Journal of Nematology 47(4):356–369. 2015.

Description of a New and Two Known Species of the Free-living Nematode *Paroigolaimella* Paramonov, 1952 (Diplogastridae) from India

Qudsia Tahseen,[1] Shikha Ahlawat,[1] and Malka Mustaqim[1]

Abstract: This paper describes a new and two known species of *Paroigolaimella* collected from India. *Paroigolaimella helalii* n. sp. is characterized by having conspicuous sexual dimorphism in the stoma and pharynx, ovaries with a sphincter separating the mature oocyte from developing ones, a vagina leading to a strong ovijector, a pore-like vulva with cuticular flap; males with slender strongly arcuate spicules with dilated capitula; the gubernaculum slender with expanded plate-like distal end and nine pairs of genital papillae, and four to five pairs of copulatory muscle bands. *P. coprophila* (Sudhaus and Rehfeld, 1990) Sudhaus and Fürst von Lieven, 2003 collected from leaf litter from a farmyard has been redescribed with reassessment of its distinguishing characters from *P. bernensis*. *P. bodamica* (Micoletzky, 1922) n. comb. has been described and its status has been discussed with context to *P. bernensis*.

Key words: description, Diplogastridae, *Paroigolaimella bernensis*, *P. bodamica*, *P. coprophila*, *P. helalii* n. sp., Rhabditida, sexual dimorphism, taxonomy.

The genus *Paroigolaimella* was named by Paramonov (1952) who transferred the species *Diplogaster coprophages* de Man, 1876 and *D. stressmanni* Sachs, 1950 to the genus as *Paroigolaimella coprophages* and *P. stressmanni*, respectively. Weingartner (1955) treated *Paroigolaimella* as a subgenus of *Diplogaster* after considering it a senior synonym of *Paradiplogaster*. She considered the congeners (*P*). *coprophages*, (*P*). *spirifer*, (*P*). *bernensis*, and (*P*). *stressmanni* under the "coprophages" group and also described (*P*). *microcercus*. Andrássy (1984) considered *Paroigolaimella* as a valid genus with six nominal species namely, *P. anomala* Gagarin, 1977; *P. bernensis* (Steiner, 1914) Andrássy, 1958, *P. coprophages* (de Man, 1876) Paramonov, 1952; *P. micrura* (Weingartner, 1955) Andrássy, 1958, *P. paraspirifera* Zullini and Loof, 1980 and *P. stressmanni* (Sachs, 1950) Paramonov, 1952. Sudhaus and Fürst von Lieven (2003) in their catalog of Diplogastridae, included three more species namely, *P. affinis* (Sudhaus and Rehfeld, 1990) Sudhaus and Fürst von Lieven, 2003; *P. coprophila* (Sudhaus and Rehfeld, 1990) Sudhaus and Fürst von Lieven, 2003 and *P. ornata* (Stefański, 1922) Sudhaus and Fürst von Lieven, 2003 to make a total of nine nominal species belonging to the genus.

The genus *Paroigolaimella* includes medium- to large-sized species, usually provided with cuticular ridges and fine punctations. The characteristic features of the species are the following: small setose labial sensilla; a large and spacious stoma, cheilostom with 12 adradial flaps, dorsal metastegostomal tooth moderately large, subventral metastegostomal plates bearing wart-like denticles; female reproductive system didelphic, amphidelphic; vagina usually conspicuous with associated vesicle(s) (bladder[s]); males with spicules of variable shapes and nine pairs of genital papillae with three precloacal and six postcloacal pairs. Tail filiform usually with whip-like terminal part.

This article describes and illustrates three species of *Paroigolaimella* of which one is new to science, while the other two add to the existing information. The species *P. coprophila* has been redescribed with additional characters, whereas *P. bodamica* (Micoletzky, 1922) n. comb. has been redescribed and its status has been discussed.

Materials and Methods

The soil samples were processed using Cobb's (1918) sieving and decantation and modified Baermann's funnel techniques. The nematodes were extracted and fixed in hot formalin-glycerol fixative, dehydrated by the slow evaporation method (Seinhorst, 1959), and mounted in anhydrous glycerin. Permanent mounts were prepared using the paraffin wax ring method (de Maesneer and d'Herde, 1963). The measurements were taken with an ocular micrometer and drawings made using a drawing tube. The photographs were taken with a Jenoptik ProgRes C5 digital camera mounted on an Olympus BX-51 DIC microscope (Singapore).

Description

Paroigolaimella helalii[1] n. sp.
(Figs. 1,2)

Measurements of holotype and paratypes are given in Table 1.

Female (n = 10): Body slender, straight to ventrally arcuate, gradually tapering toward extremities, more toward posterior end. Cuticle 1 to 2 μm with fine transverse striations and longitudinal ridges (Fig. 2I). Amphidial openings ovoid, usually obscure. Lip region continuous with adjoining body. Lips six, closed, amalgamated; each lip with papilliform inner labial and setose outer labial sensilla (Fig. 2B). Stoma spacious,

Received for publication June 2, 2015.
[1]Nematode Research Laboratory, Department of Zoology, Aligarh Muslim University, Aligarh 202002, India.
We are grateful to the Department of Science and Technology, and Ministry of Environment and Forests, New Delhi, India, for the financial support to carry out the present work.
E-mail: qtahseen@yahoo.com
This paper was edited by Zafar A. Handoo.

[1] The species name is in the honor of the father of first author Mr. A. M. Helali who has been a continuous source of motivation.

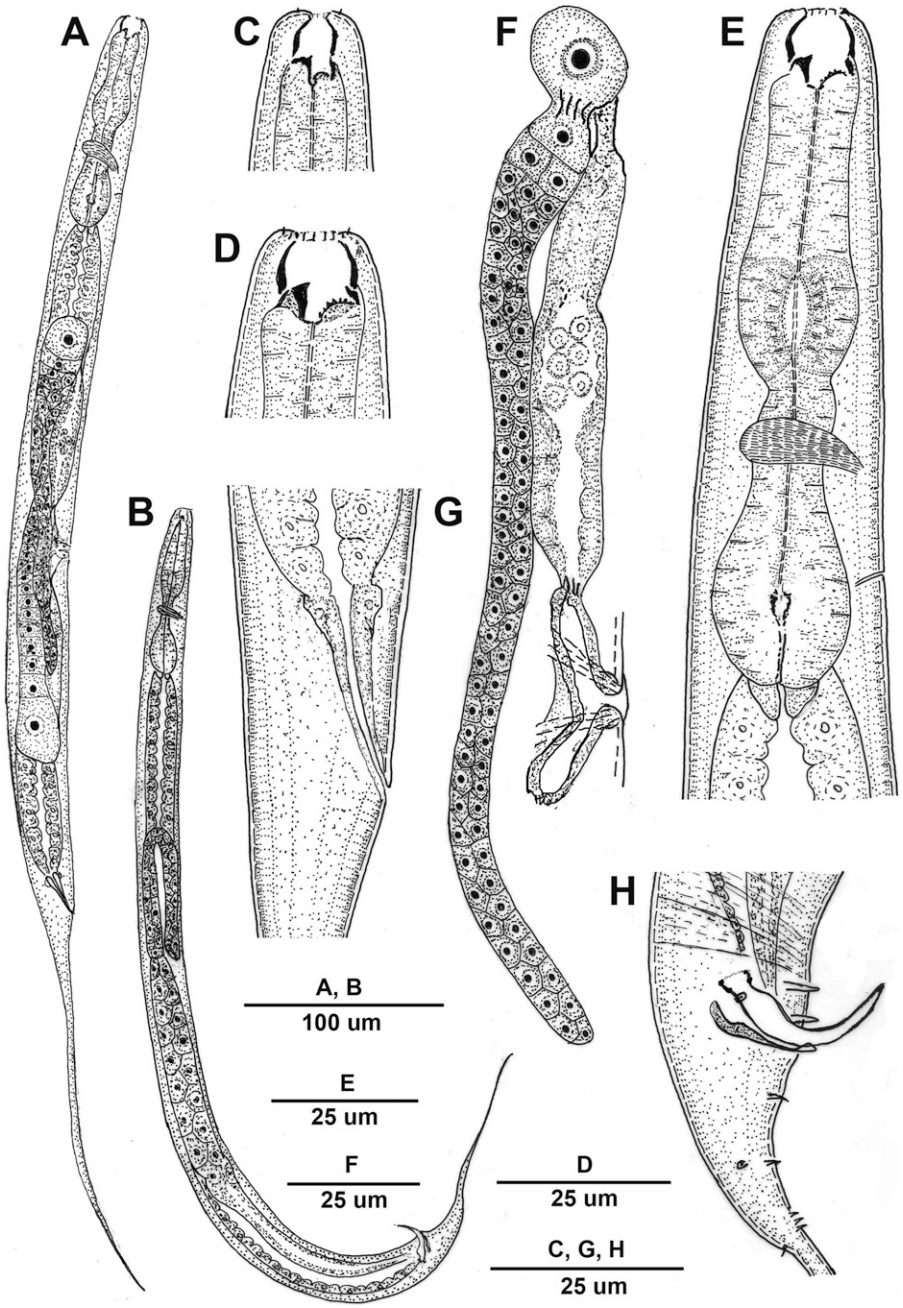

FIG. 1. *Paroigolaimella helalii* n. sp. A. Entire female. B. Entire male. C. Anterior end (male). D. Anterior end (female). E. Pharyngeal region. F. Anterior genital branch (female). G. Female tail region. H. Male tail region.

representing a rounded to globular stomal chamber. Cheilostom cuticularized, diverging posteriorly having 12 adradial plates (Fig. 2D,E). Gymnostom thickly cuticularized, isotopic, and isomorphic. Stegostom anisomorphic, dorsal wall with a moderately large tooth; each subventral metastegostomal swelling representing a seven to eight wart-like denticles with one or two central ones slightly larger than rest (Figs. 1D,2A,C). Pharyngeal tissue surrounding stoma at stegostom level. Pharyngeal corpus prominently swollen, muscular 52- to 60-μm long forming a metacorpus with thickened lumen (Figs. 1E,2H); isthmus differentiated from corpus, 20- to 28-μm long; basal bulb unusually massive, rounded to rectangular, 21 to 30 μm × 13 to 17 μm in dimension with thickened lumen dilated into a small haustrulum-like structure (Figs. 1E,2H) in few specimens. Nerve ring encircling middle of isthmus, located at 68.7% to 71.8% of pharyngeal length from anterior end. Secretory-excretory pore at 86.7% to 89.5% of pharyngeal length from anterior end. Body at pharyngeal end 1.4 to 2.0 times labial diameter wide. Cardia with conical flaps. Intestine with wide lumen, often containing cuticularized remnants of prey nematodes. Rectum 1.3 to 1.4 times anal body diameter long.

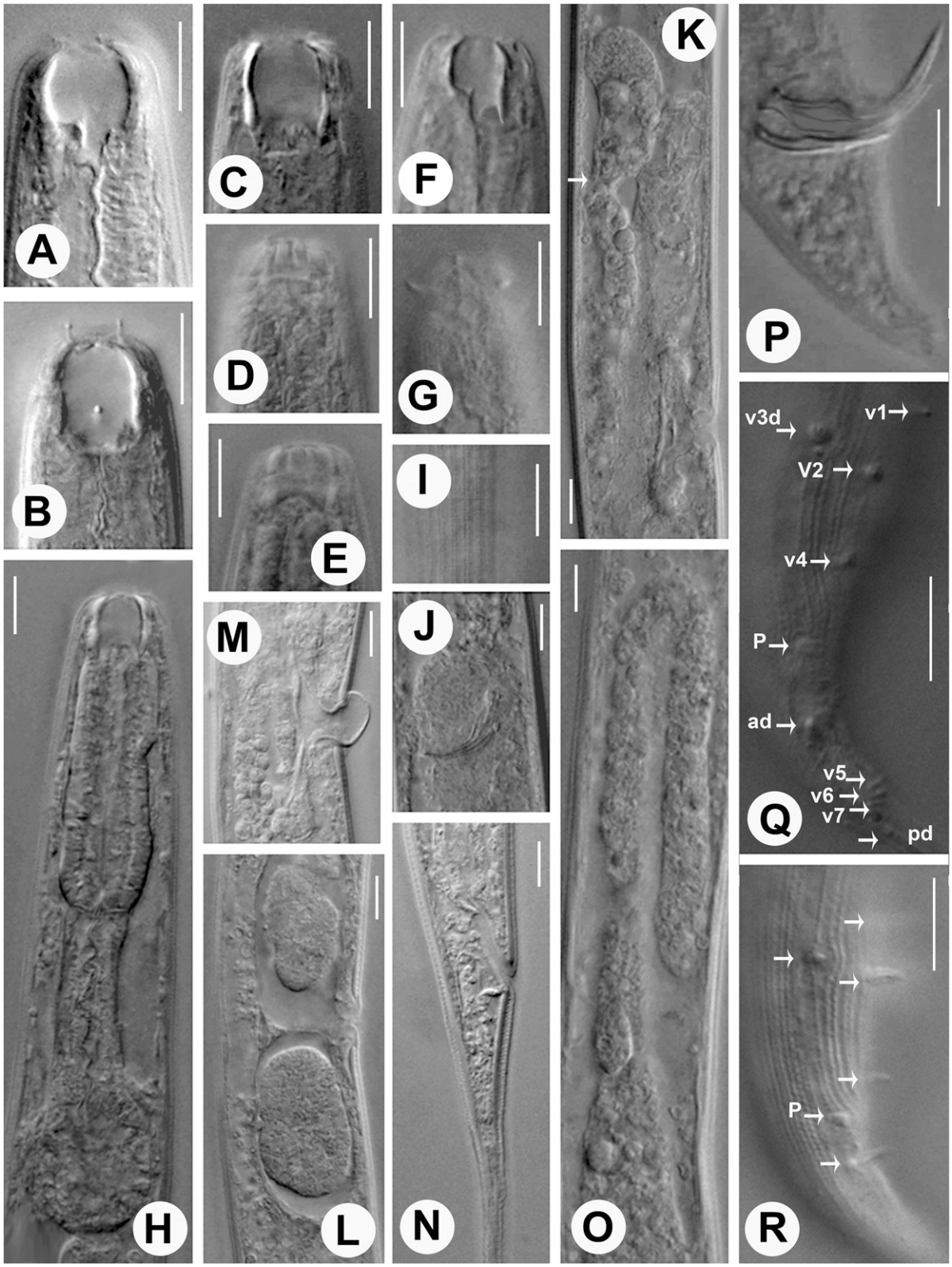

FIG. 2. *Paroigolaimella helalii* n. sp. A–E, G. Anterior end (female). F. Anterior end (male). H. Pharyngeal region. I. Body showing longitudinal ridges. J. Intestine containing spicule and gubernaculum of prey. K. Anterior genital branch (female). L. Uterus with embryonating eggs. M. Vulval region showing cuticular flap. N. Female tail region. O. Male testis and vas deferens. P–R. Male tail region. Scale bar = 10 μm.

Female reproductive system didelphic, amphidelphic; ovaries reversed, long, extending beyond vulva or crossing each other (Fig. 1F). Anterior ovary on right and posterior one on left side of intestine. Oocytes in each ovary arranged in two or more rows in germinal zone separated from large proximal oocyte by a sphincter

TABLE 1. Morphometrics of *Paroigolaimella helalii* n. sp., *P. coprophila* (Sudhaus and Rehfeld, 1990) Sudhaus and Fürst von Lieven, 2003, and *P. bodamica* (Micoletzky, 1922) n. comb. Measurements in micrometers and in the form: mean ± standard deviation (range).

	P. helalii n. sp.			*P. coprophila* (Sudhaus and Rehfeld, 1990) Sudhaus and Fürst von Lieven, 2003		*P. bodamica* (Micoletzky, 1922) n. comb.	
Character	Holotype female	Paratype female (n = 10)	Paratype male (n = 6)	Female (n = 10)	Male (n = 5)	Female (n = 3)	Male (n = 1)
Body length	790	755.6 ± 61.1 (667–836)	532.1 ± 63.5 (448–602)	708.1 ± 31.0(668–741)	503.6 ± 36.3 (453–563)	845 ± 5.6 (753—869)	822
Body diameter	39	36.6 ± 2.9 (30–40)	24.5 ± 1.2 (23–26)	28.4 ± 1.4 (27–32)	17.2 ± 0.4 (17–18)	21 ± 0.1 (19–21)	20
a	20.2	20.7 ± 1.5 (18.5–23.6)	21.6 ± 2.0 (19.4–25.1)	24.5 ± 0.7 (23.5–25.6)	29.2 ± 2.2 (26.6–33.1)	41.1 ± 1.8 (40–43)	41.1
b	7.1	7.0 ± 0.6 (5.9–7.8)	7.0 ± 0.8 (5.9–8.2)	8.8 ± 0.5 (8.1–9.6)	7.6 ± 0.4 (7.1–8.2)	6.9 ± 0.2 (6.8–7.4)	8.0
c	3.7	3.3 ± 0.1 (3.1–3.7)	5.1 ± 0.5 (4.2–5.6)	3.7 ± 0.6 (3.2–5.7)	3.9 ± 0.1 (3.7–4.2)	3.9 ± 0.2 (3.7–4.2)	5.9
c'	11.5	13.3 ± 1.4 (11.5–17.1)	6.0 ± 0.5 (5.3–6.5)	14.0 ± 1.1 (11.2–15.3)	9.2 ± 0.4 (8.7–10)	16.5 ± 0.6 (15.1–16.7)	9.2
V/T	44.9	42.4 ± 1.4 (39.6–44.9)	59.3 ± 2.6 (54.8–62.3)	41.3 ± 1.0 (40.2–43.3)	57.4 ± 1.9 (55.4–61.2)	42.8 ± 2.2 (42,3–45.4)	60.4
G1/spicule length	47.5	47.1 ± 6.1 (36.5–60.3)	23.3 ± 1.6 (21–26)	42.7 ± 5.3 (31.8–48.8)	22.6 ± 1.0 (21–24)	27.3 ± 0.8 (26.6–28.1)	25
G2/gubernaculum length	43.6	43.0 ± 5.9 (33.3–54.7)	13.8 ± 1.3 (12–16)	42.9 ± 4.6 (34.4–52.4)	11.8 ± 0.9 (10–13)	28.8 ± 1.2 (27.4–29.7)	13
Lip region height	5	5.6 ± 0.6 (5–6)	3.9 ± 0.1 (3.5–4.0)	3.5 ± 0.5 (3–4)	2.7 ± 0.4 (2–3)	2.5 ± 0.7 (2–3)	2
Lip region diameter	15	16.1 ± 0.9 (14–17)	12.0 ± 0.5 (11–13)	9.2 ± 0.4 (9–10)	8.2 ± 0.4 (8–9)	6.5 ± 0.7 (6–7)	7
Stoma length	11	14.1 ± 1.6 (11–17)	9.3 ± 0.7 (8–10)	7.5 ± 0.5 (7–8)	6.6 ± 0.4 (6–7)	5.5 ± 0.7 (5–6)	6
Stoma diameter	8	8.0 ± 1.2 (7–10)	4.6 ± 0.5 (4–5)	3.0 ± 0.2 (2.5–3.5)	2.3 ± 0.2 (2–3)	6.5 ± 0.7 (6–7)	5
Pharynx length	110	107.0 ± 4. 6 (96–112)	75.5 ± 2.0 (73–78)	79.2 ± 3.8 (73–86)	65.8 ± 2.0 (63–68)	124 ± 1.8 (121–126)	102
Nerve ring from anterior end	75	74.0 ± 2.2 (69–77)	51.6 ± 2.6 (48–55)	59.9 ± 3.7 (53–64)	50.6 ± 0.9 (50–52)	82.5 ± 10.1 (75–90)	72
Secretory-excretory pore from anterior end	100	92.2 ± 4.8 (86–100)	64.0 ± 2.6 (60–67)	65.0 ± 5.0 (67–70)	58.6 ± 2.7 (55–60)	90.8 ± 7.7 (84–96)	77
Rectum length	20	23.0 ± 1.9 (20–25)	24.2 ± 2.3 (22–27)	19.2 ± 1.1 (18–21)	22.5 ± 1.9 (20–25)	18.5 ± 0.7 (15–19)	25
Anal body diameter	18	17.2 ± 1.4 (14–19)	17.1 ± 0.6 (16–18)	14.2 ± 0.9 (12–16)	13.6 ± 0.8 (13–15)	14.5 ± 0.9 (12–15)	15
Tail length	208	227.8 ± 16.7 (205–260)	103.5 ± 5.9 (97–112)	199 ± 12.0 (184–210)	126.4 ± 8.3 (115–140)	175 ± 12.0 (170–227)	138

(Figs. 1F,2K). Each ovary narrowing down into an oviduct; spermathecae long separated from corresponding uteri by sphincter; uteri occasionally containing one to two eggs of 40 to 47 × 22 to 23 µm dimension in early stages of segmentation. Vagina 9- to 12-µm long occupying one-third to one-fourth of corresponding body diameter at right angle to main body axis, leading to a strong ovijector (Fig. 1F). Vulva pore-like with slightly protruded lips and a cuticular flap. Tail 1.0 to 1.5 times vulva-anal distance long, sharply narrowing to whip-like posterior region.

Male (n = 6): Similar to female in general appearance except smaller body size, greater posterior curvature, and dimorphism in anterior region. Stoma representing a smaller narrower cavity with weak dorsal tooth and smaller and angular subventral plates bearing minute denticles. Testis single ventrally reflexed, reflexed part 40- to 60-µm long. Spicules slender, strongly arcuate, 1.3 to 1.6 times anal body diameter long with dilated capitula and fine distal tips (Figs. 1H,2P,Q). Gubernaculum proximally curved, about half of spicule length with an expanded plate-like distal end. Genital papillae nine pairs, i.e., three precloacal and six postcloacal pairs. Precloacals fairly larger than postcloacals that gradually diminish in size and thickness posteriorly. Genital papillae arranged in configuration: *v1, v2, v3d/v4, ad, (v5 + v6, v7), pd*. The precloacal pairs *v1* and *v2* are spaced and subventral; *v3d* slightly at an anterior level to *v2*, lateral; *v4* subventral, about one-third of cloacal body diameter posterior to cloaca; *ad* subventral, almost equidistant from *v4*; *v5*, *v6*, and *v7* subventral forming a cluster; *pd* subdorsal. Phasmids located between *v4* and *ad*. Four to five pairs of copulatory muscle bands present anterior to precloacal genital papillae.

Diagnosis: Paroigolaimella helalii n. sp. is characterized by individuals having medium-sized, plump body with dimorphism in anterior body region (females with ovoid and wide stomal chamber with large dorsal tooth; strongly developed pharynx with robust basal bulb vs. males with relatively narrower stomal chamber having a small dorsal tooth; pharynx less developed with a weak basal bulb); ovaries with a sphincter separating the mature oocytes from developing ones; presence of intrauterine embryonating eggs, vagina leading to an ovijector; pore-like vulva with cuticular flap; males with slender strongly arcuate spicules with dilated capitula; gubernaculum slender with expanded plate-like distal end and nine pairs of genital papillae and four to five pairs of copulatory muscle bands.

Relationships: Paroigolaimella helalii n. sp. differs from *P. stressmanni* (Weingärtner, 1955) Andrássy, 1958 in having sexual dimorphism in stoma and pharynx (vs. sexual dimorphism absent in stoma and pharynx); greater ć values in females (11.5 to 17.1 vs. 8 to 9) and males (5.3 to 6.5 vs. up to 3 Fig. 24c *apud* Weingärtner, 1955) and a longer rectum (1.3 to 1.4 times vs. 0.5 times anal body diameter in *P. stressmanni apud* Weingärtner, 1955); from *P. coprophages* (de Man, 1876) Paramonov, 1952 having sexual dimorphism in stoma and pharynx (vs. sexual dimorphism absent in stoma and pharynx); smaller 'b' value (5.9 to 7.8 vs. 7 to 13) and males with distal end of gubernaculum smooth (vs. bidentate in *P. coprophages* (de Man, 1876) Paramonov, 1952 *apud* Weingärtner, 1955); from *P. micrura* (Weingartner, 1955) Andrássy, 1958 in having sexual dimorphism in stoma and pharynx (vs. sexual dimorphism absent in stoma and pharynx); gymnostom with arched walls (vs. parallel walled) with rasp plates strongly (vs. weakly) developed; male genital papillae *v3d* close to level of *v2* or at middle of *v1* and *v2* (vs. shifted anteriad at level of *v1*); and spicules with capitula weakly offset (vs. distinctly offset in *P. micrura apud* Weingärtner, 1955 and Sudhaus and Rehfeld, 1990); from *P. affinis* (Sudhaus and Rehfeld, 1990) Sudhaus and Fürst von Lieven, 2003 in having sexual dimorphism in stoma and pharynx (vs. sexual dimorphism absent in stoma and pharynx); gymnostom with arched walls (vs. parallel walled) with (vs. without) denticles on subventral plates and spicules strongly arcuate with long tapering part (vs. weakly arcuate with short tapering part); gubernaculum in *P. affinis apud* Sudhaus and Rehfeld, 1990).

Type habitat and locality: Samples having *P. helalii* n. sp. collected from a tree tunnel at Iglas, Aligarh, Uttar Pradesh, India, at coordinates 27.727° N, 77.933° E.

Type designation: Holotype female, 10 paratype females and six paratype males on slide *P. helalii* n. sp. SN-67/1-6 deposited in the Nematode Collection, Department of Zoology, Aligarh Muslim University, Uttar Pradesh, India.

Remarks: P. helalii n. sp. shows relatively stout individuals with a wide, barrel-shaped buccal cavity having powerful armature. Although sexual dimorphism is seen in the species of *Paroigolaimella*, the stoma in the male of *P. helalii* remarkably differs from that of female in its shape as well as size. *P. helalii* shares few features with all the three species *P. affinis*, *P. micrura*, and *P. coprophages* yet is distinct from them. However, the habitat of the species is remarkably different from the rest as it was collected from tree tunnel and not from cow pats. The large-sized spacious buccal cavity armed with a prominent dorsal tooth and serrated subventral plates of fairly conspicuous denticles may enhance the predatory abilities of the species. The presence of the spicules of presumably a diplogastrid nematode in the intestine also suggests its mode of feeding similar to mononchs, which may involve at least devouring large chunk of prey body parts. The predatory features seem to be enhanced due to its thick and short heavily muscular pharynx and robust basal bulb showing conspicuous dilation of lumen in some specimens. The reproductive system of female is well developed, and the vagina is conspicuous with strong ovijector for efficient expulsion of intrauterine eggs, an efficient strategy of progeny propagation in insect-disseminated

nematodes. The location of the species also does not rule out any possibility of phoresis.

Paroigolaimella coprophila (Sudhaus and Rehfeld, 1990) Sudhaus and Fürst von Lieven, 2003
(Figs. 3,4)

Measurements of females and males are given in Table 1.

Female (n = 10): Body medium sized, gradually tapering toward extremities more toward posterior end. Cuticle marked with fine transverse striations and longitudinal ridges. Lip region rounded or flat, with six amalgamated lips having slightly raised sensilla. Amphidial opening obscure or faintly visible at level of metastegostom. Lateral fields with two lines. Stoma barrel shaped and relatively wider occupying 40% to 60% of labial diameter. Cheilostom and gymnostom short, cuticularized (Figs. 3C,D,4C). Stegostom anisomorphic, dorsal metastegostomal wall with a moderately large tooth (Fig. 4A,B); subventral walls provided with distinct, small denticles (Fig. 3C). Pharyngeal tissue surrounding stoma at metastegostom level. Pharyngeal corpus muscular 41- to 46-µm long, median bulb prominent, ovoid. Isthmus differentiated from median bulb, 18- to 27-µm long, broad, slightly dilated posteriorly to form a glandular basal bulb (Figs.

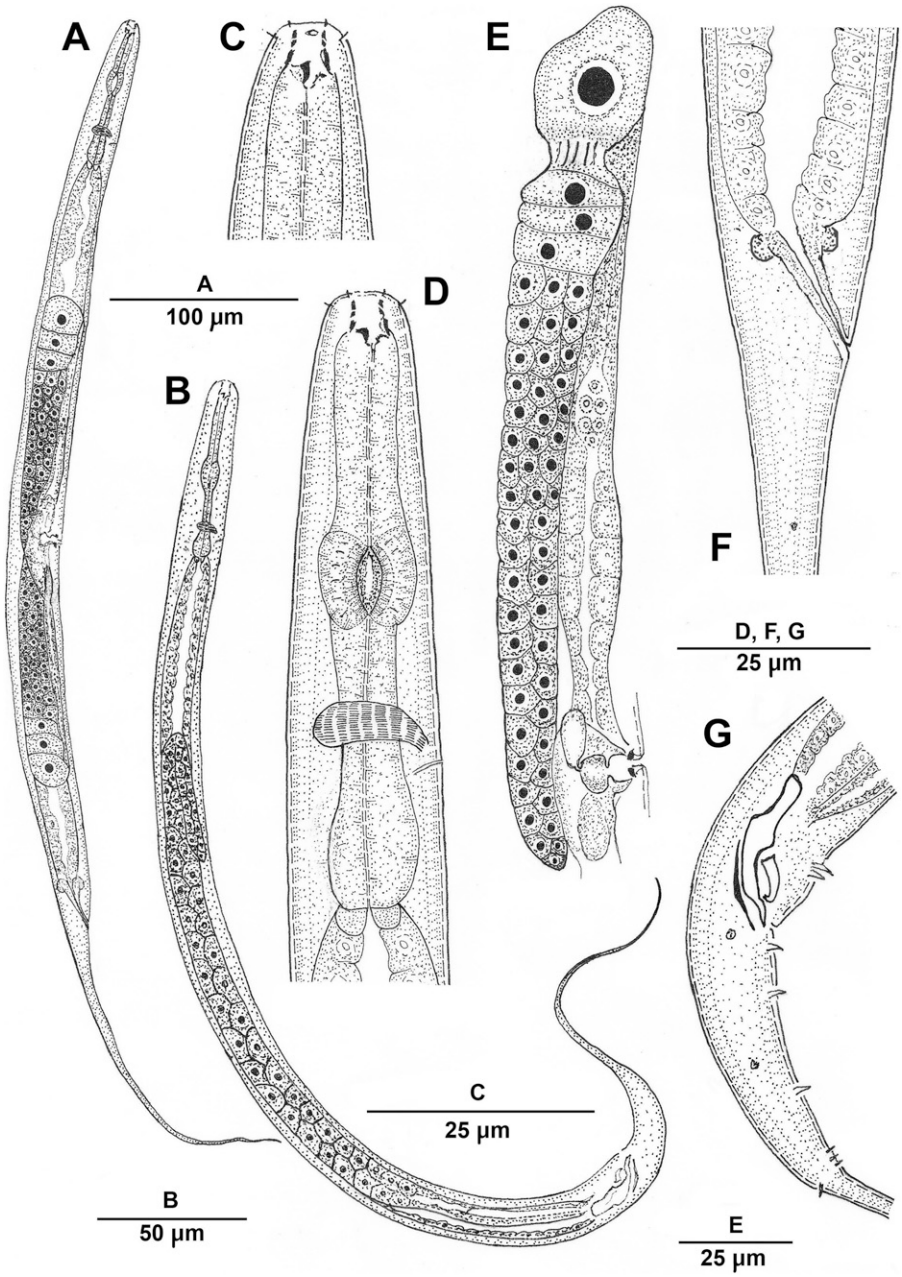

Fig. 3. *Paroigolaimella coprophila* (Sudhaus and Rehfeld, 1990) Sudhaus and Fürst von Lieven, 2003. A. Entire female. B. Entire male. C. Anterior region. D. Pharyngeal region. E. Anterior genital branch (female). F. Female tail region. G. Male tail region.

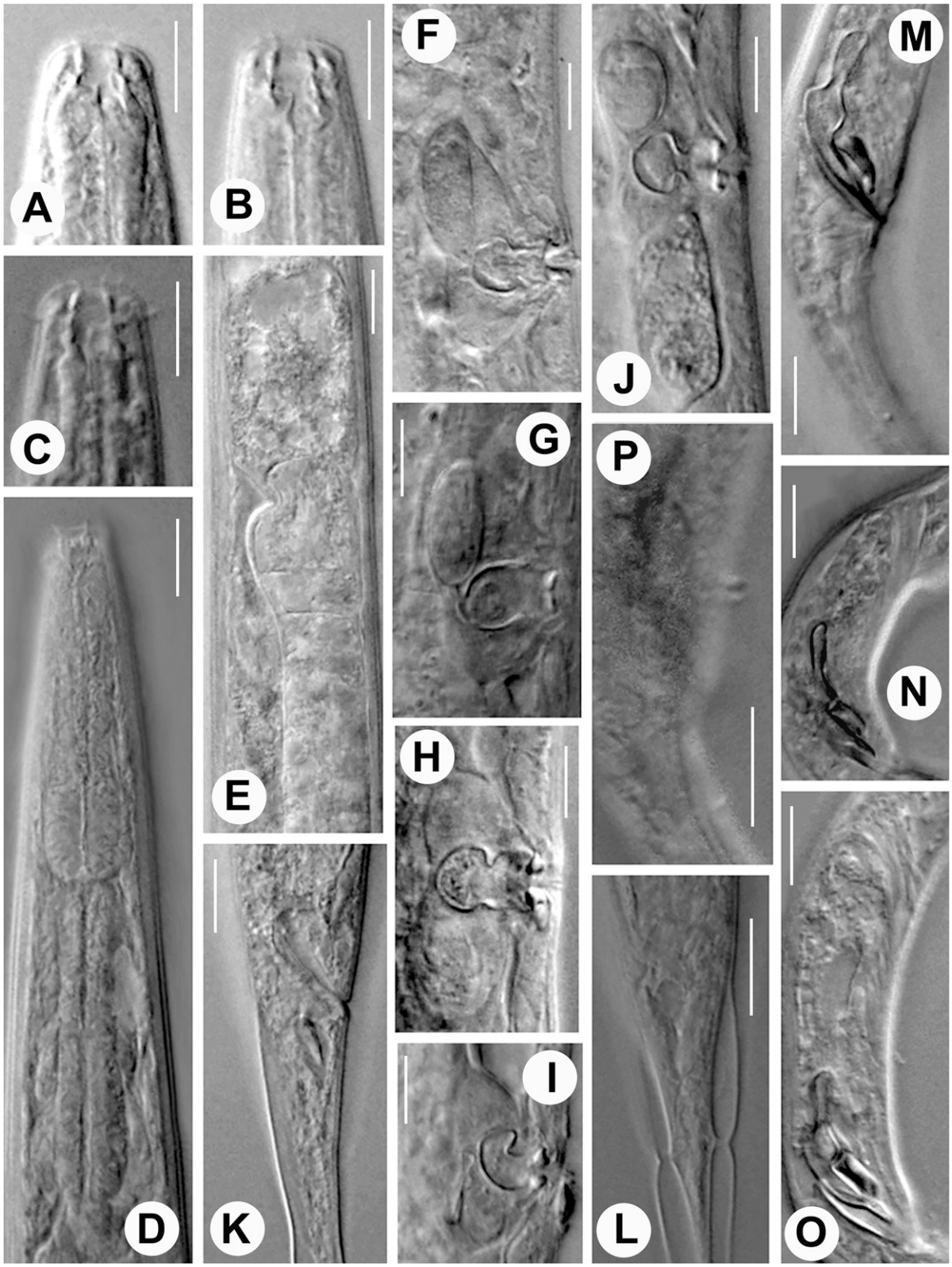

Fig. 4. *Paroigolaimella coprophila* (Sudhaus and Rehfeld, 1990) Sudhaus and Fürst von Lieven, 2003. A–C. Anterior region. D. Pharyngeal region. E. Female genital branch showing sphincter. F–J. Vulval region showing bladder(s) and vaginal chamber. K, L. Female tail region. M–P. Male tail region. Scale bar = 10 μm.

3D,4D). Nerve ring encircling middle of isthmus at 72.6% to 74.4% of pharyngeal length from anterior end. Secretory-excretory pore placed posterior to nerve ring or at 81.3% to 91.7% of pharyngeal length from anterior end. Body at pharyngeal end 2.1 to 2.5 times labial diameter wide. Intestine with narrow lumen.

Rectum 1.3 to 1.5 anal body diameter long. Female reproductive system didelphic, amphidelphic; anterior ovary branch on right and posterior ovary on left side of intestine. Ovaries reversed, often reaching level of vulva (Fig. 3E). Oocytes in each ovary, arranged in two or more rows in germinal zone separated from large proximal oocyte by a sphincter (Fig. 4E). Spermatheca oblong. Uterus divisible into muscular and glandular parts containing occasionally a single egg of 50 to 52 × 19 to 21 μm dimension. Vagina leading to a bilobed horse shoe-shaped chamber having distal triangular cuticularized pieces. Usually one anterior, occasionally two (anterior and posterior) bladder-like membranous pouches of 14.0 to 26.0 × 8 to 11 μm dimension, opening into vaginal chamber through narrow stalks (Fig. 4F,G,I,J). Vulval opening circular. Distance from anterior end to the anus about 1.7 times the distance from anterior end to vulva. Tail filiform, gradually tapering posteriorly, 0.8 to 0.9 times vulva-anal distance. Phasmid conspicuous, opening 22 to 38 μm posterior to anal opening (Fig. 4L).

Male (n = 5): Similar to female in general morphology except smaller size and greater posterior curvature. Testis single, ventrally reflexed, reflexed part 42- to 50-μm long. A band of muscles present 20 to 35 μm anterior to precloacal genital papillae. Spicules heavily cuticularized, deeply yellow or brown, heavily built, extremely complex in structure (Figs. 1G,2M–O), 1.6 to 1.8 times anal body diameter long, fused at more than half length forming a deep groove and bearing two pointed hooks or claws laterally. Dorsal wall of each spicule angular with a distinct shoulder. Gubernaculum linear, narrow, comprising 47.6% to 54.1% of spicule length. Genital papillae nine pairs, i.e., three pairs precloacal and six pairs postcloacal. Genital papillae arranged in configuration: *v1*, *v2/v3d*, *v4*, *ad*, (*v5* + *v6*, *v7*), *pd*. Precloacal pairs *v1* and *v2* closely placed (Fig. 4P) and subventral (*v1* in some specimens slightly longer than *v2*) (Fig. 3G); *v3d* slightly at an anterior level to *v2*, lateral, dorsally directed; *v4* subventral about one-third of cloacal body diameter posterior to cloaca; *ad* subventral almost equidistant from *v4*; *v5*, *v6*, and *v7* subventral forming a cluster; *pd* subdorsal. Phasmid 20 to 32 μm from cloaca. Tail gradually tapering toward end into a whip-like terminus.

Habitat and locality: Samples containing *P. coprophila* were collected from the leaf litter of a farmyard at Gabhana, Aligarh, Uttar Pradesh, India, at coordinates 28.0492° N, 77.9610° E.

Voucher specimens: Ten females and five males on slide *P. coprophila* SN-46/1-7 deposited in the Nematode Collection, Department of Zoology, Aligarh Muslim University, Uttar Pradesh, India.

Remarks: The measurements, morphometric values, and descriptions of present population reflect its conformity to *P. coprophila* (Sudhaus and Rehfeld, 1990) Sudhaus and Fürst von Lieven, 2003. On the basis of present observations, the prominent and obvious features that make *P. coprophila* distinct from the close ally *P. bernensis* are the following: the size and shape of stoma that is longer than width and similar in both sexes; a conspicuous dorsal tooth; a pre-equatorial vulva and males with long filiform tail and spicules with smooth shoulder and the obliquely placed muscle band. The species also showed a greater c (13 to 16 vs. 5 to 11) and a smaller V (36 to 42 vs. 45 to 59) value than that of *P. bernensis*. Several features considered distinguishing between *P. coprophila* and *P. bernensis* by Sudhaus and Rehfeld (1990) have been found overlapping thus unreliable in the present study. The present specimens, therefore, show similarities to *P. bernenis* on account of the presence of the sphincter within ovary; the shape and sclerotization of vaginal chamber, the greater dimension of bladder; relatively larger size of v1 in few cases. The distance of the copulatory muscle band from cloaca also shows variation in individuals. Some of the characters shared by both species are the fine transverse and longitudinal striations with punctations; lateral field represented by a band; cheilostom and gymnostom with upright walls; the relatively small dorsal tooth and very fine subventral denticles, median bulb well demarcated from isthmus; the secretory-excretory pore located in posterior pharynx; long reversed ovaries reaching vulva or crossing each other; cuticularized vaginal chamber with thick pieces and associated anterior and posterior bladders; and finally the males with heavily cuticularized brown, complex, fused spicules and genital papillae having similar configuration. The individuals show the distance from the anterior end to the anus about 1.7 times the distance from the anterior end to vulva, a characteristic of *P. bernensis* and one of the criteria used by Sudhaus and Rehfeld, 1990 for determining the conspecificity of *P. bodamica* (Micoletzky, 1922) and *P. bernensis*.

Paroigolaimella bodamica (Micoletzky, 1922) n. comb.
(Figs. 5,6)

Measurements of females and males are given in Table 1.

Female (n = 3): Body slender, straight, gradually tapering toward extremities, more toward posterior end. Cuticle 0.5 to 1.0 μm with fine transverse striations; longitudinal ridges obscure, occasionally faint lines present with elements of punctations (Fig. 6L). Amphidial openings usually obscure, ovoid, 10 to 11 μm from anterior end or posterior to base of stoma. Lateral fields usually inconspicuous, occasionally with two faint lines equivalent to the distance between three consecutive longitudinal striae (Fig. 6K). Lip region dome shaped, slightly narrower but continuous with adjoining body. Lips six, closed, amalgamated; sensilla fine, setose. Stoma representing an ovoid, shallow vestibule, occupying 75% of labial diameter with a widened and more or less flattened base (Figs. 5A,6A,B). Cheilostom cuticularized, arched having 12 adradial plates (Fig. 6C). Gymnostom with thick cuticularized, posteriorly

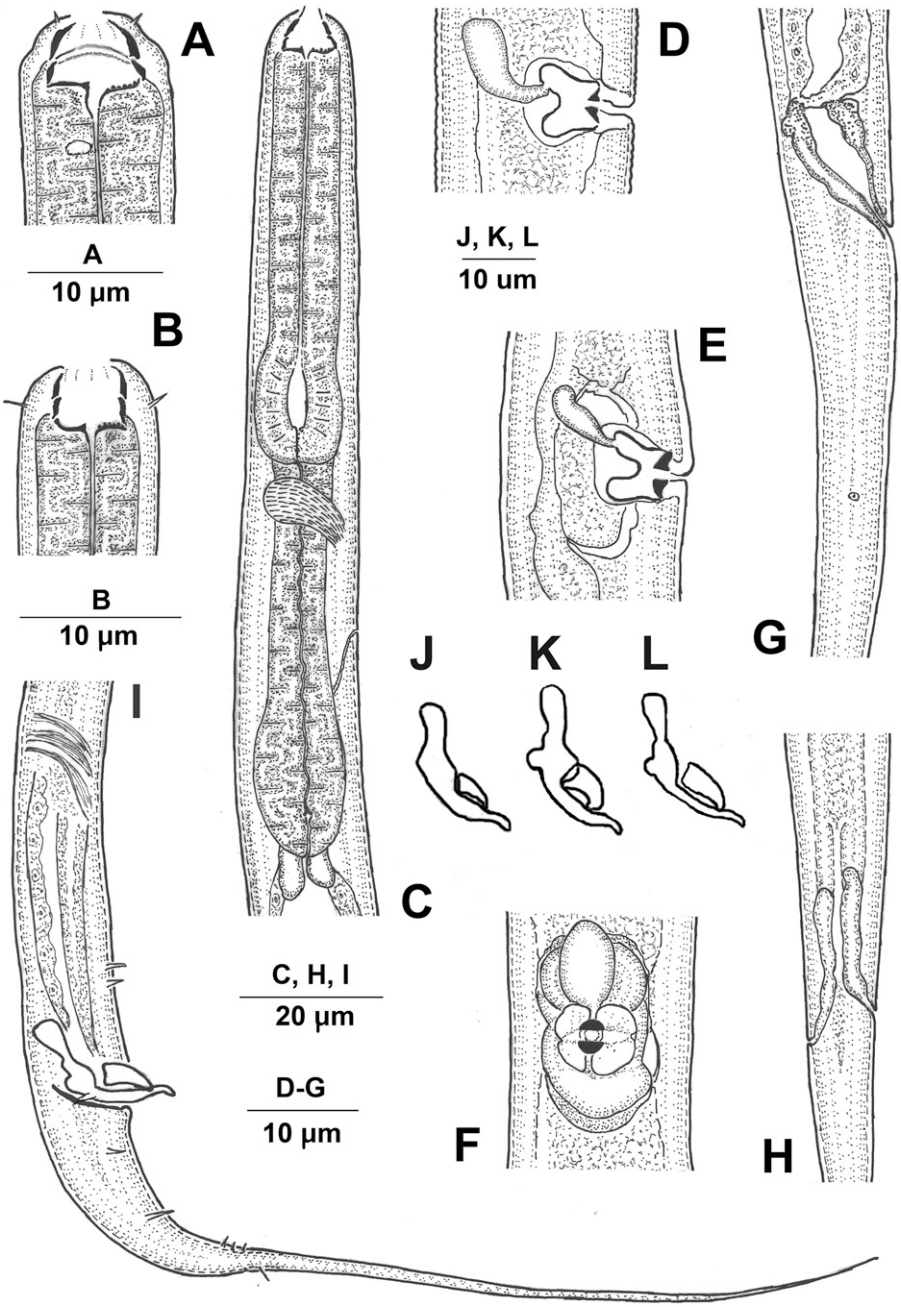

FIG. 5. *Paroigolaimella bodamica* (Micoletzky, 1922) n. comb. A. Anterior end (female). B. Anterior end (male). C. Pharyngeal region. D, E. Vulval region (lateral). F. Vulval region (ventral). G, H. Female tail region. I. Male tail region. J–L. Spicules of *P. coprophila*, *P. bernensis*, and present specimen, respectively.

diverging walls, isotopic, and isomorphic. Stegostomal walls anisomorphic, dorsal wall with a plate-like tooth; each subventral metastegostomal swelling bearing fine, row of very fine wart-like denticles. A double-arched transversal band present at midlevel of stoma presumably reflecting the gymnostomal and metastagostomal joints. Pharyngeal tissue surrounding stoma at stegostomal level. Pharyngeal corpus prominently swollen, muscular 49- to 50-µm long leading to a median bulb of 11 to 17 × 10 to 13 µm dimension with thickened lumen; isthmus differentiated, 40- to 41-µm long; basal bulb usually elongate pyriform, occasionally massive, 20 to 21 µm × 11 to 12 µm in dimension. Pharyngeal lumen in posterior part of pharynx relatively strongly cuticularized and wavy (Fig. 6F). Nerve ring encircling middle of isthmus, located at 61% to 71% of pharyngeal length from anterior end. Secretory-excretory pore in isthmus region, at 69% to 76% of pharyngeal length from anterior end (Fig. 5C). Body at pharyngeal end 1.3 to 1.5 times labial diameter wide. Cardia with conical flaps. Intestinal lumen occasionally widened anteriorly, filled with bacteria (Fig. 6G). Rectum 1.4 to 1.7 times anal body diameter long (Fig. 6N) with weakly developed rectal glands. Female reproductive system

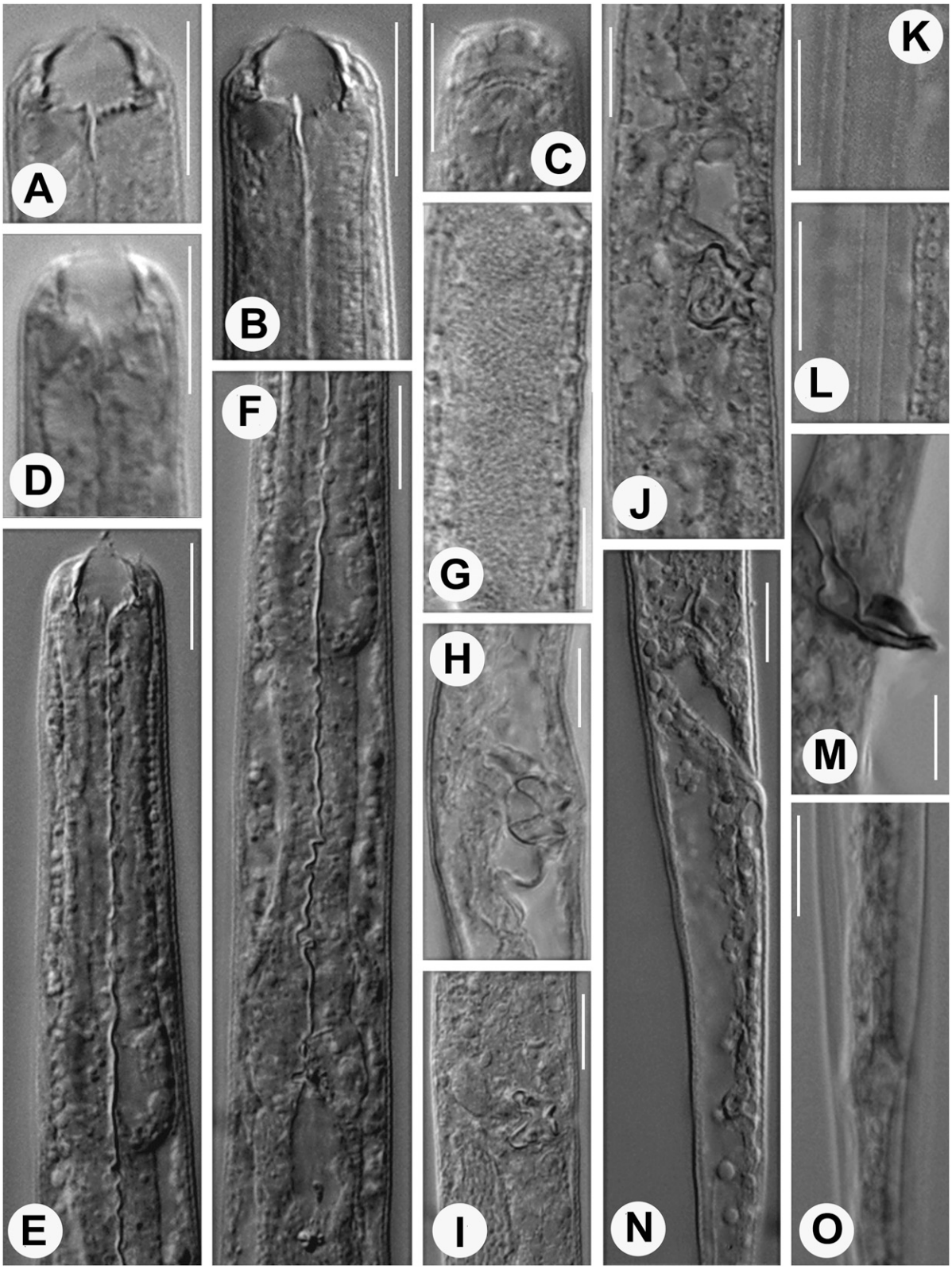

Fig. 6. *Paroigolaimella bodamica* (Micoletzky, 1922) n. comb. A–C. Anterior end (female). D. Anterior end (male). E. Anterior pharyngeal region. F. Posterior pharyngeal region. G. Intestinal region showing aggregated bacteria. H–J. Vulval region. K, L. Body with cuticular markings. M. Male tail region. N, O. Female tail region. Scale bar = 10 μm.

didelphic, amphidelphic; ovaries reversed, long, never reaching vulva or crossing each other. Anterior ovary on right and posterior one on left side of intestine. Oocytes in each ovary arranged in two or more rows in germinal zone, sphincter not observed. Spermathecae oblong; uteri spacious, divisible into muscular and glandular

parts, no intrauterine eggs observed. Vagina 8- to 10-μm long occupying one-half to one-third of corresponding body diameter, leading to a cuticularized ovoid chamber with distal cuticularized thickened pieces; outer and inner walls of vaginal chamber cuticularized with inner wall occasionally folded to form two horns of variable shapes (Figs. 5D–F,6H–J). An anteriorly placed, bladder-like membranous pouch measuring 10 to 11 × 5 to 6 μm opening into vaginal chamber through narrow stalk. Vulval opening circular. Tail filiform, gradually tapering tail 0.8 to 1.0 times vulva-anus distance long, sharply narrowing to whip-like posterior region. Phasmidial openings 24 to 30 μm posterior to anus connected to conspicuous glands (Figs. 5H,6O).

Male (n = 1): Similar to female in general morphology except smaller size, greater posterior curvature, and shape of stoma. Stoma relatively narrower occupying 50% to 60% of labial diameter. Testis single, ventrally reflexed, reflexed part 80-μm long. A curved band of muscles, present 35 μm anterior to cloaca (Fig. 5I). Spicules heavily cuticularized, dark brown in color, extremely complex in structure, 1.6 to 1.8 times anal body diameter long, fused at more than half length forming a deep groove–bearing small conspicuous protrusion of dorsal wall, a thin narrow lamina, and two robust lateral claw-like appendages. Capitulum large, triangular with blunt proximal end, dorsal shoulder, and ventral triangular process inconspicuous (Figs. 5I,6M). Gubernaculum linear, narrow, comprising 47.6% to 54.1% of spicule length. Genital papillae nine pairs, i.e., three pairs precloacal and six pairs postcloacal. Genital papillae arranged in configuration: *v1*, *v2/v3d*, *v4*, *ad*, (*v5* + *v6*, *v7*), *pd*. The precloacal pairs *v1* and *v2* close, subventral, *v1* longer than *v2*; *v3d* at level of upper cloacal lip, laterally placed but dorsally directed; *v4* subventral about one-third of cloacal body diameter posterior to cloaca; *ad* subventral about two-thirds of cloacal body diameter from *v4*; *v5*, *v6*, and *v7* subventral forming a group; *pd* subdorsal (Fig. 5I). Tail filiform gradually tapering toward a filamentous end.

Habitat and locality: Samples having *P. bodamica* collected from a ditch at Bulandshahr, Uttar Pradesh, India, at coordinates 28.4000° N, 77.8500° E.

Voucher specimens: Three females and one male on slide *P. bodamica* SN-15/1-4 deposited in the Nematode Collection, Department of Zoology, Aligarh Muslim University, Uttar Pradesh, India.

Amended Diagnosis

P. bodamica is characterized by medium-sized individuals with extremely slender body with sexual dimorphism in stoma; stomal chamber ovoid, wider than long occupying 75% of labial diameter having arched cheilostom, small tooth on dorsal metastegostomal wall, very fine rows of denticles on subventral plates; presence of heavily arched double transversal band at midlevel of stoma, amphids posterior to base of stoma; posterior part of pharynx markedly longer than anterior part; secretory-excretory pore at middle level of isthmus; females with amphidelphic reproductive system with reversed ovaries not reaching vulva; ovarian sphincter not discernible, vaginal chamber with outer and inner walls cuticularized forming two horns of variable shapes; a small anteriorly placed bladder opening into vaginal chamber, relatively long tail (c = 3.6 to 4.2; c' = 15.1 to 16.7) and males with thick, brown, cuticularized spicules with large claw-like appendages, an insignificant shoulder, protruded dorsal wall, weak narrow lamina and a curved ventral wall without triangular process, and nine pairs of genital papillae.

Remarks

The present population despite resembling *P. bernensis* in morphometrics shows several differences from original and subsequently reported populations of *P. bernensis*. The individuals show high degree of conformity to the species first reported by Micoletzky, 1922 as *Diplogaster bodamicus* based on five females (Sudhaus and Rehfeld, 1990). However, its status was considered doubtful due to the male being unknown. The species was later synonymized with *P. bernensis* by Liebermann (1927), and the decision was further endorsed by other workers (Schneider, 1939; Meyl, 1961; Zullini, 1974) due to several similar female features. However, Paramonov (1952) did not approve the synonymization and considered *D. bodamicus* a valid species. Goodey (1963) considered it species *inquirenda*. Zullini (1982) reported a population with both females and males from fresh water and considered it *P. bernensis* because of availability of males, which showed features similar to those of *P. bernensis*. Sudhaus and Rehfeld (1990) evaluated the features of the original female specimens and finally synonymized them with *P. bernensis*. Later Mahamood and Ahmad (2009) reported a population collected from sewage and described it as *P. bernensis*. They also put on record few conspicuous differences namely, a relative posterior position of amphids, greater 'a' value, and absence of the posterior bladder associated with vaginal chamber in their population collected from northern India. Zullini (1974) described a population from river Po and emphasized the widened cavity and presence of a double transversal band at level of stoma also reported by Micoletzky (1922) and Liebermann (1927). Presence of such band may not be a unique feature as it shows the joints of stomal components; however, its shape seems to be important as it is slightly concave in both *P. coprophila* and *P. bernensis* but deeply arched in the specimens of Micoletzky (Fig. 2O *apud* Sudhaus and Rehfeld, 1990). Though we do not support splitting of taxa on trivial grounds but accumulation of heterogeneity can also not be promoted. *P. bernensis* is a species that shows a very large range of

values with individuals extremely slender to fairly plump-bodied. Likewise, there is a lot of variation in the shape of buccal cavity, which is largely of two categories: square shaped or slightly longer than wide and much wider than long. The individuals can be further grouped into long-tailed individual with fine acute tip and individuals with long whip-like terminal parts. Similarly, *P. bernensis* (*apud* Sudhaus and Rehfeld, 1990) shows a relative anterior position of amphids and posterior location of excretory pore, which is in the region of isthmus in the present population. Other conspicuous features that make the present population different from *P. bernensis* are the strong sexual dimporphism in stoma, fine (vs. prominent and double) longitudinal lines, absence (vs. presence) of sphincter in ovaries, globular (vs. horse shoe-shaped) vaginal chamber with only anterior (vs. anterior/posterior) bladder, and a swollen/dilated (vs. non-dilated) rectum. The only male found in the present population also revealed few features that could be worth considering. A comparison of spicules of *P. coprophila*, *P. bernensis*, and present specimen (*P. bodamica*) shows some differences as depicted in Fig. 5J–L. All the three species have thick cuticularized spicules of brown color; however, the spicules of *P. coprophila* are relatively smaller showing a distinct dorsal shoulder compared to other two species, which lack a conspicuous shoulder but a small bulge/protrusion in dorsal wall. The hook- or claw-like lateral appendages are relatively small in *P. coprophila* but robust in the other two species. The ventral triangular process is distinct and angular in *P. bernensis*, whereas very weak or rounded in the present specimen. Also, the capitulum is relatively larger and triangular with broad proximal end and the lamina much narrower and thinner compared to the corresponding structures in *P. coprophila* and *P. bernensis* as illustrated by Zullini (1982).

By comparing the morphometrics of the populations reported from time to time as *P. bernensis* by various workers (Table 2), some inference can be drawn: *P. bodamica* shows an overlapping range of values with *P. bernensis*. The values given by Sudhaus and Rehfeld (1990) fully interpret the species *P. bernensis*. The populations studied by Steiner (1914), Leibermann (1927) seem to be of *P. bernensis* only, whereas those by Zullini (1982) and Dassonville and Heyns (1984) appear to represent *P. bodamica*. The two species seem to be coexisting in several other cases namely, Zullini (1974), Andrássy (1958), and Pillai and Taylor (1968). The latter case spells out this fact clearly as the natural population showed more variations with quite large-sized individuals while cultured population supported relatively smaller and plump individuals (smaller 'a' value). An increase in length and width of individuals in cultures is well understandable as the cultured individuals tend to overgrow due to good nutrient resources. Contrarily, the cultured population of Pillai

TABLE 2. A comparison of the morphometrics of populations published as *Paroigolaimella bernensis* with the present population of *P. bodamica* (Micoletzky, 1922) n. comb.

Character	Populations										Present population
	Steiner (1914)	Micoletzky (1922)	Liebermann (1927)	Pillai and Taylor (1968) (natural)	Pillai and Taylor (1968) (cultured)	Zullini (1974)	Zullini (1982)	Dassonville and Heyns (1984)	Andrássy (1984)	Sudhaus and Rehfeld (1990)	Mahamood and Ahmad (2009)	
Female body length (mm)		0.82–1.16	0.71–0.83	0.67–1.30	0.62–0.85	0.79–1.20	0.85–1.20	0.81–1.11	0.80–1.16	0.65–1.33	0.76–0.79	0.75–0.86
a		33–37	21.6–29.6	21.4–45.0	15.4–26	37–53	30–48	34.5–45.2	26–37	17.3–30.8	35.4–37.8	40–43
b		5.4–7.1	5.2–5.9	5.3–9.5	5.2–7.8	5.8–8.0	6–8	4.8–8.9	5.2–7.1	5.0–9.3	5.7–6.3	6.8–7.4
c		6.3–8.1	5.8–6.4	4.2–7.9	4.5–7.0	6.2–8.8	6.7–9.0	6.3–7.4	6.3–9.0	4.5–6.8	5.1–5.4	3.6–4.2
V		49.5–52.5	~50	49–66	46–55	50–52	50–53	49.4–54.2	50–59	45–59	47.5–49.4	42.3–45.4
Male body length (mm)	0.74–0.79		0.64–0.81	0.73–1.10	0.57–0.78	0.72–0.85		0.72–0.99	0.60–0.79	0.63–0.91	0.57–0.69	0.82
a	41–44		39–50	33–51	23–40	44–54		42–51.6	39–50	33.8–40.7	34.5–44.8	41.1
b	6.6–6.9		6–6.5	6.3–9.0	5–7	6.3–6.4		5.9–8.6	5.6–7.0	5.6–6.7	5.2–5.6	8.0
c	6.6–7.3		6.5–9	5.6–9.0	4.2–7	10–11		7.4–8.9	6.6–7.03	5.5–7.1	5.3–6.7	5.9
Spicule length (µm)						24–26	20–26		20–25	22–25	21–25	25
Gubernaculum length (µm)									10–13	10–13	10–12	13

TABLE 3. Comparison between the three closely related species, *Paroigolaimella coprophila* Sudhaus and Rehfeld, 1990, *P. bernensis* (Steiner, 1914) Andrássy, 1958, and *P. bodamica* (Micoletzky, 1922) n. comb. based on morphometric and morphological characteristics.

Character	*P. coprophila* (original population)	*P. coprophila* (present population)	*P. bernensis* (*apud* Sudhaus and Rehfeld, 1990)	*P. bodamica* (Micoletzky, 1922) n. comb.
L	0.51–1.06 mm	0.66–0.74 mm	0.65–1.33 mm	0.75–1.16 mm
a	15.5–28.9	23.5–25.6	17.3–30.8	33–53
b	6.2–11.7	8.1–9.6	5.0–9.3	4.8–8.9
c	2.9–3.6	3.2–5.7	4.5–6.8	4.2–9.0
V	38–42	40.2–43.3	45–59	42.3–54.2
Longitudinal lines	Fine	Fine	Prominent, double	Fine
Amphid position	At level of dorsal tooth	At level of dorsal tooth	Indistinct/at stoma base level	At a level posterior to stoma base
Stoma shape	Longer than width	Longer than width	Slightly dimorphic, as wide as long	Strongly dimorphic, wider than long
Tooth type	Prominent, anteriorly directed	Conspicuous, anteriorly directed	Small, anteriorly directed	Small , usually plate like
Pharynx length	83–93 µm	73–86 µm	83–101 µm	122–126 µm
Excretory pore position	At the end level of pharynx	In region of posterior bulb	At the end of pharynx	In isthmus region
Basal bulb shape	Oblong	Oblong	Oblong	Oblong wide
Anterior Vs. posterior part of pharynx	Posterior longer	Posterior longer	Anterior equal or longer	Posterior longer
Rectum length	Not dilated	Not dilated	Not dilated	Dilated
Sphincter in ovary	Absent	Present	Present	Absent
Vaginal chamber shape	Globular	Horse shoe-shaped	Horse shoe-shaped	Globular
Orientation of bladder	Anterior/posterior	Anterior/posterior or both	Anterior/posterior	Anterior only
Bladder dimension	8.5–14.0 × 5–10 µm	14–26 × 8–11 µm	13–17 × 10–11 µm	7–11 × 5–9 µm
L	0.49–0.65 mm	0.45–0.56 mm	0.63–0.91 mm	0.57–0.99 mm
a	23.8–34.5	26.6–33.1	33.8–40.7	34.5–54
b	6.4–8.0	7.1–8.2	5.6–6.7	5.2–9.0
c	3.2–3.8	3.7–4.2	5.5–7.1	5.3–9.0
Length of reflexed part of testis	33–61 µm	42–50 µm	86–135 µm	80 µm
Male tail	130–180 µm	184–210 µm	92–132 µm	138 µm
Spicule size	18–22 µm	21–24 µm	22–25 µm	20–26 µm
Spicule shape	Prominent shoulder; weak ventral triangular process; small and slender lateral appendage	Prominent shoulder; weak ventral triangular process; small and slender lateral appendage	Inconspicuous shoulder followed by dorsal protrusion; prominent ventral triangular process; large lateral appendage	Inconspicuous shoulder followed by dorsal protrusion; obscure ventral triangular process; robust lateral appendage, narrow lamina
Muscle band from cloaca	30–35 µm; oblique	25–40 µ; curved/oblique	43–60 µm; curved	35–45 µm; slightly curved
Genital papillae	*v1* and *v2* equal	Equal	*v1* larger	*v1* slightly larger

and Taylor (1968) showed small-sized individuals with a narrow range of morphometric values compared to natural population, thus indicating the probability of displacement of the other less-competent species in cultures leaving pure population of *P. bernensis*. This also indicates that *P. bernensis* shows a greater range of lengths including medium- to small-sized individuals as also reported by Sudhaus and Rehfeld (1990). It can be inferred that the congeners *P. bernensis*, *P. coprophila*, and *P. bodamica* are closely related sharing good number of characteristics (Table 3) and seem to have developed minor differences during the course of evolution. Due to restricted number of specimens and the destruction of the habitat, further samples could not be procured for molecular characterization. Nevertheless, we are looking forward to any such opportunity in future. However, based on the present study and the descriptions given by Micoletzky (1922), Zullini (1982), Dassonville and Heyns (1984), and Mahamood and Ahmad (2009), we strongly feel that the species *P. bodamica* (=*D. bodamicus* Micoletzky, 1922) is a valid species that may be a sibling species of *P. bernensis*, hence showing similarity in many features but demonstrating marked sexual dimorphism. The individuals may occur along with *P. bernensis* probably due to sharing similar habitats, a condition also reported with *P. affinis*, *P. coprophages*, and *P. micrura* (*apud* Sudhaus and Rehfeld, 1990).

Literature Cited

Andrássy, I. 1958. *Diplogaster lepidus* n. sp. und der Schlüssel der *Diplogaster*-Arten von unpaarigem Ovar. Nematologica 3:295–300.

Andrássy, I. 1984. Klasse Nematoda (Ordnungen Monhysterida, Desmoscolecida, Araeolaimida, Chromadorida, Rhabditida). *In* H. Franz, ed. *Bestimmungsbücher zur Bodenfauna Europas*. Stuttgart: Gustav Fischer, 509 pp.

Cobb, N. A. 1918. Estimating the nema population of the soil. Agricultural Technical Circular of U.S. Department of Agriculture 1:1–48.

Dassonville, A. F., and Heyns, J. 1984. Freshwater nematodes from South Africa. 7. New and known species collected in Skinnerspruit, Pretoria. Phytophylactica 16:15–32.

de Maeseneer, J., and D' Herde, J. 1963. Méthodes utilisées pour l'étude des anguillules libres du sol. Revue de Agriculture Bureaux 16:441–447.

de Man, J. G. 1876. Onderzoekingen over vrij in de aarde levende Nematoden. Tijdschrift der Nederlansche Dierkundige Vereenigning 2:78–196.

Gagarin, V. G. 1977. Three new species of nematodes from the order Rhabditida from areas of sewage discharge. Zoologicheskii Zhurnal 56:1245–1248.

Goodey, J. B. 1963. Soil and freshwater nematodes (Revised by Goodey, J. B.), ed. 2 edition. London: Methuen, 544 pp.

Liebermann, A. 1927. Die freilebenden Nematoden der Cakovicer Zuckerfabriksteiche. Internationale Revue der gesamten Hydrobiologie und Hydrographie 17:145–188.

Mahamood, M.d, and Ahmad, I. 2009. Nematodes of the Order Rhabditida from India. Description of *Diplogasteroides uriceus* sp. n. and *Rhabditoides papillatus* sp. n. (Diplogastrina). Nematology 11:541–550.

Micoletzky, H. 1922. Die freilebenden Erd-Nematoden mit besonderer Berücksichtigung der Steiermark und der Bukowina, zugleich mit einer Revision sämtlicher nicht mariner, freilebender Nematoden in Form von Genus-Beschreibungen und Bestimmungsschlüsseln. Archiv für Naturgeschichte 87:1–650.

Meyl, A. H. 1961. Die freilebenden Erd-und Süsswassernematoden (Fadenwürmer). *In* Die Tierwelt Mitteleuropas 1/5a: 164 pp.

Paramonov, A. A. 1952. Opyt ekologicheskoi klassificatsii fitonematod. Trudy Gelmintologicheskoi Laboratorii. Akademia Nauk SSSR 6:338–369.

Pillai, J. K., and Taylor, D. P. 1968. Biology of Paroigolaimella bernensis and Fictor anchicoprophaga (Diplogasterinae) in laboratory culture. Nematologica 14:159–170.

Sachs, H. 1950. Die Nematodenfauna der Rinderexkremente. Eine ökologisch systematische studie. Zoologische Jahrbücher (Systematik) 79:209–272.

Schneider, W. 1939. Würmer oder Vermes, II. Fadenwünner oder Nematoden. I. Freilebende und pflanzen-parasitische Nematoden. Die Tierwelt Deutschlands 36:1–260.

Seinhorst, W. 1959. A rapid method for the transfer of nematodes from fixative to anhydrous glycerin. Nematologica 4:67–69.

Stefański, W. 1922. Excrétion chez les nématodes libres. Archivum Nauk Biologicznych Towarzystwa Naukowego Warszawaskiego 1:1–33.

Steiner, G. 1914. Freilebende nematoden aus der schweiz. 1. Teil. Archiv für Hydrobiologie und Planktonkunde 9:259–276.

Sudhaus, W., and Fürst von Lieven, A. 2003. A phylogenetic classification and catalogue of the Diplogastridae (Secernentea, Nematoda). Journal of Nematode Morphology and Systematics 6:43–90.

Sudhaus, W., and Rehfeld, K. 1990. *Diplogaster coprophilus* n. sp. and *D. affinis* n. sp. (Nematoda, Rhabditidae) from cow pats and related species, with notes on distribution, ecology and phylogeny. Revue de Nematologie 13:51–65.

Weingartner, I. 1955. Versuch einer Neuordnung der Gattung *Diplogaster* Schulze, 1857 (Nematoda). Zoologische Jahrbücher. Abteilung für Systematik 83:248–317.

Zullini, A. 1974. The nematological position of the Po River. Bollettino di Zoologia 41:183–210.

Zullini, A. 1982. Nematodi (Nematoda). Guide per il riconosciemento delle specie animali delle acque interne italiane. Consiglio nationale delle Richerche AQ/1/90 17:1–117.

Zullini, A., and Loof, P. A. A. 1980. Systematic notes on some species of Diplogasteridae (Rhabditida). Nematologica 26:17–26.