

## Description of *Goffartia phalacra* n. sp. (Diplogastridae: Nematoda) from India

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**Abstract:** A new species, *Goffartia phalacra* n. sp. is described and illustrated. The body is thin and slender with L = 511 to 646  $\mu\text{m}$ ; a = 37.1 to 47.4; b = 4.8 to 6; c = 2.6 to 4.8; c' = 13.6 to 32.8; V = 40% to 49% in females. Males are smaller but similar to females and the posterior region is strongly curved. The species is characterized by a tubular stoma, a smooth round lip region, anterior pharynx much smaller than posterior pharynx, two pairs of unicellular glands associated with the vagina, and males with a broad keel-shaped gubernaculum. *G. phalacra* n. sp. can be differentiated from all other species of the genus by its lip region and the structure of the gubernaculum. This is the first instance of a species of *Goffartia* occurring in a terrestrial habitat and the first report of a species from India.

**Key words:** description, ecology, *Goffartia*, gubernaculum, morphology, species, sensilla, spicules, stoma, taxonomy.

The genus *Goffartia* Hirschmann, 1952 was established for species of diplogastrids that were slender with large amphidial apertures, a stoma without tooth or denticles, amphidelphic gonads and with long filiform, and whip-like tails in both sexes. Hirschmann (1952) described *G. heteroceri* as the type species and transferred *Diplogasteroides variabilis* Micoletzky, 1921 and *D. africana* Micoletzky, 1915 to the genus *Goffartia*. The only other and the most recently described species of the genus is *G. praeopilata* Shoshin, 1989 from Lake Baikal. Sudhaus and Fürst von Lieven (2003) in their revision of the genera and species of Diplogastridae synonymized *Paramonovnema* Andrassy, 1968 and transferred *P. filicaudatum* to *Goffartia*. All these five species were present in, or were associated with the aquatic habitats. The new species *G. phalacra* n. sp., collected from two different sites, always occurred in farmyard manure.

### MATERIALS AND METHODS

The nematodes were extracted from farmyard manure by the sieving and decantation and the Baermann's funnel technique (Flegg, 1967). Extracted nematodes were fixed in FA (4:1) for 24 hr and then transferred to glycerin-alcohol (5 parts: 95 parts of 30% alcohol) for slow dehydration in a desiccator. Dehydrated specimens were mounted in anhydrous glycerin on glass slides using the wax ring method (de Maeseneer & d'Herde, 1963). All observations, drawing, and photographs were made on an Olympus BX 50 DIC microscope.

### DESCRIPTION

*Goffartia phalacra* n. sp.  
(Fig. 1, A-M; Fig. 2, A-J)

**Measurements:** Morphometrics of the holotype female, paratypes and other specimens are given in Table 1.

**Female:** Body small, always less than 1 mm; slender, almost straight upon fixation. Cuticle thin, transverse striations not visible. Subcuticle finely striated. Lip region round, smooth, continuous with body contour. Lips fused, labial papillae not discernable. Amphidial apertures large transverse slits with an indentation in the middle, almost as wide as corresponding body; about one lip diam. from anterior end. Amphidial pouches (foveae) large, wine glass-shaped, almost as wide as lip diam.; amphidial canal short, fusus slightly swollen. Lateral fields obscure. Stoma narrow, tubular. Cheilorhabdia weakly sclerotized, straight, or slightly inwardly directed. Gymnostom barrel-shaped (anteriorly and posteriorly curved anteriorly) and about as long as cheilostom. Stegostom short, without tooth or denticles. Procorpus muscular, median bulb slightly set off. Isthmus broad, long, gradually widening in the posterior third to form the glandular basal bulb. In fixed specimens, the ratio of anterior pharynx (from anterior end to base of median bulb) to posterior pharynx 1:1.6 to 1.8. Nerve ring in the middle or posterior half of isthmus, at 55% to 60% of pharyngeal length. Excretory pore obscure/faint; hemizonid not visible. Intestinal cells small, granular.

Reproductive system amphidelphic, anterior branch on right and posterior on left side of intestine. Ovaries reflexed, oocytes in one or more rows in the germinal zone. Oviduct long, narrow, distally expanded to form the spermatheca and usually set off from the uterus by a constriction. Uterus simple, undifferentiated. Vagina muscular, with two pairs of unicellular glands opening at the junction with uterus. Vulval opening small, oval, transverse. Rectum 1.2 anal-body diam. long. Phasmids large, prominent, 3.0 to 3.5 anal-body diam. posterior to anus. Tail very long, whip-like, tapering to a pointed tip, 1.1 to 1.6 times vulva to anus distance long.

**Male:** Similar to females in general morphology, but smaller in size and with posterior region strongly curved. Lip region is as is in females, cephalic papillae/setae not visible. Testis single, outstretched on left or right side of intestine. Spicules narrow, arcuate, 1.4 to 1.6 times anal body diam. long. Gubernaculum broad,

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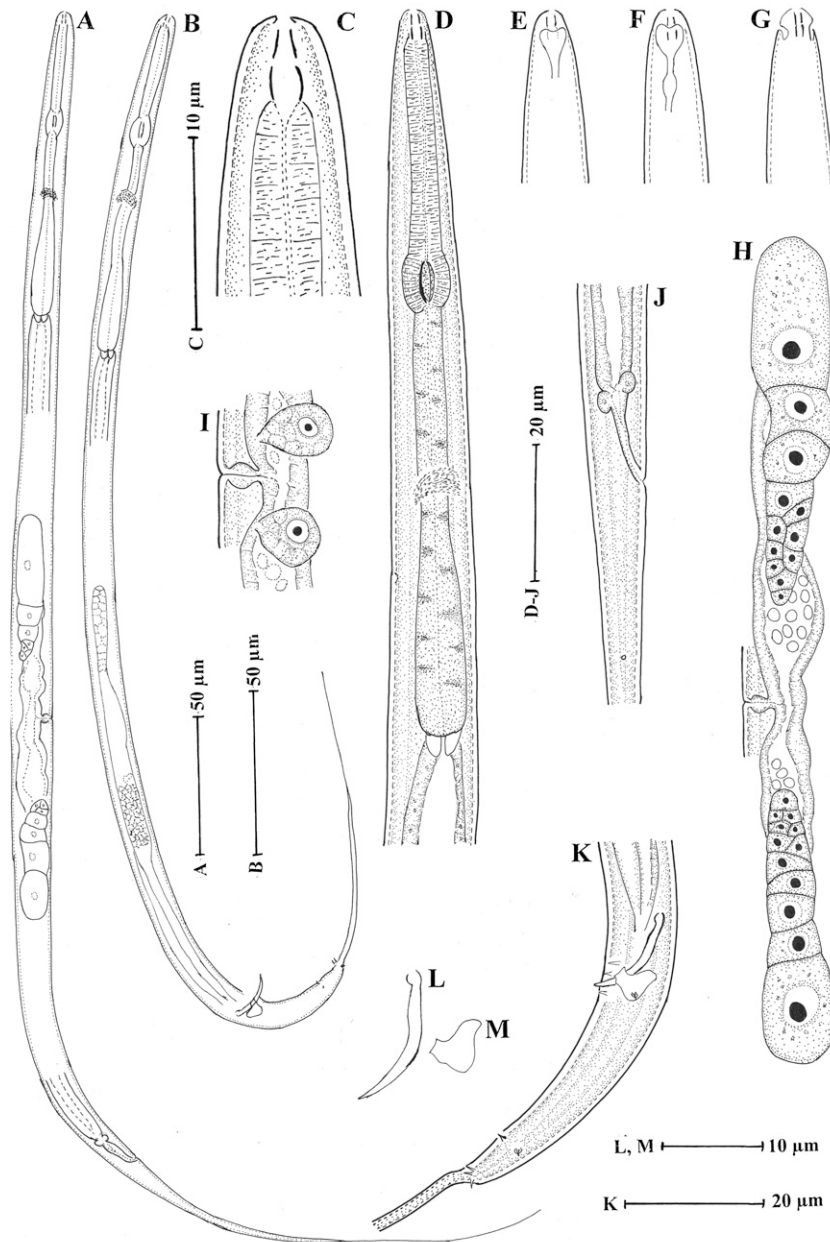


FIG. 1. *Goffartia phalacra* n. sp.: A. Entire female. B. Entire male. C. Anterior region. D. Pharyngeal region. E, F. Anterior region showing amphid. G. Anterior region (dorsoventral). H. Female genital system. I. Vulval region showing unicellular glands. J. Female posterior region. K. Male posterior region. L. Spicule. M. Gubernaculum (A-C, E, F, J—right lateral; D, H, I, K-M—left lateral).

keel-shaped, with a distal sleeve. Genital papillae comprise nine pairs; two pairs precloacal, seven pairs postcloacal. Genital papillae formula as proposed by Sudhaus and Fürst von Lieven (2003): (v1, v2), /v3d, v4, ad, phasmids, v5 (v6, v7), pd. Papilla v5 of the v5 to v7 group placed anteriorly at level of ad. Tail with a short, conoid base and a long filiform tip.

**Diagnosis and relationship:** *Goffartia phalacra* n. sp. is characterized by a small slender body, large amphidial apertures and wine glass-shaped fovea; a smooth round lip region without discernable labial papillae; stoma with cheilostom and gymnostom of almost equal lengths; pharynx with a short corpus and a long postcorpus; two

pairs of unicellular glands at base of vagina, large prominent phasmids; a broad keel-shaped gubernaculum with distal sleeve and nine pairs of genital papillae: two precloacal and seven postcloacal with papilla v5 placed separately from v5 to v7 group.

The new species is easily distinguished from all other species of the genus by the broad keel-shaped gubernaculum, the unicellular glands associated with the vagina, the smooth, round lip region without discernable labial papillae and nine pairs of genital papillae with papilla v5 separated from the v5 to v7 group. Potential differences from *G. heteroceri* Hirschmann, 1952, *G. praepilata* Shoshin, 1989, *G. africana* (Micoletzky, 1915) Hirschmann, 1952

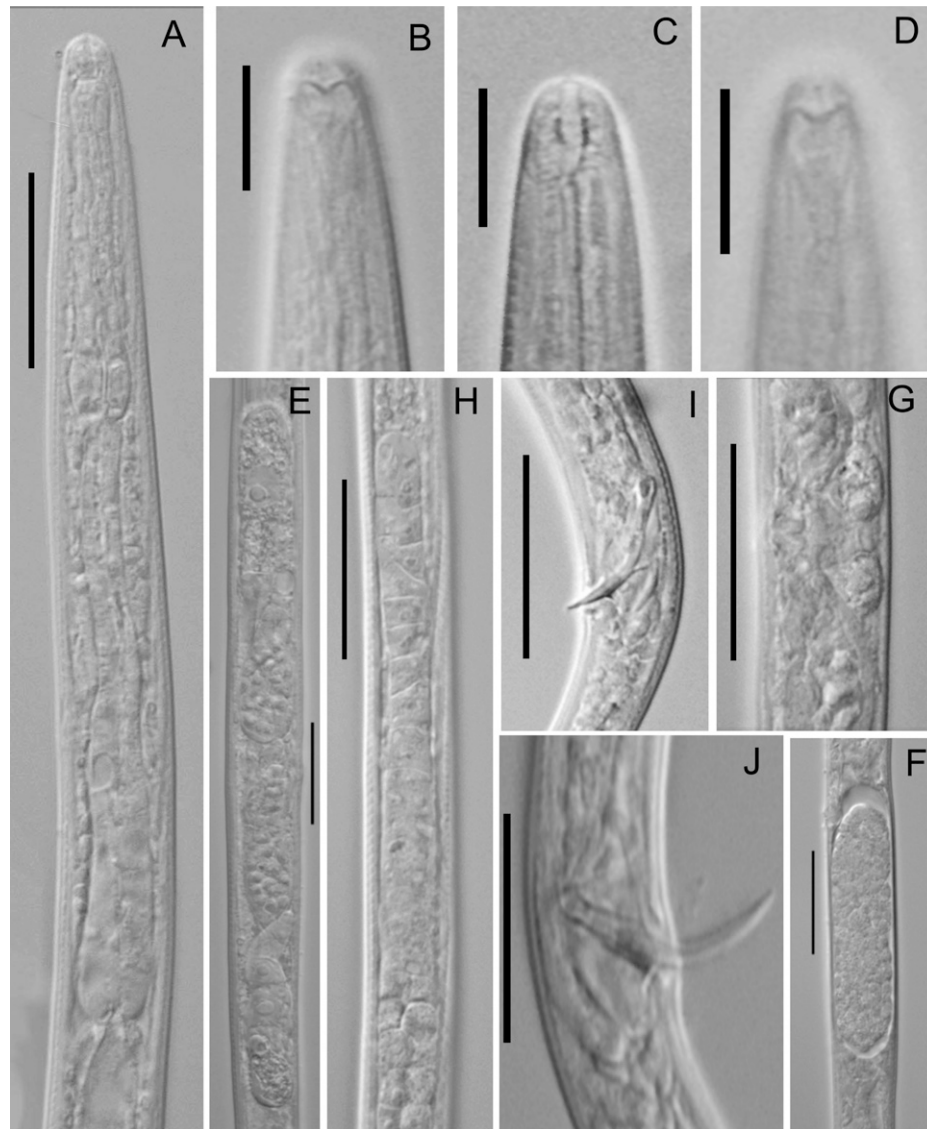


FIG. 2. *Goffartia phalacra* n. sp.: A. Pharyngeal region. B, D. Anterior region showing amphids (lateral). C. Anterior region showing stoma. E. Female reproductive system (entire). F. Female reproductive system showing egg. G. Vulval region showing unicellular glands. H. Testis. I, J. Male posterior region showing spicules and gubernaculum. Scale bars: B, C, D, J = 10  $\mu$ m; A, E-I = 20  $\mu$ m (B-F, J—right lateral; A, G-I—left lateral).

and *G. filicaudata* (Andrassy, 1968) Sudhaus & Fürst von Lieven, 2003 is in the proportion of the anterior and posterior pharynx (1:1.6 to 1.8 vs. approximately 1:1 in others; as interpreted from figures. Pharynx ratios to be interpreted with caution as this character may be prone to artifact).

*Type habitat and locality*: Collected from farmyard manure from district Baramulla, Jammu and Kashmir, India.

*Other localities*: Farmyard manure collected from Sukhravali Village, Ramghat Road, Aligarh, Uttar Pradesh, India.

*Type specimens*: Holotype female on slide *Goffartia phalacra* n. sp. /J&K 1, and 11 paratype females and 8 paratype males on slides *Goffartia phalacra* n. sp. /J&K 2 to 10 are deposited in the nematode collection of

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*Other specimens*: Eight females and seven males on slides *Goffartia phalacra* n. sp. /Alig 1 to 7 deposited in the nematode collection of Department of Zoology, Aligarh Muslim University, Aligarh, India.

*Bionomics*: The six species of *Goffartia* known so far, including the new one, show a wide distribution. Two species have been recorded from Asia, one from Africa, and three from Europe. Interestingly, all previously described species of *Goffartia* were found in aquatic or semi-aquatic habitats. *G. praepilata* was collected from Lake Baikal, *G. filicaudata* from soil at the pond edge; *G. africana* was associated with algae in freshwater habitats while *G. heteroceri* and *G. variabilis* were found on beetles in freshwater habitats. This appears to be the

TABLE 1. Morphometrics of female holotype and female and male paratypes of *Goffartia phalacra* n. sp. (Measurements are in  $\mu\text{m}$  and in the form: mean  $\pm$  sd (range)).

Character	Type population from Jammu and Kashmir			Other population from Aligarh, U.P.	
	Holotype female	Paratype females (n = 11)	Paratype males (n = 8)	Females (n = 8)	Males (n = 7)
L	626	615 $\pm$ 21.2 (573-646)	511 $\pm$ 34.5 (450-574)	587 $\pm$ 44.5 (511-638)	450 $\pm$ 34 (388-488)
a	39.5	40.2 $\pm$ 2.16 (37.4-44.7)	43.5 $\pm$ 2.7 (40-48)	44.4 $\pm$ 3.6 (37.1-47.4)	47.5 $\pm$ 3.4 (42-52)
b	5.5	5.4 $\pm$ 0.2 (4.9-5.7)	4.7 $\pm$ 0.4 (4.1-5.1)	5.5 $\pm$ 0.4 (4.8-6)	4.7 $\pm$ 0.3 (4.1-5.1)
c	2.9	3.0 $\pm$ 0.2 (2.7-3.5)	3.3 $\pm$ 0.2 (3-3.7)	3.1 $\pm$ 0.7 (2.6-4.8)	3.6 $\pm$ 0.4 (3-4)
c'	23.9	22.5 $\pm$ 2.1 (18.3-26.3)	15.6 $\pm$ 2.2 (12.4-19.7)	25.4 $\pm$ 5.9 (13.6-32.8)	14 $\pm$ 2.4 (10-18)
L'	413	411 $\pm$ 14 (394-447)	354 $\pm$ 18.4 (327-379)	387 $\pm$ 16 (357-408)	323 $\pm$ 13.4 (296-339)
a'	25.8	29.9 $\pm$ 1.3 (24.9-29.5)	30.1 $\pm$ 1.4 (28-32)	29.2 $\pm$ 0.7 (27.8-30.2)	34.2 $\pm$ 2.2 (31.6-38)
b'	3.6	3.6 $\pm$ 0.16 (3.3-3.9)	3.3 $\pm$ 0.2 (2.9-3.5)	3.6 $\pm$ 0.1 (3.5-3.8)	3.4 $\pm$ 0.1 (3.2-3.5)
V	41.4	41.9 $\pm$ 1.4 (40-45)	–	42 $\pm$ 3 (40-49)	–
Maximum body diam.	16	15.3 $\pm$ 0.76 (14-17)	12 $\pm$ 0.5 (11-13)	13.3 $\pm$ 0.5 (13-14)	9.5 $\pm$ 0.5 (9-10)
Stoma height	5	5.6 $\pm$ 0.7 (5-7)	5.2 $\pm$ 0.4 (5-6)	5	4.7 $\pm$ 0.5 (4-5)
Pharynx length	114	114 $\pm$ 4.5 (107-124)	109 $\pm$ 6.0 (96-117)	107 $\pm$ 2.5 (103-111)	96 $\pm$ 4 (90-102)
Anterior pharynx	44.5	45.8 $\pm$ 1.7 (43.5-48.5)	43.4 $\pm$ 1.5 (42-46)	45 $\pm$ 1 (44-47)	41.5 $\pm$ 2 (38-45)
Posterior pharynx	69.5	68.5 $\pm$ 3.5 (62.5-76)	65.7 $\pm$ 4.9 (54-71)	62 $\pm$ 2.5 (58.5-66.5)	55 $\pm$ 3 (50-58)
Median bulb width	6	6.3 $\pm$ 0.4 (6-7)	5.9	5.9	5.1 $\pm$ 0.4 (5-6)
Nerve ring from ant. end	69	69.5 $\pm$ 3.5 (62-76)	65 $\pm$ 4 (59-73)	66 $\pm$ 3 (61.5-69.5)	57.5 $\pm$ 2.5 (53.5-60.5)
Cardia	2	2.3 $\pm$ 0.5 (2-3)	2.8 $\pm$ 0.4 (2-3)	2.6 $\pm$ 0.5 (2-3)	2.4 $\pm$ 0.5 (2-3)
Anterior gonad	60.5	65 $\pm$ 4.5 (55.5-73.5)	–	60 $\pm$ 5.5 (49.5-67.5)	–
Posterior gonad	74	64 $\pm$ 10 (44.5-83)	–	59 $\pm$ 7.5 (51.5-75)	–
Vulval body diam.	16	15.5 $\pm$ 0.7 (14-17)	–	13.2 $\pm$ 0.5 (13-14)	–
Rectum/cloaca	10	10.8 $\pm$ 0.8 (10-12)	16 $\pm$ 1.5 (14-18)	8.5 $\pm$ 0.5 (8-9)	15 $\pm$ 1 (14-16)
Tail length	213	204 $\pm$ 18.5 (163-235)	158 $\pm$ 20 (123-195)	200 $\pm$ 43 (108-238)	450 $\pm$ 33 (388-488)
Anal body diam.	9	9 $\pm$ 0.4 (9-10)	10.5 $\pm$ 0.5 (10-11)	8 $\pm$ 0.5 (7-9)	9 $\pm$ 0.5 (8-10)
Phasmids from anus	26	28.5 $\pm$ 1.8 (26-32)	19.5 $\pm$ 1.5 (18-22)	25 $\pm$ 2 (23-28)	–
Testis	–	–	162 $\pm$ 21 (129-203)	–	158 $\pm$ 9.5 (146-176)
Spicule length (curve)	–	–	15 $\pm$ 0.5 (15-16)	–	12.6 $\pm$ 1 (11-14)
Gubernaculum length	–	–	6.9	–	4.8 $\pm$ 0.6 (4-6)

L' = Length of body up to anus or cloaca. a' = L'/maximum body diameter. b' = L'/pharynx length.

first report of a species in this genus that is found outside an aquatic habitat and always in farmyard manure.

#### DISCUSSION

Of the five previously known species of *Goffartia*, the earliest was described by Micoletzky (1915) and the last by Shoshin (1989). Sudhaus and Fürst von Lieven (2003) have lucidly defined the stoma of *Goffartia* with an anteriorly converging cheilostom, barrel-shaped gymnostom and a stegostom without cuticularized projections. These three components of the stoma, as suggested by De Ley et al. (1995) are clearly depicted in all descriptions but there are significant variations in their proportions and in the length of stoma in relation to the lip width. While in *G. heteroceri*, *G. variabilis*, and *G. filicaudatum* the stoma is 1.5 times lip width, in *G. africana* it is 2.5 times and *G. praepilata* it is almost three times the lip width. Hence the stoma appears elongate tubular in *G. praepilata*, elongate barrel-shaped in *G. africana* and compact barrel-shaped in the other species. Therefore, the relative lengths of stomatal regions though not consistent for the genus do provide a reliable diagnostic character for individual species. The

cheilostom and gymnostom are almost equal in length and form the greater part of the length of the stoma and the stegostom represents less than 25% of the stoma length in *G. heteroceri* and *G. variabilis*. In *G. filicaudatum* and *G. africana*, the gymnostom represents the longest segment with relatively small cheilostom and stegostom and in *G. praepilata* the stegostom forms almost 75% of the length of stoma, the cheilostom and gymnostom being almost equal in size. The structure of the stoma in diplogastrids is represented by Sudhaus and Fürst von Lieven (2003) as a stable and taxonomically sound character for the genus. However, the variability in size and proportions of the stoma segments need to be treated with caution when diagnosing *Goffartia*. Furthermore, in these species that are very slender (a = 37.5 to 44.7) the anterior end is very narrow and the extent of the stoma surrounded by a thin pharyngeal tissue may not be easily discernable and hence lead to some disparity in interpretation. This is clearly borne out in the report of *G. heteroceri* and *G. variabilis* (Zullini & Loof, 1980), wherein both the species are depicted with a stoma almost completely enveloped by pharyngeal tissue and hence without a gymnostom (Fig. 31 A,B). This contrasts with the

descriptions of these species given by Hirschmann (1952), where the gymnostom and cheilostom form the greater part of stoma and the stegostom is the smallest component.

The labial sensilla also vary from being elongate setose (*G. praepilata*) to small bristle-like (*G. filicaudata* etc) or may be indiscernible in *G. phalacra* n. sp. The setae of *G. praepilata* conform to its aquatic habitat although this character is not exclusive to aquatic species and setae are also known in terrestrial nematode species. Nevertheless, it is preponderant in aquatic species. Unlike most diplogastrid males, *Goffartia* males do not show the characteristic cephalic papillae/setae. Interestingly, while all species have very long filiform tails, *G. praepilata* has the shortest tail among the group ( $c = 5.6$  to  $6.8$ ).

Sudhaus & Fürst von Lieven (2003) outlined the apomorphic characters of the genus *Goffartia* such as wide amphidial apertures, anteriorly converging cheilostom, stegostom without denticles and a barrel-shaped gymnostom. Within the species of the genus, *G. phalacra* n. sp. stands out with several features representing apomorphies. The broad keel-shaped gubernaculum, smooth lip region without discernable papillae and vaginal glands constitute the apomorphic characters of the species. The unicellular vaginal glands must be treated with caution as a structure not observed may not be strictly speaking absent and its presence or absence needs to be reconfirmed in other species. Nevertheless, *G. phalacra* n. sp. is clearly a distinct new species and expands the known distribution of this diplogastrid genus.

#### KEY TO SPECIES OF *GOFFARTIA*

1. Gubernaculum broad, keel-like; lip region smooth, papillae not discernable; unicellular glands associated with vagina. . . . . *phalacra* n. sp.  
Gubernaculum slender, labial papillae discernable . . . . . 2
2. Stoma more than two lip widths long. . . . . 3  
Stoma less than two lip widths long. . . . . 4

3. Labial papillae setose, gubernaculum small, less than  $2/3$  of spicule length. . . . . *praepilata*  
Labial papillae short, gubernaculum about  $2/3$  of spicule length. . . . . *africana*
4. Anterior pharynx slightly longer than posterior pharynx; tail very long filiform,  $c = 2.0-3.5$ . . . 5  
Anterior pharynx shorter than posterior pharynx; tail smaller,  $c = 3.9-6.1$ . . . . . *variabilis*
5. Spicules curved proximally, gubernaculum straight, slender. . . . . *heteroceri*  
Spicules straight, gubernaculum stout, distally recurved. . . . . *filicaudatum*

#### LITERATURE CITED

- Andrassy, I. 1968. Wissenschaftliche Ergebniss der ungarischen zoologischen Expedition nach Tansanien. 12. Bodennematodena der III. Expedition. Acta zoologica Academiae Scientiarum Hungaricae 14:239-257.
- De Ley, P., Van Der Velde, M. C., Mountport, D., Boujard, P., and Coomans, A. 1995. Ultrastructure of the stoma in Cephalobidae, Panagrolaimidae and Rhabditidae, with a proposal for a revised stoma terminology in Rhabditida (Nematoda). Nematologica 41:153-182.
- De Maeseneer, J., and d'Herde, J. 1963. Méthodes utilisées pour l'étude des anguillules libres du sol. Revue d'Agriculture 16:441-447.
- Flegg, J. J. M. 1967. Extraction of *Xiphinema* and *Longidorus* species from soil by a modification of Cobb's decanting and sieving technique. Annals of Applied Biology 60:420-437.
- Hirschmann, H. 1952. Die Nematoden der Wassergrenze mittelfränkischer Gewässer. Zoologische Jahrbücher (Systematik) 81:313-407.
- Micoletzky, H. 1915. Süßwasser-Nematoden aus Südafrika. Denkschrift der kaiserlichen Akademie der Wissenschaften Wien, math.-nat. Klasse 92:149-171.
- Micoletzky, H. 1922. Die Freilebenden Erdnematoden. Archiv für Naturgeschichte 87 A (1921), 1-650.
- Shoshin, A. V. 1989. New nematode species of the families Diplogasteridae and Diplogastroideidae from the Baikal Lake. In A. Y. Ryss, ed., Tylenchida and Rhabditida (Nematoda)—Parasites of plants and insects. Trudy Zoologiceskogo Instituta Akademia Nauk SSSR. (Leningrad) 194:83-95.
- Sudhaus, W., and Fürst Von Lieven, A. 2003. A phylogenetic classification and catalogue of the Diplogasteridae (Secernentea: Nematoda). Journal of Nematode Morphology and Systematics 6:43-90.
- Zullini, A., and Loof, P. A. A. 1980. Systematic notes on some species of Diplogasteridae (Rhabditida). Nematologica 26:17-26.