

<https://doi.org/10.11646/zootaxa.0000.0.0>

<http://zoobank.org/urn:lsid:zoobank.org:pub:00000000-0000-0000-0000-000000000000>

## Description of a new and two known species of *Cephaloboides* Rahm, 1928 (Nematoda: Rhabditidae) from India, with discussion on the taxonomy of the genus

QUDSIA TAHSEEN<sup>1,3</sup>, AHER HUSSAIN<sup>1</sup>, SHIKHA AHLAWAT<sup>1</sup>,  
MALKA MUSTAQIM<sup>1</sup> & ZAKAULLAH KHAN<sup>2</sup>

<sup>1</sup>Section of Nematology, Department of Zoology, Aligarh Muslim University, Aligarh-202002, India

<sup>2</sup>National Bureau of Plant Genetic Resources, Division of Plant Quarantine, New Delhi-110012, India.

<sup>3</sup>Corresponding author. E-mail: qtaheen@yahoo.com

### Abstract

A new species of Rhabditidae, collected from manure, is described and illustrated. *Cephaloboides anisospiculus* sp. n., an amphimictic species with a 1:1 sex ratio, is characterized by a small to medium-sized body (female: L = 0.5–0.7 mm,  $a = 13.6\text{--}20.0$ ,  $b = 2.7\text{--}3.6$ ,  $c = 15.4\text{--}22.7$ ,  $c' = 1.0\text{--}1.8$ , V = 51.2–60.9), finely striated, punctated cuticle; slightly raised labial papillae; stoma with slightly anisomorphic metastegostom; presence of epiptygma; eggs measuring 37–42 x 20–24  $\mu\text{m}$ ; slightly protruded vulval lips with cuticular flaps; rectum 16–19  $\mu\text{m}$  long; males with small, stout, slightly arcuate spicules with hood-like capitula and genital papillae in 1/2/(1+3)+2+P configuration; bursa leptodieran, greatly reduced and not enveloping the caudal spike. *C. curvicaudatus* (Schneider, 1866) Zullini, 1982 is also redescribed, with an emended diagnosis. The present population of *C. curvicaudatus* shows a few minor differences viz., relatively smaller ‘b’ value, presence of elongate capitula of spicules and strong copulatory muscle bands. Another species, *C. parapapillosus* (Schuurmans Stekhoven, 1951) comb. n. has been reinstated.

**Key words:** *Cephaloboides anisospiculus*, *C. curvicaudatus*, *C. parapapillosus*, description, morphology, new species, taxonomy

### Introduction

*Cephaloboides* was first proposed as a subgenus of *Rhabditis* by Rahm (1928) when he described the type species as *Rhabditis (Cephaloboides) musicola*. However, the first record of any species of the genus can be traced to 1862 when Claus reported *Anguillula brevispina*. The latter species was considered a junior synonym of *C. curvicaudatus* (Schneider, 1866) Zullini, 1982 by Sudhaus (2011). Andrassy (1983) considered the latter species under the genus *Curviditis* (Dougherty, 1953) Andrassy, 1983 along with *C. dimorphus* Sudhaus, 1976 and considered only two species viz., *C. musicola* Rahm, 1928 and *C. pseudoxycerca* (Goodey, 1929) Andrassy, 1983 under *Cephaloboides*. Sudhaus (2011), however, did not approve the status of *Curviditis* and considered it a junior synonym of *Cephaloboides*. In the catalogue of Rhabditidae Örley, 1880, Sudhaus considered six valid species of the genus, namely *C. armatus* (Fuchs, 1931) Dougherty, 1955, *C. curvicaudatus*, *C. dimorphus*, *C. musicola*\*., *C. paraciliatus* (Goodey, 1943) Dougherty, 1955 and *C. pawani* (Khan, Singh & Baird, 1999) Andrassy, 2005.

During the screening of past collections, one new and two known species of *Cephaloboides* have been identified. The present paper describes and illustrates *Cephaloboides anisospiculus* sp. n. along with *C. curvicaudatus*. We also reinstate *C. parapapillosus* (Schuurmans Stekhoven, 1951) comb. n. due to some conspicuous differences from *C. musicola*. The salient differentiating features of the congeners are also discussed.

\* The original name 'musicola' has been retained as per suggestion of the reviewer that suffix -cola is invariably being used for masculine and feminine names

## Material and methods

Nematodes were extracted using Cobb's (1918) sieving and decantation method and the modified Baermann (1917) funnel technique. For light microscopy, nematodes were fixed in 4% formaldehyde, dehydrated to pure glycerine (Seinhorst, 1959) and later mounted on slides using the wax ring technique. The nematodes were measured with an ocular micrometer and drawn using a drawing tube. LM photographs were taken with a Jenoptik digital camera, ProgRes, mounted on an Olympus BX-51 DIC microscope. For Scanning Electron Microscopy (SEM), nematodes were fixed in 2% glutaraldehyde, post-fixed in 2% osmium tetroxide, dehydrated in alcohol series and critical point dried using CO<sub>2</sub>. The mounted nematodes were coated with 10 nm gold before viewing at 10 kV under an XL30 FEG scanning electron microscope.

## Systematics

### *Cephaloboides anisospiculus* sp. n.

(Figs. 1, 2)

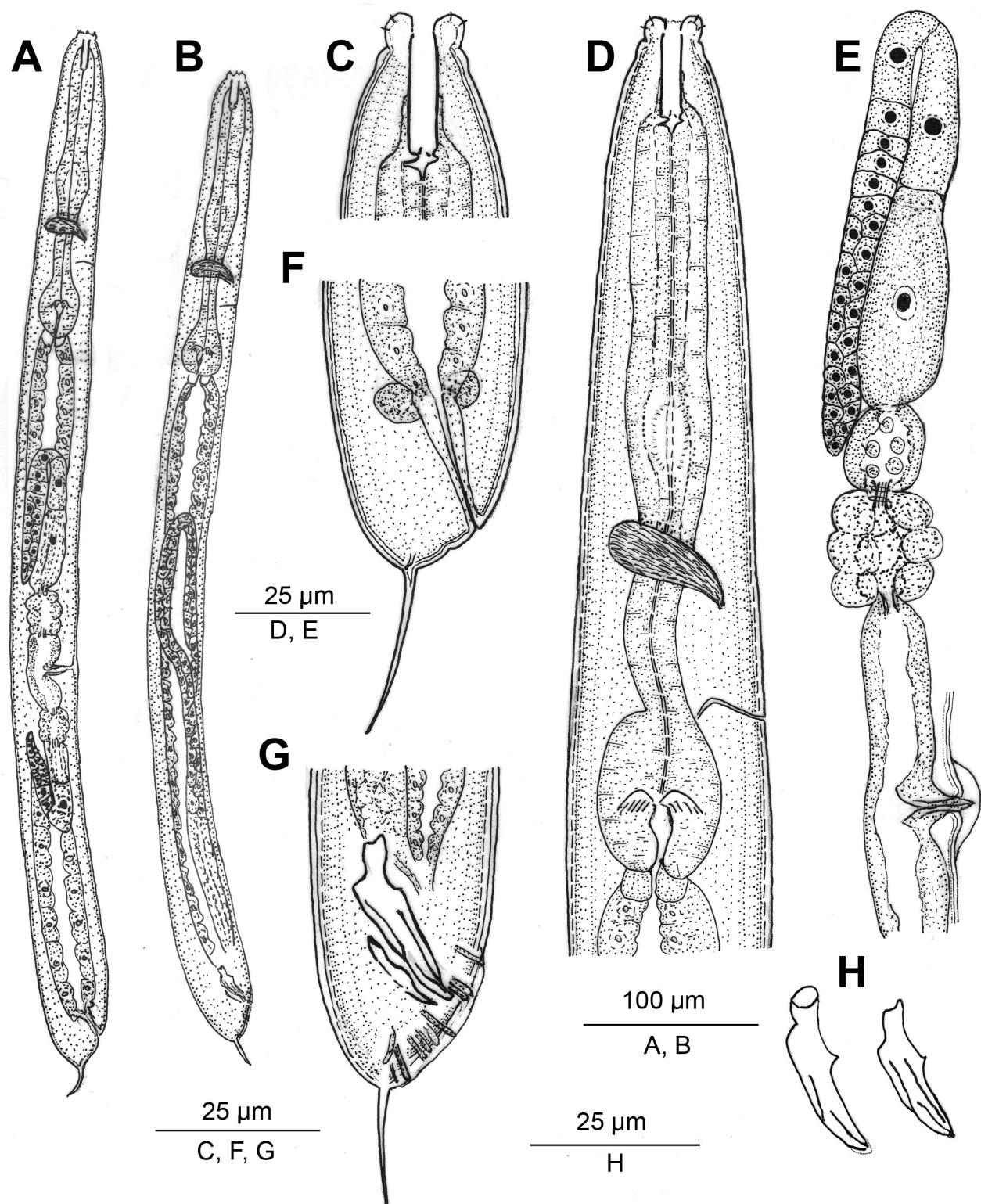
#### Measurements. Table 1.

**Description. Adult:** Body small to medium-sized, slender, almost straight or slightly ventrally curved upon fixation. Cuticle double, about 1.5–2.0 µm thick, faintly punctated, with fine transverse and longitudinal striations. Lateral fields indistinct. Lip region expanded, 11–13 µm in diameter, set off from adjoining body. Lips six, prominent, globular with smooth margins, fused at bases. Inner labial sensilla close to oral aperture; cephalic and outer labial sensilla slightly raised and towards outer border of lips. Amphids small, on lateral lips. Stoma tubular, 4.6–6.5 times longer than wide or 1.6–2.0 labial diameters in length. Cheilostom weakly cuticularized. Gymnostom tubular, with parallel walls, thickly cuticularized about 1/4<sup>th</sup>–1/3<sup>rd</sup> of stomal length. Pharyngeal tissue surrounding about 50–55% of stoma. Metastegostom isotopic and slightly anisomorphic with a fine wart on each plate. Pharyngeal corpus swollen, 97–120 µm long or 2.6–3.3 times isthmus length. Basal bulb 36–50 µm x 22–25 µm in size having a grinder and single-chambered haustrulum. Nerve ring surrounding isthmus at 59.4–64.8% of pharyngeal length from anterior end. Secretory-excretory pore located posterior to nerve ring at 71.7–72.8% of pharyngeal length from anterior end. Body at pharyngeal end 2.3–3.0 times labial diameter in width. Cardia with conical flaps, 4–6 µm long. Intestine granular with wide lumen. Rectum thin-walled, 0.7–1.0 anal body diameter long with three rectal glands. Anal opening crescentic slit.

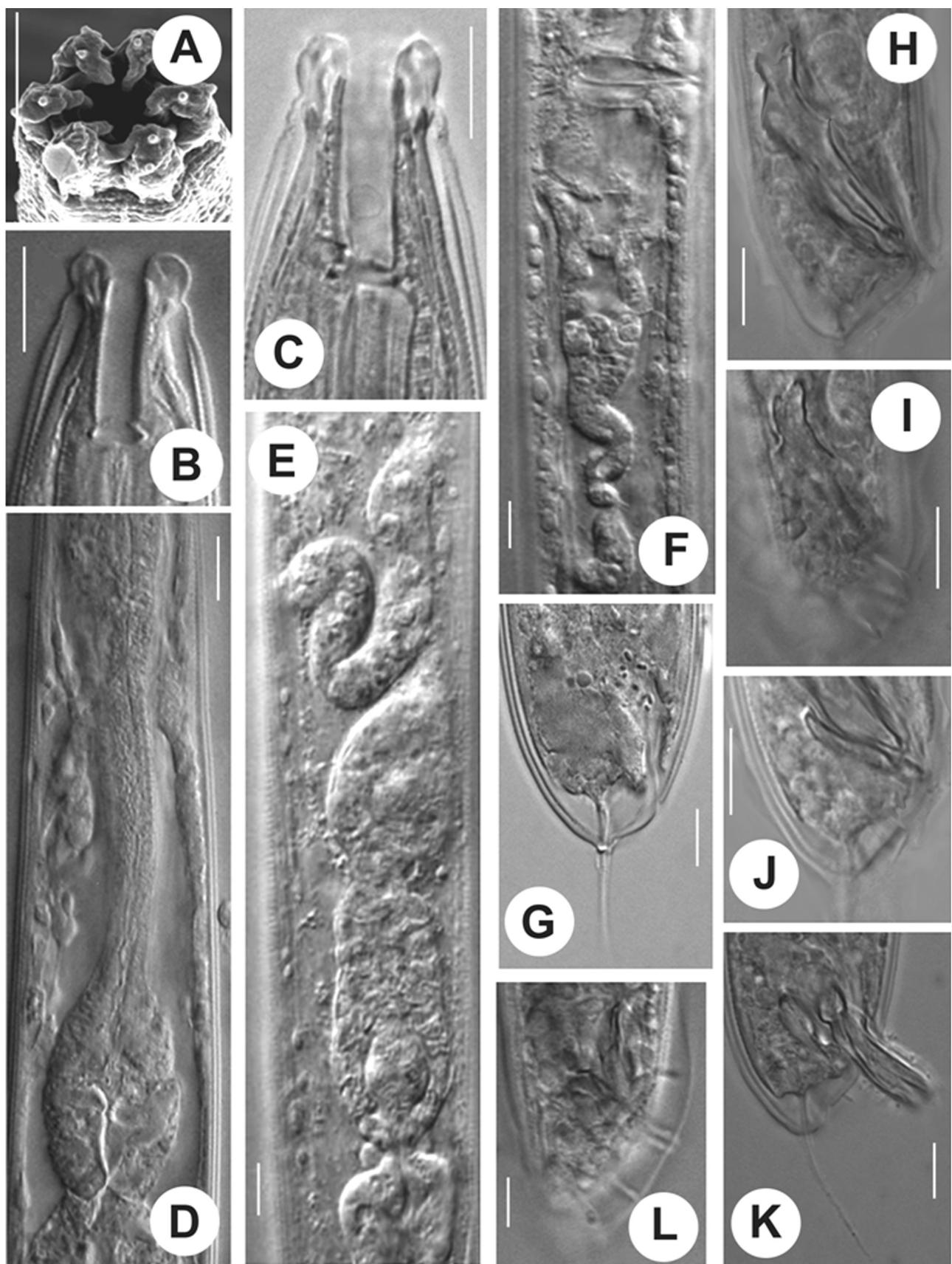
**Female:** Reproductive system didelphic, amphidelphic. Ovaries weakly-developed, dorsally reflexed, flexure small, often convoluted, never reaching vulva; anterior ovary on right, posterior ovary on left side of intestine. Proximal part of oviduct prominently dilated, separated from spermatheca by a prominent sphincter, with another strong sphincter lying between spermatheca and uterus. Uterus often with 2–8 eggs, 37–42 µm long x 20–24 µm wide, at different stages of embryonation. Intra-uterine development usually observed in older females with juveniles hatched inside the body. Vagina 13–23 µm long occupying about 2/3<sup>rd</sup> of the corresponding body diameter and perpendicular to the main body axis with distal folds appearing as internal epiptygma. Vulva a transverse slit surrounded by cuticular flaps. Distance between vulva and anus 268–315 µm or 4.4–7.1 times tail length. Tail cupola-shaped, about 1.3–1.5 times of anal body diameter long with 26–34 µm long anterior conical part and a posterior narrow, 20–24 µm long spike. Phasmidial ducts opening at base of broader part of tail or at beginning of spike.

**Male:** Similar to female in general morphology except in shorter body length and greater posterior curvature. Testis single, ventrally reflexed; reflexed part 57–95 µm long, at right side of intestine. Spicules visibly unequal, well-built, stout, about 1.1–1.4 times anal body diameter long, slightly arcuate with hood-like capitula. Each spicule with a ventral conoid process and a dorsal thorn. Left one more robust and shorter with bilobed or hood-like capitulum. Right one slender and longer with globose capitulum. Distal end of spicule usually surrounded by an extending velar cap. Gubernaculum about 51.7–52.1% of spicule length. Bursa leptoderan, rudimentary, not covering the spike and hardly differentiated from the body cuticle. Genital papillae nine pairs with one precloacal, two nearly adcloacal and six postcloacal pairs in 1/2/(1+3)+2+P configuration. Of the genital papillae, GP1, GP4 and GP8 are the longest extending beyond bursal edge. GP1 subventral, precloacal slightly spaced from nearly

adcloacal, subventral GP2, GP3. Of six postcloacal papillae, GP4 forms a group with subventral GP5, GP6 and GP7; GP8 dorsally-oriented and close to GP9. Phasmidial ducts narrower and smaller than papillae opening next to GP9 at base of tail spike. Copulatory muscle bands 6 pairs, weakly developed, often indiscernible.



**FIGURE 1.** *Cephaloboides anisospiculus* sp. n. A: Entire female. B: Entire male. C: Female anterior end. D: Female pharyngeal region. E: Female anterior genital branch. F: Female posterior region. G: Male posterior region. H: Dimorphic spicules.



**FIGURE 2.** *Cephaloboides anisospiculus* sp. n. A: En face view (scanning electron microscopy). B, C: Anterior end. D: Posterior pharyngeal region. E: Female anterior genital branch. F: Female posterior genital branch. G: Female posterior region. H, I, K: Male cloacal region showing variation in spicules. J: Male cloacal region showing gubernaculum. L: Male cloacal region showing bursa and associated papillae (Scale bars= 10 µm).

TABLE 1. Morphometric characteristics of *Cephaloboides anisospiculus* sp. n., *C. curvicaudatus* (Schneider, 1866) Zullini, 1982 and *C. parapapillosus* (Schuurmans Stekhoven, 1951) comb. n.  
Measurements are in µm and in the form: mean ± standard deviation (range).

Female	<i>C. anisospiculus</i> sp. n.		<i>C. curvicaudatus</i> (Schneider, 1866) Zullini, 1982	<i>C. parapapillosus</i> (Schuurmans Stekhoven, 1951) comb. n.
	Holotype female	Paratype (n=10)	Female (n=9)	Female (n=14)
Body length	651 609.7±59.0 (509–703)		1072.1±91.1 (970–1282)	917.8±54.8 (868–982)
Body diameter	35 34.9±1.8 (32–39)		71.6±4.7 (62–79)	50.4±4.7 (42–62)
a	18.6 17.4±1.4 (13.6–20.0)		14.6±0.9 (13.6–16.6)	18.7±1.2 (15.1–20.8)
b	3.3 3.2±0.2 (2.7–3.6)		4.2±0.1 (3.8–4.5)	4.3±0.2 (3.8–4.8)
c	21.7 19.9±1.6 (15.4–22.7)		12.9±0.8 (11.8–14.8)	32.2±5.8 (29.7–41.3)
c'	1.6 1.5±0.1 (1.0–1.8)		3.2±0.5 (2.2–4.2)	1.2±0.2 (0.9–1.5)
V	60.9 58.5±3.4 (51.2–60.9)		54.7±2.2 (50.5–58.9)	58.4±0.9 (56.6–60.1)
G1	27.6 32.0±7.4 (23.0–48.3)		40.6±2.9 (36.6–43.2)	43.0±3.7 (37.7–52.4)
G2	21.6 28.5±4.8 (18.8–33.0)		39.4±2.5 (35.1–43.2)	42.5±4.9 (37.3–57.2)
Lip region height	6 6.1±0.5 (5–7)		6.5±0.8 (5–8)	5.0±0.0 (5–6)
Lip region diameter	13 12.0±0.4 (11–13)		17.1±1.1 (16–18)	13.0±0.0 (13–15)
Stoma length	23 22.2±1.6 (20–24)		29.6±2.1 (27–32)	24.3±1.5 (22–27)
Stoma diameter	4 4.1±0.3 (3.5–4.5)		6.8±0.6 (6–8)	5.0±0.0 (4–5)
Pharynx length	192 185.1±10.9 (162–202)		256.2±13.3 (232–279)	215.5±8.7 (165–235)
Nerve ring- ant. end	120 113.1±4.6 (105–120)		177.8±26.5 (155–222)	145.6±8.7 (123–160)
Secretory-excretory pore- ant. end	144 131.5±10.5 (118–145)		179.6±14.2 (165–200)	153.8±8.6 (130–166)
Rectum length	17 17.9±0.9 (16–19)		18.2±3.1 (15–24)	17.0±1.9 (15–22)
Anal body diameter	18 20.1±2.7 (17–26)		27.0±5.7 (20–40)	24.4±1.9 (20–28)
Tail length	30 30.6±2.4 (26–34)		82.7±7.2 (70–93)	29.4±5.8 (23–40)
Vulva-anal distance: tail length	9.7 9.1±0.9 (7.6–10.4)		4.6±0.3 (4.2–4.9)	12.4±2.4 (9.6–15.3)
Egg dimension	38 x 21 38.1±1.5 x 20.7±1.8 (37–42 x 20–24)		47.0±1.8 x 33.7±2.6 (45–51 x 29–35)	40.4±3.0 x 21.3±2.2 (39–45 x 18–26)

.....continued on the next page



TABLE 1. (Continued)

	<i>C. amispiculus</i> sp. n.	<i>C. curvicaudatus</i> (Schneider, 1866) Zullini, 1982	<i>C. parapapillatus</i> (Schuurmans Stekhoven, 1951) comb. n.
	Paratype (n=7)	Male (n=8)	Male (n=3)
male			
Body length	536.5±28.0 (498–574)	1043.7±75.7 (950–1152)	887.0±14.9 (640–898)
Body diameter	31.1±1.7 (29–34)	61.6±7.2 (45–68)	39.7±0.6 (40–48)
a	17.2±0.6 (15.9–22.0)	17.1±2.5 (15.3–22.8)	22.4±0.6 (21.8–22.9)
b	3.3±0.1 (2.7–4.2)	4.2±0.3 (3.7–4.7)	4.4±0.1 (4.4–4.5)
c	20.1±1.9 (17.7–28.2)	12.7±1.0 (8.2–14.7)	31.6±3.6 (29.0–35.7)
c'	1.2±0.1 (1.0–1.4)	2.8±0.4 (2.2–3.5)	1.2±0.1 (1.0–1.3)
T	63.1±4.7 (56.8–72.2)	71.6±4.5 (63.2–76.7)	71.3±4.6 (66.1–74.6)
Lip region height	5.4±0.4 (5–6)	6.8±0.3 (6–7)	5.0±0.0 (5–5)
Lip region diameter	11.5±0.4 (11–12)	16.4±1.6 (12–17)	13.0±0.0 (13–13)
Stoma length	20.2±1.0 (19–22)	27.8±1.7 (25–29)	22.0±1.0 (20–23)
Stoma diameter	3.7±0.2 (3.5–4.0)	6.5±1.1 (6–7)	5.0±0.0 (5–5)
Pharynx length	161.8±5.9 (153–170)	244.8±13.6 (229–272)	100.6±5.6 (95–206)
Nerve ring- ant. end	100.4±4.7 (94–109)	166.3±6.8 (160–178)	137.7±6.0 (133–143)
Secretory-excretory pore- ant. end	117.0±2.9 (113–120)	171.3±10.9 (151–185)	146±5.6 (141–152)
Rectum length	24.0±0.7 (20–26)	21.0±5.2 (18–29)	20.0±6.4 (19–29)
Anal body diameter	21.7±1.7 (20–25)	29.5±5.1 (20–35)	23.6±0.6 (23–28)
Tail length	26.8±2.6 (23–31)	82.0±8.5 (70–90)	28.3±2.9 (25–30)
Spicules length	25.0±1.7 (19–29)	45.5±3.1 (42–53)	32.3±2.6 (30–35)
Gubernaculum length	13.3±1.1 (10–15)	18.7±3.1 (13–22)	13.7±1.5 (10–15)

**Type locality and habitat.** Samples containing *Cephaloboides anisospiculus* sp. n. were obtained from green manure at Lado Saray, New Delhi, India at coordinates 28.5245° N, 77.1919° E.

**Type material.** Holotype female, ten paratype females and seven paratype males on slides *Cephaloboides anisospiculus* sp. n. SA2/1–5 deposited in Nematode Collection, Department of Zoology, Aligarh Muslim University, Aligarh, Uttar Pradesh, India.

**Diagnosis and relationships.** *Cephaloboides anisospiculus* sp. n. is characterized by small- to medium-sized body; double, finely striated, faintly punctated cuticle; slightly raised labial papillae; stoma with slightly anisomorphic metastegostom; pharyngeal bulb with single-chambered haustrulum; presence of epiptygma; slightly protruded vulval lips with flaps; and males with dimorphic, small, stout, slightly arcuate spicules with hood-like capitula and genital papillae in 1/2/(1+3)+2+P configuration.

*Cephaloboides anisospiculus* sp. n. differs from *C. curvicaudatus* in having relatively smaller body (0.5–0.7 mm vs 0.6–1.8 mm); finely punctated and striated (vs smooth) cuticle; relatively smaller *b* (2.7–3.6 vs 3.4–6.0) and *c'* (1.0–1.8 vs 2.0–4.2) values; globular, prominent (vs amalgamated) lips; relatively smaller stoma (20–24 µm vs 19–32 µm) and males with relatively smaller (19–29 µm vs 30–54 µm) and unequal (vs equal) spicules with hood-shaped (vs elongate) capitulum and a trough-shaped gubernaculum with narrow acute (vs wide angular) proximal end in *C. curvicaudatus apud* (Schneider, 1866) Zullini, 1982.

The new species differs from *C. dimorphus* Sudhaus, 1976 in having a smaller body (0.5–0.7 mm vs 0.8–0.9 mm); relatively smaller *b* (2.7–3.6 vs 3.7–4.6), *c* (15.4–22.7 vs 26–30) and V (51.2–60.9 vs 61–64) values; similar labial sensilla in both sexes (vs labial sensilla dimorphic, lateral labials longer and tentacle-like in females); smaller stoma (20–24 µm vs 28–34 µm) and males with smaller spicules (19–29 µm vs 32–37 µm) and relatively smaller gubernaculum (10–15 µm vs 15–21 µm in *C. dimorphus apud* Sudhaus, 1976).

The new species differs from *C. musicola* Rahm, 1928 in having smaller body (0.5–0.7 mm vs 0.9–1.9 mm); relatively smaller *b* (2.7–3.6 vs 3.5–5.0) and *c* (15.4–22.7 vs 17–36) values; smaller stoma (20–24 µm vs 33–38 µm) and males with smaller (19–29 µm vs 42–81 µm), dissimilar and unequal (vs similar and equal) spicules in *C. musicola* Rahm, 1928.

The new species resembles the original population of *C. parapapillosum* Schuurmans Stekhoven, 1951 in having similar lengths of stoma and spicules but markedly differs in having smaller body (0.5–0.7 mm vs 1.4 mm); significantly smaller *b* (2.7–3.6 vs 6.8) and *c* values (15.4–22.7 vs 51.5 in *C. parapapillosum* (Schuurmans Stekhoven, 1951).

**Etymology.** The species name ‘*anisospiculus*’ denotes its unidentical or dissimilar spicules.

**Remarks.** The new species is unique in several features when compared with other congeners. It has a very small stoma and dimorphic spicules. Another unusual feature is the presence of a single-chambered haustrulum in the basal bulb which in most rhabditid species remains double chambered. The shifting of GP4 to form a group with GP5, GP6 and GP7 is another diagnostic feature of this new species.

### *Cephaloboides curvicaudatus* (Schneider, 1866) Zullini, 1982

(Figs. 3, 4)

= *Rhabditis brevispina* apud Hofmänner (1913), nec *Anguillula brevispina* Claus, 1862

= *Rhabditis macrospiculata* Stefański, 1916

= *Rhabditis micoletzkyi* Schneider, 1923

= *Rhabditis producta* apud Skrjabin, Shikhobalova, Sobolev, Paramonov & Sudarikov (1954), nec *Leptodera producta* Schneider, 1866

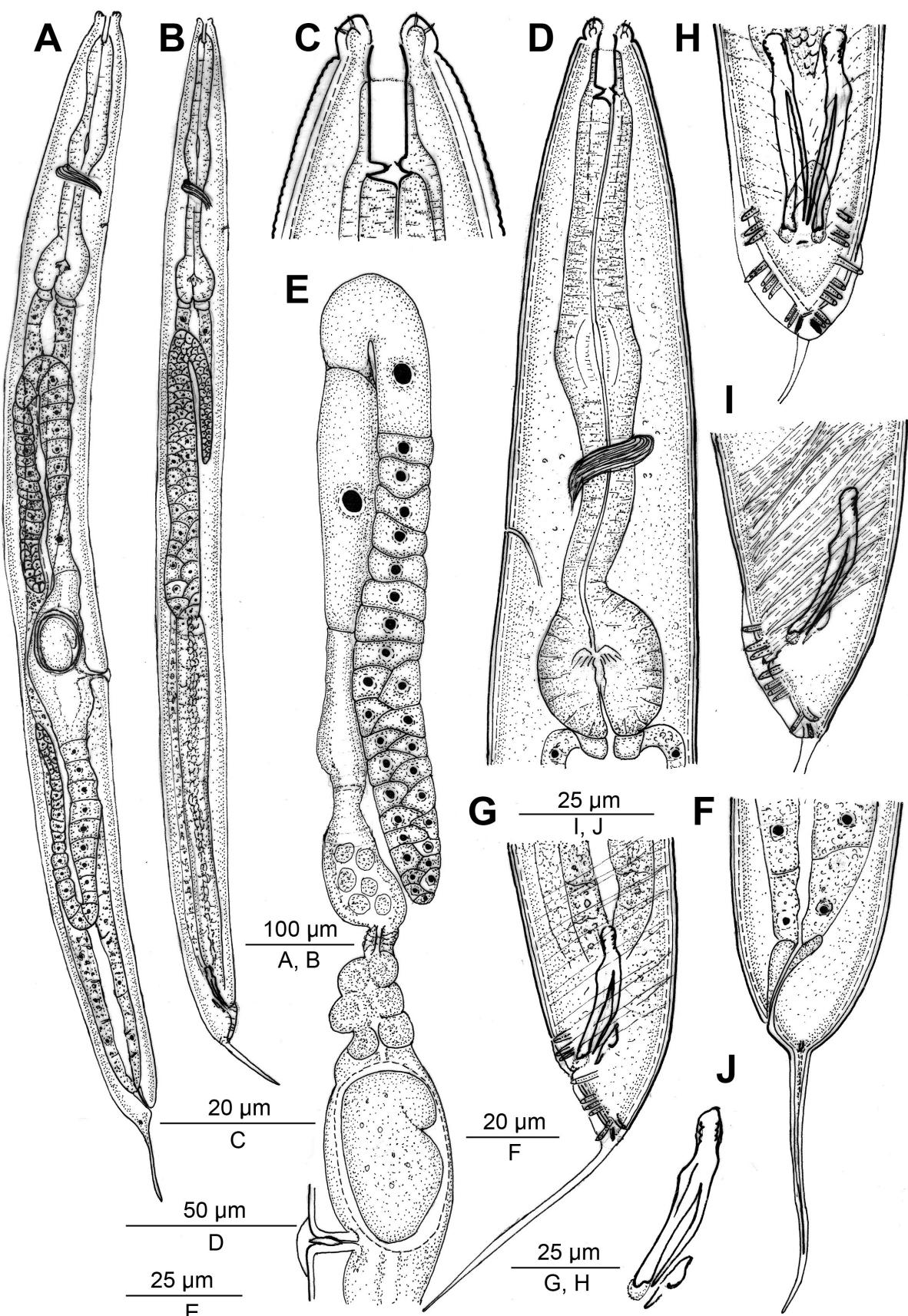
= *Rhabditis insulana* Ditlevsen, 1971

= *Odontorhabditis musicola* Timm, 1959 **syn. n.**

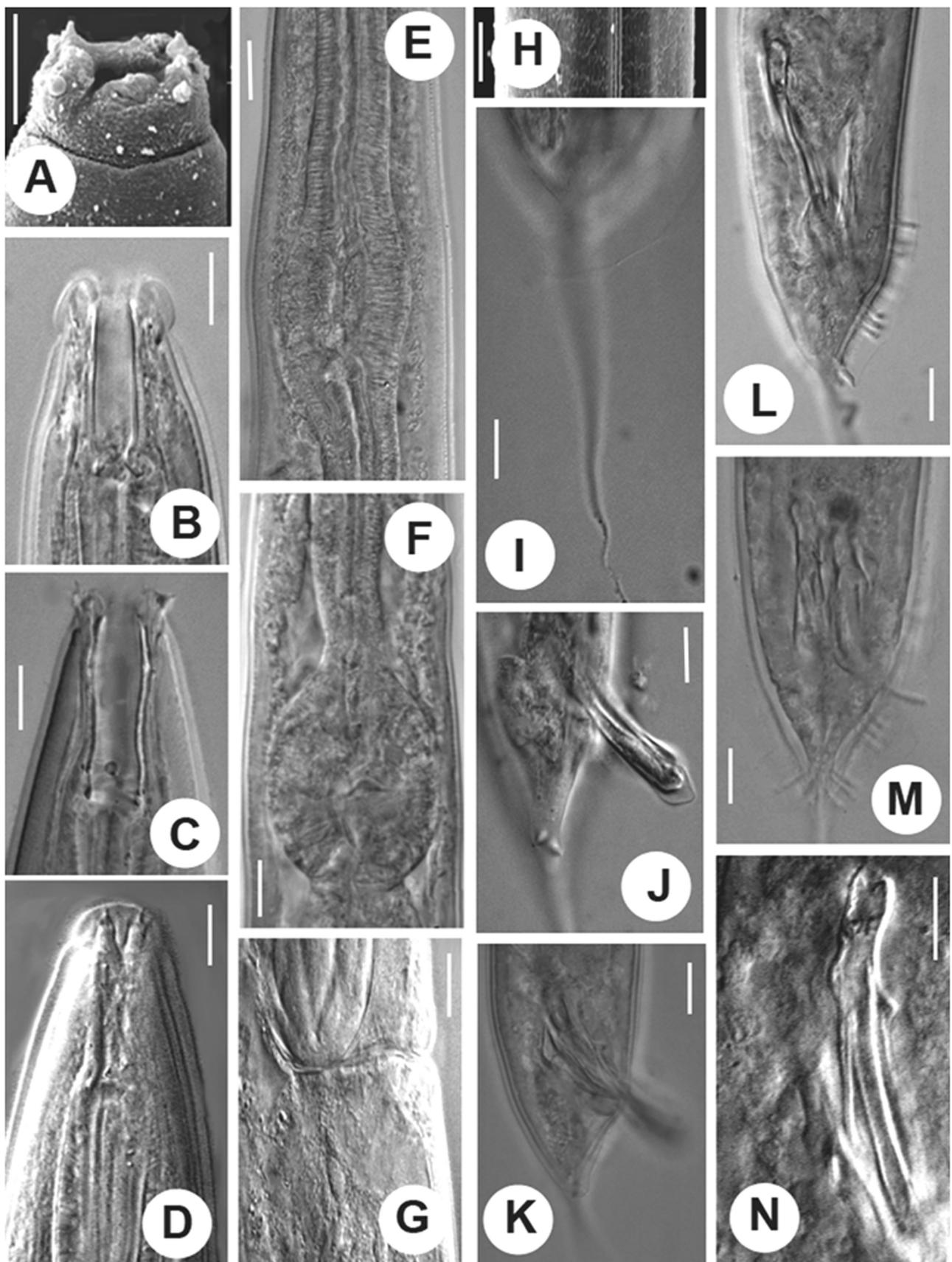
= *Flagicaudoides pawani* Khan, Singh & Baird, 1999 **syn. n.**

### Measurements. Table 1.

**Description. Adult:** Body 0.9–1.2 mm long, slender, almost straight or slightly ventrally curved upon fixation. Cuticle double, about 2.5–3.0 µm thick with fine transverse and longitudinal striations. Lateral fields indistinct. Lip region offset from adjoining body. Lips prominent, globular with smooth margins, amalgamated. Lips provided with inner labial sensilla close to oral aperture; cephalic and outer labial sensilla slightly raised and towards outer border of lips. Amphids small, on lateral lips, not easily discernible under LM. Stoma tubular, 3–4 times longer than



**FIGURE 3.** *Cephaloboides curvicaudatus* (Schneider, 1866) Zullini, 1982. A: Entire female. B: Entire male. C: Female anterior end. D: Female pharyngeal region. E: Female anterior genital branch. F: Female posterior region. G–I: Male posterior region. J: Spicule and gubernaculum.



**FIGURE 4.** *Cephaloboides curvicaudatus* (Schneider, 1866) Zullini, 1982. A: Anterior end (scanning electron microscopy). B–D: Anterior end. E: Anterior pharyngeal region. F: Posterior pharyngeal region. G: Vulval region. H: Body region showing lateral fields. I: Female posterior end. J, K: Male posterior region (lateral). L, M: Male posterior region (ventral). N: Spicule (Scale bars= 10  $\mu$ m).

wide or slightly longer than lip diameter. Cheilostom not cuticularized, with diverging walls. Gymnostom arched, thickly cuticularized about 1/4th of stomal length. Stegostom surrounded by pharyngeal collar, covering more than 50% of stoma. Each metastegostomal swelling bearing a minute wart. Metastegostom isotopic and isomorphic. Pharynx comprising of 127–155  $\mu\text{m}$  long, swollen corpus; 60–88  $\mu\text{m}$  long isthmus and a massive, ovoid, basal bulb of 40–55  $\mu\text{m}$  x 35–53  $\mu\text{m}$  dimension with a grinder and two-chambered hastrulum. Nerve ring encircling isthmus about 68–79% of neck length from anterior end. Secretory-excretory pore slightly posteriorly placed, at 71–85% of pharyngeal length; mostly obscure with indistinct duct. Body at proximal end of pharynx about 2.5–4.0 times wider than lip diameter and that at distal end about 4 times wider. Anterior part of pharynx 1.0–1.3 times longer than the posterior part. Cardia 7–11  $\mu\text{m}$  long, flattened. Intestine granular with wide lumen. Rectum thin-walled, less than anal body diameter long. Rectal glands obscure. Anus a crescent-shaped slit.

**Female:** Reproductive system didelphic, amphidelphic. Ovaries dorsally reflexed; anterior ovary on left side and posterior on right side of intestine. Oocytes at distal end arranged in two rows followed by a single row. Oviduct dilated proximally leading to an elongated spermatheca. Prominent sphincter present at junction of spermatheca and collumella. Latter provided with glandular cells. Uterus with 1–8 eggs of 45–51 x 29–35  $\mu\text{m}$  dimension in late embryonic stages. Some females showed hatched juveniles inside their bodies. Vagina thin-walled, 15–25  $\mu\text{m}$  long, at right angle to longitudinal body axis, supported with muscles. Vaginal lumen with distal folds appearing as internal epiptygma. Vulva a post-equatorial transverse slit, located at 525–680  $\mu\text{m}$  with slightly protruded and fringed lips, often bounded by small vulval flaps. Vulva-anus distance 358–509  $\mu\text{m}$ . Tail cupola-shaped with a long, fine spike, about 4.0–4.5 anal body diameters long. Phasmids opening at beginning of tail spike.

**Male:** Similar to female in general morphology except being smaller in size and more arcuate ventrally. Testis single, ventrally reflexed, at right side of intestine. Reflexed part about 115–193  $\mu\text{m}$  long. Spicules strongly cuticularized, slightly arcuate, with elongate capitula having striated outline. Each spicule cylindroid with a swollen distal end, provided with a narrow dorsal thorn reaching up to its length and a ventral triangular process at 1/3rd of its length. Protruding spicules observed with an extended gelatinous cap; gubernaculum with arcuate conical proximal end and a wide distal end and curving a little around sides. Bursa leptoderan, anteriorly open, weakly developed. Genital papillae nine pairs in 1+2/1+3+2+P configuration with three precloacal and six postcloacal pairs. GP1 subventral close to grouped GP2, GP3; GP4 lateral, protruding outside bursal margin; GP5, GP6, GP7 subventral forming a group; GP8 subdorsal, protruding outside bursal margin; GP9 close to GP8, subventral. Phasmidial ducts smaller and slenderer than genital papillae opening next to GP9. Copulatory muscles well developed with 7–8 paired bands starting at cloacal level.

**Locality and habitat.** Samples containing *Cephaloboides curvicaudatus* were obtained from ditch near Ghana Canal at Keoladeo National Park, Bharatpur, Rajasthan, India at coordinates 27.1593° N, 77.5232° E.

**Voucher specimens.** Nine females and eight males on slide *Cephaloboides curvicaudatus* KNP 15A/ 1–7 deposited in the Nematode Collection of Department of Zoology, Aligarh Muslim University, Aligarh, India.

**Emended diagnosis.** *Cephaloboides curvicaudatus* is characterized by large-sized body; double, finely striated, cuticle with faint longitudinal lines; slightly raised labial papillae; long stoma with a denticle on each metastegostomal plate; long spicate tail of 4.0–4.5 anal body diameter length; long, cylindroid spicules with elongate capitula and swollen distal ends with an extended gelatinous cap; genital papillae in 1+2/1+3+2+P configuration and 7–8 paired bands of copulatory muscles.

**Remarks.** The present population shows conformity to *C. curvicaudatus* in most characteristics except few minor ones: relatively smaller *b* value and presence of strong copulatory muscle bands (*b* = 3.8–4.5 vs 3.4–6.0 and copulatory muscle bands not reported in *C. curvicaudatus*). The present population further differs from *C. curvicaudatus* in having spicules with elongate capitula.

### *Cephaloboides parapapillosus* (Schuurmans Stekhoven, 1951) comb. n.

(Figs. 5, 6)

#### Measurements. Table 1

**Description. Adult:** Body medium-sized, 0.8–0.9 mm, slender, slightly ventrally curved upon fixation, tapering at both extremities, more towards posterior end. Cuticle double, outer smooth, inner faintly striated. Lip

region offset from adjoining body. Lips prominent, globular, elevated, provided with inner labial sensilla close to oral aperture; cephalic and outer labials prominent and towards outer border of lips. Amphids small, pore-like on lateral lips. Stoma tubular, 4.5–6.0 times longer than wide or nearly two times lip diameter. Cheilstom not cuticularized, indistinct; gymnostom thickly cuticularized, about 1/4th–1/5th of stomal length; stegostom about 2/3rd of stomal length, surrounded by pharyngeal tissue. Metastegostom isotopic and isomorphic. Each metastegostomal swelling provided with a spur-like denticle. Pharynx comprising of a cylindroid or weakly swollen, 120–135  $\mu\text{m}$  long corpus, 38–55  $\mu\text{m}$  long isthmus and a well-developed, oblong, rectangular, valvate basal bulb 37–43 x 25–31  $\mu\text{m}$  in size. Nerve ring encircling isthmus at 68–70% of pharyngeal length from anterior end. Secretory-excretory pore inconspicuous, observed slightly posterior to nerve ring in few specimens. Hemizonid prominent. Body 2.5–3.5 and 3.2–4.2 times lip diameters at proximal and distal ends of pharynx, respectively. Pharyngeal corpus about 1.2–1.6 times longer than isthmus and basal bulb together. Cardia flattened, 7–15  $\mu\text{m}$  long, with cuticularized lining, hanging into intestinal lumen. Intestine granular; intestinal cells polygonal with defined nuclei; intestinal lumen narrow with irregular outline. Rectum thin-walled, nearly one anal body diameter long; rectal glands present. Anus a crescent-shaped slit.

**Female:** Reproductive system didelphic, amphidelphic. Ovaries dorsally reflexed, anterior ovary at right side and posterior at left side of intestine. One or two pseudocoelomocytes observed in close proximity with flexures of ovaries. Oocytes in multiple rows at distal end followed by a single row proximally. Oviduct slightly dilated connected with offset, rounded spermatheca filled with sperms. Uterus broad, spacious with usually 1–4 embryonating eggs. Vagina at right angle to longitudinal body axis, thin-walled, 12–15  $\mu\text{m}$  long provided with muscle bands. Vulva a transverse wide slit, located post-equatorially at about 489–580  $\mu\text{m}$  from anterior end; vulval lips protruded, epiptygma present surrounded by vulval flaps. Vulva-anus distance 310–370  $\mu\text{m}$ . Tail short, spicate, narrowing into a whip-like terminus. Phasmidial ducts opening at base of broader part of tail or at beginning of spike.

**Male:** Similar to female in general morphology except being smaller in size and more arcuate posteriorly. Testis monorchic, ventrally reflexed, at right side of intestine, reflexed portion about 85  $\mu\text{m}$  long. Spicules stout, about 1.2–1.4 anal body diameter long, slightly arcuate with rounded to elliptical capitula. A thin dorsal arm almost reaching up to spicular length and a ventral triangular process present. Distal end of spicules rounded not notched with a thin gelatinous cap. Gubernaculum about half anal body diameter long, bifid proximally expanding into a wider middle part that continues distally into heavily sclerotized, slender dorso-lateral arms surrounded by membranous caps at ends. Bursa leptoderan, greatly reduced, not covering the tail spike. Genital papillae nine pairs in 1+2/1+3+2+P configuration with GP1 far ahead of GP2 and GP3 that appear nearly adcloacal. Of the six postcloacal, GP4 ventro-lateral and protruding from bursal edge; GP5, GP6, GP7 grouped together, subventral; GP8 directed subdorsally, close to subventral GP9. Phasmidial ducts narrower and smaller than papillae opening next to GP9. Copulatory muscles well developed with 6–8 paired bands. Tail similar to that of female, short spicate with pointed tip.

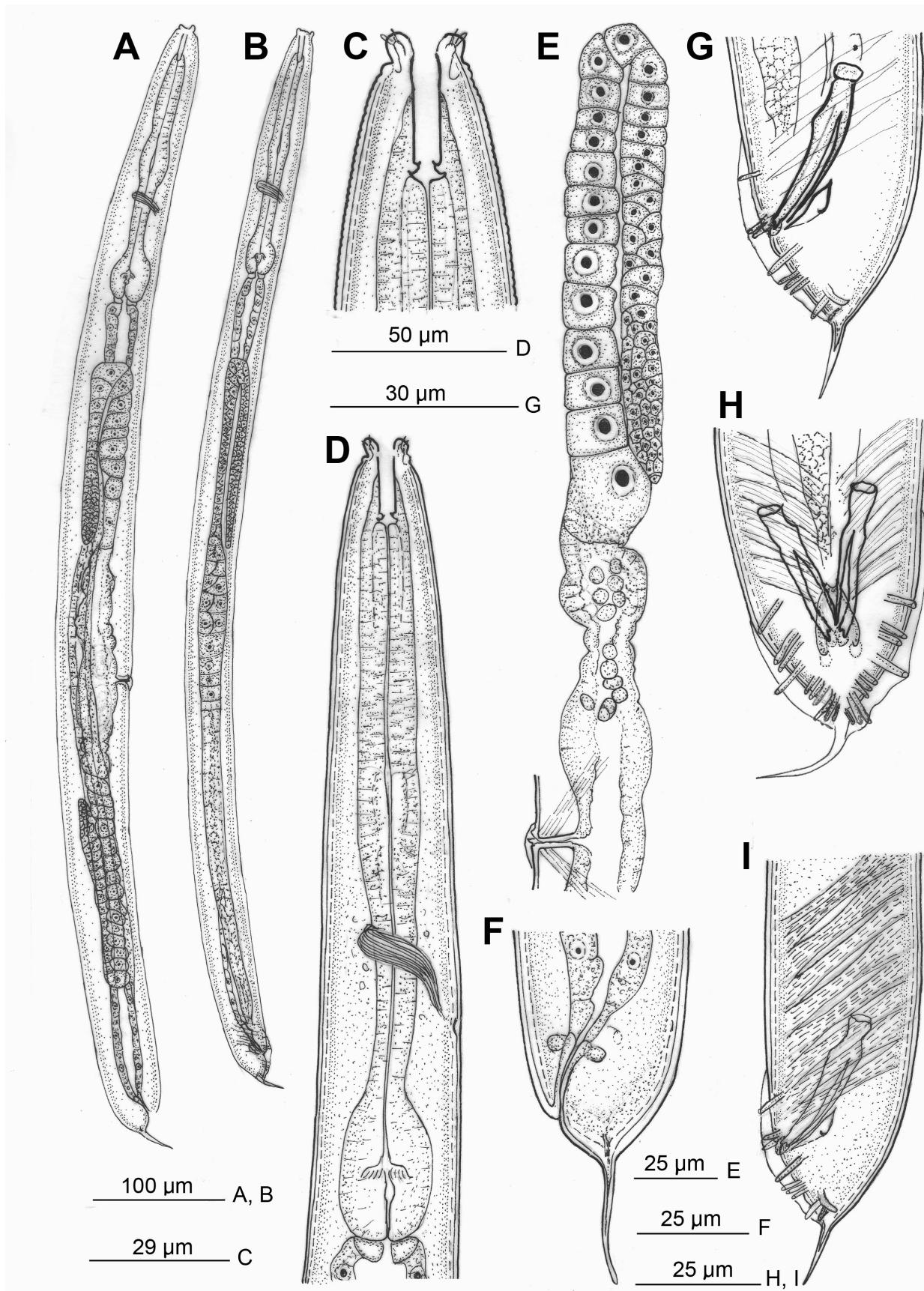
**Locality and habitat.** Samples containing *Cephaloboides parapapillosus* were obtained from a ditch behind a forest lodge in Keoladeo National Park, Bharatpur, Rajasthan, India at coordinates 27.1593° N, 77.5232° E.

**Voucher specimens.** Fourteen females and three males on slide *Cephaloboides parapapillosus* KNP 2B/ 1–7 deposited in Nematode Collection, Department of Zoology, Aligarh Muslim University, Aligarh, India.

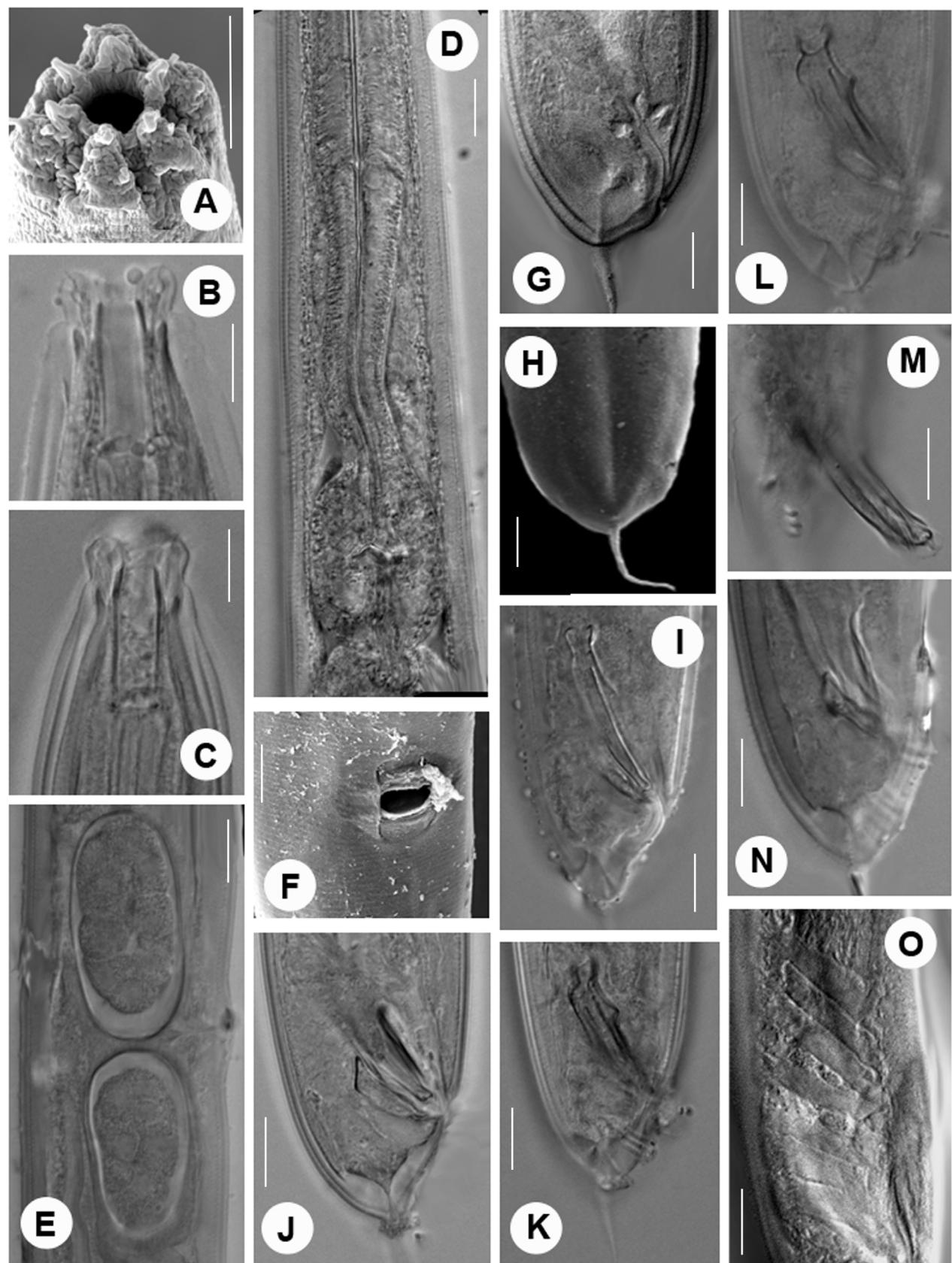
**Emended diagnosis.** *C. parapapillosus* is characterized by a medium-sized body; finely annulated cuticle; prominently raised labial sensilla; small stoma; slightly protruded vulval lips with flaps, epiptygma; males with spicules having rounded to elliptical capitula, dorsal thorn and distinct ventral conoid process, capped distal ends and genital papillae in configuration of 1+2/1+3+2+P with GP1 very distant from GP2 and GP3.

*C. parapapillosus* can be differentiated from the present population of *C. curvicaudatus* in having smaller *c'* value (0.9–1.5 vs 2.2–4.2); prominent globular, distinctly separated lips (vs lips fused at bases); relatively smaller stoma (22–27  $\mu\text{m}$  vs 27–32  $\mu\text{m}$  long), shorter spicules (30–35  $\mu\text{m}$  vs 42–53  $\mu\text{m}$  long) with round to elliptical capitula (vs with elongate capitula) and GP1 distant from the other precloacal pairs (vs GP1 closer to GP2 and GP3).

*C. parapapillosus* can be further differentiated from *C. musicola* Rahm, 1928 in having relatively smaller *c'* value (0.9–1.5 vs 1.5–2.0); relatively larger *c* value (29.7–41.3 vs 17.0–36.0); smaller stoma (22–27  $\mu\text{m}$  vs 33–38  $\mu\text{m}$  long), shorter spicules (30–35  $\mu\text{m}$  vs 42–81  $\mu\text{m}$  long) with round to elliptical capitula (vs hood-shaped capitula); proximally obtuse (vs proximally narrow and acute) gubernaculum and anterior genital papillae relatively more distant from the other precloacal pairs.



**FIGURE 5.** *Cephaloboides parapapillosus* (Schuurmans Stekhoven, 1951) comb. n. A: Entire female. B: Entire male. C: Female anterior end. D: Female pharyngeal region. E: Female anterior genital branch. F: Female posterior region. G, I: Male posterior region (lateral). H: Male posterior region (ventral).



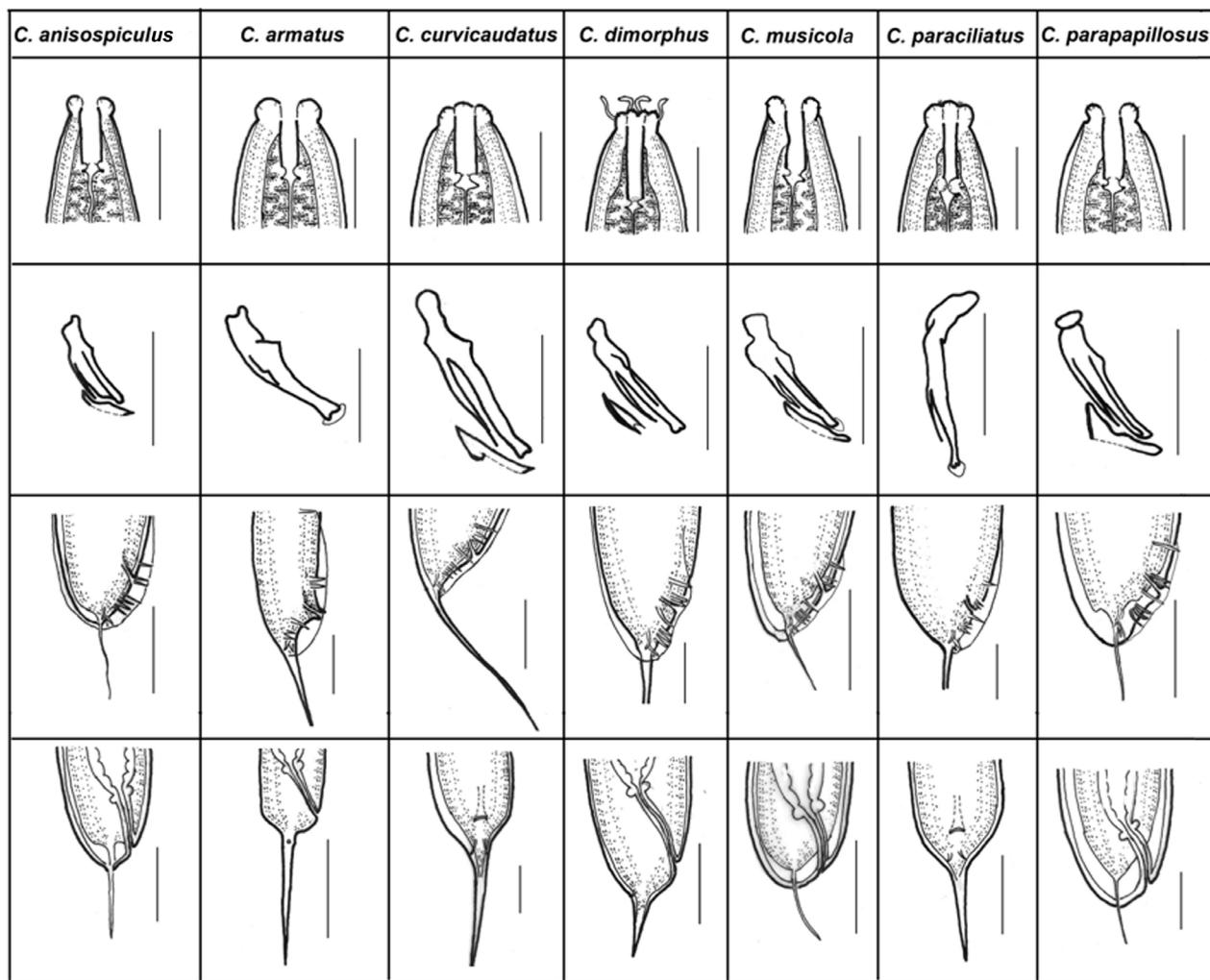
**FIGURE 6.** *Cephaloboides parapapillosus* (Schuurmans Stekhoven, 1951) comb. n. A: *En face* view (scanning electron microscopy). B, C: Anterior end. D: Posterior pharyngeal region. E: Uterine region. F: Vulval region (scanning electron microscopy). G: Female posterior region. H: Female posterior region (scanning electron microscopy). I–O: Male posterior region (Scale bars= 10  $\mu$ m).

*C. parapilosus* differs from *C. anisospiculus* sp. n. in having larger body (0.8–0.9 mm vs 0.5–0.7 mm); greater *b* (3.8–4.8 vs 2.7–3.6) and *c* (29.7–41.3 vs 15.4–22.7) values; relatively longer stoma (22–27  $\mu\text{m}$  vs 20–24  $\mu\text{m}$ ) and males with larger (30–35  $\mu\text{m}$  vs 19–29  $\mu\text{m}$ ), similar and equal (vs dissimilar and unequal spicules in *C. anisospiculus* sp. n.).

### On the taxonomy of the genus

The genus *Cephaloboides* (Fig. 7, Table 2) is a gonochoristic genus with species reported from diverse habitats. Despite its cosmopolitan status, some elements of habitat specificity have been observed in the species of *Cephaloboides*. *C. armatus*, *C. paraciliatus* and *C. dimorphus* have been reported from chicory tree roots, rotten oil palm and burnt, mouldy sycamore tree, respectively. *C. curvicaudatus* is perhaps the most cosmopolitan and versatile, having been reported from organic matter, compost and dung but predominantly from aquatic habitats, including sewage sludge. *C. musicola* has been reported from roots of banana and to some extent from manure and compost.

*Cephaloboides* species are largely ovoviparous and developing juveniles can often be seen in the uterus. Individuals possess a double cuticle and in place of regular moulting, imperfect ecdysis has been reported with retention of the old cuticle after the last molt (Sudhaus, 1977). This apomorphic character is also shared by a few species of *Diploscapteroides* Rahm, 1928 and *Rhabditis* Dujardin, 1844 (Sudhaus, 1977). Kiontke (1999b) reported instances of embryonating eggs being trapped between the two cuticles of the female.



**FIGURE 7.** Comparison of stoma, spicule, male tail and female tail of species of *Cephaloboides* Rahm, 1928. (Scale bar = 25  $\mu\text{m}$ )

TABLE 2. Differentiating characters for the species of *Cephaloboides* Rahm, 1928

Characters	<i>C. anisospiculatus</i> sp. n.	<i>C. armatus</i>	<i>C. curvicaudatus</i>	<i>C. dimorphus</i>	<i>C. musicola</i>	<i>C. paraciliatus</i>	<i>C. parapapillatus</i>
Female body length	0.5–0.7	1.03	0.6–1.8	0.8–0.9	0.9–1.9	0.7–0.9	0.8–1.4
a	13.6–20.0	16–18	13.6–24.0	13–22	13–21	18–19	15.1–20.8
b	2.7–3.6	5–6	3.4–6.0	3.7–4.6	3.5–5.0	4–5	3.8–6.8
c	15.4–22.7	21	11.2–22.0	26–30	17–36	16–19	29.7–51.5
c'	1.0–1.8	2.5–3.5	2.0–4.2	1.5–2.0	1.5–2.0	~2.2	0.5–1.8
V	51.2–60.9	–	50.5–68.2	61–64	56–60	55–57	56.5–60.1
Stoma length	20–24	–	19–32	28–34	33–38	23–25	20–27
Egg dimension	37–42×20–24	–	45.51×25–35	–	36×23	–	39–45×18–26
Male body length	0.4–0.5	0.93	0.6–1.6	0.6–1.1	0.8–1.6	0.6–0.8	0.8–0.9
a	15.9–22.0	16–20	15–25	15–23	13–16	15–17	14.6–24.6
b	2.7–4.2	5–6	3.3–6.0	3.8–5.0	3.8–5.5	3.6–5.2	4.0–4.5
c	17.7–28.2	16	8.2–20.0	20–28	13–21	12–14	20.7–35.7
c'	1.0–1.4	2–3	2.2–3.5	1.3–2.0	1.8–2.5	~2.1	0.5–1.4
Stoma length	19–22	–	19–29	28–34	38	23–25	22–27
Spicule length	19–29	39–45	30–54	32–37	42–81	39–41	26–35
Shape of capitulum of spicule	Bilobed/ hood -shaped	Rectangular	Rectangular/ elongate	Rectangular	Hood-shaped capitulum	Hammer-shaped	Rounded/ elliptical
Ventral triangular process of spicule	Moderate	Strong	Moderate	Weak	Moderate	Absent	Moderate
Dorsal shoulder of spicule	Weakly differentiated	Not differentiated	Moderately differentiated	Weakly differentiated	Rounded conspicuous	Weakly differentiated	Weak to moderately differentiated
Dorsal spine of spicule	Long	Absent	Long	Long	Short	Long	Long
Gubernaculum length	10–15	25	12–22	15–21	23	20	10–15
Position of GP1 from GP2 and GP3	Moderately close	Very far, outside bursa	Very close	Moderately close	Moderately close	Moderately close	Quite far
Position of GP4 with trio GP5, GP6 and GP7	Forms a group	Moderately	Quite far	Moderately close	Moderately close	Moderately close	Slightly far

~ denotes the approximate value calculated from original illustration.

*Cephaloboides*, as described by Rahm (1928), showed inwardly bent dorsal stomal wall giving the impression of a tooth. However, the incurved dorsal wall is not uniformly found in all species of *Cephaloboides*. Andrassy (1983), in view of this disparity, considered *Curviditis* Dougherty, 1953 and *Cephaloboides* Rahm, 1928 as valid genera. *Curviditis* was characterized by presence of parallel, straight stomal walls and isoglottoid metastegostom whereas *Cephaloboides* was considered to have a tooth bearing dorsal wall of stoma and an anisoglottoid metastegostom. This inner bulge of the dorsal wall in some members could have presumably led to an anisotopic metastegostom. Sudhaus & Fitch (2001) and Sudhaus (2011) did not consider the collapsible stoma to be of generic importance and rather emphasized on other diagnostic characters to finally treat *Curviditis* as a junior synonym of *Cephaloboides*. Sudhaus diagnosed the latter genus on the basis of gonochoristic individuals with double cuticle, cupola-shaped tail, distinctly offset lip region, metastegostom with fine warts, basal pharyngeal bulb with double hastrulum, male with spicules having dorsal thorn and distal gelatinous cap; leptoderan, reduced bursa with three precloacal and six postcloacal papillae. The presence of a hyaline cap over the distal end of spicules of these congeners seems to be an important character. Schneider's (1866) description of *C. curvicaudatus* mentioned the spicules as having stumpy distal ends with attached slimy/mucosal drops. A similar type of structure has also been reported in *Rhabditella typhae* by Kiontke (1999a) as a thin cuticular/velar extension.

Since the time of its inception, several species have been added to the genus. Due to the large amount of variability and absence of detailed descriptions highlighting subtle diagnostic features, there has been significant overlap of characters between the proposed species. We attempted to identify the salient features of the species of *Cephaloboides* that have value in their differentiation. Of the six species, *C. armatus*, *C. paraciliatus* and *C. dimorphus* stand out due to their unique features. *C. armatus* presents conspicuously angular spicules without dorsal thorn and a different configuration of the genital papillae, with GP1 lying outside the bursal limits. Such an arrangement of papillae is also found in *Rhabditella arizonae* Kiontke, 1999, the species of a closely related genus. In *C. paraciliatus*, besides the presence of tufts of small setae in the labial grooves, the spicules are unique with an elongated hammer-like capitulum and appear cylindroid with a thin dorsal spine and no ventral conoid process. Synapomorphies in the presence of setae and cupola-shaped tail are observed with the sister genus *Choriorhabditis* Osche, 1952. *C. dimorphus* happens to be the only species of *Cephaloboides* demonstrating sexual dimorphism in lip region. The females possess longer labial tentacles compared to males and the spicules are cylindroid with rectangular capitula, dorsal spine, small ventral process and a gelatinous cap at their distal ends.

Sudhaus (2011) synonymised *Rhabditis musicola brevicauda* Rahm, 1929, *R. pseudoxyicerca* Goodey, 1929, *R. parapapillosa* Schuurmans Stekhoven, 1951 and *Odontorhabditis musicola* Timm, 1959 with *C. musicola* described by Rahm (1928). It is a fact that *C. musicola* per se seems to represent a very wide range of values in most morphometric characters. This happens when the taxon in question is either universally distributed in all types of habitats or there are several closely related taxa merged together. We consider the present condition to have arisen due to placement of largely variable *R. papillosa* and *O. musicola* under the banner of *C. musicola*, thus making the latter a taxon with enormous variability.

On a closer examination, the species *C. pawani* closely resembles *O. musicola* in morphometrics and also in having been collected from similar hosts (banana trees). The only difference was observed in the length of spicules which were relatively larger in *O. musicola*. However, both markedly differ from the originally described *R. (C.) musicola* in having smaller stoma and smaller spicules and relatively smaller *c* and greater *c'* values. The present population of *C. curvicaudatus* shows a striking resemblance (Fig. 4) with both species hence after a detailed comparison of the lip region, shape and size of stoma and basal bulb, tail type and spicule morphology, we consider the two species the junior synonyms of *C. curvicaudatus* and not of *C. musicola*.

Likewise, *Rhabditis parapapillosa* (including the present population) in view of its very small spicules and stoma, does not seem to fit in the originally described *R. (C.) musicola*. The very high *c* value (51.5) of the original specimen also seems to argue against its placement in *R. (C.) musicola*. Furthermore, the relatively broad and thick-walled stoma of *R. parapapillosa* as illustrated by Schuurmans Stekhoven (1951) also looks different from that of *C. musicola* (*apud* Goodey, 1929; *apud* Osche, 1952). On critical evaluation of the specimens of *C. parapapillosa* collected from Keoladeo National Park, we noticed certain morphometric differences from *C. musicola* which, on merger of these taxa, would have increased the range of values in the species enormously. Although the spicules in the original illustration by Schuurmans Stekhoven (1951) are largely missing the key structural details, noticeable differences were found in the size of stoma (20–27 µm vs 33–38 µm), spicules (26–35 µm vs 42–81 µm) and structure of spicules and gubernaculum. In view of these differences, we now reinstate *R. parapapillosa* Schuurmans Stekhoven, 1951 as *C. parapapillosus* (Schuurmans Stekhoven, 1951) **comb. n.**

## References

- Andrássy, I. (1983) *A taxonomic review of the suborder Rhabditina (Nematoda: Secernentea)*. Orstom, Paris, 241 pp.
- Andrássy, I. (2005) *Free-living nematodes of Hungary (Nematoda errantia)*. *Pedozoologica Hungarica*. No. 3. Hungarian Natural History Museum, Budapest, 518 pp.
- Baermann, G. (1917) Eine einfache Methode zur Auffindung von *Ankylostomum* (Nematoden) Larven in Erdproben. *Geneeskundig Tijdschrift voor Nederlandsch-Indië*, 57, 131–137.
- Claus, C.F.W. (1862) Über einige im Humus lebende Anguillulinen. *Zeitschrift für wissenschaftliche Zoologie*, 12, 354–359.
- Cobb, N.A. (1918) Estimating the nema population of the soil. U.S. Department of Agriculture. *Agricultural Technical Circular of US Department of Agriculture*, 1, 1–48.
- Ditlevsen, H. (1971) Land and freshwater nematodes. In: Spärck, R. & Tuxen, S.L. (Eds.), *Zoology of the Faroes*, 1971, pp. 1–28.
- Dougherty, E.C. (1953) The genera of the subfamily Rhabditinae Micoletzky, 1922 (Nematoda). *Thaper Commemoration*, 1953, 69–76.
- Dougherty, E.C. (1955) The genera and species of the subfamily Rhabditinae Micoletzky, 1922 (Nematoda): a nomenclatorial analysis—including an addendum on the composition of the family Rhabditidae Örley, 1880. *Journal of Helminthology*, 29, 105–152.
- Dujardin, F. (1844) *Histoire naturelle des helminthes ou vers intestinaux*. Librairie Encyclopédique de Roret, Paris, 654 pp.
- Fuchs, G. (1931) Einige neue *Rhabditis*-Arten. *Zoologische Jahrbücher (Systematik)*, 62, 119–148.
- Goodey, T. (1929) On some new and little-known free-living nematodes. *Journal of Helminthology*, 7, 27–62.  
<https://doi.org/10.1017/S0022149X0001871X>
- Goodey, T. (1943) On *Rhabditis curvicaudata* (Schneider) and *R. paraciliata* n. sp. *Journal of Helminthology*, 21, 10–17.  
<https://doi.org/10.1017/S0022149X00031837>
- Hofmänner, B. (1913) Contribution à l'étude des nematodes libres du Lac Léman. *Revue Suisse de Zoologie*, 21, 589–658.  
<https://doi.org/10.5962/bhl.part.82534>
- Khan, E., Singh, M. & Baird, S. (1999) Studies on the rhabditids of India: Descriptions of *Flagicaudoides* gen. n. and two new species of *Cuticularia* (Nematoda: Rhabditida). *International Journal of Nematology*, 9, 196–202.
- Kiontke, K. (1999a) The *Rhabditis* (*Rhabditella*) *octopleura* species complex and descriptions of three new species. *Russian Journal of Nematology*, 7, 71–94.
- Kiontke, K. (1999b) *The nematode fauna of rotting cactus and phasmids in male Secernentea*. Ph.D. Dissertation, Free University, Berlin, 264 pp.
- Örley, L. (1880) Az Anguillulidák magánrajza. *Természettájzi Füzetek* (Budapest), 4, 16–150. [in Hungarian]
- Osche, G. (1952) Systematik und Phylogenie der Gattung *Rhabditis* (Nematoda). *Zoologische Jahrbücher (Systematik)*, 81, 190–280.
- Rahm, G. (1928) Alguns nematodes parasitas e semi-parasitas das plantas culturais do Brasil. *Archivos do Instituto Biológico de Defesa Agrícola e Animal* (São Paulo), 1, 239–251.
- Rahm, G. (1929) Nematodes parasitas e semi-parasitas de diversas plantas culturais do Brasil. *Archivos do Instituto Biológico de Defesa Agrícola e Animal* (São Paulo), 2, 67–136.
- Schneider, A.F. (1866) *Monographie der Nematoden*. Georg Reimer, Berlin, 357 pp.
- Schneider, W. (1923) Niederrheinische freilebende Nematoden. *Zoologischer Anzeiger*, 56, 264–281.
- Schuurmans Stekhoven, J.H. (1951) Nématodes saprozoaires et libres du Congo Belge. *Mémoires de l'Institut Royal des Sciences Naturelles de Belgique*, Série 2, 39, 3–79.
- Seinhorst, W. (1959) A rapid method for the transfer of nematodes from fixative to anhydrous glycerin. *Nematologica*, 4, 67–69.  
<https://doi.org/10.1163/187529259X00381>
- Skrjabin, K.I., Shikhobalova, N.P., Sobolev, A., Paramonov, A.A. & Sudarikov, V.E. (1954) *Camallanata*, *Rhabditata*, *Tylenchata*, *Trichocephalata* and *Dioctophymata* and the distribution of parasitic nematodes by their hosts. *Izdatelstvo Akademii Nauk SSSR (Moskva)*, 4, 1–927.
- Stefánski, W. (1916) Die freilebenden Nematoden des Inn, ihre Verbreitung und Systematik. *Zoologischer Anzeiger*, 46, 363–385.
- Sudhaus, W. (1976) Vergleichende Untersuchungen zur Phylogenie, Systematik, Ökologie, Biologie und Ethologie der Rhabditidae (Nematoda). *Zoologica*, 43, 1–229.
- Sudhaus, W. (1977) *Rhabditis dimorpha*: Ein Beispiel für unvollständige Häutung und Sexualdimorphismus bei Nematoden. *Zoologischer Anzeiger*, 199, 325–352.
- Sudhaus, W. (2011) Phylogenetic systematisation and catalogue of paraphyletic “Rhabditidae” (Secernentea, Nematoda). *Journal of Nematode Morphology and Systematics*, 14, 113–178.
- Sudhaus, W. & Fitch, D. (2001) Comparative studies on the phylogeny and systematics of the Rhabditidae (Nematoda). *Journal of Nematology*, 33, 1–70.
- Timm, R.W. (1959) *Cheilarhabditis* and *Odontorhabditis*, two new genera of soil nematodes allied to *Rhabditis*. *Nematologica*, 4, 198–204.  
<https://doi.org/10.1163/187529259X00219>
- Zullini, A. (1982) Nematodi (Nematoda) *Guide per il riconoscimento delle specie animali delle acque interne Italiane*, 17, 1–117.