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STUDIES ON THE GENUS *PARATROPHURUS* ARIAS (NEMATODA: TYLENCHINA) WITH DESCRIPTIONS OF TWO NEW SPECIES

by
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Summary. Details are given of the morphology and morphometry of four known and two new species of the genus *Paratrophurus*. The diagnosis of the genus is amended and a new combination, *Tylenchorhynchus sudanensis*, is proposed for *Paratrophurus sudanensis* Decker, Yassin *et* El-Amin, 1975. Distribution of *Paratrophurus* species is examined and a differential key for species is provided. The two new species proposed and described are: *Paratrophurus kleynsi* from South Africa and *P. striatus* from Spain. The known species briefly redescribed are *P. acristylus* from Morocco, *P. costarricensis* from Venezuela, *P. loofi* from Spain and *P. spenceri* from USA.

Since the establishment of the genus *Paratrophurus* with its type species *P. loofi* by Arias in 1970 very few records have been made of these nematodes apart from original descriptions of new species. *P. loofi* has been found in several localities of Spain, apart from the type locality, by Arias and Romero, 1971 and Zancada and Bello, 1981. In Europe it has been recorded by Katalan-Gateva and Tsoneva (1982) on corn, barley and alfalfa in Bulgaria and in Turkey by Saltukoglu *et al.* (1976) on watermelon, radish, sunflower and eggplant. *Paratrophurus anomalus* Kleynhans *et* Heyns, 1983 has been recorded from Pakistan on wheat by Maqbool and Fatima (1986). Two records of *Paratrophurus* sp. in Japan re known: Gotoh (1977) and Teruya (1979) on several plants like sugarcane, okra, sorghum, etc. The geographical distribution of the genus is summarised in Table I. The species in USA, Venezuela, South Africa and Australia have strong stylets and strongly sclerotized cephalic frameworks compared with those in Spain, Libya, Morocco and the Sudan.

Materials and methods

Nematodes were heat-killed, fixed in a 5% solution of formaldehyde, and mounted in dehydrated glycerine. Drawings and measurements were made with the aid of a drawing tube and a micrometer-scale in the eye-piece of the microscope.

PARATROPHURUS Arias, 1970

Diagnosis (amended after Fortuner *et* Luc, 1987).

Tylenchorhynchinae. Body 0.5-2.01 mm. Lateral field with 4 incisures, not areolated except in oesophageal region. Cephalic region conoid to broadly rounded, smooth rarely with distinct annuli. Stylet slender to moderately robust, 14-35 µm long (18-25 µm in type species), conus with lumen invisible in its distal half. Median bulb round to oval, strongly muscular. Basal bulb clearly offset from intestine, separated by a well differentiated cardia. Deirids absent. Ovaries paired; spermathecae rounded, axial. Female tail cylindroid or subclavate, inner protoplasmatic content regressed; terminal cuticle abnormally thickened, a post-anal intestinal sac present absent. Male tail with large hyaline terminal portion, spicules with velum, gubernaculum protrusible.

Type Species

Paratrophurus loofi Arias, 1970.

Other species

P. acristylus Siddiqi *et* Siddiqui, 1983
P. anomalus Kleynhans *et* Heyns, 1983
P. bursifer (Loof, 1960) Siddiqi, 1971
P. costarricensis López, 1986
P. dissitus (Colbran, 1969) Siddiqi, 1971
P. hungaricus Andrássy, 1973
P. kenanae Decker *et* El-Amin, 1978
P. kleynsi sp. n.
P. sacchari Edward *et* Sharma, 1984
P. spenceri Edward *et* Thames, 1979
P. striatus sp. n.

Remarks

The genus *Paratrophurus* is close to *Tylenchorhynchus* Cobb, 1913 from which it differs only in the abnormally thickened terminal cuticle of the tail. Both genera have similar face view (SEM) with labial disc and labial sectors fused into a quadrangular strucutre and the first labial annulus not indented (see López, 1986 for SEM face views of *Paratrophurus*); a conus with invisible lumen in its anterior half (in Siddiqi, 1986, p. 198, for conus tip the word tubular is a misprint for nontubular, cf. fig. 46A, p. 199); deirids absent (reported as present in *Paratrophurus* by Fortuner and Luc, 1987); oesophageal glands forming a basal bulb which is offset from the intestine; axial, spheroidal spermathecae; flanged spicules and a protrusible, rod-like gubernaculum whose distal half has raised sides except near the extremity and proximal end is rounded and not bent posteriorly.

The character of the smooth conoid head that helped in the differentiation of *Paratrophurus* becomes less important because *P. striatus* has a broadly rounded truncate and striated head and because a similar *Paratrophurus*-type head appears in species of *Tylenchorhynchus* (e.g. *T. tarjani* Andrássy, 1969, *T.leviterminalis* Siddiqi, Mukherjee *et* Dasgupta, 1982, etc.). A comparative SEM study of the heads of these species should provide conclusive evidence about the relationship of *Paratrophurus* and *Tylenchorhynchus*.

Trophurus Loof, 1956 has a similar head, stylet, oesophagus and tail (specially its abnormally thickened terminal cuticle) to those of *Paratrophurus* but this genus is characterized by its reduced posterior female genital branch which is represented by a post-vulval uterine sac. We noticed a tendency towards reduction of the posterior genital branch in females of *P. costarricensis* from Venezuela and we have observed rudiments of a posterior ovary in an undescribed species of *Trophurus* from Colombia. With reference to this character, the situation is similar to that which exists in the differentiation of *Rotylenchoides* from *Helicotylenchus*. We believe that the loss of a functional posterior genital branch is a generic character of *Trophurus* and *Rotylenchoides*. These genera belong to a group (designated as suborder Hoplolaimina by Chizhov and Berezina, 1988) which is basically didelphic and in which the absence of a functional female reproductive branch is an apomorphic character. Mereover, *Trophurus* has a different gubernaculum to that of *Paratrophurus*.

Recently Fortuner and Luc (1987) synonymized *Histotylenchus* Siddiqi, 1971 and *Telotylenchoides* Siddiqi, 1971 with the genus *Paratrophurus* and rejected the character of overlapping glands and other diagnostic characters. This action, which necessitated enlarging the diagnosis of *Paratrophurus*, is not accepted here because the abutting

TABLE I - *Records of species of* Paratrophurus.

Species	Host	Locality	Reference
acristylus	Wheat	Al 'Azizia (Libya)	Siddiqi and Siddiqui, 1983
anomalus	Reed	Blood River Mount (S. Africa)	Kleynhans and Heyns, 1983
	Wheat	Karachi (Pakistan)	Maqbool and Fatima, 1986
bursifer	Rose	Boskoop (Netherlands)	Loof, 1960
costarricensis	Rice	La Palma (Costa Rica)	López, 1986
dissidus	Blue grass	Retro (Queensland)	Colbran, 1969
hungaricus	–	Hungary	Andrássy, 1973
kenanae	Acacia	Tozi (Sudan)	Decker and El-Amin, 1978
kleynsi	Sugarcane	Mtubatuba (S. Africa)	Kleynhans and Heyns, 1983
loofi	Wheat	Sevilla (Spain)	Arias, 1970
	Beet	Galicia (Spain)	Arias and Romero, 1971
	Barley	Guadalajara (Spain)	Zancada and Bello, 1981
	Several plants	Bulgaria	Katalan-Gateva and Tsoneva, 1982
	Several plants	Büyüc Çekmece (Turkey)	Saltukoglu *et al.*, 1976
sacchari	Sugarcane	Idikarai (India)	Edward and Sharma, 1984
spenceri	Compositae	Texas (USA)	Edward and Thames, 1979
Paratrophurus sp.	Several plants	Japan	Teruya, 1979; Gotoh, 1977

(forming a definite bulb) or overlapping of oesophageal glands is not considered as a morphocline but a binary character (present/absent). Luc *et al.* (1987) established some phylogenetic trends of Tylenchina, and in trend 5 it is stated that «In the ancestral state the three glands are in a definite bulb-like structure, not overlapping the intestine and generally there is a well developed oesophago-intestinal valve (= cardia). Transitional cases are present in some families, for example, *Pararotylenchus* (Hoplolaimidae), with «bulb», where an intestinal overlapping is the rule». We do not concur with the view expressed in their second sentence since this «bulb» lacks a differentiated cardia as seen in Tylenchidae and Dolichodoridae. We call it a pseudobulb and it is this pseudobulb which has been considered as a valid apomorphic character to distinguish a *Pararotylenchus* from *Rotylenchus* (Baldwin and Bell, 1981).

Siddiqi (1971) stated that in *Paratrophurus* species the oesophageal glands are enclosed in a definite bulb which is separated from the intestine by a large-celled cardia. This type of basal bulb enclosing oesophageal glands and provided with a large cardia at its base is a plesiomorphic (ancestral) character state of the family Dolichodoridae in which apomorphic (derived) state of the same character, the overlapping glands with dorsal gland comprising most of the glandular body, is found in several genera (*Telotylenchus, Histotylenchus*).

We consider Dolichodoroidea as a separate transformation series from Hoplolaimoidea. In the latter, the overlapping glands, with subventral glands comprising most of the glandular body and extending past the dorsal glands, is a synapomorphy (shared derived character state) that distinguishes is from Dolichodoridae and Psilenchidae (see Siddiqi, 1986, p. 77). The pseudobulb of *Pararotylenchus* is the result of the shortening of the glands. In other words, in this transformation series (i.e. Hoplolaimoidea), overlapping glands represent the plesiomorphic state and the pseudobulb an apomorphic state and complying with the general rule, this plesiomorph (overlapping glands) is of common occurrence within the series.

Besides the character of the oesophageal glands, *Paratrophurus* differs from *Histotylenchus* and *Telotylenchoides* in having the stylet conus with a solid appearance in its distal half (as stated above). Moreover, the conus of *Histotylenchus* is different in being asymmetrical (see Siddiqi, 1971). We emphasize that in order to study the conus in this group it is essential that the front end of the nematode should be exactly lateral in position (which can be ascertained by looking at the lateral field on the neck region). The SEM face view of *Telotylenchoides housei*, the type species of *Telotylenchoides*, shows broken labial annuli near the amphid apertures similar to *Telotylenchus* but that of *Paratrophurus* shows complete labial annuli (see Sher and Bell, 1975; López, 1986).

PARATROPHURUS SUDANENSIS Decker, Yassin *et* El-Amin, 1975

This species was described from a single female collected from the rhizosphere of *Sorghum sudanensis* (piper) Stapf in Hudeiba, Northern Province, Sudan, with these measurements:
L = 0.827 mm; a = 31.8; b = 5.5; c = 13.1; c' = 3.2; V = 52.2; stylet = 17 µm. The tail is subcylindrical 63 µm long, with a conoid-rounded, smooth terminus and 46 annuli. The thickened terminal cuticle is 7.5 µm or about 1/8 of the entire tail length. The cephalic region is conoid-rounded, without transverse striae. On the basis of the character of the female tail, we consider this species to belong to the genus *Tylenchorhynchus* Cobb, 1913 and propose it as *Tylenchorhynchus sudanensis* (Decker, Yassin *et* El-Amin, 1975) n. comb. Since this species and *Histotylenchus sudanensis* Siddiqi, 1977 belong to separate genera, the name *Paratrophurus siddiqi* proposed as *nom. nov.* for *H. sudanensis* Siddiqi, 1977 by Fortuner *et* Luc, 1987 becomes redundant and is regarded here as a junior objective synonym of *H. sudanensis* Siddiqi, 1977.

PARATROPHURUS ACRISTYLUS Siddiqi*et* Siddiqi, 1983 (Fig. 1, Table II)

Female: body ventrally arcuate with fine transverse annuli about 1 µm wide near middle. Cephalic region anteriorly conoid rounded, continuous with body contour, framework lightly sclerotized. Stylet extremely slender, sharply pointed, conus 11.5 (11-12) µm long solid-appearing for more than half its length; knobs small rounded, 3-3.5 µm wide. Excretory pore near the distal end of basal bulb. Isthmus slender, about 2 times as long as median bulb [2.5 ± 0.13 (2.2-2.7)]. Basal bulb small, rounded pyriform 17 µm (15-18) long. Ovaries symmetrical, outstretched; spermathecae filled with sperm. Postanal intestinal sac 16-25 µm long. Tail cylindroid with smooth terminus, hyaline portion 24 (20-27)% of tail length.

Male: similar to female apart from sex characters. Spicules arcuate, prominently flanged distally. Gubernaculum protruding, with proximal end directed forward.

Discussion: specimens of *P. acristylus* were found in sugarbeet soil from Doukkala, Zemamro, in Morocco. Measurements and morphology are similar to those given by Siddiqi and Siddiqui, 1983 from Libya. This species is very close to *P. loofi* Arias, 1970 but differs in stylet (more slender vs. thicker), shape of basal bulb (rounded, pyriform vs. saccate), tail annuli (30-41 vs. 24-36), and presence of a long post-anal intestinal sac.

TABLE II - *Morphometrics of* Paratrophurus acristylus *from Morocco (measurements in μm)*

	Females n = 17			Males n = 12		
	$\bar{\chi} \pm SD$	Extr. Val.	CV %	$\bar{\chi} \pm SD$	Extr. Val.	CV %
L	690 ± 43	616 – 766	6.2	696 ± 42	637 – 791	6.0
a	32.9 ± 1.59	29.7 – 36.5	4.8	34.1 ± 1.97	31.8 – 38.4	5.8
b	5.6 ± 0.25	5.3 – 6.2	4.6	5.8 ± 0.40	5.3 – 6.8	7.3
b_1	9.8 ± 0.40	9.3 – 11.0	4.5	10.1 ± 0.8	9.4 – 12.3	8.3
V	57 ± 1.4	54 – 59	2.5	–	–	–
T	–	–	–	44 ± 4.77	36 – 51	10.7
G_1	24 ± 3.2	19 – 29	13.2	–	–	–
G_2	23 ± 3.4	19 – 30	14.6	–	–	–
c	17.2 ± 0.8	15.9 – 18.9	4.9	17.3 ± 1.3	14.8 – 19.3	7.8
c'	2.5 ± 0.14	2.3 – 2.7	5.9	2.4 ± 0.2	2.1 – 2.8	9.2
Stylet	21 ± 0.72	20 – 22	3.4	20 ± 0.8	19 – 22	4.0
m	55 ± 1.6	53 – 57	2.9	54 ± 2.2	59 – 57	4.0
O	9.4 ± 0.4	9 – 10	3.9	9.8 ± 0.3	9.5 – 10	2.7
S*	1.6 ± 0.05	1.5 – 1.7	3.7	1.6 ± 0.07	1.6 – 1.8	4.3
MB	52 ± 1.2	50 – 54	2.3	53 ± 1.2	51 – 54	2.2
Procorpus	31 ± 2.7	27 – 38	8.8	31 ± 2.2	29 – 34	6.9
Isthmus	29 ± 1.6	27 – 33	5.4	29 ± 2.4	23 – 31	8.2
Nerve ring	79 ± 5.7	72 – 90	7.2	78 ± 2.9	75 – 83	3.7
Oesophagus	122 ± 7.4	112 – 137	6.1	119 ± 3.6	114 – 124	3.0
Maximum body width	21 ± 1.54	18 – 23	7.3	20 ± 1.3	18 – 23	6.4
Anal body width	16 ± 1.01	15 – 18	6.3	17 ± 0.5	16 – 18	3.2
Tail length	40 ± 3.05	34 – 46	7.6	40 ± 2.97	37 – 47	7.4
h	9.7 ± 1.1	7 – 11	11.9	14 ± 0.8	13 – 15	5.9
Tail annuli	35 ± 3.5	30 – 41	9.9	–	–	–
Spicules	–	–	–	22 ± 1.08	21 – 24	4.8
Gubernaculum	–	–	–	11 ± 0.5	11 – 12	4.6
Bursa	–	–	–	72 ± 7.9	60 – 87	10.9

* = stylet length ÷ body width at base of stylet.

PARATROPHURUS LOOFI Arias, 1970 (Fig. 1, Table III)

Female: body cylindrical, narrowing in anterior end. Cuticle annuli 1-1.3 μm wide. Cephalic region conoid-rounded, without distinct annuli. Stylet of medium strength, conus longer than shaft, knobs 2.5-3.6 μm wide. Median bulb oval, 10-13 μm long. Isthmus about 3 times as long as median bulb [3.2 ± 0.12 (3.0-3.3)]. Basal bulb small 14-20 μm long. Excretory pore 93 μm (82-106) from anterior end. Hemizonid 1-2 annuli anterior to excretory pore.

Vulva transverse, without epiptygma, vagina about 1/2 body width long. Ovaries outstretched, spermathecae large, rounded, 11-15 μm long, filled with rounded sperm 2-2.5 μm wide. Tail cylindrical, with 24-36 annuli, terminus striated, hyaline region 9-11 μm long.

Male: morphologically similar to female except in shorter stylet (19-21 μm) and body (531-633 μm), apart from sex characters. Spicules arcuate, cephalated, 20-24 μm long. Gubernaculum 10-12 μm long.

Discussion: specimens of *P. loofi* were found around roots of *Fraxinus angustifolia* L. with herbaceous plants from Tranco de Beas, Sierra de Cazorla, Jaén, Spain. Measurements and morphological characters are similar to those given by Arias (1970), except the lengths of spicules (20-24 μm vs 26-27) and gubernaculum (10-12 μm vs 12-15 μm). Saltukoglu *et al.* (1976) reported spicules and gubernacu-

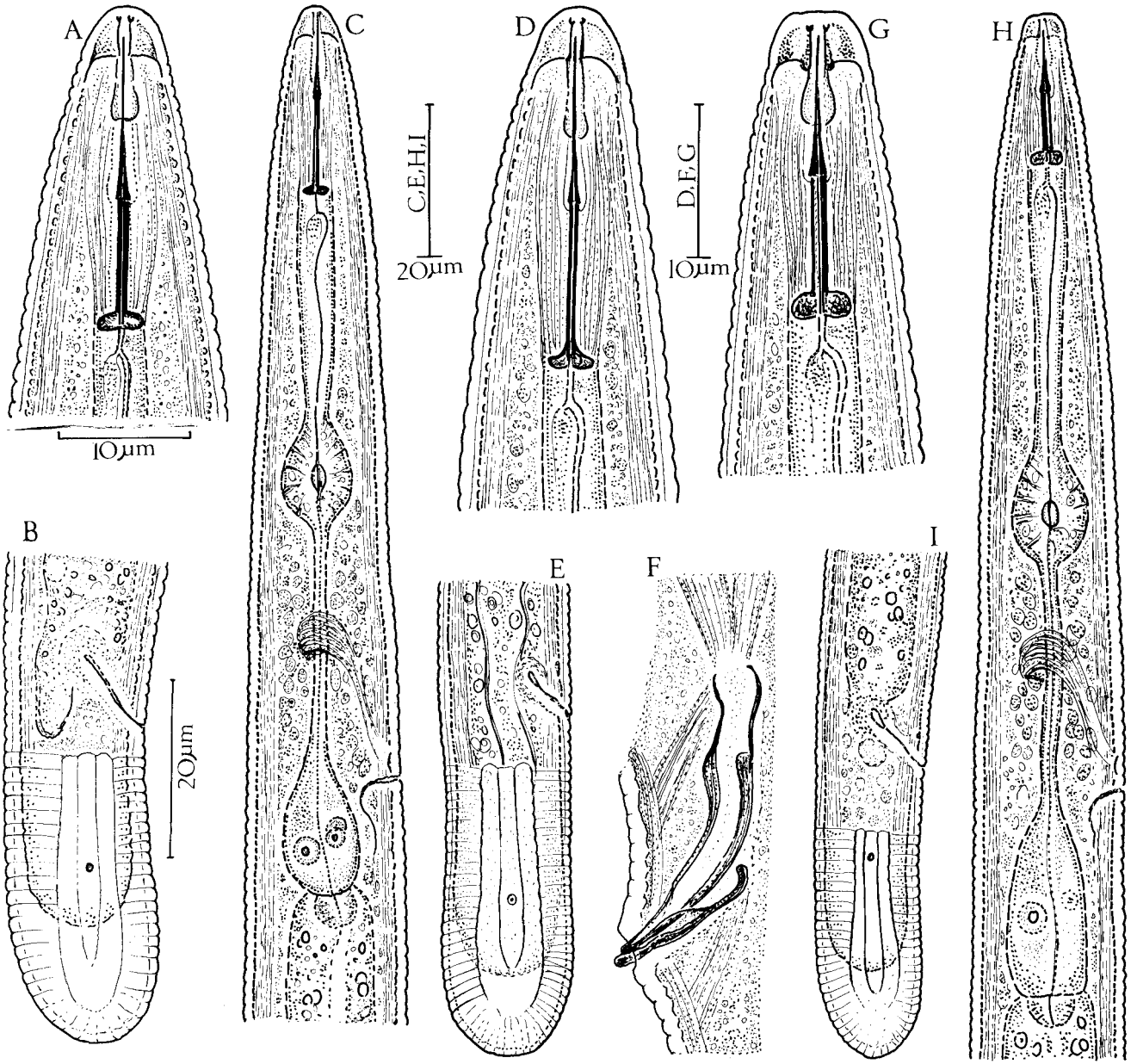


Fig. 1 A, B - *Paratrophurus loofi*, paratype: A, female anterior region; B, female tail; C-F, *Paratrophurus acristylus* from Morocco: C, female oesophageal region; D, female anterior region; E, female tail; F, male cloacal region; G-I, *Paratrophurus spenceri* paratypes: G, female anterior region; II, female oesophageal region; I, female tail.

lum in Turkish specimens to be 23-26 µm and 13 µm long, respectively and the lengths of the stylet in males and females as 22-23 µm and 22-26 µm, respectively.

PARATROPHURUS COSTARRICENSIS López, 1986 (Fig. 2, Table IV)

Female: body ventrally arcuate upon fixation. Cuticular annuli 1 µm wide at midbody. Lateral field with four smooth incisures occupying 30-38% of body width. Cephalic region rounded, 6 µm wide at base, with edges sometimes expanded, without distinct annuli. Cephalic framework sclerotized, inner extension of framework forms a stylet guiding tube which is conspicuous and inverted funnel-shaped. Stylet strong, cone 10.5-11 µm long. Stylet knobs 4.5-5 µm wide, flattened anteriorly and laterally directed. Orifice of dorsal oesophageal gland 2-2.5 µm behind stylet knobs. Median bulb oval, with valvular apparatus 3-3.5 µm long. Isthmus slender, more than twice

as long as median bulb [2.2 ± 0.10 (2.1-2.3)]. Excretory pore located at last third of isthmus. Heminozid 2 annuli long, situated 1 annulus anterior to excretory pore.Basal bulb saccate, 18-21 μm long; oesophago-intestinal valve large, 3-4 μm long. Ovaries outstretched, posterior ovary less developed than the anterior (5-6 smaller oocytes vs. 10-12 in anterior ovary), (Fig.2, A). Spermathecae indistinct, empty. Rectum 7-9 μm long, slightly overlapped by intestine. Tail cylindroid, with 21-28 annuli. Terminus smooth. Hyaline region 10-12 μm long. Phasmid located on 13-16th annulus opsterior to anus level.

Male: not found.

Habitat and locality: present specimens were collected from soil around roots of sugarcane at Lara, Barquisimeto from Venezuela.

Discussion: *Paratrophurus costarricensis* differs from *P. loofi* Arias, 1970 in having larger stylet knobs (4.5-5 μm wide vs. 2.5-3.6 μm); absence of males and distinct spermathecae, posterior ovary being smaller than anterior (vs. equally developed) and (tail/h) 2.6 (2.3-2.9) vs. 3.6 (3.1-4.2).

TABLE III - *Morphometrics of* Paratrophurus loofi *from Spain (measurements in μm).*

	Females n = 13			Males n = 6		
	$\bar{\chi} \pm SD$	Extr. Val.	CV %	$\bar{\chi} \pm SD$	Extr. Val.	CV %
L	674 ± 53	569 – 753	7.9	598 ± 36	531 – 633	6.0
a	33.7 ± 1.99	30.8 – 36.6	5.9	34.2 ± 1.84	31.2 – 36.3	5.4
b	5.8 ± 0.44	5.3 – 6.4	7.7	5.8 ± 0.66	5.2 – 6.9	11.4
b_1	10.4 ± 0.75	9.6 – 11.8	7.2	9.7 ± 0.05	9.7 – 9.8	0.6
V	57 ± 0.68	56 – 58	1.2	–	–	–
T	–	–	–	49 ± 5.38	38 – 52	11.0
G_1	27 ± 2.82	24 – 33	10.4	–	–	–
G_2	25 ± 3.80	20 – 33	15.2	–	–	–
c	17.8 ± 1.44	15.6 – 20.9	8.1	14.1 ± 1.09	12.9 – 15.8	7.8
c'	2.5 ± 0.20	2.3 – 3.0	8.3	2.8 ± 0.18	2.6 – 3.1	6.6
Stylet	21 ± 0.94	19 – 23	4.5	20 ± 0.81	19 – 21	4.1
m	58 ± 1.22	56 – 60	2.1	57 ± 1.7	56 – 60	2.9
O	9 ± 0.64	8 – 10	7.0	–	–	–
S	1.7 ± 0.1	1.5 – 1.8	6.1	–	–	–
MB	51 ± 0.9	50 – 52	1.8	51 ± 0.8	50 – 52	1.6
Procorpus	32 ± 1.89	29 – 33	6.0	–	–	–
Isthmus	30 ± 2.62	25 – 33	8.7	–	–	–
Nerve ring	76 ± 8.21	68 – 97	10.7	21 ± 2.34	68 – 73	3.3
Oesophagus	117 ± 12.11	100 – 142	10.4	102 ± 10.1	89 – 113	9.8
Maximum body width	20 ± 1.52	17 – 23	7.6	17 ± 0.54	17 – 18	3.1
Anal body width	15 ± 1.62	13 – 18	10.7	15 ± 0.98	14 – 16	6.5
Tail length	38 ± 4.38	31 – 45	11.4	43 ± 4.36	38 – 49	10.2
h	10.3 ± 0.63	9.5 – 11.5	6.1	–	–	–
Tail annuli	32 ± 3.82	24 – 36	12.1	–	–	–
Spicules	–	–	–	21 ± 1.63	20 – 24	7.6
Gubernaculum	–	–	–	10 ± 0.83	10 – 12	8.0
Bursa	–	–	–	60 ± 4.47	55 – 67	7.4

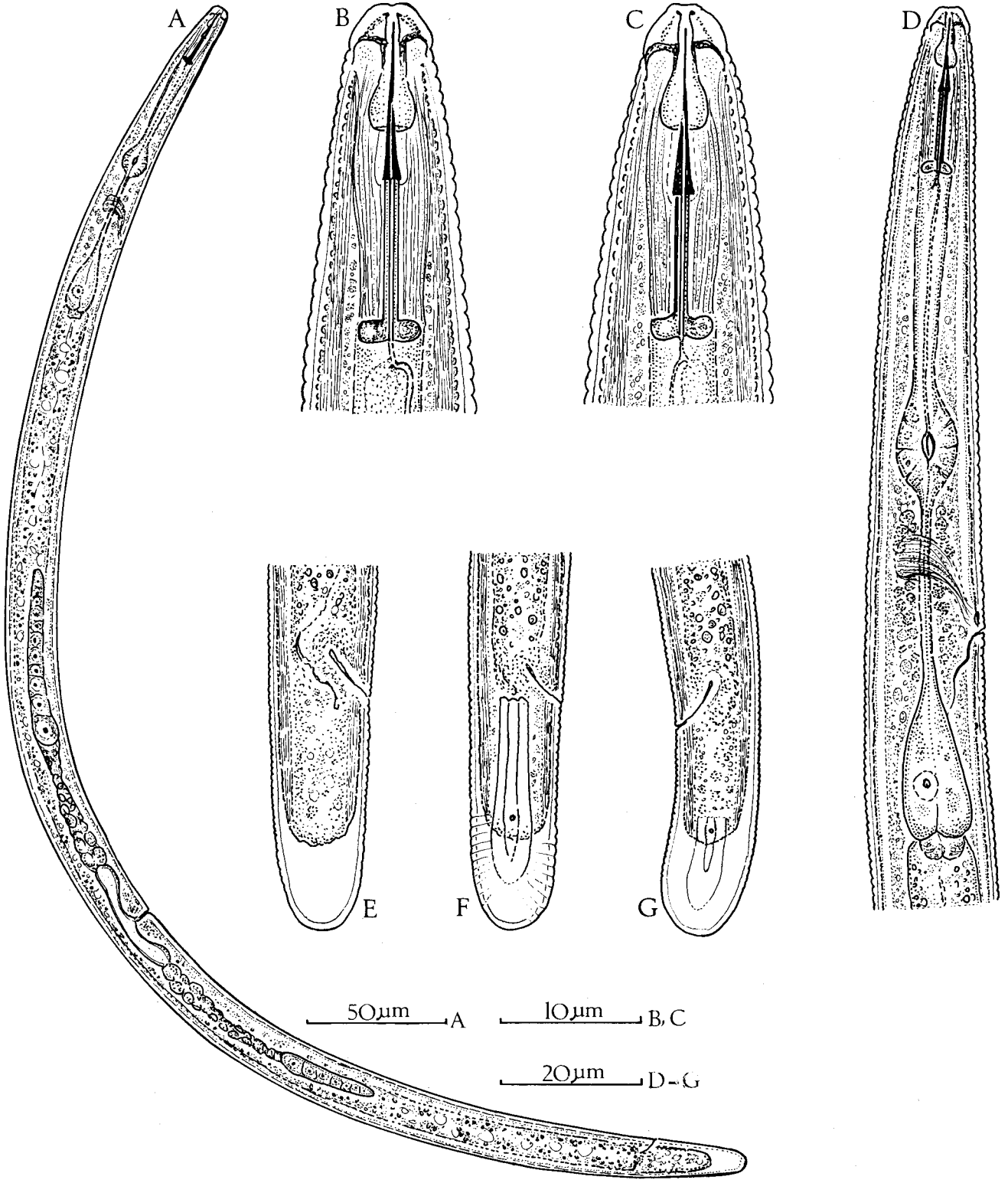


Fig. 2 - *Paratrophurus costarricensis*: A, body habitus; B and C, female anterior regions; D, female oesophageal region; E and F, femal tails.

PARATROPHURUS SPENCERI Edward *et* Thames, 1979 (Fig. 3, Table V)

Female: body ventrally curved. Lateral field with four smooth incisures, occupying 30-32% of body width. Cephalic region conoid, flattened anteriorly, 6-6.5 μm wide at base, smooth, continuous with body contour. Cephalic framework strongly sclerotized, inner extension of framework cylindrical. Stylet strong, robust, conus 8.5-9 μm long. Stylet knobs 4 μm wide, rounded, laterally directed. Orifice of dorsal oesophageal gland 1.5-2 μm behind stylet knobs. Procorpus with a depression at the beginning of median bulb, 31-30 μm long. Median bulb round-oval, 12-15 μm long × 8.5-11 μm wide; with valvular apparatus 4 μm long. Isthmus about twice as long as median bulb [2 ± 0.10 (1.9-2.2)]. Excretory pore near distal end of basal bulb. Hemizonid 3 annuli long, 2 annuli anterior to excretory pore. Basal bulb saccate, 23-25 μm long; oesophagointestinal valve rounded, 4-4.5 μm long. Vulva subpostmedian. Ovaries outstretched, equally developed. One specimen found with both genital branches directed anterior to vulva. Spermatheca indistinct. Intestine not overlapping rectum. Tail cylindrical, with 30-33 annuli. Terminus smooth. Hyaline region 9.5-12 μm long. Phasmid located 12-15 annuli posterior to anus level.

Male: not found.

Type locality: these specimens were deposited by J.C. Edwards (Allahabad, India) in the C.I.P.'s collection.

Diagnosis and relationships: *Paratrophurus spenceri* can be differentiated from *P. costarricensis* by stylet length (17-19 μm vs. 19-23 μm) and posterior ovary (equally developed than anterior vs. less developed than anterior). It differs from *P. loofi* in stylet length [17-19 μm vs. 21 (18-25) μm]; stylet knob width (4 μm vs. 2-3.6 μm); m ratio (49-50 vs. 56-60); cephalic region (conoid, flattened anteriorly vs. conoid-rounded) and position of vulva [53-54 vs. 57 (53-67)].

TABLE IV - *Morphometrics of* Paratrophurus costarricensis from Venezuela (measurements in μm).

	Females n = 7		
	$\bar{\chi} \pm SD$	Extr. Val.	CV %
L	541 ± 25	503 – 578	4.6
a	29.9 ± 1.5	27.5 – 32.0	5.0
b	4.5 ± 0.3	4.2 – 5.1	6.8
b_1	8.0 ± 0.5	7.5 – 8.9	6.4
V	60 ± 1.1	59 – 62	1.9
G_1	25 ± 1.8	22 – 27	7.3
G_2	20 ± 1.6	17 – 21	7.8
c	18.9 ± 1.4	17.5 – 21.9	7.3
c'	2.1 ± 0.1	1.8 – 2.3	7.4
Stylet	22 ± 0.9	21 – 23	4.3
m	50 ± 0.4	50 – 51	0.8
O	9.6 ± 1.1	8.5 – 12	11.8
S	1.8 ± 0.07	1.7 – 1.9	3.9
MB	51 ± 0.6	50 – 52	1.1
Procorpus	28 ± 1.1	27 – 30	3.9
Isthmus	28 ± 0.9	27 – 29	3.4
Nerve ring	74 ± 4.1	69 – 82	5.5
Oesophagus	119 ± 4.4	114 – 126	3.7
Maximum body width	18 ± 1.3	17 – 21	7.4
Anal body width	13.5 ± 0.6	13 – 14.5	4.8
Tail length	29 ± 3.1	23 – 33	10.8
h	10.7 ± 0.8	10 – 12	7.2
Tail annuli	24 ± 2.2	21 – 28	9.0

TABLE V - *Morphometrics of* Paratrophurus spenceri, *paratypes (measurements in μm).*

	Females n = 5		
	$\bar{\chi} \pm SD$	Extr. Val.	CV %
L	653 ± 26	619 – 681	4.0
a	30.8 ± 1.2	28.9 ± 32.4	4.1
b	4.9 ± 0.3	4.4 – 5.1	5.9
b_1	8.7 ± 0.7	7.7 – 9.6	7.9
V	53 ± 0.5	53 – 54	1.0
G_1	24 ± 3.6	21 – 29	14.8
G_2	22 ± 2.4	20 – 25	10.6
c	17.3 ± 0.8	16.3 – 18.4	4.8
c'	2.8 ± 0.2	2.5 – 3.0	6.6
Stylet	18 ± 0.8	17 – 19	4.7
m	50 ± 0.4	49 – 50	0.9
O	10 ± 1.6	8 – 12	15.8
S	1.6 ± 0.1	1.5 – 1.7	5.3
MB	51 ± 1.1	49 – 52	2.2
Procorpus	36 ± 3.4	31 – 40	9.4
Isthmus	27 ± 1.1	26 – 29	4.2
Nerve ring	83 ± 5.0	75 – 87	6.0
Oesophagus	133 ± 5.4	127 – 140	4.1
Maximum body width	21 ± 0.8	20 – 22	3.9
Anal body width	14 ± 0.7	13 – 14.5	4.9
Tail length	38 ± 1.8	35 – 39	4.7
h	10.6 ± 1.0	9 – 12	9.6
Tail annuli	32 ± 1.1	30 – 33	3.4

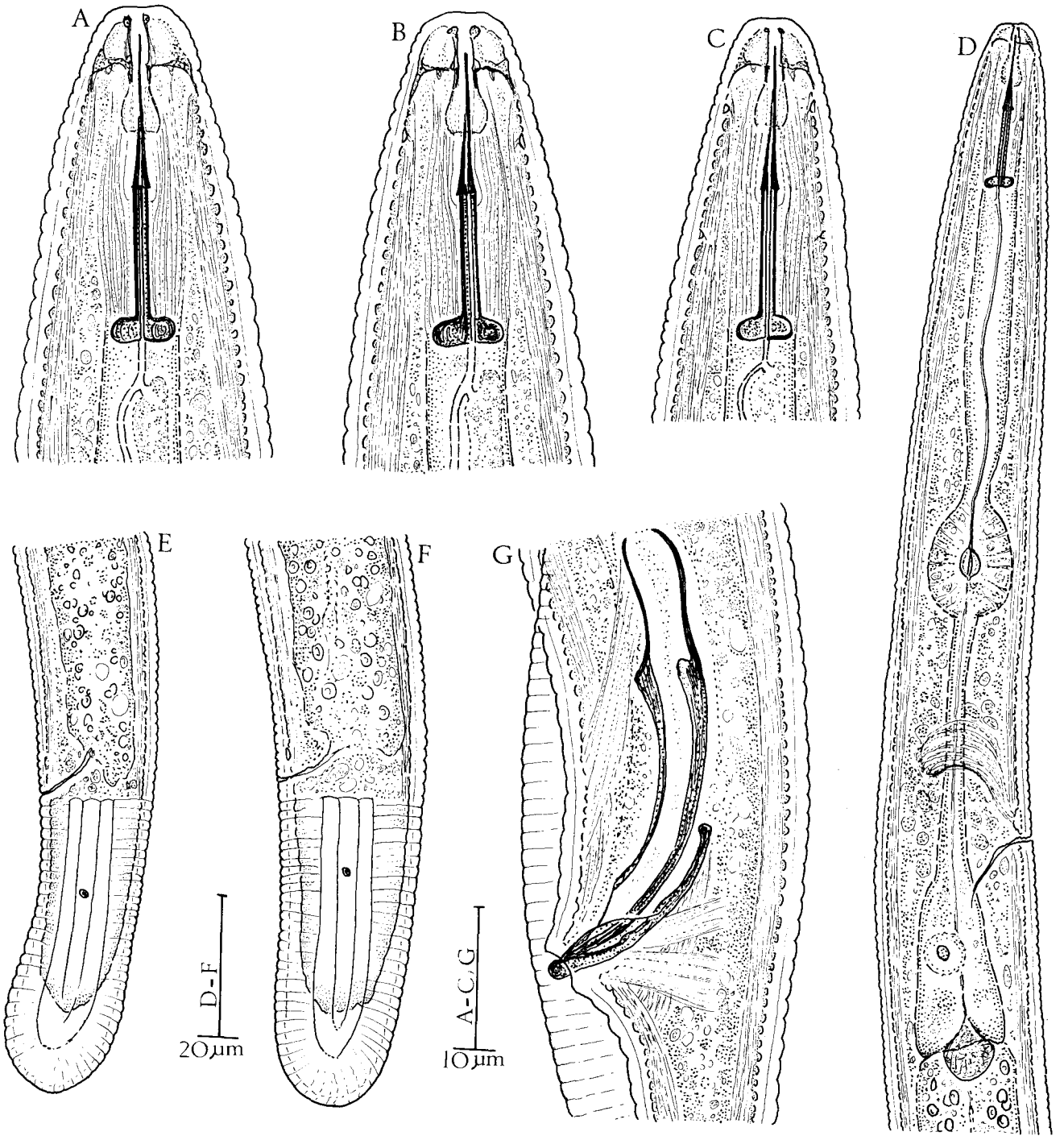


Fig. 3 -*Paratrophurus striatus* sp. n.: A-C: female anterior regions; D, female oesophageal region; E and F, female tails; G, male cloacal region.

PARATROPHURUS STRIATUS sp. n. (Fig. 3, Table VI)

Holotype female: L = 747 μm; a = 27.7; b = 5.4; b_1 = 9.2; c = 20.2; V = 53; c' = 1.9; stylet = 20 μm; O = 10; tail annuli = 30.

Allotype male: L = 797 μm; a = 34.6; b = 6.5; b_1 = 8.9; c = 21.5; T = 51; c' = 2.0; stylet = 20 μm; O = 10; spicules = 34 μm; gubernaculum = 16 μm.

Female: body slightly ventrally curved upon fixation. Cuticular striae distinct, 1-1.3 μm apart near mid body. Lateral fields occupying 1/3 of body width, with four smooth lines, areolated only in oesophageal region. Cephalic region continuous with body contour, truncate, with 5-6 distinct annuli (hence the species name). Cephalic framework strongly sclerotized. Stylet robust, with conus about as long as shaft; stylet knobs large, 4-4.5 μm wide, with anterior surfaces flat to concave. Orifice of dorsal oesophageal gland 2-2.5 μm behind stylet. Procorpus cylindrical, 1.2-1.5 times longer than isthmus. Median bulb oval-rounded, 14 μm (13-16) long × 11 μm (10-12) wide, with prominent, 4 μm long, valvular apparatus in centre. Excretory pore located near distal end of basal oesophageal bulb. Hemizonid three annuli long, 3-4 annuli above the excretory pore. Isthmus 2 ± 0.19 (1.7-2.5) longer than median bulb. Basal bulb saccate, 27 μm (21-33) long; oesophago-intestinal valve large, rounded, 6-8 μm long. Vulva transverse with a poorly developed epiptygma. Vagina 14 μm (13-16) long. Ovaries outstretched, oocytes arranged in a single row. Spermathecae with sperm. Rec-

TABLE VI - *Morphometrics of* Paratrophurus striatus sp. n., *paratypes (measurements in μm).*

	Females n = 35			Males n = 9		
	$\bar{\chi} \pm SD$	Extr. Val.	CV %	$\bar{\chi} \pm SD$	Extr. Val.	CV %
L	752 ± 65	625 – 894	8.6	711 ± 55	647 – 797	7.7
a	30.3 ± 1.67	27.2 – 34.1	5.5	31.4 ± 2.46	28.1 – 34.6	7.8
b	5.5 ± 0.4	4.9 – 6.6	7.7	5.4 ± 0.49	4.9 – 6.5	9.1
b_1	9.5 ± 0.71	8.3 – 11.1	7.5	9.3 ± 0.94	8.3 – 10.4	10.1
V	34 ± 1.48	51 – 56	2.7	–	–	–
T	–	–	–	50 ± 8.77	30 – 60	17.5
G_1	27 ± 4.13	20 – 36	15.1	–	–	–
G_2	27 ± 4.54	20 – 36	16.7	–	–	–
c	21.0 ± 1.60	18.2 – 24.1	7.6	18.3 ± 1.43	16.6 – 21.6	7.8
c'	2.0 ± 0.16	1.7 – 2.3	7.9	2.1 ± 0.15	1.9 – 2.3	7.4
Stylet	20 ± 0.56	20 – 22	2.8	20 ± 0.50	19 – 21	2.5
m	51 ± 1.11	50 – 53	2.2	50 ± 0.44	50 – 51	0.9
O	10 ± 1.0	8 – 13	10.0	10 ± 0.70	9 – 12	6.9
S	1.4 ± 0.1	1.2 – 1.5	5.5	1.4 ± 0.05	1.4 – 1.5	2.4
MB	51 ± 1.37	50 – 54	2.7	53 ± 2.13	50 – 56	4.0
Procorpus	41 ± 2.79	37 – 45	6.8	37 ± 3.1	31 – 40	8.3
Isthmus	29 ± 3.0	25 – 37	10.4	31 ± 1.97	29 – 35	6.3
Nerve ring	88 ± 5.56	70 – 98	6.3	82 ± 8.34	71 – 94	10.1
Excretory pore	109 ± 8.77	84 – 120	8.1	101 ± 7.96	90 – 112	7.9
Oesophagus	136 ± 10.5	110 – 151	7.8	130 ± 8.1	120 – 145	6.2
Maximum body width	25 ± 1.69	21 – 29	6.8	23 ± 1.65	21 – 26	7.3
Anal body width	17 ± 1.64	14 – 21	9.5	18 ± 0.86	17 – 20	4.8
Tail length	36 ± 3.89	28 – 44	10.8	39 ± 2.52	35 – 43	6.5
h	10.5 ± 0.69	10 – 12	6.6	–	–	–
Tail annuli	30 ± 3.42	22 – 36	11.3	–	–	–
Spicules	–	–	–	31 ± 1.92	29 – 34	6.2
Gubernaculum	–	–	–	15 ± 1.05	14 – 16	7.1

tum 9-11 μm long, slightly or not overlapped by intestine. Tail cylindrical, with hemispherical annulated terminus, hyaline region 10-12 μm long. Phasmid located at 11th (8-19) annuli posterior to anus level.

Male: relatively less common than female. Body more arcuate than in female. Testis single outstretched, mostly with two rows of spermagonia. Spicules cephalated, ventrally arcuate, with distinct velum. Gubernaculum slightly arcuate. Bursa with crenate margin, 72 μm (64-80) long.

Type habitat and locality: soil around roots of *Populus nigra* L. with herbaceous plants and grasses from Arroyo Frio, Sierra de Cazorla, Jaén, Spain.

Type specimens: holotype, allotype, female and male paratypes in the collection of Instituto «Lopez-Neyra» de Parasitología (C.S.I.C.), Granada, Spain; two female paratypes and one male paratype in the collection of the Muséum national d'Histoire naturelle, Paris, France and four female paratypes and one male paratype at C.I.P., St. Albans, Hertz, England.

Diagnosis and relationships: *Paratrophurus striatus* sp. n. is characterized by a truncate cephalic region which is continuous with the body contour and bears 5-6 distinct annuli. It is further distinguished by the robust stylet, 20-22 μm long, laterally directed stylet knobs and an annulated tail tip.

It differs from *P. loofi* Arias, 1970 by the cephalic region (narrow, conoid-rounded without distinct annuli in the latter), stylet (stout, with conus as long as shaft *vs* slender, with conus longer than the shaft), cephalic framework (strongly sclerotized *vs* slightly sclerotized) and c' index (1.7-2.3 *vs* 3.5), spicules (29-34 μm *vs* 20-24 μm). It can be differentiated from *P. dissitus* (Colbran, 1969) Siddiqi, 1971 in stylet length (20-21 μm *vs* 25-29 μm), DGO (2-2.5 μm *vs* 3.5 μm) and tail length (1.7-2.3 *vs* 1.2-1.6 times as long as anal body width).

PARATROPHURUS KLEYNSI sp. n. (Fig. 4)

A species of *Paratrophurus*, named *Paratrophurus* species 1, was described and illustrated by Kleynhans and Heyns (1983) based on one female, one male and one juvenile collected from clay soil about the roots of surgacane in Hlabisa district, Mtubatuba, South Africa. We have examined this material and additional specimens (one female and male on slide No. 22464 leg. Dr. M.V. Niekerk, 1-2-1984) kindly sent by K.P.N. Kleynhans. It is clearly a new species of the genus *Paratrophurus* having the longest body and stylet of all the known species of the genus. It is named here as *Paratrophurus kleynsi* sp. n. after *Kle*ynhans and He*yns* (for description see Kleynhans and Heyns, 1983).

Holotype female (own measurements): L = 1.62 mm; a = 54.1; b = 9.7; c = 23.8; c' = 2.3; V = 45.6; m = 56.6; MB = 58; stylet = 30 μm; conus = 17 μm; stylet knob width = 3.5 μm; h = 11 μm.

Paratypes: *female* (n = 1): L = 2.01 mm; a = 67.0; b = 11.5; c = 36; c' = 2.4; V = 42.8; m = 50; stylet = 35 μm; conus = 17.5 μm; stylet knobs = 3.3 μm across; h = 13.5 μm; tail = 56 μm.

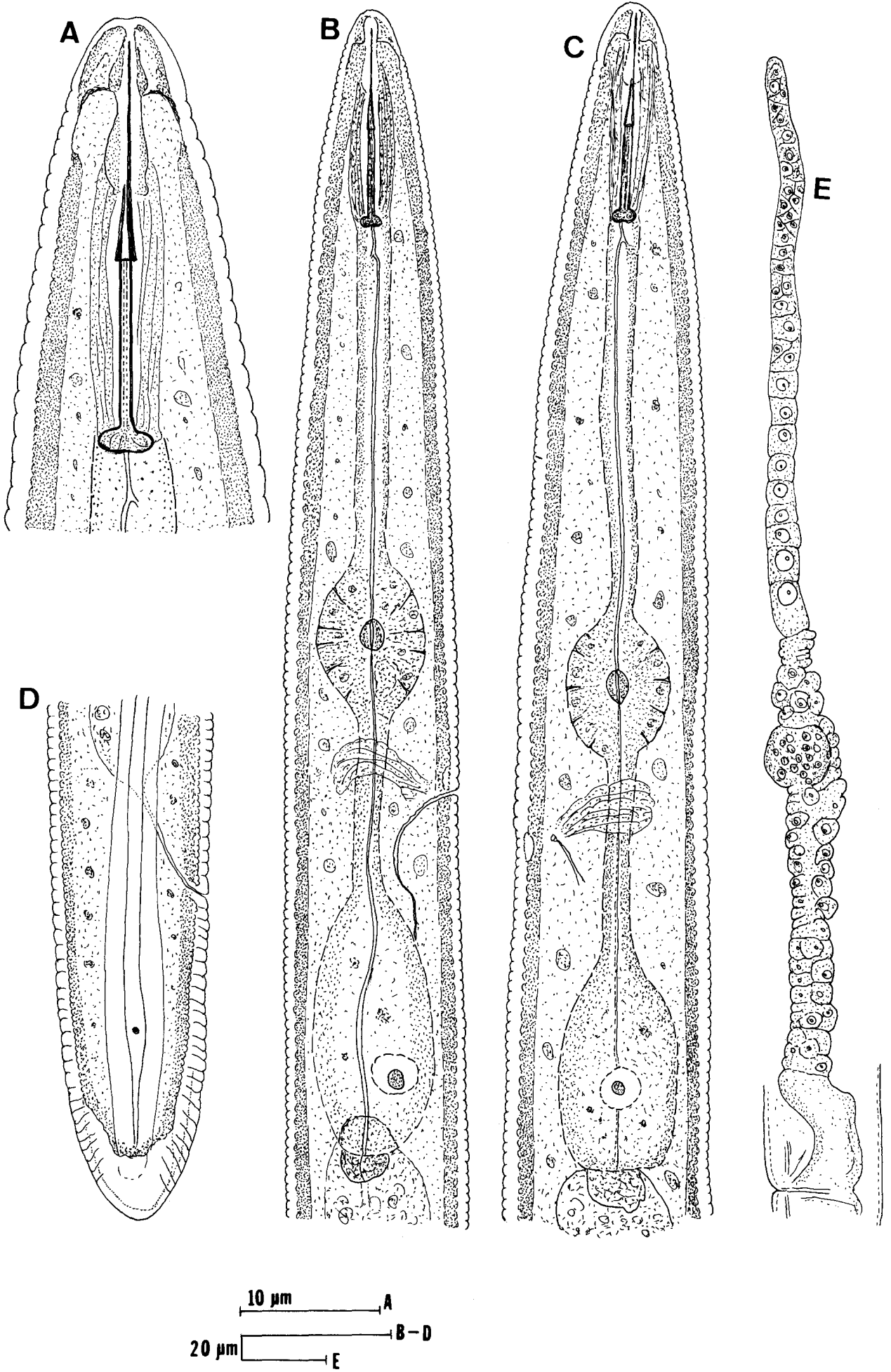
Males: (n = 2); L = (1.95-2.18) mm; a = (61.0-73.0); b = (10.2-12.4); c = (27.3-33.8); m = (52.9-54.1); MB = (53.1-65); stylet = (30.3-34) μm; spicules = (27.3-30) μm; gubernaculum = 13 μm; tail = 58-80 μm.

Type habitat and locality: clay soil around roots of sugarcane, Mtubatuba, Hlabisa district, Natal, South Africa.

Type specimens: at Plant Protection Research Institute, Pretoria, South Africa, slides No. 18642-18644 and No. 22464.

Key to species of *Paratrophurus*

1. Body more than 1.5 mm long, stylet 30-35 μm long; isthmus about as long as median bulb . . . . . .*P. kleynsi* sp. n.
   Body under 1 mm long; stylet under 30 μm long; isthmus about twice or more as long as median bulb 2
2. Stylet 14 μm long . . . . . .*P. hungaricus* Andrássy, 1973
   Stylet 16-29 μm long 3
3. Stylet 25-29 μm long; c' = 1.2-1.6 . . . . . .*P. dissitus* (Colbran, 1969) Siddiqi, 1971
   Stylet under 24 μm long; c' = 1.7 or more 4
4. Female tail bursate . . . . . .*P. bursifer* (Loof, 1960) Siddiqi, 1971
   Female tail not bursate 5
5. Cephalic region striated . . . . . .*P. striatus* sp. n.
   Cephalic region smooth 6
6. Spermathecae indistinct, empty; males not known 7
   Spermathecae distinct, usually with sperm; males abundant 9
7. V = 58-65; c' = 1.5-2.4 . . . . . .*P. costarricensis* López, 1986
   V = 51-55; c' = 2.5-4.8 8


A
B
C
D
E
10 µm
A
B – D
20 µm
E

8. Stylet 17-19 µm long . . . . . .*P. spenceri* Edward *et* Thames, 1979
   Stylet 19-21 µm long . . . . . .*P. sacchari* Edward *et* Sharma, 1984
9. Stylet knob width 2.5-3.6 µm 10
   Stylet knob width 3.7-5 µm 11
10. Basal oesophageal bulb pyriform; post-anal intestinal sac filling most of tail cavity . . . . . .*P. acristylus* Siddiqi *et* Siddiqui, 1983
    Basal oesophageal bulb saccate; post-anal intestinal sac short, indistinct or absent . . . . . .*P. loofi* Arias, 1970
11. Cephalic region conoid-truncate, offset; frame-work strongly slerotized . . . . . .*P. anomalus* Kleynhans *et* Heyns, 1983
    Cephalic region conoid-rounded, continuous; frame-work not strongly sclerotized . . . . . .*P. kenanae* Decker *et* El-Amin, 1978

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Fig. 4 (*Front page*) - *Paratrophurus kleynsi* sp. n.: A, female anterior region (holotype); B, juvenile oesophageal region; C, female oesophageal region (holotype); D, juvenile tail; E, female anterior genital branch.

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