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**Research article**

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**Six new and four known species of the genus *Axonchium* Cobb, 1920  
(Nematoda: Dorylaimida: Belondiroidea)  
from the Western Ghats of India**

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**Abstract.** Six new and four known species of the genus *Axonchium* Cobb, 1920 are described and illustrated from the Western Ghats of India. *Axonchium indicum* sp. nov. has a 1.2–1.4 mm long body, offset lip region, 8–9 µm long odontostyle, expanded part of pharynx 39–49 % of total neck length, anterior uterine sac 0.9–1.6 times the mid-body diameter long, and a bluntly conoid tail. *Axonchium microspiculum* sp. nov. has a 1.1–1.22 mm long body, offset lip region, 7–8 µm long odontostyle, 20–23 µm long spicules, two weakly developed ventromedian supplements, and obtusely rounded tail. *Axonchium nilgiriense* sp. nov. has a 1.4–1.6 mm long body, offset lip region, 8–9 µm long odontostyle, vagina strongly bent posteriad, 37–41 µm long spicules, 3–4 ventromedian supplements, and bluntly conoid tail. *Axonchium paracingulatum* sp. nov. has a 2.5–2.8 mm long body, offset lip region, 10–11 µm long odontostyle, vaginal lumen highly expanded in the middle, 69 µm long spicules, and broadly conoid tail with rounded terminus. *Axonchium tropicum* sp. nov. has a 1.7–2.0 mm long body, offset lip region, 11–12 µm long odontostyle, anterior uterine sac 2.3–4.0 times the mid-body diameter long, 40 µm long spicules, 4 widely spaced ventromedian supplements, and broadly rounded tail. *Axonchium unicum* sp. nov. has a 1.7–2.0 mm long body, offset lip region, 10–11 µm long odontostyle, anterior uterine sac 2.5–2.8 times mid-body diameter long, 68 µm long and slender spicules, and broadly conoid tail. *Axonchium nitidum*, *A. saccatum*, *A. transkeiense* and *A. vallum* are redescribed based on specimens collected from several localities. A diagnostic key to the identification of the valid species of this genus is provided.

**Keywords.** Kerala, nematode, biodiversity hotspot, description, new species.

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## Introduction

The Western Ghats of India is one of the 36 global biodiversity hotspots (Mittermeier *et al.* 2004; Kobayashi *et al.* 2019) which supports an enormous biodiversity of flora and fauna. Several species of soil-inhabiting nematodes have been described from this region (Ahmad & Jairajpuri 1982, 1983, 1984, 1986, 1988; Jairajpuri & Ahmad 1982; Ahmad & Ahmad 1992, 2002; Ahmad 1993); however, the diversity and distribution of the dorylaimid nematode genus *Axonchium* Cobb, 1920 representing the superfamily Belonidiroidea Thorne, 1939 has not been thoroughly investigated in this region. Only eight species, viz, *A. saccatum* Jairajpuri, 1964; *A. elegans* Jairajpuri, 1964; *A. heynsi* Nair, 1973; *A. shamimi* Baqri & Khera, 1976; *A. vallum* Ahmad & Jairajpuri, 1982; *A. camelliae* Dhanam & Jairajpuri, 1998; *A. cooverkolli* Dhanam & Jairajpuri, 1998; *A. hosakodii* Dhanam & Jairajpuri, 1998 have been recorded so far from this region (Jairajpuri 1964; Ahmad & Jairajpuri 1982; Dhanam & Jairajpuri 1998). The genus *Axonchium* is a widespread dorylaimoid nematode, reported from all continents except Antarctica and at present represented by 38 valid species.

During the course of the present study, we collected several populations representing this genus from different habitats covering a large area of Western Ghats. On detailed study these populations were found to represent ten species, six of which are new to science. All ten species are described and illustrated in the following. A diagnostic key to species of the genus is also provided.

## Material and methods

Soil samples were collected from around the roots of grasses, crop plants and forest trees in different localities of the Western Ghats of India. Nematodes were extracted from the soil samples by using Cobb's (1918) sieving and decantation and modified Bearman's funnel technique. Extracted nematodes were killed and fixed in hot 4% TAF (Courtney *et al.* 1955) and dehydrated by slow evaporation in desiccators containing desiccant and mounted in anhydrous glycerin on glass slides (Seinhorst 1959). Measurements of the mounted specimens were taken by using an ocular micrometer fitted in the microscope and all the line illustrations were made using a drawing tube attached to an Olympus BX 51 microscope. Photographs were taken with a digital camera attached to a "Nikon Eclipse 80i" microscope. Raw photographs of the specimens were edited using Adobe Photoshop ver. 7.0 software. Spicule morphometrics were taken as per Peña-Santiago *et al.* (2014). The formula given by Loof & Coomans (1970) was followed for the measurements of the position of pharyngeal glands and their nuclei.

Type material and others specimens are deposited in the nematode collection of the Department of Zoology, Aligarh Muslim University, India (AMU/ZD/NC), as well as in the nematode collection of the Zoological Survey of India, Kolkata, India.

### Abbreviations used in the text

- a = Body length/greatest body diameter
- b = Body length/neck length
- c = Body length/tail length
- c' = Tail length/body diameter at anus or cloaca
- DO = Orifice of dorsal pharyngeal gland nucleus from anterior end (100/total neck length)
- DN = Position of dorsal pharyngeal gland nucleus from anterior end (100/total neck length)
- G1 = Length of anterior genital branch (100/body length)
- G2 = Length of posterior genital branch (100/body length)
- n = Number of specimens
- L = Total body length
- V = Distance of vulva from anterior end (100/body length)

## Results

Phylum Nematoda Cobb, 1932  
Class Dorylaimea Hodda, 2007  
Subclass Dorylaimia Inglis, 1983  
Order Dorylaimida Pearse, 1942  
Suborder Dorylaimina Chitwood, 1933  
Superfamily Belondiroidea Thorne, 1939  
Family Belondiridae Thorne, 1939  
Subfamily Axonchiinae Thorne, 1964  
Genus *Axonchium* Cobb, 1920

*Axonchium nitidum* Jairajpuri, 1964

Fig. 1, Table 1

*Axonchium nitidum* Jairajpuri, 1964: 178–179.

*Axonchium nitidum* – Hechler 1969: 346. — Nair 1973: 529–532. — Dhanachand *et al.* 1982: 118–119.

### Material examined

INDIA • 6 ♀♀; Kerala State, Palakkad District, Mukkali; 11°3'33" N, 76°32'25" E; 5–20 cm depth; 25 Oct. 2017; soil samples collected around the roots of grasses (unidentified); slide reference number AMU/ZD/NC/*Axonchium nitidum*/1–5.

### Description

#### Female

Body curved ventrad upon fixation, 1.3–1.5 mm long. Cuticle with fine transverse striations, about 1 µm thick at anterior region, 1–2 µm at mid-body and 4–6 µm on tail tip. Lateral chords 3–4 µm wide, about one-eighth to one-seventh (12–15%) of mid-body diameter. Lateral, dorsal and ventral body pores indistinct. Lip region offset by deep constriction, 1.7–2.7 times as wide as high, or about ¼ to ⅓ (26–31%) of body diameter at neck base. Lips bluntly conoid and incompletely separate. Amphids fovea stirrup-shaped, their aperture occupying about 0.6–0.8 times the lip region diameter, fusus slightly posterior to odontophore level. Guiding ring single, at 0.7–1.0 times lip region diameter from anterior end. Odontostyle fusiform, 4–5 times as long as wide, or 1.0–1.1 times lip region diameter long, its aperture occupying about ⅓ of its length. Odontophore simple, rod-like, 1.2–1.4 times as long as odontostyle. Nerve ring encircling anterior slender part of pharynx at 20–21% of neck length from anterior end. Anterior slender part of pharynx quite muscular, separated from the posterior expanded part by a deep constriction. Expanded part of pharynx 16–26 times as long as wide, or 10.5–14.3 times longer than body diameter at neck base, and occupying about ⅔ to ⅘ (58–65%) of total neck length, enclosed in a thick muscular sheath with straight bands. Only dorsal pharyngeal gland and its orifice visible: DO = 41.4–44.1; DN = 42.3–45.1; DO–DN = 0.8–1.0. Cardia oblong, 1.0–2.2 times as long as wide, occupying about ¼ to ½ (23–50%) of corresponding body diameter.

Genital system mono-opisthodelphic. Anterior genital branch represented by a small sac, measuring 13–23 µm or 0.5–0.9 times mid-body diameter long. Posterior branch well developed; ovary reflexed, not reaching oviduct-uterus junction, measuring 31–75 µm long with squamous shaped oocytes arranged in a single row except near tip, oviduct joining ovary subterminally, measuring 41–63 µm or 1.6–2.3 times mid-body diameter long, consisting of a long slender part with prismatic cells and a well developed pars dilatata with distinct lumen; oviduct-uterus junction marked by sphincter; uterus 42–50 µm or 1.5–1.9 times mid-body diameter long, differentiated into a large proximal region with wide lumen, a narrow slightly convoluted intermediate region, and a short spherical pars dilatata with distinct lumen. Vulva

transverse. Vagina bent posteriad, extending inwards about  $\frac{3}{5}$  to less than  $\frac{3}{4}$  (57–70%) of corresponding body diameter, vaginal walls not differentiated from body cuticle; pars proximalis vaginae 7–9 × 3–4 μm; pars refringens vaginae absent; pars distalis vaginae 7–10 μm long. Prerectum 6.2–9.7 and rectum 1.3–1.6 times anal body diameter long. Tail short, broadly conoid with rounded terminus. Caudal pores two on each side.



**Fig. 1.** *Axonchium nitidum* Jairajpuri, 1964 (LM photographs). **A.** Anterior region. **B.** Anterior end showing amphid. **C.** Junction between two parts of pharynx. **D.** Cardia. **E–F.** Female vulva and vagina. **G.** Female genital branch. **H.** Female posterior region. Scale bars: A–F, H = 10 μm; G = 20 μm.

**Table 1.** Measurements of *Axonchium nitidum* Jairajpuri, 1964. All measurements in  $\mu\text{m}$ , except L in mm, and in the form: mean  $\pm$  s.d. (range).

Characters	Females
n	6
L	1.4 $\pm$ 0.1 (1.3–1.5)
a	53 $\pm$ 1.8 (51–56)
b	2.6 $\pm$ 0.1 (2.4–2.8)
c	62.4 $\pm$ 2.9 (58–67)
c'	1.2 $\pm$ 0.1(1.1–1.3)
V	54.4 $\pm$ 1.4 (52.5–56.2)
G1	1.2 $\pm$ 0.3 (0.9–1.7)
G2	8.5 $\pm$ 1.1 (6.6–10.2)
Body diam. at pharynx base	26.6 $\pm$ 1.6 (25–30)
Body diam. at mid-body	26.5 $\pm$ 1.4 (25–29)
Body diam. at anus/cloaca	18.8 $\pm$ 0.7 (18–20)
Lip region diam.	7.3 $\pm$ 0.5 (7–8)
Lip region height	3.5 $\pm$ 0.5 (3–4)
Amphid aperture	5.2 $\pm$ 0.4 (5–6)
Odontostyle length	8
Odontophore length	10.3 $\pm$ 0.5 (10–11)
Guiding ring from ant. end	6.7 $\pm$ 0.5 (6–7)
Nerve ring from ant. end	108 $\pm$ 1.9 (105–110)
Neck length	530.3 $\pm$ 20.9 (503–569)
Expanded part of pharynx	318 $\pm$ 25 (292–371)
Cardia length	9.8 $\pm$ 2.1 (6–13)
Anterior genital branch	17.5 $\pm$ 3.5 (13–23)
Posterior genital branch	119.8 $\pm$ 18.3 (93–151)
Vaginal depth	16.6 $\pm$ 0.9 (15–18)
Vulva from ant. end	763.1 $\pm$ 35.3 (723–823)
Prerectum length	145.6 $\pm$ 21.3 (118–175)
Rectum length	27.2 $\pm$ 2.0 (24–29)
Tail length	22.5 $\pm$ 0.5 (22–23)
Spicule length	–
Lateral guiding pieces	–
Ventromedian supplements	–

**Male**

Not found.

**Remarks**

Jairajpuri (1964) described this species from Jorhat, Assam, India based on females only, and differentiated it from *A. bulbosum* Williams, 1958 mainly in having ventral body posture, a longer prerectum and the shape and size of tail. Hechler (1969) synonymized *A. nitidum* with *A. bulbosum*

Williams, 1958, and mentioned that body posture and prerectum sizes may vary in the same species; hence, it can not be considered a separate species only on bases of these characters. Later, Nair (1973) re-studied the type material of both species, and revalidated *A. nitidum*. Dhanachand *et al.* (1982) for the first time reported a male of this species from Manipur, India. The present population conforms well with the original description except in having a slightly shorter odontostyle (8.0 vs 8.5–10  $\mu\text{m}$ ), longer vagina (57–70 vs 50% of corresponding body diameter), longer rectum (1.3–1.6 vs less than one anal body width) and from the Manipur population in a having comparatively longer and more slender body ( $L = 1.3\text{--}1.5$  vs  $1.32\text{--}1.34$  mm,  $a = 51\text{--}56$  vs  $42\text{--}45$ ), shorter tail ( $c = 58\text{--}67$  vs  $55\text{--}58$ ), and the absence of males (vs male present with 21  $\mu\text{m}$  long spicules).

*Axonchium saccatum* Jairajpuri, 1964

Fig. 2, Table 2

*Axonchium saccatum* Jairajpuri, 1964: 179.

*Axonchium saccatum* – Hechler 1969: 346. — Nair 1973: 535–540.

**Material examined**

INDIA • 5 ♀♀, 2 ♂♂; Kerala State, Palakkad District, Mukkali; 11°3'33" N, 76°32'25" E; 10–15 cm depth; 25 Oct. 2017; soil samples collected around the roots of grasses (unidentified); slide reference number AMU/ZD/NC/*Axonchium saccatum*/1–5.

**Description**

**Female**

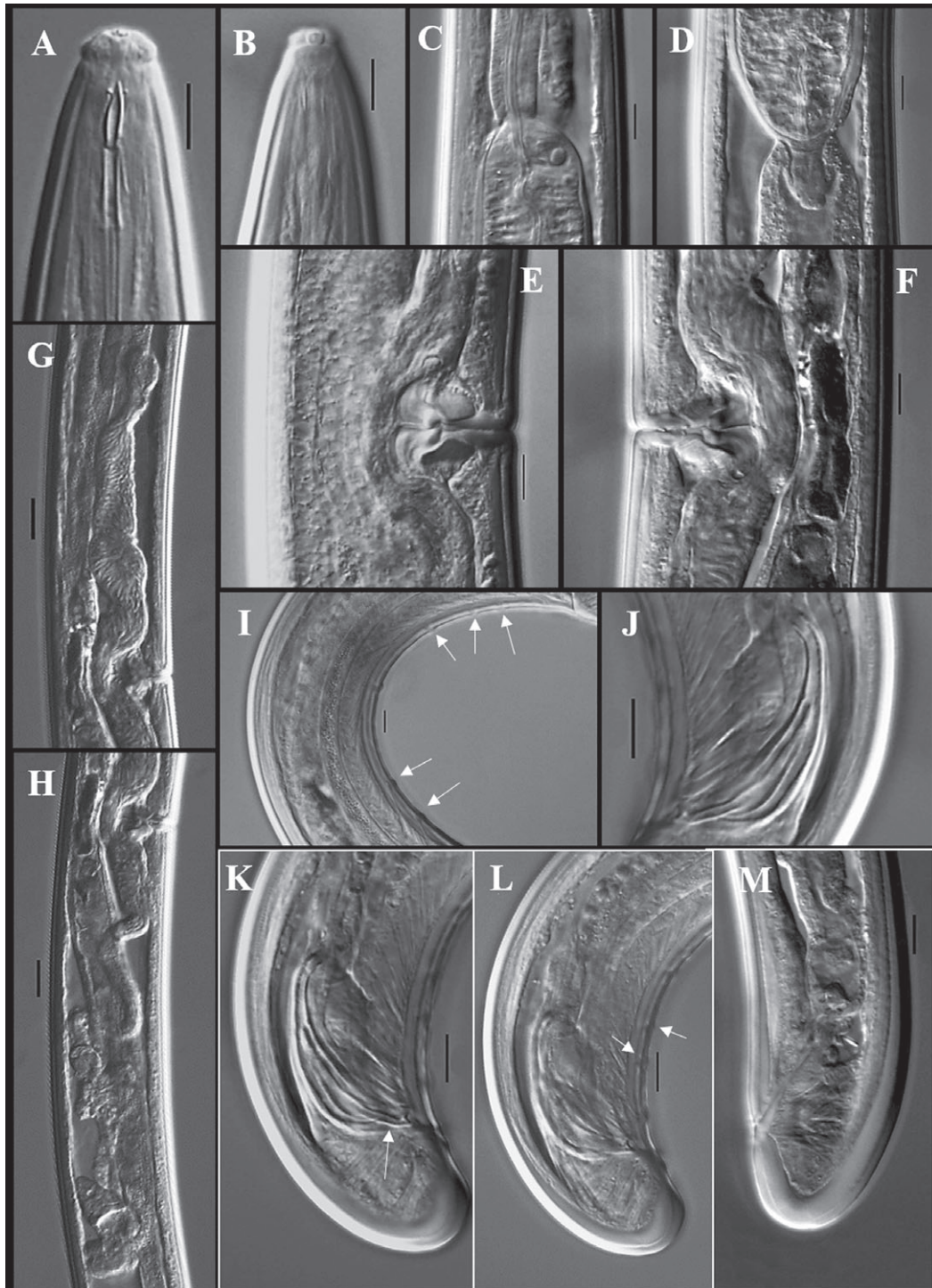
Body slightly curved ventrad upon fixation, 1.85–1.9 mm long. Cuticle with fine transverse striations, about 1–2  $\mu\text{m}$  thick at anterior region, 2–3  $\mu\text{m}$  at mid-body, 7–8  $\mu\text{m}$  on tail tip in females and 6  $\mu\text{m}$  in males. Lateral chords 5–10  $\mu\text{m}$  wide, or about  $\frac{1}{10}$  to  $\frac{1}{5}$  (9–18%) of mid-body diameter with weakly developed glandular bodies, 36–44 in number: 10–16 in pharyngeal region, 5–12 from pharyngeal base to vulva, 15–21 from vulva to anal region and one in caudal region. Lateral, dorsal and ventral body pores indistinct. Lip region offset by deep constriction, 2.2–2.5 times as wide as high, or about  $\frac{1}{7}$  to  $\frac{1}{5}$  (14–19%) of body diameter at neck base. Lips rounded, separate, outer and inner portions demarcated by weak depression. Amphid fovea stirrup-shaped, their aperture occupying about 0.6–0.7 times lip region diameter, fusus slightly anterior to or at level of odontophore base. Guiding ring single, at 0.8–1.0 times lip region diameter from anterior end. Odontostyle fusiform, 4–5 times as long as wide, or 0.9–1.0 times lip region diameter long, its aperture occupying about  $\frac{1}{3}$  of its length. Odontophore simple, rod-like, 1.3–1.5 times as long as odontostyle. Nerve ring encircling the anterior slender part of pharynx at 21–29% of neck length from anterior end. Anterior slender part of pharynx quite muscular, separated from posterior expanded part by a deep constriction. Expanded part of pharynx 7.2–12 times as long as wide, or 4.3–7.4 times longer than body diameter at neck base, occupying about  $\frac{1}{2}$  to two-thirds (50–63%) of total neck length, enclosed in a distinct muscular sheath with straight muscular bands. Only dorsal pharyngeal gland and its orifice visible: DO = 37–54; DN = 38–55; DO–DN = 0.3–0.7. Cardia tongue-like, 1.3–2.3 times as long as wide, occupying about  $\frac{1}{5}$  to  $\frac{1}{3}$  (20–35%) of corresponding body diameter.

Genital system mono-opisthodelphic. Anterior genital branch represented by simple uterine sac, measuring 111–161  $\mu\text{m}$  or 1.9–3.0 times mid-body diameter long, and occupying about 5.9–8.4% of total body length; mostly containing spindle-shaped sperms. Posterior branch well developed; ovary reflexed, not reaching oviduct-uterus junction, measuring 59–99  $\mu\text{m}$  long with squamous-shaped oocytes arranged in a single row except near tip; oviduct joining ovary subterminally, 81–126  $\mu\text{m}$  or 1.5–2.3 times mid-body

**Table 2.** Measurements of *Axonchium saccatum* Jairajpuri, 1964. All measurements in  $\mu\text{m}$ , except L in mm, and in the form: mean  $\pm$  s.d. (range) for females, and measurements for each male (n = 2) separated by a comma.

Characters	Females	Males
n	5	2
L	1.88 $\pm$ 0.1 (1.85–1.90)	1.64, 1.6
a	33.8 $\pm$ 1.8 (32–35)	31.7, 36.6
b	3.3 $\pm$ 0.3 (2.9–3.9)	3.3, 2.9
c	68 $\pm$ 5.8 (57.5–75.0)	74.8, 64.
c'	0.8 $\pm$ 0.1 (0.7–0.8)	0.7, 0.8
V	51.5 $\pm$ 0.6 (51–53)	–
G1	7.3 $\pm$ 1.1 (5.9–8.4)	–
G2	12.3 $\pm$ 1.5 (10.4–13.7)	–
Body diam. at pharynx base	56.6 $\pm$ 2.9 (54–62)	53, 44
Body diam. at mid-body	56 $\pm$ 3.3 (53–60)	52, 44
Body diam. at anus/ cloaca	34.4 $\pm$ 2.3 (33–39)	30, 31
Lip region diam.	9.6 $\pm$ 0.5 (9–10)	9
Lip region height	4	4
Amphid aperture	6	6
Odontostyle length	9.2 $\pm$ 0.4 (9–10)	8, 9
Odontophore length	13.4 $\pm$ 0.5 (13–14)	13, 14
Guiding ring from ant. end	8.8 $\pm$ 0.4 (8–9)	9
Nerve ring from ant. end	139.6 $\pm$ 2.4 (136–143)	132, 135
Neck length	572.4 $\pm$ 53.1 (482–646)	496, 556
Expanded part of pharynx	329.8 $\pm$ 55.2 (238–410)	263, 328
Cardia length	14.6 $\pm$ 2.9 (11–19)	14
Anterior genital branch	138 $\pm$ 20.7 (111–161)	–
Posterior genital branch	232.2 $\pm$ 30.9 (193–260)	–
Vaginal depth	26.6 $\pm$ 1.0 (25–28)	–
Vulva from ant. end	973.4 $\pm$ 14.3 (960–1000)	–
Prerectum length	261.8 $\pm$ 29.6 (220–309)	273, 290
Rectum length	39.6 $\pm$ 1.9 (38–43)	39, 26
Tail length	28 $\pm$ 2.7 (25–33)	22, 25
Spicule length	–	40, 43
Lateral guiding pieces	–	10, 11
Ventromedian supplements	–	6, 5

diameter long, consisting of a long slender part with prismatic cells and a well-developed pars dilatata with distinct lumen, oviduct-uterus junction marked by sphincter; uterus 98–145  $\mu\text{m}$  or 1.8–2.4 times the mid-body diameter long, differentiated into a relatively large proximal region with wide lumen, a narrow intermediate region, and a short spherical distal pars dilatata. Vulva transverse. Vagina almost straight, narrowing within sphincter, extending inwards about  $\frac{1}{2}$  (45–51%) of corresponding body diameter; vaginal wall thick, distinctly differentiated from body cuticle; pars proximalis vaginae longer



**Fig. 2.** *Axonchium saccatum* Jairajpuri, 1964 (LM photographs). **A.** Anterior region. **B.** Anterior region showing amphid. **C.** Junction between two parts of the pharynx. **D.** Cardia. **E–F.** Vulva and vagina. **G–H.** Female genital branches. **I.** Ventromedian supplements. **J.** Spicule. **K.** Male posterior region, arrow indicating lateral guiding piece. **L.** Arrow indicating beginning of ventromedian supplements. **M.** Female posterior end. Scale bars: A–F, I–M = 10  $\mu$ m; G–H = 20  $\mu$ m.



than wide,  $12\text{--}16 \times 4\text{--}6 \mu\text{m}$ , somewhat sigmoid, surrounded by well-developed circular musculature; pars refringens vaginae absent; pars distalis vaginae  $11\text{--}13 \mu\text{m}$  long. Prerectum  $6\text{--}9$  and rectum  $0.9\text{--}1.3$  times anal body diameter long. Tail short, hemispheroid. Caudal pores three on each side.

#### Male

Similar to female in general morphology, except for posterior region of the body being more curved ventrad. Genital system diorchic, with oppositely outstretched testes; sperms spindle-shaped, measuring  $3\text{--}4 \times 1\text{--}2 \mu\text{m}$ . In addition to adcloacal pair, located at  $9 \mu\text{m}$  from cloacal aperture,  $5\text{--}6$  irregularly spaced ventromedian supplements, beginning at  $13 \mu\text{m}$  from adcloacal pair, or slightly posterior to proximal end of spicules. Copulatory muscles conspicuous, beginning from level of middle of spicules and continuing until level of last supplement. Spicules well developed, arcuate, proximal region slender with curved ends and broad and truncate distal ends; total length along arc 1.3 times as long as chord,  $5.0\text{--}5.4$  times maximum width or  $1.3\text{--}1.4$  times body diameter at cloacal aperture. Curvature about  $132^\circ\text{--}136^\circ$ . Dorsal contour regularly convex, comparatively thick at distal end; ventral contour concave without a distinct hump; head slender with curved ends, occupying about  $37\text{--}38\%$  of total spicules length; median piece simple,  $8\text{--}9$  times as long as wide, occupying about  $37\%$  of spicules maximum width; posterior ends  $6\text{--}7 \mu\text{m}$  wide. Lateral guiding pieces sclerotized, slightly curved with bifid distal end, about  $5.0\text{--}5.5$  times as long as wide or about  $\frac{1}{4}$  of total spicule length. Prerectum long,  $9.1\text{--}9.3$  and rectum  $0.8\text{--}1.3$  times cloacal body diameter long. Tail hemispheroid with bluntly truncated terminus. Caudal pores two on each side.

#### Remarks

Jairajpuri (1964) described *A. saccatum* from Trivandrum, Kerala, India, and differentiated it from *A. gossypii* De Coninck, 1962 by the presence of a longer body, longer pharynx and prerectum. Hechler (1969) synonymized *A. saccatum* with *A. gossypii* De Coninck, 1962. Nair & Coomans (1973) synonymized *A. gossypii* with *A. metobtusicaudatum* Schuurmans-Stekhoven & Teunissen, 1938. Nair (1973) redescribed this species based on two paratype females and two paratype males loaned from the original author, and differentiated it from *A. metobtusicaudatum*, in having a relatively wider lip region with conoid lips, in the shape of the lateral guiding pieces and the presence of two caudal pores on each side, and concluded that both species are distinctly different. The two male specimens observed showed variation in the shape of spicules and arrangements of ventromedian supplements, i.e., a robust spicule in combination with ventromedian supplements beginning just opposite to the proximal end of the spicule (Nair 1973: 539, fig. 10c, h) vs a comparatively slender spicule with a strongly curved head region and ventromedian supplements beginning the spicule range (Nair 1973: 539, fig. 10c, h). Probably the males were from two different species; however, she (l.c.) left it for further observation on additional specimens. In the present population both the male specimens have slender spicules with a curved head region and ventromedian supplements beginning within the range of the spicules; however, the females conform well to the original and subsequent descriptions except in having a slightly shorter prerectum in females ( $6\text{--}9$  vs  $11$  times anal body diameter).

#### *Axonchium transkeiense* Nair, 1973

Fig. 3, Table 3

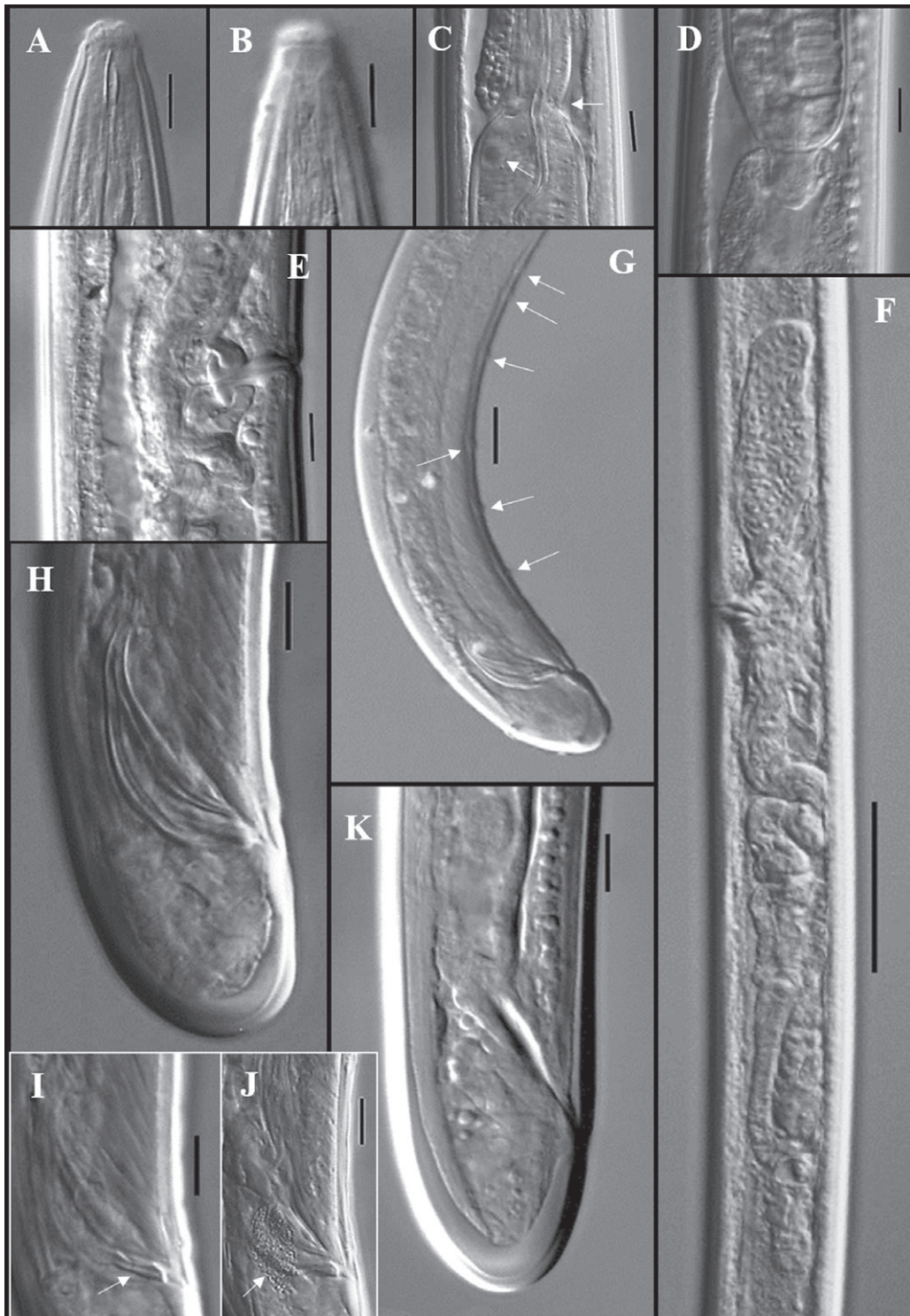
*Axonchium transkeiense* Nair, 1973: 545–548.

#### Material examined

INDIA – Kerala State • 8 ♀♀, 4 ♂♂; Palakkad District, Silent Valley National Park;  $11^\circ 08' 0''$  N,  $76^\circ 28' 0''$  E;  $10\text{--}15$  cm depth; 25 Oct. 2017; soil samples collected around the roots of grasses (unidentified); slide reference number AMU/ZD/NC/*Axonchium transkeiense*/4–8. – **Kozhikode**

**Table 3.** Measurements of *Axonchium transkeiense* Nair, 1973. All measurements in  $\mu\text{m}$  except L in mm, and in the form: mean  $\pm$  s.d. (range).

Localities Characters	Silent Valley population		Mukkali population	
	Females	Males	Female	Males
n	8	4	1	3
L	1.47 $\pm$ 0.1 (1.41–1.58)	1.47 $\pm$ 0.1 (1.3–1.5)	1.5	1.5 $\pm$ 0.1(1.5–1.52)
a	34.79 $\pm$ 2.7 (31.7–40.3)	37.6 $\pm$ 1.3 (35.9–39.6)	30.3	33.6 $\pm$ 3.3 (28.94–36.23)
b	2.6 $\pm$ 0.2 (2.3–2.7)	2.9 $\pm$ 0.1 (2.8–3.0)	2.9	3.1 $\pm$ 0.1 (3.0–3.2)
c	57.2 $\pm$ 3.1 (52.5–61.4)	56.5 $\pm$ 3.8 (51.9–61.1)	54	55.2 $\pm$ 1.7 (53.7–57.7)
c'	0.85 $\pm$ 0.1 (0.78–0.9)	0.95 $\pm$ 0.1 (0.89–1.03)	0.9	0.9 $\pm$ 0.0 (0.86–0.93)
V	52.3 $\pm$ 0.9 (50.8–53.5)	–	50.5	–
G1	6.3 $\pm$ 0.7 (5.2–7.3)	–	6.5	–
G2	15.4 $\pm$ 0.9 (14–17)	–	10.8	–
Body diam. at pharynx base	43.38 $\pm$ 3.8 (40–51)	40.5 $\pm$ 1.8 (38–43)	51	47 $\pm$ 3.7 (43–52)
Body diam. at mid-body	42.75 $\pm$ 3.5 (39–50)	39.2 $\pm$ 1.3 (38–41)	50	45.33 $\pm$ 4.7 (42–52)
Body diam. at anus/cloaca	30.2 $\pm$ 1.6 (28–33)	27.5 $\pm$ 0.9 (26–28)	31	30.33 $\pm$ 0.5 (30–31)
Lip region diam.	8.75 $\pm$ 0.7 (8–10)	8.75 $\pm$ 0.4 (8–9)	9	9
Lip region height	4.1 $\pm$ 0.3 (8–10)	4	5	4.3 $\pm$ 0.5 (4–5)
Amphid aperture	5.5 $\pm$ 0.5 (5–6)	5.5 $\pm$ 0.5 (5–6)	6	5.3 $\pm$ 0.5 (5–6)
Odontostyle length	9.8 $\pm$ 0.3 (9–10)	9.2 $\pm$ 0.7 (8–10)	9	8.6 $\pm$ 0.5 (8–9)
Odontophore length	13.37 $\pm$ 0.7 (12–14)	13.25 $\pm$ 0.4 (13–14)	13	12.3 $\pm$ 0.5 (12–13)
Guiding ring from ant. end	7.5 $\pm$ 0.7 (6–8)	6.5 $\pm$ 0.5 (6–7)	8	8.3 $\pm$ 0.5 (8–9)
Nerve ring from ant. end	120.1 $\pm$ 4.7 (114–128)	119.75 $\pm$ 5.9 (113–129)	120	115.3 $\pm$ 3.7 (111–120)
Neck length	571.7 $\pm$ 23.6 (538–601)	505.5 $\pm$ 12.8 (489–524)	521	478 $\pm$ 10.2 (464–488)
Expanded part of pharynx	374.5 $\pm$ 27 (343–410)	307.75 $\pm$ 7.2 (300–318)	316	278 $\pm$ 5.0 (271–282)
Cardia length	8.6 $\pm$ 0.9 (7–10)	7.75 $\pm$ 1.3 (7–10)	11	8 $\pm$ 2.2 (6–11)
Anterior genital branch	94.1 $\pm$ 11.7 (77–111)	–	98	–
Posterior genital branch	227.75 $\pm$ 16 (199–244)	–	163	–
Vaginal depth	20.37 $\pm$ 0.5 (20–21)	–	23	–
Vulva from ant. end	774.1 $\pm$ 41.1 (723–842)	–	764	–
Prerectum length	160.5 $\pm$ 18.6 (136–193)	179.5 $\pm$ 14.1 (165–198)	193	194.3 $\pm$ 19.4 (173–220)
Rectum length	35.1 $\pm$ 2.2 (31–39)	39.5 $\pm$ 2.1 (37–42)	35	40.3 $\pm$ 0.5 (30–31)
Tail length	25.87 $\pm$ 1.1 (24–27)	26.25 $\pm$ 2.4 (23–29)	28	27.3 $\pm$ 0.9 (26–28)
Spicule length	–	36.75 $\pm$ 1.1 (35–38)	–	37
Lateral guiding pieces	–	9.25 $\pm$ 0.8 (8–10)	–	9.67 $\pm$ 1.2 (8–11)
Ventromedian supplements	–	6–7	–	7–8



**Fig. 3.** *Axonchium transkeiense* Nair, 1973 (LM photographs). **A.** Anterior region. **B.** Anterior end showing amphid. **C.** Junction between two parts of pharynx. **D.** Cardia. **E.** Vulva and vagina. **F.** Female genital branches. **G.** Ventromedian supplement series. **H.** Male posterior end. **I.** Lateral guiding piece. **J.** Arrow indicating sac-like structure in the male posterior region. **K.** Female posterior end. Scale bars: A–E, H–K = 10 µm; F = 50 µm; G = 20 µm.

**District** • 1 ♀, 3 ♂♂; village Mukkali; 11°40'10.38" N, 75°33'26.64" E; 10–15 cm depth; 25 Oct. 2017; soil samples collected around the roots of shrubs plants (unidentified); slide reference number AMU/ZD/NC/*Axonchium transkeiense*/1–3.

## Description

### Female

Body curved ventrad upon fixation, 1.4–1.6 mm long. Cuticle with fine transverse striations, about 1–2 µm thick at anterior and mid-body, 8–10 µm on tail tip in females and 5–7 µm in males. Lateral chords 4–6 µm wide, or one-tenth to one-seventh (9–14%) of mid-body diameter, with weakly developed glandular bodies, 34–45 in number: 10–15 in pharyngeal region, 4–6 from pharyngeal base to vulva, 19–23 from vulva to anal region and one in caudal region. Lip region offset, marked by deep constriction, 1.8–2.5 times as wide as high, or about  $\frac{1}{6}$  to  $\frac{1}{4}$  (17–23%) of body diameter at neck base. Lips conoid, separate, outer and inner portions demarcated by shallow depression. Amphid fovea stirrup-shaped, their aperture occupying about 0.6–0.7 times lip region diameter, fusus lying opposite or slightly above odontophore level. Guiding ring single, at 0.7–1.0 times lip region diameter from anterior end. Odontostyle fusiform, 4–5 times as long as wide, or 1.0–1.3 times lip region diameter long; aperture occupying about  $\frac{1}{3}$  of its length. Odontophore simple, rod-like, 1.2–1.6 times as long as odontostyle. Nerve ring encircling anterior slender part of pharynx at 19–23% of neck length from anterior end. Anterior slender part of pharynx quite muscular, separated from posterior expanded part by a deep constriction. Expanded part of pharynx 11–18 times as long as wide, or 7.1–10.2 times as long as body diameter at neck base, occupying about  $\frac{3}{5}$  to  $\frac{2}{3}$  (61–70%) of total neck length, enclosed in a thick muscular sheath with straight bands. Only dorsal pharyngeal gland and its orifice visible: DO = 31.7–41.2; DN = 32.2–41.6; DO–DN = 0.4–0.8. Cardia oblong, 0.9–1.3 times as long as wide, occupying about  $\frac{1}{7}$  to  $\frac{1}{4}$  (15–25%) of corresponding body diameter.

Genital system mono-opisthodelphic. Anterior genital branch represented by a simple uterine sac, with slight proximal constriction, measuring 77–111 µm or 1.8–2.5 times mid-body diameter long, and occupying about 5.2–7.3% of total body length; mostly containing spindle-shaped sperms. Posterior genital branch well developed; ovary reflexed, not reaching oviduct-uterus junction, measuring 74–128 µm long with squamous-shaped oocytes arranged in a single row except near tip; oviduct joining ovary subterminally, 85–107 µm or 1.6–2.5 times mid-body diameter long, consisting of a long slender part with prismatic cells and well developed pars dilatata with distinct lumen; oviduct-uterus junction marked by sphincter; uterus 70–127 µm or 1.7–3.0 times mid-body diameter long, differentiated into a long proximal region with distinct lumen, and a short spherical distal pars dilatata. Vulva transverse. Vagina almost straight, or slightly bent posteriorly, extending inwards about  $\frac{2}{5}$  to  $\frac{1}{2}$  (42–52%) of corresponding body diameter; vaginal walls thick, not differentiated from body cuticle, widening toward uterus with anchor-shaped ends, posterior half encircled by well developed circular musculature; pars proximalis vaginae 10–12 × 5–6 µm; pars refringens vaginae absent; pars distalis vaginae 15–18 µm long. Prerectum 4.5–6.2 and rectum 1.1–1.3 times anal body diameter long. Tail broadly conoid to hemispherical. Caudal pores two on each side.

### Male

Similar to female in general morphology, except for posterior region of body being more curved ventrad. Genital system diorchic, with oppositely outstretched testes, enclosed in a conspicuous muscular sheath, sperms spindle-shaped, measuring 4–5 × 1–2 µm. In addition to adcloacal pair, located at 7–9 µm from cloacal aperture, a series of 6–8 irregularly spaced ventromedian supplements, beginning at 27–40 µm from adcloacal pair, or slightly above range of spicules. Copulatory muscles conspicuous, beginning from level of middle of spicules and continuing until the level of last supplement. Spicules arcuate, proximal part slender with slightly curved ends, distal part unusually wide; total length along arc 1.0–1.1 times as long as chord, 4.1–4.7 times maximum width, or 1.3–1.4 times body diameter at cloacal

aperture. Curvature about 139–149°. Dorsal contour regularly convex with curved distal end; ventral contour concave with weakly developed hump, located at 50–54% of spicule total length from its anterior end; head slender, curved, occupying about 13–28% of spicule total length; median piece simple with or without fine projection in head region, 9–15 times as long as wide, or occupying about 25–37% of spicule maximum width; posterior region with blunt ends, 5–6 µm wide; a sac-like structure filled with small granules, located at level of middle part of spicules. Lateral guiding pieces with slightly bifurcated distal end, about 4.5–6.6 times as long as wide or about  $\frac{1}{5}$  to  $\frac{1}{3}$  (21–30%) of total spicule length. Prerectum 5.9–7.3 and rectum 1.3–1.5 times cloacal body diameter long. Tail with bluntly rounded terminus. Caudal pores two on each side.

### Remarks

Nair (1973) described this species from the Transkei, South Africa, and differentiated it from *A. heynsi* Nair, 1973 and *A. metobtusicaudatum* (Schoorhans Stekhoven & Teunissen, 1938) on the basis of its shorter and less curved body, longer vagina, shape of spicules, shape of lateral guiding pieces and arrangements of ventromedian supplements. The present population from Kerala, India, conforms well with the type description except for having a shorter body (1.3–1.6 vs 1.8–2.0 mm); comparatively thinner cuticle at mid-body (1–2 vs 3–4 µm); presence of lateral glandular bodies (vs indistinct glandular bodies); narrower amphid aperture (two-thirds vs fourth-fifths of lip region diameter); shorter cardia (15–25 vs 33% of corresponding body diameter); shorter prerectum (4.5–5.2 vs 6.5–8.0 times the anal body diameter long); shorter spicules (35–38 vs 43–46 µm); shorter and simple rod-like lateral guiding pieces with poorly bifurcated distal end (8–10 vs 16–17 µm long with prominent bifurcate distal end and its proximal end slightly expanded); sac-like structure filled with small granules present at the level of spicules (vs absent) and longer tail ( $c = 51–61$  vs 64–81). This is the first record of this species from India and first ever report since its original description.

### *Axonchium vallum* Ahmad & Jairajpuri, 1982

Fig. 4, Table 4

*Axonchium vallum* Ahmad & Jairajpuri, 1982: 23–25.

### Material examined

INDIA – Kerala State • 4 ♀♀, 1 ♂; Kollam District, Pathananpuram; 9°5'33.72" N, 76°51'40.32" E; 10–15 cm depth; 3 Nov. 2017; soil samples collected around the roots of grasses (unidentified) in *Ficus elastica* garden; slide reference number AMU/ZD/NC/*Axonchium vallum*/1–3. – Thiruvananthapuram District • 3 ♀♀, 3 ♂♂; Ponmudi Hill; 8°45'37" N, 77°7'0" E; 10–15 cm depth; 4 Nov. 2017; soil samples collected around the roots of grasses (unidentified); slide reference number AMU/ZD/NC/*Axonchium vallum*/4–6.

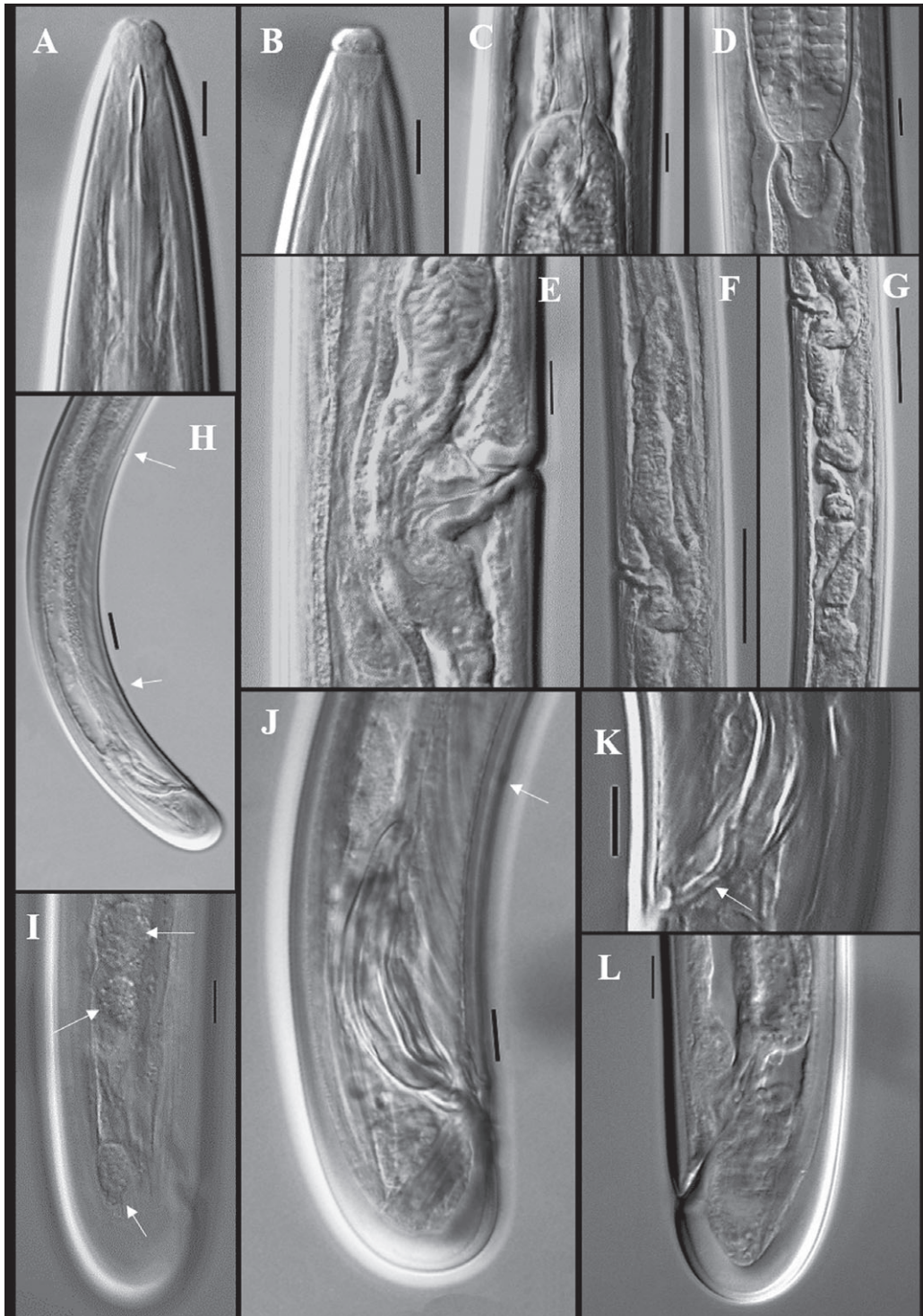
### Description

#### Female

Body slightly curved ventrad upon fixation, 1.7–1.8 mm long. Cuticle with fine transverse striations, about 2 µm thick at anterior region, 2–3 µm at mid-body, 7–9 µm at tail tip in females and 6–8 µm in males. Lateral chords 4–8 µm wide, or about  $\frac{1}{13}$  to  $\frac{1}{6}$  (7–15%) of mid-body diameter, with distinct glandular bodies: 13–14 in pharyngeal region, 5–6 from pharyngeal base to vulva, 4–21 from vulva to anal region and one in caudal region. Lateral, dorsal and ventral body pores indistinct. Lip region rounded, offset by deep constriction, 1.8–2.5 times as wide as high, or about  $\frac{1}{6}$  to  $\frac{1}{5}$  (16–20%) of body diameter at neck base. Amphid fovea cup-shaped, their aperture occupying about 0.7–0.9 times lip region diameter, fusus just opposite odontophore level. Guiding ring single, at 1.0–1.1 times lip region diameter from anterior end. Odontostyle fusiform, 6–7 times as long as wide, or 1.2–1.4 times

**Table 4.** Measurements of *Axonchium vallum* Ahmad & Jairajpuri, 1982. All measurements in  $\mu\text{m}$  except L in mm, and in the form: mean  $\pm$  s.d. (range).

Localities	Kollam population		Thiruvananthapuram population	
	Females	Male	Females	Males
n	4	1	3	3
L	1.75 $\pm$ 0.1 (1.7–1.8)	1.6	1.78 $\pm$ 0.1 (1.75–1.83)	1.71 $\pm$ 0.1 (1.68–1.76)
a	35.4 $\pm$ 1.3 (33–37)	35	34.8 $\pm$ 1.5 (33–36)	37.5 $\pm$ 2.3 (34–40)
b	2.7 $\pm$ 0.3 (2.3–3.0)	3.0	2.6 $\pm$ 0.2 (2.4–2.9)	2.8 $\pm$ 0.1 (2.7–2.9)
c	59.4 $\pm$ 2.7 (56–63)	56.3	62.4 $\pm$ 2.8 (59–65.8)	56.4 $\pm$ 1.8 (54–58)
c'	0.8 $\pm$ 0.1 (0.7–0.9)	0.8	0.7 $\pm$ 0.1 (0.8–0.9)	0.86 $\pm$ 0.1 (0.8–0.9)
V	53.9 $\pm$ 0.4 (53–54)	–	54.4 $\pm$ 0.3 (54–55)	–
G1	6.6 $\pm$ 0.4 (6.2–7.3)	–	8.2 $\pm$ 0.3 (7.9–8.7)	–
G2	12.2 $\pm$ 1.3 (10.2–13.5)	–	15.6 $\pm$ 1.3 (13.9–17.0)	–
Body diam. at pharynx base	49.2 $\pm$ 2.3 (47–53)	45	53 $\pm$ 2.4 (50–56)	46.3 $\pm$ 1.2 (45–48)
Body diam. at mid-body	48.5 $\pm$ 1.5 (47–51)	44	51.3 $\pm$ 1.2 (50–53)	45.7 $\pm$ 2.4 (44–49)
Body diam. at anus/cloaca	35 $\pm$ 1.2 (34–37)	34	35.7 $\pm$ 1.2 (34–37)	35.3 $\pm$ 0.5 (35–36)
Lip region diam.	9.4 $\pm$ 0.4 (9–10)	9	10	9.6 $\pm$ 0.2 (9–10)
Lip region height	4.5 $\pm$ 0.5 (4–5)	4	5	4.5 $\pm$ 0.1 (4–5)
Amphid aperture	7.2 $\pm$ 0.4 (7–8)	8	7.5 $\pm$ 0.5 (7–8)	7
Odontostyle length	12.2 $\pm$ 0.4 (12–13)	12	12	12
Odontophore length	13.7 $\pm$ 0.4 (13–14)	15	13.7 $\pm$ 0.9 (13–15)	14 $\pm$ 0.8 (13–15)
Guiding ring from ant. end	10	10	10	10
Nerve ring from ant. end	133 $\pm$ 4.9 (127–140)	126	136 $\pm$ 5.7 (128–140)	134.7 $\pm$ 4.1 (130–140)
Neck length	634.2 $\pm$ 64.2 (588–745)	532	676 $\pm$ 42.5 (625–729)	610.3 $\pm$ 26.7 (573–634)
Expanded part of pharynx	404.7 $\pm$ 65.7 (350–517)	311	442 $\pm$ 57.4 (376–516)	375.7 $\pm$ 27.4 (337–396)
Cardia length	15.2 $\pm$ 1.8 (13–17)	16	18.3 $\pm$ 1.7 (16–20)	15 $\pm$ 1.6 (13–17)
Anterior genital branch	114.2 $\pm$ 5.7 (110–124)	–	146.7 $\pm$ 5.2 (142–154)	–
Posterior genital branch	210.2 $\pm$ 25 (173–239)	–	278.3 $\pm$ 26.3 (142–303)	–
Vaginal depth	26 $\pm$ 1.2 (25–28)	–	25.7 $\pm$ 2.5 (23–29)	–
Vulva from ant. end	927.5 $\pm$ 22.5 (905–965)	–	970 $\pm$ 18.9 (905–992)	–
Prerectum length	201 $\pm$ 6.7 (191–210)	207	186.7 $\pm$ 28.5 (147–213)	252 $\pm$ 15.2 (235–272)
Rectum length	44.7 $\pm$ 1.1 (43–46)	49	43.6 $\pm$ 0.9 (43–45)	52.6 $\pm$ 0.5 (52–53)
Tail length	29 $\pm$ 1.6 (27–31)	28	28.9 $\pm$ 1.6 (27–31)	30.3 $\pm$ 0.9 (29–31)
Spicule length	–	49	–	54.6 $\pm$ 0.5 (54–55)
Lateral guiding pieces	–	14	–	16.7 $\pm$ 1.2 (15–18)
Ventromedian supplements	–	2	–	2



**Fig. 4.** *Axonchium vallum* Ahmad & Jairajpuri, 1982 (LM photographs). **A.** Anterior region. **B.** Anterior region showing amphid. **C.** Junction between two parts of pharynx. **D.** Cardia. **E.** Vulva and vagina. **F–G.** Female genital branches. **H.** Ventromedian supplements. **I.** Lateral glandular bodies. **J.** Male posterior end. **K.** Lateral guiding piece. **L.** Female posterior end. Scale bars: A–E, I–L = 10  $\mu$ m; F–G = 50  $\mu$ m; H = 20  $\mu$ m.

lip region diameter long, its aperture occupying about  $\frac{1}{3}$  of its length. Odontophore simple, rod-like, 1.0–1.2 times as long as odontostyle. Nerve ring encircling anterior slender part of pharynx at 17–24% of neck length from anterior end. Anterior slender part of pharynx quite muscular, separated from the posterior expanded part by a deep constriction. Expanded part of pharynx 10.5–17.8 times as long as wide, or 7.1–11 times as long as body diameter at neck base, and occupying about  $\frac{3}{5}$  to  $\frac{2}{3}$  (60–70%) of total neck length, enclosed in a thick muscular sheath with straight bands. Only dorsal pharyngeal gland and its orifice visible: DO = 30.3–42; DN = 30.5–42.3; DO–DN = 0.3–0.5. Cardia tongue-like, 1.4–2.5 times as long as wide, occupying about  $\frac{1}{4}$  to  $\frac{2}{5}$  (24–37%) of corresponding body diameter. Uninucleated coelomocytes observed near cardia and in post-vulval region, 1–3 between pharyngeal base to vulva, measuring  $16\text{--}72 \times 10\text{--}23 \mu\text{m}$  and 2–4 from vulva to anal region, measuring  $16\text{--}32 \times 6\text{--}10 \mu\text{m}$ , each glandular organ ovoid in shape.

Genital system mono-opisthodelphic. Anterior genital branch represented by simple uterine sac, measuring 110–154  $\mu\text{m}$  or 2.1–3.0 times mid-body diameter long and occupying about 6.2–8.6% of body length; mostly containing spindle-shaped sperms. Posterior branch well developed; ovary reflexed, rarely reaching oviduct-uterus junction, measuring 47–135  $\mu\text{m}$  long with squamous shaped oocytes arranged in a single row except near tip; oviduct joining ovary subterminally, measuring 67–91  $\mu\text{m}$  or 1.3–1.8 times mid-body diameter long, consisting of a long slender part with prismatic cells and a well developed pars dilatata with distinct lumen; oviduct-uterus junction marked by a sphincter; uterus 90–169  $\mu\text{m}$  or 1.9–3.4 times mid-body diameter long, differentiated into a large proximal region with wide lumen, a narrow intermediate region, and a short spherical pars dilatata with distinct lumen. Vulva transverse. Vagina slightly bent posteriad, extending inwards about two-fifths to three-fifths (43–57%) of corresponding body diameter; pars proximalis vaginae longer than wide,  $10\text{--}17 \times 3\text{--}4 \mu\text{m}$ , with somewhat sigmoid walls surrounded by circular musculature; pars refringens vaginae absent; pars distalis vaginae 12–14  $\mu\text{m}$  long, distinctly enlarged at posterior half with rounded walls. Prerectum 4–6 and rectum 1.1–1.4 times anal body diameter long. Tail short, hemispheroid. Caudal pores two on each side.

### Male

Similar to female in general morphology, except for posterior region of the body being more curved ventrad. Genital system diorchic, with oppositely outstretched testes; sperms elongate spindle-shaped, measuring  $5\text{--}6 \times 2 \mu\text{m}$ . In addition to adcloacal pair, located at 6–9  $\mu\text{m}$  from cloacal aperture, only two very widely spaced ventromedian supplements, beginning just in front of proximal end of spicules; first located at 43–61  $\mu\text{m}$  from adcloacal pair, second at 108–136  $\mu\text{m}$  from first supplement. Copulatory muscles conspicuous, beginning from level of middle of spicules and continuing until the level of last supplement. Spicules arcuate with distal and proximal region curved; total length along arc 1.0–1.1 times as long as chord, 5.4–6.1 times maximum width and 1.4–1.6 times body diameter at cloacal aperture. Curvature about  $118^\circ\text{--}126^\circ$ . Dorsal contour regularly convex; ventral contour concave, bearing weakly developed hump, located at 31–43% of spicule total length from its anterior end; head slender and slightly curved, occupying about 13–18% of spicule total length; median piece 7–12 times as long as wide and occupying about 40–60% of spicule maximum width; posterior end 4–5  $\mu\text{m}$  wide. Lateral guiding pieces sclerotized, slightly curved with bifurcated distal end, about 7–9 times as long as wide or about  $\frac{1}{3}$  of total spicule length. Prerectum long, 6.0–7.8 and rectum 1.4–1.5 times cloacal body diameter long. Tail short, hemispheroid. Caudal pores two on each side.

### Remarks

Ahmad & Jairajpuri (1982) described this species from Silent Valley, India and differentiated it from *A. shamimi* Baqri & Khera, 1976 and *A. siddiqii* Coomans & Nair, 1975 in having a longer body and odontostyle, the shape and size of spicules and the number of ventromedian supplements. The morphometrics in the two populations are very similar. However, the Kollam population differs slightly from the Thiruvananthapuram population in having a shorter body in the male ( $L = 1.6$  vs 1.68–1.76 mm);



shorter spicules (49 vs 54–55  $\mu\text{m}$ ) and lateral guiding pieces (14 vs 15–18  $\mu\text{m}$ ). The present population conforms well with the original description except for having distinct lateral glandular bodies (vs indistinct); comparatively narrower lip region (9–10 vs 10–11  $\mu\text{m}$  or  $\frac{1}{6}$  to  $\frac{1}{5}$  vs  $\frac{1}{4}$  body diameter at neck base); longer odontostyle (12–13 vs 10–12  $\mu\text{m}$  or 1.2–1.4 times vs about one lip region diameter long); shorter prerectum (4–6 vs 6–7 anal body diameter in females and 6.0–7.8 vs 8–9 times cloacal body diameter in males); and slightly shorter spicules (49–55 vs 55–57  $\mu\text{m}$  or 1.4–1.6 vs 1.6–1.7 times cloacal body diameter).

*Axonchium indicum* sp. nov.

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Figs 5–6, Table 5

### Diagnosis

*Axonchium indicum* sp. nov. is characterized by having a 1.2–1.4 mm long body; lip region angular and offset; odontostyle fusiform, 8–9  $\mu\text{m}$  long; the two parts of the pharynx separated by a deep constriction; expanded part of pharynx short, occupying about 39–49% of total neck length; vagina lumen narrow with thickened walls, slightly bent posteriorly; vulva transverse and pre-equatorial; anterior uterine sac short, 0.9–1.6 times the mid-body diameter; tail bluntly conoid.

### Etymology

The new species is named after its country of origin, India.

### Material examined

#### Holotype

INDIA • ♀; Kerala State, Kollam District, Pathanamparam; 9°5'27.5136" N, 76°53'22.6702" E; 10–15 cm depth; 3 Nov. 2017; roots of grasses (unidentified); slide reference number AMU/ZD/NC/*Axonchium indicum*/1.

#### Paratypes

INDIA • 6 ♀♀; same collection data as for holotype; slide reference number AMU/ZD/NC/*Axonchium indicum*/2–3 • 2 ♀♀; same collection data as for holotype; slide reference number AMU/ZD/NC/*Axonchium indicum*/4, nematode collection of the Zoological Survey of India, Kolkata, India.

### Type habitat and locality

Soil samples collected around the roots of grasses (unidentified) from Pathanamparam, Kollam District, Kerala State, India.

### Description

#### Female

Body curved ventrad upon fixation, 1.2–1.4 mm long. Cuticle with fine transverse striations, about 1–2  $\mu\text{m}$  thick at the anterior, 1–2  $\mu\text{m}$  at mid-body, and 4–5  $\mu\text{m}$  on tail tip. Lateral chords 5–7  $\mu\text{m}$  wide, or  $\frac{1}{7}$  to  $\frac{1}{5}$  (14–20%) of mid-body diameter with indistinct glandular bodies. Lateral, dorsal and ventral body pores indistinct. Lip region angular, offset by deep constriction, 2.0–2.5 times as wide as high, or about  $\frac{1}{5}$  to  $\frac{1}{4}$  (22–25%) of body diameter at neck base. Lips incompletely separate. Amphid fovea stirrup-shaped, their aperture occupying about 0.7–0.8 times lip region diameter, fusus just opposite or slightly posterior to odontophore level. Guiding ring single, at 0.9–1.1 times lip region diameter from anterior end. Odontostyle fusiform, 4.0–4.5 times as long as wide, or 0.9–1.1 times lip region diameter long, its aperture occupying about  $\frac{1}{3}$  of its length. Odontophore simple, rod-like, 1.2–1.6 times as long as odontostyle. Nerve ring encircling anterior slender part of pharynx at 28–33% of neck length from anterior end. Anterior slender part of pharynx quite

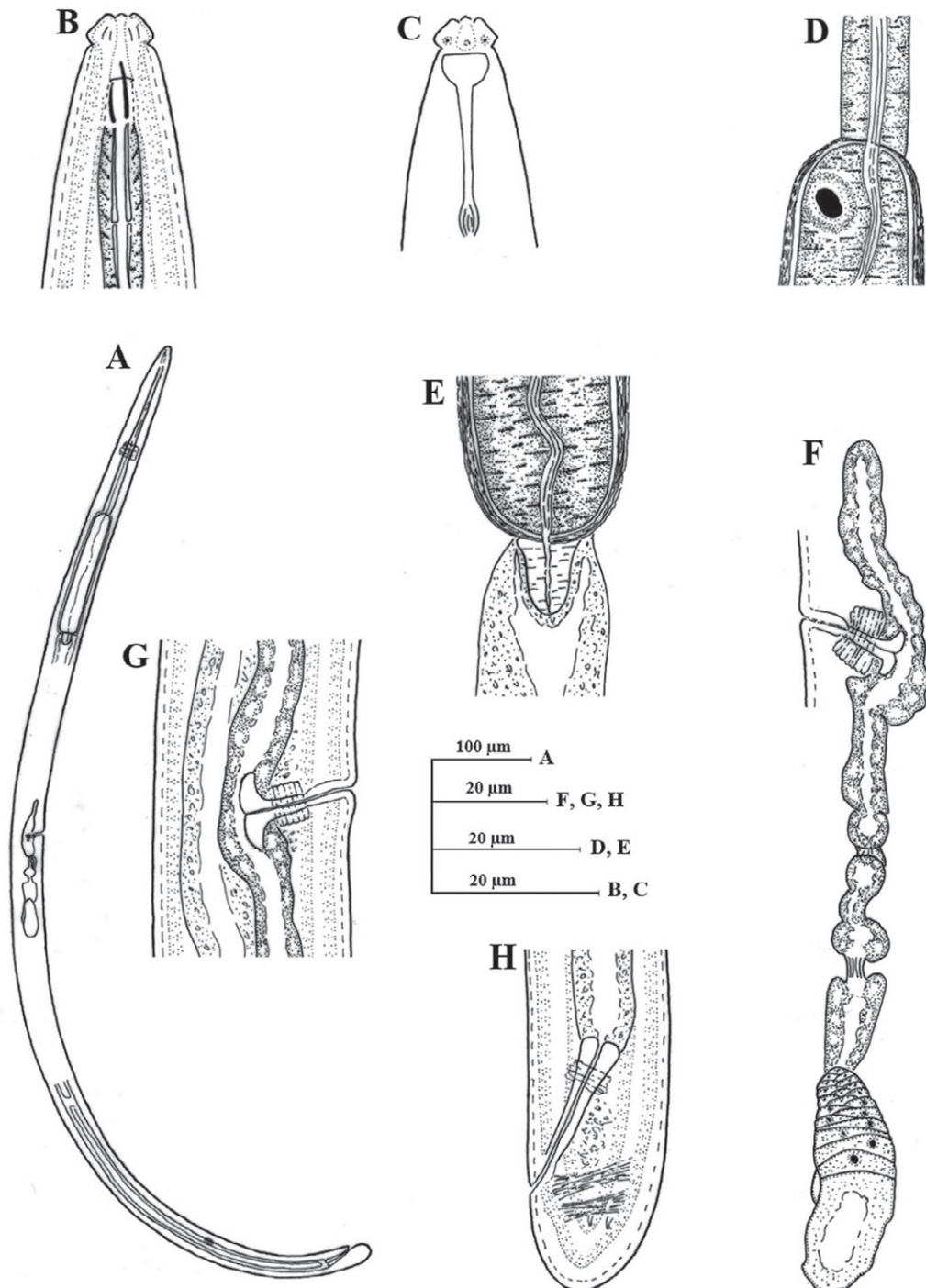
**Table 5.** Morphometrics of *Axonchium indicum* sp. nov. All measurements in  $\mu\text{m}$  except L in mm, and in the form: mean  $\pm$  s.d. (range).

Characters	Holotype female	Paratype females
n	1	8
L	1.25	1.32 $\pm$ 0.1 (1.23–1.37)
a	33.9	36.5 $\pm$ 1.1 (35.1–37.7)
b	3.8	3.5 $\pm$ 0.1 (3.3–3.7)
c	54.5	61.2 $\pm$ 2.9 (58–65.8)
c'	1.0	0.9 $\pm$ 1.0 (0.8–1.0)
V	46.6	46 $\pm$ 1.0 (45–48)
G1	4.7	3.3 $\pm$ 0.5 (2.6–4.1)
G2	10.8	9.3 $\pm$ 1.0 (7.5–10.6)
Body diam. at pharynx base	36	35.4 $\pm$ 0.7 (34–36)
Body diam. at mid-body	37	36.4 $\pm$ 1.1 (35–38)
Body diam. at anus/cloaca	23	23.5 $\pm$ 0.5 (23–24)
Lip region diam.	9	8.25 $\pm$ 0.4 (8–9)
Lip region height	4	4
Amphid aperture	6	6.4 $\pm$ 0.5 (6–7)
Odontostyle length	9	8.7 $\pm$ 0.4 (8–9)
Odontophore length	12	12.2 $\pm$ 0.7 (11–13)
Guiding ring from ant. end	9	8.2 $\pm$ 0.4 (8–9)
Nerve ring from ant. end	108	114.7 $\pm$ 3.2 (110–121)
Neck length	133	381.7 $\pm$ 19 (355–409)
Expanded part of pharynx	132	172.7 $\pm$ 19.2 (150–201)
Cardia length	12	11.2 $\pm$ 0.8 (10–13)
Anterior genital branch	59	43.5 $\pm$ 5.2 (35–50)
Posterior genital branch	135	124 $\pm$ 15.5 (92–141)
Vaginal depth	22	20.7 $\pm$ 0.7 (20–22)
Vulva from ant. end	584	610 $\pm$ 13.2 (589–628)
Prerectum length	168	155.7 $\pm$ 45.5 (95–209)
Rectum length	32	32.2 $\pm$ 1.4 (30–34)
Tail length	23	21.8 $\pm$ 1.2 (20–23)

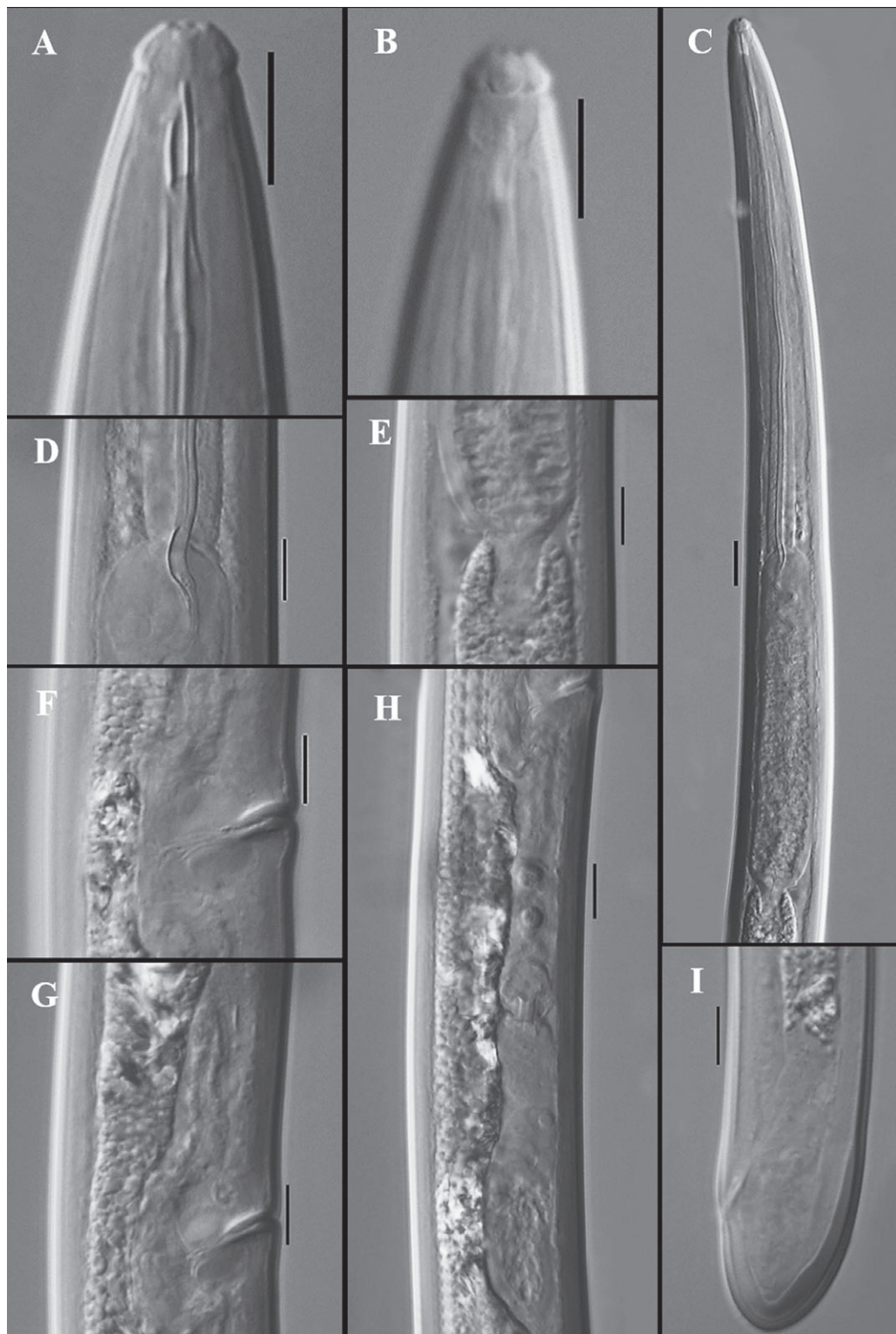
muscular, separated from posterior expanded part by a deep constriction. Expanded part of pharynx 6.0–10 times as long as wide, or 3.7–5.6 times as long as body diameter at neck base, and occupying about  $\frac{2}{5}$  to  $\frac{1}{2}$  (39–49%) of total neck length, enclosed in a thick muscular sheath with straight bands. Only dorsal pharyngeal gland and its orifice visible: DO = 53–62; DN = 55–64; DO–DN = 0.3–1.9. Cardia oblong, 1.1–2.0 times as long as wide, and occupying about  $\frac{2}{7}$  to  $\frac{2}{5}$  (28–37%) of corresponding body diameter.

Genital system mono-opisthodelphic. Anterior genital branch represented by a small sac, measuring 35–59  $\mu\text{m}$  or 0.9–1.6 times mid-body diameter long, and occupying about 2.6–4.7% of total body length. Posterior branch well developed; ovary reflexed, measuring 43–71  $\mu\text{m}$  long with squamous shaped oocytes arranged in a single row except near tip; oviduct joining ovary subterminally, measuring 35–70  $\mu\text{m}$  or 1.0–1.9 times mid-body diameter long, consisting of a long slender part with prismatic

cells and a wide pars dilatata; oviduct-uterus junction marked by sphincter; uterus 46–68  $\mu\text{m}$  or 1.2–1.9 times mid-body diameter long, differentiated into a large proximal part with distinct lumen, and a short spherical pars dilatata with clear lumen; sperms not observed. Vulva transverse. Vagina slightly



**Fig. 5.** *Axonchium indicum* sp. nov. A–C. Paratype 2, ♀ (slide 2). D–H. Paratype 6, ♀ (slide 4). A. Entire body. B. Anterior region. C. Anterior end showing amphid. D. Junction between anterior slender and posterior expanded part of pharynx. E. Cardia. F. Female genital system. G. Vulva. H. Female posterior region.



**Fig. 6.** *Axonchium indicum* sp. nov. (LM photographs). **A–B.** Paratype 2, ♀ (slide 2). **C–I.** Paratype 6, ♀ (slide 4). **A.** Anterior region. **B.** Anterior end showing amphid. **C.** Pharynx. **D.** Junction between two parts of the pharynx. **E.** Cardia. **F.** Vulva. **G.** Anterior uterine sac. **H.** Posterior genital branch. **I.** Posterior region. Scale bars: A–B, D–I = 10 µm; C = 20 µm.

bent posteriad, extending inwards about  $\frac{1}{2}$  to three-fifths (52–60%) of corresponding body diameter long, vaginal lumen slender with thickened distal region but not differentiated from body cuticle; pars proximalis vaginae slender, surrounded by well-developed circular musculature; pars refringens vaginae absent; pars distalis vaginae 7–9  $\mu\text{m}$  long. Prerectum 5.2–9.0 and rectum 1.2–1.5 times anal body diameter long. Tail short, bluntly conoid. Caudal pores two on each side.

#### Male

Not found.

#### Taxonomic remarks

The new species differs from all known species of *Axonchium* in its comparatively short posterior expanded part of the pharynx. However, it comes close to *A. nitidum* Jairajpuri, 1964 in its body size and tail shape, but differs from it in having a shorter pharynx ( $b = 3.3\text{--}3.7$  vs  $2.2\text{--}3.0$ ); anterior vulva position ( $V = 45\text{--}48$  vs  $52\text{--}53$ ); longer anterior uterine sac ( $G1 = 2.5\text{--}4.7$  vs  $0.8\text{--}1.3$  or  $0.9\text{--}1.6$  vs  $0.5$  times the corresponding body diameter long) and male not found (vs known).

In the body size and vaginal character, the new species also resembles *A. perplexans* Siddiqi, 1995 but differs in having a robust body ( $a = 34\text{--}38$  vs  $49\text{--}57$ ); shape of lip region (angular vs hemispheroid); shorter pharynx ( $b = 3.3\text{--}3.7$  vs  $2.8\text{--}3.0$ ); anterior vulva position ( $V = 45\text{--}48$  vs  $54\text{--}56$ ); longer anterior uterine sac ( $0.9\text{--}1.6$  times vs less than corresponding body diameter long); and tail shape (conoid vs hemispherical to clavate).

The new species also resembles *A. bulbosum* Williams, 1958 but differs in the shape of the lip region (angular lips vs with rounded outer and inner portion); shorter pharynx ( $b = 3.3\text{--}3.7$  vs  $2.4\text{--}2.9$ ); anterior vulva position ( $V = 45\text{--}48$  vs  $55\text{--}57$ ); slightly longer anterior uterine sac ( $G1 = 2.5\text{--}4.7$  vs  $1.7\text{--}2.3$  or  $0.9\text{--}1.6$  times vs shorter than corresponding body diameter long); the nature of the vagina (vaginal lumen slender, not enlarged vs distinctly enlarged with rounded or spheroid walls); and tail shape (conoid vs bulboid with extremely thick cuticle at terminus).

#### *Axonchium microspiculum* sp. nov.

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Figs 7–8, Table 6

#### Diagnosis

*Axonchium microspiculum* sp. nov. is characterized by its 1.1–1.22 mm long body; lip region offset by deep constriction; odontostyle fusiform, 7–8  $\mu\text{m}$  long; two parts of the pharynx separated by a deep constriction; anterior uterine sac 1.7–2.3 times the corresponding body diameter long; vulva transverse, vagina slightly bent posteriorly with distinct thickening in the middle; spicules short, slightly arcuate, 20–23  $\mu\text{m}$  long; lateral guiding pieces slightly curved dorsally with bifurcated distal end; two weakly developed ventromedian supplements and obtusely rounded tail.

#### Etymology

The new species is named *A. microspiculum* because of its characteristic small-sized spicules.

#### Material examined

##### Holotype

INDIA • ♀; Kerala State, Idukki District, Vagamon Hill;  $9^{\circ}41'10.25''$  N,  $76^{\circ}54'18.82''$  E; 10–15 cm depth; 31 Oct. 2017; roots of grasses (unidentified); slide reference number AMU/ZD/NC/*Axonchium microspiculum*/1.

### Paratypes

INDIA • 2 ♀♀, 4 ♂♂; same collection data as for holotype; slide reference number AMU/ZD/NC/*Axonchium microspiculum*/2–3 • 1 ♀, 2 ♂♂; same collection data as for holotype; slide reference number AMU/ZD/NC/*Axonchium microspiculum*/4, nematode collection of the Zoological Survey of India, Kolkata, India.

### Other material

INDIA • 4 ♀♀, 1 ♂; Kerala State, Thiruvananthapuram District, Ponmudi Hill; 8°45'37" N, 77°7'0" E; 10–15 cm depth; 4 Nov. 2017; roots of grasses (unidentified); slide reference number AMU/ZD/NC/*Axonchium microspiculum*/4–6.

### Type habitat and locality

Soil samples collected around the roots of the grasses (unidentified) from Vagamon Hill, Idukki District, Kerala State, India.

### Other habitat and locality

Soil samples collected around the roots of the grasses (unidentified) from Ponmudi Hill, Thiruvananthapuram District, Kerala State, India.

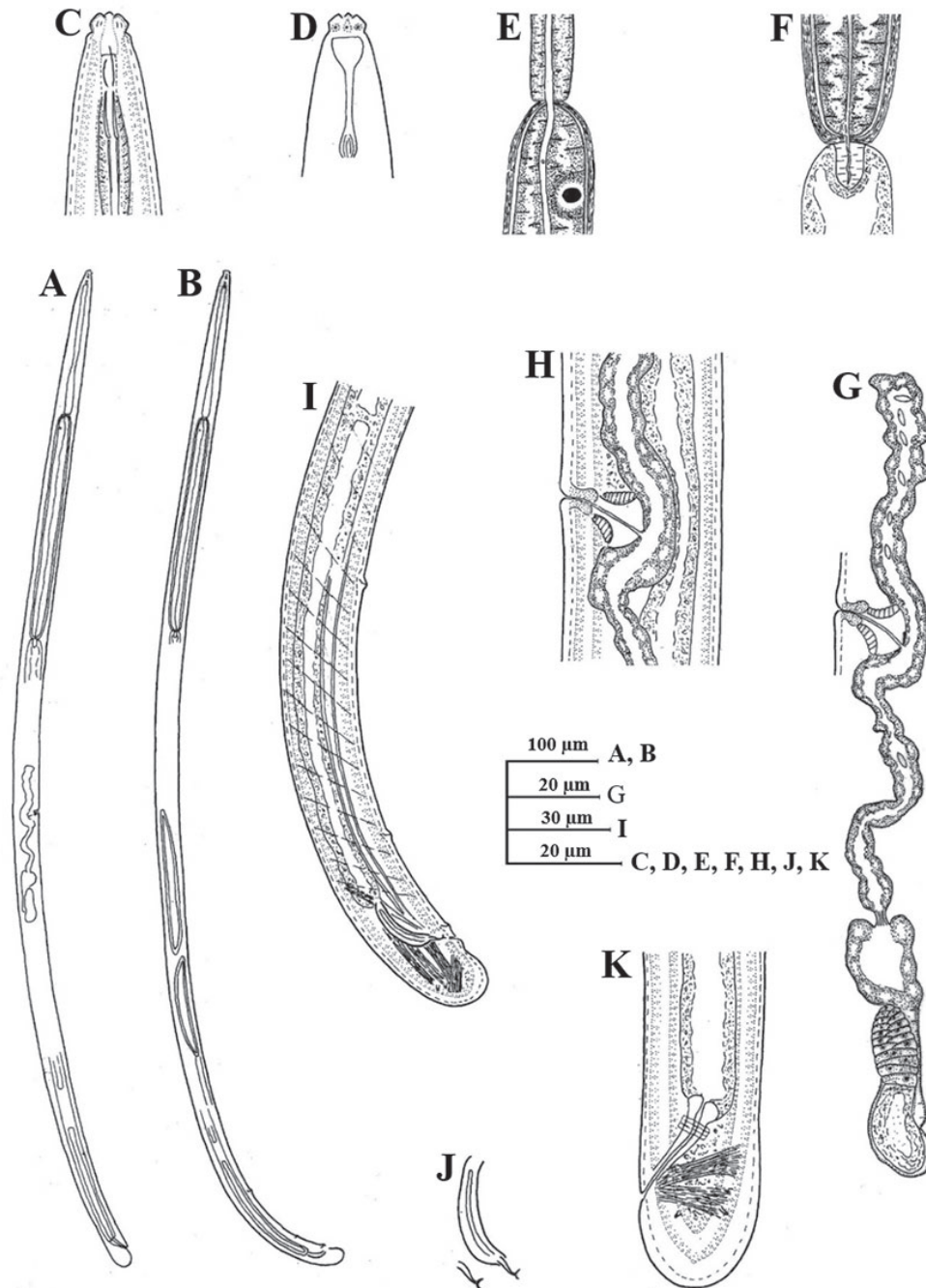
### Description

#### Female

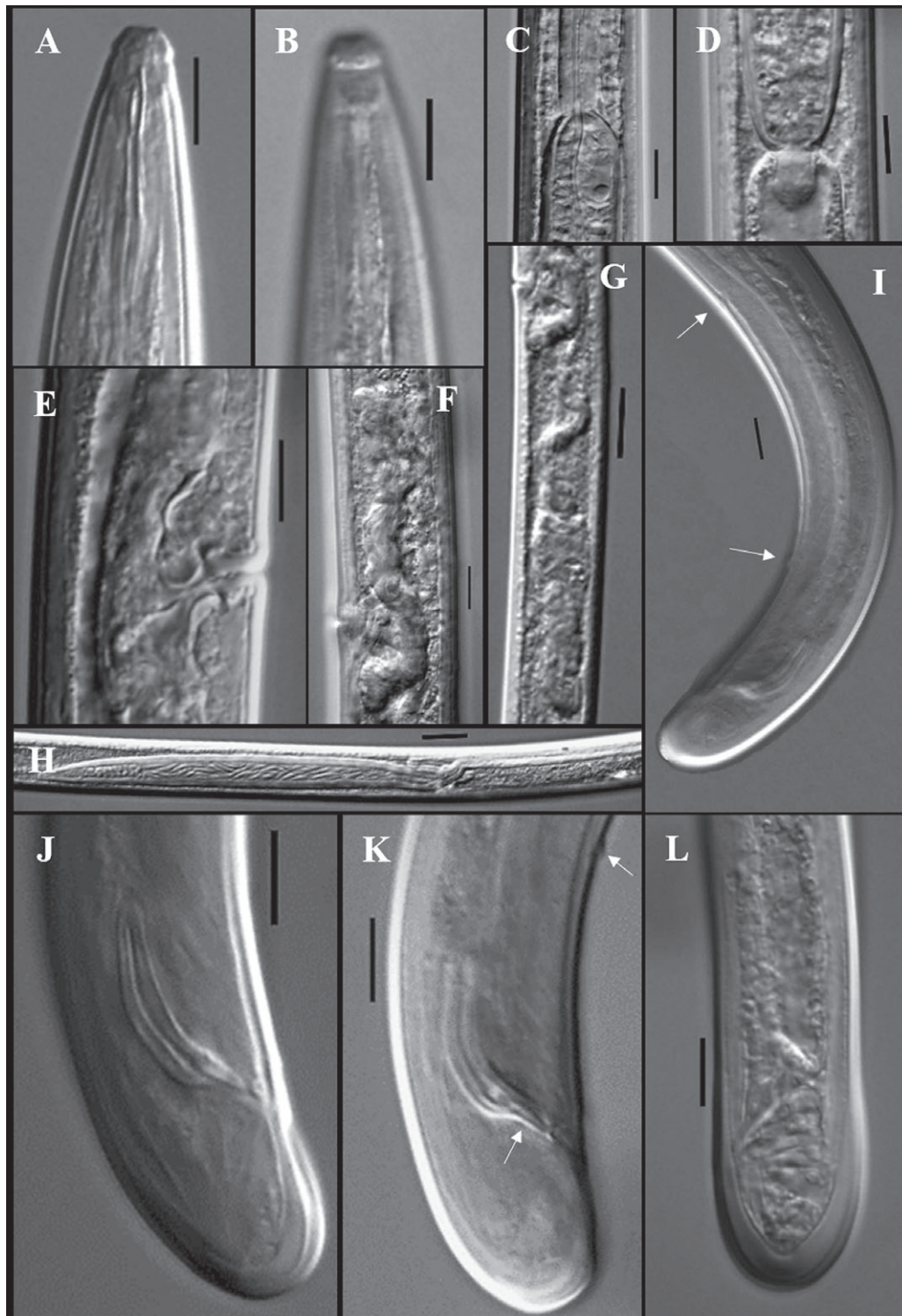
Body slightly curved ventrad upon fixation, 1.1–1.2 mm long. Cuticle with fine transverse striations, about 1 µm thick at anterior region, 1–2 µm at mid-body and 3–5 µm on tail tip. Lateral chords 2–4 µm wide, about  $\frac{1}{13}$  to  $\frac{1}{7}$  of mid-body diameter, glandular bodies indistinct. Lateral, dorsal and ventral body pores indistinct. Lip region high, offset by deep constriction, 1.7–2.1 times as wide as high, or about  $\frac{1}{4}$  to  $\frac{2}{7}$  (23–28%) of body diameter at neck base. Lips incompletely separate. Amphid fovea stirrup-shaped, their aperture occupying about 0.7–0.8 times lip region diameter, fusus slightly posterior to odontophore level. Guiding ring single, at 1.0–1.1 times lip region diameter from anterior end. Odontostyle fusiform, 3.5–5.0 times as long as wide, or 1.0–1.2 times lip region diameter long, its aperture occupying about  $\frac{1}{3}$  of its length. Odontophore simple, rod-like, 1.1–1.3 times as long as odontostyle. Nerve ring encircling anterior slender part of pharynx at 21–25% of neck length from the anterior end. Anterior slender part of pharynx quite muscular, separated from posterior expanded part by a deep constriction. Expanded part of pharynx 12.6–16.5 times as long as wide, or 8.9–10.6 times as long as body diameter at neck base, and occupying about  $\frac{1}{2}$  to  $\frac{2}{3}$  (57–64%) of total neck length, enclosed in a thick muscular sheath with straight bands. Only dorsal pharyngeal gland and its orifice visible: DO = 37–45; DN = 38.7–46.3; DO–DN = 0.7–1.6. Cardia oblong, 1.5–2.4 times as long as wide, occupying about  $\frac{1}{4}$  to  $\frac{2}{5}$  (25–41%) of corresponding body diameter.

Genital system mono-opisthodelphic. Anterior genital branch represented by simple uterine sac, measuring 47–65 µm or 1.7–2.3 times mid-body diameter long, and occupying about 4.0–5.9% of total body length, filled with a few scattered spindle-shaped sperms. Posterior branch well developed, strongly convoluted; ovary reflexed, not reaching oviduct-uterus junction, measuring 28–98 µm long with squamous shaped oocytes arranged in a single row except near tip; oviduct joining ovary subterminally, measuring 46–72 µm or 1.5–2.6 times mid-body diameter long, consisting of a long slender part with prismatic cells and a slightly wider pars dilatata with distinct lumen; a distinct sphincter present at oviduct-uterus junction; uterus 33–64 µm or 1.2–2.3 times mid-body diameter long, differentiated into a large proximal region with wide lumen, a long narrow intermediate region, and a spherical distal pars dilatata with distinct lumen. Vulva transverse. Vagina slightly

bent posteriorly with a constriction in middle, extending inwards about  $\frac{1}{2}$  to two-thirds (55–66%) of corresponding body diameter; vaginal wall not differentiated from body cuticle, but distinctly thickened in middle; pars proximalis vaginae longer than wide,  $9\text{--}11 \times 1.5\text{--}3 \mu\text{m}$ , with somewhat



**Fig. 7.** *Axonchium microspiculum* sp. nov. **A, C–H, K.** Holotype, ♀ (slide 1). **B, I–J.** Paratype 4, ♂ (slide 2). **A.** Entire female. **B.** Entire male. **C.** Anterior region. **D.** Anterior end showing amphid. **E.** Junction between anterior slender and posterior expanded part of pharynx. **F.** Cardia. **G.** Female genital system. **H.** Vulva. **I.** Male posterior region. **J.** Spicule and lateral guiding piece. **K.** Female posterior end.



**Fig. 8.** *Axonchium microspiculum* sp. nov. (LM photographs). **A–G, L.** Holotype, ♀ (slide 1). **H–K.** Paratype 4, ♂ (slide 2). **A.** Anterior region. **B.** Anterior end showing amphid. **C.** Junction between two parts of the pharynx. **D.** Cardia. **E.** Vulva and vagina. **F–G.** Female genital branches. **H.** Male testes. **I.** Ventromedian supplements. **J.** Male posterior end. **K.** Arrows showing lateral guiding piece and first ventromedian supplement. **L.** Female posterior end. Scale bars: A–G, I–L = 10 µm; H = 20 µm.



**Table 6.** Measurements of *Axonchium microspiculum* sp. nov. All measurements in  $\mu\text{m}$  except L in mm, and in the form: mean  $\pm$  s.d. (range).

Localities	Idukki population (type population)			Thiruvananthapuram population	
	Characters	Holotype female	Paratype females	Paratype males	Females
n	1	3	6	4	1
L	1.1	1.13 $\pm$ 0.1 (1.1–1.16)	1.2 $\pm$ 0.1 (1.14–1.3)	1.16 $\pm$ 0.1 (1.1–1.22)	1.16
a	39.5	40.1 $\pm$ 1.1 (38.6–41.4)	46.7 $\pm$ 1.9 (42.4–48.2)	42.7 $\pm$ 2.0 (40–45.3)	48.3
b	2.6	2.6 $\pm$ 0.1 (2.5–2.7)	3.0 $\pm$ 0.2 (2.6–3.2)	2.7 $\pm$ 0.1 (2.6–2.8)	3.2
c	55.4	61.6 $\pm$ 2.1 (59.4–64.3)	63.8 $\pm$ 3.5 (57.3–67.9)	65.7 $\pm$ 4.9 (59.7–71.9)	57.9
c'	0.9	0.9 $\pm$ 0.1 (0.8–0.95)	0.9 $\pm$ 0.1 (0.8–1)	0.9 $\pm$ 0.1 (0.8–0.9)	1.0
V	54.7	54.2 $\pm$ 0.3 (54–55)	–	54.4 $\pm$ 1.6 (53–56)	–
G1	5.9	5.4 $\pm$ 0.3 (5.0–5.7)	–	4.5 $\pm$ 0.4 (4.0–5.1)	–
G2	13	10.7 $\pm$ 0.8 (10–11.9)	–	9.9 $\pm$ 0.5 (9.2–10.4)	–
Body diam. at pharynx base	28	28.3 $\pm$ 0.5 (28–29)	27.7 $\pm$ 0.5 (27–28)	26.5 $\pm$ 0.9 (25–27)	25
Body diam. at mid-body	28	28.7 $\pm$ 0.9 (28–30)	26.14 $\pm$ 1.0 (24–27)	27.2 $\pm$ 0.4 (27–28)	24
Body diam. at anus/cloaca	21	21 $\pm$ 0.8 (20–22)	21 $\pm$ 0.8 (20–22)	20 $\pm$ 0.7 (19–21)	21
Lip region diam.	7	6.8 $\pm$ 0.2 (6–7)	7.2 $\pm$ 0.2 (7–8)	7	8
Lip region height	4	3.7 $\pm$ 0.5 (3–4)	4	4	4
Amphid aperture	5	5.3 $\pm$ 0.5 (5–6)	5.5 $\pm$ 0.4 (5–6)	5.25 $\pm$ 0.4 (5–6)	5
Odontostyle length	8	7.6 $\pm$ 0.5 (7–8)	8	7.5 $\pm$ 0.5 (7–8)	7
Odontophore length	9	9.3 $\pm$ 0.5 (9–10)	9.1 $\pm$ 0.4 (9–10)	9.5 $\pm$ 0.5 (9–10)	10
Guiding ring from ant. end	7	7	6.9 $\pm$ 0.5 (6–8)	7.2 $\pm$ 0.4 (7–8)	7
Nerve ring from ant. end	100	103.5 $\pm$ 1.5 (102–105)	106.8 $\pm$ 3.1 (103–112)	100 $\pm$ 10.6 (85–108)	114
Neck length	433	443 $\pm$ 13.9 (429–462)	407 $\pm$ 14.7 (388–432)	429 $\pm$ 19.2 (402–456)	367
Expanded part of pharynx	272	274 $\pm$ 16.3 (261–297)	230.7 $\pm$ 19.3 (210–263)	253.7 $\pm$ 14.2 (240–277)	184
Cardia length	10	9.0 $\pm$ 2.2 (7–12)	9.2 $\pm$ 0.7 (8–10)	7.2 $\pm$ 1.6 (5–9)	8
Anterior genital branch	65	61.7 $\pm$ 2.6 (58–64)	–	53 $\pm$ 6.0 (47–62)	–
Posterior genital branch	145	123.3 $\pm$ 7.7 (116–134)	–	114.7 $\pm$ 7.3 (108–127)	–
Vaginal depth	17	17.7 $\pm$ 17.7 (17–19)	–	16.5 $\pm$ 1.5 (15–18)	–
Vulva from ant. end	606	622.3 $\pm$ 4.6 (616–627)	–	633.7 $\pm$ 24.6 (605–662)	–
Prerectum length	142	134.7 $\pm$ 5.4 (127–139)	176.8 $\pm$ 25 (142–215)	129.2 $\pm$ 8.8 (120–139)	105
Rectum length	21	22.7 $\pm$ 0.5 (22–23)	31 $\pm$ 1.4 (28–32)	23.5 $\pm$ 2.3 (20–26)	26
Tail length	20	18.7 $\pm$ 0.5 (18–19)	19.3 $\pm$ 0.7 (18–20)	20 $\pm$ 0.7 (19–21)	20
Spicule length	–	–	21.5 $\pm$ 1.0 (20–23)	–	22
Lateral guiding pieces	–	–	6.0 $\pm$ 0.8 (5–7)	–	7
Ventromedian supplements	–	–	2	–	2

concave walls surrounded by well developed circular musculature; pars refringens vaginae absent; pars distalis vaginae 6–8  $\mu\text{m}$  long. Prerectum 6.0–7.3 and rectum 1.0–1.3 times anal body diameter long. Tail short, obtusely rounded. Caudal pores two on each side.

### Male

Similar to female in general morphology, except for posterior region of body being more curved ventrad. Genital system diorchic, with oppositely outstretched testes, surrounded by a thick muscular wall; sperms elongate spindle-shaped, measuring  $9\text{--}11 \times 2 \mu\text{m}$ . In addition to adcloacal pair, located at 4–5  $\mu\text{m}$  from cloacal aperture, with two widely spaced and weakly developed ventromedian supplements, first at 30–41  $\mu\text{m}$  from adcloacal pair, and the second at 62–75  $\mu\text{m}$  from first supplement. Copulatory muscles less conspicuous, beginning from level of middle of spicules and continuing until the level of last supplement. Spicules slightly arcuate, slender and weakly developed; total length along arc 1.0–1.1 times as long as chord, 5.0–5.8 times maximum width, or about equal to the body diameter at cloacal aperture. Curvature about  $130\text{--}150^\circ$ . Dorsal contour regularly convex, except its distal end being slightly curved ventrally; ventral contour concave, without distinct hump; head short, with rounded ends, occupying 4.8–9.5% of spicule total length; median piece simple with rounded proximal end, 19–21 times as long as wide and occupying 25% of spicule maximum width; posterior end 2–3  $\mu\text{m}$  wide. Lateral guiding pieces lightly sclerotized, slightly curved dorsally with bifurcate distal end, about 5–7 times as long as wide or about  $\frac{1}{5}$  to  $\frac{1}{3}$  of spicules length. Prerectum long, 5.0–10.8 and rectum 1.2–1.6 times cloacal body diameter long. Tail similar to than in female but having slight depression on ventral side. Caudal pores two on each side.

### Taxonomic remarks

In the presence of only two ventromedian supplements, the new species comes close to *A. vallum* Ahmad & Jairajpuri, 1982, *A. siddiqii* Coomans & Nair, 1975 and *A. noreasum* Naz & Ahmad, 2012 but differs from the former mainly in having a shorter body length (1.1–1.2 vs 1.6–1.95 mm long); indistinct glandular bodies (vs distinct); shorter odontostyle (7–8 vs 10–12  $\mu\text{m}$ ); shorter odontophore (9–10 vs 13–14  $\mu\text{m}$ ); in the nature of the spicules (20–23  $\mu\text{m}$  long with regularly arcuate ventral arm without hump vs 50–57  $\mu\text{m}$  long with prominent hump), median piece with blunt end in head region (vs simple, ending with a very sharply pointed projection); shorter and slender lateral guiding pieces, slightly curved dorsally (5–7  $\mu\text{m}$  vs 14–16  $\mu\text{m}$  long and robust, slightly bent ventrally in middle) and differently shaped tail (obtusely rounded vs hemispherical).

From *A. siddiqii* it differs in the shape of the lip region (outer and inner lip depression indistinct vs inner lips rounded amalgamated and outer lips demarcated by a depression); posterior vulva position ( $V = 53\text{--}56$  vs  $52\text{--}52.5$ ); in shape and size of the vagina (15–19  $\mu\text{m}$  long and slightly bent posteriorly with a constriction in the middle vs 25–28  $\mu\text{m}$  long and highly bent posteriad, regularly narrowing toward the uterus); in the shape and size of spicules (vs 32  $\mu\text{m}$  long, simple arcuate, with proximal slender part about  $\frac{1}{3}$  of total spicule length with slightly curved ends), in the nature of the median pieces (vs ending with a long sharp pointed projection) and in the shape and size of the lateral guiding pieces (5–7  $\mu\text{m}$ , slightly curved dorsally vs 10  $\mu\text{m}$  long, slightly bent ventrally).

From *A. noreasum*, it differs in the shape of the vagina (vagina slightly bent posteriad vs strongly bent posteriad); mainly in the shape and size of spicules (vs 30–36  $\mu\text{m}$  with proximal slender part about  $\frac{2}{5}$  of the total spicule length, and distal part comparatively robust and slightly arcuate), in the shape of the median piece (vs expanded in the middle and ending in a long pointed projection in slender part of spicules); in the shape and size of the lateral guiding pieces (5–7  $\mu\text{m}$  long, slightly curved dorsally vs 8–13  $\mu\text{m}$  long, almost straight) and the cuticle thickening on the tail terminus (3–5 vs 6–8  $\mu\text{m}$ ).

*Axonchium nilgiriense* sp. nov.

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Figs 9–10, Table 7

**Diagnosis**

*Axonchium nilgiriense* sp. nov. is characterized by having a 1.4–1.6 mm long body; lip region offset; amphids stirrup-shaped; odontostyle fusiform, 8–9  $\mu\text{m}$  long; two parts of the pharynx separated by deep constriction; anterior uterine sac, 2.6–4.1 times the mid-body diameter long; vulva transverse, vagina strongly bent posteriad, almost as deep as corresponding body diameter; spicules robust, strongly arcuate, 37–41  $\mu\text{m}$  long; lateral guiding pieces arcuate, 15–16  $\mu\text{m}$  long with thickened distal end; 3–4 widely spaced ventromedian supplements, beginning at just in front of proximal end of the spicules and tail bluntly conoid with rounded terminus.

**Etymology**

The new species is named after its type locality.

**Material examined**

**Holotype**

INDIA • ♀; Tamil Nadu State, Nilgiri District, Mudumalai National Park; 11°35'0" N, 76°33'0" E; 10–15 cm depth; 14 Nov. 2016; roots of grasses (unidentified); slide reference number AMU/ZD/NC/*Axonchium nilgiriense*/1.

**Paratypes**

INDIA • 5 ♀♀, 1 ♂; same collection data as for holotype; slide reference number AMU/ZD/NC/*Axonchium nilgiriense*/2–5 • 3 ♀♀, 2 ♂♂; same collection data as for holotype; slide reference number AMU/ZD/NC/*Axonchium nilgiriense*/6–7, nematode collection of the Zoological Survey of India, Kolkata, India.

**Type habitat and locality**

Soil samples collected around the roots of grasses (unidentified) from Mudumalai National Park, Nilgiri District, Tamil Nadu State, India.

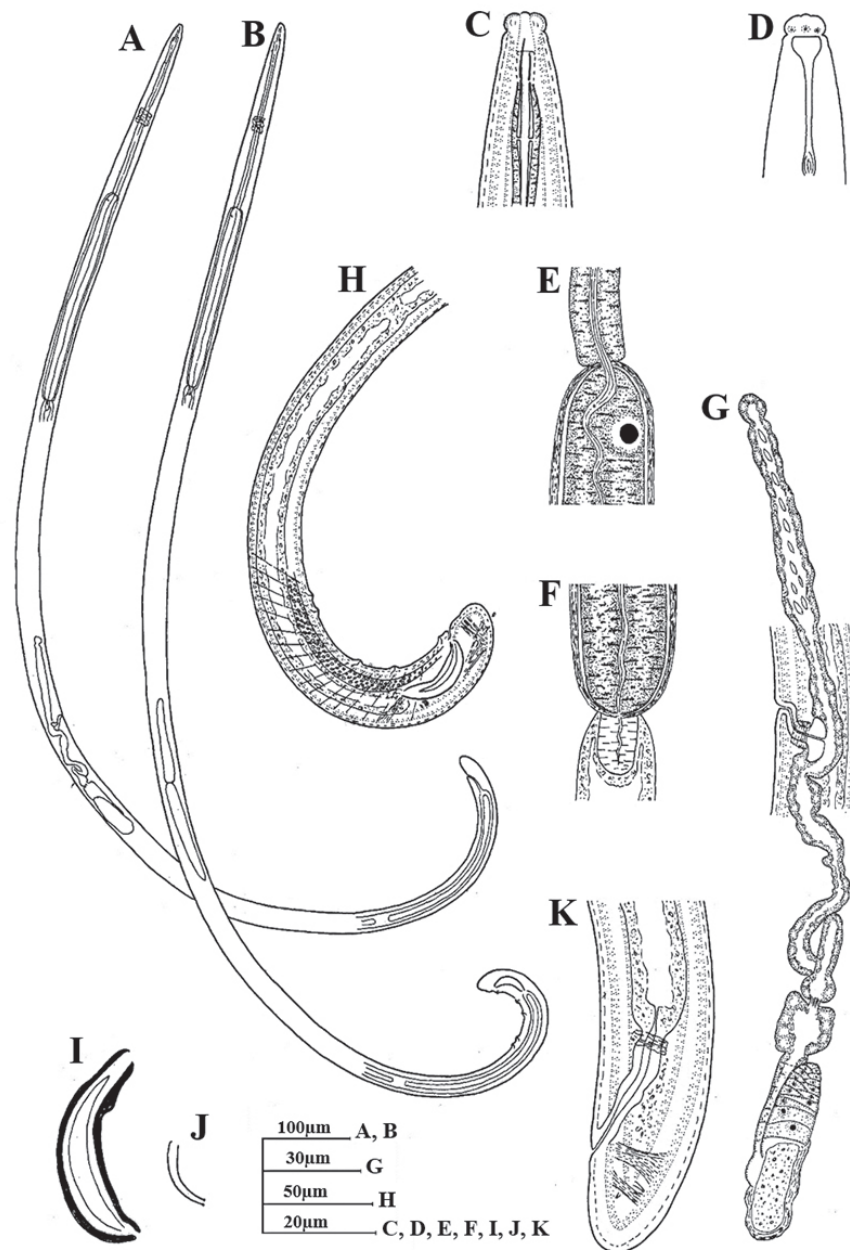
**Description**

**Female**

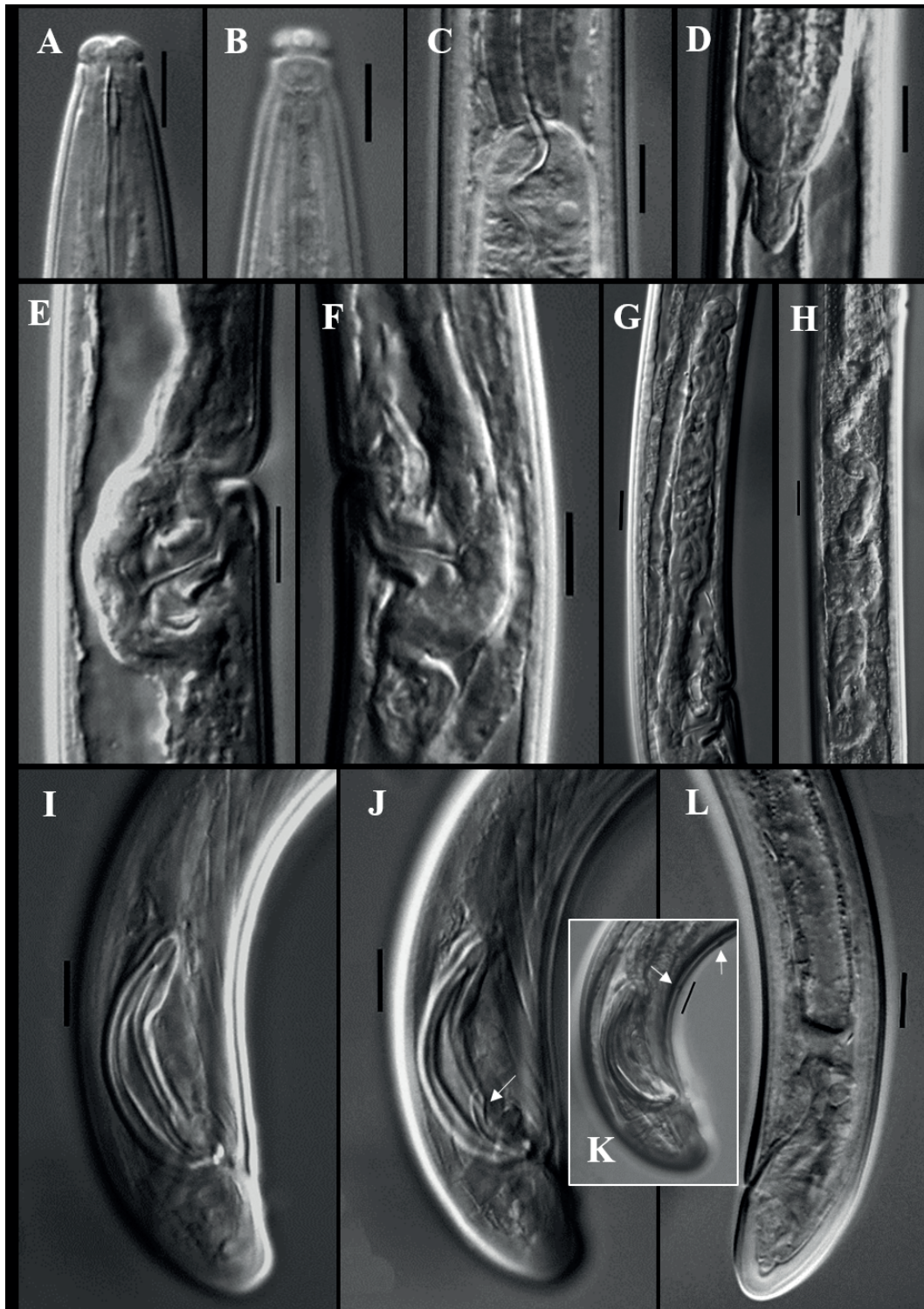
Body slender, curved ventrad upon fixation, 1.4–1.6 mm long. Cuticle with fine transverse striations, about 1  $\mu\text{m}$  thick at anterior region, 2  $\mu\text{m}$  at mid-body, 4–5  $\mu\text{m}$  on tail tip in females and 3–4  $\mu\text{m}$  in males. Lateral chords 3–5  $\mu\text{m}$  wide, about  $\frac{1}{10}$  to  $\frac{1}{5}$  (10–18%) of mid-body diameter, with weakly developed glandular bodies in posterior region, 10–18 in number. Lateral, dorsal and ventral body pores indistinct. Lip region distinctly offset, twice as wide as high, or about  $\frac{1}{4}$  to slightly less than  $\frac{1}{3}$  (25–30%) of body diameter at neck base. Lips high, bluntly conoid and separate. Amphid fovea stirrup-shaped, their aperture occupying about 0.6–0.8 times lip region diameter, fusus posterior to odontophore level. Guiding ring single, at 0.6–1.0 times lip region diameter from anterior end. Odontostyle fusiform, 3.5–5.3 times as long as wide, or 0.9–1.1 times lip region diameter long, its aperture occupying about  $\frac{1}{3}$  of its length. Odontophore simple, rod-like, 1.1–1.6 times as long as odontostyle. Nerve ring encircling anterior slender part of pharynx at 18–24% of neck length from anterior end. Anterior slender part of pharynx quite muscular, separated from posterior expanded part by a deep constriction. Expanded part of pharynx 14–22 times as long as wide, or 9.3–14 times as long as body diameter at neck base, and occupying about  $\frac{1}{2}$  to two-thirds (54–64%) of total neck length, enclosed in a thick muscular sheath with straight bands. Only dorsal pharyngeal gland and its orifice visible: DO = 37.8–49.2; DN = 38.8–49.4;

DO–DN = 0.2–1.2. Cardia oblong, 1.4–2.0 times as long as wide, occupying about  $\frac{1}{3}$  to  $\frac{1}{2}$  (34–46%) of corresponding body diameter.

Genital system mono-opisthodelphic. Anterior genital branch represented by a simple uterine sac with slight proximal constriction, measuring 76–111  $\mu\text{m}$  or 2.6–4.1 times corresponding body diameter long,



**Fig. 9.** *Axonchium nilgiriense* sp. nov. **A, C–F, G, K.** Paratype 4, ♀ (slide 4). **B, H–J.** Paratype 5, ♂ (slide 4). **A.** Entire female. **B.** Entire male. **C.** Anterior region. **D.** Anterior end showing amphid. **E.** Junction between anterior slender and posterior expanded part of pharynx. **F.** Cardia. **G.** Female genital system. **H.** Male posterior region. **I.** Spicule. **J.** Lateral guiding pieces. **K.** Female posterior end.



**Fig. 10.** *Axonchium nilgiriense* sp. nov. (LM photographs). A–D. Paratype ♀, (slide 2). E. Paratype 4, ♀. I–K. Paratype 5, ♂ (slide 4). F–H, L. Paratype 6, ♀ (slide 5). A. Anterior region. B. Anterior end showing amphid. C. Junction between two parts of the pharynx. D. Cardia. E–F. Vulva and vagina. G–H. Female genital branches. I. Male posterior end. J. Arrow indicating lateral guiding piece. K. Arrows indicating ventromedian supplements. L. Female posterior end. Scale bars = 10 µm.

**Table 7.** Measurements of *Axonchium nilgiriense* sp. nov. All measurements in  $\mu\text{m}$  except L in mm, and in the form: mean  $\pm$  s.d. (range).

Characters	Holotype female	Paratype females	Paratype males
n	1	8	3
L	1.55	1.5 $\pm$ 0.1 (1.4–1.6)	1.6 $\pm$ 0.1 (1.5–1.7)
a	55.5	54.5 $\pm$ 4.5 (46.7–60.6)	57.6 $\pm$ 1.8 (55–60)
b	2.8	3.0 $\pm$ 0.3 (2.6–3.4)	3.4 $\pm$ 0.2 (3.16–3.7)
c	74	73.0 $\pm$ 2.8 (66.4–76.6)	78.8 $\pm$ 5.4 (71.3–83.6)
c'	1.0	1.1 $\pm$ 0.1 (0.9–1.2)	0.8 $\pm$ 0.1 (0.7–0.9)
V	52	52.3 $\pm$ 1.0 (51–54)	–
G1	5.7	5.8 $\pm$ 0.6 (5.0–6.8)	–
G2	11	10.8 $\pm$ 1.0 (9.2–12.5)	–
Body diam. at pharynx base	26	27.9 $\pm$ 1.4 (26–31)	27
Body diam. at mid-body	28	28.2 $\pm$ 1.6 (27–32)	27.3 $\pm$ 0.9 (26–28)
Body diam. at anus/cloaca	21	19.6 $\pm$ 0.5 (19–20)	24.7 $\pm$ 0.5 (24–25)
Lip region diam.	8	7.9 $\pm$ 0.3 (7–8)	8
Lip region height	4	4	4
Amphid aperture	6	5.6 $\pm$ 0.4 (5–6)	5.5 $\pm$ 0.5 (5–6)
Odontostyle length	8	8.0 $\pm$ 0.5 (7–9)	8
Odontophore length	11	10.9 $\pm$ 0.3 (10–11)	10.67 $\pm$ 0.5 (10–11)
Guiding ring from ant. end	7	6.4 $\pm$ 0.7 (5–7)	7
Nerve ring from ant. end	105	110.9 $\pm$ 3.9 (104–115)	110.3 $\pm$ 7.8 (100–119)
Neck length	564	511.1 $\pm$ 43.1 (445–574)	460.3 $\pm$ 22.6 (437–491)
Expanded part of pharynx	366	307.3 $\pm$ 43.5 (241–367)	251.3 $\pm$ 25.6 (225–286)
Cardia length	11	11.1 $\pm$ 0.9 (10–12)	11.3 $\pm$ 0.9 (10–12)
Anterior genital branch	88	89.7 $\pm$ 10.7 (76–111)	–
Posterior genital branch	171	164.3 $\pm$ 11.3 (147–182)	–
Vaginal depth	22	22.9 $\pm$ 1.7 (21–26)	–
Vulva from ant. end	804	801.3 $\pm$ 43.2 (738–865)	–
Prerectum length	–	201.4 $\pm$ 27.7 (142–239)	214 $\pm$ 4.0 (210–218)
Rectum length	30	28.8 $\pm$ 2.9 (24–33)	40.3 $\pm$ 2.1 (38–43)
Tail length	21	21 $\pm$ 1.4 (19–24)	20 $\pm$ 0.8 (19–21)
Spicule length	–	–	39.3 $\pm$ 1.7 (37–41)
Lateral guiding pieces	–	–	15.3 $\pm$ 0.5 (15–16)
Ventromedian supplements	–	–	3–4

and occupying about 5.0–6.7% of total body length; mostly containing spindle-shaped sperms. Posterior branch well developed; ovary reflexed, not reaching oviduct-uterus junction, measuring 44–120  $\mu\text{m}$  long with squamous shaped oocytes arranged in a single row except near tip; oviduct joining ovary subterminally, 45–92  $\mu\text{m}$  or 1.6–3.4 times mid-body diameter long, consisting of a long slender part with prismatic cells and a wide pars dilatata with distinct lumen; oviduct-uterus junction marked by a sphincter; uterus 40–108  $\mu\text{m}$  or 1.3–4.0 times mid-body diameter long, differentiated into a relatively

long proximal region with wide lumen, a narrow intermediate region, and a large spherical distal pars dilatata with distinct lumen. Vulva transverse with wide opening. Vagina bent posteriorly at the right angle with constriction in middle, extending inwards about two-thirds to almost as deep as (70–93%) corresponding body diameter, vaginal walls thick, not differentiated from body cuticle; pars proximalis vaginae longer than wide, 7–12 × 2–4 µm, surrounded by circular muscles; pars refringens absent; pars distalis 12–14 µm long. Prerectum 7–12 and rectum 1.2–1.7 times anal body diameter long. Tail bluntly conoid with rounded terminus. Caudal pores two on each side.

### Male

Similar to females in general morphology, except for posterior region of body being more curved ventrad. Genital system diorchic, with oppositely outstretched testes; sperms spindle-shaped, measuring 5–6.2 µm. In addition to adcloacal pair, located at 5–7 µm from cloacal aperture, 3–4 weakly developed, spaced ventromedian supplements, beginning just in front of proximal end of spicule; first located at 26–31 µm from adcloacal pair, second at 16–18 µm from first, third at 29–38 µm from second and fourth at 9–11 µm from third ventromedian supplement. Copulatory muscles conspicuous, beginning from level of middle of spicules and continuing until the level of last supplements. Spicules robust, strongly arcuate, total length along arc 1.0–1.1 times as long as chord, or 4.1–5.2 times maximum width, and 1.5–1.6 times body diameter at cloacal aperture. Curvature about 113°–124°. Dorsal contour regularly convex; ventral contour concave, with prominent hump located at 27–28% of spicule total length from its anterior end; head 3–6 µm long, occupying about 8–15% of total spicule length; median piece simple, 8.5–13.3 times as long as wide, and occupying about 30–57% of spicule maximum width; posterior end 3–4 µm wide, bent ventrally. Lateral guiding pieces lightly sclerotized, ventrally arcuate with thickened distal end, about 8–10 times as long as wide or 1/3 to 2/5 of spicule length. Prerectum 8.4–8.7 and rectum 1.5–1.7 times cloacal body diameter long. Tail less conoid, having slight depression on ventral side, bluntly truncated terminus. Caudal pores two on each side.

### Taxonomic remarks

The new species comes close to *A. elegans* Jairajpuri, 1964 and *A. parasaccatum* Rahman, Jairajpuri & Ahmad, 1985 in general body morphology, but it distinctly differs in the nature of the vagina (vagina almost as deep as corresponding body diameter vs about 1/2); strongly arcuate spicules with curved posterior ends (vs spicules slightly arcuate and unusually wide with blunt distal end); shape of lateral guiding pieces (arcuate vs almost straight to slightly curved) and tail shape (bluntly conoid vs obtusely rounded).

From *A. parasaccatum*, it differs in having a shorter body (1.4–1.6 vs 1.87–1.9 mm); narrower lip region (7–8 vs 9–10 µm wide); shorter odontostyle (8–9 vs 10–11 µm); shorter expanded part of pharynx (54–64 vs 67–69% of total neck length); anterior vulva position (V = 51–54 vs 58–60); arrangements of ventromedian supplements (beginning just in front of proximal end of spicules vs anterior to proximal end of spicules); in having short robust, strongly arcuate spicules (37–41 vs 49–53 µm long, comparatively less arcuate and slender spicules); in nature of lateral guiding pieces (arcuate with thickened distal end vs almost straight with bifurcated distal end) and tail shape (bluntly conoid with rounded terminus vs hemispheroid).

The new species also resembles *A. cooverkollii* Dhanam & Jairajpuri, 1998 in its posterior inclined vagina, long anterior uterine sac and arrangements of ventromedian supplements, but differs in having a longer body (1.4–1.6 vs 1.1–1.3 mm long); longer and strongly arcuate spicules (37–41 vs 30 µm long, relatively less arcuate); lower number of ventromedian supplements (3–4 vs 6); lateral guiding pieces large and ventrally arcuate (15–16 vs 9 µm long, rod-shaped with blunt ends); and in tail shape (bluntly conoid with rounded terminus vs broadly rounded).

*Axonchium paracingulatum* sp. nov.

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Figs 11–12, Table 8

**Diagnosis**

*Axonchium paracingulatum* sp. nov. is characterized by having a 2.5–2.8 mm long body; lip region offset by constriction; odontostyle fusiform, 10–11  $\mu\text{m}$  long; both parts of the pharynx separated by deep constriction; anterior uterine sac 1.6–2.2 times mid-body diameter long; vaginal lumen highly expanded in the middle, somewhat diamond-shaped in lateral view; male with 69  $\mu\text{m}$  long and massive spicules; lateral guiding pieces slightly ventrally arcuate, 21  $\mu\text{m}$  long with bifurcated distal ends; seven irregularly spaced ventromedian supplements, beginning just in front of proximal end of spicules and tail broadly conoid with rounded terminus.

**Etymology**

The new species is named *A. paracingulatum* because of its resemblance with *A. cingulatum* Nair, 1973.

**Material examined**

**Holotype**

INDIA • ♀; Maharashtra State, Sangli District, Chandoli National Park; 17°11'30" N, 73°46'30" E; 10–15 cm depth; 14 Apr. 2016; roots of grasses (unidentified); slide reference number AMU/ZD/NC/*Axonchium paracingulatum* /1.

**Paratypes**

INDIA • 3 ♀♀, 1 ♂; same collection data as for holotype; slide reference number AMU/ZD/NC/*Axonchium paracingulatum*/2–3; nematode collection of the Zoological Survey of India, Kolkata, India.

**Type habitat and locality**

Soil samples collected around the roots of grasses (unidentified) from Chandoli National Park, Sangli District, Maharashtra State, India.

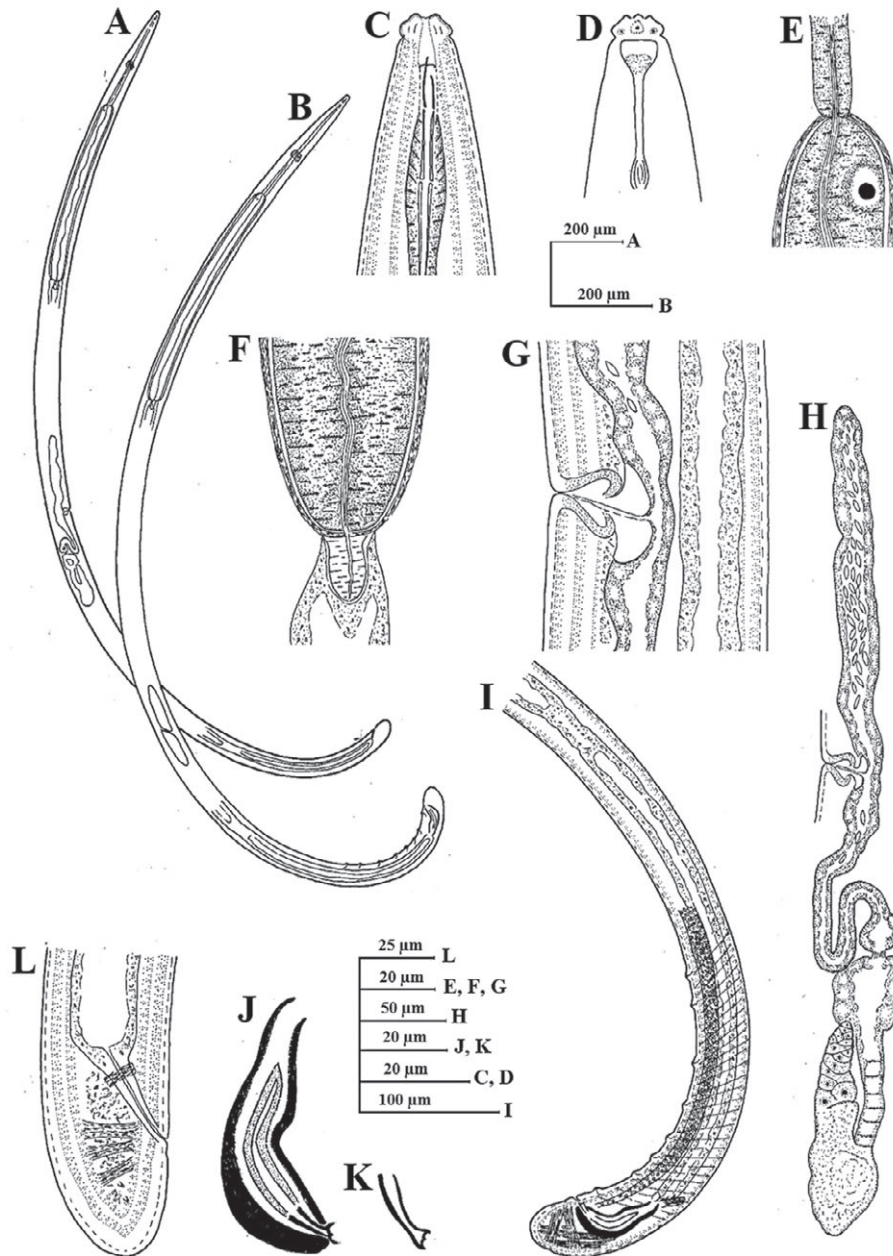
**Description**

**Female**

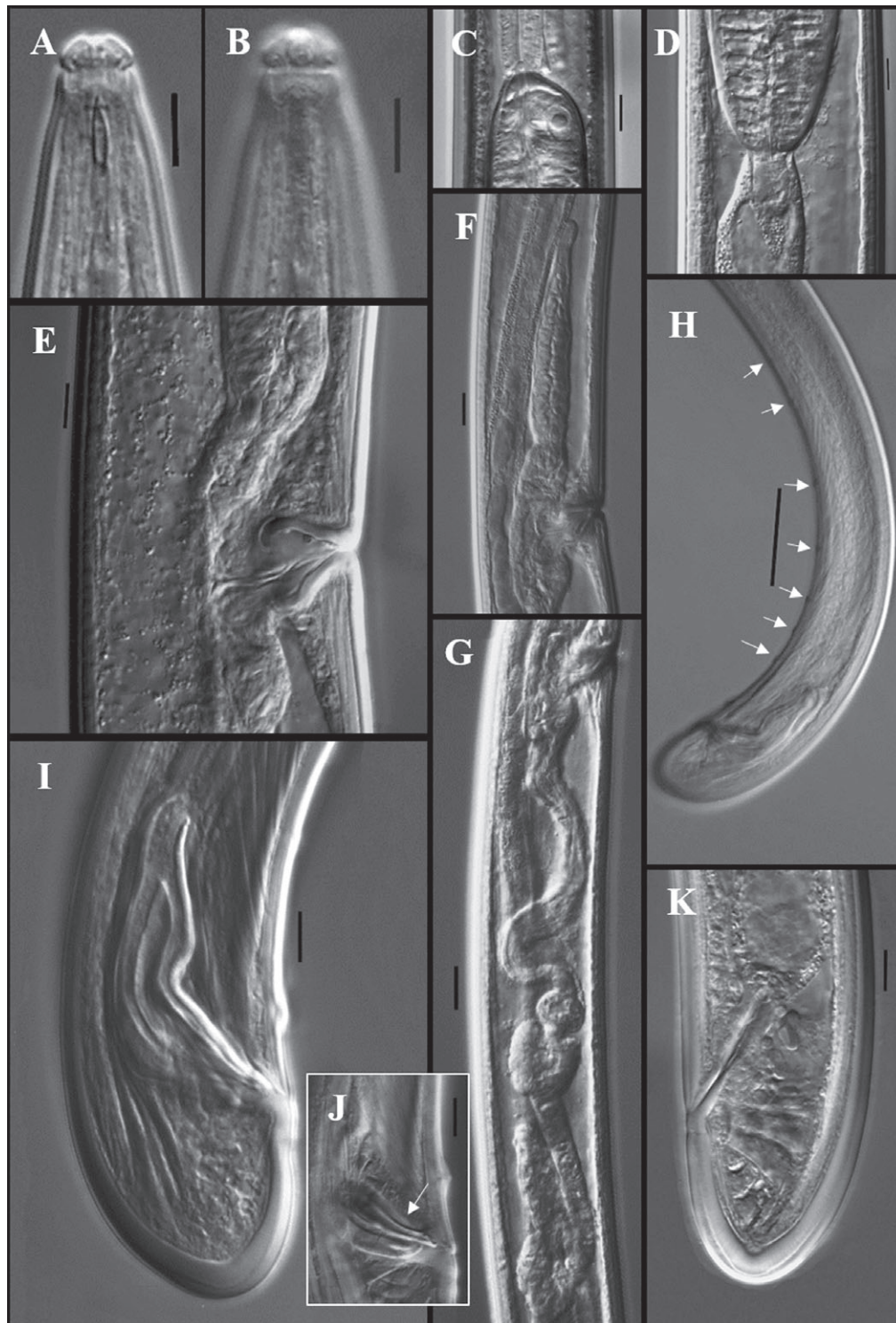
Body curved ventrad upon fixation, 2.5–2.8 mm long. Cuticle with fine transverse striations, about 2  $\mu\text{m}$  thick at anterior region, 2–3  $\mu\text{m}$  at mid-body and 6–7  $\mu\text{m}$  on tail tip. Lateral chords 6–9  $\mu\text{m}$  wide, about  $\frac{1}{9}$  to  $\frac{1}{7}$  (11–13.6%) of mid-body diameter. Lateral, dorsal and ventral body pores indistinct. Lip region distinctly offset, twice as wide as high, or about  $\frac{1}{7}$  to  $\frac{1}{5}$  (14–19%) of body diameter at neck base. Lips high, less conoid, outer and inner portions demarcated by slight depression. Amphid fovea stirrup-shaped, their aperture occupying about 0.6–0.7 times lip region diameter, fusus just opposite to odontophore level. Guiding ring single, at 0.9–1.0 times lip region diameter from anterior end. Odontostyle fusiform, 5.0–5.5 times as long as wide, or 1.0–1.1 times lip region diameter long, its aperture about  $\frac{1}{3}$  of its length. Odontophore simple, rod-like, 1.2–1.4 times as long as odontostyle. Nerve ring encircling anterior slender part of pharynx at 19–22% of neck length from anterior end. Anterior slender part of pharynx quite muscular, separated from posterior expanded part by a deep constriction. Expanded part of pharynx 12–15 times as long as wide, or 8.0–10 times longer than body diameter at neck base, and occupying about  $\frac{2}{3}$  (63–67%) of total neck length, enclosed in a thick muscular sheath with straight muscular bands. Only dorsal pharyngeal gland and its orifice visible: DO = 34–38; DN = 35.5–38.3; DO–DN = 0.1–0.9. Cardia oblong, 1.3–1.6 times as long as wide, occupying about  $\frac{1}{4}$  to  $\frac{1}{3}$  (24–30%) of corresponding body diameter.



Genital system mono-opisthodelphic. Anterior genital branch represented by a simple uterine sac with a slight proximal constriction, measuring 152–221  $\mu\text{m}$  or 2.5–3.3 times corresponding body diameter long, and occupying about 5.8–7.8% of total body length; mostly containing ovoid sperms. Posterior branch well developed; ovary reflexed, not reaching oviduct-uterus junction, measuring 94–201  $\mu\text{m}$  long with squamous shaped oocytes arranged in a single row except near tip; oviduct joining ovary subterminally,



**Fig. 11.** *Axonchium paracingulatum* sp. nov. A, H. Holotype ♀ (AMU/ZD/*Axonchium paracingulatum* sp. nov. /1). B, I–K. Paratype 1, ♂ (slide 2). C–G, L. Paratype 3, ♀ (slide 2). A. Entire female. B. Entire male. C. Anterior region. D. Anterior end showing amphid. E. Junction between anterior slender and posterior expanded part of pharynx. F. Cardia. G. Vulva. H. Female genital system. I. Male posterior region. J. Spicule. K. Lateral guiding piece. L. Female posterior end.



**Fig. 12.** *Axonchium paracingulatum* sp. nov. (LM photographs). **A–G, K.** Paratype 3, ♀ (slide 3). **H–J.** Paratype 2, ♂ (slide 2). **A.** Anterior region. **B.** Anterior end showing amphid. **C.** Junction between two parts of the pharynx. **D.** Cardia. **E.** Vulva and vagina. **F–G.** Female genital branches. **H.** Ventromedian supplements. **I.** Male posterior end. **J.** Arrow indicating lateral guiding piece and distal end of spicule. **K.** Female posterior end. Scale bars: A–E, I–K = 10 µm; F–G = 20 µm; H = 50 µm.

**Table 8.** Measurements of *Axonchium paracingulatum* sp. nov. All measurements in  $\mu\text{m}$  except L in mm, and in the form: mean  $\pm$  s.d. (range) for females.

Characters	Holotype female	Paratype females	Paratype male
n	1	3	1
L	2.6	2.7 $\pm$ 0.1 (2.5–2.8)	2.1
a	43.7	44 $\pm$ 1.8 (42.7–46.6)	47
b	3.6	3.3 $\pm$ 0.1 (3.2–3.4)	3
c	80.6	62.4 $\pm$ 2.3 (60.2–65.7)	51.5
c'	0.7	0.9 $\pm$ 0.1 (0.9–1.0)	0.9
V	52	52.7 $\pm$ 0.4 (52.2–53.1)	–
G1	5.9	7.2 $\pm$ 0.6 (6.5–7.8)	–
G2	11.9	10.4 $\pm$ 1.3 (8.6–11.8)	–
Body diam. at pharynx base	55	61 $\pm$ 5.9 (53–67)	47
Body diam. at mid-body	59	60.7 $\pm$ 5.0 (54–66)	46
Body diam. at anus/cloaca	43	43 $\pm$ 2.2 (41–46)	45
Lip region diam.	10	10	10
Lip region height	5	5	5
Amphid aperture	6	7	7
Odontostyle length	11	10	10
Odontophore length	14	14	13
Guiding ring from ant. end	9	9.7 $\pm$ 0.5 (9–10)	9
Nerve ring from ant. end	160	164 $\pm$ 6.5 (155–170)	159
Neck length	726	809 $\pm$ 17.5 (785–826)	723
Expanded part of pharynx	463	535.7 $\pm$ 6.2 (527–541)	472
Cardia length	16	15.7 $\pm$ 0.5 (15–16)	16
Anterior genital branch	152	192.7 $\pm$ 24 (163–221)	–
Posterior genital branch	307	276 $\pm$ 34.8 (227–305)	–
Vaginal depth	32	31.7 $\pm$ 1.7 (30–34)	–
Vulva from ant. end	1341	1403 $\pm$ 56 (1332–1471)	–
Prerectum length	430	372.7 $\pm$ 48.5 (328–440)	380
Rectum length	42	40.3 $\pm$ 0.5 (40–42)	60
Tail length	32	42.7 $\pm$ 1.2 (41–44)	42
Spicule length	–	–	69
Lateral guiding pieces	–	–	21
Ventromedian supplements	–	–	7

measuring 101–145  $\mu\text{m}$  or 1.6–2.2 times mid-body diameter long, consisting of a long slender part with prismatic cells and a well developed pars dilatata with distinct lumen; oviduct-uterus junction marked by a sphincter; uterus 95–170  $\mu\text{m}$  or 1.5–2.8 times mid-body diameter long, differentiated into a relatively large proximal region with wide lumen, a long narrow intermediate region, and a large spherical distal pars dilatata with clear lumen. Vulva transverse. Vagina slightly bent posteriorly, extending inwards about  $\frac{1}{2}$  (46–55%) of corresponding body diameter; vagina lumen highly expanded in middle, somewhat diamond-shaped in lateral view, its wall not differentiated from body cuticle; pars proximalis vaginae longer than wide, 10–13  $\times$  4–6  $\mu\text{m}$ , surrounded by weak circular musculature; pars refringens vaginae

absent; pars distalis vaginae 21–24  $\mu\text{m}$  long with convex walls. Prerectum 7.6–10.4 and rectum 0.9–10 times anal body diameter long. Tail short, broadly conoid with rounded terminus. Caudal pores two on each side.

### Male

Similar to females in general morphology, except for posterior region of body being more curved ventrad. Genital system diorchic, with oppositely outstretched testes, sperms ovoid, measuring  $5\text{--}6 \times 1\text{--}2 \mu\text{m}$ . In addition to adcloacal pair, located at 17  $\mu\text{m}$  from cloacal aperture, a series of seven irregularly spaced ventromedian supplements, beginning at 33  $\mu\text{m}$  from adcloacal pair, or just in front of proximal end of spicules. Copulatory muscles conspicuous, beginning from posterior end of spicules and continuing until the level of last supplements. Spicules massive, strongly bent ventrally with crenate inner walls; total length along the arc 1.1 times as long as chord, 4.0 times maximum width and 1.5 times body diameter at cloacal aperture. Curvature about  $128^\circ$ . Dorsal contour irregularly convex with comparatively robust posterior end; ventral contour concave with a prominent hump, located at 43.4% of spicule total length from its anterior end; head comparatively slender, slightly curved, occupying about 24.6% of spicule total length; median piece robust with crenate outer walls, 10.4 times as long as wide, and occupying about 29.4% of spicule maximum width; posterior end 7  $\mu\text{m}$  wide. Lateral guiding pieces distinctly sclerotized, slightly ventrally arcuate with bifurcated distal end, 5.3 times as long as wide or about  $\frac{1}{3}$  (30.4%) of total spicule length. Prerectum 8.4 and rectum 1.3 times cloacal body diameter long. Tail short, dorsally convex, conoid with broadly rounded terminus. Caudal pores two on each side.

### Taxonomic remarks

In its large body size, long anterior uterine sac and the shape of the vagina, the new species comes close to *A. cingulatum* Nair, 1973, but differs in the nature of the cuticle towards the anterior ends (thin vs very thickened); obscure body pores (vs distinct); the shape of the lips (comparatively high vs small and low); shorter odontostyle (10–11 vs 12–13  $\mu\text{m}$ ); shorter odontophore (14–16 vs 23  $\mu\text{m}$ ); junction between two parts of the pharynx separated by a deep constriction (vs separated by an isthmus-like portion); in intestino-prerectal junction (simple vs surrounded by a sphincter-like structure with long microvilli in the intestine present just anterior to the sphincter) and presence of male (vs not found but spindle-shaped sperms are present).

In body size, shape of spicules and lateral guiding pieces, the new species comes close to *A. heynsi* Nair, 1973, but differs in the nature of the cuticle striations (with fine transverse striations vs distinct transverse striations); shape of vagina (vs the vagina abruptly narrows within the sphincter); middle tubular part of uterus relatively less narrow (vs very narrow); longer prerectum in male (8.4 vs 12–18 times the cloacal body diameter long); longer spicules (69 vs 41–58  $\mu\text{m}$  long with comparatively slender and more arcuate head region), median piece ending with bluntly conoid projection towards the head region of spicules (vs ending with a long sharp pointed projection); longer lateral guiding pieces (21 vs 12–16  $\mu\text{m}$  long); in shape of median piece (with blunt projection in anterior region of spicule vs simple with fine projection) and first ventromedian supplement located just in front of proximal end of spicules (vs at about  $\frac{1}{2}$  the anal body diameter anterior to the proximal end of the spicules).

The new species also resembles to *A. manalicum* Ali, Jairajpuri & Coomans, 1974 in the large body size, large and robust spicules and tail shape but differs in the shape of the vagina (vs not expand in middle, narrowing within the sphincter); shorter prerectum in male (8.4 vs 11–13 times cloacal body diameter long); in shape of spicules (vs spicule walls smooth and relatively less thick), spicule ventral arm with prominent hump (vs indistinct), median piece robust with irregularly crenate walls (vs relatively less thick with smooth walls); first ventromedian supplement located just in front of proximal end of spicules (vs behind the proximal end of spicules).

*Axonchium tropicum* sp. nov.

urn:lsid:zoobank.org:act:84CBC84A-16B6-424A-B6C9-635525595B0A

Figs 13–14, Table 9

**Diagnosis**

*Axonchium tropicum* sp. nov. is characterized by having a 1.7–2.0 mm long body; lip region offset; amphids stirrup-shaped; odontostyle large, 11–12  $\mu\text{m}$  long, about equal to the odontophore; two parts of the pharynx separated by deep constriction; anterior uterine sac 2.3–4.0 times the mid-body diameter long; vagina slightly bent posteriad, tail broadly rounded; spicules 40  $\mu\text{m}$  or 1.1 times the cloacal body diameter long; lateral guiding pieces 14  $\mu\text{m}$  long with bifurcated distal end; four widely spaced ventromedian supplements, beginning above the range of spicules.

**Etymology**

The new species is named *A. tropicum* because of its distribution in tropical rain forests.

**Material examined**

**Holotype**

INDIA • ♀; Kerala State, Kasaragod District, Ranipuram National Park; 12°25'16.01" N, 75°21'0.27" E; 10–15 cm depth; 7 Nov. 2016; roots of plants (unidentified); slide reference number AMU/ZD/NC/*Axonchium tropicum*/1.

**Paratypes**

INDIA • 2 ♀♀, 1 ♂; same collection data as for holotype; slide reference number AMU/ZD/NC/*Axonchium tropicum*/2; nematode collection of the Zoological Survey of India, Kolkata, India.

**Type habitat and locality**

Soil samples collected around the roots of plants (unidentified) from Ranipuram National Park, Kasaragod District, Kerala State, India.

**Description**

**Female**

Body slightly curved ventrad upon fixation, 1.7–2.0 mm long. Cuticle with fine transverse striations, about 2  $\mu\text{m}$  thick at anterior region, 2–3  $\mu\text{m}$  at mid-body, 5–7  $\mu\text{m}$  on tail tip in females and 3  $\mu\text{m}$  in male. Lateral chords 5–7  $\mu\text{m}$  wide, about  $\frac{1}{8}$  (11–12%) of mid-body diameter; glandular bodies poorly developed, 28–42 in number: 14 in pharyngeal region, 3–5 from pharynx base to vulva, 22–23 from vulva to anal region and 1–2 in caudal region. Lateral, dorsal and ventral body pores indistinct. Lip region rounded, offset by deep constriction, 2.0–2.5 times as wide as high or about  $\frac{1}{5}$  (17–21%) of body diameter at neck base. Lips separate, outer and inner portions demarcated by shallow depression. Amphid fovea stirrup-shaped, their aperture occupying about 0.6–0.7 times lip region diameter, fusus slightly posterior to odontophore level. Guiding ring single, at 1.0–1.1 times lip region diameter from anterior end. Odontostyle fusiform, 5–6 times as long as wide, or 1.2 times lip region diameter long, its aperture occupying about  $\frac{1}{3}$  of its length. Odontophore simple, rod-like, 1.0–1.2 times as long as odontostyle. Nerve ring encircling anterior slender part of pharynx at 18–19% of neck length from anterior end. Anterior slender part of pharynx quite muscular, separated from posterior expanded part by a deep constriction. Expanded part of pharynx 13–17 times as long as wide, or 8–10 times as long as body diameter at neck base, and occupying about  $\frac{3}{5}$  to slightly more than  $\frac{2}{3}$  (63–71%) of total neck length, enclosed in a thick muscular sheath with straight bands. Only dorsal pharyngeal gland and its orifice visible: DO = 33.8–38.4; DN = 34.2–39; DO–DN =

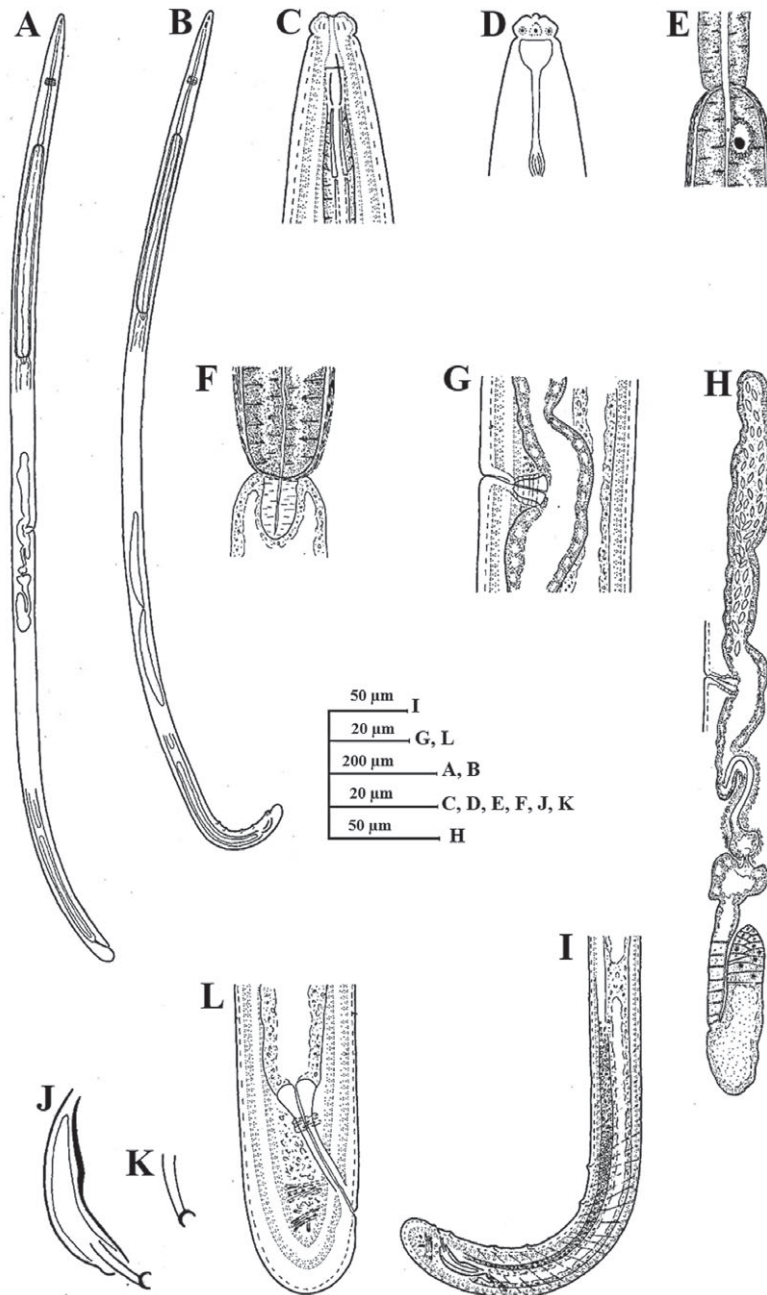
**Table 9.** Measurements of *Axonchium tropicum* sp. nov. All measurements in  $\mu\text{m}$  except L in mm, and measurements for each female (n = 2) separated by a comma.

Characters	Holotype ♀	Paratypes ♀	Paratype ♂
n	1	2	1
L	1.9	2.0, 1.7	1.8
a	44.5	32.9, 40.7	48.1
b	2.8	2.7	3.0
c	71.9	61.7, 67.2	77.4
c'	0.9	0.8, 0.9	0.8
V	53.1	54.6, 56.2	–
G1	8.0	6.9, 9.6	–
G2	10.6	13, 11.2	–
Body diam. at pharynx base	43	59, 45	40
Body diam. at mid-body	42	60, 43	37
Body diam. at anus/cloaca	29	40, 28	30
Lip region diam.	9	10, 9	9
Lip region height	4	5, 4	4
Amphid aperture	6	7	6
Odontostyle length	11	12, 11	11
Odontophore length	13	13, 12	13
Guiding ring from ant. end	10	10, 9	11
Nerve ring from ant. end	125	140, 120	130
Neck length	661	718, 657	592
Expanded part of pharynx	420	485, 467	360
Cardia length	10	22, 21	13
Anterior genital branch	149	136, 168	–
Posterior genital branch	199	258, 196	–
Vaginal depth	21	26, 18	–
Vulva from ant. end	993	1078, 982	–
Prerectum length	270	180, 209	252
Rectum length	40	45, 36	45
Tail length	26	32, 26	23
Spicule length	–	–	40
Lateral guiding pieces	–	–	14
Ventromedian supplements	–	–	4

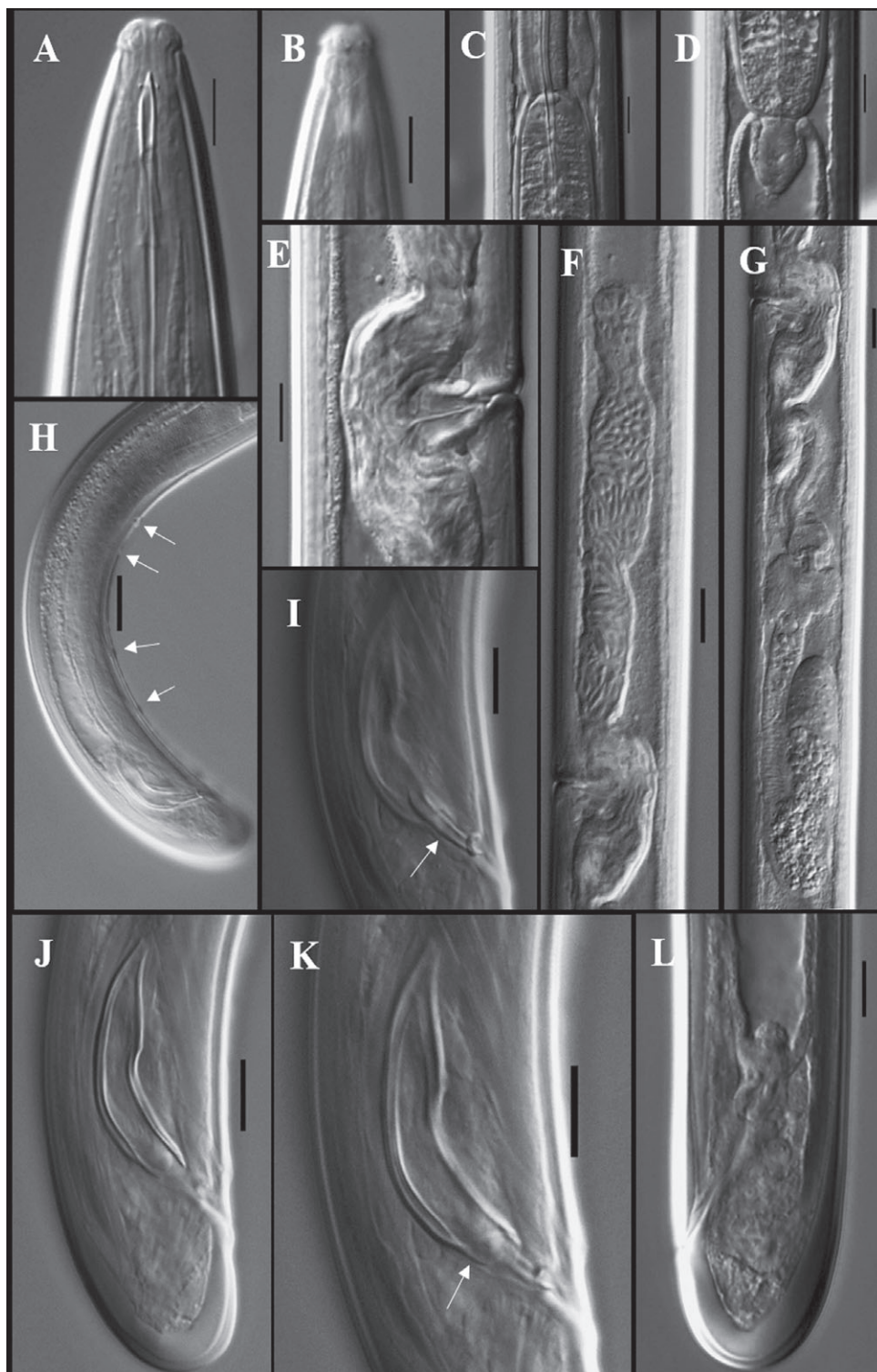
0.4–0.5. Cardia tongue-like, 1.8–2.3 times as long as wide, occupying about  $\frac{1}{3}$  to  $\frac{1}{2}$  (37–47%) of corresponding body diameter.

Genital system mono-opisthodelphic. Anterior genital branch represented by simple uterine sac with a slightly proximal constriction, measuring 136–168  $\mu\text{m}$  or 2.3–4.0 times mid-body diameter long,

and occupying 6.8–9.6% of body length; mostly containing spindle-shaped sperms. Posterior branch well developed; ovary reflexed, not reaching oviduct-uterus junction, measuring 82–105  $\mu\text{m}$  long with squamous shaped oocytes arranged in a single row except near tip; oviduct joining ovary subterminally,



**Fig. 13.** *Axonchium tropicum* sp. nov. **A, D–H, L.** Holotype, ♀ (AMU/ZD/*Axonchium tropicum* sp. nov. /1). **B, I–K.** Paratype 1, ♂ (slide 2). **C.** Paratype 2, ♀ (slide 2). **A.** Entire female. **B.** Entire male. **C.** Anterior region. **D.** Anterior end showing amphid. **E.** Junction between anterior slender and posterior expanded part of pharynx. **F.** Cardia. **G.** Vulva. **H.** Female genital system. **I.** Male posterior region. **J.** Spicule. **K.** Lateral guiding pieces. **L.** Female posterior end.



**Fig. 14.** *Axonchium tropicum* sp. nov. (LM photographs). **A.** Paratype 2, ♀ (slide 2). **B–G, L.** Holotype, ♀ (AMU/ZD/*Axonchium tropicum* sp. nov. /1). **H–K.** Paratype 1, ♂ (slide 2). **A.** Anterior region. **B.** Anterior end showing amphid. **C.** Junction between two parts of pharynx. **D.** Cardia. **E.** Vulva and vagina. **F–G.** Genital branches. **H.** Ventromedian supplements. **I.** Lateral guiding pieces. **J.** Male posterior region and spicule. **K.** Spicule with arrow indicating its distal end. **L.** Female posterior region. Scale bars: A–E, I–L = 10 µm; F–H = 20 µm.



measuring 85–105  $\mu\text{m}$  or 1.6–2.4 times mid-body diameter long, consisting of a long slender part with prismatic cells and a well developed pars dilatata with distinct lumen; sphincter present at oviduct-uterus junction; uterus 71–126  $\mu\text{m}$  or 1.6–2.1 times mid-body diameter long, appearing strongly convoluted, and differentiated into a large proximal region with wide lumen, a narrow intermediate region, and a short spherical distal pars dilatata with distinct lumen; vagina slightly bent posteriad, extending inwards about  $\frac{1}{2}$  (42–50%) of corresponding body diameter; pars proximalis vaginae longer than wide,  $10\text{--}12 \times 3\text{--}4 \mu\text{m}$ , surrounded by circular musculature; pars refringens vaginae absent; pars distalis vaginae 8–15  $\mu\text{m}$ . Prerectum 4.5–9.3 and rectum 1.1–1.4 times anal body diameter long. Tail short, broadly rounded. Caudal pores three on each side.

### Male

Similar to female in general morphology, except for posterior region of body being more curved ventrad. Genital system diorchic, with oppositely outstretched testes, sperms spindle-shaped, measuring  $4\text{--}6 \times 2 \mu\text{m}$ . In addition to adcloacal pair, located at 10  $\mu\text{m}$  from cloacal aperture, four irregularly spaced ventromedian supplements, beginning just in front of proximal end of spicules; first located at 43  $\mu\text{m}$  from adcloacal pair, second at 23  $\mu\text{m}$  from the first, third at 51  $\mu\text{m}$  from second and fourth at 25  $\mu\text{m}$  from third ventromedian supplement. Copulatory muscles conspicuous, beginning from level of middle of spicules and continuing until level of last supplement. Spicules well developed, arcuate, unusually wide with blunt distal end; total length along arc 1.1 times as long as chord, 5 times maximum width or 1.3 times body diameter at cloacal aperture. Curvature about  $135^\circ$ . Dorsal contour regularly convex, except distal end bent ventrally at right angle; ventral contour concave, bearing a prominent hump, located at 42% of spicule total length from its anterior end; head narrow, slightly curved, and occupying about 15% of spicule length; median piece simple, 7 times as long as wide, and occupying about 62% of spicule maximum width; posterior end 6  $\mu\text{m}$  wide. Lateral guiding pieces almost straight, rod-like, with bifurcated distal ends; about 7.0 times as long as wide, and occupying about  $\frac{1}{3}$  (35%) of total spicule length. Prerectum long, 8.4 and rectum 1.5 times cloacal body diameter long. Tail similar to that of female. Caudal pores three on each side.

### Taxonomic remarks

The new species comes close to *A. shamimi* Baqri & Khera, 1976, *A. elegans* Jairajpuri, 1964 and *A. neoletum* Rahman, Jairajpuri & Ahmad, 1985 on the basis of its body size, anterior uterine sac size, spicule and lateral guiding piece sizes, and arrangements of ventromedian supplements, but it differs from the former in having a longer body ( $L = 1.7\text{--}2.0$  vs  $1.3\text{--}1.6$  mm), longer odontostyle (11–12 vs 8–9  $\mu\text{m}$ ); longer prerectum (8.4 vs 6–7 times cloacal body diameter long); smaller number of ventromedian supplements (4 vs 6–7); and in the arrangement of ventromedian supplements (beginning just in front of proximal end of spicules vs posterior to the proximal end of spicules), slightly longer spicules (40 vs 36–39  $\mu\text{m}$  long).

It differs from *A. elegans* in having a wider lip region (9–10 vs 6–8  $\mu\text{m}$ ); longer odontostyle (11–12 vs 7–9  $\mu\text{m}$ ); in the shape of the spicules (vs unusually wide with blunt distal end); shape of lateral guiding pieces (bifurcated distal end vs with thickened distal end) and in shape of tail (broadly rounded vs obtusely rounded).

It differs from *A. neoletum* in having a longer body ( $L = 1.7\text{--}2.0$  vs  $1.4\text{--}1.6$  mm); comparatively wider lip region (9–10 vs 7–9  $\mu\text{m}$ ); longer odontostyle (11–12 vs 8–9  $\mu\text{m}$ ); smaller number of ventromedian supplements (4 vs 4–8); comparatively slender spicules (five times the maximum width vs 3.5–4.6 times the maximum width) and in shape of lateral guiding pieces (rod-like, almost straight with bifurcated distal end vs slightly curved in proximal region).

*Axonchium unicum* sp. nov.

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Figs 15–16, Table 10

**Diagnosis**

*Axonchium unicum* sp. nov. is characterized by having a 1.7–2.0 mm long body; lip region offset; amphid fovea stirrup-shaped; odontostyle fusiform, 10–11  $\mu\text{m}$  long; both part of the pharynx separated by a deep constriction; basal expanded part of pharynx 71–72% of total neck length; anterior uterine branch 2.5–2.8 times the mid-body diameter long; vulva transverse; vagina expanding gradually in middle; spicules slender, somewhat sickle-shaped, 68  $\mu\text{m}$  long; nine irregularly spaced ventromedian supplements, beginning posterior to the proximal end of the spicules; lateral guiding pieces 20  $\mu\text{m}$  long with bifurcate distal ends; tail broadly conoid.

**Etymology**

The new species is named *A. unicum* because of the unique shape of its spicule.

**Material examined**

**Holotype**

INDIA • ♀; Maharashtra State, Raigad District, Mahabaleshwar Hill; 17°55'50.52" N, 73°38'51.72" E; 10–15 cm depth; 12 Apr. 2016; roots of plants (unidentified); slide reference number AMU/ZD/NC/*Axonchium unicum*/1.

**Paratypes**

INDIA • 3 ♀♀, 1 ♂; same collection data as for holotype; slide reference number AMU/ZD/NC/*Axonchium unicum*/2–3; nematode collection of the Zoological Survey of India, Kolkata, India.

**Type habitat and locality**

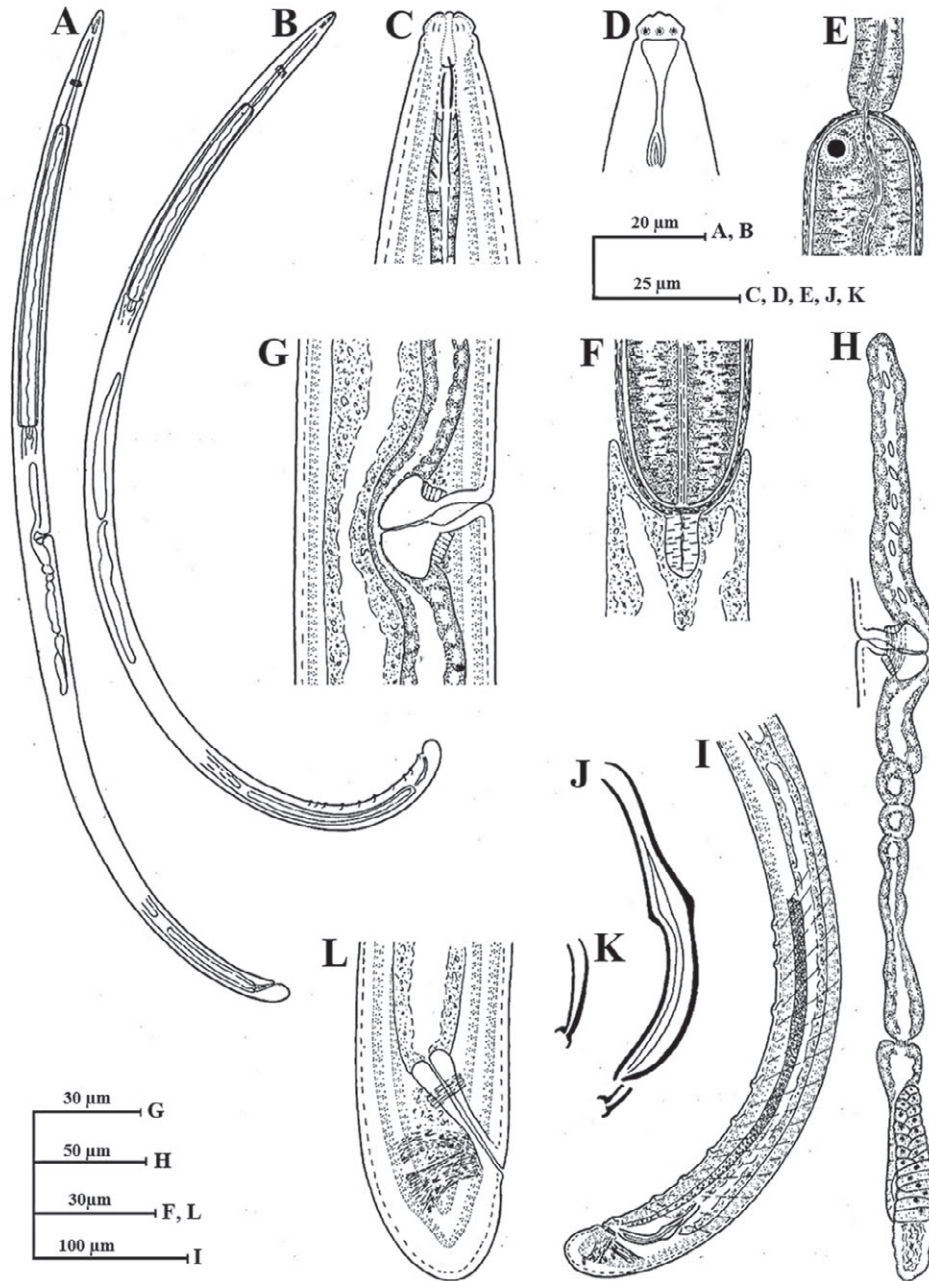
Soil samples collected around the roots of plants (unidentified) from Mahabaleshwar Hill, Raigad District, Maharashtra State, India.

**Description**

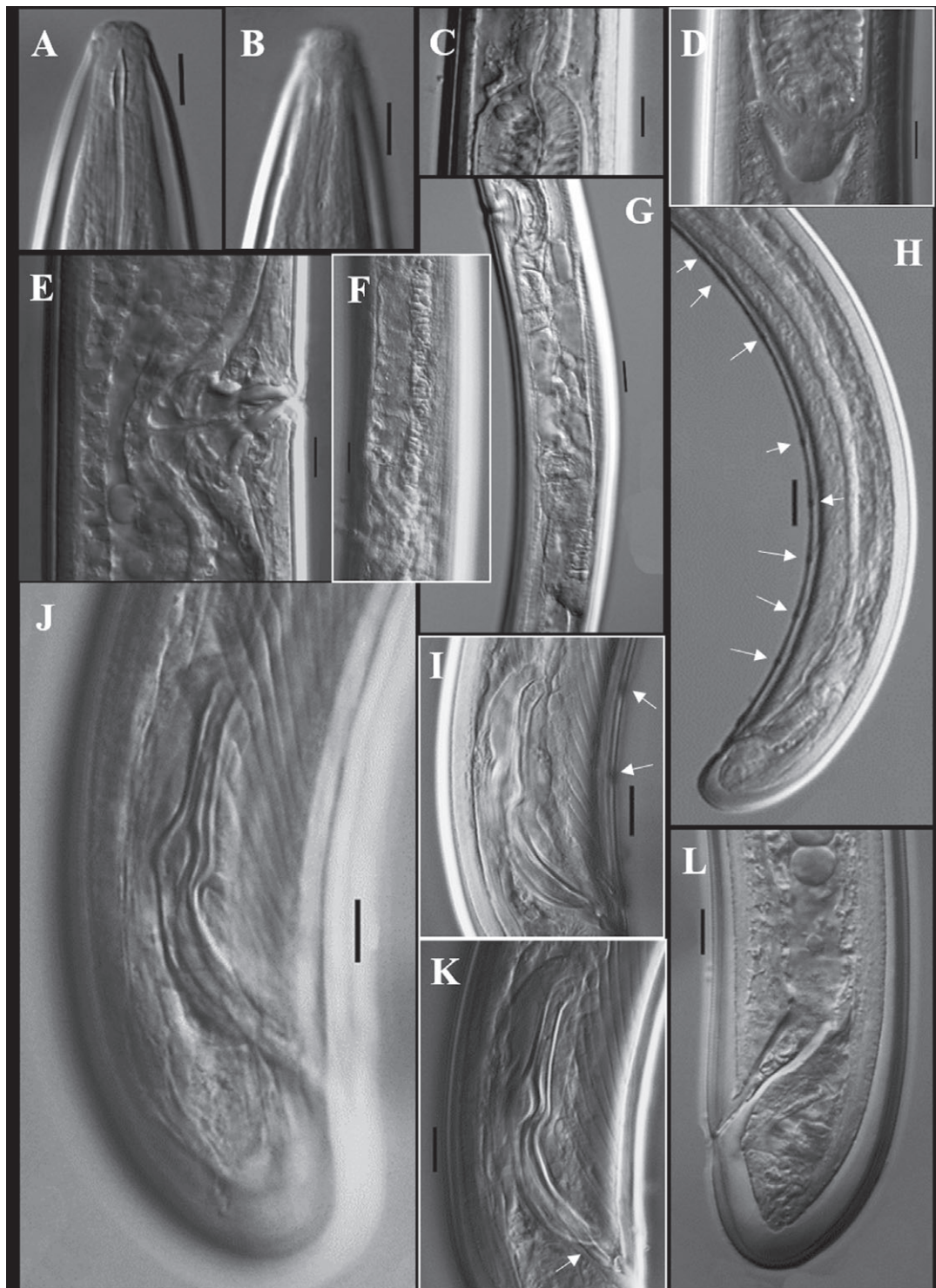
**Female**

Body curved ventrad upon fixation, 1.7–2.0 mm long. Cuticle with fine transverse striations, about 2  $\mu\text{m}$  thick at anterior region, 2–3  $\mu\text{m}$  at mid-body and 8–10  $\mu\text{m}$  on tail tip. Lateral chords 5–13  $\mu\text{m}$  wide, about  $\frac{1}{10}$  to  $\frac{1}{5}$  (8–21%) of mid-body diameter; glandular bodies indistinct. Lateral, dorsal and ventral body pores indistinct. Lip region distinctly offset, 2.2–2.5 times as wide as high, or about  $\frac{1}{7}$  to  $\frac{1}{6}$  (14–16%) of body diameter at neck base. Lips low, bluntly conoid, incompletely separate. Amphid fovea stirrup-shaped, their aperture occupying about 0.7–0.8 times lip region diameter, fusus just opposite to odontophore level. Guiding ring single, at 0.9–1.1 times lip region diameter from anterior end. Odontostyle fusiform, 5.0–5.5 times as long as wide, 1.0–1.1 times longer than lip region diameter, its aperture occupying about  $\frac{1}{3}$  of its length. Odontophore simple, linear, 1.1–1.4 times as long as odontostyle. Nerve ring encircling anterior slender part of pharynx at 16–19% of neck length from anterior end. Anterior slender part of pharynx quite muscular, separated from posterior expanded part by a deep constriction. Expanded part of pharynx 16.5–16.8 times as long as wide, or 8.2–10.4 times as long as body diameter at neck base, and occupying about  $\frac{3}{4}$  (71–72%) of total neck length, enclosed in a thick muscular sheath with straight bands. Only dorsal pharyngeal gland and its orifice visible: DO = 29; DN = 30; DO–DN = 0.3 (n = 1). Cardia oblong, 1.5–2.5 times as long as wide, occupying about  $\frac{1}{4}$  to  $\frac{1}{3}$  (23–31%) of corresponding body diameter.

Genital system mono-opisthodelphic. Anterior genital branch represented by simple uterine sac, measuring 147–171  $\mu\text{m}$  or 2.5–2.8 times mid-body diameter long, occupying about 7.2–9.8% of total body length. Posterior branch well developed, its tract always appeared strongly convoluted; ovary reflexed, not



**Fig. 15.** *Axonchium unicum* sp. nov. A, C–D, G, L. Holotype, ♀ (AMU/ZD/*Axonchium unicum* sp. nov. /1). B, I–K. Paratype 3, ♂ (slide 3). E–F, H. Paratype 2, ♀ (slide 3). A. Entire female. B. Entire male. C. Anterior region. D. Anterior end showing amphid. E. Junction between anterior and posterior expanded part of pharynx. F. Cardia. G. Vulva. H. Female genital system. I. Male posterior end. J. Spicule. K. Lateral guiding piece. L. Female posterior end.



**Fig. 16.** *Axonchium unicum* sp. nov. (LM photographs). **A–B, E, L.** Holotype, ♀ (AMU/ZD/*Axonchium unicum* sp. nov. /1). **C–D, F–G.** Paratype 2, ♀ (slide 3). **H–K.** Paratype 3, ♂ (slide 3). **A.** Anterior region. **B.** Anterior end showing amphid. **C.** Junction between anterior and posterior expanded part of the pharynx. **D.** Cardia. **E.** Vulva and vagina. **F–G.** Female genital branches. **H.** Ventromedian supplements. **I.** Arrows indicating ventromedian supplements beginning. **J.** Male posterior end. **K.** Spicule and lateral guiding piece. **L.** Female posterior end. Scale bars: A–E, I–L = 10 µm; F–H = 20 µm.

**Table 10.** Measurements of *Axonchium unicum* sp. nov. All measurements in  $\mu\text{m}$  except L in mm, and in the form: mean  $\pm$  s.d. (range), and measurements for each female (n = 2) separated by a comma.

Characters	Holotype ♀	Paratypes ♀	Paratype ♂
n	1	3	1
L	2.0	1.9, 1.8 (n = 2)	2.06
a	34.4	30.9, 28.7 (n = 2)	40
b	2.6	2.1, 2.5 (n = 2)	3.1
c	63.4	68.5, 53 (n = 2)	71.2
c'	0.8	0.7, 0.8 (n = 2)	0.8
V	48.7	57.4, 53.5 (n = 2)	–
G1	7.2	9.8	–
G2	14.5	15.6	–
Body diam. at pharynx base	56	39, 30 (n = 2)	50
Body diam. at mid-body	59	62, 61 (n = 2)	52
Body diam. at anus/cloaca	38	42, 41 (n = 2)	35
Lip region diam.	9	9.3 $\pm$ 0.5 (9–10)	10
Lip region height	4	4	5
Amphid aperture	6	7	6
Odontostyle length	–	11	10
Odontophore length	14	13, 12 (n = 2)	15
Guiding ring from ant. end	9	9.7 $\pm$ 0.5 (9–10)	9
Nerve ring from ant. end	145	144.5 $\pm$ 7.0 (135–152)	145
Neck length	783	910, 690 (n = 2)	663
Expanded part of pharynx	561	654, 495 (n = 2)	435
Cardia length	16	20, 14 (n = 2)	11
Anterior genital branch	147	171	–
Posterior genital branch	295	265	–
Vaginal depth	34	35	–
Vulva from ant. end	988	1101, 935 (n = 2)	–
Prerectum length	211	150	325
Rectum length	37	42	43
Tail length	32	28, 33 (n = 2)	29
Spicule length	–	–	68
Lateral guiding pieces	–	–	20
Ventromedian supplements	–	–	9

reaching oviduct-uterus junction, measuring 63–95  $\mu\text{m}$  long with squamous-shaped oocytes arranged in a single row except near tip; oviduct joining ovary subterminally, 82–90  $\mu\text{m}$  or 1.3–1.5 times mid-body diameter long, consisting of a long slender tubular part with prismatic cells and a wider pars dilatata; oviduct-uterus junction marked by weakly developed sphincter; uterus 75–181  $\mu\text{m}$  or 2.9–3.1 times mid-body diameter long, differentiated into a relatively long and convoluted proximal region with wide lumen, and a spherical distal pars dilatata with distinct lumen. Vulva transverse. Vagina straight to slightly bent posterior, extending inwards about three-fifths (57–58%) of corresponding body diameter long; vaginal wall expanding gradually near middle, but not differentiated from body cuticle; pars proximalis vaginae

longer than wide, 18–19 × 7–8 µm, surrounded by well developed circular musculature; pars refringens absent; pars distalis 16–17 µm long. Prerectum 3.7–5.6 and rectum 0.9–1.0 times anal body diameter long. Tail broadly conoid with rounded terminus. Caudal pores three on each side.

#### Male

Similar to female in general morphology, except for posterior region of body being more curved ventrad. Genital system diorchic, with oppositely outstretched testes; sperms ovoid, measuring 3–4 × 1–2 µm. In addition to adcloacal pair, located at 10 µm from cloacal aperture, a series of nine irregularly spaced ventromedian supplements, beginning at 30 µm from adcloacal pair, or posterior to proximal end of spicules. Copulatory muscles conspicuous, beginning from level of middle of spicules and continuing until level of last supplements. Spicules large, comparatively slender, ventrally arcuate, somewhat sickle-shaped in lateral view; total length along arc 1.5 times as long as chord, or 11.3 times maximum width, and about 1.9 times body diameter at cloacal aperture; curvature about 132°. Dorsal contour irregularly convex, bulge at level of hump, ventral contour concave, bearing a distinct hump, located at 45.6% of spicule total length from its anterior end; head slender with slightly curved tip, occupying about 22.1% of total spicule length; median piece simple, 20.8 times as long as wide, and occupying about 41.6% of spicule maximum width; posterior end about 2 µm wide. Lateral guiding pieces almost straight with bifurcated distal end, about 10 times as long as wide, or about 1/3 (31%) of total spicule length. Prerectum 9.3 and rectum 1.2 times cloacal body diameter long. Tail similar to that of female but having slight depression on ventral side. Caudal pores four on each side.

#### Taxonomic remarks

In having large and slender spicules and in the arrangement of its ventromedian supplements, the new species comes close to *A. sabulum* (Yeates, 1967) sensu Coomans & Yeates 1969 and *A. sinclairi* Heyns & Furstenberg, 1993, but it differs from both, in its unique spicular morphology (large, sickle-shaped).

It further differs from the former in having a robust body ( $a = 29\text{--}34$  vs  $43\text{--}44$ ); narrower lip region with comparatively low lips ( $9\text{--}10$  vs  $12$  µm wide with comparatively high lips); longer pharynx ( $b = 2.1\text{--}2.6$  vs  $3.6\text{--}3.7$ ); shorter prerectum ( $3.7\text{--}5.6$  vs  $9\text{--}10$  times the anal body diameter long); vagina expanded near the middle (vs not expanded); in shape and size of spicules ( $69$  µm with dorsal contour irregularly convex, bulge at level of hump vs  $50\text{--}56$  µm with simple regularly convex dorsal contour); longer lateral guiding pieces ( $20$  vs  $10$  µm); in the number and arrangement of ventromedian supplements ( $9$  beginning from posterior to the proximal end of the spicules vs  $5\text{--}6$  starting just opposite to the proximal end of the spicules) and its comparatively longer tail ( $c = 53\text{--}68$  vs  $81\text{--}86$ ).

From *A. sinclairi*, it differs in the absence of a hemizonid (vs present at level of nerve ring); narrow lip region ( $9\text{--}10$  vs  $13\text{--}15$  µm), lips low and incompletely separate (vs well separated from each other with outer and inner portions prominently demarcated by a depression); narrower amphid aperture ( $6\text{--}7$  vs  $9$  µm wide); single guiding ring (vs double); comparatively longer pharynx ( $b = 2.1\text{--}2.6$  vs  $2.6\text{--}3.0$ ); vagina almost straight to slightly posteriorly bent with its walls expanded in the middle (vs posteriad directed and its walls thicker but not expanded); shorter prerectum ( $3.7\text{--}5.6$  vs  $7$  times the anal body diameter long); in shape and size of spicules (vs  $78\text{--}81$  µm long, strongly curved ventrad with simple regularly convex dorsal arm); lateral guiding pieces rod-shaped with bifurcated distal ends (vs simple arcuate without bifurcated distal end) and its longer tail ( $c = 53\text{--}68$  vs  $80\text{--}114$ ).

#### **Key to species of the genus *Axonchium* Cobb, 1920 (based on females) (modified after Naz & Ahmad 2012)**

1. Lips completely amalgamated ..... 2
- Lips incompletely separated or well separated ..... 3

2. Body length 1.2–1.4 mm; anterior uterine branch present ..... *A. perplexans* Siddiqi, 1995  
 – Body length 1.5–1.6 mm; anterior uterine branch absent..... *A. tochiense* Khan & Araki, 2002
3. The inner portion of the lips deeply offset and appearing as subspherical liplets .....  
 ..... *A. labiatum* Thorne, 1939  
 – The inner portion of the lips less offset and marked by depression of the contour ..... 4
4. Odontostyle straight and narrow; anterior part of pharynx very narrow; pharyngeal constriction inconspicuous; body pores numerous ..... 5  
 – Odontostyle fusiform; anterior part of pharynx quite muscular; pharyngeal constriction very deep or isthmus-like; body pores few ..... 6
5. Body length 1.8–2.0 mm; odontostyle 8–10 µm; uterus without ‘Z’-organ.....  
 ..... *A. geminum* Coomans & Nair, 1975  
 – Body length 2.6–3.8 mm; odontostyle 10.5–15 µm; uterus with ‘Z’-organ.....  
 ..... *A. variabile* Coomans & Nair, 1975
6. Vulva broad, lengthwise oval; vaginal lumen adjacent to vulva very wide; pharyngeal constriction short isthmus-like..... *A. propinquum* (de Man, 1921) sensu Thorne 1939  
 – Vulva transverse, broad or narrow; vaginal lumen narrow; pharyngeal constriction deep or rarely isthmus-like..... 7
7. Intestino-prerectal junction marked by a constriction, surrounded by a sphincter-like structure.....  
 ..... *A. cingulatum* Nair, 1973  
 – Constriction or sphincter-like structure at the intestino-prerectal junction absent ..... 8
8. Anterior genital branch less than  $\frac{3}{4}$  of the corresponding body diameter long..... 9  
 – Anterior genital branch usually long, very rarely slightly less than the body diameter long ..... 12
9. Vagina straight, vaginal cuticle wide with rounded or spheroid walls .. *A. bulbosum* Williams, 1958  
 – Vagina bent posteriad, vaginal cuticle not wide ..... 10
10. Body slender (body width 27–35 µm); lips with a shallow notch in the middle separating the outer and inner portions ..... *A. nitidum* Jairajpuri, 1964  
 – Body rather stout (body width 41–58 µm); lips with a deep notch in the middle separating the outer and inner portions ..... 11
11. Expanded part of pharynx 74–80% of total neck length; anterior uterine branch rudimentary; tail hemispherical with clavate end and 3 caudal pores on each side .....  
 ..... *A. camelliae* Dhanam & Jairajpuri, 1998  
 – Expanded part of pharynx 55–73% of total neck length; anterior uterine branch a simple sac; tail convex-conoid to bluntly rounded and 2 caudal pores on each side .....  
 ..... *A. amplicolle* Cobb, 1920
12. Posterior genital branch with ‘Z’-organ..... *A. bihariense* Popovici, 1990  
 – Posterior genital branch without ‘Z’-organ ..... 13
13. Vagina with a constriction in the middle ..... 14  
 – Vagina without constriction, or gradually widening towards the uterus ..... 24

14. Expanded part of pharynx short, about 39–49% of total neck length; tail bluntly conoid ..... *A. indicum* sp. nov.  
 – Expanded part of pharynx long, more than 50% of total neck length; tail hemispheroid ..... 15
15. Vagina wall appears somewhat darker than and offset from the body cuticle..... *A. saccatum* Jairajpuri, 1964  
 – Vaginal cuticle not differentiated from the body cuticle..... 16
16. Body length 1.0–1.7 mm ..... 17  
 – Body length 1.8–2.8 mm ..... 21
17. Body almost straight, 1.1–1.3 mm long; anterior uterine sac 1.7–2.3 times corresponding body diameter long; tail obtusely rounded ..... *A. microspiculum* sp. nov.  
 – Body slightly ventrally arcuate or straight, over 1.3 mm long; anterior uterine sac more than 2.3 times the body diameter; tail hemispheroid..... 18
18. Vagina straight; anterior uterine branch a simple sac without proximal constriction..... *A. thoubalicum* Dhanachand & Jairajpuri, 1981  
 – Vagina straight or slightly to completely directed posteriad; anterior uterine branch provided with a proximal constriction ..... 19
19. Body almost straight; vaginal wall distinctly thicker than the body cuticle, vaginal sphincter well developed..... *A. phukani* Rahman, Jairajpuri & Ahmad, 1985  
 – Body slightly ventrally arcuate; vaginal wall almost of same thickness as the body cuticle, vaginal sphincter weakly developed..... 20
20. Odontostyle 8–9  $\mu\text{m}$  ..... *A. neoletum* Rahman, Jairajpuri & Ahmad, 1985  
 – Odontostyle 11–12  $\mu\text{m}$ ..... *A. tropicum* sp. nov.
21. Vagina straight; anterior uterine sac without a proximal constriction ..... *A. khasianum* Rahman, Jairajpuri & Ahmad, 1985  
 – Vagina bent posteriad; anterior uterine sac with a proximal constriction..... 22
22. Body length 2.1–2.8 mm; middle tubular part of uterus very narrow ..... *A. heynsi* Nair, 1973  
 – Body length 1.8–2.2 mm; middle tubular part of uterus wide..... 23
23. Body almost straight; vaginal lumen becoming cross-shaped within the sphincter; anterior uterine branch 2–3 times body diameter long..... *A. transkeiense* Nair, 1973  
 – Body curved ventrad; vaginal lumen narrow and straight; anterior uterine branch 3–4 times body diameter long ..... *A. parasaccatum* Rahman, Jairajpuri & Ahmad, 1985
24. Vaginal lumen highly expanded toward the uterus, with diamond-shaped lumen in lateral view ..... *A. paracingulatum* sp. nov.  
 – Vaginal lumen moderately expanded..... 25
25. Lip region distinctly wide (13–15  $\mu\text{m}$ ); odontophore more than 1.5 times the odontostyle length ... *A. sinclairi* Heyns & Furstenberg, 1993  
 – Lip region narrow (less than 12  $\mu\text{m}$ ); odontophore less than 1.5 times the odontostyle length..... 26
26. Body almost straight ..... 27  
 – Body ventrally arcuate ..... 28



27. Lip region high, with conoid lips; cardia more or less heart-shaped; tail broadly conoid, shorter than anal body diameter.....*A. sabulum* (Yeates, 1967) sensu Coomans & Yeates 1969  
 – Lip region low, with small offset inner portions of the lips; cardia cylindrical; tail cylindroid, longer than the anal body diameter.....*A. latespiculatum* Nair, 1973
28. Body more than 2 mm long; cardia linguiform; posterior uterus with very narrow tubular part.....  
 .....*A. manalicum* Ali, Jairajpuri & Coomans, 1974  
 – Body 2 mm or less; cardia rounded to heart-shaped..... 29
29. Vagina completely directed posteriad..... 30  
 – Vagina slightly inclined posteriad..... 32
30. Lip region with incompletely separated lips and amalgamated inner parts.....  
 .....*A. siddiqii* Coomans & Nair, 1975  
 – Lip region with well separated lips and separated inner parts..... 31
31. Vagina about two-thirds of the corresponding body diameter; prerectum 3.5–6.5 times anal body diameter; tail hemispheroid to almost clavate .....*A. noreasum* Naz & Ahmad, 2012  
 – Vagina large, more than two-thirds of the corresponding body diameter; prerectum 7–12 times anal body diameter; tail bluntly conoid.....*A. nilgiriense* sp. nov.
32. Anterior part of pharynx slender, separated from the posterior expanded part by an isthmus-like constriction .....*A. meghalayense* Naz & Ahmad, 2012  
 – Anterior part of pharynx moderately to highly muscular, separated from the posterior expanded part by a constriction, isthmus-like structure absent..... 33
33. Anterior part of pharynx moderately muscular, separated from the posterior expanded part by a weak constriction; tail broadly rounded, distinctly clavate due to expansion of cuticle.....  
 .....*A. cooverkolli* Dhanam & Jairajpuri, 1998  
 – Anterior part of pharynx quite muscular, separated from the posterior expanded part by a very distinct constriction; tail not clavate..... 34
34. Prerectum 10–13 times anal body diameter long; tail bluntly rounded, slightly clavate .....  
 .....*A. hosakodii* Dhanam & Jairajpuri, 1998  
 – Prerectum less than 10 times anal body diameter long; tail rounded or hemispheroid..... 35
35. Expanded part of pharynx 60% or less of total neck length; tail obtusely rounded.....  
 .....*A. elegans* Jairajpuri, 1964  
 – Expanded part of pharynx more than 60% of total neck length; tail hemispherical or broadly rounded..... 36
36. Body length 1.3–1.4 mm .....*A. shamimi* Baqri & Khera, 1976  
 – Body more than 1.5 mm long..... 37
37. Body length 1.5–1.6 mm; odontostyle 7–9 µm; anterior genital branch without proximal constriction.....*A. eletum* Dhanachand & Jairajpuri, 1981  
 – Body length 1.6–1.9 mm; odontostyle 10.5–12 µm; anterior genital branch with proximal constriction..... 38
38. Lip region with well separated lips; odontostyle 1.1–1.3 times lip region width long.....  
 .....*A. metobtusicaudatum* (Sch.Stekhoven & Teunissen, 1938) sensu Nair & Coomans 1973

- Lip region with incompletely separated lips; odontostyle about lip region width long ..... 39
- 39. Lip region low, bluntly conoid; tail bluntly conoid with rounded terminus ..... *A. unicum* sp. nov.
- Lip region moderately high, rounded; tail hemispherical ..... *A. vallum* Ahmad & Jairajpuri, 1982

**Key to species of the genus *Axonchium* Cobb, 1920 (based on males) (modified after Naz & Ahmad, 2012)**

1. Lip region offset with incompletely separated lips ..... 2
  - Lip region offset with well separated lips ..... 4
- 2.– Body more than 1.5 mm long; odontostyle 10–12  $\mu\text{m}$ ; spicules 55–57  $\mu\text{m}$  .....
  - ..... *A. vallum* Ahmad & Jairajpuri, 1982
  - Body about or less than 1.5 mm long; odontostyle 8–9  $\mu\text{m}$ ; spicules less than 40  $\mu\text{m}$  ..... 3
3. Spicules 36–39  $\mu\text{m}$ ; ventromedian supplements 7; lateral guiding pieces 13–15  $\mu\text{m}$  .....
  - ..... *A. shamimi* Baqri & Khera, 1976
  - Spicules 32  $\mu\text{m}$ ; ventromedian supplements 2; lateral guiding pieces 10  $\mu\text{m}$  .....
    - ..... *A. siddiqii* Coomans & Nair, 1975
4. Over 150 lateral and over 80 ventral body pores; 7–10 caudal pores; spicules very stout, 52–71  $\mu\text{m}$  long with almost straight ventral side; anterior pharynx very slender .....
  - ..... *A. variabile* Coomans & Nair, 1975
  - Body pores less numerous; up to 4 caudal pores ..... 5
5. First ventromedian supplement above the range of spicules ..... 6
  - First ventromedian supplement within the range of spicules ..... 16
6. Ventromedian supplements 2 ..... 7
  - Ventromedian supplements 4 or more ..... 8
7. Spicules 20–23  $\mu\text{m}$ , regular in shape ..... *A. microspiculum* sp. nov.
  - Spicules 30–36  $\mu\text{m}$ , proximally slender about two-fifths of the total spicule length, and distal part comparatively robust ..... *A. noreasum* Naz & Ahmad, 2012
8. Tail about 1.2 anal body diameter long; spicules short and stout, with greatest width in distal half and complex median piece without posterior projection; lateral guiding pieces less than 10  $\mu\text{m}$ , very heavily sclerotized, without distal bifurcation ..... *A. latespiculatum* Nair, 1973
  - Tail one or less than one anal body width long; spicules stout with simple median piece and posterior projection at the distal end; lateral guiding pieces more than 10  $\mu\text{m}$ , with distal bifurcation... 9
9. Spicules longer, 1.7–1.9 cloacal body diameter long, ventromedian supplements 4 .....
  - ..... *A. parasaccatum* Rahman, Jairajpuri & Ahmad, 1985
  - Spicules 1.5 or less cloacal body diameter long; supplements 4 or more ..... 10
10. Spicules bent ventrally with bluntly rounded distal ends, inner walls heavily sclerotized ..... 11
  - Spicules arcuate, weakly sclerotized ..... 13
11. Spicules 1.2 cloacal body diameter long, proximal end of spicules less thickened, median piece thin at most of its length, swollen near distal end ..... *A. thoubalicum* Dhanachand & Jairajpuri, 1981
  - Spicules 1.2–1.4 cloacal body diameter long, median piece of spicules not swollen near distal end ..... 12

12. Body 2.1–2.8 mm long; spicules bent ventrally at right angle, stout with blunt posterior projection at distal end, inner walls of spicules sometimes crenate; 5–10 ventromedian supplements .....  
 ..... *A. heynsi* Nair, 1973
- Body 1.4–1.7 mm long; spicules slightly ventrally curved without posterior projection at distal end, inner walls of spicules uniformly thickened; 4–6 ventromedian supplements.....  
 ..... *A. phukani* Rahman, Jairajpuri & Ahmad, 1985
13. Body 1.6 mm long; expanded part of pharynx 50–54% of total neck length; lateral guiding pieces with sclerotized bifid tip ..... *A. hosakodii* Dhanam & Jairajpuri, 1998
- Body 1.7–2.0 mm long; expanded part of pharynx more than 60% of total neck length; lateral guiding pieces with bifurcated distal ends ..... 14
14. Body L-shaped; 6–7 irregularly spaced ventromedian supplements; lateral guiding pieces swollen with diverging distal ends; tail with three caudal pores on each side..... *A. transkeiense* Nair, 1973
- Body slightly curved ventrad; 5–7 regularly spaced ventromedian supplements; lateral guiding pieces with bifurcated distal ends; tail with two caudal pores on each side..... 15
15. Spicules 1.2 cloacal body diameter long; prerectum 11–14 cloacal body diameter long; 6–7 regularly spaced ventromedian supplements; tail one anal body width long .....  
 ..... *A. khasianum* Rahman, Jairajpuri & Ahmad, 1985
- Spicules 1.5 cloacal body diameter long; prerectum 6 anal body diameter long; 5 regularly spaced ventromedian supplements; tail about 0.7 anal body diameter long .....  
 ..... *A. meghalyense* Naz & Ahmad, 2012
16. Spicules slender ..... 17
- Spicules robust..... 20
17. Lip region 9–10 µm wide; spicules somewhat sickle-shaped, its dorsal contour with irregularly convex bulge at level of hump..... *A. unicum* sp. nov.
- Lip region more than 11–15 µm wide; spicules simple in shape, dorsal contour regularly convex.... 18
18. Spicules 50–56 µm long; ventromedian supplements 5–6 .....  
 ..... *A. sabulum* (Yeates, 1967) sensu Coomans & Yeates 1969
- Spicules more than 70 µm long; ventromedian supplements 7–12 ..... 19
19. Guiding ring ‘double’; 7–11 irregularly spaced ventromedian supplements; spicules 78–81 µm, ventrally arcuate, head of spicules distinctly ventrally curved; lateral guiding pieces arcuate.....  
 ..... *A. sinclairi* Heyns & Furstenberg, 1993
- Guiding ring single; 8–12 ventromedian supplements in two groups; spicules 73–79 µm, ventrally arcuate, head of spicules not ventrally curved; lateral guiding pieces slender, straight .....  
 ..... *A. dubium* Siddiqi, 1995
20. Spicules large, 66–70 µm long ..... 21
- Spicules 55 µm or less long ..... 22
21. Body 2.5–2.8 mm long; first ventromedian supplement just in front of proximal end of spicules; spicules strongly bent ventrally at right angle, inner walls of spicules crenate.....  
 ..... *A. paracingulatum* sp. nov.
- Body 1.9–2.0 mm long; 5 ventromedian supplements posterior to proximal end of spicules; spicules ventrally curved, inner walls of spicules smooth, not crenate; lateral guiding pieces rod-like and provided with a distal inward projection ..... *A. manalicum* Ali, Jairajpuri & Coomans, 1974

22. Body 1.2–1.3 mm long; spicules less than 33  $\mu\text{m}$  long ..... 23  
– Body 1.4–2.2 mm long; spicules more than 39  $\mu\text{m}$  long ..... 24
23. Spicules unusually wide at the blunt distal end; lateral guiding pieces with bifid distal ends; tail with two caudal pores on each side ..... *A. elegans* Jairajpuri, 1964  
– Spicules with narrow distal end; lateral guiding pieces with blunt distal ends; tail with three caudal pores on each side ..... *A. cooverkolli* Dhanam & Jairajpuri, 1998
24. Spicules strongly arcuate; lateral guiding pieces ventrally arcuate with thickened distal end; tail bluntly conoid ..... *A. nilgiriense* sp. nov.  
– Spicules not strongly arcuate; lateral guiding pieces straight with bifurcated distal end; tail hemispherical rounded or convex conoid ..... 25
25. Spicules with wide distal end ..... 26  
– Spicules with narrow distal end ..... 29
26. Spicules 39–44  $\mu\text{m}$  or 1.0–1.1 cloacal body diameter long with very broad and truncate distal end ..... *A. saccatum* Jairajpuri, 1964  
– Spicules over 1.5 cloacal body diameter long with blunt distal end ..... 27
27. 9 ventromedian supplements in two groups of three and six; first supplements posterior to the proximal end of spicules; lateral guiding pieces weakly sclerotized .....  
..... *A. eletum* Dhanachand & Jairajpuri, 1981  
– 4–8 irregularly spaced ventromedian supplements; first supplement just in front of spicules; lateral guiding pieces heavily sclerotized ..... 28
28. Odontostyle 11–12  $\mu\text{m}$  long; ventromedian supplements 4; lateral guiding pieces simple rod-like with bifurcated distal end ..... *A. tropicum* sp. nov.  
– Odontostyle 8–9  $\mu\text{m}$  long; ventromedian supplements more than 4; lateral guiding pieces slightly curved in proximal region ..... *A. neoeletum* Rahman, Jairajpuri & Ahmad, 1985
29. Ventromedian supplements 10–13; lateral guiding pieces slender; prerectum 9.4–12.2 anal body widths long; tail with 4 caudal pores on each side .....  
..... *A. propinquum* (de Man, 1921) sensu Thorne 1939  
– Ventromedian supplements less than 10; lateral guiding pieces not so slender; prerectum less than 10 anal body widths long; tail with 2 caudal pores on each side ..... 30
30. Prerectum 4.3–7.4 anal body widths long; lateral guiding pieces simple with bifurcated distal ends ..... *A. amplicolle* Cobb, 1920  
– Prerectum 8.7–9.9 anal body diameters long; lateral guiding pieces with thickened distal end .....  
..... *A. metobtusicaudatum* (Sch.Stekhoven & Teunissen, 1938) sensu Nair & Coomans 1973

#### Not included in key due to unavailability of literature

*A. cephalatum* (Schuurmans Stekhoven, 1951) Andrásy, 1986.

*A. monhysteroides* (Altherr, 1974) Andrásy, 1990.

*A. subeletum* Gambhir & Dhanachand, 1990.

#### Discussion

The genus *Axonchium* has a worldwide distribution; it occurs in all the continents except Antarctica, and is represented by a total of 38 valid species, out of which 21 species have so far been recorded from

India, mostly from the tropical rainforest region (Northeast states and Western Ghats of India). The Western Ghats constitutes a range of tropical rainforest with a very high degree of species richness and endemism; however only eight species of *Axonchium* have been recorded from this region so far (Jairajpuri 1964; Ahmad & Jairajpuri 1982; Dhanam & Jairajpuri 1998). During this study, several populations of *Axonchium* were recorded, including two species already recorded from this region (*A. saccatum* and *A. vallum*) and eight new records, which represented two known (*A. nitidum*, *A. transkeiense*) and six new species. *Axonchium transkeiense* is recorded for the first time from India and the first time since its original description. With the addition of the species described here, the Indian fauna now represents 28 species of the genus *Axonchium*, of which 15 species are represented in the Western Ghats and the total number of valid species in this genus is 44. This constitutes about 53.6% of the genus diversity in India and 35% of the world's *Axonchium* diversity.

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