tylenchidae. Gubernaculum thin, trough-like. Bursa enveloping tail.

The above description based on specimens from infested wheat collected in Georgia by Mr. A. L. Taylor.

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[5] Chitwood (1935) reestablished *Anguina* as a valid genus and made *Anguillulina* Gervais and van Beneden a synonym, in accordance with the international rules of zoological nomenclature which do not invalidate old genera which were described without mention of a specific name.

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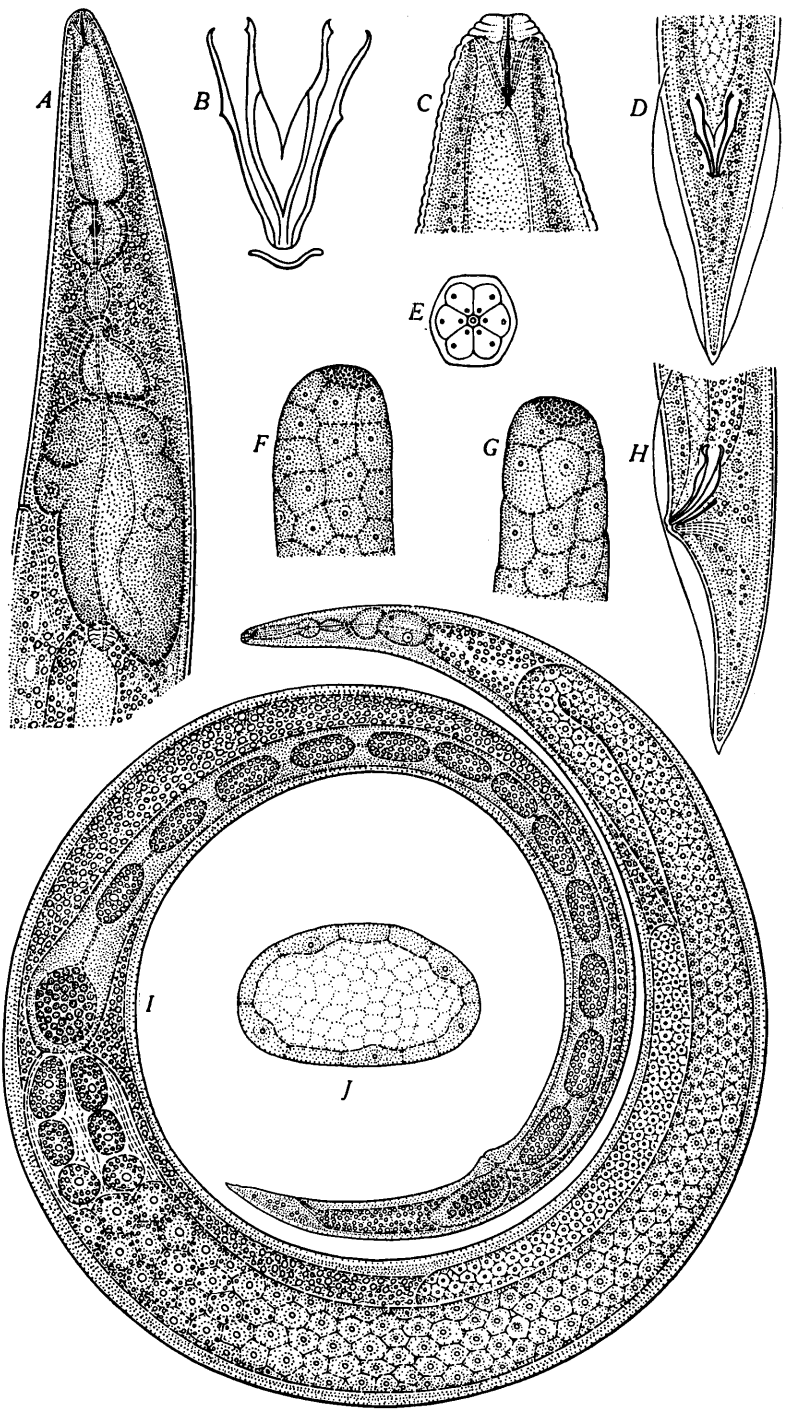

FIG. 12. *Anguina tritici.* A—Neck of female with greatly developed esophageal glands; ×680. B—Spicula and cross section of gubernaculum; ×1020. C—Head; ×1020. D—Male tail, ventral view, ×340. E—Face view; ×1360. F—End of ovary; ×340. H—Male tail, ×1020.

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Studies on Potential Snail Hosts of *Schistosoma japonicum*. I. Notes on the Amnicolid Snails *Blanfordia, Tricula* and a New Genus, *Fukuia* from Japan

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INTRODUCTION

During World War II considerable attention was devoted to schistosomiasis japonica. This was inevitable, since the disease was known to be endemic in the Philippines, Japan and China. Not only was the epidemiology of the disease restudied and evaluated in both the Philippines and Japan (Sullivan and Ferguson, 1946; Faust, Wright, McMullen and Hunter, 1946; Wright et al. 1947; Hunter, Dillahunt and Dalton, MMS) but also the ecology of the known snail intermediate hosts was investigated (McMullen, 1947; Abbott, 1945, 1946, 1948, 1948a, 1948b; Hunter, Bennett, Ingalls and Greene, 1947). The Armed Forces also published various data on these areas. One such (TB Med 160) stated that Fukui Prefecture on Honshu Island was reported to be a schistosomiasis area. If this were so, then it constituted a new endemic center for the disease. Consequently, it was decided to make an epidemiological survey in Fukui Prefecture to

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