

Revision of the Genus Paratylenchus Micoletzky, 1922, and Descriptions of New Species. Part II of Three Parts.¹

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Abstract: Part II covers species with average female stylet length of 22-38 μm . Seven new species are described and further observations are given on 12 other species. A key to the species covered in Parts I and II is included. *Paratylenchus curvitatatus* van der Linde, 1938, is transferred to *species inquirendae*. *Key Word:* taxonomy.

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Taxonomic studies on the genus *Paratylenchus* Micoletzky, 1922 (12) are particularly difficult because of their small size and the apparent overlapping of many characters; i.e., total length, stylet length, 'V' value, tail shapes, etc. It is also common to find more than one species of this genus in the same soil sample, in some cases as many as four different species. This complicates decisions on relationships of males and juvenile specimens with females. The Brazilian species [*P. humilis*, *P. perlatus*, (13)

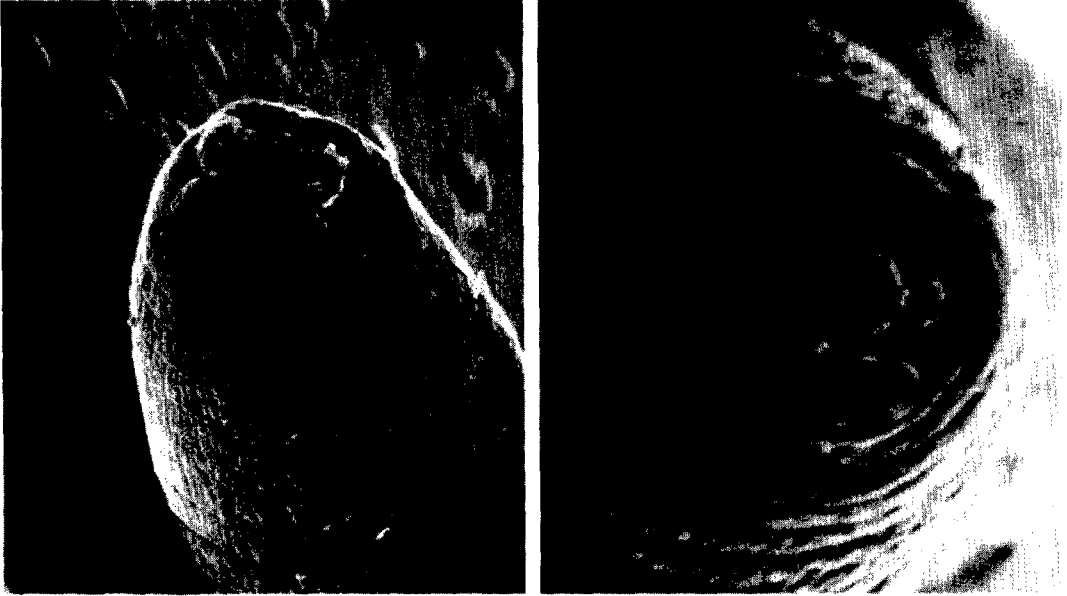


PLATE I-(A, B). En-face views of females of *Paratylenchus neoamblycephalus*. A) $\times 4,840$, B) $\times 8,800$.

and the two new species below] are among the smallest reported, and specimens of all four species occurred in at least one sample from that country. Fortunately, other samples held only single species and were most important in helping to sort out the different species.

Despite the very small size of the lip region of *Paratylenchus*, there are differences which certainly will be increasingly useful in distinguishing species when the lip regions can be described completely and accurately. In this study, the head is defined as that part of the anterior end of the body from the base of the cephalic framework forward. The lip region is defined as the anterior-most area including the submedian lobes, amphids, lateral lobes or lips, oral plate, and oral aperture. Geraert (5) illustrated several types of head regions conforming to species groups, including his Fig. 2-B 'conical-truncate head (*P. neoamblycephalus*)'. This and many other species are judged here to be more rounded in outline. The definition 'conoid-truncate and slightly set-off' is used for *P. projectus*, *P. pesticus*, *P. halophilus*, and *P. neonanus*. To the head types illustrated by Geraert should be added the lip pattern of *P. nainianus* with prominent submedian lobes which is even more pronounced in *P. similis* and *P. tateae*. The fine indentation setting off the lips in *P. coronatus* and *P. perlatus* is another distinctive type of lip region.

Scanning electron microscopy (SEM) undoubtedly will be a valuable aid in contributing information to determine more accurately and precisely the nature of the differences in these head structures. Unfortunately, techniques for handling small specimens such as most *Paratylenchus* species have been a severe handicap in preparation of material for SEM. Cuticular distortion resulting from the process used in preparing specimens for SEM also has been a problem. Two photographs of females of *P. neoamblycephalus* (Plate I-A, B) are indications of the details that might be found by use of SEM. There are two prominent, rounded, contiguous submedian lobes on the ventral side, two similar lobes on the dorsal side, and broad amphid apertures. The oral aperture is on a slightly raised, oval plate, and appears to be roughly I-shaped. Exact outlines of the oral plate, amphid apertures, and lateral lobes are obscured by artifacts. Comparative studies of the lip regions of other species by the use of SEM would be invaluable.

Further use is made of males in the taxonomy of this group. The male stylet is considered a profound specific character based on many collections in which it is constant. The few collections reported by Geraert (5) in which some males are found with others without a stylet probably can be

explained by mixtures of species which is common in this group. *P. hamatus*, *P. neoamblycephalus*, and two new species described below are four closely related species which are distinguished primarily by male characteristics. For this reason males for the first time have been selected as holotypes for the two new species mentioned.

MATERIALS AND METHODS

Most of the specimens used in this study were mounted in glycerine but the precise methods used in killing, fixing, and processing them to dehydrated glycerine are not known. The usual procedure followed with fresh specimens collected here was to separate the specimens from soil by a combined gravity-screening and mist-extraction technique, killing them by gentle heat, and fixing in 5% formaldehyde. The specimens then were passed through F.A.A., 2.5% glycerine in 30% alcohol, and 5% glycerine in 30% alcohol. They were allowed to dehydrate from the last solution to glycerine, then mounted in dehydrated glycerine.

Females of *P. neoamblycephalus* were prepared for examination on the scanning electron microscope by the following procedure: Living specimens in tap water were killed by fumes of glutaraldehyde at room temperature. A 15-sec sonication in 3% aqueous glutaraldehyde was then followed by a distilled water rinse. A further treatment with 2% osmium tetroxide was used and rinsed with distilled water. The specimens then were dried by fuming with acetone followed by critical-point drying and a 200-Å coating with silver and gold.

Paratylenchus vandenbrandei de Grisse, 1962

Two females and one juvenile identified as *P. vandenbrandei* were found in a collection made from jungle soil near Kotagala, Sri Lanka (Ceylon).

Measurements for the two females were: L = .23-.26 mm; a = 22-26; b = 3.2-3.3; V = ²⁵⁻²⁷80-81; stylet = 32-36 μ m; prorhabdion = 22-25 μ m; excretory pore = 55-61 μ m. One female is slightly less in length than the minimum of the range reported by de Grisse (6) for the type population. Also the range of V is

extended to 80 and the stylet to 36 μ m. In other respects these closely resemble *P. vandenbrandei*. The lateral field is very faint, and it is especially difficult to resolve the inner incisure. However, there seem to be three longitudinal incisures on these specimens.

Also present in the above sample were females and males identified as *P. minutus*.

Paratylenchus salubris n. sp.

(Fig. 1-6)

Paratypes (30 females): L = .23 (.20-.25) mm; a = 19 (12-24); b = 3.2 (2.8-3.6); c = 16 (12-19); V = ^{31 (21-52)}80 (78-82); stylet = 32 (28-35) μ m; prorhabdion = 23 (20-25) μ m; excretory pore = 61 (55-66) μ m.

Paratypes (13 males): L = .24 (.20-.27) mm; a = 24 (17-28); c = 14 (13-15); spicules = 15 (13-16) μ m; gubernaculum = 2.4 (2-3) μ m; T = 30 (21-37); excretory pore = 57 (48-64) μ m.

Holotype (female): L = .21 mm; a = 17; b = 3.1; c = 19; V = ³⁰82; stylet = 31 μ m; prorhabdion = 23 μ m; excretory pore = 57 μ m. Head not set off; narrows with sloping, slightly rounded outline; submedian lobes protrude very slightly; anterior surface truncate. Sclerotization delicate except darker, pronounced vestibule housing stylet tip, heavily sclerotized with rounded outline. Stylet slender, with posteriorly directed knobs. Dorsal esophageal gland orifice about 4 μ m from stylet knobs (3-5 μ m in paratypes). Hemizonid two cuticular rings in width immediately anterior to excretory pore at posterior end of isthmus. Esophago-intestinal valve small, lobate (more distinct in some paratypes). Ovary outstretched; spermatheca small, rounded, full of small spermatozoa. Vulvar flap small, rounded. Tail narrows gradually to bluntly rounded terminus. Body annules average about 1 μ m in width. Lateral field with four longitudinal incisures; inner two lighter than the outer two.

Allotype (male): L = .24 mm; a = 25; c = 14; spicules = 16 μ m; gubernaculum = 2 μ m; T = 36; excretory pore = 59 μ m. Body narrows anteriorly to rounded head, lip region truncate. Sclerotization delicate. Esophagus degenerate, but outline can be seen. Hemizonid about 2 body annules in width immediately anterior to excretory pore. Testis outstretched. Anal sheath protrudes with distinctly projecting posterior edge. Tail conoid with subacute to bluntly rounded terminus.

Holotype: Female, collected by R. D. Sharma in 1973, slide number 1346, University of California Nematode Survey (UCNS) Collection, Davis, California.

Allotype: Male, same data and slide number as holotype.

Paratypes: 73 females and 46 males same data as holotype deposited as follows: 48 females, 36 males UCNS Collection, Davis, California; 9 females, 4 males UCNS Collection, Riverside, California; 2 females, 1 male United States Department of Agriculture (USDA) Nematode Collection, Beltsville, Maryland; 7 females, 2 males National Nematode Collection, Indian Agricultural Research Institute (IARI), New Delhi, India; 3 females, 1 male Nematology Department, Rothamsted Experimental Station (RES), Harpenden, England; 4 females, 2 males Plantenziektenkundige Dienst (PD), Wageningen, The Netherlands.

Type host: *Theobroma cacao* L.

Type locality: Pousa Alegre, Porto Seguro, Brazil.

Diagnosis: This species is most closely related to *P. morius* and *P. coronatus*. It differs from both species by its bluntly rounded terminus (conoid to acute tip in *P. coronatus*, finely pointed with mucro-shaped tip in *P. morius*). It differs from *P. coronatus* also by its smaller size (L = .27-.30 mm in *coronatus*). *P. salubris* is also closely related to *P. mimulus* from which it differs by its longer stylet [28 (24-31) μm for *P. mimulus*] and by its bluntly rounded tail (conoid-subacute in *P. mimulus*).

This species was also collected from soil about roots of *Theobroma cacao* L. at Boa Sorte, Porto Seguro, Brazil, in 1973 by R. D. Sharma. All characteristics fit within the limits of the type collection.

Paratylenchus coronatus
Colbran, 1965

Four female and two male paratypes of *P. coronatus* were available for this study. Also 58 females, 16 males, and 12 juveniles were sent by R. C. Colbran from Late Valencia orange trees at Koah, North Queensland, which was recorded in the original description (2) as another collection site of *P. coronatus*. A third collection of 4 females from citrus at Palmwoods also was sent for comparison.

Measurements for the last two collections are:

		34 females (Koah)
L (mm)	=	.28 (.24-.31)
a	=	21 (17-29)
b	=	3.8 (3.4-4.2)
c	=	16 (13-18)
V	=	81 (79-83)
stylet (μm)	=	31 (29-33)
excretory pore (μm)	=	59 (48-69)
spicules (μm)	=	...
gubernaculum (μm)	=	...
T	=	...
		6 males (Koah)
L (mm)	=	.27 (.22-.32)
a	=	29 (23-35)
b	=	...
c	=	17 (13-21)
V	=	...
stylet (μm)	=	...
excretory pore (μm)	=	57 (48-65)
spicules (μm)	=	17 (14-19)
gubernaculum (μm)	=	3.0
T	=	35 (30-42)
		4 females (Palmwoods)
L (mm)	=	.30 (.29-.33)
a	=	20 (17-24)
b	=	3.7 (3.6-3.9)
c	=	15 (14-16)
V	=	81 (79-82)
stylet (μm)	=	33 (31-35)
excretory pore (μm)	=	71 (67-73)
spicules (μm)	=	...
gubernaculum (μm)	=	...
T	=	...

These collections extend the range of total length of both the female and male, length of stylet of the female, and minor differences in other characters. The tails of female paratypes were consistently more slender-conoid to the terminus and generally more bluntly-conoid in the other two collections. Also the head region of the paratype females had more distinctly rounded lips set off by a deeper, more pronounced indentation than in the other collections. However, the variability of

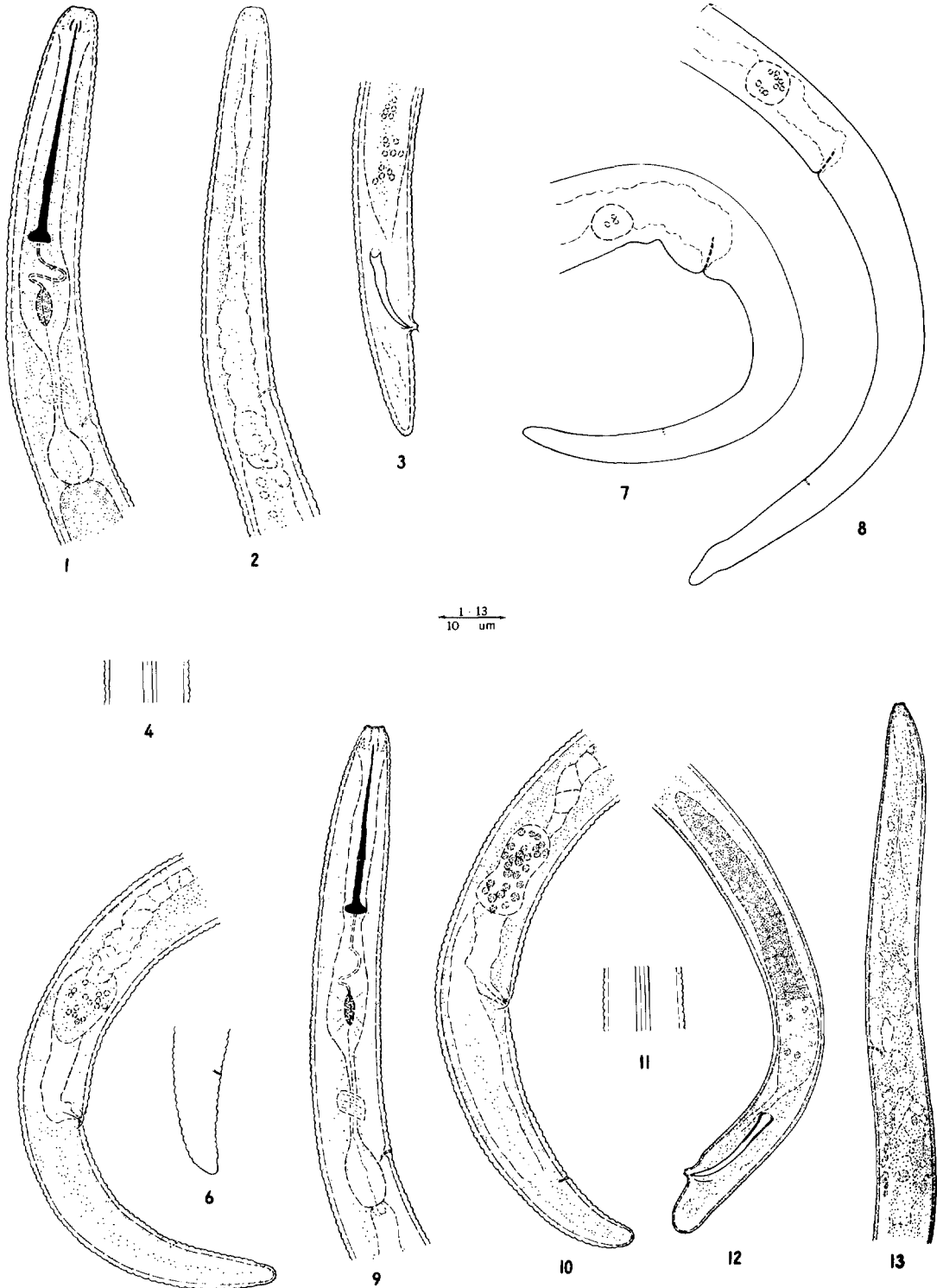


FIG. 1-13. 1-6) *Paratylenchus salubris* n. sp.; 7-8) *Paratylenchus minusculus*; 9-13) *Paratylenchus nainianus*.

these characters in the paratypes, and the consistent similarities of the males in the first two collections, indicate the variations are intraspecific in nature.

Paratylenchus minusculus

Tarjan, 1960

(Fig. 7-8)

Five slides with a total of 12 females, 6 males and 4 juveniles labeled as paratypes of *P. minusculus* were kindly loaned by A. C. Tarjan for this study. The females were found to be very distinctive with a vulva much farther forward than most other species of *Paratylenchus*. The average and range of the 'V' value for these paratypes are at variance with the measurements given in the original description, except for one female which has the vulva at 80%. That specimen also has a stylet 30 μm long, whereas the paratype stylets do not exceed 27 μm . Furthermore, that female also has small, distinctly set-off lips which suggests it is *P. nainianus*, not *P. minusculus*. This identification is supported by the single male described by Tarjan (15) in the original description under Fig. 9, (K) and referred to as 'tail of aberrant male' in which the tail is very short, about one-fourth as long as that of the normal male. This closely resembles the male of *P. nainianus* which has been collected from many localities throughout the world, including one near Lake Alfred, Florida.

Some of the original measurements for the female of *P. minusculus* probably were taken from a mixture which included *P. nainianus*. The following measurements are from the paratypes studied here. These figures amend the description of *P. minusculus* as reported below. Reexamination of the holotype and all other paratypes is needed to complete the study and determine more accurately the parameters of the type population.

Paratypes (9 females): L = .24 (.21-.28) mm; a = 25 (18-33); b = 3.5 (3.0-4.0); V = 72 (69-73); stylet = 25 (22-27) μm ; prorhabdion = 19 (17-21) μm ; excretory pore = 58 (56-62) μm .

Paratypes (4 males): L = .26 (.25-.26) mm; a = 28 (23-34); c = 13 (12-14); spicules = 15 (15-16) μm ; gubernaculum = 3.0 μm ; excretory pore = 58 μm .

The female is very much as described by Tarjan with the following amendments: Sclerotization of head delicate except darker, rounded, pronounced vestibule housing stylet

tip (very similar to *P. mimulus* and *P. salubris*). Tail of many females tapers very slightly giving a longer, more graceful and distinctive outline than shown in Fig. 9-A (15). Terminus bluntly rounded on most specimens. Lateral field very narrow and it is difficult to determine exactly how many incisures are present. Two incisures are distinct on all females, less clear on males. Occasionally, a faint inner incisure is evident but never two inner incisures. This is very similar to *P. humilis* in which most females show two incisures clearly and occasionally one has a definite faint inner one. My conclusion based on these paratypes is that *P. minusculus* has three incisures. Final confirmation must be made by examination of the holotype.

Paratylenchus nainianus

Edward and Misra, 1963

(Fig. 9-13)

A single female collected and identified by J. C. Edward from the type locality at Allahabad was sent by him for this study and is now deposited in the UCNS Collection at Davis. In addition 16 collections from 15 different localities also have been identified as this species and were part of this study.

At first there was doubt that most or all of these collections were *P. nainianus* because most of the males have shorter, more bluntly rounded tails than described for *P. nainianus* (4). The 'c' value averages 27-28 and ranges from 21-36. One exception is a single male with a 'c' value of 20 in a collection from *Rhagodia* in Australia. In other respects, the females and males are similar to the illustrations and data given for *P. nainianus* (3). These specimens are judged conspecific with *P. nainianus*, and extend the range of some characters as discussed below.

The major characteristics of this species are the following: (i) female head with extremely fine annules terminating anteriorly with small but distinct, rounded submedian lobes. These are paired dorsally and ventrally and stand out best as two separate rounded lobes when the microscope is focused up or down to lateral position of head; (ii) total length of female generally averages .27-.28 mm with a total range of .21-.35 mm. Very few specimens were found larger than .32 mm; (iii) female stylet generally averages 26-28 μm with a total range of 21-32 μm ; (iv) the average 'V' value

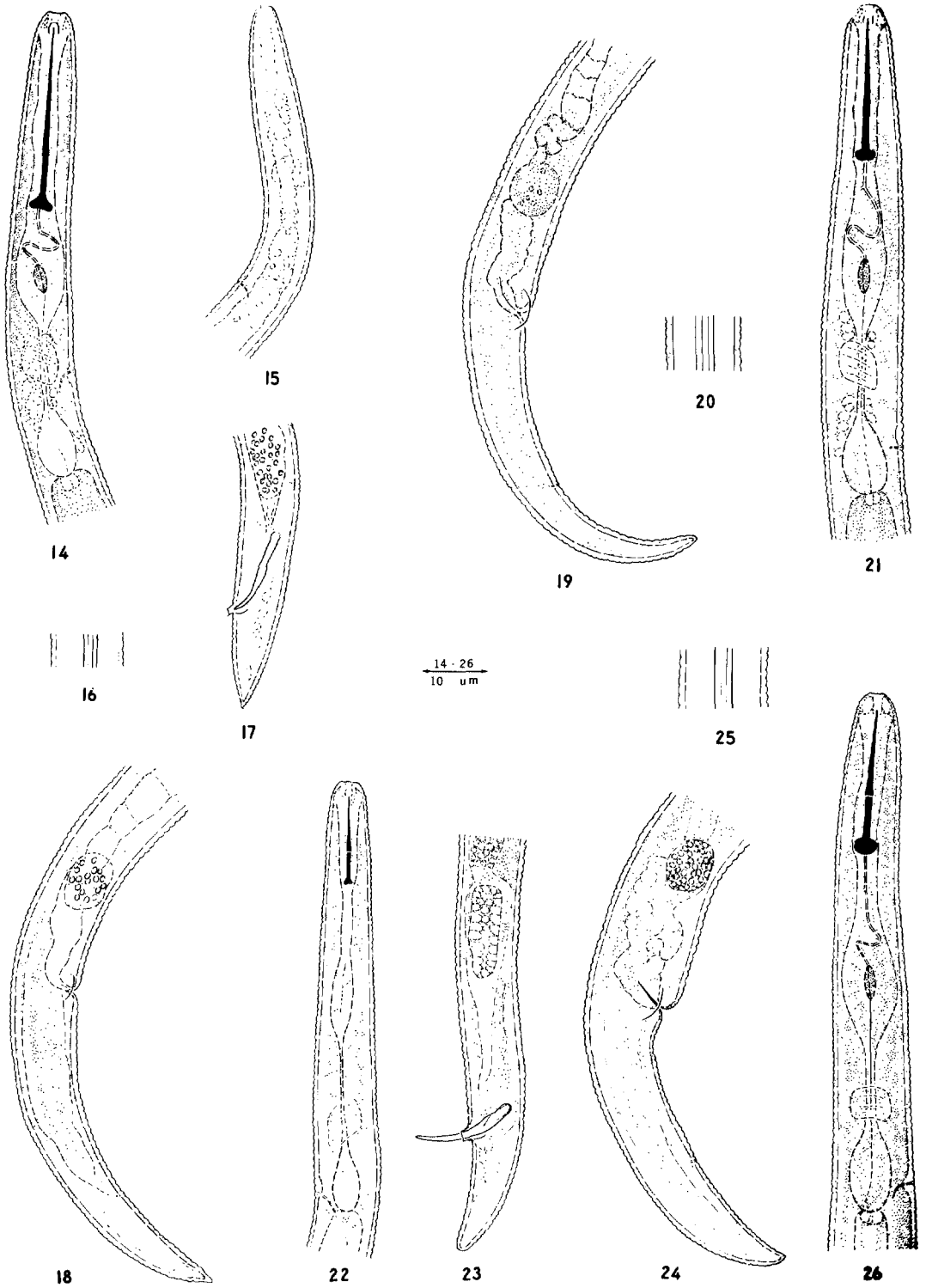


FIG. 14-26. 14-18) *Paratylenchus mimulus* n. sp.; 19-21) *Paratylenchus lepidus* n. sp.; 22-26) *Paratylenchus holdemani* n. sp.

varies from 80-82 with a total range of 78-86; (v) female tail narrows gradually to a bluntly rounded terminus; some specimens have a blunt-conoid terminus; (vi) male head narrow, conoid with small rounded lips similar to female; (vii) male tail very short, blunt-rounded, often curved dorsad.

Collections in California include specimens from hops, Santa Rosa; grapevine, St. Helena; walnut, Meridian; grapevine, University of California campus, Davis; peach and almond, Winters; prunes, Red Bluff; grapevine, Gilroy; grapevine, Evergreen; grapevine, Rutherford; also from magnolia and camphor, Lake Alfred, Florida; pistachio, Nineveh, Iraq; hibiscus, St. Lucia, Australia; native shrub (*Rhagodia gaudichaudiana* Moq.), Wentworth, NSW, Australia; apple, Tzuba, Israel; grapevine, Palermo, Sicily; grapevine, Borgonuovo, Sicily; fig, Pernumia (Padova), Italy.

Paratylenchus mimulus n. sp.

(Fig. 14-18)

Paratypes (44 females): L = .22 (.18-.26) mm; a = 18 (13-25); b = 3.2 (2.7-3.5); c = 14 (12-16); V = $^{33(16-51)}$ 80 (78-82); stylet = 28 (24-31) μ m; prorhabdion = 20 (16-23) μ m; excretory pore = 60 (51-74) μ m.

Paratypes (15 males): L = .21 (.19-.25) mm; a = 23 (18-28); c = 13 (12-15); spicules = 14 (13-15) μ m; gubernaculum = 2.4 (2.0-3.0) μ m; T = 31 (28-36); excretory pore = 51 (45-63) μ m.

Holotype (female): L = .20 mm; a = 20; b = 2.8; c = 13; V = 25 81; stylet = 28 μ m; prorhabdion = 21 μ m; excretory pore = 57 μ m. Head not set off, narrows with sloping, slightly rounded outline, submedian lobes protrude very slightly, anterior surface truncate. Sclerotization delicate except darker, pronounced vestibule heavily sclerotized and rounded in outline and housing stylet tip. Stylet slender with posteriorly directed knobs. Dorsal esophageal gland orifice about 4 μ m from stylet knobs. Hemizonid two cuticular rings in width immediately anterior to excretory pore at about level of nerve ring. Esophago-intestinal valve small, lobate. Ovary outstretched, spermatheca prominent, rounded to ovate, filled with spermatozoa. Vulvar flap small rounded. Tail narrows gradually to give a slender conoid outline with subacute terminus, tip finely rounded, almost acute (other paratypes mostly like holotype, but

some vary from more finely drawn-out extreme acute terminus, others are more bluntly subacute). Body annules average about 1.0-1.3 μ m. Lateral field marked with four longitudinal incisures, inner two lighter than outer two.

Allotype (male): L = .21 mm; a = 19; c = 13; spicules = 13 μ m; gubernaculum = 3 μ m; T = 28; excretory pore = 46 μ m. Body curved tightly into an almost closed 'C' (other paratypes only slightly curved ventrad). Body narrows to rounded head with truncate lip region. Sclerotization very delicate. Stylet lacking. Esophagus degenerate. Hemizonid about two body annules in width immediately anterior to excretory pore. Testis outstretched, testicular gland not clearly discernible. Anal sheath protruded prominently. Tail conoid with finely rounded terminus, tip almost acute as in holotype.

Holotype: Female, collected by R. D. Sharma in 1973, slide number 1233, UCNS Collection, Davis, California.

Allotype: Male, same data as holotype, slide number 1234, UCNS Collection, Davis, California.

Paratypes: 73 females, 21 males, 1 juvenile same data as holotype deposited as follows: 68 females, 16 males, 1 juvenile UCNS Collection, Davis, California; 1 female, 1 male, each at UCNS Collection, Riverside, California; National Nematode Collection, IARI, New Delhi, India; USDA Nematode Collection, Beltsville, Maryland; Nematology Department, RES, Harpenden, England; PD, Wageningen, The Netherlands.

Type host: *Theobroma cacao* L.

Type locality: Ouro Preto, Porto Seguro, Brazil.

Diagnosis: This species is related to *P. perlatus* but lacks the set-off lobes of *P. perlatus* and has a longer stylet [20 (19-22) μ m for *P. perlatus*]. *P. mimulus* is also closely related to *P. salubris* but differs by its shorter stylet [28 (24-31) μ m vs. 32 (28-35) μ m for *P. salubris*]. *P. salubris* also has a bluntly rounded tail in the female and subacute to bluntly rounded male tail.

Other collections: Three females of this species were found in the type collection of *P. salubris* in Pouso Alegre, Porto Seguro which also held specimens of *P. humilis* and *P. perlatus*. There were also 17 females and 3 males in the type collection of *P. humilis* from Fax. Pirangi-Prado, Brazil where *P. humilis* and *P. mimulus* were the only species present.

Two females of *P. humilis* were also found in the type collection of *P. mimulus*. *Theobroma cacao* L. was the host in all three samples.

One female, 2 males, 2 other males which were molting and had not completed development, and 7 juveniles were found in a collection from soil about coconut at Ustupo, Naragana, Panama. These key nearest to *P. mimulus* with the following measurements:

1 female: L = .28 mm; a = 25; b = 3.8; V = 77; stylet = 27 μ m; prorhabdion = 20 μ m; excretory pore = 69 μ m.

2 males: L = .28-.29 mm; a = 22-31; c = 11-12; spicules = 16 μ m; gubernaculum = 4 μ m; excretory pore = 60-65 μ m.

The total length of both female and males is slightly greater than the range of *P. mimulus*. Also the vulva is slightly more anterior than the range of *P. mimulus*. These differences are not considered great enough to merit specific status and these specimens are judged to be *P. mimulus*.

Paratylenchus holdemani n. sp.

(Fig. 22-26)

Paratypes (7 females): L = .32 (.29-.35) mm; a = 22 (19-24); b = 4.0 (3.7-4.7); c = 17 (16-19); V = ⁴¹⁽³²⁻⁶⁰⁾85 (84-86); stylet = 22 (21-23) μ m; prorhabdion = 13 (13-14) μ m; excretory pore = 73 (67-77) μ m.

Paratypes (5 males): L = .29 (.27-.32) mm; a = 27 (24-29); b = 4.0 (3.8-4.3); c = 14 (12-16); stylet = 15 (14-16) μ m; excretory pore = 65 (63-71) μ m; spicules = 17 (16-18) μ m; gubernaculum = 3(2-3) μ m; T = 30 (28-35).

Holotype (female): L = .35 mm; a = 21; b = 4.7; c = 19; V = ⁶⁰84; stylet = 22 μ m; prorhabdion = 13 μ m; excretory pore = 73 μ m. Body curves ventrad after fixation, most strongly posterior to vulva. Head rounded, not set off, with fine annulation and small rounded lips. Stylet short but well-developed, knobs only slightly posteriorly directed, almost squared-off (in some paratypes knobs appear to be definitely posteriorly directed). Dorsal esophageal gland orifice about 5 μ m from knobs. Excretory pore at level of hemizonid, opposite posterior bulb. Esophago-intestinal valve minute and rounded. Ovary outstretched, spermatheca not clearly evident (in some paratypes it is well-developed and full of spermatozoa). Vulvar flaps rounded. Tail conoid with rounded terminus. Lateral field with four incisures, inner two less prominent than the

outer two. Body annules average 1.5-1.7 μ m wide.

Allotype (male): L = .32 mm; a = 24; b = 4.3; c = 16; stylet = 16 μ m; prorhabdion = 10 μ m; spicules = 18 μ m; gubernaculum = 3 μ m; T = 35; excretory pore = 71 μ m. Body almost straight after fixation. Head rounded, not set off. Stylet weak, but clearly visible. Esophagus degenerate but outline clear. Excretory pore immediately posterior to hemizonid opposite posterior bulb. Testis outstretched, with strongly developed testicular gland. Spicules only slightly curved. Tail narrows gradually to a rounded terminus (some paratypes have more conoid, finely rounded terminus). Lateral field with four incisures, inner two less prominent than outer two. Body annules average 1.2-1.4 μ m wide.

Holotype: Female, collected by Q. L. Holdeman 8 March 1960, slide number 1395, UCNS Collection, Davis, California.

Allotype: Male, same data and slide number as holotype.

Paratypes: 6 females, 4 males, same data as holotype deposited as follows: 2 females, UCNS Collection, Davis, California; 1 female, 1 male each at the following: USDA Nematode Collection, Beltsville, Maryland; National Nematode Collection, IARI, New Delhi, India; Nematology Department, RES, Harpenden, England; PD, Wageningen, The Netherlands.

Type host: Soil about roots of *Coffea arabica* L.

Type locality: La Florida, Finca Los Naranjos, Santa Anna, El Salvador.

Diagnosis: This species is most closely related to *P. hamatus* and *P. baldaccii* from which it differs in its short female stylet [22 (21-23) μ m vs. > 30 (28-35) μ m].

This species is named in honor of Quintin L. Holdeman who collected the specimens in El Salvador.

Paratylenchus hamatus
Thorne and Allen, 1950

Two slides with a total of 9 females, 1 male, and 10 juveniles from G. Thorne's original Salt Lake City (USDA) collection were available for this study. These are labeled as collected 20 March 1944 from a fig orchard on the Boyd Farm near Planada, California, the type locality and type host for *P. hamatus*. Thorne (*private communication*) recognized these slides as containing some of the

specimens on which the original description was based, and thus they can be used for designation of type specimens as follows:

Lectotype (female): L = .40 mm; a = 22; b = 4.2; c = 13; V = ³⁷82; stylet = 29 μ m; prorhabdion = 19 μ m; excretory pore = 91 μ m.

Paralectotype (male): L = .41 mm; a = 35; c = 11; spicules = 24 μ m; gubernaculum = 5 μ m; stylet = 17 μ m.

Paralectotypes (8 females): L = .38 (.37-.41) mm; a = 23 (18-28); b = 3.9 (3.7-4.4); V = 82 (81-83); stylet = 30 (28-33) μ m; prorhabdion = 20 (17-24) μ m; excretory pore = 82 (75-87) μ m.

These specimens conform closely with the original description (16) except in the female the stylet is slightly longer (averaging 30 μ m vs. 28 μ m) and the vulva is further forward [V = 82 (81-83) vs. 84].

Lectotype: Female, collected 20 March 1944 by E. A. Davey, specimen #6 on slide 1a with 4 females and 4 juveniles, deposited in the USDA Nematode Collection, Beltsville, Maryland.

Paralectotypes: 8 females, 1 male, and 10 juveniles, same data as lectotype, deposited in the USDA Nematode Collection, Beltsville, Maryland.

Type host: *Ficus carica* L.

Type locality: Planada, California.

Other collections: There are 24 other collections in this study identified as *P. hamatus*. Most of these fit the characteristics and measurements of *P. hamatus* very closely but extend the range of some of the female measurements. Total length generally averages .35 mm or more (total range is .30-.47); stylet generally averages 30 μ m or more (total range is 27-34); most populations show an average V of 82 (total range 78-84). Included are specimens collected in California from grapevine, Reedley; grapevine, Lodi; grapevine, Madera; grapevine, Ivanhoe; grapevine, Delano; prunes, various rural areas in Butte County, Sutter County, and Red Bluff and Vina, Tehama County; peach, Modesto; oak, Escalon; rose, Half Moon Bay; plum, Dinuba; pear, Placerville; walnut, Lompoc; mesembryanthemum, Dillon's Beach, Marin County; and from peach, Lyra, Queensland (?), Australia.

Paratylenchus baldaccii n. sp.

(Fig. 27-31)

Paratypes (21 males): L = .37 (.30-.44) mm; a = 35 (30-40); b = 4.4 (3.6-5.3); c = 12 (11-13); stylet = 16 (14-18) μ m; prorhabdion = 10 (9-12) μ m; spicules = 22 (20-24) μ m; gubernaculum = 4 (3-5) μ m; T = 39 (32-46); excretory pore = 74 (66-84) μ m.

Paratypes (14 females): L = .36 (.28-.43) mm; a = 26 (21-29); b = 4.0 (3.5-4.5); c = 13 (10-15); V = ³⁶⁽³¹⁻⁴⁴⁾81 (80-83); stylet = 31 (28-35) μ m; prorhabdion = 20 (17-23) μ m; excretory pore = 77 (66-89) μ m.

Holotype (male): L = .34 mm; a = 33; b = 4.1; c = 12; stylet = 16 μ m; prorhabdion = 11 μ m; spicules = 21 μ m; gubernaculum = 4 μ m; T = 36; excretory pore = 74 μ m. Body an open 'C' shape after fixation, narrows gradually to a rounded head. Head smooth, weak sclerotization. Stylet present, weakly developed with small rounded knobs. Esophagus degenerate but with a definite outline. Excretory pore at level of hemizonid opposite posterior bulb. Testis outstretched, full of large spermatozoa. Testicular gland large, prominent. Anal sheath protrudes in conical shape with projecting posterior edge. Spicules slightly curved ventrad. Gubernaculum simple rod-shaped. Tail narrows gradually to give a slender conoid shape with a finely rounded terminus. (In some paratypes tail curves sharply almost to right angles to body posterior to cloaca.) Body annules distinct, averaging 1.3-1.4 μ m wide. Lateral field with four incisures, inner two very faint.

Allotype (female): L = .34 mm; a = 28; b = 3.8; c = 13; V = ⁴¹80; stylet = 30 μ m; prorhabdion = 20 μ m; excretory pore = 73 μ m. Body an open 'C' shape after fixation, narrows gradually to a rounded head which appears to have very fine annules. Dorsolateral and ventro-lateral lips very small, rounded, lateral lips project slightly. Head sclerotization faint but with thickened central stylet-guiding apparatus which appears as two dark rods in lateral view. Stylet well-developed, with rounded knobs. Dorsal esophageal gland orifice about 6 μ m posterior to knobs. Excretory pore at same level as hemizonid at posterior end of isthmus. Rounded, lobed esophago-intestinal valve present. Deirids present at level of nerve ring. Ovary outstretched. Spermatheca prominent, ovoid, 8 \times 13 μ m, full of large spermatozoa. Vulvar flaps rounded. Tail narrows gradually and regularly, giving a slender conoid outline with extremely fine round (almost acute)

terminus. Body annules coarse, averaging 1.5 μm wide. Lateral field with four incisures, inner two very faint.

Holotype: Male, collected 17 April 1963 by D. J. Raski, slide number 1393, UCNS Collection, Davis, California.

Allotype: Female, same data as holotype, slide number 1394, UCNS Collection, Davis, California.

Paratypes: 41 males, 15 females, 27 juveniles same data as holotype deposited as follows: 31 males, 10 females, 24 juveniles UCNS Collection, Davis, California; 1 male, 1 female, 1 juvenile UCNS Collection, Riverside; 3 males, 1 female, 1 juvenile National Nematode Collection, IARI, New Delhi, India; 3 males, 1 female, 1 juvenile USDA Nematode Collection, Beltsville, Maryland; 2 males, 1 female Nematology Department, RES, Harpenden, England; 1 male, 1 female PD, Wageningen, The Netherlands.

Type host: Paulsen grape hybrid 1103.

Type locality: Italian Government Nursery near Palermo, Sicily.

Diagnosis: This species is most closely related to *P. hamatus* from which it differs by its weaker stylet in the male and more slender, sharply conoid tail of both male and female.

Other collections: Grapevine, Borgonuovo (near Palermo), Sicily; grapevine, Bari, Italy; grapevine, Camarague, Delta of Rhône, France; grapevine, Department Garden, Beaucare, France.

This species is named in honor of Professor Elio Baldacci, Director of the Istituto di Patologia Vegetale, Milano, Italy.

Paratylenchus projectus Jenkins, 1956

syn. *Paratylenchus amblycephalus* Reuver, 1959 new synonymy
Paratylenchus nanus of Thorne and Smolik, 1971 new synonymy

No type specimens of *P. projectus* were preserved by Jenkins (7) but a neotype was established by Tarjan (15) selected from a subculture of Jenkins' original population on tall fescue, *Fescue elatior* L. 'Kentucky 31'. Those specimens were not available for study, but 12 females from the same subculture previously sent for deposit in the UCNS Collection, Davis, were examined. Also the holotype and 13 paratype slides of *P. amblycephalus* Reuver were available for examination. The paratype slides held a mixture of females and males of

neoamblycephalus plus 8 females of *amblycephalus* which I judge to be *P. projectus*. Twenty-six other collections listed below also were identified as *P. projectus*.

The principal characters which distinguish this species are total length of the female, stylet length, position of vulva, shapes of head and the tail. The head is set off by a slight narrowing to conoid sloping sides that appear smooth, without annulation and with truncate lip region. The tail is relatively broadly conoid, usually with a bluntly rounded terminus. Often there is a slight indentation on the dorsal surface near the tail tip giving a coarse digitate appearance. The spermatheca is also useful in that it has not been seen to contain spermatozoa and, although it is of moderate size, it does not stand out because of a rather granular nondescript appearance. The first three characters are reported as measurements which are included in the following:

25 females [Jenkins' original description (7)]: L = .37 (.29-.48) mm; a = 19 (16-21); b = 4.0 (3.5-4.9); c = 15 (11-20); V = 84 (83-87); stylet = 32 (25-37) μm .

9 females (Tarjan from type subculture): L = .36 (.30-.43) mm; a = 22 (20-23); b = 3.7 (3.5-4.0); c = 13 (11-15); V = 83 (82-84); stylet = 27 (25-29) μm . For L and stylet length 35 females mounted in formaldehyde were measured.

13 females (UCNS Collection from type subculture): L = .39 (.34-.43) mm; a = 21 (17-25); b = 4.2 (3.6-5.0); V = 84 (82-85); stylet = 27 (25-30) μm .

10 females (Thorne and Smolik from Devil's Lake): L = .35-.42 mm; a = 19-22; b = 3.6-4.3; c = 13-18; V = 83-88; stylet = 28-32 μm .

8 females (Devil's Lake, slide 8f measured at UCD): L = .33 (.28-.35) mm; a = 18 (16-22); b = 3.9 (3.5-4.1); V = 84 (83-85); stylet = 28 (27-29) μm .

8 females (*P. amblycephalus*, Reuver): L = .40 (.32-.43) mm; a = 23 (20-27); b = 4.1 (3.5-4.8); c = 16 (14-19); V = 85 (84-86); stylet = 30 (28-32) μm .

The above figures closely resemble those of the other 26 collections and the specimens have similar head and tail morphology. The stylet usually averages 27 or 28 μm , with a total range most often within 25-30 μm , occasionally as high as 32 μm . None was found longer than 32 μm or up to the 37- μm size reported by Jenkins (7). The collections were taken from the following host plants and

localities: California—lettuce, Salinas; moss, Half Moon Bay; strawberry, Morgan Hill and Santa Cruz County; carnation, Santa Cruz and Los Angeles; home garden, Oakland; bean, Oxnard; rape, Betteravia; also from grass soil, Williams, Arizona; cactus and *Pinus* sp., Idaho Springs, Colorado; trefoil, Beltsville, Maryland; grass, La Guardia Airport, New York; alfalfa, Hopkinton, New York; Birdsfoot trefoil, Spencerport, New York; teasel, Molalla, Oregon; mint, Oregon; virgin soil, Cedar City, Utah; pine near Mt. Vernon Highway, Alexandria, Virginia; cabbage, Dalveen, Australia; peach, Gosford, Australia; sod, Ottawa, Canada; sod, Blackwell, Canada; strawberry, Proszowice, Poland.

Paratylenchus bukowinensis
Micoletzky, 1922

Redescription of the holotype by Loof and Oostenbrink (10) gives more detail on this species. Apparent absence of a post-uterine branch is consistent with most other members of this genus. Determination of the stylet length with more certainty as 24 μm (anterior part 17 μm) was also important.

A collection made by M. Brzeski from a celery field at Szczesliwice, near Warsaw, Poland has been identified here as *P. bukowinensis* with the following measurements: (4 females): L = .33 (.28-.38) mm; a = 22 (20-23); b = 3.8 (2.9-4.3); V = 82 (81-84); stylet = 24 (23-26) μm ; prorhabdion = 16 (14-17) μm ; excretory pore = 72 (68-80) μm . Head rounded with distinct annulations. Rounded submedian lobes protrude very slightly. Spermatheca large rounded, filled with spermatozoa. Vulvar flaps small and inconspicuous. Tail evenly conoid, curved slightly ventrad, ending in a rounded to finely-rounded terminus. Males have not been described for this species.

Paratylenchus lepidus n. sp.
(Fig. 19-21)

Paratypes (21 females): L = .33 (.28-.40) mm; a = 25 (23-31); b = 4.0 (3.4-4.6); c = 14 (11-16); V = ³¹⁽²³⁻⁴⁷⁾82 (80-84); stylet = 25 (22-27) μm ; prorhabdion = 16 (14-18) μm ; excretory pore = 75 (69-82) μm .

Holotype (female): L = .30 mm; a = 26; b = 3.7; c = 11; V = ¹¹81; stylet = 22 μm ; prorhabdion = 16 μm ; excretory pore = 72 μm . Body an open 'C' shape after fixation, slightly more curved ventrad posterior to vulva (some paratypes are almost straight to vulva then curve more than 90 degrees between vulva and terminus). Body annules distinct up to base of sclerotization of head, but no distinct annules on head. Head rounded. Stylet knobs squared-off or slightly posteriorly directed, but not anchor-shaped. Dorsal esophageal gland orifice about 5 μm from stylet knobs (5-6 μm in some paratypes). Hemizonid occupies about 3 annules immediately anterior to excretory pore at level of anterior part of posterior bulb. Esophago-intestinal valve small, round. Ovary outstretched. Spermatheca ovoid, prominent, on right latero-ventral side, with small spermatozoa. Vulvar flaps large, rounded. Tail tapers gradually to a finely rounded terminus giving a slender conoid profile. Body annules distinct, averaging 1.1-1.3 μm wide. Four incisures in lateral field, inner two slightly less distinct than outer two.

Male: Unknown.

Holotype: Female, collected 5 November 1960 by C. A. Loos, slide number 1232, UCNS Collection, Davis, California.

Paratypes: 20 females same data as holotype deposited as follows: 10 females UCNS Collection, Davis, California; 2 females each at UCNS Collection, Riverside, California; National Nematode Collection, IARI, New Delhi, India; USDA Nematode Collection, Beltsville, Maryland; Nematology Department, RES, Harpenden, England; PD, Wageningen, The Netherlands.

Type host: Tea, *Thea sinensis* L.

Type locality: Balangoda Tea Estate, Balangoda, Sri Lanka.

Diagnosis: This species is most closely related to *P. bukowinensis* from which it differs in its slender, conoid tail shape and large vulvar flaps.

Additional collection: 13 females: L = .32 (.29-.37) mm; a = 27 (23-31); b = 3.8 (3.5-4.6); V = 82 (80-83); stylet = 25 (23-28) μm ; prorhabdion = 16 (14-17) μm ; excretory pore = 68 (66-75) μm . These specimens were collected by M. T. Hutchinson in September 1959 from soil about tea plants at the Ferham Estate, Talawakelle, Sri Lanka. They conform very closely with the type specimens in measurements and morphology.

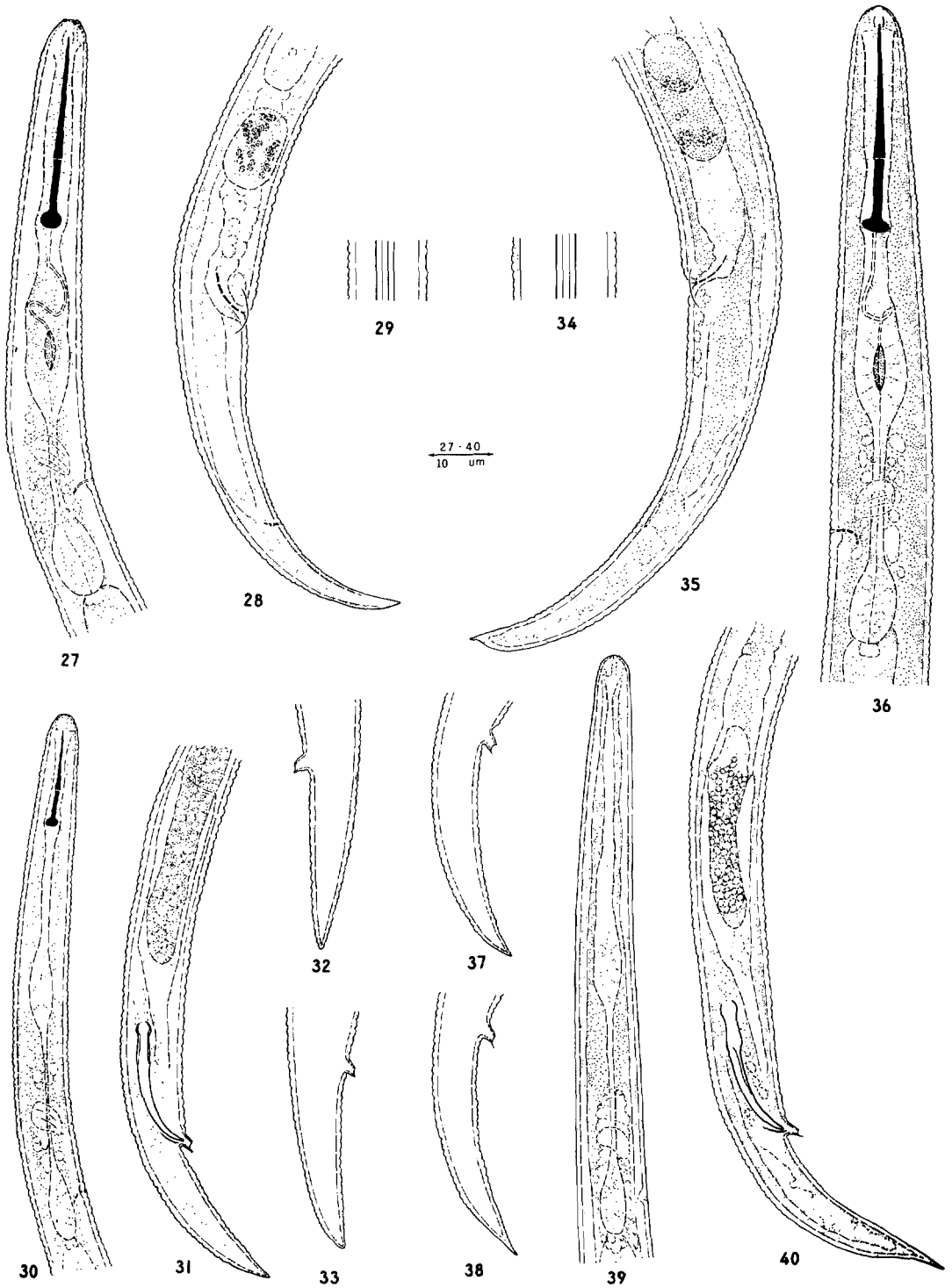


FIG. 27-40. 27-31) *Paratylenchus baldaccii* n. sp.; 32-33) *Paratylenchus neoamblycephalus*; 34-40) *Paratylenchus ciccaronei* n. sp.

Paratylenchus neoamblycephalus

Geraert, 1965

(Fig. 32-33)

This species was first described as *P. amblycephalus* by Reuver (14), but the population studied by Reuver was in fact a mixture of two species. The description and illustrations were based on the predominantly represented species which made up more than 80% of the population, but Reuver selected as holotype a female specimen which later proved to be *P. projectus*. Geraert (5) selected a suitable holotype for the principal species and proposed the name, *Paratylenchus neoamblycephalus*.

I had the opportunity of examining all the type slides designated by Reuver as 1₄-1₁₃ plus four others deposited at UC Davis. Eight female specimens identifiable as conspecific with the holotype of *P. amblycephalus* and reported above to be synonymous with *P. projectus* were found along with 40 females and 20 males of *P. neoamblycephalus*. Two other slides from soil about pear trees in the type locality had the same mixture of the above two species.

Measurements from 32 of the *P. neoamblycephalus* females were similar to those reported by Geraert, but showed a slightly wider range of L = .39 (.34-.48) mm and V = 82 (80-84). The stylet range of 30 (27-32) μ m was exactly the same.

Other collections of *P. neoamblycephalus* were found in an extensive survey of prune orchards in California by Lownsbery et al. (11) which showed *Paratylenchus* spp. in 67% of the 97 prune orchards sampled and *P. neoamblycephalus* the most common species. In addition it is identified in California from soil about apricot, Greenfield, Monterey County; home garden, San Francisco; *Ulmus americana* L., University of California Berkeley campus; plum on peach root, Newcastle; rose, Alameda County; soil and moss near walnut, Tilden Regional Park, Contra Costa County; fig, Vacaville; *Laurus nobilis* L., Berkeley; *Umbellularia californica* Nutt., University of California Davis campus; apple and pear, Watsonville; cypress, Berkeley; *Arctostaphylos* sp. and *Aesculus californica* (Spach) Nutt., Mix Canyon near Vacaville; grapevine, Acampo; peach, Hanford; also from soil about pine, between Mexico City and Toluca, Mexico; apricot, Sde Boker, Israel; apple, Tzuba, Israel; tea, Balanoor

Estate, Balehonnur District, Karnataka, India.

A collection made by H. J. Jensen from soil about the roots of native (?) walnut near Moraga, Contra Costa County, California held over 100 females and two males that resemble *P. neoamblycephalus* in most characteristics. The females differ in having a shorter stylet [26 (23-29) μ m] and a more anteriorly located vulva [V = 80 (79-82)]. These figures are just enough outside the range of *P. neoamblycephalus* to suggest a different species but overlap leaving doubt they are in fact a separate species. Most of the specimens are poorly fixed and it is concluded no decision should be made on this collection until more and better fixed material can be obtained.

Paratylenchus ciccaronei n. sp.

(Fig. 34-40)

Paratypes (21 males): L = .37 (.33-.42) mm; a = 34 (31-38); b = 4.3 (4.0-4.7); c = 10 (9-12); spicules = 22 (18-25) μ m; gubernaculum = 4 (3-5) μ m; T = 32 (27-35); excretory pore = 78 (72-88) μ m.

Paratypes (21 females): L = .38 (.32-.41) mm; a = 27 (20-32); b = 4.0 (3.6-4.2); c = 11 (10-13); V = ³²⁽²⁷⁻³⁸⁾80 (79-83); stylet = 31 (27-34) μ m; prorhabdion = 20 (18-23) μ m; excretory pore = 80 (70-87) μ m.

Holotype (male): L = .39 mm; a = 32; b = 4.3; c = 11; spicules = 25 μ m; gubernaculum = 4 μ m; T = 28; excretory pore = 83 μ m. Body after fixation curved slightly ventrad to cloaca, then tail curves almost 90 degrees ventrad. Head rounded, sclerotization light. Annules on head too fine to resolve with certainty. Stylet lacking. Esophagus degenerate, but outline of median bulb, isthmus and posterior bulb visible. Excretory pore at level of hemizonid opposite posterior bulb. Testis outstretched (one paratype has a flexure 28 μ m long). Spicules curved slightly. Anal sheath with prominent projection on posterior edge. Tail narrows to give a very slender conoid outline narrowing more so in the last 10 μ m, ending in a filiform tip with an acute terminus. Body annules averaging 0.8-1.6 μ m wide. Lateral field with four incisures, outer two distinct, inner two faint.

Allotype (female): L = .39 mm; a = 29; b = 4.0; c = 11; V = ²⁹81; stylet = 32 μ m; prorhabdion = 20 μ m; excretory pore = 82 μ m. Body an open 'C' shape after fixation.

Head rounded, cephalic framework weakly developed, guiding apparatus of stylet appears as two dark rods. Stylet robust with slightly posteriorly directed knobs. Dorsal esophageal gland orifice not seen (in some paratypes 6-7 μm from knobs). Excretory pore immediately anterior to hemizonid opposite posterior end of isthmus. Esophago-intestinal valve prominent, lobed. Ovary outstretched, spermatheca a long, oval shape and full of spermatozoa. Posterior edge of vagina with a rounded protuberance, but not a definite post-uterine branch. Vulvar flaps rounded. Tail narrows evenly with a long very slender outline; curves dorsally near tip to give a slight digitate appearance then a very finely rounded almost acute terminus. Body annules average 1.2-1.5 μm wide. Lateral field with four incisures, outer two more prominent than inner two.

Holotype: Male, collected by D. J. Raski, 24 July 1962, slide number 1391, UCNS Collection, Davis, California.

Allotype: Female, same data as holotype, slide number 1392, UCNS Collection, Davis, California.

Paratypes: 28 males, 31 females, 22 juveniles same data as holotype deposited as follows: 23 males, 26 females, and 17 juveniles UCNS Collection, Davis, California; 1 male, 1 female, and 1 juvenile each at UCNS Collection, Riverside, California; National Nematode Collection, IARI, New Delhi, India; USDA Nematode Collection, Beltsville, Maryland; Nematology Department, RES, Harpenden, England; PD, Wageningen, The Netherlands.

Type host: *Laurus* sp.

Type locality: Dolceacqua, Italy.

Diagnosis: This species is most closely related to *P. neoamblycephalus* from which it differs in the more attenuated tail shape of both male and female in *P. ciccaronei*; and the longer male tail [$c = 10$ (9-12) in *P. ciccaronei* vs. 13 (11-13) in *P. neoamblycephalus*].

This species is named in honor of Professor Antonio Ciccarone, former Director of the Istituto di Patologia Vegetale, Bari, Italy.

Paratylenchus nawadus

Khan, Prasad and Mathur, 1967

One paratype slide with 8 females, 1 male and 2 juveniles was sent for this study on loan from the National Nematode Collection, IARI, New Delhi, India. The 8 female

paratypes were measured and found to fit very closely the figures reported in the original description (9). They also were found to have a head outline with submedian lobes near the oral aperture which protrude more markedly than illustrated in the original description.

Three other collections from Thailand have been identified as *P. nawadus* with the following measurements:

21 females (Thonburi): $L = .35$ (.27-.39) mm; $a = 23$ (19-26); $b = 4.2$ (3.5-4.8); $c = 14$ (12-16); $V = {}^{30(24-51)}79$ (77-83); stylet = 26 (23-29) μm ; prorhabdion = 18 (14-20) μm ; excretory pore = 66 (57-75) μm . These specimens were collected by S. A. Sher from soil about roots of tangerine.

2 females (Bangkhen): $L = .28-.30$ mm; $a = 19$; $b = 4.0$; $c = 14$; $V = 81-83$; stylet = 23-37 μm ; prorhabdion = 16-18 μm . These were collected by S. A. Sher from *Butea frondosa* Roxb.

4 females (Tamay, Kratumban): $L = .35$ (.30-.39) mm; $a = 22$; $b = 3.8-3.9$; $V = 80$ (77-84); stylet = 27 (25-29) μm ; prorhabdion = 18 (16-20) μm . These were collected from grapevine soil by S. A. Sher.

These females from Thailand have a stylet larger than the range of the types of *P. nawadus* and a 'V' value slightly lower, but more closely resemble *P. nawadus* than any other species.

Paratylenchus mexicanus n. sp.

(Fig. 41-48)

Paratypes (23 females): $L = .35$ (.31-.39) mm; $a = 20$ (14-26); $b = 4.0$ (3.6-4.3); $c = 16$ (13-20); $V = {}^{44(35-55)}85$ (83-87); stylet = 28 (25-30) μm ; prorhabdion = 18 (15-20) μm ; excretory pore = 81 (75-90) μm .

Holotype (female): $L = .34$ mm; $a = 23$; $b = 3.8$; $c = 14$; $V = {}^{40}85$; stylet = 29 μm ; prorhabdion = 21 μm ; excretory pore = 76 μm . Body narrows only slightly towards anterior end, head bluntly rounded, almost hemispherical, with definite annulation. Spear well-developed, knobs posteriorly directed. Esophago-intestinal valve rounded. Excretory pore at same level as hemizonid at anterior end of posterior bulb. Ovary outstretched; spermatheca prominent, ovoid, filled with large spermatozoa (obscure and empty in some paratypes). Vulvar flaps prominent, rounded. Tail, narrows only slightly with definite annulation almost to terminus which is bluntly rounded, almost

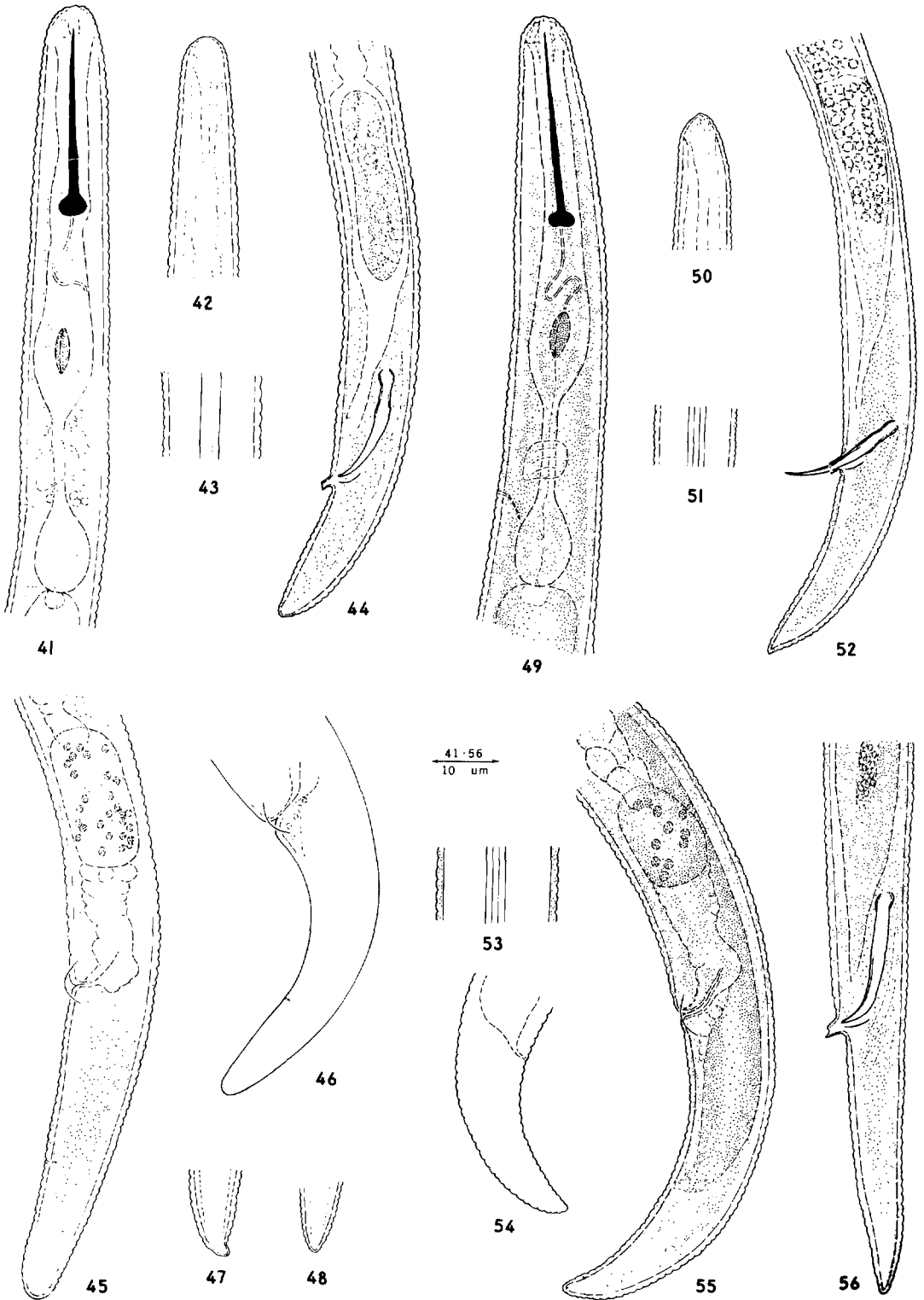


FIG. 41-56. 41-48) *Paratylenchus mexicanus* n. sp.; 49-55) *Paratylenchus nanus*; 56) *Paratylenchus tenuicaudatus*.

hemispherical (bluntly conoid in some paratypes). Body annules average 1.5 μm wide. Lateral field with four prominent incisures, inner two slightly less prominent than outer two.

Allotype (male): L = .37 mm; a = 29; c = 15; spicules = 21 μm ; gubernaculum = 4 μm ; T = 44; excretory pore = 79 μm . Body narrows slightly in anterior part, head bluntly rounded, almost hemispherical, with definite annulations. Esophagus degenerate, stylet absent. Excretory pore at same level as hemizonid. Testis outstretched, packed with large spermatozoa in posterior region. Spicules only slightly curved. Anal sheath protrudes but without projection on posterior edge. Tail short, terminus bluntly conoid, annulations definite almost to tip.

Holotype: Female, collected 28 December 1960 by D. J. Raski, slide number 1235, UCNS Collection, Davis, California.

Allotype: Male, same data as holotype, slide number 1236, UCNS Collection Davis, California.

Paratypes: 29 females, 5 juveniles same data as holotype deposited as follows: 23 females, 2 juveniles UCNS Collection, Davis, California; 1 female each at UCNS Collection, Riverside, California; National Nematode Collection, IARI, New Delhi, India; USDA Nematode Collection, Beltsville, Maryland; 1 female, 1 juvenile Nematology Department, RES, Harpenden, England; 2 females, 2 juveniles PD, Wageningen, The Netherlands.

Type habitat: Soil about California Buckwheat, *Eriogonum fasciculatum* Benth. and Laurel Sumac, *Rhus laurina* Nutt. in T. and G.

Type locality: Five miles north of Ensenada on Highway 101, Baja California, Mexico.

Diagnosis: This species is most closely related to *P. nanus* from which it differs in the bluntly rounded tail of the female (subacute in *P. nanus*) and more posterior vulva in *P. mexicanus* [V = 85 (83-87) vs. 83 (82-85) in *P. nanus*].

Paratylenchus nanus

Cobb, 1923

(Fig. 49-55)

The description of this species by Cobb (1) was based on specimens from two different localities, one a collection by 'Dr. Young' from Devil's Lake, North Dakota, and another by J. R. Christie from Falls Church,

Virginia. Cobb included one formula for a preserved female and another for a living female. Some of Cobb's original notes were available to Tarjan (15) including formula measurements of a single female from North Dakota and three females from Virginia. Tarjan also found Cobb's type specimens for study including a single female from North Dakota and one female plus the anterior part of another from Virginia. He selected the specimen from Virginia as lectotype of *P. nanus*.

Thorne and Smolik (17) redescribed *P. nanus* from specimens collected in 1968 near Devil's Lake, N.D. and designated the specimens as topotypes.

The action of Tarjan designating a lectotype preceded the report of Thorne and Smolik and firmly established the Falls Church species as *P. nanus*. In my opinion, this was a sound decision because it appears Cobb based his description and illustrations principally on the Virginia specimens and it is distinct from the North Dakota species. As indicated under *P. projectus*, it is my belief the Devil's Lake specimens belong to that species.

In 1958, J. R. Christie made another collection of specimens from grass soil from the Falls Church, Virginia, type locality and made them available for this study. These fit the description of *P. nanus* very closely and are considered topotypes which permit still further redescription of this species.

Topotypes (18 females) (Falls Church, Virginia): L = .33 (.27-.35) mm; a = 19 (17-21); b = 3.7 (3.2-3.9); c = 14 (13-16); V = ²⁸⁽²¹⁻³⁶⁾83 (82-85); stylet = 29 (27-31) μm ; prothabdon = 19 (17-20) μm ; excretory pore = 70 (65-74) μm . Body an open 'C' shape after fixation. Head not set off, slightly rounded, in some specimens almost straight sloping sides to rounded anterior end. Submedian lobes very small and close to oral aperture. Lateral lips protrude slightly to give a rounded outline, not truncate. Four or five distinct annules on head. Stylet with posteriorly directed knobs. Ovary outstretched, spermatheca rounded to ovate, filled with spermatozoa only in some of the specimens. Body annules distinct almost to subacute terminus. Lateral field with four incisures equally distinct.

These specimens have a lesser total length than the figures given by Cobb and Tarjan, but the greater dimensions are from Cobb's fixed specimens. This may well be the result of the drastic fixatives used by Cobb. His

measurements for a living specimen show $L = .36$ mm and $V = 83$. The stylet length of the topotypes is less than the figures given by Tarjan based on Cobb's formulae. However calculations from Cobb's formulae are probably high because they appear to include the distance from the end of the body to the anterior tip of the stylet.

P. nanus also has been identified in 14 other collections in three of which males were found.

15 females (Visalia, California): $L = .37$ (.30-.46) mm; $a = 24$ (20-28); $b = 3.7$ (3.2-4.3); $c = 12$ (11-14); $V = 83$ (82-84); stylet = 28 (25-30) μm ; prorhabdion = 17 (15-19) μm ; excretory pore = 92 (86-103) μm . These closely resemble the topotype females though the tail in some specimens tends to be more blunt; in others the tail is slightly indented near the terminus. Spermatheca present but without spermatozoa in most specimens.

2 males (Visalia, California): $L = .37$ -.39 mm; $a = 28$; $b = 4.3$; $c = 10$ -11; spicules = 20-22 μm ; gubernaculum = 4 μm ; $T = 28$ -35; excretory pore = 87-93 μm . Body curves only slightly ventrad including tail. Body narrows to a finely rounded head similar to females but smaller. Esophagus degenerate without clearly identifiable structure. Gonad outstretched with large testicular gland. Tail narrows to a slender conoid shape with rounded terminus. Lateral field with four incisures averaging 0.9 μm apart, occupying 23% of body width.

This collection was made 20 February 1974, by Vern Marble from an alfalfa field (Moapa type) with chickweed [*Stellaria media* (L.) Cyr.] near Visalia, Tulare County, California.

4 females (Berkeley, California): $L = .37$ (.34-.39) mm; $a = 23$ (20-25); $b = 3.7$ (3.4-4.0); $V = 82$ (81-84); stylet = 30 (29-32) μm ; excretory pore = 79 (74-82) μm . These females are very similar to the topotypes except one with a more pointed, conoid tail.

1 male (Berkeley, California): $L = .37$ mm; $a = 32$; $c = 13$; spicules = 22 μm ; gubernaculum = 4 μm ; excretory pore = 76 μm .

This collection was made by D. J. Raski in March 1952 from soil about roots of *Pinus* sp. near Berkeley, California.

11 females (New Zealand): $L = .31$ (.28-.35) mm; $a = 23$ (18-26); $b = 3.7$ (3.3-4.0); $c = 15$; $V = 83$ (82-85); stylet = 27 (23-32) μm ; prorhabdion = 17 (15-23) μm ; excretory pore = 69 (65-73) μm . The body of these females

curls more tightly in some specimens especially posterior to the vulva. Also the tail outline seems a bit more acute, but in general resemble the types so closely these differences are judged not to be indicators of a different species.

2 males (New Zealand): $L = .31$ -.32 mm; $a = 25$ -28; $c = 13$ -15; spicules = 24 μm ; gubernaculum = 4 μm ; excretory pore = 57 μm . These are similar to the above males except the tail curves slightly dorsad. This collection of 39 females and 2 males was made at the top of Porter's Pass, New Zealand.

Other collections in California: alfalfa near Manteca; alfalfa (cultivar El Unica) in the Pixley-Tipton area; garbanzo bean, Santa Maria; soil about redwoods and *Umbellularia californica* Nutt. on stream bank near Felton; grass of meadow in Yosemite Park; sycamore, *Platanus racemosa* Nutt., near Santa Barbara; soil about roots of *Pinus ponderosa* Dougl. and *Chamaebatia foliolosa* Benth. near Volcano, Amador County; also from alfalfa, Le Roy, Jefferson County, New York; red clover, Allegheny, Cattaraugus County, New York; loganberry near Aurora, Oregon; soil about roots of grass at Arlington Farms (near Falls Church), Virginia; *Carex* sp. at Guanella Pass, Colorado; grassland near Matador, Saskatchewan, Canada; citrus soil, Curlwaa, NSW, Australia.

P. nanus is closely related to *P. projectus* and the characters most important in distinguishing these two species are: (i) the head region which is truncate, often set off by slight but distinct narrowing, annules indistinct in *P. projectus*, head rounded with distinct annules, not set off, in *P. nanus*; (ii) vulva more posterior in *projectus* (average V value generally 84 to 85 with total range of 83-88 vs. *P. nanus* with an average most generally 82-83 and a total range of 80-85); (iii) tail bluntly rounded, often digitate in *P. projectus*; subacute in *nanus*; (iv) spermatheca lacking or poorly developed in *P. projectus* as contrasted with *P. nanus* with distinct spermatheca sometimes filled with spermatozoa. Males are rare in *P. nanus* and as noted above have been found in three collections, none have been definitely reported and illustrated for *P. projectus*.

Paratylenchus tenuicaudatus

Wu, 1961

(Fig. 56)

Four collections of this species from the

United States were studied, three of which contained males described below for the first time.

One collection held 40 females and 11 males from soil about roots of grass and moss in a desert wash near Paradise Valley, Phoenix, Arizona, taken by R. Mankau on 25 January 1970, with the following measurements:

14 females (Arizona): L = .42 (.31-.51) mm; a = 26 (22-30); b = 4.4 (3.9-5.1); c = 12 (10-15); V = ³²⁽²⁷⁻⁴⁵⁾80 (78-81); stylet = 27 (24-29) μ m; prorhabdion = 17 (15-19) μ m; excretory pore = 87 (68-99) μ m. These are slightly smaller than the types described by Wu (19) which covered a range of .47 (.38-.60) mm. The stylet also is slightly smaller [types were 28 (25-32) μ m], otherwise these females resemble *P. tenuicaudatus* very closely.

11 males (Arizona): L = .38 (.34-.45) mm; a = 30 (26-33); c = 10 (9-12); spicules = 22 (19-26) μ m; gubernaculum = 4 (4-5) μ m; T = 39 (39-40); excretory pore = 78 (71-87) μ m. Body tapers gradually to bluntly rounded head which is not set off. Sclerotization delicate. Esophagus degenerate, no definite structure except remnant of median bulb seen in some specimens. Hemizonid occupies about two body annules at same level or immediately anterior to excretory pore. Testis outstretched, with small spermatozoa. Testicular gland large, about 41-43 μ m long and well-developed. Anal sheath prominent, posterior margin projects more than the anterior, but is not recurved or hooked. Tail long, body narrows definitely behind cloaca then tapers only gradually giving a slender outline with blunt rounded terminus. Some specimens taper more abruptly near tip to a finely rounded terminus. Body annules average 1.3-1.6 μ m in width. Lateral field obscure.

Additional collections: 7 females (Minnesota): L = .44 (.37-.56) mm; a = 28 (25-29); b = 4.1 (3.6-4.6); V = 80 (78-83); stylet = 29 (27-30) μ m; prorhabdion = 18 (16-19) μ m; excretory pore = 91 (81-109) μ m.

6 males (Minnesota): L = .41 (.37-.44) mm; a = 26 (23-28); c = 10 (9-11); spicules = 22 (20-23) μ m; gubernaculum = 4 (3-5) μ m; T = 28 (21-33); excretory pore = 78 (73-89) μ m. There were 61 females and 9 males in this collection made by S. A. Sher 10 September 1973 from soil about roots of elm and cottonwood trees on the bank of the Mississippi River near St. Paul, Minnesota.

10 females (Louisiana): L = .38 (.34-.42)

mm; a = 24 (18-28); b = 4.0 (3.8-4.5); c = 14 (13-16); V = 81 (78-86); stylet = 26 (23-28) μ m; prorhabdion = 16 (15-18) μ m; excretory pore = 83 (76-89) μ m. This collection was made by J. Martin 4 September 1951, from soil about roots of strawberry near Hammond, Louisiana.

17 females (California): L = .50 (.45-.61) mm; a = 26 (21-30); b = 4.2 (3.9-4.6); V = 81 (80-82); stylet = 29 (29-30) μ m.

2 males (California): L = .40 (.34-.45) mm; a = 30 (29-31); c = 12 (11-12); excretory pore = 77 (71-82) μ m. This collection was made from vineyard soil near Clovis, California.

Paratylenchus dianthus
Jenkins and Taylor, 1956

This species (8) was synonymized with *P. curvatus* by Tarjan (15). It was later assigned by Geraert (5) to a '*P. curvatus*-group' along with *P. hamatus*, *P. nainianus* and *P. projectus*. The action taken below to place *P. curvatus* in *species inquirendae* again opens the question of the status of *P. dianthus*.

Type material has not been available for this study but a number of collections assembled here have been identified as *P. dianthus*. On the basis of these specimens it is concluded *P. dianthus* should be restored as a valid species.

The principal characters distinguishing this species are: (i) the average length of female which varies from .33 to .37 mm (with a total range of .30-.44 mm); (ii) length of female stylet with an average that varies from 23 to 25 μ m and a total range of 21-29 μ m; (iii) position of the vulva in which the average value for 'V' varies from 83 to 84 and a total range of 81-87; (iv) female tail shape which is conoid with a rounded terminus; (v) female head rounded and slightly truncate; (vi) males present, relatively common; (vii) male stylet absent; (viii) male tail mostly straight, conoid with rounded terminus.

Collections which fit these characteristics are from carnation, College Park, Maryland; carnation, New Brunswick, New Jersey; carnation, Springfield, Ohio; carnation, Richmond, Indiana; parsnip, Wilson, Connecticut; chrysanthemum, Kirkwood, Missouri; sage, Monterey County, California; rose, Los Angeles, California; carnation, Los Angeles, California; lettuce, Stanthorpe, Queensland, Australia; Bridley, Mildura, Australia.

SPECIES INQUIRENDAE

Paratylenchus curvitus
van der Linde, 1938

There are no type specimens of *P. curvitus* preserved and available for examination and restudy. Tarjan reported (15) on collections made in the type locality of *P. curvitus* in which some species of *Paratylenchus* were found but none fitted the description of *P. curvitus*.

The extreme 'truncate cone' shape of the head as illustrated by van der Linde (18) appears to be unique but may be an effect of fixative and to some degree from flattening of the specimens. In addition the stylet length of the original *P. curvitus* is unknown. As Geraert (5) pointed out, 'the description gives a quarter of the esophagus (22.5 μm), the drawing a third (29.5 μm)'. Without reliable, accurate data on the shape of the head region and the stylet length it is not possible to compare this species with other known species.

Until future collections can establish topotype material it is best to designate *P. curvitus* as *species inquirendae*.

KEY TO PARATYLENCHUS SPP.
WITH STYLET < 38 μm ;
PARTS I AND II OF THIS STUDY

Asterisk (*) indicates name endings changed to agree with masculine gender of generic name.

1. Lateral field with 3 longitudinal incisures.....2.
Lateral field with 4 longitudinal incisures.....6.
2. V = 72 (69-73)
..... *minusculus* Tarjan, 1960.
V = 77-863.
3. Female stylet = 31 (28-33) μm .. *vandenbrandei* de Grisse, 1962.
Female stylet < 23 μm 4.
4. Female length = .34 (.27-.37) mm.....*aquaticus* Merny, 1966.
Female length < .26 mm5.
5. Female tail finely rounded; L = .18 (.17-.19) mm *humilis* Raski, 1975.
Female tail bluntly rounded, digitate; L = .22 (.20-.26) mm. *leptus* Raski, 1975.*
6. Tail serrated near terminus
- *serricaudatus* Raski, 1975.
Tail not serrated near terminus7.
7. Body of female appears smooth, annules indistinct .. *leiodermus* Raski, 1975.*
Body annules of female distinct8.
8. Tail of female with deep cleft
- *uncinatus* Samibaeva, 1966.
Tail of female without deep cleft9.
9. Female head with slight but definite constriction posterior to lip region ..
.....10.
Female head conoid, lips close to oral aperture projecting in a rectangular outline truncate in front13.
- Female head rounded to conoid-truncate15.
10. Female stylet = 19-28 μm11.
Female stylet = 29-39 μm12.
11. Female stylet = 20 (19-22) μm
..... *perlatus* Raski, 1975.
Female stylet = 24-28 μm
..... *arculatus* Luc and de Guiran, 1962.
12. Vulvar flaps absent
- *morius* Yokoo, 1970.
Vulvar flaps present
- *coronatus* Colbran, 1965.
13. Tail bluntly rounded
- *similis* Khan, Prasad and Mathur, 1967.
Tail mostly slender conoid, finely rounded to acute14.
14. Female length = .28 (.23-.34) mm.....
..... *italiensis* Raski, 1975.
Female length = .32-.43 mm
- ... *tateae* Wu and Townshend, 1973.
15. Female head with distinct depression near oral aperture, submedian lobes distinct, prominent16.
Female head rounded to truncate in front, submedian lobes obscure19.
16. Female stylet = 16 (15-18) μm
..... *colbrani* Raski, 1975.
Female stylet > 19 μm 17.
17. Female stylet = 27 (21-32) μm
..... *nainianus* Edward and Misra, 1963.
Female stylet = 22 (19-23) μm18.
18. Female length = .26 (.24-.28) mm; male unknown
- *obtusicaudatus* Raski, 1975.
Female length = .33 (.27-.39) mm; male tail conoid, c = 13-14
- *nawadus* Khan, Prasad and Mathur, 1967.
19. Female head conoid-truncate, slightly set off
-20.

- Female head round to rounded truncate, not set off 23.
20. Female tail finely conoid, rounded, often digitate *halophilus* Wouts, 1966. Female tail bluntly rounded or bluntly digitate 21.
21. Female stylet = 19 (18-20) μm *pesticus* Thorne and Malik, 1968. Female stylet > 25 μm 22.
22. Female tail bluntly rounded, not digitate; V = 79-80 *neonanus* Khan, Prasad and Mathur, 1967. Female tail often dorsally indented, digitate; V = 82-88 *projectus* Jenkins, 1956.
23. Female tail bluntly rounded 24. Female tail conoid, subacute to finely rounded 31.
24. Female stylet = 14-21 μm 25. Female stylet = 21-35 μm 28.
25. Female length = .21 (.19-.23) mm *breviculus* Raski, 1975. Female length > .25 mm 26.
26. V = 80 (78-81) *goldeni* Raski, 1975. V = 81-87 27.
27. Female stylet = 14 (13-16) μm ; male length = .31 (.29-.33) mm *variabilis* Raski, 1975. Female stylet = 18 (16-20) μm ; male length = .40 mm *alleni* Raski, 1975.
28. Female length = .23 (.20-.25) mm *salubris* n. sp. Female length > .29 mm 29.
29. V = 80 (78-82); male tail long, c = 10-12 *tenuicaudatus* Wu, 1961. V = 81-87; male tail shorter, c = 12-15 30.
30. Female tail broadly conoid with bluntly rounded, almost hemispherical terminus *mexicanus* n. sp. Female tail more slender conoid with rounded terminus *dianthus* Jenkins and Taylor, 1956.
31. Female stylet = 38 μm *paramonovi* Bagaturia and Solovyova, 1972. Female stylet < 35 μm 32.
32. Males unknown 33. Males known and described 34.
33. Female tail slender conoid; large vulvar flaps *lepidus* n. sp. Female tail broadly conoid; vulvar flaps small, inconspicuous *bukowinensis* Micoletzky, 1922.
34. Males with stylet 35.
- Males without stylet 39.
35. Female stylet < 24 μm 36. Female stylet > 27 μm 38.
36. Female stylet = 13 (12-14) μm *veruculatus* Wu, 1962. Female stylet > 19 μm 37.
37. Female length = .25 (.24-.27) mm *besoekianus* Bally and Reidon, 1931. Female length = .32 (.29-.35) mm *holdemani* n. sp.
38. Tail of male and female sharply conoid *baldaccii* n. sp. Tail of male and female conoid rounded *hamatus* Thorne and Allen, 1950.
39. Male tail sharply pointed 40. Male tail conoid-rounded 41.
40. Female stylet = 15-16 μm *vexans* Thorne and Malek, 1968. Female stylet = 31 (27-34) μm *ciccaronei* n. sp.
41. Female stylet < 24 μm 42. Female stylet > 23 μm 45.
42. V < 80 *longicaudatus* Raski, 1975. V > 80 43.
43. Female length > .30 mm *microdorus* Andr assy, 1959. Female length < .30 mm 44.
44. Female stylet averages 16-18 (total range = 14-21) μm ; tail evenly conoid with rounded terminus *minutus* Linford, 1949. Female stylet averages 20-22 (total range = 19-24) μm ; tail slender conoid, terminus finely rounded to acute *elachistus* Steiner, 1949.
45. Female length = .18-.26 mm *mimulus* n. sp. Female length > .26 mm 46.
46. Female tail subacute *nanus* Cobb, 1923. Female tail slender conoid to finely rounded terminus *neoamblycephalus* Geraert, 1965.

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