

Morphology and Morphometrics of Six Species of *Pratylenchus*¹

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Abstract: Six species of *Pratylenchus* (*P. penetrans*, *P. vulnus*, *P. coffeae*, *P. scribneri*, *P. zeae* and *P. brachyurus*) were propagated aseptically on alfalfa callus tissue at 27 C and in greenhouse pot culture on suitable hosts. Morphological and morphometric comparisons revealed a high degree of variability of most taxonomic characters studied. The number of annules in the lip region, the number and arrangement of incisures in the lateral field, the shape of stylet knobs and tail varied considerably within most of the species. Of 20 morphometric characters, vulva percent and stylet length had the lowest coefficients of variability and were found to be of diagnostic value. A slightly greater morphometric variability was encountered in *P. vulnus* females and males from greenhouse than from callus cultures. A small spermatheca containing no spermatozoa was present in the monosexual species *P. scribneri*, *P. zeae* and *P. brachyurus*. A few males were found only in *P. brachyurus*. The distal part of the uterus was composed of 12 cells arranged in three rows of four cells each (tricolumella). A detailed description of each species is given.

The genus *Pratylenchus* Filipjev comprises over 40 described species of worldwide distribution which parasitize a wide variety of plants. The taxonomic separation of the various species is difficult since they exhibit little morphological diversity. Taxonomic difficulties often arise from underestimation of intraspecific variability of certain morphological characters presently used for distinguishing species. Since Sher and Allen's classical review of the genus (17), other investigators have studied the morphology and taxonomy of the genus. Taylor and Jenkins (18) pointed out the importance of variation of certain morphometric and morphological characters in species identification of greenhouse populations of four *Pratylenchus* species from Maryland. Loof (13) published an extensive taxonomic treatment of 20 species, and emphasized the identity of five of them

with special reference to the variability of tail shape in rearing tests. Ovary length and lateral field structure were also considered in certain species. Seinhorst (15) recently emended four known *Pratylenchus* species, described three new ones from the Netherlands, and evaluated the stylet, cephalic framework, spermatheca and number of annules on the tail as distinguishing characters for species separation. Although all previous research has contributed substantially to our knowledge of the genus, in no case were nematode populations reared under standard conditions. The present comparative study of six *Pratylenchus* species cultured monoxenically under controlled conditions was undertaken to assess the intraspecific variability of a number of morphological and morphometric characters and to determine which of them are most useful for species identification.

For comparison, greenhouse cultured *P. vulnus* was also analyzed. A preliminary report was presented earlier (14).

MATERIALS AND METHODS

The various *Pratylenchus* species (Table 1) were propagated on alfalfa callus tissue cultures using the method of Krusberg (12) with only 2,4-D (2,4-dichlorophenoxyacetic acid) as growth regulator. Twenty to 25 sterile

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TABLE 1. Sources, hosts and greenhouse culture hosts of *Pratylenchus* species studied.

Species	Source	Greenhouse culture
<i>P. penetrans</i>	peach, Canada	cowpea
<i>P. vulnus</i>	boxwood, Virginia	boxwood
<i>P. coffeae</i>	Chinese evergreen, Florida	Chinese evergreen
<i>P. scribneri</i>	sweetcorn, California	corn, cowpea
<i>P. zaeae</i>	corn, North Carolina	corn
<i>P. brachyurus</i>	cotton, North Carolina	cotton, cowpea

seedlings, about 1.5 cm long, were transferred to culture tubes (2.5 × 15 cm) containing 10 ml of sterile, slanted agar medium. Cultures were incubated in the dark at 27 C for 2 weeks before inoculation with 25 surface-sterilized nematodes. Nematodes were surface sterilized with 0.1% hibitane diacetate (bis [p-chlorophenyldiguanido]—hexane-diacetate) for 18 min and were rinsed for 2 to 3 min in each of five changes of sterile distilled water. Subculturing was done every 3 months by transferring a piece of infected tissue into a fresh callus culture.

Greenhouse cultures of the *Pratylenchus* species were also maintained on various host plants (Table 1).

Nematodes were obtained from callus tissue by placing small pieces of infected callus on tissue paper supported by a 17-mesh screen in a shallow layer of water in a petri dish. Nematodes from greenhouse cultures were recovered from thoroughly washed, infected roots in a mist chamber, and sieved six times through a 325-mesh screen. Adult nematodes were picked at random (avoiding very old individuals), relaxed by heat in a drop of water, and mounted in 2% formalin on a glass slide under a glass coverslip supported by a ring of Zut (Glyceel) the thickness of the nematode. All specimens were examined within 24 hr. For examination of

the reproductive system, specimens were stained with 1% acetic orcein (10). *En face* views and free-hand serial cross sections of nematodes were prepared by the method of Thorne (20).

For the morphometric studies, 20 previously studied characters that appeared useful in species differentiation were selected, and fifty females of each monosexual species and 25 females and 25 males of each bisexual species were measured. The data were analyzed statistically, and the range, mean, standard error of the mean and coefficient of variability were calculated.

OBSERVATIONS

VARIATION OF CERTAIN TAXONOMIC CHARACTERS IN FEMALES AND MALES: *Lateral Field*.—The lateral field is often difficult to observe, especially in stout specimens. It extends from near the median esophageal bulb to the tail and usually has four mutually equidistant straight incisures forming three bands of the same width (Fig. 1-A). The outer incisures may occasionally be slightly crenate in the tail region where areolation may also occur. Deviations from the basic pattern are observed within a given species. These usually extend along most of the length of the lateral field but in some cases are restricted to the region of the vulva. Thus, the incisures may not be equidistantly spaced, and the inner band is narrower (Fig. 1-B) or wider (Fig. 1-C) than the outer bands which are usually of the same width. Occasionally, the inner band has short, equally spaced, diagonal lines (Fig. 1-D). Some specimens of *P. penetrans* (Cobb) Filipjev & Schuurmans Stekhoven, have straight rows of punctations in the center of the outer bands, in addition to short, diagonal lines in the inner band (Fig. 1-E). Specimens of *P. coffeae* (Zimmermann) Filipjev & Schuurmans Stekhoven, may have punctations scattered in the outer bands (Fig. 1-F).

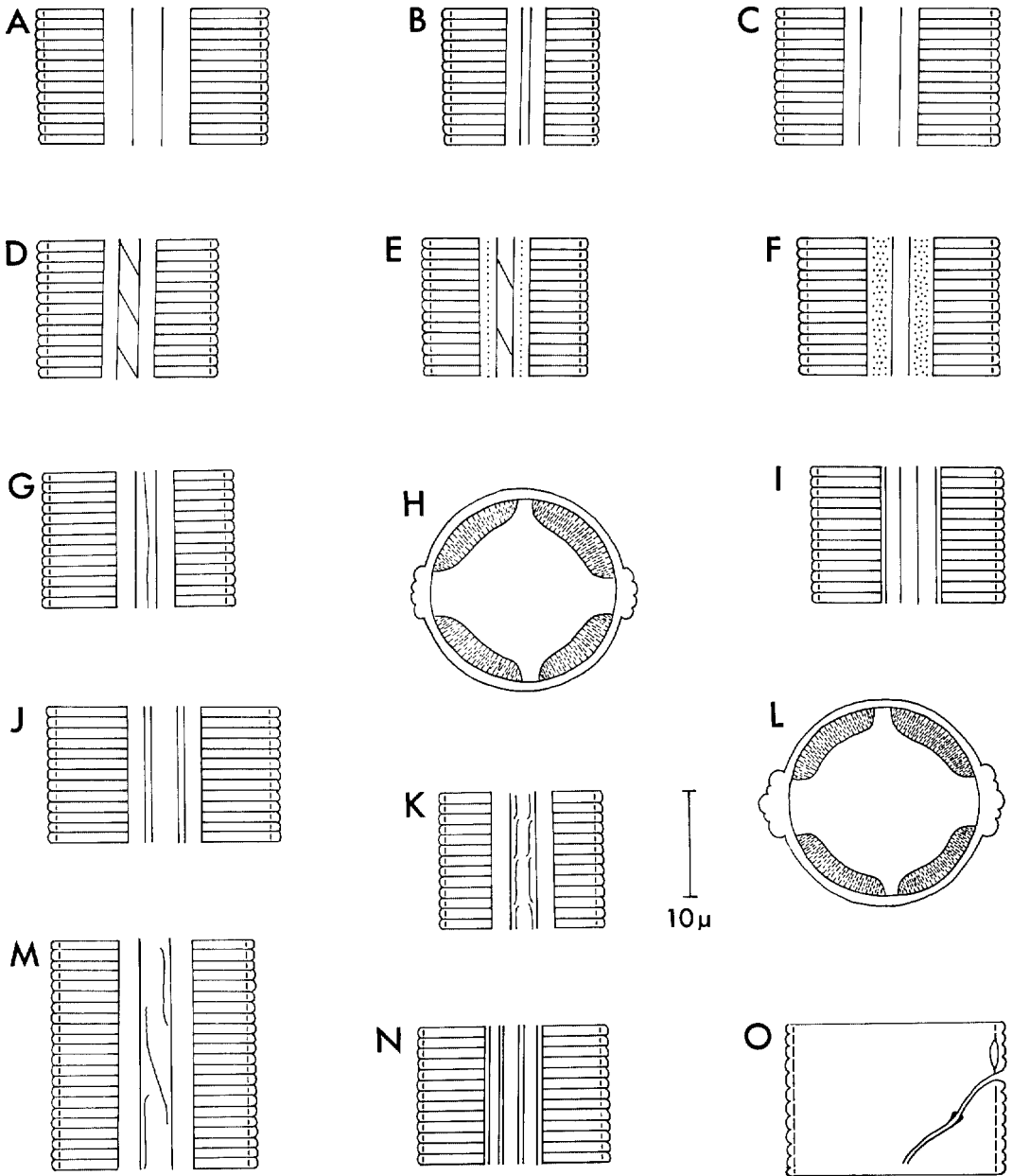


FIG. 1. Variation in lateral field of *Pratylenchus* spp. A. Four incisures forming three equally spaced bands; B. Four incisures with inner band narrower; C. Four incisures with inner band wider; D. Four incisures with diagonal lines in inner band; E. Four incisures with diagonal lines in inner band and straight lines of punctations in outer bands; F. Four incisures with scattered punctations in outer bands; G. Five incisures; H. Cross section of specimen with five incisures; I. Six incisures, outer lines doubled; J. Six incisures, inner lines doubled; K. Six incisures, innermost lines broken and bent at their ends; L. Cross section of specimen with six incisures; M. Six incisures with diagonal line in middle band; N. Eight incisures; O. Excretory duct with culticularized thickening.

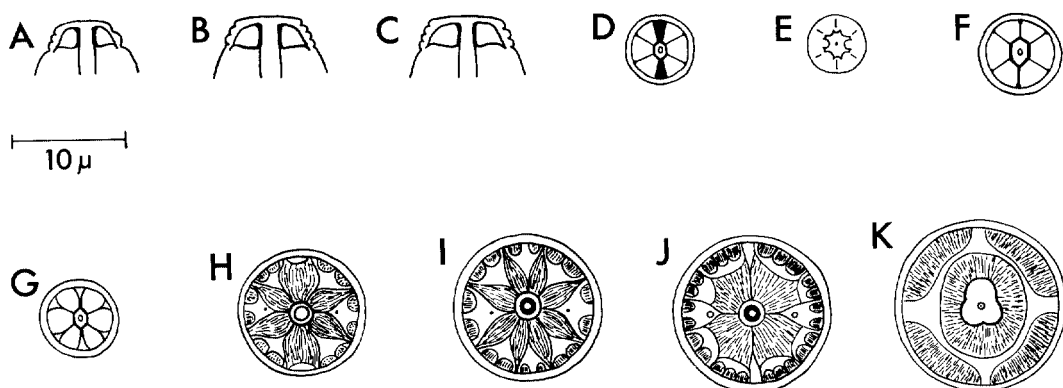


FIG. 2. Variation in number of annules in lip region, cephalic framework, and serial cross sections through stylet protractor muscles. A. *P. coffeae* with three annules on one side and two annules on the other; B, C. *P. zaeae* and *P. vulnus*, respectively, with three annules on one side and four annules on the other; D. Cephalic framework in *P. zaeae*; E-K. Serial cross sections of *P. brachyurus*; E. Anterior end of vestibule; F. Cephalic framework; G. Base of cephalic framework; H. Six protractor muscles in region of vestibule extension; I. Eight protractor muscles at joint of stylet shaft and conical part; J. Four protractor muscles at level of one of the two guiding sheath rings; K. Protractor muscles forming one solid ring at level of stylet knobs.

The lateral field may exhibit five incisures, when an additional incisure, which may be straight or slightly wavy, continuous or broken at intervals, is present in the center of the middle band (Fig. 1-G, H). Six incisures may occur when the outer or inner incisures are doubled. When the outer incisures are doubled, they are usually continuous (Fig. 1-I). When the inner incisures are doubled, they may be continuous (Fig. 1-J, L), or broken at intervals with their ends bent outward or inward (Fig. 1-K). Occasionally, short striae may cross diagonally through the center band (Fig. 1-M). The lateral field may exhibit four doubled incisures making a total of eight incisures (Fig. 1-N). These incisures are generally straight and continuous, but the innermost may be broken or bent occasionally.

All above modifications were observed in each of the six species studied, except the two modifications characterized by straight rows of punctations in the outer bands and short diagonal lines in the center, or by punctations

scattered in the outer bands, which were present only in *P. penetrans* and *P. coffeae*, respectively.

Structures Associated with the Cuticle (excluding lip region).—Deirids were not observed in any of these species. The excretory pore is located ventrally near the esophago-intestinal junction. The excretory duct has a cuticularized thickening about $5\ \mu$ from the pore (Fig. 1-O). In some specimens the duct is visible up to the middle of the body where it may join the excretory canal. The hemizonid is two to three annules long and is generally conspicuous. It is usually located directly in front of the excretory pore (Fig. 1-O) but was observed three annules in front of the excretory pore in one specimen of *P. penetrans* and five annules in front of the excretory pore in one specimen of *P. brachyurus* (Godfrey) Filipjev & Schuurmans Stekhoven. The hemizonion, which is one to one and a half annules long, was visible only in very few specimens, and was located about 10 annules behind the excre-

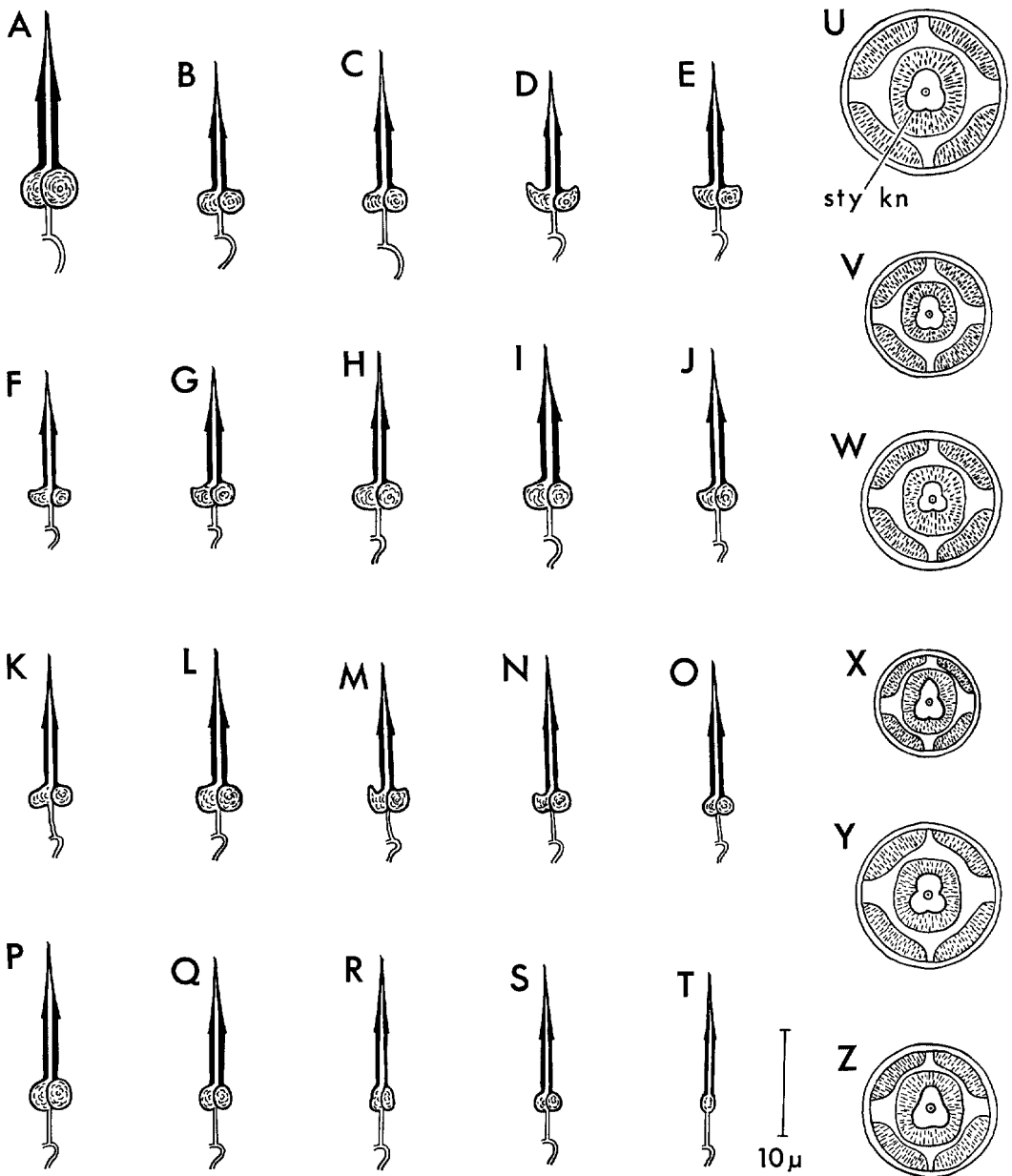


FIG. 3. Variation in shape of stylet knobs. A. *P. brachyurus*; B. *P. scribneri*; C. *P. vulnus*; D-G. *P. zaeae*; H-O. *P. penetrans*, H-M. Female, N, O. Male; P-T *P. coffeae*, P-R. Female, S, T. Male; U-Z. Cross sections through knobs, U. *P. brachyurus*, V. *P. scribneri*, W. *P. vulnus*, X. *P. zaeae*, Y. *P. penetrans*, Z. *P. coffeae*

tory pore. The phasmids are slightly posteriad of the middle of the tail.

Lip Region.—In *P. brachyurus* and *P. scribneri* Steiner, the lip region is distinctly set off from the body. It is slightly set off in *P. coffeae* and in *P. penetrans* and continuous with the body contour in *P. vulnus* Allen & Jensen and *P. zaeae* Graham. The number of annules in the lip region varies both within and between the species. Among species characterized by two annules in the lip region such as *P. brachyurus*, *P. scribneri* and *P. coffeae*, individuals were also found with two annules on one side and three annules on the other (Fig. 2-A), and some specimens of *P. scribneri* even had three annules throughout the lip region. Some specimens of *P. zaeae*, which usually has three lip annules, exhibited three annules on one side and four annules on the other (Fig. 2-B). *P. vulnus*, characterized by three or four annules in circumference, also had individuals with three annules on one side and four on the other (Fig. 2-C). On the other hand, all specimens of *P. penetrans* possessed three annules in the lip region.

Lips, Amphids, Cephalic Framework.—In *en face* views, six thin, transparent lips are visible. The lateral lips are slightly larger than the subventral ones, and no labial papillae are detectable. The amphidial apertures are located in the middle of the lateral lips and the ducts are traceable to the pouches located in the region of the stylet shaft. The hexaradiate cephalic framework extends the height of the lip region and is strongly sclerotized (Fig. 2-F). In *P. zaeae*, the dorsal and ventral blades of the framework are thicker than the sublateral blades (Fig. 2-D). In *P. brachyurus*, the anterior end of the heavily walled, hexagonal vestibule is refractively "ornamented" (Fig. 2-E). This "ornamentation" is less pronounced in *P. penetrans* and *P. coffeae* and absent in *P. scribneri*, *P. zaeae*, and *P. vulnus*. The less sclerotized vestibule

extension ends about the middle of the conical part of the stylet when the latter is not protruded, and connects with a thin sheath that extends posteriad, forming two rings around the middle of the stylet shaft. The sheath and the vestibule extension apparently serve as a guiding apparatus for the stylet.

Stylet.—The shape of the stylet knobs within a species may be stable or may show much variation. *P. brachyurus* (Fig. 3-A, U), *P. scribneri* (Fig. 3-B, V) and *P. vulnus* (Fig. 3-C, W) have little variation in shape. *P. zaeae*, *P. penetrans* and *P. coffeae*, however, exhibit pronounced knob shape variation. *P. zaeae* (Fig. 3-D to G, X) and *P. penetrans* (Fig. 3-H to O, Y) have knobs which vary from more or less rounded to very cup-shaped anteriorly, whereas *P. coffeae* shows a variation from a rounded to a narrow knob type (Fig. 3-P to T, Z). This reduction in knob width is most pronounced in the males (Fig. 3-T).

In *en face* views of all species, the retracting muscles of the stylet originate below the cephalic framework. They appear as six strands attached to the body wall and vestibule extension: one dorsal, one ventral and four sublateral (Fig. 2-H). Near the beginning of the shaft, the dorsal and ventral strands divide, forming two additional strands each, to make a total of eight (Fig. 2-I, 11-D). Just anterior to the stylet knobs, the muscles appear more compact forming four strands (Fig. 2-J). Near the point of attachment at the knobs, the muscles coalesce into one large, solid ring (Fig. 2-K).

Esophagus.—The long esophageal gland lobe overlaps the intestine laterally and ventrally and contains three gland nuclei (Fig. 13-D, G). In a population of *P. zaeae* from North Carolina, the esophageal glands of one specimen overlapped the intestine laterally and dorsally (Fig. 12-E). The dorsal esophageal gland orifice is commonly located 1.8 to 3.6 μ posteriad to the stylet knob base. The

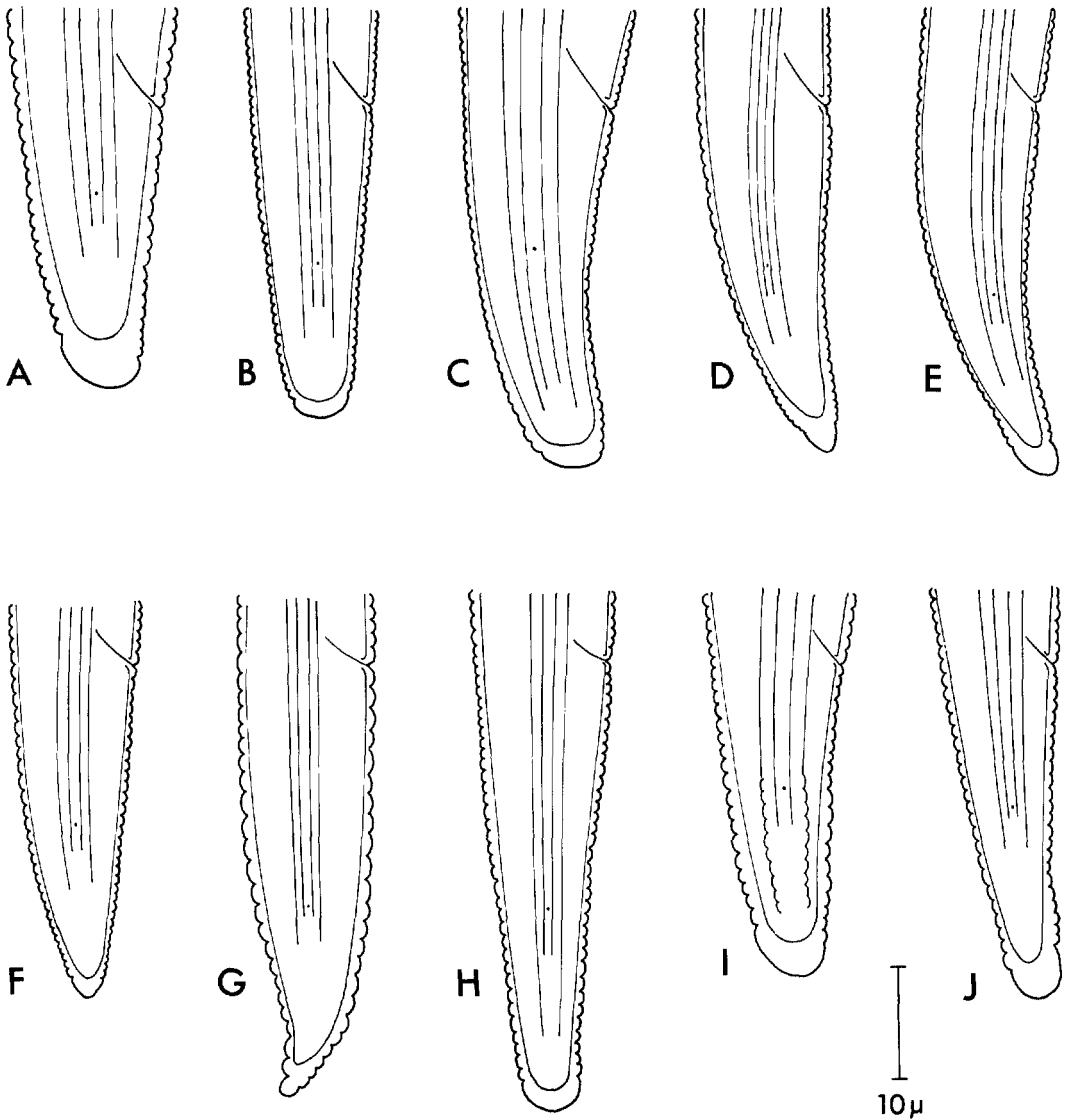


FIG. 4. Variation in shape of tail. A. *P. brachyurus*; B. *P. scribneri*; C. *P. coffeae*; D-H. *P. zaeae*; I, J. *P. penetrans*.

esophago-intestinal junction in the vicinity of the excretory pore appears to be provided with a small valve.

Tail.—The shape of the tail varies within and between the species. The least variation is present in *P. brachyurus* (Fig. 4-A), *P. scribneri* (Fig. 4-B) and *P. coffeae* (Fig. 4-C)

which have broadly rounded, smooth tails. *P. brachyurus* (Fig. 4-A) has a thicker cuticle, and the hyaline portion of the terminus is longer than in the two other species. *P. zaeae*, *P. penetrans*, and *P. vulnus* exhibit a wide variety of tail shapes. Different types of pointed, smooth termini were observed in *P.*

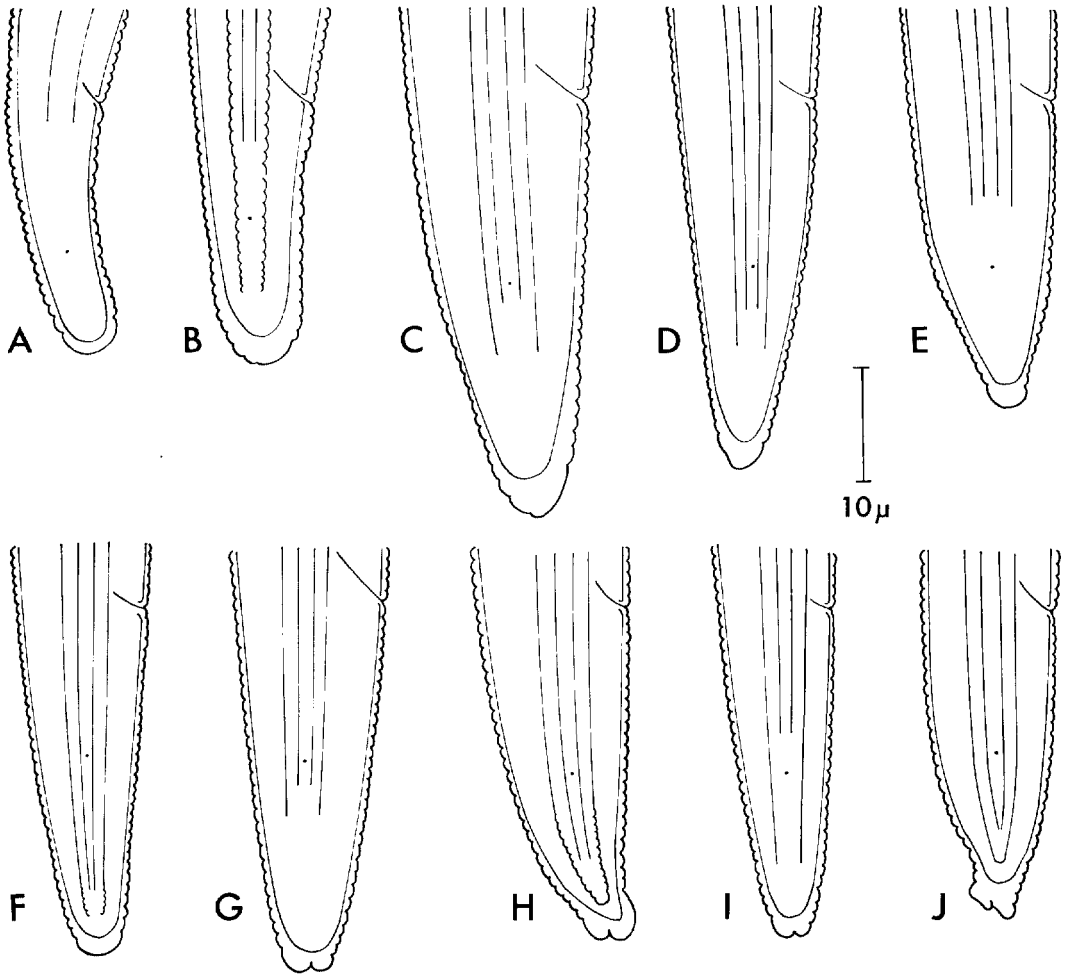


FIG. 5. Variation in shape of tail (continued). A-C. *P. penetrans*; D-J. *P. vulnus*.

zeae (Fig. 4-D to F). One specimen had a pointed, annulated, dorsally curved terminus (Fig. 4-G); another had a rounded, smooth terminus (Fig. 4-H). In *P. penetrans* the tail terminus is more or less rounded and smooth (Figs. 4-I, J; 5-A to C) and the hyaline portion of the terminus is long, but specimens with a short hyaline terminus were also found (Fig. 5-A). The annulation may continue farther down on the dorsal side than on the ventral side (Fig. 5-B, C); however, the annules of this species never extend completely around the terminus. *P. vulnus* tails were the

most variable (Fig. 5-D to J; 6-A, B). Pointed tails (Fig. 5-D), were most common but variations included rounded, smooth (Fig. 5-E, F), annulated (Fig. 5-G to I), truncate (Fig. 5-J; 6 A) and digitate termini (Fig. 6-B).

Reproductive System.—The reproductive system of the adult female consists of a single, anteriorly directed gonad and a postvulvar uterine branch (Fig. 7-A, B). The ovary is typically outstretched and only rarely re-flexed. It is lined with epithelium that terminates in a single apical cap cell. The ovary is shorter in monosexual than in bisexual spe-

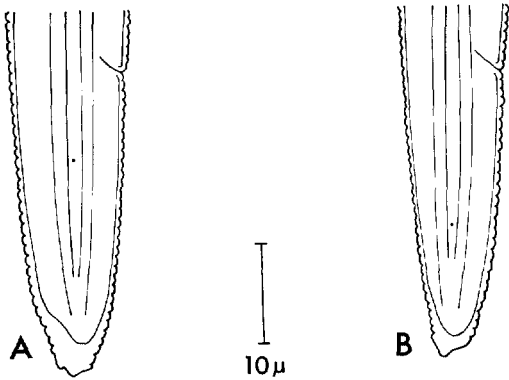


FIG. 6. Variation in shape of tail (continued). A, B. *P. vulnus*.

cies. It is followed by the oviduct which appears as a narrow, folded tube in young females, but is usually obscured by large oocytes in older, actively reproducing females. The oviduct is connected to the spermatheca by a 12-celled constriction. In orcein-stained specimens, the nuclei of these cells appear elongated and deeply stained. The spermatheca in *P. vulnus* is oblong; in *P. penetrans* it is round; and in *P. coffeae* it may be round or oval. In noninseminated females of these species, stained with orcein, the spermatheca is composed of about 10 epithelial cells. In inseminated females, the spermatheca is filled with large, elongated spermatozoa each consisting of a granulated nucleus and a hyaline portion. Spermatozoa are distinctly visible in formalin-preserved specimens, particularly in those with few spermatozoa in the spermatheca (Fig. 7-C). The spermatheca of *P. scribneri*, *P. zae*, and *P. brachyurus* is small and empty and often obscured by a large oocyte. In orcein-stained specimens of *P. scribneri*, the spermatheca is also composed of about 10 epithelial cells. The spermatheca is followed by the uterus which consists of two parts. The distal part is composed of 12 cells arranged in three rows of four cells each (tricolumella). The

proximal part is a short tube lined with flat epithelium. The postvulvar uterine branch is usually short in *P. brachyurus*, *P. zae* and *P. scribneri* (11 to 31 μ), slightly longer in *P. penetrans* and *P. coffeae* (15 to 36 μ), and longest in *P. vulnus* (30 to 48 μ). It is considerably longer, when a vestigial ovary is present. The posterior branch in specimens of *P. zae*, which had a posterior vestigial ovary, measured about 58 μ . This posterior gonad may or may not possess a tricolumella. In contrast, some specimens may have a tricolumella and no vestigial ovary.

Males are monorchic. The testis consists of a multiple row of spermatogonia. The vas deferens is generally filled with spermatozoa and unites ventrally with the cloaca. The slightly arcuate spicules rest on a simple trough-shaped gubernaculum. The caudal alae have crenate edges and enclose the tail tip.

MORPHOMETRIC VARIABILITY OF 20 FEMALE AND MALE CHARACTERS: *Females* (Tables 2, 3, 5).—Body length of all six species overlaps (Tables 2, 3). On the average, *P. vulnus* is the longest, most slender species, whereas *P. scribneri* is the shortest and *P. brachyurus* the stoutest species. Ranges for lip height do not overlap in *P. coffeae* and *P. scribneri* vs. *P. vulnus* and *P. zae*. Also, the ranges of lip width do not overlap between *P. coffeae* and *P. vulnus*. *P. coffeae* has the lowest, most narrow lip region, whereas *P. vulnus* has the highest, widest lip region. *P. brachyurus* has a low and very wide lip region. It also has the longest stylet, and there is no overlap in this character with all other species. *P. brachyurus* also has the highest, widest knobs, whereas in *P. vulnus*, the knobs are very low and relatively narrow. *P. coffeae* has the most narrow knobs of all species. Distance of dorsal gland orifice from stylet knob base does not overlap in *P. scribneri*, which has the shortest distance, vs. *P. vulnus*, *P. coffeae* and *P. brachyurus*. There

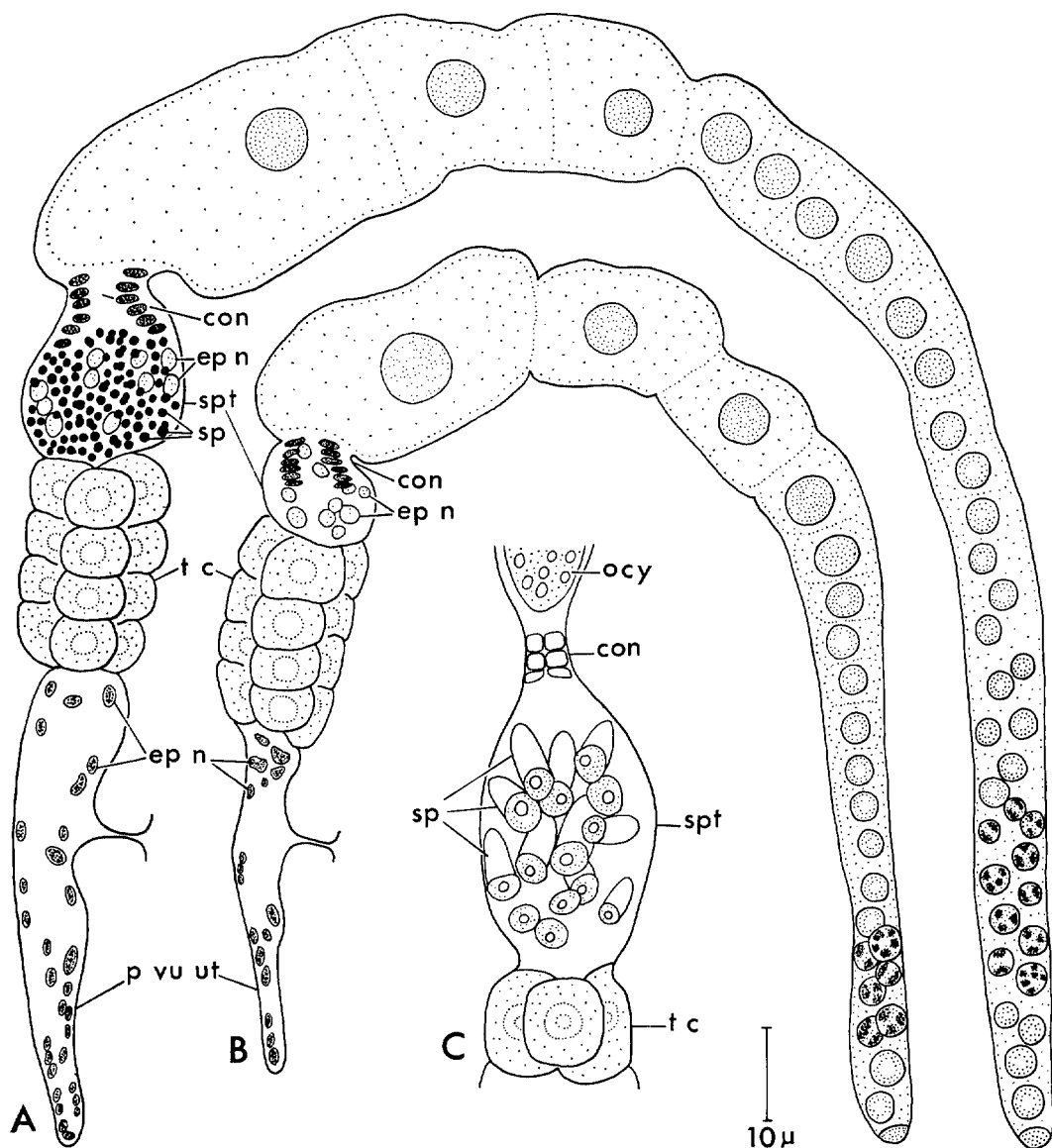


FIG. 7. Adult female reproductive system. A. Reproductive system of *P. coffeae* stained with orcein; B. Reproductive system of *P. scribneri* stained with orcein; C. Spermatheca of *P. vulnus* in formalin-preserved material (gonads are typically straight, but were curved for convenience in illustration).

ABBREVIATIONS FOR FIGURES

con—constriction
ep n—epithelial nuclei
ocy—oocyte
p vu ut—postvulvar uterine branch

sp—spermatozoa
spt—spermatheca
sty kn—stylet knobs
tc—tricollema

is no overlap in esophagus length between *P. vulnus* with the longest and *P. scribneri* with the shortest esophagus. The b ratio is

lowest in *P. brachyurus* and highest in *P. penetrans*. The excretory pore in *P. scribneri* is located farther forward than in all other

TABLE 2. Morphometrics of 25 females each of three bisexual *Pratylenchus* species cultured on callus tissue.

Character	<i>Pratylenchus penetrans</i>					<i>Pratylenchus vulnus</i>					<i>Pratylenchus coffeae</i>				
	Range (μ)	Mean	S.E.m.	C.V. (%)		Range (μ)	Mean	S.E.m.	C.V. (%)		Range (μ)	Mean	S.E.m.	C.V. (%)	
Lip height	1.8– 3.0	2.52	0.060	11.9		2.4– 3.0	2.95	0.033	5.6		1.8– 2.4	2.26	0.052	11.6	
Lip width	7.2– 8.4	7.87	0.072	4.6		7.8– 9.0	8.35	0.084	5.0		6.6– 7.8	7.32	0.060	4.1	
Stylet point	7.2– 7.8	7.63	0.061	3.6		7.2– 7.8	7.27	0.040	2.7		7.2– 7.8	7.32	0.051	3.4	
Stylet shaft	5.4– 6.6	5.96	0.056	4.7		4.8– 6.0	5.33	0.053	4.9		4.8– 6.0	5.59	0.075	6.7	
Sty. kn. ht.	1.8– 3.0	2.42	0.042	8.7		1.8– 2.4	2.28	0.049	10.7		2.4– 3.0	2.57	0.055	10.7	
Sty. kn. wd.	3.6– 5.4	4.30	0.096	11.2		3.0– 4.2	3.82	0.068	8.9		3.0– 4.8	3.77	0.095	12.6	
Stylet	15.0– 16.8	15.96	0.096	2.8		14.4– 15.6	14.88	0.077	2.6		14.4– 16.8	15.47	0.125	3.9	
D. g. o.	1.8– 3.0	2.63	0.099	15.9		3.0– 3.6	3.23	0.062	9.2		2.4– 3.6	2.97	0.048	7.6	
Esophagus	72.8– 88.4	80.10	0.947	5.8		88.0–101.2	93.36	0.683	3.7		77.6– 96.8	86.97	0.893	5.1	
Ex. pore	79.2– 95.6	87.70	0.994	5.4		83.6– 99.6	91.98	0.876	4.7		81.0–104.0	87.46	1.013	5.8	
Body width	18.0– 28.2	21.71	0.538	12.4		16.8– 27.0	20.21	0.506	12.5		19.2– 27.0	22.48	0.481	10.7	
Vulva	415.3–534.9	455.53	6.404	7.0		425.5–578.0	504.21	6.402	6.3		400.0–569.2	469.00	8.544	9.1	
Vu. an. dist.	63.6– 88.4	75.47	1.612	10.7		79.2–111.2	92.29	1.884	10.2		72.4–116.0	91.50	2.298	12.5	
Tail	25.2– 40.8	31.30	0.792	12.6		27.0– 36.0	31.90	0.526	8.2		27.0– 38.4	32.45	0.515	7.9	
Phasmid	13.8– 20.4	16.81	0.447	11.6		13.2– 22.8	16.42	0.445	13.5		12.0– 20.4	15.67	0.433	13.8	
Length	511.3–658.0	562.30	7.826	6.9		537.3–708.8	628.76	7.275	5.8		516.4–721.2	592.67	10.538	8.9	
a (ratio)	21.7– 31.0	26.13	0.496	9.5		25.2– 35.8	31.32	0.541	8.6		20.1– 33.7	26.31	0.567	10.8	
b (ratio)	5.8– 8.1	7.00	0.111	7.7		5.7– 7.7	6.74	0.089	6.6		5.2– 7.5	6.69	0.120	8.9	
c (ratio)	14.0– 22.5	18.10	0.389	10.7		17.4– 24.3	19.89	0.348	8.7		14.9– 20.8	18.19	0.319	8.8	
Vulva (%)	77.0– 83.0	80.60	0.231	1.4		77.0– 82.0	79.52	0.295	1.8		74.0– 79.0	78.60	0.370	2.3	

ABBREVIATIONS FOR TABLES

D. g. o.—dorsal gland orifice
 Ex. pore—excretory pore
 Sty. kn. ht.—stylet knob height
 Sty. kn. wd.—stylet knob width
 Vu. an. dist.—vulva-anus distance

TABLE 3. Morphometrics of 50 females each of three monosexual *Pratylenchus* species cultured on callus tissue.

Character	<i>Pratylenchus scribneri</i>					<i>Pratylenchus zeae</i>					<i>Pratylenchus brachyurus</i>				
	Range (μ)	Mean	S.E.m.	C.V. (%)		Range (μ)	Mean	S.E.m.	C.V. (%)		Range (μ)	Mean	S.E.m.	C.V. (%)	
Lip height	1.8- 2.4	2.28	0.034	10.6		2.4- 3.0	2.45	0.023	6.7		1.8- 2.7	2.39	0.015	4.4	
Lip width	7.2- 7.8	7.76	0.020	1.8		7.2- 8.4	7.81	0.032	2.9		7.2- 9.0	8.38	0.042	3.5	
Stylet point	6.6- 7.8	7.16	0.055	4.5		6.6- 7.8	7.18	0.030	2.7		7.2- 8.4	7.67	0.039	3.6	
Stylet shaft	5.4- 6.0	5.45	0.022	2.8		4.8- 6.6	5.94	0.035	4.2		6.0- 7.8	7.14	0.046	4.6	
Sty. kn. ht.	2.4- 3.0	2.42	0.017	4.9		1.8- 3.0	2.52	0.038	10.7		3.0- 3.6	3.45	0.098	8.0	
Sty. kn. wd.	4.2- 4.8	4.52	0.043	6.7		4.2- 5.4	4.75	0.038	5.6		3.6- 5.4	4.74	0.047	6.3	
Stylet	14.4- 16.8	15.03	0.059	2.3		13.6- 16.6	15.50	0.076	3.2		17.4- 19.2	18.36	0.068	2.6	
D. g. o.	1.8- 2.4	2.15	0.042	13.8		1.8- 3.0	2.38	0.036	9.2		2.4- 3.0	2.70	0.045	11.2	
Esophagus	70.0- 87.2	79.10	0.528	4.7		68.0- 98.0	81.90	0.897	7.7		73.6-104.0	92.46	0.728	5.6	
Ex. pore	74.0- 86.0	80.88	0.447	3.9		74.8-104.4	88.14	0.921	7.4		79.2-113.2	99.25	0.997	7.1	
Body width	16.8- 23.4	19.30	0.211	7.7		16.2- 24.0	19.80	0.339	12.1		19.8- 28.8	24.92	0.315	8.9	
Vulva	338.4-433.8	393.18	2.492	4.5		341.5-444.6	385.68	3.949	7.2		320.6-569.2	484.68	6.820	9.9	
Vu. an. dist.	57.6-100.4	84.19	1.081	9.0		99.2-148.0	118.43	1.503	8.9		39.0- 64.2	50.57	0.718	10.0	
Tail	24.0- 30.6	27.33	0.221	5.7		24.0- 40.2	35.57	0.436	8.6		25.2- 37.8	31.56	0.332	7.4	
Phasmid	12.0- 18.0	15.51	0.253	9.2		16.2- 22.2	19.16	0.258	8.5		7.8- 19.2	14.46	0.337	14.5	
Length	436.8-553.2	504.43	3.290	4.6		463.1-657.2	540.10	5.400	7.0		398.6-656.0	567.81	7.541	9.4	
a (ratio)	21.4- 29.0	26.30	0.224	5.9		20.5- 32.8	27.19	0.357	9.2		15.4- 26.4	22.83	0.346	10.7	
b (ratio)	5.7- 7.0	6.32	0.045	5.0		5.5- 7.9	6.53	0.068	7.3		5.5- 7.0	6.09	0.082	9.5	
c (ratio)	16.9- 20.6	18.43	0.110	4.2		13.0- 17.7	15.22	0.186	8.5		14.1- 21.5	17.96	0.228	9.0	
Vulva (%)	75.0- 82.0	77.39	0.169	1.5		69.0- 75.0	70.94	0.153	1.5		80.0- 87.0	84.82	0.197	1.6	

TABLE 4. Morphometrics of 25 males each of three bisexual *Pratylenchus* species cultured on callus tissue.

Character	<i>Pratylenchus penetrans</i>				<i>Pratylenchus vulnus</i>				<i>Pratylenchus coffeae</i>			
	Range (μ)	Mean	S.E.m.	C.V. (%)	Range (μ)	Mean	S.E.m.	C.V. (%)	Range (μ)	Mean	S.E.m.	C.V. (%)
Lip height	2.4- 3.0	2.51	0.045	9.0	2.4- 3.0	2.93	0.040	6.8	1.8- 2.4	2.21	0.057	12.9
Lip width	7.2- 7.8	7.51	0.061	4.1	6.6- 7.8	7.24	0.045	3.1	6.0- 7.2	6.41	0.067	5.2
Stylet point	7.2- 8.4	7.58	0.074	4.6	6.6- 7.2	6.77	0.055	4.1	6.6- 7.2	7.15	0.033	2.3
Stylet shaft	5.4- 7.2	6.02	0.073	6.1	4.8- 5.4	5.21	0.057	5.5	4.8- 6.0	5.28	0.060	5.7
Sty. kn. ht.	1.8- 2.4	2.06	0.061	14.7	1.8- 2.4	1.85	0.033	9.0	1.8- 2.4	1.92	0.049	12.7
Sty. kn. wd.	3.0- 4.2	3.66	0.049	6.7	3.0- 3.6	3.19	0.057	8.9	1.8- 3.0	2.69	0.078	14.6
Stylet	14.4- 17.4	15.68	0.133	4.0	13.2- 14.4	13.82	0.065	2.3	13.8- 15.6	14.35	0.084	2.9
D. g. o.	2.4- 3.0	2.78	0.068	10.7	2.4- 3.6	3.50	0.057	8.1	3.0- 3.6	3.19	0.061	9.0
Esophagus	72.0- 93.2	81.22	1.086	6.7	82.4- 95.2	88.13	0.672	3.8	72.8- 92.8	80.61	0.949	5.9
Ex. pore	74.8- 94.4	85.03	0.962	5.5	75.2- 94.8	81.94	0.888	5.4	70.0- 90.0	78.16	0.989	6.3
Body width	17.4- 24.6	19.38	0.352	9.1	15.0- 18.0	16.58	0.227	6.8	16.0- 22.8	18.64	0.362	9.7
Tail	22.2- 31.8	26.95	0.485	9.0	23.0- 31.2	27.30	0.456	8.3	22.8- 33.0	26.50	0.493	9.3
Phasmid	11.4- 19.2	13.58	0.357	13.2	9.0- 15.0	12.58	0.364	14.4	9.6- 15.0	12.82	0.323	12.6
Spicules	13.8- 19.2	16.34	0.271	8.3	13.8- 16.2	15.46	0.135	4.4	15.0- 18.0	16.22	0.255	7.7
Gubernaculum	4.2- 6.0	5.16	0.105	9.7	4.2- 6.0	5.04	0.110	9.8	4.2- 6.0	4.69	0.116	11.6
Length	498.0-661.5	545.43	6.972	6.4	475.1-592.1	538.21	6.067	5.6	430.7-600.0	516.81	7.919	7.7
a (ratio)	24.3- 36.7	28.02	0.513	9.2	29.9- 36.3	32.44	0.312	4.8	23.5- 32.2	27.82	0.485	8.7
b (ratio)	5.9- 7.1	6.70	0.810	6.0	5.6- 6.7	6.05	0.055	4.5	5.1- 7.0	6.37	0.084	6.6
c (ratio)	16.6- 23.9	20.34	0.344	8.4	17.7- 22.3	19.75	0.223	5.6	17.1- 23.0	19.51	0.288	7.4
Testis (%)	29.0- 56.0	38.84	1.415	15.9	36.0- 54.0	45.08	1.028	11.2	36.0- 68.0	51.36	1.548	15.1

TABLE 5. Morphometrics of 25 females of *Pratylenchus vulnus* from greenhouse cultures.

Character	Range (μ)	Mean	S.E.m.	C.V. (%)
Lip height	2.4— 3.6	3.02	0.042	7.0
Lip width	7.8— 9.0	8.66	0.070	4.0
Stylet point	7.2— 7.8	7.30	0.048	3.2
Stylet shaft	5.4— 6.0	5.50	0.045	4.1
Sty. kn. ht.	1.8— 2.4	2.38	0.024	5.0
Sty. kn. wd.	3.0— 4.2	3.84	0.077	10.1
Stylet	14.4— 15.6	15.18	0.070	2.2
D. g. o.	2.4— 3.6	3.02	0.044	7.1
Esophagus	86.0—104.0	93.57	0.988	5.3
Ex. pore	86.0—109.2	98.21	1.382	7.0
Body width	18.0— 30.0	22.42	0.564	12.6
Vulva	425.5—574.4	529.03	6.926	6.5
Vu. an. dist.	80.0—133.6	98.29	2.426	12.3
Tail	25.2— 36.0	30.54	0.524	8.6
Phasmid	12.0— 20.0	14.72	0.346	11.8
Length	562.5—741.0	655.68	8.766	6.7
a (ratio)	18.7— 39.1	30.02	0.749	12.5
b (ratio)	5.8— 7.7	6.96	0.095	6.8
c (ratio)	17.0— 25.1	21.51	0.334	7.8
Vulva (%)	75.0— 83.0	80.16	0.373	2.3

TABLE 6. Morphometrics of 25 males of *Pratylenchus vulnus* from greenhouse cultures.

Character	Range (μ)	Mean	S.E.m.	C.V. (%)
Lip height	2.4— 3.0	2.86	0.052	9.1
Lip width	7.2— 7.8	7.34	0.052	3.6
Stylet point	6.6— 7.2	7.03	0.055	3.9
Stylet shaft	4.8— 5.4	5.16	0.060	5.8
Sty. kn. ht.	1.2— 1.8	1.78	0.024	6.7
Sty. kn. wd.	3.0— 3.6	3.12	0.049	7.8
Stylet	13.2— 14.4	13.97	0.074	2.6
D. g. o.	3.0— 3.6	3.27	0.062	9.3
Esophagus	74.8— 94.0	85.44	0.948	5.5
Ex. pore	76.8— 93.6	82.77	0.854	5.2
Body width	14.4— 19.8	16.34	0.246	7.5
Tail	21.0— 30.0	24.75	0.469	9.5
Phasmid	7.2— 13.8	9.94	0.286	14.4
Spicules	15.0— 18.0	15.73	0.181	5.5
Gubernaculum	4.2— 6.0	4.88	0.120	11.6
Length	489.3—602.8	545.77	5.890	5.4
a (ratio)	29.0— 37.7	33.44	0.447	6.7
b (ratio)	5.7— 7.1	6.36	0.091	7.2
c (ratio)	19.4— 25.1	22.13	0.333	7.5
Testis (%)	36.0— 65.0	49.39	1.466	14.2

species. No overlap occurs in vulva percent between *P. zae* and *P. brachyurus*, as well as *P. scribneri* and *P. zae*. Vulva-anus distance also does not overlap in *P. brachyurus* vs. *P. zae*, *P. coffeae* and *P. vulnus*. Tail lengths of all species overlap. *P. scribneri* has the shortest tail, *P. zae* the longest with the lowest c value, whereas the c value is highest in *P. vulnus*.

A comparison of the coefficients of variability of all female characters studied shows that vulva percent and stylet length are the least variable (Tables 2, 3). Vulva percent varies from 1.4% in *P. penetrans* to 2.3% in *P. coffeae*. Stylet length varies from 2.3% in *P. scribneri* to 3.9% in *P. coffeae*. All other characters, including those commonly used in nematode taxonomy, such as body length, a, b and c ratios, and distance of dorsal gland orifice from base of stylet knobs, have relatively high coefficients of variability.

The means of all characters for females of *P. vulnus* from greenhouse cultures (Table 5) are in general slightly higher than those of

specimens from callus cultures (Table 2). Thirteen of the 20 female characters measured, also have a higher coefficient of variability in specimens from greenhouse cultures than in those from callus cultures. In contrast to this, the stylet knob height shows greater variation in females from callus cultures (C.V. = 10.7%) than from greenhouse cultures (C.V. = 5.0%).

Males (Tables 4, 6).—Body length of males of the three bisexual species overlaps (Table 4). Males of *P. penetrans* are longer than those of *P. coffeae* and *P. vulnus* which has the most slender males. As in the females, males of *P. coffeae* have the lowest, most narrow lip region. Ranges of lip width do not overlap in *P. coffeae* and *P. penetrans*. *P. vulnus* has the shortest stylet with the lowest knobs, whereas *P. penetrans* has the longest stylet with the largest knobs in respect to height and width. In *P. coffeae*, the knobs are drastically reduced in width. No overlap occurs in dorsal gland orifice distance between *P. penetrans* and *P. coffeae*. *P. vulnus*

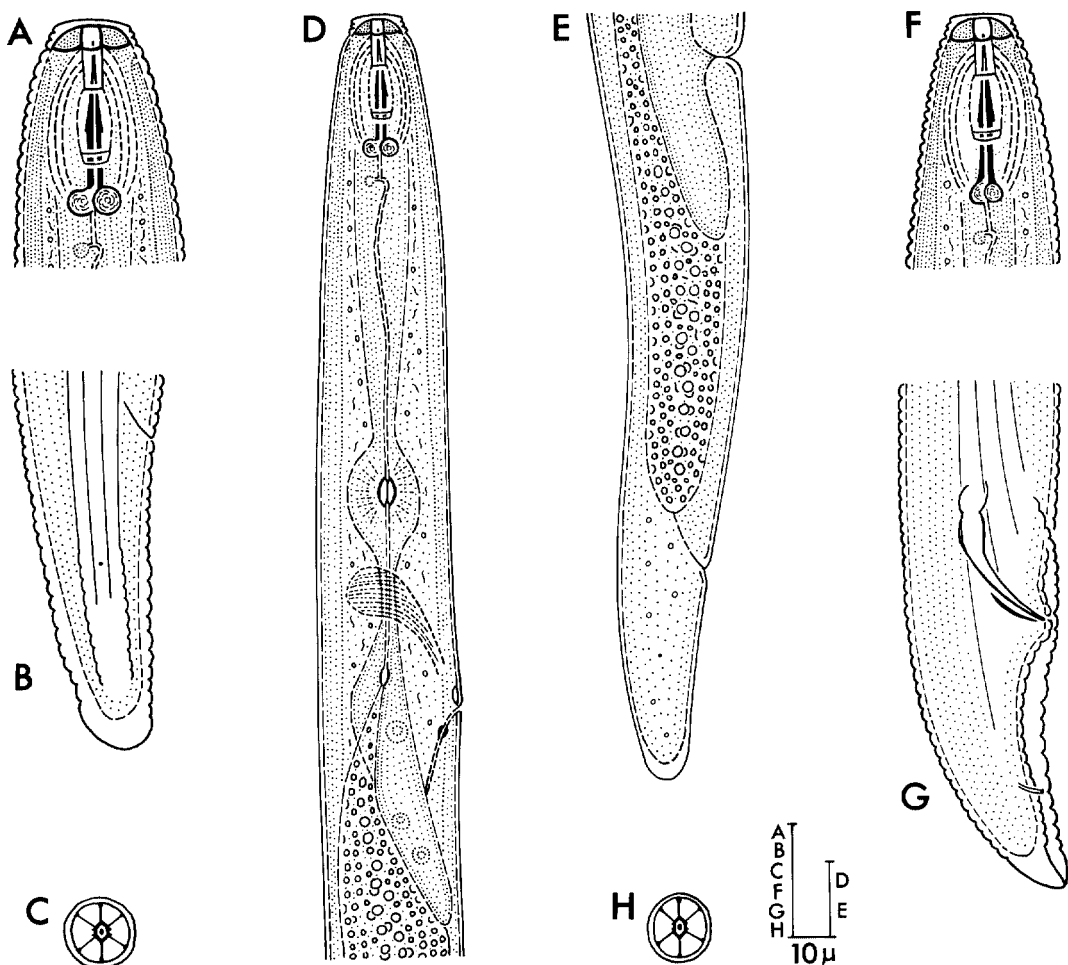


FIG. 8. *Pratylenchus penetrans*. A-E. Female, A. Head, B. Tail, C. Cephalic framework, D. Esophagus, E. Posterior region; F-H. Male, F. Head, G. Tail, H. Cephalic framework.

has the longest esophagus and lowest b ratio. Average tail length as well as c values are the same in all three species. *P. penetrans* has slightly larger spicules than *P. coffeae* and *P. vulnus*, whereas ranges and means of gubernacula are the same in all three species.

Coefficients of variability of all male characters studied show similar trends as in females (Table 4). The stylet is the least variable character with a coefficient of vari-

ability ranging from 2.3% in *P. vulnus* to 4.0% in *P. penetrans*.

The means of some male characters of *P. vulnus* from greenhouse cultures (Table 6) are slightly higher, but others are slightly lower than those of specimens from callus cultures (Table 4). Fourteen of the 20 male characters have higher coefficients of variability in specimens from greenhouse cultures than in those from callus cultures.

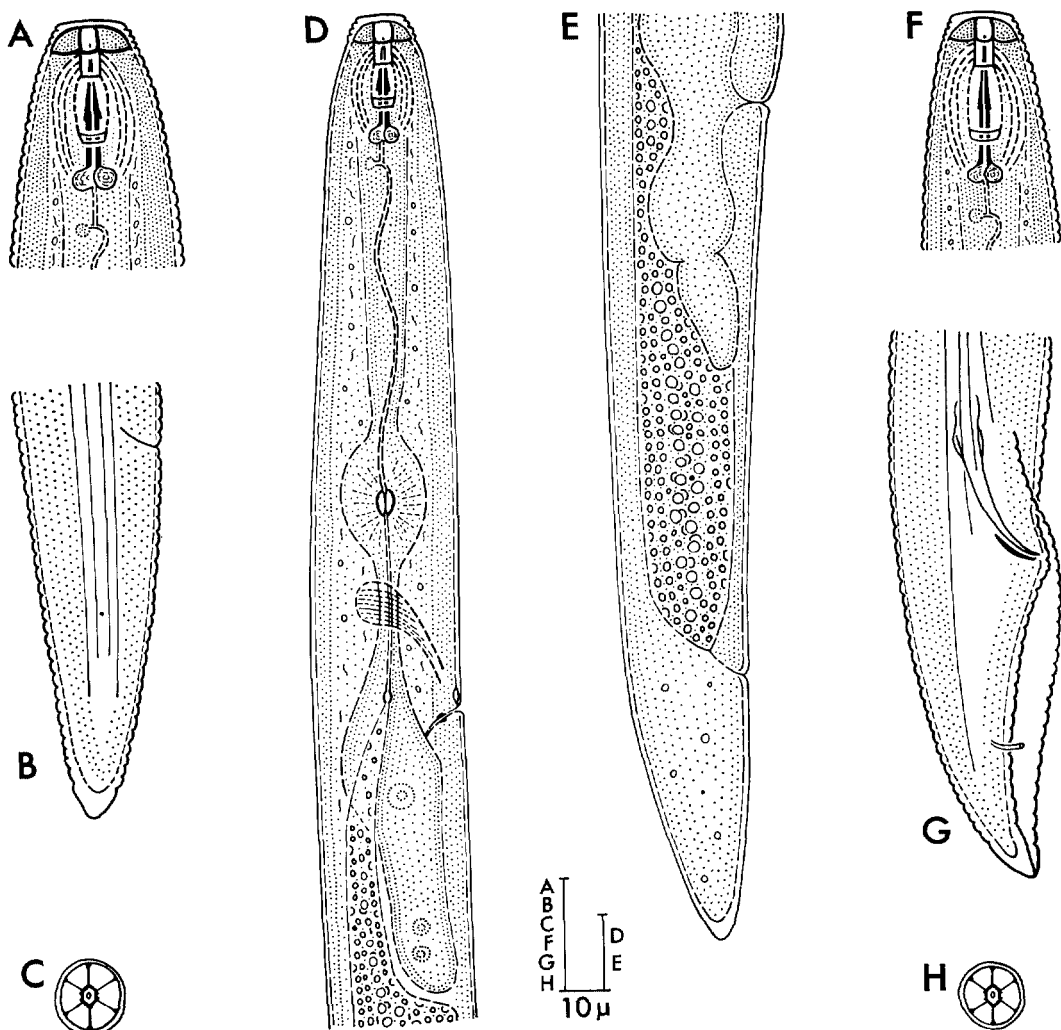


FIG. 9. *Pratylenchus vulnus*. A-E. Female, A. Head, B. Tail, C. Cephalic framework, D. Esophagus, E. Posterior region; F-H. Male, F. Head, G. Tail, H. Cephalic framework.

CHARACTERIZATION OF SPECIES:

Pratylenchus penetrans

(Cobb, 1917) Filipjev & Schuurmans
Stekhoven, 1941

(Fig. 8-A to H; Tables 2, 4)

Females.—Lateral field often marked by four incisures, but may exhibit all variations described above. Some specimens with straight rows of punctations in center of outer bands, in addition to diagonal lines in inner

band (Fig. 1-E). Lip region slightly set off from body, bearing three annules. Anterior end of vestibule with slight refractive “ornamentation.” Stylet knobs varying from rounded to anteriorly concave (Fig. 3-H to M). Glandular lobe of esophagus overlapping anterior end of intestine ventrally and slightly laterally. Hemizonid two to three annules long, located immediately in front, or up to three annules in front of excretory pore.

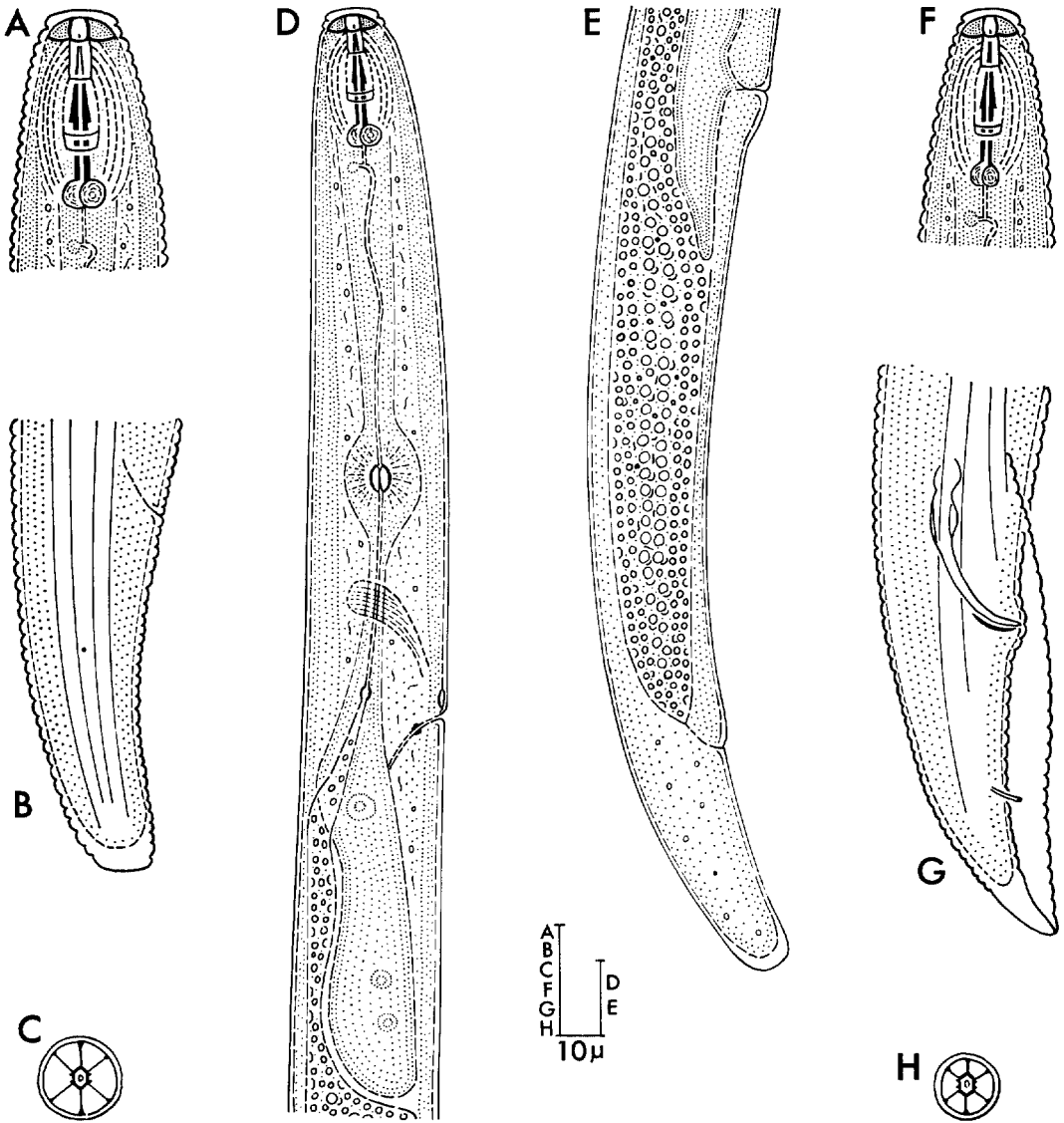


FIG. 10. *Pratylenchus coffeae*. A–E. Female, A. Head, B. Tail, C. Cephalic framework, D. Esophagus, E. Posterior region; F–H. Male, F. Head, G. Tail, H. Cephalic framework.

Gonad measuring 139.6 to 234.0 μ ($n = 19$). Spermatheca rounded, usually containing spermatozoa. Postvulvar uterine branch 15.0 to 36.0 μ ($n = 20$) long. Tail variable in shape (Figs. 4-I, J; 5-A to C), annulations not extending completely around terminus.

Males.—Similar to females. Stylet knobs variable in shape (Fig. 3-N, O). Hemizonid two to three annules long, located immediately in front, or up to two annules in front of excretory pore. Gonad 165.0 to 336.5 μ ($n = 19$) long.

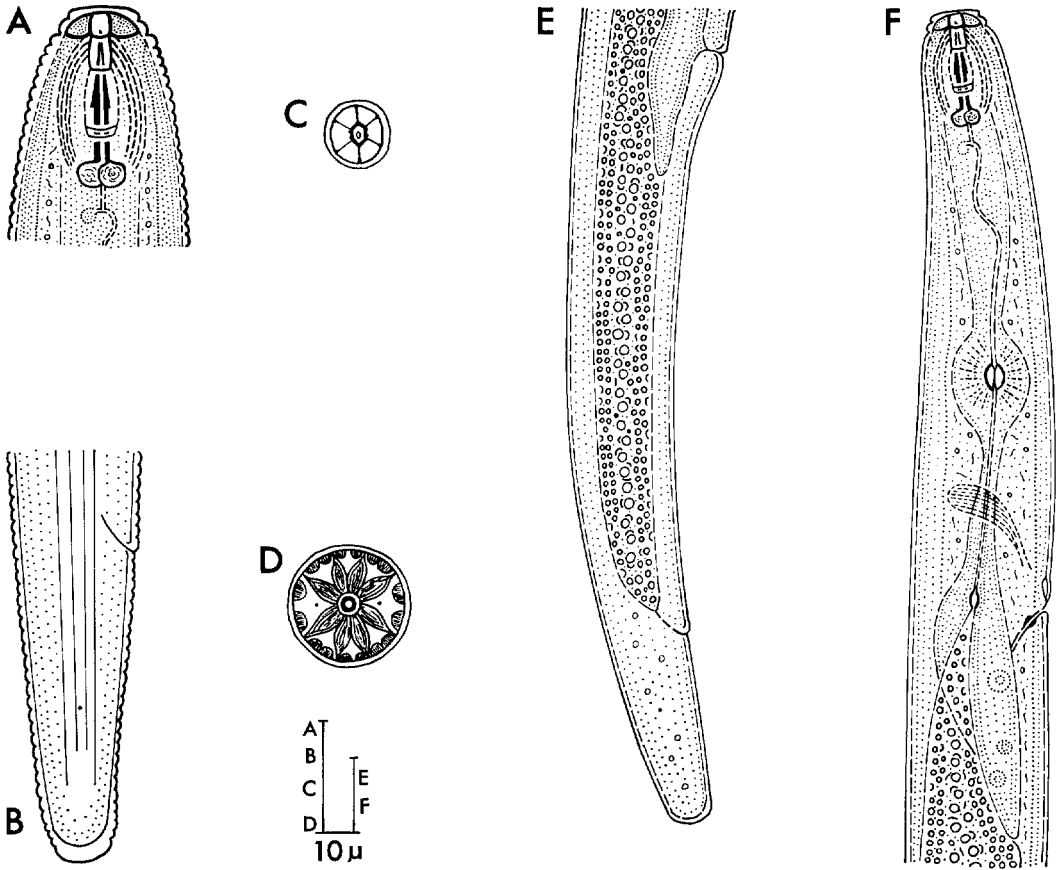


FIG. 11. *Pratylenchus scribneri*. A-F. Female, A. Head, B. Tail, C. Cephalic framework, D. Cross section at level of junction of stylet shaft and conical part, E. Posterior region, F. Esophagus.

Pratylenchus vulnus

Allen & Jensen, 1951

(Fig. 9-A to H; Tables 2, 4, 5, 6)

Females.—Lateral field often marked by four incisures, but may exhibit variations. Lip region continuous with body contour, marked by three to four annules, commonly with three annules on one side and four annules on the other (Fig. 2-C). Refractive “ornamentation” of terminal end of vestibule lacking. Stylet knobs rounded with little variation in shape (Fig. 3-C). Glandular lobe of esophagus overlapping anterior end of intestine ventrally and slightly laterally. Hemi-

zonid two to three annules long, located immediately, or one annule in front of excretory pore. Gonad 166.8 to 326.1 μ ($n = 18$) long. Spermatheca oblong, usually containing spermatozoa. Postvulvar uterine branch 30.0 to 48.0 μ ($n = 21$) long. No oogonia observed in posterior branch. Tail often pointed, but exhibiting pronounced variation (Figs. 5-D to J; 6-A, B). Annulations may extend around terminus (Fig. 5-G to J).

Males.—Similar to females. Stylet knobs rounded. Hemizonid located immediately, or one annule in front of excretory pore. Gonad 184.6 to 320.0 μ ($n = 24$) long.

Pratylenchus coffeae

(Zimmermann, 1898)

Filipjev & Schuurmans Stekhoven, 1941

(Fig. 10-A to H; Tables 2, 4)

Females.—Lateral field often marked by four incisures, but may exhibit variations. Some specimens with punctations scattered in outer bands (Fig. 1-F). Lip region slightly set off from body, bearing two annules. Some specimens with two annules on one side and three annules on the other (Fig. 2-A). Anterior end of vestibule with slight refractive "ornamentation." Stylet knobs round to oblong (Fig. 3-P to R), showing much reduction in width in some specimens. Glandular lobe of esophagus overlapping anterior end of intestine ventrally and slightly laterally. Hemizonid two to three annules long, located immediately in front of excretory pore. Gonad 108.0 to 313.2 μ ($n = 24$) long. Spermatheca oval to round, usually containing spermatozoa. Postvulvar uterine branch 18.0 to 36.0 μ ($n = 23$) long. Tail terminus rounded and smooth, little variation in shape.

Males.—Similar to females. Stylet knobs variable in shape (Fig. 3-S, T), frequently showing considerable reduction in width (Fig. 3-T). Hemizonid two to three annules long, located immediately, or one annule in front of excretory pore. Gonad measuring 186.0 to 356.0 μ ($n = 25$).

Pratylenchus scribneri

Steiner, 1943

(Fig. 11-A to F; Table 3)

Females.—Lateral field often marked by four incisures, but may exhibit variations. Lip region set off from body, bearing two, occasionally three annules; basal annule higher than first annule. Some specimens with two annules on one side and three on the other. Refractive "ornamentation" of terminal end of vestibule lacking. Stylet knobs almost rounded, little variation in shape (Fig. 3-B). Glandular lobe of esophagus overlapping an-

terior end of intestine ventrally and slightly laterally. Hemizonid two to three annules long, located immediately, or one annule in front of excretory pore. Gonad 99.2 to 227.6 μ ($n = 42$) long, with small, empty spermatheca. Postvulvar uterine branch 13.8 to 31.2 μ ($n = 42$) long. Tail terminus rounded and smooth, little variation in shape.

Males.—Not found.

Pratylenchus zeae

Graham, 1951

(Fig. 12-A to F; Table 3)

Females.—Lateral field often marked by four incisures, but may exhibit variations. Lip region continuous with body contour, generally bearing three annules, but occasionally three on one side and four on the other (Fig. 2-B). Refractive "ornamentation" of terminal end of vestibule lacking. Median blades of cephalic framework thicker than sublateral blades (Fig. 2-D). Stylet knobs varying from rounded to anteriorly concave (Fig. 3-D to G). Glandular lobe of esophagus overlapping anterior part of intestine ventrally and slightly laterally. One specimen with aberrant type of esophagus: glandular lobe overlapping intestine dorsally and laterally (Fig. 12-E). Hemizonid two to three annules long, located immediately, or one annule in front of excretory pore. Gonad measuring 96.0 to 252.0 μ ($n = 46$), with small, empty spermatheca. Postvulvar uterine branch 21.0 to 31.2 μ ($n = 32$) long. Oogonia observed in posterior branch. Tail generally pointed, but may exhibit much variation (Fig. 4-D to H).

Males.—Not found.

Pratylenchus brachyurus

(Godfrey, 1929)

Filipjev & Schuurmans Stekhoven, 1941

(Fig. 13-A to G; Table 3)

Females.—Lateral field often marked by

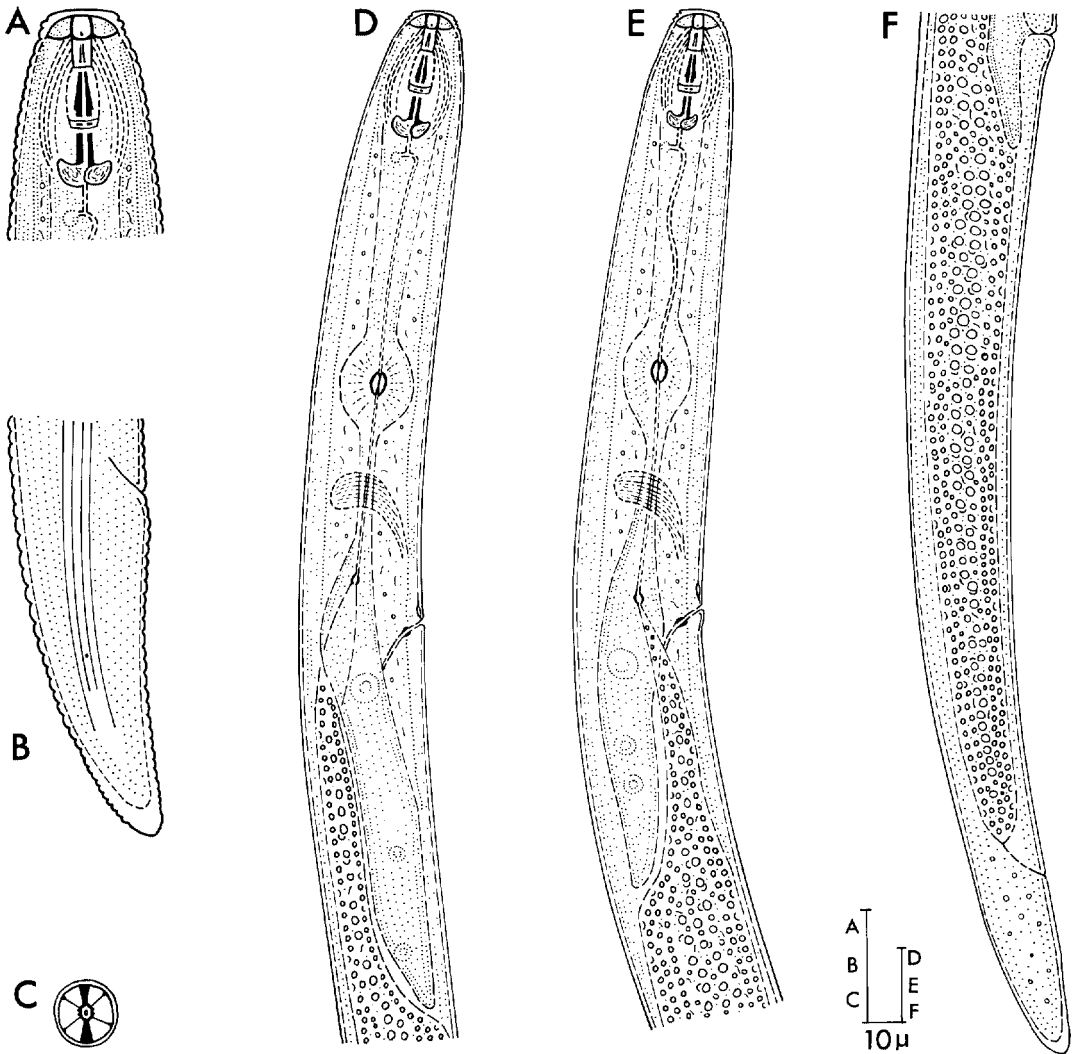


FIG. 12. *Pratylenchus zeae*. A-F. Female, A. Head, B. Tail, C. Cephalic framework, D. Normal esophagus overlapping intestine laterally and ventrally, E. Aberrant esophagus overlapping intestine laterally and dorsally, F. Posterior region.

four incisures, but may exhibit variations. Lip region set off from body, generally bearing two annules, occasionally with two annules on one side and three on the other. Angular shape of lip region not always distinct, depending on orientation of mounted specimen. Anterior end of vestibule in *en face* view with pronounced refractive “orna-

mentation” (Fig. 2-E). Stylet knobs rounded, little variation in shape (Fig. 3-A). Glandular lobe of esophagus overlapping anterior end of intestine ventrally and slightly laterally. Hemizonid two to three annules long, located one to five annules in front of excretory pore. Gonad measuring 100.8 to 277.2 μ ($n = 46$), with small, empty spermatheca. Postvulvar

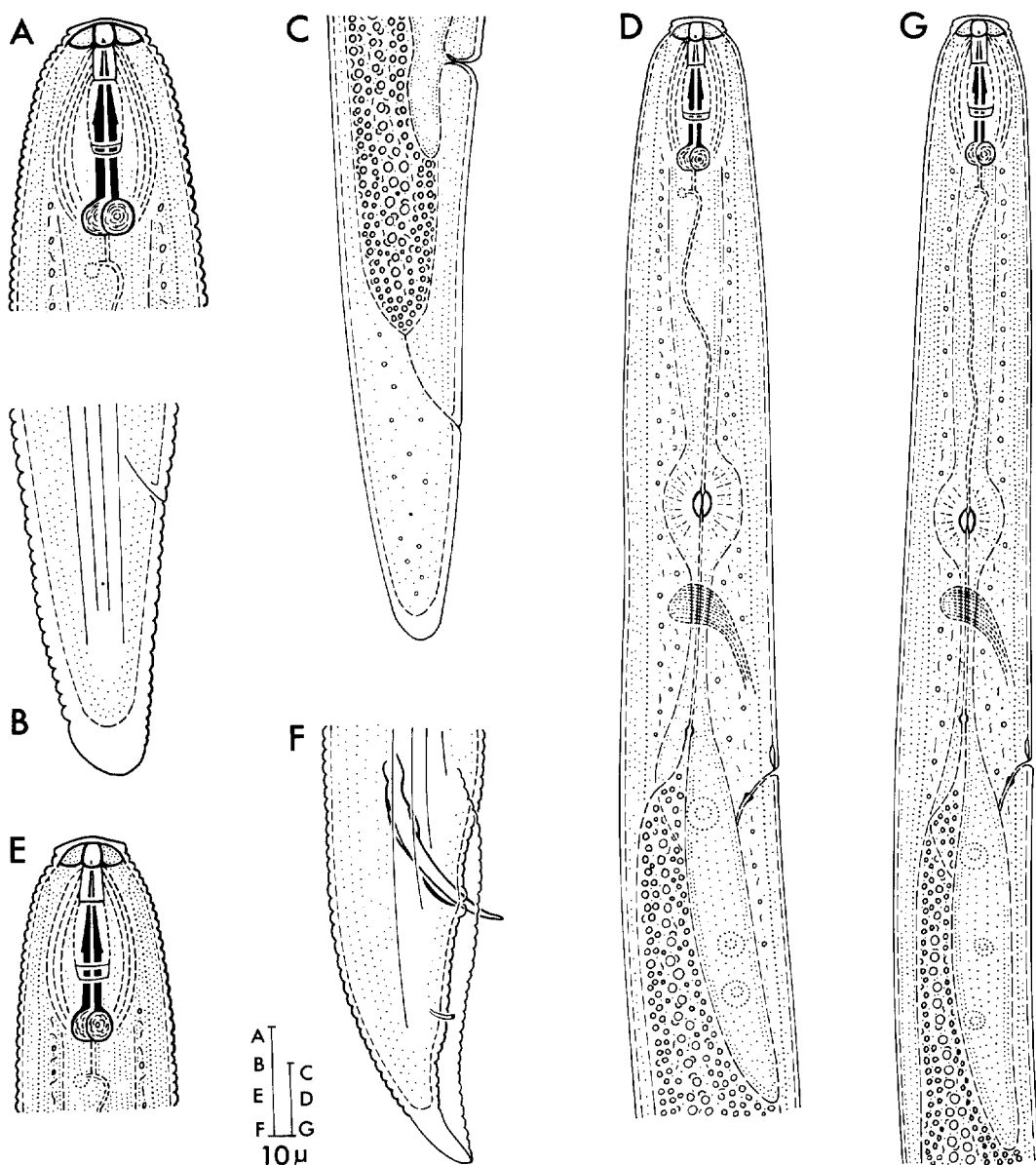


FIG. 13. *Pratylenchus brachyurus*. A–D. Female, A. Head, B. Tail, C. Posterior region, D. Esophagus; E–G. Male, E. Head, F. Tail, G. Esophagus.

uterine branch 10.8 to 24.0 μ ($n = 32$) long. Tail terminus rounded and smooth, little variation in shape.

Males.—Very rare; only eight specimens

found. Similar to females. $L = 430\text{--}625\ \mu$; $a = 21\text{--}32$; $b = 5.2\text{--}7.3$; $c = 18\text{--}23$; $T = 36\text{--}54\%$; stylet length = 16.2–18.0 μ ; dorsal esophageal gland orifice = 2.0–3.0 μ .

DISCUSSION

The foregoing results show that extensive morphological variation exists within each of the six *Pratylenchus* species studied, and raises questions as to the dependability of certain characters presently used in the taxonomy of the genus.

With respect to the number and arrangement of the incisures in the lateral field, our results verify Loof's (13) findings and show that additional variations may occur. *P. hexincisus* Taylor & Jenkins was described mainly on the basis of the presence of six incisures in the lateral field (18). Although this species was not included in the present study, the results indicate that six incisures may occur in any of the six species studied.

The number of annules in the lip region, a character heavily weighted in separating *Pratylenchus* species, should be used with reservation. Each species studied, except *P. penetrans*, exhibits deviations from the number of lip annules recorded in the literature.

In *en face* views of *P. brachyurus*, the anterior end of the vestibule is characteristically "ornamented." This ornamentation, although less pronounced, is present also in *P. penetrans* and *P. coffeae*. The dorsal and ventral blades of the cephalic framework in *P. zae* are thicker than the sublateral blades. To what extent these characters can be used in species identification is not known.

The shape of the stylet knobs of *P. brachyurus*, *P. scribneri* and *P. vulnus* are quite stable, whereas considerable variations are present in *P. zae*, *P. penetrans* and *P. coffeae*. This indicates that stylet knob shape is a questionable character for separating species of *Pratylenchus* and supports Loof's (13) statement that the shape of the stylet knobs should be used with caution.

The arrangement of the stylet protractor muscles of *Pratylenchus* species, although basically similar, appears to differ in some details from that described in *Rotylen-*

chus goodeyi Loof & Oostenbrink (3), *Helicotylenchus pseudorobustus* (Steiner) Golden (4), *Heterodera glycines* Ichinohe (9) and *Criconemoides xenoplax* Raski (16). Differences in the number of muscle strands in these various nematode genera may be due to the limits of resolution of cell membranes in the light microscope rather than real differences. In all instances, the protractors are divided into a dorsal and a ventral group in the regions of stylet point and shaft and form a compact ring around the stylet knobs. Connections to the body wall among these genera are visible throughout the point and most of the shaft region only in *Pratylenchus*. The same arrangement of the stylet protractors as demonstrated in our investigations is illustrated in a cross section through the cephalic base plate of *P. pratensis* (De Man) Filipjev (19). In this instance, however, the muscles were included as part of the cephalic framework.

A short portion of the esophageal glands overlaps the intestine laterally at the junction of the esophagus and intestine and then the posterior portion of the glandular lobe extends over the intestine ventrally. This is in contrast to reports that in *Pratylenchus* the esophageal glands overlap the anterior part of the intestine ventrally. The occurrence of a dorsal gland overlap in one specimen of *P. zae* may represent an anomalous case.

The shape of the tail terminus is a questionable character for separating species of *Pratylenchus*. *P. zae* exhibits considerable variation in the shape of the tail as has been previously reported (18). *P. penetrans* and *P. vulnus* also have a large variety of tail shapes. On the other hand, *P. brachyurus*, *P. scribneri* and *P. coffeae* vary only slightly in this respect. The possibility cannot be excluded, however, that this character may exhibit variability within different natural populations of *P. brachyurus*, since five vari-

ations in tail shape were illustrated in the original description of this species (8). A similar statement may be made for different populations of *P. scribneri* and *P. coffeae*. After completion of this study, the senior author examined a population of *P. coffeae* from Puerto Rico which exhibited considerable variation in tail shape.

The ovaries of actively reproducing females of all species studied extend to the region of the esophageal glands. The length of the ovary in these species, therefore, cannot be considered a good differentiating character since it appears to be dependent on age and nutritional status of the individual. Other *Pratylenchus* species not included in this investigation may behave differently (13).

In contrast to earlier reports (13, 17), a well-developed spermatheca is always present in the monosexual species of *P. brachyurus*, *P. scribneri* and *P. zaeae*. This confirms Seinhorst's (15) findings in *P. scribneri*. The shape of the spermatheca in the bisexual species *P. penetrans*, *P. vulnus* and *P. coffeae* can be a good diagnostic character if used with caution and in combination with other characteristics. The 12-celled constriction between oviduct and spermatheca appears similar to that reported for *Helicotylenchus dihystra* (Cobb) Sher (11) and cannot be considered as a sphincter-like organ (15) since it is devoid of muscular tissue.

The term tricolumella is adopted for the distal part of the uterus, composed of 12 cells arranged in three rows of four cells each, following the same nomenclature of this gonad part as in *Helicotylenchus dihystra* (11). Determination of the arrangement and number of the cells of the tricolumella in *Pratylenchus* is difficult if the specimens are not properly killed and mounted. This may explain earlier reports that this uterus region is composed of 20 cells arranged in four rows of five cells each (5, 15).

It is doubtful whether the length of the posterior uterine branch can be used as a diagnostic character as has been suggested earlier (13). Although this branch may be rather long in *P. vulnus*, overlapping of measurements occurs with all the other species studied.

Statistical analyses of measurements also indicate great variability of various morphometric characters presently used in the taxonomy of the genus. Although ranges of most of the characters studied overlap, means may be different enough to allow differentiation of one species vs. another when based on sufficiently large samples. Characters useful in distinguishing between some of the six species studied are: Lip height and width, length of stylet, width and height of stylet knobs, distance of dorsal gland orifice from stylet knob base, esophagus length, location of excretory pore, vulva position, vulva percent and vulva-anus distance. Among these characters, vulva percent and stylet length have a low coefficient of variability and are useful as diagnostic characters, although their means are close and their ranges overlap among some of the species. The esophageal length seems to depend on body length in females of *P. vulnus* and *P. scribneri*, whereas this is not the case in *P. brachyurus*. Female tail length appears to be constant in all species, and independent of body length. The same may be true for males. These findings support in part those of Taylor and Jenkins (18) with *Pratylenchus* and those of Geraert (7) with other nematode species.

The slightly greater morphometric variability, observed in specimens of *P. vulnus* from greenhouse cultures as compared to specimens from callus cultures, is probably the result of greater variation in the micro-environmental conditions existing in pots in the greenhouse. This supports observations by Bird and Mai (1) with *Trichodorus christiei* Allen, who found that nematodes sub-

jected to different environmental conditions and different host plants differed in many morphometric relationships.

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