Descriptions of *Pelodera scrofulata* sp. nov. and *Pelodera aligarhensis* sp. nov. (Nematoda: Rhabditidae) with supplementary information on *Pelodera teres* (Schneider, 1866).

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*Pelodera scrofulata* sp. nov. is characterized by cuticle with longitudinal lines and punctations; offset lip region with separate lips, wider in females, moderately developed cheilostom, presence of glandular bodies associated with uterus, tail conoid to spicate; males with spicules fused up to 60–68% from distal end; peloderan bursa with two precloacal papillae 9–12 μm apart and seven postcloacal pairs in the configuration of $1 + 1/4 + P + 2 + 1$. *Pelodera aligarhensis* sp. nov. is characterized by sexual dimorphism in anterior body region; cuticle often with faint longitudinal lines; slightly offset lip region; tail cupola-shaped; males with spicules fused up to 20-25% from distal end; peloderan bursa; one precloacal pair at anterior level of cloaca; two precloacals shifted posteriad to the cloacal level; seven postcloacal pairs of genital papillae in $1/2 + (2 + P) + (3 + 1)$ configuration. Some new information is added to the description of *Pelodera teres* (Schneider, 1866) with special reference to labial structure.

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**Keywords:** *Pelodera aligarhensis* sp. nov; *Pelodera scrofulata* sp. nov; *Pelodera teres*; taxonomy; relationship

**Introduction**

The genus *Pelodera* was raised by Schneider in 1866 with *Pelodera strongyloides* as the type species. Andrássy (1976) placed the genus within the subfamily Peloderinae. Earlier, Dougherty (1953) also gave *Pelodera* a generic rank and proposed within it two subgenera, *Coarctadera* and *Cylindridera*. Later, Sudhaus and Fitch (2001) considered *Pelodera* as a subgenus of *Rhabditis* under the subfamily Rhabditinae. However, Sudhaus in his later (2011) revision of Rhabditidae considered *Pelodera* as a genus and, following the cladistic approach, considered *Pelodera* as a clade including three major monophyletic species groups: the ‘*strongyloides*’, the ‘*coarctata*’ and the ‘*teres*’. In the present paper, two new species of the genus, *Pelodera scrofulata* sp. nov. and *Pelodera aligarhensis* sp. nov. belonging respectively to *strongyloides* and *coarctata* groups, are described and illustrated, whereas *Pelodera teres* is redescribed.

**Material and methods**

*Pelodera scrofulata* sp. nov. and *P. teres* were obtained from fixed samples stored in 4% formaldehyde from previous surveys. Before fixation, nematodes were extracted...
from soil samples by Cobb’s (1918) sieving, decanting and modified Baermann funnel technique. For light microscopy, fixed specimens were processed to anhydrous glycerin (Seinhorst 1959) and mounted on slides using the wax ring technique. The nematodes were measured with an ocular micrometer and illustrated using a drawing tube. Light microscopy photographs were taken with a Jenoptik digital camera ‘ProgRes’ attached to an Olympus BX-51 DIC microscope. For scanning electron microscopy, the specimens were fixed in 2% glutaraldehyde, post-fixed in 2% osmium tetroxide, dehydrated in an ethanol series and critical-point dried using CO₂. The nematodes were mounted on a stub on double-sided adhesive tape and coated with 10 nm gold before observing at 10 kV under a scanning electron microscope model XL30 FEG. *Pelodera aligarhensis* sp. nov. was collected from a landfill area and was cultured on standard NGM plates seeded with *Escherichia coli*. To prepare the medium, 3 g NaCl, 17 g agar and 2.5 g peptone were mixed in 975 ml H₂O and autoclaved for 50 min. The autoclaved mixture was cooled in a 55°C water bath for 15 min and 1 ml 1 M CaCl₂, 1 ml 5 mg/ml cholesterol in ethanol, 1 ml 1 M MgSO₄ and 25 ml 1 M KPO₄ buffer were added. Finally the mixture was poured into Petri plates after swirling it well. Stock cultures were maintained from single gravid females. The nematodes were observed under an Olympus BX-51 DIC microscope and photographs were taken by a Jenoptik digital camera ‘ProgRes’ coupled to the microscope.

**Cluster analysis**

The morphological characters (Tables 1 and 2) were used to compare *P. scrofulata* sp. nov. with other species of the ‘*strongyloides*’ group and *P. aligarhensis* with other species of ‘*coarctata*’ group. All the characters were selected by experience as being taxonomically informative. The characters were ranked on the basis of the commonality principle. Character state ‘0’ represented the most commonly occurring trait while a gradual increase in value represented relative rarity and presumed increasing deviation. Data matrices (Tables 3 and 4) were prepared, and analysed using Statistica-99 software including cluster analysis. The relationships were interpreted from the dendrograms obtained.

**Descriptions**

*Pelodera scrofulata* sp. nov.  
(Figures 1–3)

**Measurements**

See Table 5.

**Description**

*Female.* Body medium to large, almost straight or slightly ventrally curved upon fixation; tapering at extremities. Cuticle about 1 μm thick, transversely striated, often with fine longitudinal lines and faint dot-like punctations. Lateral field with six to
eight prominent lines along the body length; distinct in a few specimens. Lip region offset, lips well separated, globular with flattened apices; labial sensilla slightly raised. Stoma tubular, c.1.5–1.8 lip diameter, 5.2–7.0 times longer than wide. Cheilostom moderately cuticularized, gymnostom comprising 60–75% of stoma length. Metastegostom relatively expanded, isomorphic. Each metastegostomal swelling bearing three setose denticles. Pharyngeal tissue surrounding basal part of stoma (stegostom) at 20–24% of its length. Pharynx 110–130 µm long, with strongly swollen corpus, 55–68 µm long isthmus and a well-developed, muscular, ovoid (31–39 × 25–36 µm wide) basal bulb with grinder and double-chambered haustrulum. Pharyngeal corpus c.1.1–1.5 times longer than isthmus and basal bulb together. Nerve ring surrounding isthmus at c.64–74% of pharyngeal length. Secretory–excretory pore cuticularized, located at c.71–92% of pharyngeal length, leading to prominent secretory–excretory glandular cells. Hemizonid visible in few specimens, slightly anterior to excretory pore. Body at level of posterior terminus of pharynx c.2.4–4.0 labial diameter wide. Cardia (pharyngeal–intestinal valve) conoid, 5–10 µm long; often appearing as an extension of the basal bulb. A pair of pseudocoelomocytes 10–15 × 12–15 µm long or one large pseudocoelomocyte 20–25 × 15–20 µm long located 50–104 µm posterior to base of cardia or close to reflexed part of gonad. Intestine granular, comprising large polygonal cells with prominent nuclei. A portion of the posterior intestinal region equal to about twice the length of the rectum, although not distinctly separated or set off from main part of the intestine is nevertheless slightly demarcated by having relatively larger cells and a constricted lumen. Rectum thin-walled, with length c.0.9–1.5 times the body diameter at the level of the anus and with

Table 1. Characters and character states for comparison of species of Pelodera (strongyloides-group).

| No. | Character                              | Character state                      |
|-----|----------------------------------------|--------------------------------------|
| 1   | Long striations and punctations        | absent (0), present (1)              |
| 2   | Lip region setoff                      | weakly (0), moderately (1), strongly (2) |
| 3   | Lips with sexual dimorphism           | yes (0), no (1)                      |
| 4   | Cheilostom cuticularization            | present (0), absent (1)              |
| 5   | Metastegostomal teeth                  | weak (0), conspicuous (1)            |
| 6   | Basal bulb                             | of moderate (0), considerable (1)    |
| 7   | Pseudocoelomocytes                     | medium-sized (0), large-sized (1)    |
| 8   | Glandular bodies                       | absent (0), present (1)              |
| 9   | Prerectum                              | inconspicuous (0), conspicuous (1)   |
| 10  | Phasmid                                | up to 1/4 (0), 1/3 (1), 1/2 (2)      |
| 11  | Cuticle at tail                        | not thickened (0), thickened (1)    |
| 12  | Female tail                            | cupola-shaped (0), conoid (1)        |
| 13  | Tail spike                             | up to 1/4 (0), 1/3 (1), 1/2 (2) of the tail length |
| 14  | Female tail                            | straight (0), bent ventrally (1)     |
| 15  | Spicule length                         | up to 65 µm (0), above 80 µm (1)    |
| 16  | Gubernaculum length                    | upto 45 µm (0), more than 50 µm (1) |
| 17  | Bursal velum                           | smooth (0), striated (1), punctated (2) |
| 18  | GP1 and GP2                            | up to 6 µm or less (0), more than 6 µm (1) |
| 19  | Rods between papillae                  | absent (0), present (1)              |
| 20  | Papillae base                          | normal (0), swollen (1)              |
| 21  | Phasmid base                           | normal (0), swollen (1)              |
well-developed rectal glands. Anus a crescent-shaped slit. Reproductive system didelphic, amphidelphic with reflexed ovaries; anterior ovary positioned on right lateral and posterior on left lateral side of intestine. Each ovary bent twice at right angle to form a dorsal flexure. Oocytes arranged in multiple rows at relatively wider distal end and larger oocytes located proximally. Each oviduct connected to round, axial receptaculum seminalis (spermatheca) containing few sperms. Columella comprising prominent glandular cells arranged in three columns, connected to adjacent side of uterus. A pair of dorsal and a pair of ventral elongate, fusiform glandular bodies with defined nuclei and granular inclusions, opening into a kidney-shaped uterine chamber continuous with dilated lumen of vagina uteri having thick walls and wide lumen with some corrugations in the wall. Uterus with smooth-shelled eggs, at most two or three eggs at one time, with dimensions 58–62 × 36–43 μm. Vagina at right angles to longitudinal body axis, thick-walled, about one-third of corresponding body diameter long, and with ovjector and two sets of oblique muscle bands. Vulva a transverse, post-equatorial slit with fringed and protruded lips. Vulva–anus distance about 312–397 μm. Tail conoid with posterior one-third relatively more tapered and terminating as narrow spicate or occasionally cupola-shaped. Cuticle uniformly thick at level of phasmid; in rare instances slightly swollen. Phasmid opening posterior to anus by c.20–25% of tail length.
Table 3. Data matrix for cluster analysis of the species of *Pelodera* (*strongyloides*-group).

| Characters      | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|-----------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|
| *P. cutanea*    | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 2  | 0  | 0  | 2  | 0  | 0  | 1  | 1  | 1  | 1  | 1  | 1  |
| *P. nidicolis*  | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 2  | 1  | 0 | 2  | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *P. orbitalis*  | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2  | 0  | 0 | 2  | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |    |
| *P. strongyloides* | 0 | 2 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 2  | 1  | 0 | 2  | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| *P. termitis*   | 0 | 0 | 0 | 0 | 1 | 1 | ? | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 2 | 0 | 0 | 0 | 0 |
| *P. scrofulata* | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 |    |
Table 4. Data matrix for cluster analysis of the species of *Pelodera (coarctata-group)*.

|        | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|--------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|
| *P. aligarhensis* | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 |
| *P. coarctata* | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *P. cylindrica* | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 |
| *P. cystilarva* | 0 | 1 | 0 | 2 | 1 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *P. par* | 2 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 |
| *P. serrata* | 1 | 1 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *P. tretzeli* | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| *P. voelki* | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *P. isociensis* | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 |
| *P. kolbi* | 1 | 1 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
Figure 1. *Pelodera scrofulata* sp. nov. (all lateral) (A) Entire female; (B) entire male; (C) female anterior end; (D) female pharyngeal region; (E) female reproductive system; (F) female tail region; (G) male tail region.
Figure 2. *Pelodera scrofulata* sp. nov. female. (A–D) Anterior end; (E) anterior pharyngeal region; (F) posterior pharyngeal region; (G) anterior genital branch; (H, I) uterine region with glandular bodies (lateral); (J) uterus with thick muscular walls (lateral); (K, L) bean-shaped central chamber of uterus; (M–O) uterine region (ventral); (P) posterior intestinal region; (Q–S) caudal region (lateral). Scale bars: 10 μm.
Figure 3. *Pelodera scrofulata* sp. nov. male. (A) Anterior pharyngeal region; (B) posterior pharyngeal region; (C, D) cuticular surface pattern showing longitudinal lines and punctations; (E) pseudocoelomocytes close to reflexed testis; (F) male genital tract at level of ejaculatory gland (lateral); (G) posterior body region with copulatory muscle bands; (H–N) Posterior region (lateral); (O, P) posterior region (ventral). Scale bars: 10 μm.
Table 5. Morphometric data of *Pelodera scrofulata* sp. nov. and *Pelodera aligarhensis* sp. nov. Measurements are in μm and in the form: mean ± standard deviation (range).

| Character   | *P. scrofulata* sp. nov. Holotype female | *P. scrofulata* sp. nov. Paratype female | *P. scrofulata* sp. nov. Paratype male | *P. aligarhensis* sp. nov. Holotype female | *P. aligarhensis* sp. nov. Paratype female | *P. aligarhensis* sp. nov. Paratype male |
|-------------|------------------------------------------|------------------------------------------|---------------------------------------|-------------------------------------------|-------------------------------------------|------------------------------------------|
| n           | –                                        | 15                                       | 10                                    | –                                         | 20                                        | 15                                       |
| Body length | 963                                      | 920.6 ± 53.2 (830–1042)                  | 870.8 ± 86.5 (743–1056)               | 724                                       | 762.5 ± 58.5 (688–841)                    | 588.2 ± 34.8 (526–608)                   |
| Body diameter |                                      | 60                                       | 54.6 ± 6.6 (45–67)                     | 46.2 ± 3.8 (40–54)                        | 40                                       | 42 ± 5.0 (36–48)                        |
| A           | 16.5                                     | 17 ± 2.3 (13.9–23.2)                     | 18.8 ± 1.7 (17.2–23.6)                | 18.1                                      | 18.2 ± 1.3 (16.3–20.0)                   | 17.8 ± 0.3 (17.5–18.4)                   |
| B           | 4.2                                      | 4.2 ± 0.2 (3.8–4.8)                      | 4.3 ± 0.3 (3.6–4.9)                   | 4                                         | 4.2 ± 0.2 (3.9–4.6)                      | 4.1 ± 0.2 (3.8–4.4)                      |
| C           | 23.4                                     | 22.4 ± 2.1 (17.7–25.7)                   | 21.1 ± 1.0 (19.3–22.9)                | 27.8                                      | 30.0 ± 7.7 (22.1–41.2)                   | 19 ± 3.1 (16.2–24.3)                     |
| c'          | 1.4                                      | 1.5 ± 0.1 (1.2–1.8)                      | 1.1 ± 0.1 (1.0–1.3)                   | 1.1                                      | 1.1 ± 0.2 (0.8–1.4)                      | 1.5 ± 0.3 (1.0–1.8)                      |
| V/T         | 59.2                                     | 58.6 ± 1.5 (56.7–63.5)                   | 66.2 ± 10.3 (61.4–77)                 | 62.5                                      | 62.6 ± 0.7 (61.6–63.5)                   | 72.8 ± 3.7 (68.5–76.3)                   |
| G1          | 38.4                                     | 38.8 ± 4.1 (32.7–48.1)                   | –                                     | 38.3                                      | 47.2 ± 9.8 (34.8–60.0)                   | –                                        |

(Continued)
Table 5. (Continued).

|                  | G2   | Lip height | Lip diameter | Stoma length | Stoma diameter | Pharynx length | Nerve ring | Secretory–excretory pore | Anal body diameter |
|------------------|------|------------|--------------|--------------|----------------|----------------|------------|--------------------------|--------------------|
|                  | 37.5 | 6.4 ± 0.4  | 15.6 ± 1.4   | 26.2 ± 1.3   | 4.2 ± 0.3      | 214 ± 10.3     | 164 ± 20.6 | 170 ± 19.2               | 25.8 ± 2.1         |
|                  |      | (6.0–7.0)  | (14–18)      | (24–28)      | (4–5)          | (202–235)      | (144–180)  | (123–190)                | (23–30)            |
|                  |      | 6.2 ± 0.4  | 14.6 ± 1.0   | 23.4 ± 1.3   | 4.1 ± 0.3      | 199 ± 7.9      | 138 ± 8.4  | 163.2 ± 12.3             | 35.2 ± 3.8         |
|                  |      | (6–7)      | (13–16)      | (20–25)      | (4–5)          | (185–213)      | (125–150)  | (152–185)                | (30–42)            |
|                  |      | 8          | 15           | 25           | 5              | 180           | 120        | 135                      | 22                 |
|                  |      | (7–9)      | (15–18)      | (24–25)      | (5–5)          | (173–186)      | (118–125)  | (129–148)                | (19–25)            |
|                  |      | 34.7       | 16.1 ± 1.1   | 24.8 ± 0.4   | 5              | 177.5 ± 4.8    | 120.6 ± 2.8| 133.6 ± 7.5              | 23.3 ± 2.4         |
|                  |      | (26.2–41.8)| (12–14)      | (20–1)       | (5–5)          | (142.6 ± 13.7) | (98 ± 3.3) | (113.2 ± 6.8)            | (18.0 ± 3.3)       |
|                  |      | 32.1 ± 5.4 | 13.4 ± 0.8   | 20 ± 1       | 4.4 ± 0.5      | 142.6 ± 13.7  | 98 ± 3.3   | 113.2 ± 6.8              |                    |
|                  |      | (26–35.5)  | (12–14)      | (19–21)      | (4–5)          | (119–155)     | (93–102)   | (106–121)                | (18–27)            |
|                  |      | –          | 164 ± 20.6   | 120          | 5              | 177.5 ± 4.8    | 120.6 ± 2.8| 133.6 ± 7.5              |                    |
|                  |      | –          | (144–180)    | (118–125)    | (5–5)          | (142.6 ± 13.7)| (98 ± 3.3) | (113.2 ± 6.8)            | (18.0 ± 3.3)       |

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| Character        | *P. scrofulata* sp. nov. Holotype female | *P. scrofulata* sp. nov. Paratype female | *P. scrofulata* sp. nov. Paratype male | *P. aligarhensis* sp. nov. Holotype female | *P. aligarhensis* sp. nov. Paratype female | *P. aligarhensis* sp. nov. Paratype male |
|------------------|----------------------------------------|----------------------------------------|----------------------------------------|------------------------------------------|------------------------------------------|------------------------------------------|
| Rectum length    | 31                                     | 30.1 ± 2.5                             | 32.6 ± 2.1                             | 19                                       | 19.6 ± 2.3                               | 29.4 ± 5.4                               |
|                  | (25–35)                                | (29–35)                                | (29–35)                                | (16–22)                                  | (20–33)                                  | (20–33)                                  |
| Tail length      | 41                                     | 41.3 ± 3.2                             | 41.2 ± 4.2                             | 26                                       | 26.3 ± 4.8                               | 31.4 ± 4.9                               |
|                  | (36–48)                                | (35–48)                                | (35–48)                                | (20–31)                                  | (25–31)                                  | (25–37)                                  |
| Spicule length   | –                                      | –                                      | 60.6 ± 2.8                             | –                                        | –                                        | 33.8 ± 3.1                               |
|                  |                                        |                                        | (56–65)                                |                                          |                                          | (30–38)                                  |
| Gubernaculum     | –                                      | –                                      | 41.7 ± 1.26                            | –                                        | –                                        | 15.6 ± 1.3                               |
| length           |                                        |                                        | (40–44)                                |                                          |                                          | (15–18)                                  |
Male. Similar to females in general morphology except having slightly more slender body, relatively narrower lips and greater posterior curvature. Testis monorchic, laterally reflexed; flexure on right lateral side of intestine. Reflexed portion about 103–141 μm long. A pair of oblong ejaculatory glands present, often at slightly different levels. Spicules with distinct, elongate capitula and tapering toward distal end where it terminates as a slightly curved beak-like structure; 1.4–2.0 anal body diameter long, fused distally up to 60–68% of length. In some specimens capitula tends to be rounded. Gubernaculum length equal to about 64–74% of spicule length, slender, trough-shaped with tapering, often hooked proximal end. Bursa peloderan, anteriorly open with nine pairs of genital papillae (two precloacal and seven postcloacal pairs) in variable configuration of $1 + 1/4 + P + (2 + 1)$, $1 + 1/3 + (1 + P) + (2 + 1)$ or $1 + 1/(4 + P) + (2 + 1)$. GP1 and GP2 subventral, spaced, 9–12 μm apart; GP3 dorsally oriented, GP4, GP5 subventral and closely placed with a swollen base while GP6 slightly spaced from the trio; GP7 and GP8, subventral, closely placed along with dorsally oriented smaller GP9. Phasmid opening on a papillum-like structure appearing slightly thicker than other papillae with a swollen base, dorsally oriented, located between GP6 and GP7, close to GP6 or grouping with the four anteriormost postcloacals. Bursal velum very slightly crenate, rod-like cuticular markings as reported in *Pelodera cutanea* in precloacal region absent. Copulatory muscles well developed with seven or eight paired oblique bands arising from cloacal level. Tail conoid, longer than females.

Type habitat and locality

Samples containing *P. scrofulata* sp. nov. were collected from a drain at Quarsi, Aligarh, Uttar Pradesh, India located at coordinates 27°53′37.36″N, 78°05′16.79″E.

Type material

Holotype female, 14 paratype females and 9 paratype males on slide *Pelodera scrofulata* sp. nov. No. NOQ/1-14 deposited in the Nematode Collection, Department of Zoology, Aligarh Muslim University, Aligarh, India. One paratype female and one paratype male on slide *Pelodera scrofulata* sp. nov. No. NOQ/15 deposited at the Wageningen Nematode Collection (WaNeCo), Wageningen, the Netherlands.

Diagnosis and relationships

*Pelodera scrofulata* sp. nov. is a gonochoristic species with females having more expanded lips than males; moderately developed cheilostom; reflexed part of ovary conspicuously bent at right angle; few (one to three) intrauterine eggs; glandular bodies associated with uterus; prerectum inconspicuously separated from intestine; tail conoid with acutely pointed spicate tip; cuticle uniformly thick in the region of phasmids; males with slender spicules fused up to 60–68% from distal end; open, peloderan bursa with smooth velum; GP1 and GP2 9–12 μm apart and GP4, GP5 and phasmids with swollen bases.

*Pelodera scrofulata* sp. nov. differs from *P. strongyloides* Schneider, 1860 in having relatively shorter body length (0.8–1.0 mm vs 1.0–2.3 mm) with presence
(vs absence) of longitudinal lines and punctations; smaller “b” (3.8–4.8 vs 4.9–7.6) and “c” (17.7–25.7 vs 26.3–37.9) values; moderately developed cheilostom (vs inconspicuous cheilostom); relatively smaller stoma (24–28 vs 33–38 μm); reflexed part of ovary conspicuously bent at right angle (vs rounded); smaller gubernaculum (40–44 vs 45–60 μm) and cuticle uniformly thick (vs greatly thickened) in the region of phasmids in *P. strongyloides* Schneider, 1860 *apud* Sudhaus and Schulte (1988).

The new species further resembles *Pelodera termitis* Carta et al., 2010 but differs in females showing presence (vs absence) of longitudinal lines and punctations; lateral lines (6–8 vs 4); relatively greater “V” (56.7–63.5 vs 55–58); relatively smaller stoma (24–28 vs 26.2–33.3 μm); cheilostom moderately developed (vs indistinct); reflexed part of ovary conspicuously bent at right angle (vs curved); glandular bodies associated with uterus present (vs absent); prerectum inconspicuously (vs conspicuously) separated from rest of intestine; smaller spicules (56–65 vs 70–77 μm); smaller gubernaculum (40–44 vs 45.2–53.6 μm); smooth (vs ornamented) bursal velum in *P. termitis* *apud* Carta et al., 2010.

The new species is similar to *Pelodera orbitalis* Sudhaus and Schulte, 1986 in most morphometric characteristics but differs in having cheilostom moderately cuticularized (vs not cuticularized); metastegostomal teeth conspicuous (vs less conspicuous); conoid (vs cupola-shaped) tail; proximally wider (vs narrow) spicules; bursal velum not crenate (vs proximally crenate); and greater distance between precloacal papillae GP1 and GP2 (9–12 μm vs 4–6 μm) apart in *P. orbitalis* Sudhaus and Schulte, 1986.

The new species differs from another closely related species, *Pelodera nidicolis* Sudhaus and Schulte, 1986, in having cheilostom moderately cuticularized (vs strongly cuticularized); glandular bodies associated with uterus (vs not reported); spicules proximally wider (vs narrower); bursal velum not crenate (vs prominently crenate); greater distance between precloacal papillae GP1 and GP2 (9–12 μm vs 4–6 μm); conoid (vs cupola-shaped) tail with tail spine straight (vs bent ventrad); cuticle of uniform thickness (vs thickened in the region of phasmids in *P. nidicolis* *apud* Sudhaus and Schulte, 1986).

The new species further differs from *P. cutanea* Sudhaus et al., 1987 by its relatively smaller body length (0.8–1.0 vs 1.0–1.7 mm); smaller b (3.8–4.8 vs 5.2–7.3) and greater V (56.7–63.5 vs 55–58) values; relatively smaller stoma (24–28 vs 26–34 μm); cheilostom moderately developed (vs indistinct); seminal receptacle axial (vs adaxial); glandular bodies associated with uterus present (vs not reported); lesser number of eggs in uterus (up to three vs up to eight); tail conoid (vs dome-shaped with a spike); larger gubernaculum (40–44 vs 29–40 μm); rod-like cuticular structure in the region of precloacal papillae absent (vs present) and base of GP4, GP5 and region surrounding phasmid opening swollen (vs base of GP2 swollen while that associated with phasmid opening slender in *P. cutanea* *apud* Sudhaus et al., 1987).

**Remarks**

Cluster analysis (Figure 4) based on 21 morphological characters (Tables 1 and 3) indicates a close affinity of *P. cutanea* with *P. nidicolis*. In fact, these two species have previously been identified as sibling species (Sudhaus and Schulte 1988).
Likewise, two other species of the group, *P. strongyloides* and *P. orbitalis*, showed a close relationship. These four species formed a more inclusive cluster from which *P. termitis* is excluded, at least at low distance values (< 0.6). In addition, *P. scrofulata* sp. nov. clearly stands out as the most morphologically divergent species considered in the cluster analysis.

The species of *Pelodera* constituting the ‘*strongyloides*’ group have largely been reported to be parasitic with third-stage juveniles (J3) having association with vertebrate or invertebrate hosts, namely chicken, wood mice, voles, horses and termites. The present species was collected from the muddy sample of a ditch. Unfortunately, juvenile specimens were not recorded from this sample and only the adults were preserved for morphological evaluation. The locality apparently indicates any association with termites, mice or voles to be unlikely. The new species is morphologically similar to *P. strongyloides*, *P. termitis* and *P. punctata*, but not convincingly enough to place it in any of the corresponding species. Table 6 gives a comparative account of the differences between *P. scrofulata* and other congeners of the *strongyloides* group. The species apparently resembles *P. punctata* with respect to the freshwater type habitat as well as the longitudinally striated and punctated body cuticle; however, a short conoid tail, and more slender spicules (including an angular dorsal profile), and widely spaced precloacal papillae are features that clearly differentiate the two species. With *P. termitis*, the species shows similarity with respect to lip morphology, female tail shape and spacing of precloacal papillae; however, the presence of longitudinal cuticular lines and punctations, as well as the shape and length of spicules and their trapezoid capitulum, the length of the gubernaculum and the continuous prerectum region are some of the prominent distinguishing features. Another interesting feature is their putative association with termites that were not found and were unlikely to be found in the ditch with mud and slurry around. Hence it is perhaps another sibling species in the group such as *P. cutanea*, *P. nidicolis* and *P. orbitalis* that have had its status confirmed through cross-breeding tests with *P. strongyloides* (Sudhaus and

Figure 4. Cluster analysis (complete linkage) showing relationship between species of *Pelodera* (*strongyloides*-group) based on morphological data.
Table 6. A comparison of closely related species of *Pelodera* (Schneider, 1960) based on morphological and morphometric characters.

| Characters                        | *P. cutanea* | *P. nidicolis* | *P. orbitalis* | *P. strongyloides* | *P. termitis* | *P. scrofulata* |
|----------------------------------|--------------|----------------|----------------|--------------------|---------------|----------------|
| Female maximum body length       | 1423 µm      | 1236 µm        | 1454 µm        | 1629 µm            | 1627 µm       | 1042 µm        |
| Longitudinal striations and       | +            | –              | +              | –                  | –             | +              |
| punctations                      |              |                |                |                    |               |                |
| Lip region setoff                | Weakly       | Hardly         | Moderately     | Strongly           | Weakly        | Moderately     |
| Labial dimorphism                | –            | +              | +              | –                  | +             | +              |
| Cheilostom cuticularization      | +            | +              | –              | –                  | –             | +              |
| Metastegostomal teeth            | Conspicuous  | Conspicuous    | Weak           | Conspicuous        | Conspicuous   | Conspicuous    |
| Stoma length                     | 26–34 µm     | 28–38 µm       | 22–34 µm       | 30–38 µm           | 26.2–33.3 µm  | 24–28 µm       |
| Excretory pore: pharynx          | 84–104 µm    | 73–95 µm       | 67–91 µm       | 79–108 µm          | 64–96 µm      | 90–102 µm      |
| Maximum basal bulb width         | 37 µm        | 39 µm          | 52 µm          | 50 µm              | ~55 µm        | 39 µm          |
| Egg dimension                    | 49–67×28–40 µm| 53–67×32–42 µm| 47–63×30–40 µm| 51–67×34–40 µm     | ~60–70×40–45 µm| 58–62×36–43 µm |
| Maximum no. of intrauterine eggs | 8            | 15             | 15             | 19                 | at least 3    | 4              |
| Spermatheca                      | Ad axial     | Axial          | Axial          | Axial              | Axial         | Axial          |
| Pseudocoelomocyte diameter       | 13–22 µm     | 13–27 µm       | 14–22 µm       | 15–38 µm           | ?             | 20–25×15–22 µm |

(Continued)
|                                                                 | 55–60% | 48–57% | 43–56% | 32–61% | 26–46% | 20–25% |
|-----------------------------------------------------------------|--------|--------|--------|--------|--------|--------|
| Phasmid versus tail length                                      |        |        |        |        |        |        |
| Cuticular thickening at phasmid                                 | –      | +      | –      | +      | –      | –      |
| Female tail shape                                               | Cupola | Cupola | Cupola | Cupola | Conoid–cupola | Conoid–cupola |
| Female tail bent                                                | –      | +      | –      | –      | –      | –      |
| Spike: tail length                                              | 15–21% | 30–50% | 25–40% | 18–20% | 25–30% | 20–25% |
| Male maximum length                                             | 1159 µm | 1115 µm | 1121 µm | 1416 µm | 1321 µm | 1042 µm |
| Spicule length                                                  | 46–61 µm | 43–56 µm | 44–58 µm | 55–82 µm | 70–77 µm | 56–65 µm |
| Spicular fusion distally                                        | 65–71% | 70–75% | 69–74% | 69–74% | 65% | 60–68% |
| Gubernaculum length                                             | 29–40 µm | 29–38 µm | 27–39 µm | 35–60 µm | 45.2–53.6 µm | 40–44 µm |
| Bursal velum                                                    | Striated | Smooth | Striated | Striated | Punctated | Striated |
| GP1–GP2 distance                                                | 6–18 µm | <5 µm | 4–6 µm | 5–20 µm | 10–13 µm | 9–12 µm |
| Rods between papillae                                           | +      | –      | –      | –      | –      | –      |
| Papillae base swollen                                           | +      | –      | +      | –      | –      | +      |
| Phasmid base swollen                                            | –      | –      | –      | –      | –      | +      |
Schulte 1986). It appears that the process of speciation in the group has led to different species adaptations for parasitism and switching over to a variety of hosts with very little change in morphology. This would have given rise to several cryptic sibling species. The present species seems to form one such example.

**Pelodera aligarhensis** sp. nov.  
(Figures 5–7)

**Measurements**

See Table 5.

**Description**

**Female.** Body medium-sized, straight to slightly arcuate with tapering ends. Females are relatively obese with prominent and expanded lip region compared with their male counterparts. Cuticle very finely annulated, with very fine longitudinal lines and inconspicuous punctuations. Lateral field with three ridges. Lip region expanded, slightly offset from adjoining body. Lips rounded, separate and distinct, outer labial sensilla slightly raised, inner labials slightly shifted outward. Amphid openings small and rounded, labial. Stoma well developed, fairly long, rhabditoid type 4.8–5 times longer than wide or 13.4–13.8% of pharyngeal length. Cheilostom cuticularized, appearing dot-like in lateral view; gymnostom not markedly conspicuous. Metastegostom strongly cuticularized, widened with each swelling bearing three setose denticles; telostegostom heavily cuticularized. Pharyngeal collar usually surrounding 50–55% of length of stoma as measured from base. Pharynx differentiated into a swollen corpus, slightly narrower isthmus and a muscular, ovoid (27–33 × 22–25 μm wide) basal bulb with well-developed grinder and a faintly two-chambered haustulum. Nerve ring encircling anterior half of isthmus at 67.2–68.2% of the pharyngeal length. Secretory–excretory pore in close proximity with the nerve ring at 74.5–79.8% of pharyngeal length; cell bodies located at pharyngeal base 95–103% of pharyngeal length. Cardia (pharyngeal–intestinal valve) 5–9 μm long, often appearing as the extension of basal bulb. Intestine with wide lumen, often anteriorly dilated and distinguishable there as a sac. Posterior intestinal region with dilated lumen bounded by enlarged cells. Rectum 16–22 μm long, about three-quarters of anal body diameter, often with dilated lumen; rectal glands inconspicuous. Reproductive system didelphic, amphidelphic, ovaries well-developed, paired, opposed and lateroventrally reflexed, often with distal end of posterior ovary extending further posterior to the vulva; anterior and posterior ovaries respectively on right and left lateral side of intestine, spermatheca and uterus not differentiated by sphincter. Intrauterine eggs about 42–48 × 30–38 μm with three or four eggs at different stages of embryonation within uterus. Vagina thick-walled, at right angle to longitudinal body axis. Vulva a transverse slit with protruded vulval lips. Vulva–anus distance 9.4–11.6 times that of tail length. Tail conical, often cupola-shaped with a small spike of one-half to one-third of tail length. Phasmid openings positioned at 50–55% of the broader conical part of the tail.
Male. Similar to female in general morphology except lip region structure, tail shape and greater curvature of the posterior region. Lip region in males narrow, continuous with adjoining body. Lips relatively smaller and amalgamated. Stoma very narrow in most individuals while relatively wider in a few; metacorpal swelling weak; basal bulb

Figure 5. *Pelodera aligarhensis* sp. nov. (all lateral) (A) Entire female; (B) entire male; (C) female anterior end; (D) male anterior end; (E) female pharyngeal region; (F) female reproductive system; (G) female tail region; (H) male tail region.
Figure 6. *Pelodera aligarhensis* sp. nov. female. (A, B) En face view (scanning electron microscopy); (C) anterior end (lateral); (D) anterior pharyngeal region (lateral); (E, F) posterior pharyngeal region (lateral); (G) lateral field; (H) anterior genital branch; (I) vulval region (lateral); (J) vulval region (ventral); (K, L) posterior intestinal region (lateral); (M–O) caudal region (lateral). Scale bars: 10 μm.
Figure 7. *Pelodera aligarhensis* sp. nov. male. (A–C) Anterior end (A is scanning electron micrograph); (D) anterior pharyngeal region (lateral); (E) posterior pharyngeal region (lateral); (F) male genital tract at level of ejaculatory gland (ventral); (G) posterior region (lateral); (H–J) tail end showing bursa and genital papillae (lateral) (J is scanning electron micrograph); (K–N) Tail end showing bursa and genital papillae (ventral) (K is scanning electron micrograph). Scale bars: 10 μm.
relatively smaller than that of female. Secretory–excretory pore located at c.68–75% of the length of pharyngeal region with secretory-excretory gland cells visible near anterior region of isthmus. Cardia very narrow, often appearing as a postbulbar extension continuing into an equally narrow intestine. Testis single, dorsally reflexed, on right lateral side of intestine. Seminal vesicle separated from vas deferens by a constriction. Ejaculatory glands present; right lateral gland slightly anterior to left one. Tail conical, narrowing into a spike with fine terminus. Bursa well-developed peloderan, anteriorly closed, ovoid. Spicules fused up to 20–25% of length from distal end, provided with rounded capitula, narrow necks and slender shafts with velum terminating as a short spur. Gubernaculum slender, trough-shaped, about 40–45% of spicule length. Genital papillae comprising nine pairs in $1/2 + (2 + P) + (3 + 1)$ configuration. Two precloacal pairs shifted posteriorly: GP1 with base in precloacal region reaches the level of cloaca; GP2 and GP3 slightly posterior to GP1 opening posterior to cloacal level. GP4, GP5 in close proximity. Region surrounding phasmid openings relatively swollen relative to papillae, located between GP5 and GP6. GP6, GP7 and GP8 basally joined in close proximity to dorsally oriented GP9.

Type habitat and locality
Sample containing *Pelodera aligarhensis* sp. nov. collected from land fill area of Harduaganj, Aligarh, Uttar Pradesh, India at coordinates 27°56′39″N, 78°9′31″E.

Type material
Holotype female, 19 paratype females and 14 paratype males on slide *Pelodera aligarhensis* sp. nov. No. NOH/1-8 deposited in the Nematode Collection of the Department of Zoology, Aligarh Muslim University, Aligarh, India. One paratype female and one paratype male on slide *Pelodera aligarhensis* sp. nov. No. NOH/2 deposited at the Wageningen Nematode Collection (WaNeCo), Wageningen, the Netherlands.

Diagnosis and relationships
*Pelodera aligarhensis* sp. nov. is characterized by gonochoristic individuals having cuticle with fine longitudinal striations and punctations; sexual dimorphism in anterior region with females having conspicuously dilated lips, large stoma; cupola-shaped tail; males with stoma smaller than females, an elongated cardia and narrower anterior intestine; slender spicules fused up to 20–25% of length from distal end; anteriorly closed peloderan bursa; three precloacal papillae pairs with two other pairs shifted posterior to cloacal opening.

The new species resembles *Pelodera tretzeli* (Sachs 1950) in most morphometric characteristics as well as by the presence of three pairs of precloacal papillae in males but differs in females by the smaller body (0.6–0.8 mm vs 1.1–1.3 mm) with presence (vs absence) of fine longitudinal lines and punctations; smaller b (3.9–4.6 vs 5.9–7.9) and relatively greater V (56.7–63.5 vs 56.2–57.7) values; intestine not overlapping (vs overlapping) the basal pharyngeal region; tail spike smaller (vs larger) than cupola-shaped part of tail; males having relatively smaller (30–38 vs 35–47 μm) spicules and
precloacal papillae positioned posterior (vs anterior) to cloacal opening in *P. tretzeli* *apud* Sachs (1950).

The new species resembles *Pelodera par* Andrássy, 1962 in most morphometric characteristics as well as by the presence of three pairs of precloacal papillae in males but differs in having (vs lacking) sexual dimorphism in lip region; presence (vs absence) of fine longitudinal lines and punctations on the cuticle; smaller *b* (3.9–4.6 vs 7.1) and relatively greater *V* (56.7–63.5 vs 59) values; presence of small-sized eggs (42–48 vs 58–64 μm); tail spike smaller (vs larger) than cupola-shaped part; males having smaller (30–38 vs 40–44 μm) spicules and two precloacal papillae pairs positioned posteriorly (vs anteriorly) in *P. par apud* Andrássy (1962).

Remarks

Sudhaus (2011) identified 10 species under the *coarctata*-group. The species of the group have been reported from dung, cow pats, moulds, horse droppings and in most cases, associated with beetles or mites. *Pelodera aligarhensis* sp. nov. was, however, reared in the laboratory on an *E. coli* culture at a temperature of 25 ± 2°C; the development was found to be normal without any dauer stage.

The species of the *coarctata*-group are characterized by obese females and relatively slender, smaller males. Most of them show sexual dimorphism in the lip region with lips more prominent, wide and offset in females and they have a wide stoma with heavily cuticularized metastegostom bearing conspicuous teeth compared with their male counterparts. The only species lacking sexual dimorphism in the group is stated to be *P. par apud* Andrássy (2006). The species *P. tretzeli*, *P. voelki* and *P. kolbi* in particular have males with an extremely reduced anterior region. In the present species males were observed to have a slightly reduced or extremely reduced labial region with amalgamated lips as well as a narrower stoma. Even the pharynx was found to be relatively cylindrical and the anterior intestinal region was considerably narrowed. On the contrary, the anterior end of the intestinal lumen was widened in the female similar to the bacterial pouch found in many entomopathogenic nematodes. The excretory cells in males were small and confined to the level of the middle of the isthmus in males while the females possessed relatively larger cells. Females of all the species of the *coarctata* group have a cupola-shaped tail with a terminal spike except in *Pelodera cylindrica* where the female tail is bluntly rounded. As a rule the males have an anteriorly closed peloderan bursa that appears sucker-shaped and often indented and lobed, however, variation has been observed in the number of precloacal genital papillae. Most of them possess two pairs of precloacals with the exception of *P. tretzeli* and *P. par*, which possess three precloacal pairs.

Cluster analysis (Figure 8) based on 20 morphological characters (Tables 2 and 4) indicates a close affinity of *P. aligarhensis* with *P. tretzeli* compared with other existing species of the group. Both species appears to form a more inclusive cluster with *P. par* and *P. voelki*. This larger cluster is related to two other species, *Pelodera cystilarva* and *Pelodera serrata*, and the resulting cluster is itself related to a cluster containing a sister relationship between *P. cylindrica* and *P. isociensis* which together are distantly related to *P. kolbi*. *Pelodera coarctata* maintains a separate identity and clearly stands out as the most morphologically divergent species showing an overall affinity with other species of the group. The species *Pelodera operosa* has not been included in the analysis because the species is represented by females only.
Some observations on *Pelodera teres* (Schneider, 1866)
(Figure 9)

A few fixed specimens of *P. teres* described earlier by Hussain et al. (2006), were processed for scanning electron microscopy to observe labial details. Although the results were not particularly good, due to some debris adhering to the specimens, nevertheless some observations together with light microscope observations could be taken and the description summarized as follows.

The population of *P. teres* with 1:1 sex ratio, represented by ovoviviparous females with relatively wider lip region than males; low, apically compressed slightly offset lip region; heavily cuticularized inner labial margins; four to six fine bristles in each interlabial groove with the peripheral ones slightly longer than central ones; pharyngeal sleeve surrounding more than 50% of stoma; pharyngeal corpus moderately swollen, basal bulb with single-chambered haustrulum; intestinal cells compactly arranged at anterior and posterior extremities, intestinal lumen thick and refractive; reproductive system didelphic; large, conspicuous sphincter between spermatheca and uterus; males with dorsally reflexed testis; ejaculatory glands present; spicules massive with an indistinct neck; fused at distal end; bursa moderately developed, open peloderan with three pairs of precloacal genital papillae and six postcloacal pairs.

*Pelodera* has been considered a taxon with three monophyletic groups (Sudhaus and Fitch 2001; Sudhaus 2011). Some of the important features present among these groups include: sexual dimorphism in the lip region (most species though more pronounced in the *coarctata* group); buccal cavity relatively wide, expanding posteriorly with heavily cuticularized telostegostom in the *coarctata* group; pharyngeal sleeve lacking in *strongyloides* group but present in the other two groups; pharyngeal corpus usually swollen (few exceptions in the males of the species showing sexual dimorphism); female reproductive system usually with a sphincter between the oviduct and uterus, spermatheca conspicuous; lining of intestine lumen thickened intestinal cells most compactly arranged anteriad and posteriad, the latter forming...
Figure 9. *Pelodera teres* (Schneider, 1866). (A–E) Anterior end (A and B, scanning electron micrographs); (F) anterior pharyngeal region (lateral); (G) posterior pharyngeal region (lateral); (H) posterior intestinal region; (I) anterior genital branch; (J, K) uterine region with embryonating eggs; (L) vulval region (lateral); (M) vulval region (Ventral); (N) female posterior region (lateral); (O–Q) male posterior region (lateral) (Q is scanning electron micrograph); (R) male posterior region (ventral) (R is scanning electron micrograph). Scale bars: 10 μm.
prerectum conspicuously seen in the *strongyloides* group; female tail conoid, cupola-shaped to spicate; phasmid openings usually on the cupola part of tail or at 30–50% of tail length from anal opening in spicate tail; males with dorsally reflexed testis; ejaculatory glands often of unequal dimensions; spicules fused distally up to 70% of their length in *strongyloides* group and to lesser degrees in *coarctata* and *teres* groups respectively; bursa peloderan, anteriorly closed, sucker-shaped in *coarctata* group but anteriorly open in others; bursal velum smooth to striated or punctated; two pairs of precloacal genital papillae in all members of *strongyloides* group and in most species of the *coarctata* group with few exceptions whereas three pairs of precloacals present in members of *teres* group. Few members (*P. teres* and *P. pseudoteres*) in *teres* group are distinct from the rest in having markedly low, apically compressed lip region with heavily cuticularized inner labial margins and interlabial grooves bearing fine bristles.

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**Notes**

1. Name derived from the latin word ‘scrofulae’ = glands, reflecting the presence of conspicuous openings of glands into the uterus
2. The name of the species is based on its locality i.e., Aligarh

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