Three new species of the genus *Pratylenchoides* from Germany (Tylenchida: Pratylenchidae)

A. Ryss & D. Sturhan

Ryss, A. & Sturhan, D. 2001. Three new species of the genus *Pratylenchoides* from Germany (Tylenchida : Pratylenchidae). *Zoosystematica Rossica*, **10**(1): 15-31.

Three new *Pratylenchoides* species from Germany are described: *P. acuticauda* sp. n. is recorded from a deciduous forest and river bank in Nordrhein-Westfalen, *P. arenicola* sp. n. from dune vegetation on the Isle of Sylt, North Sea, and *P. rivalis* sp. n. from river bank vegetation at several places in Germany and from forest soil in Åland, Finland.

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Introduction

Only four species of the genus *Pratylenchoides* Winslow, 1958 have been recorded from central and northern Europe: *P. crenicauda* Winslow, 1958; *P. laticauda* Braun & Loof, 1966; *P. magnicauda* (Thorne, 1935) Baldwin, Luc & Bell, 1983 and *P. maritimus* Bor & s'Jacob, 1966 (Bongers, 1989; Loof, 1991; Ryss & Sturhan, 1994).

An examination of *Pratylenchoides* specimens in the German Nematode Collection revealed the presence of a total of ten species in Germany, among them three new species are described in the present paper. One of the new species appears to be widespread on river bank vegetation. The second species is recorded from two localities, from a deciduous forest and a river bank, the third from one site with coastal vegetation.

Material and methods

Pratylenchoides specimens were isolated from soil samples collected between 1978 and 1992 by a sieving-decanting or centrifugation-flotation methods. The nematodes were killed and fixed in hot TAF and processed to glycerine by a modified slow method. All investigations were made on specimens mounted in dehydrated glycerine.

Pratylenchoides acuticauda sp. n.
(Figs 1-3; Tables 1, 2)

Holotype. ♀, **Germany**: Nordrhein-Westfalen, 4 km E of Lemgo (UTM MC96), beech-oak forest (*Fagus silvatica*, *Quercus robur*) with *Lamium maculatum* and grasses, very moist to wet soil on a slope, 24.XI.1980 (D. Sturhan). Slide deposited in the German Nematode Collection, Biologische Bundesanstalt, Institut für Nematologie und Wirbeltierkunde, Münster/Westf., Germany.

Paratypes. **Germany**: 11 ♀, 10 ♂ and 17 juv., same data as holotype; 10 ♀, 14 ♂ and 15 juv., Berge near Meschede, river bank vegetation (*Fraxinus excelsior*, *Urtica dioica*, *Heracleum sphondylium*, *Galium* sp. and grasses) near forest, sandy loam, 28.VII.1992 (D. Sturhan). Forty-six paratypes (14 ♀, 16 ♂, 16 juv.) are deposited in the same collection as holotype; 20 paratypes (5 ♀, 4 ♂, 11 juv.) in the Nematode Collection of the Zoological Institute, Academy of Sciences, St. Petersburg, Russia; 6 paratypes (1 ♀, 3 ♂, 2 juv.) in the Nematode Collection of the Agricultural University, Wageningen, The Netherlands; 5 paratypes (1 ♀, 1 ♂, 3 juv.) at the Nematological Department, University of California, Riverside, U.S.A.

Description. Female. Body almost straight with slight ventral curvature. Width of ten cuticle annuli 10-20 μm at mid-body. Cephalic region set off, anteriorly flattened, with rounded sides and four or five annuli anterior to basal plate of the moderately developed cephalic framework. Basal plate 1 μm thick; its posterior

extensions 2-3 μm long, extending over two annuli. Therefore number of cephalic annuli anterior to basal ring of cephalic framework combined with those along its posterior extensions, is six or seven. Anterior cephalids immediately behind posterior extensions of cephalic framework; posterior cephalids five to seven annuli behind anterior ones. Stylet base 5-6.5 μm wide, height of base 0.50-0.75 of its width; stylet knobs directed laterally, their anterior surface sloping near stylet shaft and concave laterally. Dorsal oesophageal gland orifice 4-4.5 μm from stylet base. Median bulb oval. Excretory pore one or two annuli behind hemizonid. Hemizonid two to three annuli wide. Hemizonion six to seven annuli behind hemizonid. Deirids at level of hemizonid. Oesophageal gland overlap may be absent to 4.8±1.03 (0-8) μm long, which is equal to 0.21±0.042 (0-0.38) of corresponding body diameter. The most common arrangement of oesophageal gland nuclei: dorsal gland nucleus anteriorly on dorsal side; first subventral gland nucleus slightly posteriorly on ventral side; second subventral nucleus posterior to the first one located on dorsal side. Oesophago-intestinal valve (cardium) pyriform, 5-9 μm long, 4-6 μm wide, situated at posterior end of the gland part of oesophagus, in center of the body or shifted to dorsal or ventral side. First subventral gland nucleus may be located at level of dorsal nucleus or above it; the second subventral nucleus may be located at level of the oesophago-intestinal valve. Both subventral nuclei sometimes located at the same level in posterior part of gland lobe. Lateral field with six lines at mid-body, four at deirid, four or six at the end of the oesophageal gland lobe, and four on tail. Outer bands of lateral field occasionally areolated on tail and at level of the oesophageal gland part. Central band usually with oblique additional lines in vulval region. Intestinal fasciculi present or indistinct. Spermatheca round to oval, axial. Sperm round, 1-1.5 μm in diameter. Preuteral gland consists of 15-16 cells usually arranged in three rows. Oviduct consists of 12-16 cells arranged in two or three rows. Tail tip variable from broadly rounded to pointed, occasionally concave dorsally, mostly coarsely and irregularly annulated. Six to fourteen tail annuli at tip distinctly (1.5-2 times) narrower than the adjoining tail annuli.

Holotype. Hemizonion six annuli behind hemizonid. Oesophago-intestinal valve 7 μm × 7 μm, rounded.

Male. Body straight or slightly curved dorsad; tail curved to dorsal side at level of cloaca. Width of ten cuticle annuli 12.5 (9-18) μm at mid-body. Cephalic region set off, rounded with straight anterior margin; with three to five annuli anterior to basal plate of the cephalic framework. Posterior extensions of the moderately developed cephalic framework 2 μm long, extending two or three annuli posteriorly. Therefore number of cephalic annuli situated anterior to cephalic framework plus those along its posterior extensions, is five to seven. Anterior cephalids immediately behind posterior extensions of cephalic framework; posterior cephalids five to seven annuli behind anterior cephalids. Stylet base 4.3 (3.5-5.0) μm wide, height of its base half of its width, stylet knobs round to anchor-shaped, directed laterally. Median bulb oval. Excretory pore located immediately behind hemizonid. Hemizonid two annuli wide. Hemizonion situated seven annuli behind hemizonid. Oesophageal gland overlap absent or up to 13 μm long, which is equal to 0.34±0.076 (0-0.73) of corresponding body diameter. Arrangement of oesophageal gland nuclei as in female. Glands often reduced, without distinct nuclei. Cardium 3.5 μm × 3.5 μm, rounded. Lateral field occupying 30-35 % of body diameter, not areolated, with six incisures, four incisures between oesophageal base and excretory pore. Deirid at level of excretory pore, surrounded by four lines. Intestinal fasciculi present. Caudal alae 66 (55-88) μm long, 10-22 μm wide, with crenate margins. Tail tip pointed, rarely bifurcate. Ratio caudal alae length to their width 4.0 (3.6-4.4). Clavicula of spicule 15%, conical part 59-61% of total spicule length. Sperm round, 1.0-1.5 μm in diameter.

Juveniles. Stage and sex of juveniles was identified using the genital primordium structure and position, as described for other Tylenchida (Hirschmann & Triantaphyllou, 1968; Roman & Hirschmann, 1969; Hirschmann, 1971; Ryss, 1981).

Fig. 1. *Pratylenchoides acuticauda* sp. n., female (A-F, K, holotype; G-J, L-Q, paratypes). **A,** general view; **B,** head; **C,** posterior part of oesophagus; **D,** posterior part of genital tract; **E,** tail; **F-Q,** tail terminus shape. Scale bar = 500 μm for A, 50 μm for B-G, 86 μm for H-R.

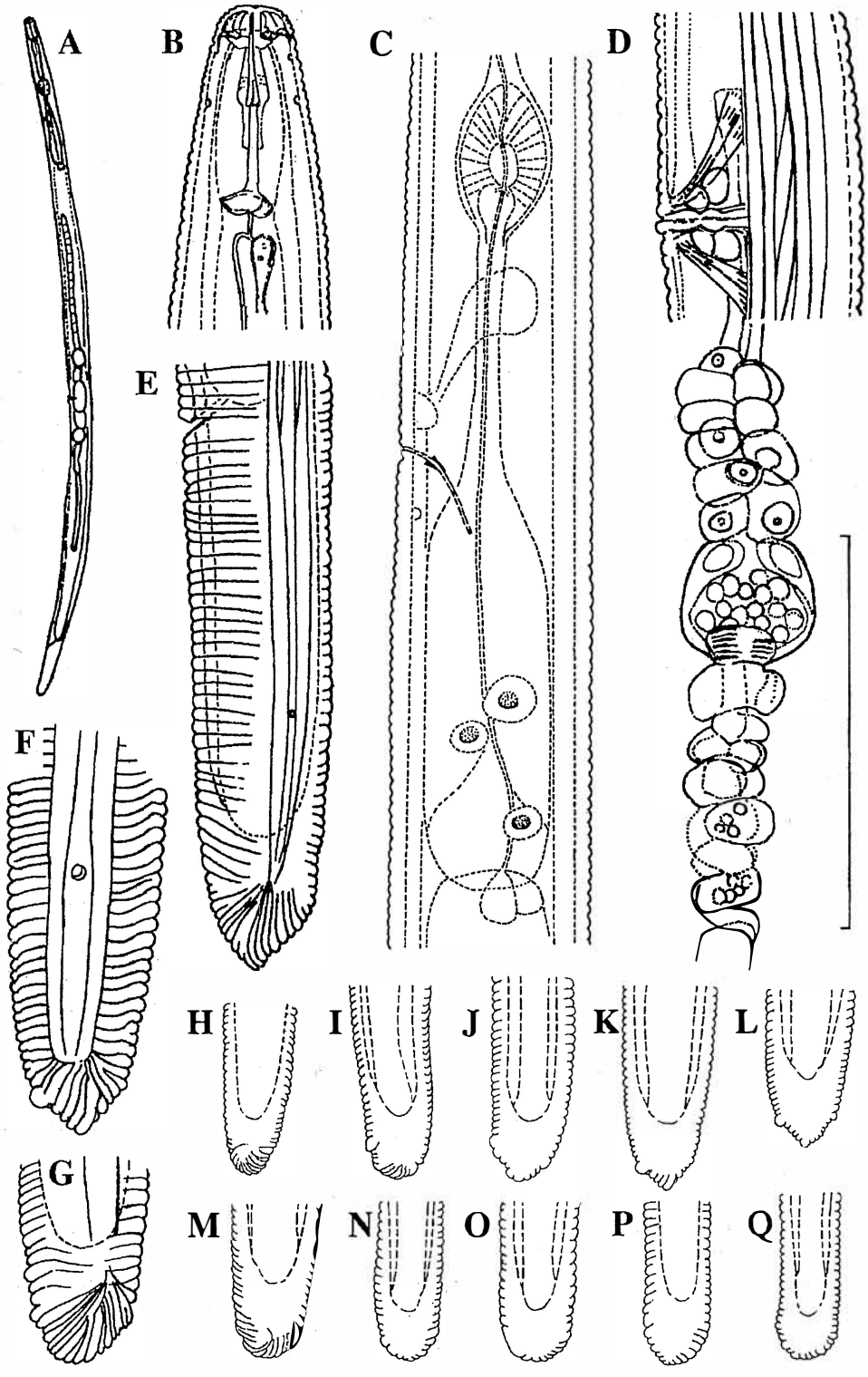
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Table 1. Measurements (in μm), morphometric ratios and other diagnostic characters of *Pratylenchoides acuticauda* sp. n. (Average, standard error, minimum and maximum are given for each value. Only minimum and maximum and average are given for values of restricted range).

Character	Holotype female	Paratypes	
		(females, n = 23)	(males, n = 23)
L	840	793±19.8 (640-970)	658±13.8 (480-810)
a	31.6	35.0±0.87 (28-45)	36.1±0.65 (30-40)
b	4.9	4.78±0.097 (3.8-6.0)	5.09±0.090 (4.3-5.8)
c	13.2	14.7±0.30 (12.0-17.4)	13.4±0.20 (11.6-15.8)
c'	3.2	3.26±0.086 (2.5-4.1)	3.61±0.107 (2.7-5.0)
V	56.4	57.2±0.37 (54-61)	–
Body width	26.5	22.8±0.60 (16-28)	18.3±0.39 (15-22)
Stylet length	24	22.9±0.22 (21-24.5)	21.0±0.24 (18-23.5)
MB	46.5	46.5±0.78 (43-54)	49.3±0.86 (42-59)
Spicule length	–	–	24.2±0.34 (21-26.5)
Gubernaculum length	–	–	8.3±0.30 (6-12.5)
Cephalic width	10.5	9.2±0.19 (7-10)	8.4±0.16 (6-10)
Cephalic height	3.5	3.7±0.06 (3-4.5)	3.7±0.09 (3-5)
Ratio: cephalic width to height	3	2.51±0.052 (2.0-3.2)	1.98±0.097 (1.2-2.6)
Median bulb length	16.0	16.9±0.60 (11-21)	14.2±0.25 (12.5-17)
Median bulb width	11.5	10.8±0.44 (8-14)	7.4±0.15 (6-9)
Ratio: median bulb length to width	1.40	1.58±0.05 (1.2 -2.0)	1.92±0.041 (1.6-2.3)
Excretory pore from anterior end	115	119.4±2.48 (88-131)	102.8±2.37 (73-125)
Gland part of oesophagus*	d+sv,sv,c	d+sv,sv,c; sv,d,sd,c; d,sv+sd,c; d,sv+sd+c	d+sv,sv,c or nuclei not seen
Oesophagus length	172	166±3.3 (133-201)	130±3.0 (95-156)
Spermatheca width	16-17	12.6±0.77 (8.5-16.5)	–
Ratio: spermatheca length to width	0.7	0.84±0.04 (0.6-1.0)	–
Tail length	64	54.3±1.34 (43-66.5)	49.4±1.21 (37.5-67)
Tail annuli	46	41.9±1.6 (30-63)	46 (34-51)
Phasmid from tail tip	26-29	24.4±1.08 (17.5-34)	23.9±0.82 (18-34)
Ratio: distance phasmid-anus to tail length	0.58	0.54±0.022 (0.29-0.64)	–
Annuli between phasmid and tail tip	23-24	22.9±1.0 (17-26)	–
Hyaline part length	13.5	11.3±0.46 (6.5-15.5)	13.4±0.56 (9-18)
Hyaline part width	13	12.5±0.40 (9-16)	5.0±0.16 (3-6.5)
Ratio: hyaline part length to width	1.0	0.91±0.042 (0.6-1.3)	2.77±0.158 (2.0-4.5)
Ratio: tail length to hyaline part length	4.7	4.91±0.181 (3.5-6.7)	3.79±0.143 (2.7-5.3)
Ratio: tail length to distance from phasmid to tail tip	2.2-2.5	2.26±0.098 (1.4-2.7)	2.09±0.056 (1.7-2.9)
Ratio: tail width to hyaline part width	1.4	1.33±0.033 (1.0-1.6)	2.84±0.143 (2.0-5.1)

* Arrangement of nuclei of glandular part of oesophagus from anterior to posterior end of a glandular part: c –oesophago-intestinal valve (cardia); d – dorsal gland nucleus; sv – subventral gland nucleus located ventrally in glandular part . Arrangement "d+sv" means that dorsal gland nucleus and subventral gland nucleus are located at the same level; "d,sv,sv,c" – dorsal gland nucleus, subventral gland nuclei and oesophago-intestinal junction are located one after another.

Table 2. Measurements (in μm) and ratios of paratype juveniles of *Pratylenchoides acuticauda* sp. n. (Average, standard error, minimum and maximum are given for each value).

Character	J2 (n = 13)	J3 female (n = 10)	J4 female (n = 6)	J3 male (n = 1)	J4 male (n = 1)
L	325±14.4 (280-410)	445±11.9 (390-510)	575±23.1 (510-690)	450	660
a	22.6±0.72 (16-25)	27.8±0.70 (25-31)	29±1.0 (26-33)	28	33
b	2.66±0.114 (1.6-3.2)	3.37±0.078 (3.0-3.7)	3.95±0.149 (3.6-4.7)	3.3	4.4
c	9.5±0.47 (6.1-12.1)	12.4±0.81 (10.3-18.7)	12.7±0.33 (11.3-13.9)	10.9	12.3
c'	3.62±0.172 (2.4-4.5)	3.29±0.182 (2.0-3.9)	3.3±0.109 (3.0-3.8)	3	3.6
(V) *	63±0.20 (61-63.5)	59 ±1.0 (53-63)	62±3.0 (58-78)	60	71
Body width	14.5±0.66 (11-19)	16.1±0.44 (15-17.5)	19.4±1.00 (16-22.5)	16	20
Stylet length	16.7± 0.34 (15.5-20)	17.5±0.28 (16-19)	19.4±0.39 (19-21)	17.5	20.5
MB	46.0±0.59 (44-48)	46.4±0.25 (45-48)	46.8±0.79 (44-49)	45	45
Cephalic width	7.1±0.25 (6-9.5)	8.1±0.14 (7.5-9)	8.7±0.27 (7.5-9.5)	8	9
Cephalic height	2.8±0.20 (2-4.5)	2.9±0.10 (2.5-3)	3.3±0.12 (3-4)	2.5	4
Ratio: cephalic width to height	2.63±0.124 (2.0-3.7)	2.71±0.074 (2.6-3.3)	2.6±0.062 (2.4-2.8)	3.3	2.3
Median bulb length	14.0±0.93 (10-12)	13.9±0.45 (12.5-16.5)	15.4±0.76 (12.5-19.0)	15	15
Median bulb width	7.8±0.28 (6-10)	8.2±0.32 (7.0-10)	8.6±0.37 (7-10)	10	10
Ratio: median bulb length to width	1.78±0.076 (1.2-2.3)	1.71±0.065 (1.5-2.2)	1.82±0.171 (1.4-2.7)	1.5	1.5
Excretory pore from anterior end	84±4.00 (69-103)	89.7±1.36 (82.5-97.5)	99.4±2.61 (91-109)	98	104
Oesophagus length	118±3.8 (94-146)	132.1±1.60 (125-138)	145.6±1.37 (141-150)	138	150
Tail length	33.9±0.94(30-40)	37.1±2.27 (22.5-46)	45.5±1.87 (41-52)	41	43
Tail annuli	36.5±1.76 (28-41)	33.2±1.25 (29-42)	31.7±1.19 (29-37)	30	35
Phasmid from tail tip	20.7±0.81 (17.5-26)	22.5±1.08 (17.5-27.5)	25.2±0.80 (22.5-29)	24	30
Hyaline part length	7.2±0.52 (5-10)	7.4±0.61 (4-10)	8.3±0.91 (6-12.5)	6	6
Hyaline part width	4.1±0.50 (2.5-7.5)	6.8±0.26 (5.5-7.5)	9.0±0.35 (7.5-10.0)	9	8.5
Ratio: hyaline part length to width	1.99±0.235 (0.9-3.5)	1.13±0.09 (0.6-1.6)	0.94±0.114 (0.6-1.4)	0.7	0.7
Ratio: Tail length to hyaline part length	5.0±0.38 (3-7.3)	5.14±0.27 (3.7-6.0)	5.73±0.46 (4.2-6.8)	6.6	7.2
Ratio: tail length to distance from phasmid to tail tip	1.65± 0.043 (1.4-1.9)	1.65±0.094 (1.3-2.3)	1.81±.0.061 (1.6-2.1)	1.7	1.8
Ratio: tail width to hyaline part width	2.68±0.268 (1.3-5.0)	1.68±0.074 (1.3-2.0)	1.53±0.033 (1.3-1.6)	1.57	1.41

* Ratio: distance between center of genital primordium and anterior end of body to the whole body length, in percentage.

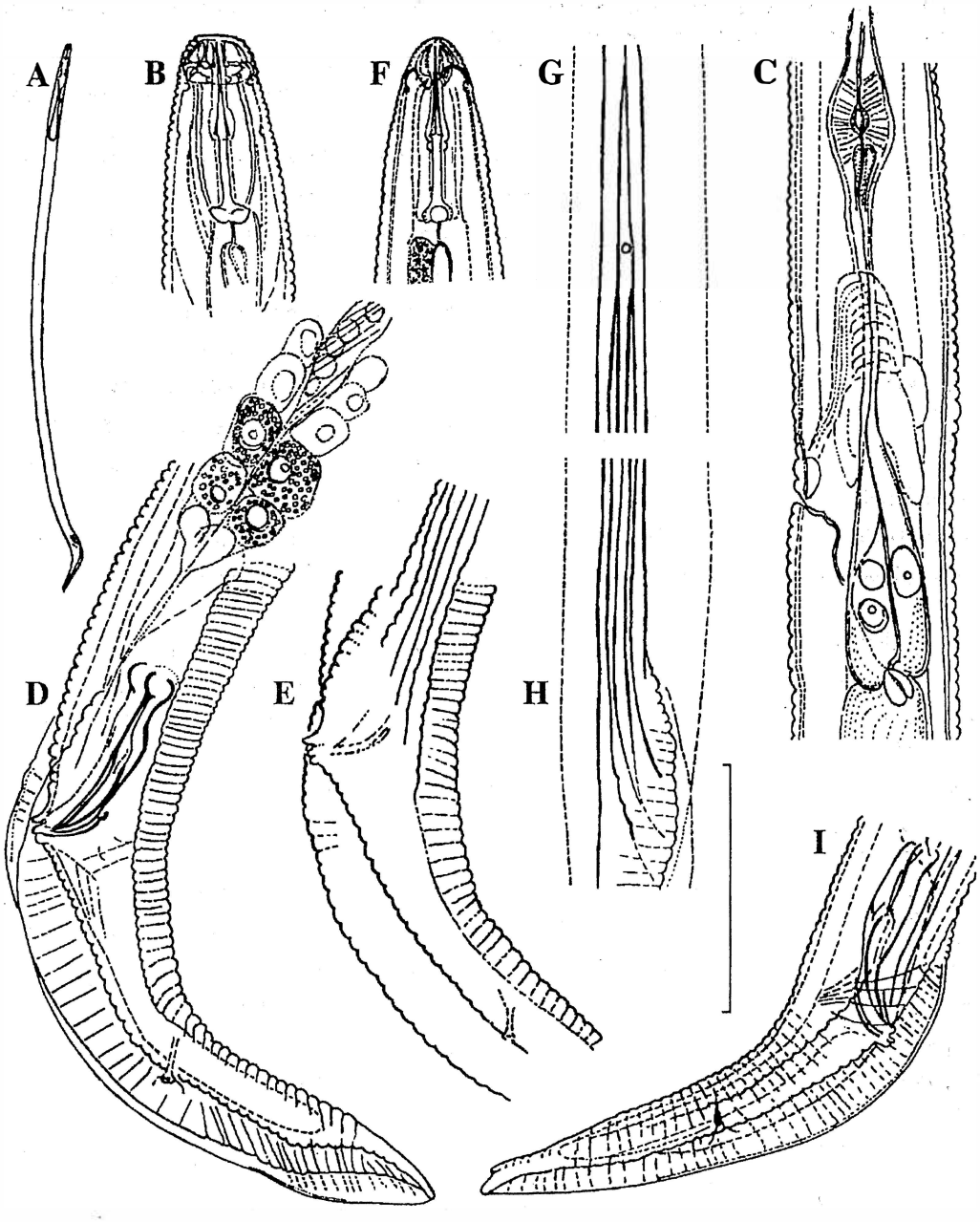

Fig. 2. *Pratylenchoides acuticauda* sp. n., male. **A**, general view; **B, F**, head: **B,** lateral view, **F,** dorso-ventral view; **C**, posterior part of oesophagus; **D, E, I**, tail shape: **D**, typical, **E,** surface structure, **I**, tail with notched tip in one specimen; **G, H**, lateral field structure: **G**, in anterior region, **H,** near cloaca. Scale bar = 320 μm for A, 32 μm for other images.

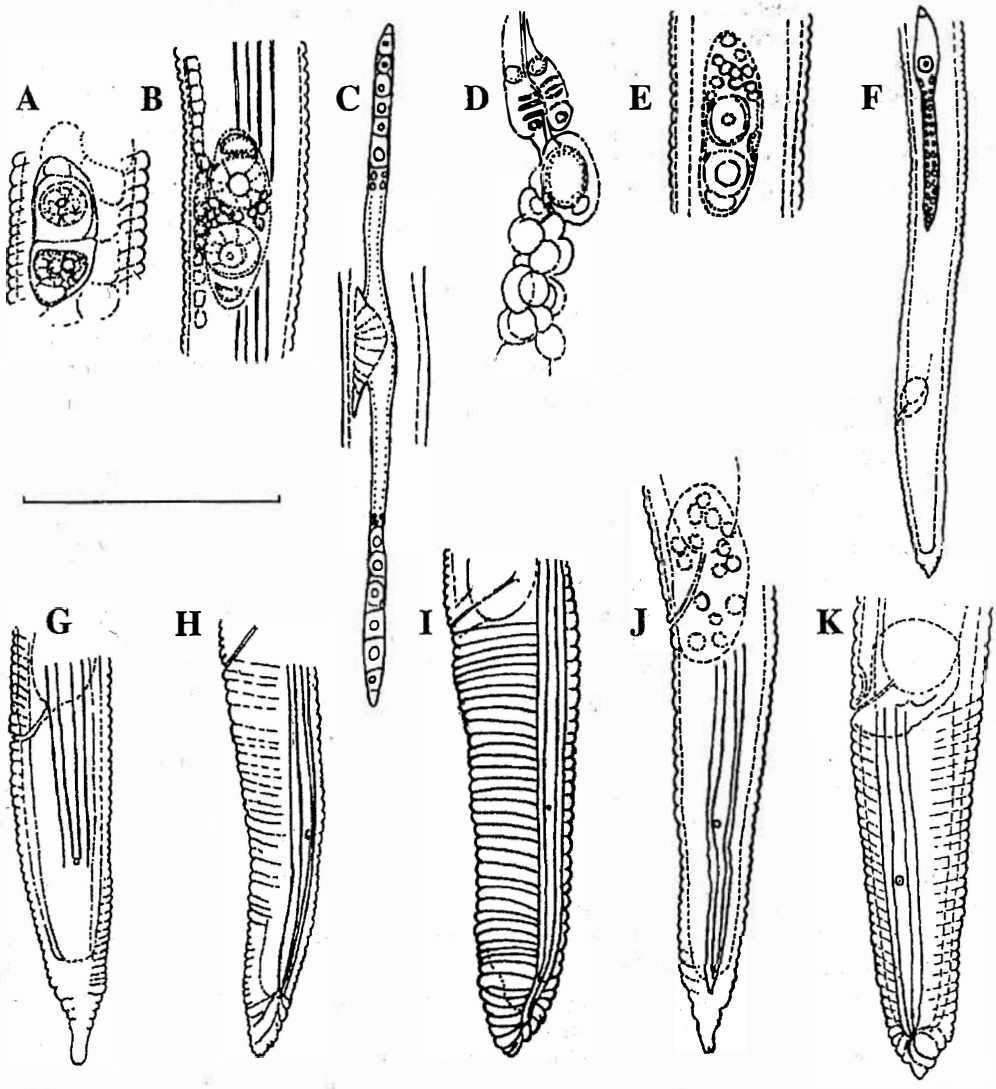

Fig. 3. *Pratylenchoides acuticauda* sp. n., juveniles. Genital primordia (A-F) and tail shape (G-K) in different juvenile stages. **A, G,** second stage juvenile; **B, H,** third stage juvenile (female); **C, I,** fourth stage juvenile (female); **D,** young female during the last moult, **E, J,** third stage juvenile (male), **F, K,** fourth stage juvenile (male). Scale bar = 68 μm for C and F, 30 μm for rest.

Second stage juvenile. Primordium consists of four cells: two apical nuclei one at each end of primordium and two germinal cells each with large nucleus, in center of primordium (Fig. 3 A).

Third stage female juvenile. In addition to second stage genital primordium, there is a group of somatic nuclei between two germinal cells in the center of primordium and a group of enlarged nuclei in the ventral cord near primordium (Fig. 3 B).

Fourth stage female juvenile. Bibranching genital primordium attached to the body wall at mid-body. One to five germinal cells at the end of each branch of primordium (Fig. 3 C). Young hatching females have round empty spermatheca set off dorsally from genital tract in each genital branch (Fig. 3 D).

Third stage male juvenile. In addition to genital primordium of the second stage juvenile, there

is a group of somatic cells in the anterior end of asymmetrical primordium. No enlarged cells of ventral cord present near primordium (Fig. 3 E).

Fourth stage male juvenile. Primordium tubular, shifted to posterior part of body. Three to eight germinal cells at anterior end of primordium. An enlarged cloacal primordium situated around rectum (Fig. 3 F, K).

In female and male juveniles of all stages mentioned above, body straight. Lateral field with four incisures. Tail tip pointed and annulated. In juveniles of the second and third stages, tail tip sometimes digitate. Annuli at the tail tip fine, of same width as other tail annuli, occasionally annulation on the tail tip of fourth stage female juvenile finer than on the rest of tail.

Differential diagnosis. P. acuticauda sp. n. shares with *P. magnicaudoides* Minagawa, 1984, *P. magnicauda* (Thorne, 1935) Baldwin, Luc & Bell, 1983, *P. riparius* (Andrássy, 1985) Luc, 1986 and *P. rivalis* sp. n. the short oesophageal gland overlap (0.3 body diameter or less) and large number of tail annuli (35 or more). It differs from *P. magnicauda* in the shape of the tail tip (pointed, with terminal annuli of approximately equal width *vs.* rounded, with terminal tail annuli distinctly larger than other tail annuli) and the stylet length (21-24.5 µm *vs.* 25-34 µm); from *P. riparius* in the pointed tail terminus of the females (*vs.* rounded), the number of lateral field incisures on the tail (4 *vs.* 6), the c-value (12-16 *vs.* 16-17), the c′-value (2.7-4.1 *vs.* 2.4-2.7) and the number of tail annuli (35-63 *vs.* 29-42); from *P. rivalis* sp. n. in the pointed tail terminus of the females (*vs.* rounded), the cephalic region being set off (*vs.* continuous), and the length of the gland lobe overlap (up to 0.3 body diameter *vs.* no overlap); and from *P. magnicaudoides* in the b-value (3.8-5.5 *vs.* 5.6-7.1), c-value (12-16 *vs.* 16.6-18.6), number of tail annuli (35-63 *vs.* 29-42), length of spicules (22-26 µm *vs.* 25-29 µm), and the length of oesophageal gland overlap (up to 0.38 *vs.* no overlap).

Pratylenchoides rivalis sp. n.
(Figs 4-6; Table 3)

Holotype. ♀. **Germany**, Niederachdorf near Regensburg (UTM UQ 12), Danube (Donau) river bank vegetation with *Salix* sp., *Rumex* sp., *Mentha* sp. and *Urtica dioica*; loamy fine sand, pH = 7.0, 5.X.1988 (D. Sturhan). Slide deposited in the German Nematode Collection, Biologische Bundesanstalt, Institut für Nematologie und Wirbeltierkunde, Münster/Westf., Germany.

Paratypes. **Germany**: 13 ♀, 10 ♂ and 7 juv., same data as holotype. *Additional paratypes.* **Germany**: Elmau near Creuzburg, bank of Werra River, with *Salix* sp. and grasses, loamy sand, pH = 7.0, 3.V.1991 (D. Sturhan); Oberhofen near Muhldorf-Inn, bank of a brook, with *Alnus glutinosa*, *Euonymus europaea*, *Cirsium oleraceum*, umbellifers and grasses, loamy soil, 9.IX.1979 (D. Sturhan); Immenstadt, Miesbach, Bitburg, Gernsheim and Oppenheim from soil under river bank vegetation. **Finland**: Åland Islands, Soderby, forest with *Alnus glutinosa*, *Filipendula ulmaria* and grasses, moist place, humous soil, 17.VII.1978 (D. Sturhan). Of the paratypes, 15 ♀, 20 ♂ and 3 juv. are deposited in the same collection as holotype; 8 ♀, 7 ♂ and 3 juv. in the Nematode Collection of the Zoological Institute, Academy of Sciences, St. Petersburg, Russia; 3 ♀ and 3 ♂ in the Nematode Collection of the Agricultural University Wageningen, The Netherlands; 2 ♀ and 1 ♂ at the Nematology Department, University of California, Riverside, U.S.A.

Description. Female. Body curved ventrad to almost straight. Width of ten cuticle annuli 10-20 µm at mid-body. Cephalic region continuous or slightly set off, flattened anteriorly, with rounded sides and four to six annuli anterior to basal plate of the strongly developed cephalic framework. Basal plate 1 mm thick; its posterior extensions 2 mm long, extending over 2-3 annuli. Therefore number of cephalic annuli anterior to basal ring of cephalic framework combined with those along its posterior extensions, is six to eight. Anterior cephalids immediately behind posterior extensions of cephalic framework; posterior cephalids five or six annuli behind anterior ones. Stylet base 4.0-5.5 µm wide, height of base 0.5-0.6 of its width; stylet knobs rounded, slightly sloping posteriorly. Dorsal oesophageal gland orifice 3.5-4.5 µm from stylet base. Median bulb oval. Excretory pore two to four annuli behind hemizonid. Hemizonid three annuli wide. Hemizonion 16 (14-19) annuli behind hemizonid. Deirids at level of hemizonid. Oesophageal gland nuclei located significantly anterior to oesophago-intestinal valve, the following arrangement being the most common: anterior subventral gland nucleus ventrally at level of dorsal gland nucleus or slightly posterior, rarely anterior; posterior subventral gland nucleus dorsally behind anterior one. Oesophageal glands part overlaps intestine 11 (7-12) µm dorso-laterally, a distance equal to 0.3-0.5 of corresponding body diameter. Oesophago-intestinal valve pear-shaped, 8-9 µm × 4-4.5 µm, situated ventrally at the left side. Lateral field occupying 33-36% of body diameter; outer bands occasion-

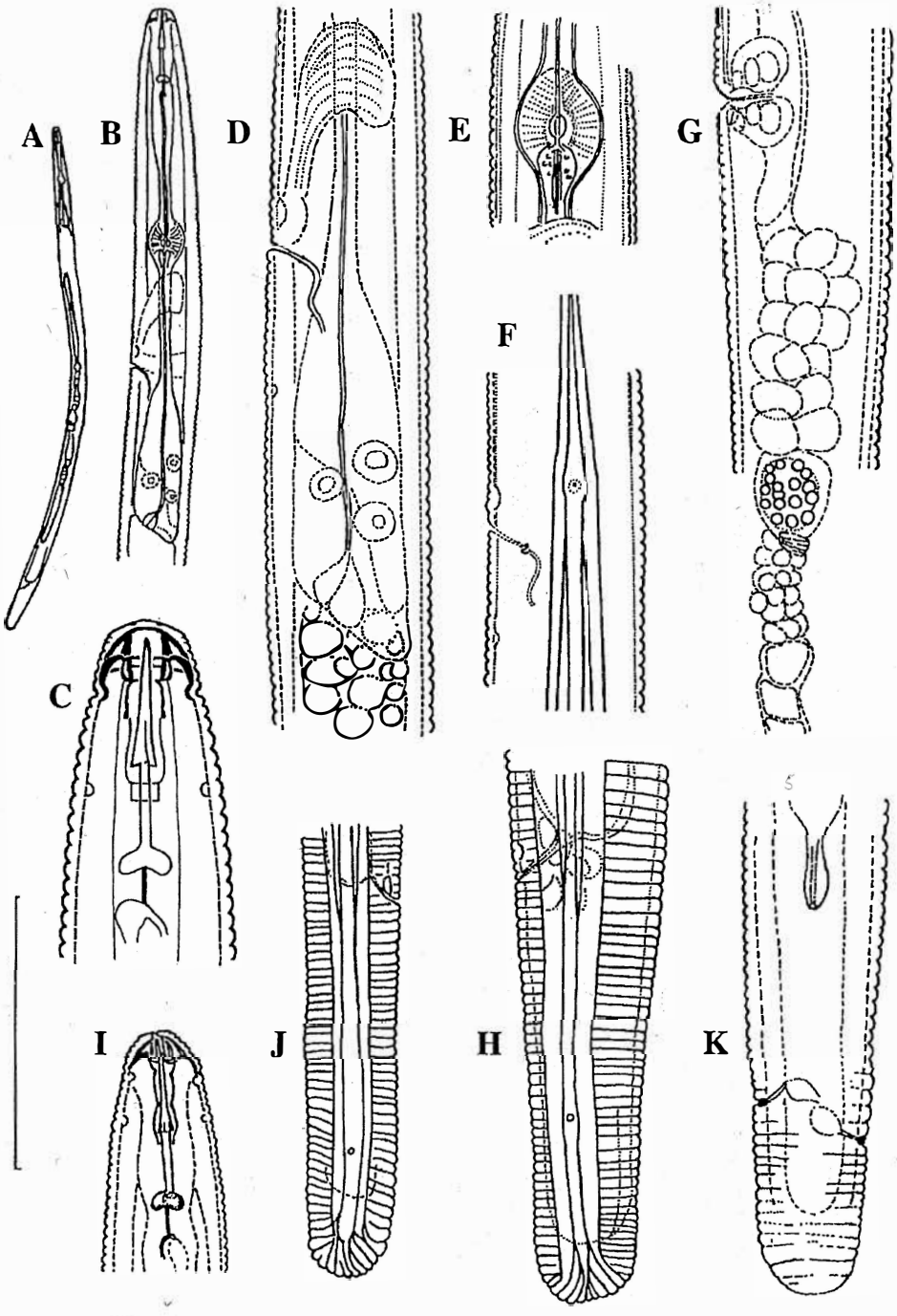

Fig. 4. *Pratylenchoides rivalis* sp. n., female (A-G, holotype; H-K, paratypes). **A**, general view; **B**, anterior end; **C, I**, head (C, lateral view; I, dorso-ventral view); **D**, posterior part of oesophagus; **E**, median bulb; **F**, deirid and lateral field at anterior end; **G**, spermatheca and part of genital tract; **H, J, K**, tail (H, J, lateral view; K, dorso-ventral view). Scale bar = 376 µm for A, 90 µm for B, 26 µm for C, 38 µm for rest.

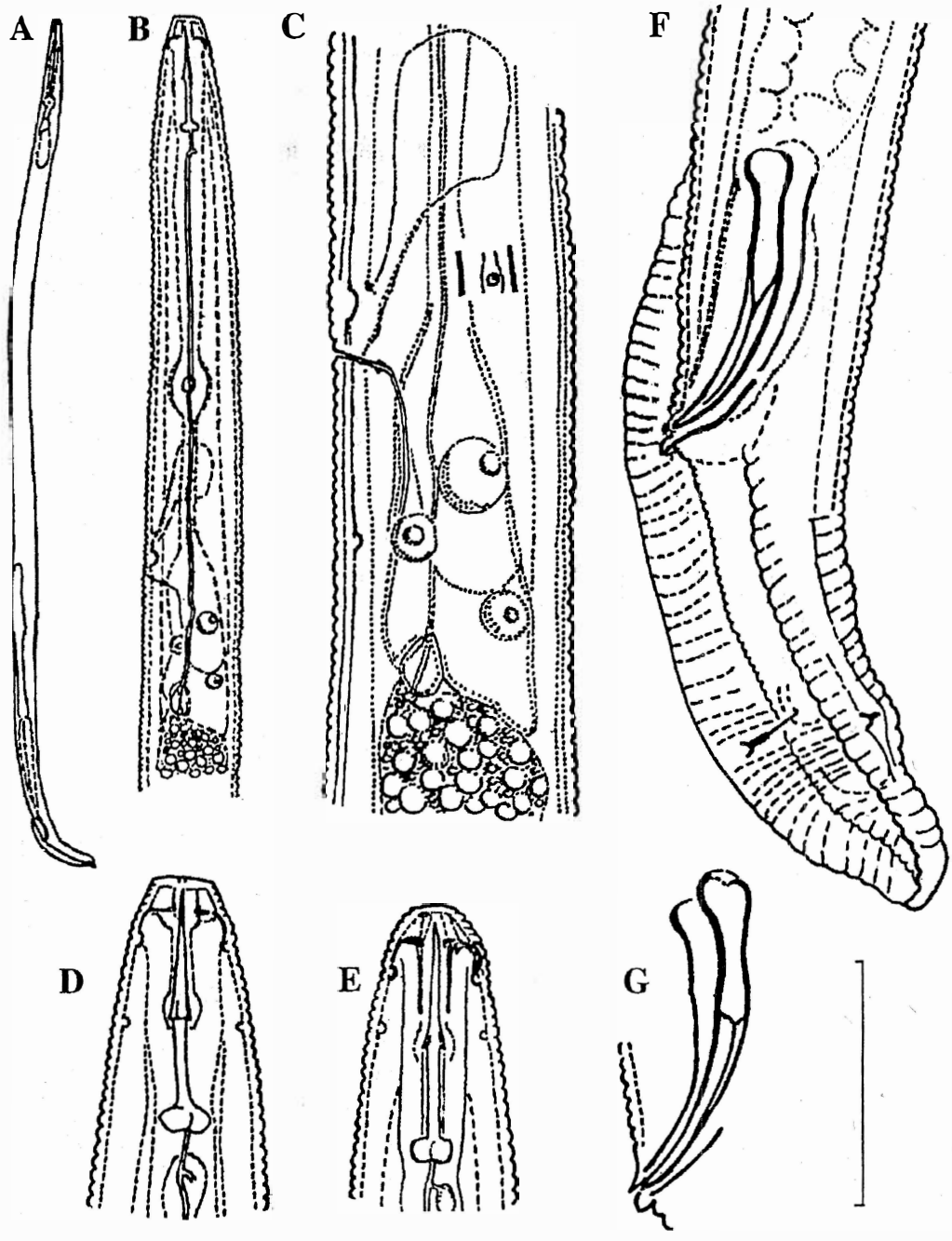

Fig. 5. *Pratylenchoides rivalis* sp. n., male (paratypes). **A,** general view; **B,** anterior end; **C**, posterior part of oesophagus and deirid; **D, E**, head; **F,** tail; **G**, spicules and gubernaculum. Scale bar = 220 µm for A, 53 µm for B, 22 µm for rest.

Table 3. Measurements (in μm), morphometric ratios and other diagnostic characters of *Pratylenchoides rivalis* sp. n. (Average, standard error, minimum and maximum are given for each value. Only minimum and maximum are given for values of restricted range).

Character	Holotype female	Paratypes	
		(females, n = 25)	(males, n = 23)
L	720	825±16.3 (690-970)	667±23.6 (510-920)
a	31	35.0±0.61 (29-40)	34.6±0.63 (27-40)
b	4.1	4.55±0.074 (3.9-5.2)	4.90±0.122 (4.0-6.1)
c	12.6	15.1±0.38(9.8-17.9)	14.9±0.31 (12-17)
c'	2.9	3.04±0.066(2.6-3.9)	3.09±0.097 (2.1-4.1)
V	58	58.3±0.31 (54-62)	–
Stylet length	23	22.9±0.16 (21-24)	21.3± 0.29 (19-23.5)
MB	44	42.4±0.48 (38-45)	47.9±0.94 (40-59)
Spicule length	–	–	25.3±0.32 (23-28)
Gubernaculum length	–	–	7.8±0.22 (6-9)
Cephalic width	9.0	8.8±0.20 (6-10)	7.8±0.20 (5-9)
Cephalic height	3.5	3.0-4.0	2.0-3.5
Ratio: cephalic width to height	2.6	2.47±0.065 (1.7-3.3)	2.39±0.096 (1.7-4.0)
Median bulb width	11	11.6±0.22 (9.5-15)	7.8±0.25 (6-9)
Median bulb length	17.5	17.7±0.17 (16-20)	13.8±0.46 (10-18)
Ratio: median bulb length to width	1.6	1.53±0.024 (1.2-1.7)	1.77±0.055 (1.3-2.2)
Excretory pore from anterior end	117	117.0±1.95 (90-132)	104.4±2.41 (87-130)
Gland part of oesophagus*	d+sv,sd,c	d,sv,sd,c; d+sv,sd,c; sv+d,sv,c	d,sv,sd or degenerated
Oesophagus length	180	181.2±2.56 (157-216)	140.1±5.21(100-173)
Body width	23	23.6±0.43 (19-28)	19.3±0.67 (14-26)
Spermatheca width	9	10.4±0.29 (7-14)	–
Spermatheca length	9; 10	11.2±0.37 (8-16)	–
Ratio: spermatheca length to width	1.0-1.2	1.08±0.034 (0.7-1.5)	–
Tail length	57	55.5±1.85 (42-85)	44.6±1.22 (35-60)
Tail annuli	47	46.2±1.27 (35-63)	–
Phasmid from tail tip	18; 23	22.4±0.91 (11-29)	19.8±0.58 (16-25)
Annuli between phasmid and tail tip	19; 23	19.6±0.97 (12-30)	–
Hyaline part length	9.0	10.3±0.35 (6-13)	12.5±0.48 (8-18)
Hyaline part width	14	14.1±0.42 (10-18)	6.4±0.35 (4-10)
Ratio: hyaline part length to width	0.6	0.74±0.031 (0.4-1.1)	2.03±0.109 (1.1-3.3)
Annuli between tail tip and anterior border of hyaline part	9	10.7±0.43 (7-14)	–
Ratio: Tail length to hyaline part length	6.3	5.57±0.301 (3.3-10.6)	3.72±0.215 (2.4-7.5)
Ratio: tail length to distance between phasmid and tail tip	2.5-3.2	2.55±0.100 (1.8-3.8)	2.24±0.042 (1.9-2.6)
Ratio: tail width to hyaline part width	1.4	1.31±0.040 (1.1-2.1)	2.34±0.151 (1.5-4.5)

* Arrangement of nuclei of glandular part of oesophagus from anterior to posterior end of the glandular part: c – oesophago-intestinal valve (cardia); d – dorsal gland nucleus; sv – subventral gland nucleus located ventrally in glandular part; sd – subventral gland nucleus located dorsally in glandular part. Arrangement "d+sv" means that dorsal gland nucleus and subventral gland nucleus are located at the same level; "d,sv,sd,c" – dorsal gland nucleus, subventral gland nuclei and oesophago-intestinal junction are located one after another.

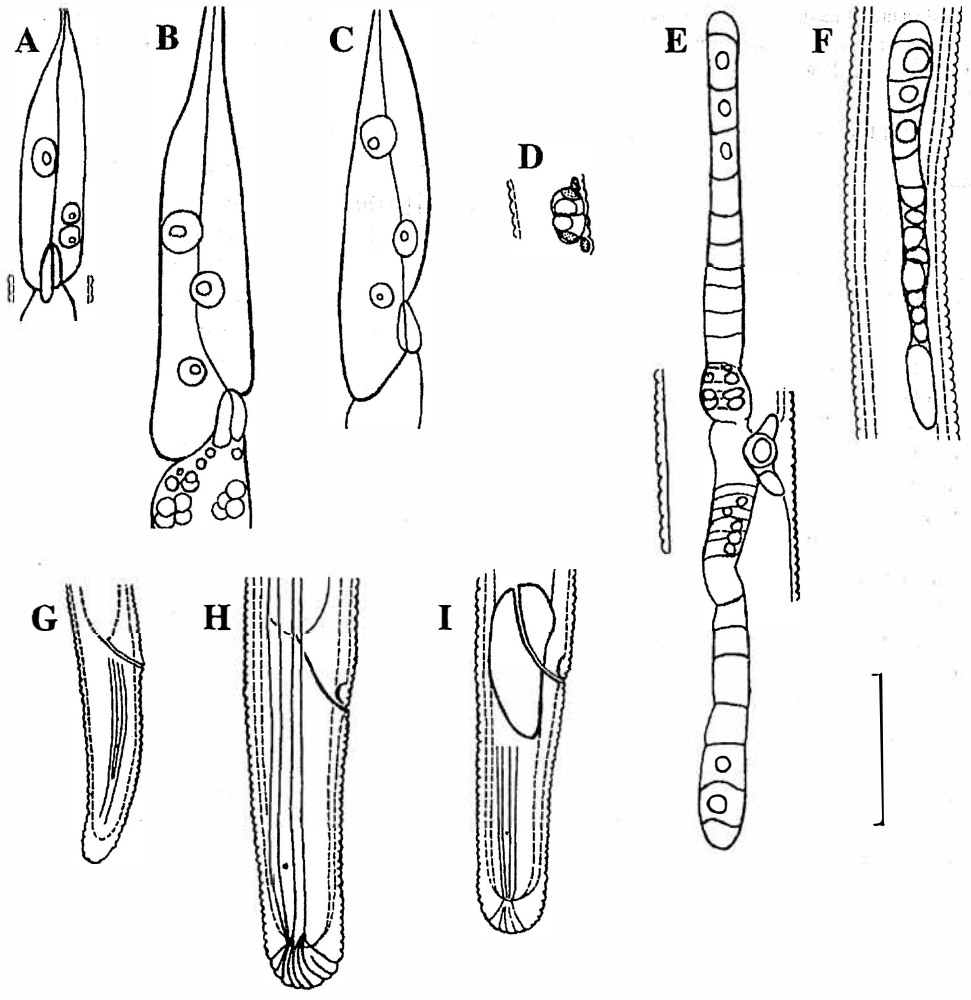

Fig. 6. *Pratylenchoides rivalis* sp. n., juveniles. Glandular part of oesophagus, genital primordia and tail shape in different juvenile stages (A, D, G, second-stage juvenile; B, E, H, fourth stage juvenile, female; C, F, I, fourth stage juvenile, male). **A-C**, glandular part of oesophagus; **D-F**, genital primordium; **G-I**, tail shape. Scale bar = 20 µm.

ally irregularly areolated. Lateral field with six incisures at mid-body, four at deirid, four to six at anus, four at level of phasmid. Incisures of lateral field extending to tail terminal annuli. Intestinal fasciculi present, sometimes invisible. Spermatheca round to oval, axial or directed slightly dorsally. Sperm round, rarely oval, 1.0-1.5 µm in diameter. Preuteral gland consists of 18 cells arranged in three rows of six. Tail nearly cylindrical; terminus broadly rounded, occasionally almost clavate, annulated. Annuli on terminus mostly of equal width, similar to width of other annuli on posterior half of tail. Occasionally some annuli on tail tip wider than others. Phasmids on posterior half of tail.

Holotype. Excretory pore located two annuli behind hemizonid. Hemizonion 15 annuli behind hemizonid. Oesophageal gland overlap 11 µm long.

Male. Body straight to slightly curved ventrad. Tail curved to dorsal side at level of cloaca. Width of ten cuticle annuli 10-15 µm at mid-body. Cephalic region continuous with body contour, conical, with straight anterior margin (rounded in

dorso-ventral view), with four to six annuli anterior to basal plate of the well developed cephalic framework. Posterior extensions of cephalic framework 2 µm long, extending two or three annuli posteriorly. Therefore number of cephalic annuli situated anterior to basal plate of cephalic framework plus those along its posterior extensions, is six to eight. Anterior cephalids immediately behind posterior extensions of cephalic framework; posterior cephalids five or six annuli behind anterior ones. Stylet with rounded knobs usually directed laterally, rarely sloping posteriorly. Median bulb oval. Excretory pore two to six (usually two or three) annuli behind hemizonid. Hemizonid three annuli wide. Hemizonion 14-17 annuli behind hemizonid. Deirids near level of hemizonid. Arrangement of oesophageal gland nuclei as in female; in many specimens, glands degenerated and indistinct. Lateral field occupying 30-36% of body diameter, not areolated, with six lines fusing into four lines at level of stylet base. Intestinal fasciculi present. Caudal alae 64 (47-88) µm long, 18 (13-24) µm wide, narrow, with slightly crenate margins. Ratio caudal alae length to their width 3.7 (2.7-4.5). Tail terminus pointed, rarely curved ventrally; ventral enlargement present near base of hyaline part. Spicules curved, clavicula 16 (12-19)%, conical part 59 (50-63)% of spicule length. Sperm round, rarely oval, 1.0-1.5 µm in diameter.

Juveniles. Stage and sex of juveniles was identified as described above for *P. acuticauda*. Juveniles of all stages have rounded, annulated tail tips and four incisures in their lateral fields (Fig. 6).

Differential diagnosis. P. rivalis shares with *P. acuticauda* sp. n., *P. magnicauda* (Thorne, 1935) Baldwin, Look & Bell, 1983, *P. magnicaudoides* Minagawa, 1984 and *P. riparius* (Andrássy, 1985) Luc, 1986 the extremely short overlap of the oesophageal gland lobe and large number of tail annuli (35-63). It differs from *P. riparius* in the smaller number of incisures on the tail (4 *vs.* 6) and the longer tail (c′ = 2.6-3.9 *vs.* 2.4-2.7); from *P. magnicauda* in the terminal and the other tail annuli being of equal width (*vs.* terminal annuli distinctly wider than other tail annuli), the shorter stylet (21-24 µm *vs.* 25-34 µm) and spicules (23-28 µm *vs.* 27-29 µm) and the number of tail annuli (35-63 *vs.* 23-47); from *P. acuticauda* in the rounded tail tip of the females and preadult female juveniles (*vs.* pointed) and the mostly ventral position of the cardium (*vs.* mostly dorsal); from *P. magnicaudoides* in the rounded tail tip of the females (*vs.* pointed), the b-value (3.9-5.2 *vs.* 5.6-7.1) and the number of tail annuli (35-63 *vs.* 29-42).

Pratylenchoides arenicola sp. n.
(Figs 7, 8; Table 4)

Holotype. ♀. **Germany**, *Schleswig-Holstein*, Isle of Sylt (on the east side), about 2 km north of Hörnum (UTM MF56), coastal dunes, almost pure sand, around roots of *Ammophila arenaria, Leymus arenarius* and *Limonium vulgare*, 11.X.1974 (D. Sturhan). Slide deposited in the German Nematode Collection, Biologische Bundesanstalt, Institut für Nematologie und Wirbeltierkunde, Münster/Westf., Germany.

Paratypes. 2 ♀ and 4 ♂, same data as holotype. One ♀ and 3 ♂ deposited in the same collection as holotype; 1 ♀ and 1 ♂ at Zoological Institute, Russian Academy of Sciences, St. Petersburg, Russia.

Description. Female. Body with slight ventral curvature. Width of ten cuticle annuli 20 µm at mid-body. Cephalic region set off, flattened, rounded in dorso-ventral view, with five annuli anterior to basal plate of the strongly developed cephalic framework. Posterior extensions of cephalic framework 1.5-2.0 µm long, extending 1.5-2 cuticle annuli posteriorly. Therefore number of the cephalic annuli anterior to basal plate of cephalic framework combined with those along its posterior extensions, is seven. Basal plate of the cephalic framework about 1.5 µm thick. Four annuli between anterior and posterior cephalids. Stylet knobs oval, sloping posteriorly; stylet base 6.0-6.5 µm wide. Dorsal oesophageal gland orifice 1.5-3.0 µm from stylet base. Median bulb oval. Excretory pore four annuli behind hemizonid. Hemizonid about two annuli long. Deirids mostly at level of hemizonid. Hemizonion 20-21 annuli behind hemizonid. Oesophageal gland nuclei significantly anterior to oesophago-intestinal valve; dorsal gland nucleus and posterior subventral gland nucleus located dorsally, another subventral gland nucleus located ventrally, posterior to dorsal and anterior to the first subventral gland nucleus. Glandular part of oesophagus overlapping intestine dorso-laterally. Overlap 12.5 (8.5-18.5) µm from anterior border of oesophago-intestinal valve, which is equal to 0.2-0.7 of corresponding body diameter. Valve pear-shaped, 8.3 (8-10) µm long and 6.7 (5-8) µm wide, located ventrally at the right side. Lateral field occupying 32-38% of body diameter, not areolated, with six lines at mid-body, four at deirid, six at anus, and four at phasmid. Intesti-

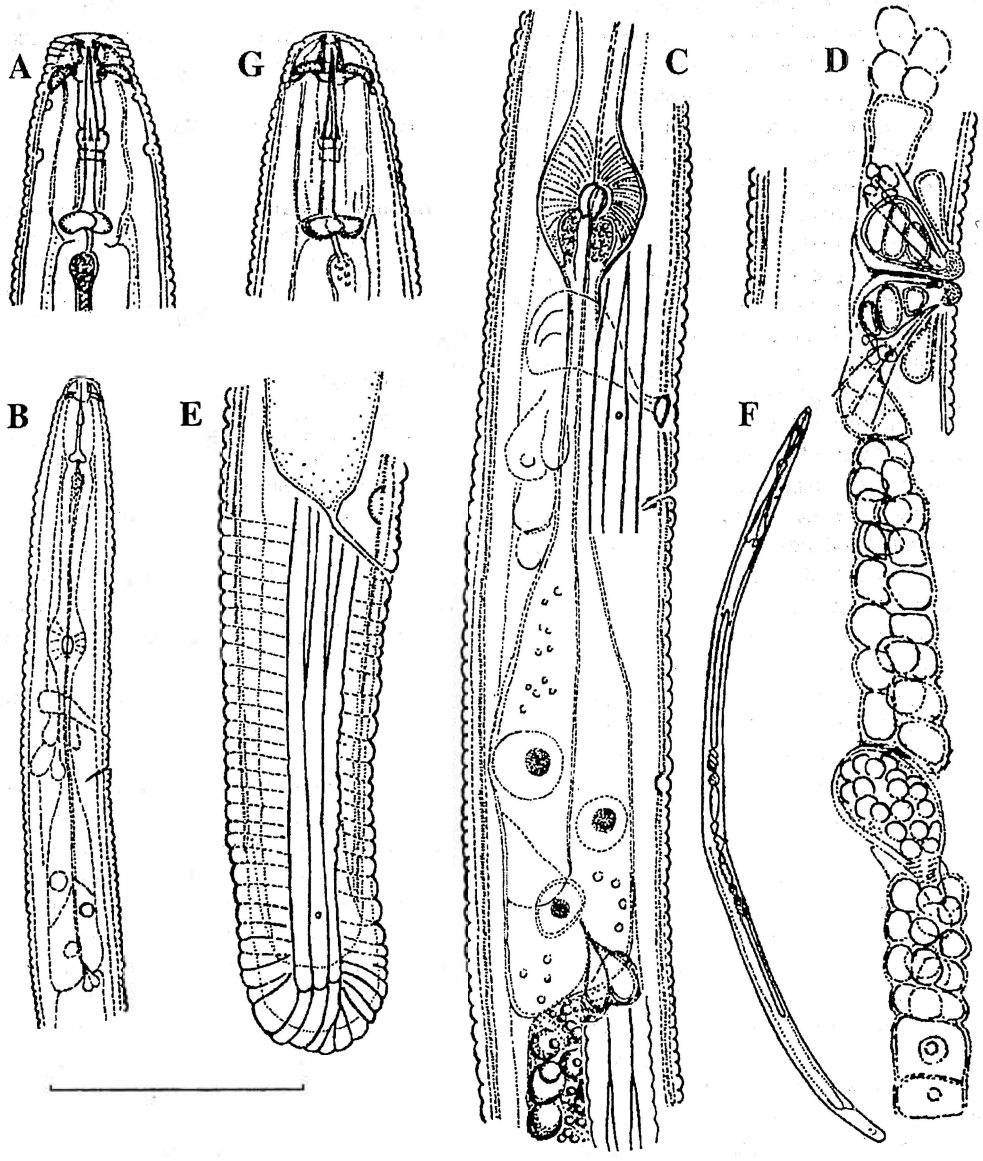

Fig. 7. *Pratylenchoides arenicola* sp. n., female (A-F, holotype; G, paratype). **A, G,** head; **B,** anterior end; **C**, posterior part of oesophagus; **D,** genital tract; **E**, tail, **F,** general view. Scale bar = 77 μm for B, 320 μm for F, 32 μm for rest.

nal fasciculi present. Spermatheca oval, its long axis at slight angle to genital tract. Sperm round, 2-3 μm in diameter. Preuteral gland consists of 16 to 18 cells arranged in three rows of six or in two rows of eight. Oviduct consists of 15 to 16 cells arranged in four or five rows. Tail cylindrical, with broadly rounded, annulated terminus. One or two annuli on dorsal and ventral side of tail tip wider than other annuli.

Holotype. Hemizonion 21 annuli behind hemizonid. Oesophageal gland lobe extending 8.5 μm behind anterior end of oesophago-intestinal valve. Valve 8 μm × 8 μm.

Male. Body straight or curved dorsad; tail straight or slightly curved to dorsal side at level of cloaca. Width of ten cuticle annuli 20 μm at mid-body. Cephalic region continuous, flattened to rounded anteriorly; with five to six annuli an-

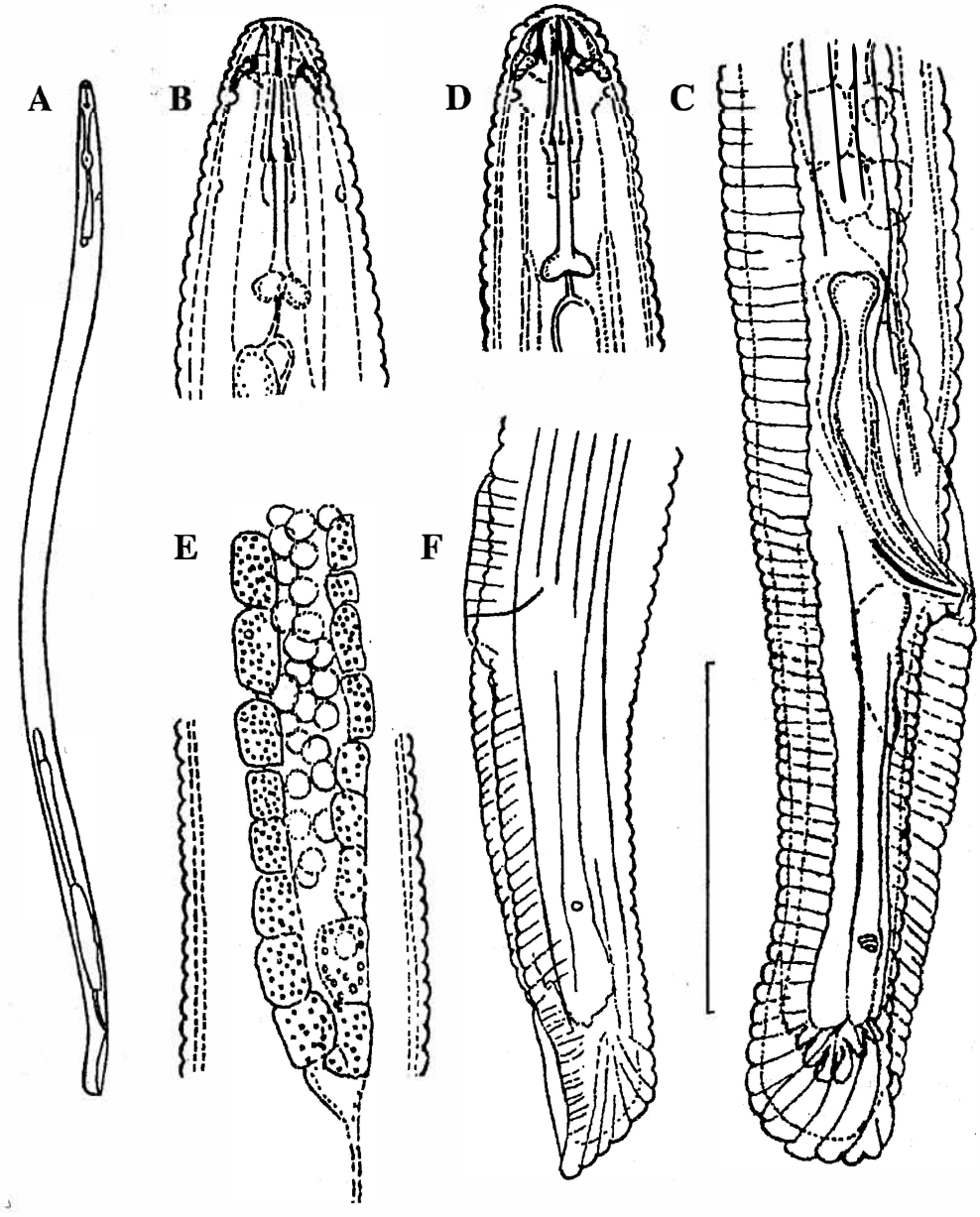

Fig. 8. *Pratylenchoides arenicola* sp. n., male (paratypes). **A,** general view; **B, D,** anterior end; **C, F,** tail shape: **C,** typical form, **F,** variation in one male; **E,** sperm in genital tract. Scale bar = 320 μm for A and 32 μm for rest.

terior to basal plate of the strongly developed cephalic framework. Posterior extensions of cephalic framework extending 1.5-2 annuli posteriorly. Therefore number of cephalic annuli situated anterior to basal plate of cephalic framework plus those along its posterior extensions, is seven or eight. Basal plate of cephalic framework about 1.5 μm thick. Anterior cephalids immediately behind posterior extensions of cephalic framework; posterior cephalids four to six an-

Table 4. Measurements (in μm), morphometric ratios and other diagnostic characters of *Pratylenchoides arenicola* sp. n. (Average, minimum and maximum are given for each value).

Character	Holotype female	Paratypes and holotype	
		(females, n = 3)	(males, n = 4)
L	1030	1033 (980-1100)	862 (800-890)
a	36	37 (36-39)	34 (31-35)
b	5.3	5.4 (5.2-5.8)	6.1 (5.5-6.3)
c	17.1	17.5 (16.6-18.8)	17.6 (16.7-18.5)
c'	3.0	2.7 (2.5-3.0)	2.9 (2.7-3.1)
V	57	58.7 (57-61)	–
Stylet length	25	25	24 (23-25)
MB	42.7	43.3 (42-44)	50-51
Spicule length	–	–	27-28
Gubernaculum length	–	–	8.5
Cephalic width	12	11.5-12	9-11
Cephalic height	3.5	3.5-4.0	3.5-5.0
Ratio: cephalic width to height	3.4	2.9 (2.6-3.4)	2.5 (1.8-3.1)
Median bulb length	19	18-19	16 (14-18)
Median bulb width	13.5	12.0 (11.5-13.5)	8-8.5
Ratio: median bulb length to width	1.4	1.5 (1.4-1.6)	1.9 (1.6-2.1)
Excretory pore from anterior end	120	121 (117-127)	107 (103-108)
Gland part of oesophagus	d,sv,sd,c	d,sv,sd,c	d,sv,sd,c
Oesophagus length	193	189 (187-193)	143 (140-145)
Body width	29	27.9 (27-29)	25 (23-28)
Spermatheca width	12-14	11 (10-14)	–
Ratio: spermatheca length to width	0.8-1.0	0.7-1.0	–
Tail length	60	59 (58-60)	49 (47-53)
Tail annuli	28	27-28	35-36
Phasmid from tail tip	22-23	21-23	21 (15.5-25)
Annuli between phasmid and tail tip	10	10	–
Hyaline part length	11	12.4 (11-13.5)	10.6 (8.5-13)
Hyaline part width	18	18-19	13 (11-16)
Ratio: hyaline part length to width	0.6	0.68 (0.6-0.7)	0.9 (0.6-1.1)
Annuli between tail tip and anterior border of hyaline part	6	6-7	–
Ratio: tail length to hyaline part length	5.2	4.7 (4.1-5.2)	4.8 (3.7-6.3)
Ratio: tail length to distance between phasmid and tail tip	2.6-2.7	2.7 (2.6-2.8)	2.4 (1.9-3.0)
Ratio: tail width to hyaline part width	1.1	1.2 (1.1-1.3)	1.4 (1.1-1.6)

* Arrangement of nuclei of glandular part of oesophagus from anterior to posterior end of the glandular part: c – oesophago-intestinal valve (cardia); d – dorsal gland nucleus; sv – subventral gland nucleus located ventrally in glandular part; sd – subventral gland nucleus located dorsally in glandular part. Arrangement "d,sv,sd,c" means that dorsal gland nucleus, subventral gland nuclei and oesophago-intestinal junction are located one after another.

nuli behind anterior one. Stylet knobs rounded, sloping posteriorly; stylet base 5.0 µm wide. Dorsal oesophageal gland orifice 2.0-3.5 µm from stylet base. Excretory pore located immediately behind hemizonid. Hemizonid two annuli wide. Hemizonion eight annuli behind hemizonid. Arrangement of oesophageal gland nuclei as in female. Cardium pear-shaped or rounded, 5-6 µm in diameter, located dorsally at right side. Lateral field occupying 34-43% of body diameter, arrangement of incisures as in female. Four incisures at deirid. Intestinal fasciculi present. Tail wide, with broadly rounded, clavate or truncate terminus. Caudal alae 71 (61-75) µm long, 19 (15-20) µm wide, with crenate margins, extending to tail terminus. Ratio caudal alae length to their width 3.8 (3.7-4.1). Phasmids conspicuous. Tail terminus broadly rounded to truncate. Spicules slender, elongate, with distinct lateral flanges (vela). Clavicula of spicule about 16%, conical part about 50% of total spicule length. Sperm round (2 µm in diameter) to spindle-shaped (3-4 µm × 1.5-2 µm).

Differential diagnosis. P. arenicola shares with *P. crenicauda* Winslow, 1958, *P. erzurumensis* Yuksel, 1977, *P. heathi* Baldwin, Luc & Bell, 1983, *P. magnicauda* (Thorne, 1935) Baldwin, Luc & Bell, 1983, *P. laticauda* Braun & Loof, 1966 the short overlap of the oesophageal gland lobe (0.2-0.7 of the corresponding body diameter), 25-30 tail annuli, a crenate tail terminus and four incisures of the lateral field on the tail. *P. arenicola* differs from these species in the wide tail of the male. In addition, it differs from *P. crenicauda* in its longer body (978-1093 µm *vs.* 530-860 µm), greater a-value (36-39 *vs.* 21-29), stylet length (25 µm *vs.* 21-24 µm), spicules length (27-28 µm *vs.* 20-24 µm) and number of cephalic annuli (5 *vs.* 3-4); from *P. erzurumensis* in the shape of the tail tip (rounded *vs.* truncate), larger number of cephalic annuli (5 *vs.* 3 to 4), stylet length (25 µm *vs.* 21-22 µm), c′-value (2.5-3.0 *vs.* 2.0), body length (978-1093 µm *vs.* 550-670 µm), and a-value (36-38.6 *vs.* 24-26); from *P. heathi* in the set off cephalic region (*vs.* continuous); from *P. magnicauda* in the ventral position of the cardium (*vs.* central to dorsal position) and the greater b-value (5.2-5.8 *vs.* 4.3-5.3); from *P. laticauda* in the larger number of cephalic annuli (5 *vs.* 3 to 4), body length (978-1093 µm *vs.* 760-830 µm), a-value (36-38.6 *vs.* 26-34), b-value (5.2-5.8 *vs.* 4-4.9), c-value (2.5-3 *vs.* 2-2.4), stylet length (25 µm *vs.* 23-24 µm), number of tail annuli (27-28 *vs.* 18-26) and tail length (58-66 µm *vs.* 24-37 µm).

P. arenicola shares with *P. camachoi* Gomez Barcina, Castillo & Gonzalez Pais, 1990 and *P. clavicauda* Geraert, Young Eoun Choi & Dong Ro Choi, 1990 the wide tail of the males. The females of *P. arenicola* differ from females of both these species in their annulated tail tip (*vs.* smooth), from females of *P. camachoi* in the larger number of cephalic annuli (5 *vs.* 3 to 4), and from females of *P. clavicauda* in the greater stylet length (25 µm *vs.* 20-22 µm) and shorter oesophageal gland overlap (0.2-0.7 *vs.* 1-2).

Acknowledgements

This work was financially supported by the German-Russian Programme of Cooperation in Agricultural Research. The authors thank Dr. N. Minagawa, Dr. P.A.A. Loof and Dr. M. Luc for the opportunity to investigate their collection slides, and Dr. W.M. Wouts for critical comments and linguistic improvements.

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Received 27 April 2000